Transitioning to SUSTAINABLE LIFE ON LAND

Volker Beckmann (Ed.)

MDPI

SUSTAINABLE DEVELOPMENT GOALS

15 LIFE ON LAND

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Sustainable Life on Land

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Abstracts

Biodiversity and the UN's Sustainable Development Goals
by Clement A. Tisdell

This chapter critically assesses each of the targets for biodiversity conservation listed as part of Sustainable Goal 15 (SDG 15) of the UN's 2030 Agenda for Sustainable Development. The targets include ensuring forest conservation and restoration, combatting desertification and restoring degraded land and soil, conserving mountain ecosystems and reducing the degradation of natural habitats. In addition, they include urgent action to prevent poaching and trafficking in protected flora and fauna, the adoption of measures to adequately address the impact of invasive alien species and the need to take account of biodiversity conservation in local development processes and poverty reduction. It is found that the targets for SDG 15 are not well integrated with those for the other sustainable development goals, are vague and fail to pay attention to economic factors such as opportunity costs as well as economic valuation of biodiversity. India's approach for implementing SDG 15 illustrates the limitations of the UN's specification of SDG 15.

Integrating Environmental Value Systems: A Proposal for Synthesis
by Konrad Ott and Karl Christoph Reinmuth

A philosophical analysis of different typologies of values, which are used for environmental decision making, can contribute to an informed choice of a comprehensive value system. This chapter discusses classificatory maps of values and patterns of reasoning in environmental affairs. The Total Economic Value, the Ecosystem Service approach and value systems being conceived in environmental ethics will be analysed and their strengths and weaknesses will be presented. It is argued that a comprehensive and integrated synthesis of existing approaches is possible, but that even such synthesis will not simplify decision making. Nevertheless, such a synthesis is significant for the implementation of sustainability goals and for science-based policy advice.

Can Justice Respect Needs and Nature? The Idea of a Nature-Respecting Sufficiency
by Rafael Ziegler

In light of current unsustainability trends, achieving major sustainability goals, such as the protection of life on land and below water (SDG 14 and 15), requires transformative change. This paper focuses on transformative change of values and, for this, on the idea of a nature-respecting sufficiency. Sustainability discussions are motivated by two important sufficiency considerations: a focus on basic needs and on reaching and securing a social minimum for all; and a social maximum via a focus on limits to production and consumption. This intuitive appeal derives from the idea of minimum threshold as a central requirement of justice along with the idea of justice demanding respect for environmental limits. This paper proposes a nature-respecting, capabilitarian conception of sufficiency. Its starting point is the dignity of all living beings and their central capabilities. Rather than being indifferent about distribution in the space above a sufficiency threshold, this conception requires resource use above the threshold to be justified. For both the agency and patiency aspects of moral subjects, the positional and quasi-positional nature of central capabilities plays an important role, orienting intrinsic and instrumental reasons towards equal distribution. Implications of nature-respecting sufficiency are discussed in relation to (sustainable) economy and the technological and social innovations highlighted by the 2019 Global Biodiversity Assessment.

Germany's Agriculture and UN's Sustainable Development Goal 15
by Ulrich Hampicke

For 8000 years, until around 1950, agriculture in Central Europe respected and even enhanced biodiversity, although sometimes at the expense of soil fertility. During the last 50 to 60 years, the trend veered dramatically due to advancements in technology. Studies show that hundreds of common plant species, flourishing in the countryside for millennia, are now reduced to little more than five percent of their former population size. The situation is similar with birds, insects and other animals. Agriculture is directly or indirectly responsible for two thirds of the plants included in "Red Data Books" of endangered species. In addition, harm is done to groundwater due to nitrate leakage in regions with excessive livestock rearing. Even appreciating the contribution of modern agriculture to food security, the overall situation is incompatible with the UN's Sustainable Development Goal 15. Eighteen percent of Germany's agricultural area is devoted to crops used to produce electric power or fuel for motor vehicles, or which are exported in excess of agricultural imports. Energy crops perform poorly in the face of the large area required. Exports neither ensure food security in poor countries nor are necessary for Germany's balance of trade. The nation could do well without both types of products and thereby gain three million hectares available for low-input and species-rich agriculture and livestock rearing. With efficient spatial planning, the costs of such reorientation would amount to less than one per mil of Germany's gross national product and could easily be afforded by reorienting funds already existing but used inefficiently. From an economic point of view, the situation is a clear example of the poor capacity of modern societies to care for public goods.

Ecosystem Restoration and Agriculture — Putting Strong Sustainability into Practice

by Stefan Zerbe

Modern and high-yield oriented agriculture today has to be considered as one of the most important causes of global environmental problems. Besides ecosystem degradation and the loss of ecosystem services, non-sustainable agriculture can also have a significant, negative socio-economic impact. Against this background, new approaches in agriculture have to be developed to meet the need for ecological sustainability taking also social and economic capital into account. Ecosystem restoration could be one option to cope with the worldwide loss of provisioning, regulating, and cultural ecosystem services. All approaches in agriculture that meet the Sustainable Development Goals (SDGs), and in particular SDG 15, should be considered as potential solutions to the global environmental crisis. In this chapter, agroforestry systems and social agriculture are discussed as an approach for sustainable land use and ecosystem restoration. Both approaches have a high potential to meet sustainability objectives based on the triple-bottom line paradigm of sustainability. The focus will be put on Central Europe and, in particular, the mountain areas of the European Alps. The restoration of degraded land by agroforestry systems and the various environmental and social activities of eco-social agriculture can meet several objectives of sustainable land use, particularly the restoration of natural as well as social and economic capital, the promotion of biodiversity and agrobiodiversity, and the development of multifunctional cultural landscapes. Additionally, it can prevent or reverse land abandonment.

Forest Landscape Restoration and Sustainable Biomass Utilization in Central Asia
by Niels Thevs

Forest landscape restoration (FLR) has become an approach that addresses a wide range of landscapes beyond forests as woodlands, and includes restoration approaches like agroforestry. Under the Bonn Challenge, FLR has gained global attention in forest rich as well as forest poor countries, like the countries in Central Asia. Globally, countries have committed themselves to implement FLR on 350 million ha by 2030. FLR, as other restoration efforts, needs to yield income for the people, in particular for rural communities in poor countries. Central Asia is a region that offers abundant places to implement FLR and other restoration and produce biomass in settings that do not displace current land uses as food production. As examples, the following approaches are introduced: agroforestry, land use on saline land, and reed as biomass plant. Among the many possible agroforestry systems, tree wind breaks, in particular from poplars, mulberry, or paulownia, yield timber, but also silk fibers, without competing with other land uses. On saline lands, Kendir and licorice offer opportunities to yield fibers and medicinal raw materials. Reed, finally, yields huge biomass amounts across Central Asia, which is a potential feed stock for paper, paper board, OSB boards, and chemical inputs.

The Transition to Sustainable Life on Wetlands: How the Sustainable Use of Peatlands Appears on the Political Agenda
by Stefan Ewert and Susanne Abel

In intact, living peatlands, peat accumulates due to high water tables. The drainage of peatlands, particularly for agriculture and forestry, leads to peat degradation and CO2 emissions. Even though peatlands cover only three percent of the Earth's land surface, their carbon storage potential makes them crucial ecosystems for the greenhouse gas concentrations in the atmosphere. In order to use peatlands as a global carbon sink, but also to create other ecosystem services, wet peatlands have to stay wet, and drained peatlands have to be rewetted and could be used wet as well. The sustainable use of peatlands is called paludiculture. We explain how paludiculture, as an alternative approach to the unsustainable use of drained peatlands, came to be on the agenda of global climate protection initiatives and how this concept also found its way on the agenda for European agricultural policy reforms. For this, we use John Kingdon's Multiple Streams Approach and di_erent theoretical refinements as an analytical frame.

Evolution of the Land Consolidation System in China
by Kaiwen Zhang and Rong Tan

Land consolidation is regarded as an effective approach to improving agricultural productivity and promoting rural sustainable development. The modern land consolidation system started in China in 1997 in response to the potential food security crisis. This research traced back the formation and evolution of the land consolidation system in the past 20 years to gain insight into the patterns of institutional change in China. This study distinguished three main stages, each of which has a distinctive driver mechanism: the exploring period (1997 to 2004), the developing period (2005 to 2012), and the comprehensive period (since 2013). Based on policy analysis, this research concluded that the goals of the Chinese land consolidation system changed from land quantity preservation to addressing multiple concerns including food security, sustainable development, rural vitalization, and environment protection. Though these aims have not been perfectly achieved, land consolidation projects have had some positive influence. This study illustrates the mechanisms, performance, and government logic of different land consolidation systems in the Chinese context and provides results useful for other developing countries with similar land issues.

Combating Pasture Degradation in Central Asia and the Caucasus —A Review of Approaches
by Regina Neudert

In Central Asia and the Caucasus region (CAC), pastures are the dominating use of land. There is also a great variation of livestock keeping systems, stationary and mobile livestock keeping as well as horizontal and vertical migration systems. Despite these differences, the region shares a common history of socialist influence. Degradation of pasture resources, measures to combat degradation and appropriate levels of land use are recurring themes in discussions about land use in the CAC region and are relevant for achieving SDG 15.3 globally. Crucial for sustainable rangeland management are governance regimes regulating access and use of pastures. Especially after 1990, alongside diverging economic and political developments, various rangeland governance approaches were implemented in the CAC countries. In this contribution, I review the governance approaches to combat pasture degradation applied in the CAC region and relate them to theoretical paradigms of rangeland governance, namely, private, state, common and open management regimes. The analysis shows that there is evidence for all theoretical paradigms, while their suitability depends on the ecological and social contexts in which they are applied. Thus, there is no "silver bullet" to prevent pasture overuse and degradation. A central concern for sustainable rangeland management is to enable mobility, which seems theoretically compatible with all governance paradigms. In many countries, the development of rangeland governance approaches shows trial and error processes involving paradigm shifts or refinements of existing approaches to improve fit with ecological conditions and local practices of the pastoral population.

Impacts of the Land Tenure System on Sustainable Land Use in Ethiopia

by Hossein Azadi, Saghi Movahhed Moghaddam, Hossein Mahmoudi, Stefan Burkart, Diriba Dadi Debela, Dereje Teklemariam, Michal Lodin and Philippe Lebailly

On Earth, land is the most vital resource from which living things derive their essential necessities. There are many methods for managing and maintaining this vital resource in a sustainable manner, but it is more important to first understand the root cause of malfunctioning land management strategies. This chapter aims at understanding the underlying causes of socio-economic and policy-related factors affecting the sustainability of land tenure systems in Ethiopia. It also presents a review of historical and sociopolitical literature to evaluate the challenges with an insecure land tenure system, which lead to land degradation, soil erosion and low incomes. In most developing countries, systematic evaluation mechanisms of land tenure performance are very inadequate. In particular, Ethiopia has no systematic framework for assessing and measuring the state of its land tenure system. In this line, this study applies a systematic review to explore theoretical considerations and overviews on current estimates related to land tenure security in Ethiopia. Through an in-depth literature review and a qualitative analytical approach, the results identified a collection of good practices and indicators that can provide a framework for a systematic evaluation of sustainable land use in Ethiopia. The findings also showed performance gaps in land management, the application of enacted legislation and the allocation of land for agricultural investments. This study provides recommendations to federal and regional institutions with a mandate for land management, land holding and resource rights and land use on how to resolve these bottlenecks.

New Types of Land Ownership to Sustain Life on Land
by Insa Theesfeld and Jarmila Curtiss

The SDG 15, sustainable Life on Land, has a strong relation to farming. In Europe and in Germany we experience a growth in community- and civil society-supported organizations of farmland ownership. Those new types of organizations governing land ownership are to a large part not-for-profit organizations that answer to the ecological values of their supporters. In this contribution we show for Germany that this type of community-supported land ownership appears in numerous and diverse legal forms with a range of 1-68 partner farms each. Each individual legal form of governing such community-supported organization allows for different styles and formal arrangements of land stewardship, with the focus here on combating land degradation and reducing biodiversity loss. They are found in a full geographical spread across Germany although publically beneficial associations prevail in old Federal States for historic reasons. The empirical material is based on a German-wide scoping study conducted in 2020. With a spotlight on two case studies, we will exemplify the new opportunities for supporting the ecological transition of land use by means of community-supported land ownership.

Agricultural Policy for Biodiversity: Facilitators and Barriers for Transformation
by Sebastian Lakner, Christian Schleyer, Jenny Schmidt and Yves Zinngrebe

The Common Agricultural Policy (CAP) has integrated some environmental aspects into its instruments and measures. Since the 1990s, environmental measures have been introduced and iteratively adjusted with a new funding period every four to seven years. This chapter presents four stages of the policy cycle as an analytical framework in order to assess whether CAP decision makers have learned from experience to improve the performance of the CAP in preserving biodiversity. Following these four stages, we, first, present the evolution of the agriculture-related environmental agenda in the CAP. Second, we give an overview of key CAP instruments as policy output, including Agri-Environmental Programs/Agri-Environmental and Climate Measures, Cross-Compliance, and Greening of Direct Payments. Third, we compile information on the implementation performance of these instruments to assess the social outcome and ecological impact of the CAP. Finally, we evaluate the learning potential of the CAP process and derive underlying causes. We conclude that CAP reforms have repeatedly failed to draw on the accumulated knowledge on agri-environmental instruments and give some recommendations for improved biodiversity conservation.

Strategic Engagement in Institutions of Organic Farming in Indonesia
by Dimas D. Laksmana and Martina Padmanabhan

Indonesia was one of the then authoritarian states that spearheaded and thoroughly institutionalized the green revolution. The emergence of organic farming (OF), proposed as a strategy for environmental conservation in Indonesia, is embedded in this history. This article uses social network analysis (SNA) to investigate institutional aspects of OF in Indonesia, focusing on the dynamic interactions amongst the actors that drive its development. The Net-Map method was applied as a tool to explore the tensions, areas of cooperation, and potential spaces for resolution that are constructed by OF actors, with the active engagement of the actors themselves. Based on two indices of network centrality—betweenness centrality and degree of centrality—three distinct groups of actors emerged, characterized by different modes of interaction with government actors. Disengaged actors are not linked to any government actors in sustaining their movement; partially engaged actors strategically adapt to government OF regulations while maintaining their commitment to the foundational principles of the OF movement; fully engaged actors pursue OF wholly within the framework of government regulations. Our analysis suggests different notions of sustainability are enacted by these actors. In addition, the current OF institutions highlight the contradiction between centralized governance structures in the agricultural sector and the government's stance that OF should prioritize the use of local resources and knowledge. However, spaces exist for negotiation between the civil society and government, which could lead to the formulation of more coherent OF policies that can accommodate a diversity of goals, strategies, and views on the sustainability of OF.

Biotechnology, Bioeconomy, and Sustainable Life on Land
by Justus Wessler and David Zilberman

New developments in biotechnology have reduced the use of pesticides and increased yield per hectare for crops including canola, cotton, corn, and soybeans. These developments have often been accompanied by the adoption of reduced or zero-tillage systems and an increase in double-cropping, thereby reducing pressure on land and contributing to the protection of terrestrial ecosystems. They directly contribute to achieve SDG 15, but also to achieving SDG 2. This chapter presents a summary of these developments. It further includes a discussion of promising developments within the bioeconomy and their potential to promote sustainable life on land. These developments include major changes in food production, as well as innovations in the conversion of biological resources into high-value products other than biofuels. The discussion also addresses several potential obstacles, the most important of which consists of government regulations.

Barriers to Zero Tropical Deforestation and 'Opening up' Sustainable and Just Transitions

by Izabela Delabre and Callum Nolan

The UN Sustainable Development Goals include ambitious targets for tackling deforestation and emphasise the roles of diverse actors and partnerships for transformative change. Initiatives for governing tropical forests take multiple forms, including 'zero deforestation' supply chain initiatives, carbon forestry, Reducing Emissions from Deforestation and Forest Degradation (REDD+), legislative frameworks that intend to cut off markets for illegally harvested timber, and emerging landscape and jurisdictional approaches. Drawing on insights from political ecology and sustainability transitions research, this chapter discusses the barriers to transitioning to 'zero deforestation' through consideration of: (1) the contested framing of the problem of deforestation, (2) how sustainable forest governance is translated and enacted across scales, and (3) who is represented in 'the transition'. This reveals opportunities for sustainable and just transitions for forests. We argue that careful attention must be paid to the influences of power and politics surrounding forest governance and its social and ecological outcomes, and the need to challenge orthodoxies around economic growth that currently underpin policy responses.

Transitioning to Sustainable Life on Land—Introduction to SDG 15 and the Volume

Volker Beckmann

1. Introduction

Land constitutes only 29.3% of planet Earth's surface area but harbors 86.1% of the global biomass (Bar-On et al. 2018). Out of the 8.7 million species estimated to exist globally, 75% live in terrestrial ecosystems (Mora et al. 2011). Some scholars even found biodiversity on land was 25 times higher than in the sea (Benton 2001). Although numbers of species and levels of biodiversity are still subject to significant scientific uncertainty, there is no doubt that life on land is essential for life on Earth, global biodiversity, and humans.

Over history, humans have transformed land, other species, and ecosystems to an unprecedented magnitude. During the past 12,000 years, anthropogenic land use increased tremendously on a global scale (Ellis et al. 2020). It is estimated that 75% of the land surface area has been directly affected by human activities (Riggio et al. 2020). Almost all terrestrial areas and part of the sea are claimed today by the 193 United Nation Member States as territory under sovereignty control, leaving Antarctica and the High Sea as the only partly unclaimed areas on Earth. Human life, economic activities, and many critical human institutions, such as states, public administration, property, or residency are related to land. Agricultural land use currently covers up to 50% of the habitable land (34% of the total terrestrial area), followed by forests and shrubs, used to different degrees. However, settlements still cover only 1% of the habitable land (Ritchie and Roser 2019). The Great Acceleration of human land use began in 1750, whereas land use intensity has increased in particular since 1950 (Steffen et al. 2015). Today, the biomass of livestock by far exceeds the biomass of all wild living mammals and birds (Bar-On et al. 2018). In 2020, the total human-made mass for the first time in history has exceeded the biomass of all forms of life (Elhacham et al. 2020). In the Antropocence, humans have become a force of geological significance (Lewis and Maslin 2015).

In fact, human impact has risen to a level that endangers the survival of many species on planet Earth and human welfare itself. It has become increasingly evident that human impacts exceed the planetary boundaries in multiple dimensions, particularly the effects on biodiversity, nutrient cycles, and greenhouse gas emissions (Rockström et al. 2009). Additionally, other indicators, such as Earth Overshoot Day, clearly signal that current use levels are unsustainable (Wackernagel and Pearce 2018). As regards biodiversity, scientists claim that Earth is in the middle of an anthropogenically caused Sixth Great Extinction, with the risk of losing 75% of all species (Ceballos et al. 2020). According to a report by IPBES, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, humanity is at the risk of driving 1 million species to extinction, mainly due to the extension and intensification of agriculture (IPBES 2019).

It must be noted that these developments occurred despite significant conservation efforts, which began in the 18th and 19th century with the first establishment of conservation organizations and the creation of the Yellowstone national park in 1872 (Dyke 2008). The development of protected areas "exploded" since 1980th (Naughton-Treves et al. 2005), and today almost 16% of the terrestrial area is protected to different extents (Protected Planet 2021). However, the effectiveness of protected areas to halt biodiversity loss is questioned (Geldmann et al. 2019). Although there is some indication that biodiversity in protected areas is higher inside than outside (Gray et al. 2016), protected areas are also affected by surrounding human activities (Hallmann et al. 2017), not least by human-induced climate change (Thomas and Gillingham 2015). According to the 20 Aichi targets proposed by the Convention on Biological Diversity (CBD), there is an agreement that worldwide societies must expand protected areas on land and sea (Lewis et al. 2019). However, this will likely not be enough to hold biodiversity decline and sustain life on land (Venter et al. 2018). Conservation must be integrated into all human activities and must be an integral part of the sustainable use of resources.

The Sustainable Development Goals (SDGs) agreed in 2015 by the United Nations offer in principle such an integrative perspective and include Life on Land as one among 17 goals. This editorial provides a brief introduction to SDG 15, also relating to other SDGs, and reflects mainly on the contributions to this volume.

2. The Sustainable Development Goals and SDG 15

The Sustainable Development Goals (SDGs) and the Agenda 2030 are a milestone in a long journey of humankind recognizing its joint responsibility for planet Earth and identifying sustainability as a guiding principle for economic and political development (Shi et al. 2019). The key idea of sustainable development translates into 17 goals, 169 targets, and 231 indicators (United Nations 2015, 2017). Although the goals can be best interpreted as a political compromise which cannot be expected to be free of contradictions, it is the first time that at a global level development goals were formulated for all nations (Sachs 2012). The SDGs can be divided according to the three pillars of sustainable development into social (SDG 1–5, 7, 11, 16), economic (SDG 8–10, 12, 17), and environmental objectives (SDG 6, 13–15), but more common is the division in the 5P's, people (SDG 1–6), planet (SDG 11–15), prosperity (SDG 7–10), peace (SDG 16), partnership (SDG 17) (Tremblay et al. 2020). Life on Land, SDG 15, is clearly classified as a planet or environmental objective and calls to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (United Nations 2015) (see Table 1).

Table 1. Sustainable Development Goal 15 and its targets and indicators.

SDG 15	**Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.**	
Target		**Indicator**
SDG 15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.	15.1.1 Forest area as a proportion of total land area 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
SDG 15.2	By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.	15.2.1 Progress towards sustainable forest management

Table 1. *Cont.*

SDG 15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.	15.3.1 Proportion of land that is degraded over total land area
SDG 15.4	By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.	15.4.1 Coverage by protected areas of important sites for mountain biodiversity 15.4.2 Mountain Green Cover Index
SDG 15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.	15.5.1 Red List Index
SDG 15.6	Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.	15.6.1 Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits
SDG 15.7	Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products.	15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked

Table 1. *Cont.*

SDG 15.8	By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species
SDG 15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.	15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting
SDG 15.A	Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.	15.a.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments

Table 1. *Cont.*

SDG 15.B	Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.	15.b.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments
SDG 15.C	Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities.	15.c.1 Proportion of traded wildlife that was poached or illicitly trafficked

Source: United Nations (2015, 2017), with refinements United Nations (2021a).

SDG 15 divides into 12 targets and 15 indicators. They concern ecosystem conservation, restoration, and sustainable use in particular of soils, forests, mountains, and genetic resources (SDG 15.1–15.4, 15.6), the protection of biodiversity, natural habitats, and endangered species (SDG 15.5, 15.7, 15.8, 15.C), and policy improvements by better integrating biodiversity into planning and enhancing financial resources for conservation and sustainable use (SDG 15.9, 15.A, 15.B). Thus, the targets combine conservation and sustainable use, support the development of clear property rights in natural resources and species and request improved governance and financial resources. It should be noted that the indicators only partly reflect the targets and continue to be disputed and adjusted (Janoušková et al. 2018).

Since the SDGs provide an integrative set of goals, complex interactions among goals and targets in terms of synergies and trade-offs can be expected. Pradhan et al. (2017) identified SDG 15 as one of the SGDs with the highest number of trade-offs and the lowest number of synergies. Fonseca et al. (2020) identified the most pronounced trade-offs between SDG 15 and SDG 2 "Zero hunger—End hunger, achieve food security and improved nutrition, and promote sustainable agriculture". That is because the expansion and intensification of agricultural land use are considered a prominent cause of biodiversity loss, deforestation and land degradation. The most considerable synergies occur between SDG 15 and SDG 14 "Life under Water—Conserve and sustainably use the oceans, seas and marine resources for sustainable development" (Fonseca et al. 2020). However, the relationships between SDGs and the possibility and constraints to reach them simultaneously within the envisioned timeframe are debatable and require context-specific analysis and actions.

3. The Contributions to This Volume

This volume is about transitioning to SDG 15 specifically and to sustainable life on land more generally. Transitioning can be understood in different ways. In a narrow sense, transitioning is about reaching the specific targets of SDG 15 by using the particular indicators of SDG 15. This view is mainly the policy, reporting, and monitoring perspective. In a more general sense, transitioning is about broader changes in policy, economies, and societies at different levels towards integrating the protection, restoration, and sustainable use of terrestrial ecosystems into the general agenda of sustainable development. The latter is the central perspective of this volume.

The contributions to this volume are structured into four parts. The first section reflects more broadly on goals and trade-offs as well as on values and ethics of conservation and restoration. The second part provides specific cases of ecosystem restoration in cultivated landscapes such as agriculture, forestry, and peatlands. The third part is devoted to studies focusing on land property rights and governance issues and how they relate in different contexts to land degradation and biodiversity loss. The final part addresses political and social challenges connected with the transition to SDG 15. Thus, the structure does not follow the SDG targets but addresses more underlying and cross-cutting issues.

Altogether, the papers provide an overview of some of the transitions in policy, economies, and societies needed to achieve SDG 15 and the trade-offs and synergies within and with other SDGs from different social science disciplines, including economics, philosophy, political science, administration science, sociology, anthropology, and landscape ecology. The geographical focus is mainly on Europe, Central Asia, East and South East Asia, with some studies addressing Africa and America. Moreover, this volume mainly focuses on the protection, restoration, and sustainable use of cultural ecosystems, not on the conservation of "wilderness". The usual tool to protect life on land, establishing protected areas, will not be investigated explicitly. This perspective is elaborated extensively elsewhere (Dudley et al. 2017; Ansari et al. 2021). Thus, this volume is less about the separation of use and conservation but its integration.

3.1. Goals, Trade-Offs, Values, and Ethics

SDGs govern by goals. This is considered as a major institutional innovation in international sustainability governance, from rules based to goal based (Kanie et al. 2019). However, as already mentioned, multiple goals are usually interconnected, sometimes with synergies but more often with trade-offs. Tisdell (2021), in this volume, provides an excellent introduction to the specific targets of SDG 15 concerning biodiversity and its possible contradictions both within SDG 15 and with other SDGs. He argues that the targets are pretty vague and that trade-offs are not specified. Moreover, Tisdell criticizes that the main drivers of biodiversity loss are not addressed, and biodiversity loss in cultural landscapes is not sufficiently recognized. He observes that economic principles and valuation methods did not play a significant role in formulating the SDGs and requests a better integration of targets and a recognition of opportunity costs. Tisdell sees that there is a continuous need to "evaluate biodiversity in its contributions to anthropocentric economic goals and to allow for the felt obligation to conserve the web of life even when there is little or no apparent material economic value to humankind" (p. 39).

In a world of limited resources, pursuing multiple goals require decisions to be made. Goals need to be prioritized, trade-offs to be evaluated. In this volume, Ott and Reinmuth (2021) discuss the importance of environmental valuation in decision-making. In reflecting on economic approaches to valuation, such as the Ecosystem Service (ESS) perspective and the Total Economic Value (TEV) concept, and combining them with ideas from environmental ethics, they argue for an integrative approach that appreciate the heterogeneity of values. They request economists to think about the scarcity of nature in close connection to environmental ethics, distributional justice, and sustainability sciences. Many decisions require ethical disputes over property rights, which economists often try to avoid. Ott and Reinmuth state that, in particular, existence and option values open the doors for reflections about environmental ethics.

Environmental ethics is a mainly normative discipline (Palmer et al. 2014) and discusses the way people should behave and the values people should hold. Ziegler (2021), in this volume, offers such a normative discussion. He raises questions about the transformative change of fundamental values to achieve the SDGs in general and SDG 14 and 15 in particular. He reflects on values of what he calls "nature-respecting sufficiency". Sufficiency, as Ziegler shows, can be viewed as a standard, requirement, or limit defining a morally legitimate space of actions and outcomes. In further distinguishing weak, strong, and transformative sufficiency, the concept of nature-respecting sufficiency is developed as the latter. It calls for a focus on “both agents and patients, and the thresholds and principles required for leading a life in dignity” (ibid., p. 96). Most fundamentally, however, nature-respecting sufficiency requires “to recognize us as one species among others” (ibid., p. 97).

3.2. Ecosystem Restoration in Cultural Landscapes

Cultivated or cultural landscapes dominated by agriculture and managed forests cover a significant part of the terrestrial area. Sometimes the cultivated landscapes have existed for centuries, or millennials and have profoundly shaped the past and current biodiversity (Jouffroy-Bapicot et al. 2021). Hampicke (2021), in this volume, reviews the history of German agriculture and shows how biodiversity in Central Europe was largely related to cultural landscapes that developed over centuries. The intensification of agriculture in Germany since 1950, like in other countries worldwide, increased yields impressively but, among others, caused a decline of biodiversity. Most of the biotope types related to the Red List of extinct and endangered species in Germany are agricultural biotopes, such as dry grassland. Hampicke discusses alternatives to the current system, e.g., organic farming and the reduction in agricultural output and exports, and suggests a conservation program covering 13 % of the agricultural land in Germany at an annual cost of EUR 2 billion. This program would promote semi-cultured landscapes, set aside for the least productive croplands, and add structural elements in highly productive agricultural regions. For the case of Germany, he argues that it should be easily possible to finance the necessary restoration, given the wealth of the country and the possibilities to reallocate funds of the Common Agricultural Policy (CAP).

For the mountainous regions of the alps, also Zerbe (2021), in this volume, argues that the current agricultural system is unsustainable and a primary cause of biodiversity loss. He further reasons for the need to diversify agriculture by supporting different farming systems, particularly agroforestry and social farming approaches. Both systems offer advantages in terms of the ecosystem services they provide. They reduce the intensity level and increase the contribution to social and ecological objectives. Zerbe, like Hampicke, suggests restoring nature in a cultural landscape mainly by lowering the land-use intensity and increasing the structural diversity of cultivars and landscape elements.

Thevs (2021), in this volume, adds to this discussion by moving to forest landscape restoration and sustainable biomass utilization in Central Asia. Central Asia is relatively poor in forests, but according to Thevs, it offers multiple opportunities for forest restoration in the mountains and the lowlands, steppes, drylands, and wetlands. He argues that forest restoration should also provide income opportunities for local people. Forest restoration efforts can contribute to the transition to a sustainable bioeconomy. Thevs suggests, among others, the protection and restoration of Tugai forests along the river systems and wetlands. He develops opportunities for agroforestry systems, mainly the plantation of wind-breaks or the plantation of salt-tolerant trees. As alternative biomass resources, Thevs also mentions the vast amount of reeds that grow in Central Asia's wetlands, which could develop into a valuable source of the bioeconomy.

For centuries, wetlands and peatlands in Europe have been drained to expand agricultural land (Swindles et al. 2019). Today, the restoration of peatlands is considered a necessity mainly because drained peatlands are a large emitter of GHG emissions, and wet peatlands can serve as an effective sink for carbon (Schwieger et al. 2021). Ewert and Abel (2021), in this volume, show how in this context, the concept of paludiculture was developed and arrived overtime on the political agenda of the European policy. Paludiculture is the idea that wet peatlands, while reducing emissions of GHG and restoring nature, can also be used in a sustainable way to produce diverse biomass, e.g., reed, cattail, for the bioeconomy. Ewert and Abel apply the Multiple Stream Approach of policy science and argue that a combination of restoration and innovative use turned paludiculture into an attractive concept for political entrepreneurs. The restoration of peatland contributes not only to SDG 15, but as well to SDG 6 (clean water), SDG 13 (climate action), and SGD 9 (innovation).

3.3. Land Property Rights and Governance

Over history, different property rights systems and governance structures related to land and terrestrial ecosystems emerged (Kavanagh et al. 2021; Ellickson 1993). Open access regimes, which often lead to resource overuse and degradation, were increasingly replaced by state, communal and private property regimes (Lerch 1998). In particular, the private property of land, animals, and plants governed by markets has resulted in investments and innovation fueling economic growth. At the same time, conservation used to be connected with state ownership and public governance. However, increasingly it is recognized that conservation must be better integrated into the diversity of land tenure systems (Robinson et al. 2018; Kamal et al. 2015).

For more than 40 years, China's land property rights system attracted a lot of attention since it combines state and collective ownership of land with individual and tradable use rights. Zhang and Tan (2021), in this volume, review the evolution of the land consolidation system in China. Land consolidation, that is, the reallocation and readjustment of land parcels in rural and urban areas, has for a long time been an instrument to improve farming and settlement efficiency, but often at the expense of the environment. Zhang and Tan show that land consolidation in China developed from a policy focusing purely on increasing farmland area and reclaiming undeveloped land into an approach that aims to maintain and improve farmland, rearrange construction land, and improve ecological protection and restoration. However, according to the authors, there are still contradictions and leakages in the system, and better integration of ecosystem and biodiversity conservation in the Chinese land consolidation system is warranted.

Neudert (2021), in this volume, exemplifies the diversity of property rights and governance structures for pastures in Central Asia and the Caucasus. With about 30% of the terrestrial area classified as grasslands, grassland ecosystems have a significant share in the terrestrial land area. Central Asia and the Caucasus share a common history of being part of the Soviet Union and the socialist heritage. All these countries have vast grasslands degraded to a different extent. Neudert argues that different paradigms of rangeland governance exist: (a) the classical economic theory recommending privatization, (b) the legacy of the Soviet Union perspective arguing for strong state control, (c) the common property scholars arguing for common management, and the (d) new rangeland science in favor of open property regimes. The empirical analysis of ten countries shows that all four paradigms are present and offer advantages and disadvantages. Thus, no blueprint approach is appropriate for achieving sustainable land governance and use. Instead, governments should adjust a general approach to the specific socio-ecological conditions within the respective country.

Turning the attention to the case of Ethiopia, the second most populous country in Africa., Azadi et al. (2021), in this volume, focus on tenure security and its relationship with land degradation and unsustainable land use. The authors introduce the history of land tenure in Ethiopia, which turned from diverse and complex ownership, including concepts of private land property, into a mainly state-owned land tenure system. According to the constitution, ownership of land and all-natural resources is with the state and the people of Ethiopia, while private ownership of land is prohibited. However, peasants, pastoralists, and semi-pastoralists are granted free access and use rights (Agegnehu 2020). Azadi et al. argue that this system has created tenure insecurity and, connected with population growth, caused land degradation, biodiversity loss, and unsustainable use. The conversion of forest land, protected areas, and wetlands for agricultural investments are considered as the main problem. Therefore, they argue for more effective land administration, including the official demarcation, mapping and registration of public lands, and better implementation of the existing laws.

Theesfeld and Curtiss (2021), in this volume, refer to a completely different setting, the land tenure and ownership structure in Germany. Private property is dominating, and tenure security is often not regarded as an issue there. Still, access to agricultural land, biodiversity loss, and land degradation due to highly intensive agriculture on private land are of concern. Moreover, also land grabbing for for-profit occurs. Theesfeld and Curtiss report the results of an investigation into new types of community-supported ownership, thus cases where owners provide financial capital to support ecological outcomes and not primarily financial returns. All over Germany, such new cooperative initiatives emerged. In detail, two initiatives are analyzed. They show that the organizations "adopt the right of defining land use conditions in exchange for long-term tenure and below-market price rental conditions for farmers" (ibid., p. 329). Thus, these are compelling cases of private initiatives for supporting SDG 15 when public policy is considered to fail.

3.4. Political and Societal Challenges

Transition to the SDGs and to SDG 15 specifically create many political and societal challenges. Dealing with diverse, complex and conflicting structures of land ownership is one of them. Others are related to the policy process or the acceptance of different technology. Policy has multiple and often conflicting objectives, it is affected by powerful actors and ideologies. Policy might be difficult to change quickly and path dependencies might be prominent. Moreover, there might be tensions between political, economic, technological, and societal processes.

Lakner et al. (2021), in this volume, reflect on the Common Agricultural Policy (CAP) of the European Union (EU) and its link to biodiversity. Although the CAP responded to the increasing negative impact of intensive agriculture on the environment, particularly by introducing Agri-environmental Programs (AEP) since 1992, Cross-Compliance since 2005, and Greening since 2013, the biodiversity loss in agricultural landscapes could not be halted or reversed. Lakner et al. offer a very detailed analysis of the policy cycle and its implementation and show that CAP is difficult to reform. It transforms only slowly, and they conclude that "without including other political and other stakeholders in negotiations on budget allocations and policy design, agricultural interest groups will continue to preserve current trajectories and undermine any initiative for sustainable transformation" (ibid., p. 369). In this regard, Ewert and Abel (2021), in this volume, present a successful case of transformation. They show that paludiculture, which emerged as a concept entirely outside the agricultural cycles, managed to become recognized at the EU agricultural policy level. A policy might also change slowly until a certain momentum is reached, as the example of supporting organic farming in the EU may exemplify. Although the EU has supported organic agriculture since 1992, it is only since 2020 that the EU Commission declared in its Farm-to-Fork Strategy that the EU-wide organic farming target is 25% of the total agricultural area in 2030 (European Commission 2020).

In contrast, in Indonesia the share of organic agriculture, according to the available statistics, is still meager, with 0.4% (Willer and Lernoud 2019). In this context, Laksmana and Padmanabhan (2021), in this volume, examine the sustainability of organic farming institutions. The authors show that organic agriculture started in Indonesia, as in many other counties, as a grassroots civil society project in 1983. In 2002, the government started supporting the expansion of organic farming with the "Go Organic" program. The government developed ambitious objectives of developing organic agriculture in Indonesia as an export industry and established a respective certification and monitoring system. This created tension between the organic farming movement and the government. By performing an actor-network analysis, Laksama and Padmanabhan disentangle the influence of different actors on organic farming regulation in Indonesia. The analysis exemplifies the conflict between central and decentral knowledge, and between governments and civil society. They argue that progress towards SDG depends on the pressure of social movements on governments.

Organic farming seems to be one way to reduce the tension between SDG 15 and SDG 2 by integrating biodiversity conservation within farming systems; however, another is modern biotechnology. In their contribution to this volume, Wesseler and Zilberman (2021), outline the potential of biotechnology for achieving the SDGs. Biotechnology crops require fewer inputs, secure high yields, and reduce land-use pressure by opening up opportunities to set aside land for biodiversity conservation. Moreover, biotechnology also offers new opportunities, like cultured meat, which might reduce livestock numbers and improve animal welfare. Thus, they consider biotechnology is essential for any transformation towards a bioeconomy. The authors also discuss the political economy of plant biotechnology in the EU, where a strict regulatory environment emerged. They show the struggle between proponents of organic farming and proponents of biotechnology and the role of the precautionary principle in EU policy. Additionally, others argue that conservationists overemphasize the risks of new technologies at the expense of missed opportunities (Brister et al. 2021). It is claimed that also organic farming should make use of modern biotechnology (Purnhagen et al. 2021).

The final paper in this volume by Delabre and Nolan (2021) focuses on key issues of deforestation in tropical forests. It takes off from the observation that the SDG target of zero-deforestation (SDG 15.2) was not met in 2020. They argue that "attention must be paid to the influences of power and politics in forest governance ... " (ibid., p. 438). Forest landscape changes do not just happen but are shaped by a complex network of human actors. The authors discuss contested definitions of forests and deforestation and the meaning of "zero" in deforestation, the problem of translating sustainable forest governance into practice, including the measuring, reporting, and verification systems finally, asking the question about who is represented in decision making. According to them, priority is given to agricultural development and the economic growth paradigm, which is in conflict with the zero-deforestation objective. They recommend, among others, that "local actors should be placed at centre stage in decision making, early on in processes related to land use change" (ibid., p. 447).

4. Conclusions

Transitioning to Sustainable Life on Land requires humanity to protect, restore and promote sustainable use of terrestrial ecosystems. In total, 193 Nation States have committed themselves to moving towards SDG 15 while paying attention to all other 16 SDGs. Trade-offs are unavoidable, and choices need to be made. As Tisdell (2021), in this volume, has put it: opportunity costs are inevitable. It is therefore not surprising that different countries set different priorities in achieving various goals or targets in different time frames (Forestier and Kim 2020).

The contributions to this volume shed light on the transitioning of different societies towards SDG 15, with a focus on four cross-cutting issues: (1) goals, trade-offs, values, and ethics; (2) ecosystem restoration in cultural landscapes; (3) land property rights and governance structures; and (4) political and societal challenges. The contributions offer diverse perspectives and sometimes also conflicting recommendations. Many contributions reflected on one of the most challenging trade-offs between SDG 15 and SDG 2, biodiversity and agriculture. The search for a model of sustainable agriculture is critical. The recommendations range from reducing farming intensity, increasing structural diversity, supporting organic farming to developing high-yield–low-input farming systems and cultured meat based on modern biotechnology. This provides much food for thought.

Given the urgent need to prevent the expected upcoming biodiversity crises, the overall transition towards SDG 15 must be considered to be very slow. Almost none of the SDG 15 targets for 2020 have been reached at the global level (United Nations 2020). Some contributions in this volume show how long it takes to change policies even if the financial resources are available and that severe tensions can occur between policy, business, and society, preventing innovative solutions. Otto et al.

(2020) argue for the case of climate policy that social tipping point interventions are needed to reach momentum for change. Some hints for social tipping elements can be found in this volume, although a systematic analysis of the literature remains to be done. It is now well known that the SDG are pursuing the 5 P's, people, planet, prosperity, peace, and partnership. The latest progress report of the United Nations (2021b) suggested a small change that might make a big difference: "It is time to put the health of the planet at the centre of all our plans and policies" (p. 56).

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Part 1: Goals, Trade-Offs, Values, and Ethics

Biodiversity and the UN's Sustainable Development Goals

Clement A. Tisdell

1. Introduction

The 2030 Agenda for Sustainable Development (which was adopted by all United Nations States in 2015) presents an ambitious set of goals for achieving sustainable development. According to a United Nations' source, "it provides a shared blueprint for peace and prosperity for people and the planet, now and into the future" (United Nations 2015a). "At its heart are 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries—developed and developing in a global partnership. They recognize that ending poverty and other deprivations must go hand in hand with strategies that improve education, reduce inequality and spur economic growth—all while tackling climate change and working to preserve our oceans and forests" (United Nations 2015a).

While the purpose of this agenda is admirable, in reality, it promises much more than it is likely to deliver. This is partly because the statements of its SDGs and their related targets had to be crafted in a way to obtain their political acceptability by nations with diverse and often conflicting interests. In order to satisfy all countries ratifying the agenda, many of the targets are rather vague and open-ended and lack compatibility. Moreover, it is left to individual nations to decide which targets they will focus on and how these will be addressed. This includes the biodiversity targets present in this agenda. Furthermore, no penalties will be imposed on individual nations failing to address any of the SDGs adequately. Basically, the extent to which individual nations pursue the SDGs is voluntary. In addition, because individual nations report on their own progress in achieving the SDGs, this gives them scope to paint a more favourable picture of their achievements than may be warranted. These limitations all reflect the need of the UN to respect national sovereignty.

Despite these limitations, the SDGs provide nudges, prompts or reminders to individual nations and communities of the need to adopt policies to respond to significant global environmental and sustainable development problems. Furthermore, the SDGs and their associated targets provide platforms for the academic community and for the general public to discuss and analyse pressing sustainable development issues.

This chapter focuses mainly, but not entirely, on examining the biodiversity targets listed or implied in SDG 15. SDG 15 is intended to promote the sustainability of life on land and lists several targets for doing this. This list includes objectives for forest conservation, for combatting desertification, for limiting and reversing land degradation, and for stopping biodiversity loss. The discussion of the SDG 15 biodiversity targets is preceded in this article by considerations on the nature of biodiversity and its valuation. This discussion is important for showing the types of challenges that have to be overcome in specifying biodiversity targets and for setting the biodiversity targets contained in the 2030 Agenda for Sustainable Development. After this, the biodiversity targets contained in SDG 15 are scrutinized, and then other relevant targets and additional biodiversity targets contained in the 2030 Agenda for Sustainable Development are considered, giving particular attention to their compatibility with the biodiversity targets listed in SDG 15. Subsequently, in order to provide a concrete example of how one country has decided to respond to the SDG 15 biodiversity targets, the approach of India is briefly outlined and critically examined. This is followed by a general discussion.

2. The Concept of Biodiversity and Its Valuation

2.1. The Complexity of the Concept of Biodiversity

Biodiversity is both a multi-layered and a multidimensional concept (Juhász-Nagy 1993; Magurran 2003). Two major layers include:

- The diversity of ecosystems
- The extent of genetic diversity

Within each layer, the dimensions of this diversity can be measured in different ways. For example, in relation to genetic diversity, one can account for the number of genera, the number of species and the diversity of sub-species and varieties in each category. The geographical extent of each of these can be another consideration, for example, the extent to which these biodiversities are locally present, their regional occurrence and their global prevalence. Given the multilayered and multidimensional nature of biodiversity, the prospect of constructing a general index which satisfactorily embraces all the characteristics of biodiversity seems to be slim. This (as well as differences of opinion about how best to value biodiversity) makes it difficult to determine appropriate sustainable development goals for biodiversity.

2.2. The Specification of SDG 15 Inadequately Related to the Nature of Biodiversity

To a large extent, the diversity of extant organisms depends on the variety of existing ecosystems and their adequacy for enabling varied organisms to survive. In other words, the number of available environmental niches has a major influence on the extent of species diversity. This is highlighted by the fact that loss of habitat is the main cause of the global reduction in genetic diversity in the wild (Joppa et al. 2016, p. 418). Economic development is the main contributor to this loss because of its impact on natural ecosystems. Unfortunately, this relationship is not explicitly mentioned in the specification of SDG 15. Instead, it focuses on objectives to reduce poaching and illegal trafficking in wildlife and the control of invasive organisms as measures to sustain biodiversity. While attention to both these threats to biodiversity is warranted, more significant threats ought to have been considered in formulating SDG 15. Moreover, not only the loss of wild biodiversity but also the loss of existing diversity in agriculture and other bio-industries (that is, other industries culturing or husbanding living resources, such as aquaculture) should have been taken into account in proposing targets for sustaining life on earth.

These shortcomings might have been overcome if more attention had been paid to the concept and nature of biodiversity and to establishing an overarching framework for the scientific discussion of policies to promote sustainable development. However, it is unrealistic to expect scientific precision in the formulation of the targets for the Global Agenda 2030. This is because this agenda had to be formulated and modified, for it to be accepted by existing nations and stakeholders with varied interests and aims.

2.3. Valuation, Biodiversity Conservation and the SDGs

Rationally determining biodiversity targets requires some acceptable and logical method of valuing objectives. Whether or not the consensus-type political method adopted in formulating the targets for the SDG goals and the biodiversity component embedded within these is adequate in this regard is open to question. The UN's sustainable development agenda appears to pay little or no attention to the type of methods that economists have been developing to value biodiversity conservation and to economic principles but appears to rely heavily on the opinion of natural scientists for its background formulation and for the determination of its targets for biodiversity conservation. This may be because ecologists and many other natural scientists have been prominent in portraying sustainable development as primarily an ecological problem.

This raises the question of why there is a lack of attention to economics in formulating the Global Agenda 2030 targets for biodiversity conservation. There are a number of possible reasons for this. These include:

- Lack of respect for the methods used by economists for valuing biodiversity conservation
- Possible dislike of the fact that economic methods, such as social cost–benefit analysis, often indicate that some modification of natural ecosystems to supply marketable goods can be economically optimal
- The partial nature of the results obtained so far by economists;
- The use of disparate methods of economic analysis which result in different policy conclusions

As far as the latter aspect is concerned, two different economic approaches to conservation of biodiversity (which can result in different policy conclusions) include:

- Methods based on the principles of welfare economics, as, for example, previously reviewed (Pascual et al. 2010)
- Methods based on economic impact analysis as, for example, applied to the conservation of ecosystems (Costanza et al. 2014)

The first mentioned approach is based on social cost–benefit analysis. In this case, estimates of the willingness to pay for marketed commodities as well as unmarketed environmental ones are often taken into account in determining social benefits. The second mentioned approach concentrates on the effect of the conservation of environmental resources on the level of incomes and employment. These effects are generated by marketed commodities, for example, by the sale of tourism services. This approach gives inadequate attention to the economic value of unmarketed ecological services. Disparities in the policy implications of the application of the methods of welfare economics and of economic impact analysis have been pointed out by Tisdell (2012; 2015, chp. 16). Nevertheless, all have a role to play in evaluating biological conservation.

With this background in mind, let us start to consider the nine conservation targets contained in SDG 15 (as well as three added policy proposals) and then subsequently explore additional dimensions of biodiversity conservation evident in the other SDG goals. As pointed out by Schultz et al. (2016, p. 23), targets listed under SDG 15 only directly refer to terrestrial ecosystems and biodiversity.

3. The SDG 15 Targets and Biodiversity Conservation

3.1. Background Information

The aim of SDG 15 is to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss" (United Nations 2015b). It is accompanied by nine targets and three policy suggestions. *Target 15.1* is "by 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands and mountains and drylands, in line with obligations under international agreements". One of the questions that arises in that regard is whether all sustainable uses of ecosystems are compatible with one another and beneficial to biodiversity conservation. Cases will arise in which trade-offs are involved. How will or should the desirability of these trade-offs be determined? This remains an open question. If the three-pillar approach to analysing sustainability is adopted, it may be necessary to forgo some components of ecological sustainability (including biodiversity) in order to obtain economic and social sustainability (Barbier 1987; Barbier and Burgess 2017). As natural capital and biodiversity become scarcer due to economic growth, the economic case for their preservation becomes stronger (Tisdell 2005).

3.2. Forest Conservation and Restoration

Target 15.2 is "by 2020, promote the implementation of sustainable management of all types of forests and substantially increase afforestation and reforestation globally" (United Nations 2015b). This target raises a query about the type of services for which forests should be sustainably managed. For example, to what extent should they be sustainably managed for timber production rather than other valued services provided by the use or preservation of forests. These can be in conflict and may call for trade-offs. In developing countries, many poor rural communities depend heavily for their livelihoods on the utilization of non-timber forest resources (as illustrated by (Ren and Tisdell 2002)). The availability of these resources can be jeopardized when forests are sustainably managed for timber production (Tisdell et al. 2002). Furthermore, the sustainable management of forests is complicated by the fact that some local communities use these to their own advantage, which results in biodiversity losses or negative environmental consequences for other communities (Tisdell et al. 2002). This target does not take account of these issues.

3.3. Target 15.3

Target 15.3 is "by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods and strive to achieve a land degradation-neutral world" (United Nations 2015b).

While at first glance this seems to be a desirable target, it also has some limitations. First, to what end or purpose should the degraded land be restored? Second, what ought to be the state to which it should be returned? Is it to a state that is supportive of some feature of biodiversity or to the state in which it was able to be used in the past? For example, if it is a forest restoration project, should the forest be restored (as far as possible) to its most recent natural state or should it be restored to a modified state? Because of altering natural conditions, the attributes of land are liable to vary with the passage of time and can become 'degraded'; therefore, which of the past states (if any) should the land be returned to?

Most importantly, consideration should be given to the costs and benefits of land restoration. Available resources for land restoration are scarce, and opportunity costs are involved in such restoration. It is unrealistic to ignore these costs. though some land restorations may be justified on economic grounds, it is unlikely that all restorations could be justified on these grounds. Nevertheless, economic considerations require to minimize the costs of whatever type of land restoration is planned. Moreover, in some cases, it may prove to be impossible for humans to prevent the spread of deserts or changes in the attributes of land that arise as a result of climate change (Tisdell 2017, chp. 2), due to either natural or anthropocentric causes. In turn, these changes alter the ecosystems and impact on the sustainability of biodiversity.

3.4. Target 15.4—Conserving Mountain Ecosystems

The purpose of *Target 15.4* is "by 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development." (United Nations 2015b)

A problem with this target is that, given climate change, it is likely to be impossible to conserve or maintain all mountain ecosystems and their associated biodiversity. It is necessary to tailor policies for ecosystem conservation so as to allow for the forces of climate change, which are, to a large extent, not controlled locally. Even if current anthropocentric contributions to global warming are significantly reduced in the near future, lagged climate effects will still take their toll on existing ecosystems and contribute to further biodiversity loss. To some extent, it may be possible to mitigate some of these effects, but several can be expected to be irreversible and not preventable.

3.5. Target 15.5—Halting Biodiversity Loss by Reducing the Degradation of Natural Habitats and by Other Means

Target 15.5 calls for the taking of "urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and by 2020, protect and prevent the extinction of threatened species" (United Nations 2015b). This in itself appears to be a desirable goal, especially for those holding ecocentric values. However, conserving biodiversity does not only depend on the conservation of natural habitats. A few species depend on human alterations to some natural habitats for their existence, and some are entirely dependent on human nurturing and the provision of suitable habitats for their survival. For example, the survival of avocados depends entirely on human efforts to cultivate them. It is also believed that the traditional land management practices of Australian Aborigines (such as systematic fire burns) were instrumental in ensuring the survival of some wild species of marsupials. The survival of threatened species sometimes undoubtedly depends on human alterations to natural habitats. This can increase their chances of survival, given, for example, the reduced size of the remaining available natural habitats and the lack of suitable natural resources for sustaining threatened species within these habitat pockets. In other words, human management and some alterations to natural (and other) habitats may be required to promote biodiversity conservation, because existing natural habitats are no longer adequate for this purpose. Of course, such human interventions involve an economic cost, and there are limits to improvements in biodiversity conservation which can be achieved by altering natural habitats.

3.6. Benefits from the Utilization of Genetic Resources

Target 15.6 states: "Promote fair and equitable sharing of benefits arising from utilization of genetic resources and promote appropriate access to such resources, as internationally agreed" (United Nations 2015b). This aspect is discussed at some length in Tisdell (2015, chp. 10). It might be noted that the emphasis in the above statement is on equity. In reality, two different aspects of this objective should be considered. These are the equity aspect and whether such payments make a positive contribution to biodiversity conservation. In some cases, even if the full 'excess economic return (rent)' received by those using genetic resources is paid to those initially having possession of these resources, this may be ineffective in providing adequate economic incentives for them to conserve these resources. Furthermore, the amount received by holders of such resources could be negligible after the costs of benefit transfers (transactions costs) are taken into account.

There is the further complication that property rights in some genetic resources (such as property rights in new plant varieties, including genetically modified organisms (GMOs)) can have negative consequences for the stock of existing biodiversity and, in some instances, could have inequitable impacts on income distribution. Consequently, this target raises a few unresolved dilemmas.

3.7. Target 15.7

Target 15.7 calls for "urgent action to end poaching and trafficking of protected species of flora and fauna and address both the demand and the supply of illegal wildlife products" (United Nations 2015b). The intended biodiversity conservation aim of this target is clear. It does, however, overlook the fact that in some cases, the sustainable use of protected species and the marketing of wildlife products can contribute to their survival. For example, the managed commercial use of saltwater crocodiles in the Northern Territory (Australia) has made a significant contribution to their survival in the wild (Tisdell 2014, chp. 9). More attention needs to be given to the ways in which the market system (for example, via ecotourism) can promote the conservation of wildlife and supplement other means of conserving genetic diversity in the wild.

3.8. Invasive Alien Species

Target 15.8 is as follows: "By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species" (United Nations 2015b).

The introduction of invasive alien species to new territories has resulted in a substantial decline in global biodiversity. In many cases, natural ecosystems have been degraded, and significant economic losses have been experienced in agriculture and other bio-industries as a result of these introductions. Given growing global movements of people and goods, the risk of further unwelcome introduction of undesired alien species remains quite high. The human introduction of alien species to new territories may be deliberate or accidental (incidental). Sometimes, deliberate introductions are made by government bodies to increase the productivity of ecologically based industries. Some of these have had unintended negative environmental consequences, and the benefits of their introduction have been greatly exceeded by their negative environmental costs. The introduction to Australia of the cane toad from South America to control insects infesting the sugar cane provides one such example. It can also happen that an alien introduction to assist one industry, such as agriculture, can have adverse consequences for natural biodiversity. For example, the introduction of the semi-aquatic grasses *Hymenachne amplexicaulus* and *Urochloa mutica* to increase the productivity of the pastoral industry in the Northern Territory (Australia) has led to their invasion of the Kakadu National Park, with negative consequences for the conservation of natural habitats in this park (Setterfield et al. 2013). Furthermore, individuals who deliberately (and sometimes secretly) introduce alien species to new territories rarely take account of any negative environmental externalities which their action may endanger.

Given the limited amount of resources available for regulating the introduction of invasive alien species to new territories and for controlling or eradicating those which are already present, it is desirable to establish priorities for all of these activities. Furthermore, attention should be given to determining the appropriate total amount of public funding for pest control. In addition, public finance considerations associated with addressing issues involving the exclusion and management of alien species should be considered. In the latter respect, to what extent should industry beneficiaries of efforts to exclude or manage alien species be required to contribute to the costs of the effort involved?

Although it is reasonable to recommend in SDG *target 15.8* that priority alien species (which are already in a new territory) should be controlled or eradicated, the time frame suggested for doing that is rather short. However, more importantly, there is no prevailing clear pathway for establishing priorities for the control or eradication of invasive alien species. Several different approaches to establishing these priorities are possible, but there is as yet no resolution as to what the ideal approach is, if there is one (Tisdell et al.). Furthermore, it is important for more research to be done on how resources are, in fact, allocated for the management and eradication of alien invasive species. This can help to uncover shortcomings in current pest control practices and how these might be addressed. The need should have been highlighted for more research funding to investigate the establishment of priorities for the control and eradication of alien invasive species, instead of ostensibly assuming that these priorities are already well established.

3.9. SDG Target 15.9

The objective of SDG *target 15.9* is to integrate, by 2020, ecosystem and biodiversity values into national and local planning development processes, poverty reduction and accounts. While this appears to be commendable as a scheme for the implementation of ecosystems and biodiversity conservation, one possible problem is the lack of guidance about the relevant values which should be taken into account and how this valuation should occur. Furthermore, there is limited guidance about what actions should be taken in the light of this valuation. More extensive consultations between national and local government bodies (as is, for example, happening in India in order to implement its contribution to the SDGs) could have little practical effect, especially if the discussions involve mainly a limited number of public (civil) servants.

3.10. Recommendations 15A, 15B and 15C

Three recommendations are added to the targets for SDG 15 to provide extra policy guidance on how some of its targets might be achieved. Recommendation 15A is to seek more finance from all sources to conserve and sustainably use biodiversity and ecosystems. While extra finance for this purpose would help achieve this aim, finance alone is not sufficient to ensure that it is achieved. Another unresolved issue is whether it is desirable to maintain all existing ecosystems and the whole of the existing stock of genetic diversity, both the genetic stock developed by human effort as in agriculture and that present in the wild. The opportunity costs associated with the implementation of this recommendation need to be considered.

Policy recommendation 15B advocates increasing the funding for sustainable forest management and the provision of "adequate incentives to developing nations to advance such management, including for conservation and reforestation" (United Nations 2015b). It is, however, unclear what types of sustainable forest management are proposed for support. Forests can be managed sustainably to satisfy different targets. These targets can include maintaining their maximum economic yield for timber and ensuring the lasting availability of non-timber products, as well as the conservation of wild biodiversity (and other) services provided by forests. Attention to trade-offs is usually involved in utilizing and managing forests. Consequently, this policy recommendation is too open-ended to provide practical guidance for desirable forestry management.

Recommendation 15C is to "Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities" (United Nations 2015b). This implies, among other things, that more attention should be given to ensuring compliance with the Convention on International Trade in Endangered Species (CITES). While undoubtedly there is a case for greater control of poaching and trafficking of some endangered species, this recommendation ignores the fact that the managed sustainable use of some endangered species is likely to be more effective in ensuring their conservation. In some cases, ranching and farming as well as other commercial uses of endangered species can be more effective in conserving endangered species. The possibilities are quite complex (Tisdell 2005, chp. 6).

Again, the proposal that local communities be provided with sustainable livelihood opportunities in order to reduce their economic motivation to engage in poaching and trafficking can contribute to biodiversity conservation in the wild. Nevertheless, one needs to take account of the limitations of such a policy. The economic opportunities open to many remote communities for increasing incomes are often quite limited (see, for example, Tisdell 2014, chp. 16). In addition, the illegal use of protected ecosystems may still remain comparatively profitable for some individuals. The main economic beneficiaries from such illegal use are often the richer and more influential members of societies (see, for example, (Wibowo et al. 1997)). This adds to the difficulty of curbing the illegal use of protected wildlife and ecosystems.

4. Biodiversity Conservation and Goals Other Than SDG 15

4.1. How Well Are the Biodiversity Targets for SDG 15 Integrated with the Other SDGs?

Although it is recognized by the UN that the SDGs and their associated targets should be implemented in an integrated manner in order to progress the 2030 Agenda for Sustainable Development, the actual statement of these goals and their associated targets display limited integration. The outlines of these items tend to be compartmentalized. This improves their comprehension but fails to take account of several of their cross-effects on biodiversity.

In order to illustrate this problem, consider first SDG14, life below the water, which focuses on life in the seas and the use of marine resources and then let us pay attention to selected targets for achieving SDG2, that is, achieving zero hunger by 2030.

4.2. Conservation on Land and the Sustainability of Marine Biodiversity

Rather surprisingly, the targets for meeting the 2030 Agenda for Sustainable Development make no allowances for the impacts of terrestrial activities of the humankind on the conservation of marine biodiversity. It is well known that several terrestrial activities of humans can have negative effects on life in the ocean. These effects are additional to those climate changes which are attributable to human activities.

Negative effects of activities on land on marine ecosystems include:

1. Soil and fertilizer run-off from agriculture entering oceans to the detriment of coral reefs;
2. Similarly, increased soil erosion and run-off as a result of some forest practices and deforestation;
3. Loss of habitat for marine animals that breed and rest on the shores of oceans, for example, yellow-eyed penguins, (Tisdell and Wilson 2012, chp. 13) and sea turtles (Tisdell and Wilson 2012, chp. 9);
4. Loss of mangroves and tidal marshes due to human activities, the consequence of which is a reduction in the populations of several marine species which depend on these resources;
5. The entry of plastic waste into the oceans to the detriment of some marine species, for example, some species of sea turtles;
6. The building of dams and infrastructures on inland waterways which prevent some marine creatures from completing their life cycles.

4.3. SDG2—The Zero Hunger Goal and Biodiversity Conservation

Five targets for ending hunger by 2030 and three measures to support this goal are outlined in the 2030 Agenda for Sustainable Development. Although each of the targets appears to be desirable, no attention is paid to considering trade-offs between the targets. It is unlikely to be possible to achieve all the targets simultaneously, and no attention is paid to the obstacles that have to be overcome to achieve them. For example, to what extent is the target of doubling the agricultural productivity and incomes of small-scale food producers by 2030 (target 2.3) compatible with the conservation of genetic diversity as set out in target 2.5? How is it proposed to ensure this compatibility? The statement of SDG2 provides no information about these matters.

Policy recommendations 2B and 2C call for reduced international trade restrictions and market 'distortions' in accordance with the Doha Development Round and suggest ways to ensure the "proper functioning of food commodity markets and their derivatives" (United Nations 2015a). It does not take into account the possibility that the extension of and the increasing reliance of agriculture on the market system can result in losses in agricultural biodiversity (Tisdell 2015, chps. 5 and 6) as well as in wild biodiversity. Nevertheless, policy recommendation 2A states that there should be greater investment in plant and livestock gene banks "in order to enhance agricultural productivity in developing countries, in particular least developed countries" (United Nations 2015a). This seems to be intended as a way to offset reductions in the agricultural genetic pool resulting from market extension.

A couple of observations are in order as far as gene banks are concerned. First, the economics of these banks is poorly researched (Tisdell 2016). Second, it is not clear that developing countries will be the main beneficiaries of these gene banks. It is quite possible that large companies (with headquarters in higher income countries) engaging in the development and marketing of improved agricultural seed varieties and the upgrading of livestock breeds could be the prime economic beneficiaries. Nevertheless, there could still be global benefits. For example, agricultural seed varieties could be developed which are better able to cope with climate change than the current ones. This might not happen in the absence of these gene banks and without the presence of larger companies with a goal to develop improved seed varieties.

It is not being argued that the type of targets and policy recommendations stated in the 2030 Agenda for Sustainable Development are irrelevant but rather that they are too simplistic and, in many cases, vague. Their shortcomings are further exposed because individual nations are given considerable freedom about what targets to focus on and how. Aspects of India's plans for implementing the 2030 Agenda for Sustainable Development are revealing in that regard.

5. Brief Notes on India's Implementation of the Biodiversity Targets in the 2030 Agenda for Sustainable Development

India has developed its plan for implementing the 2030 Agenda for Sustainable Development (United Nations and NITI Aayog 2018). In relation to SDG 15, it proposes an increase of 33% in its tree cover by 2030 compared to 2015. In the same time period, it plans to raise the surface area of its inland waters in forested areas by the same percentage. Just what policy measures it will adopt to achieve these ends are not specified, and the targeted qualities of the tree cover and of its inland water bodies are not mentioned. At present, India's inland water bodies are highly polluted by effluents and human wastes (Lélé et al. 2018). This presumably has negative consequences for biodiversity.

As for SDG target 15.5 which calls for "action to reduce the degradation of natural habitat, halt the loss of biodiversity and, by 2020, protect and prevent the extermination of threatened species" (United Nations 2015b), India intends to measure its success in satisfying this target by the extent to which it is able to increase its wild elephant population. It intends to maintain this population at its 2017 level.

The choice of wild elephant numbers as a barometer of India's progress in conserving wild biodiversity is based on the belief that their presence is positively associated with healthy natural ecosystems. Wild elephants are also sometimes seen as an umbrella species (one that enables the diversity of other species) and a flagship species (species favoured by the public for conservation). Nevertheless, wild elephants are only present in a limited geographical area in India. In areas where they are not present, and especially in areas where the habitat is unsuited to their presence, other indicators of success in the conservation of wild biodiversity would be required. There is also the problem that wild elephants can cause significant crop losses and consequently reduce the amount of food available for humans (Bandara and Tisdell 2002). The effects can be devastating for the subsistence of small-scale farmers.

In response to target SDG 2.3 (increasing agricultural food productivity), India plans to double its average yield of rice, wheat and coarse grains from the 2015 baseline figure of 2509.22 kg/ha to 5018.44 kg/ha by 2030. No indication is given of how this doubling will be achieved, and in fact, the target is probably unrealistic (Tisdell 2019). No mention is made of how this strategy will benefit small-scale farmers and other disadvantaged food producers who are identified in the UN's specification of SDG target 2.3 as being most worthy of support for increasing their food production and incomes. In addition, there is no discussion of how the doubling of these yields will affect biodiversity conservation.

India's plans for implementing the 2030 Sustainable Development Goals appear to be piecemeal. However, in this regard, it is not unique among nations. Its focus on the level of population of just one wild species, wild elephants, is inadequate as a measure of its success in conserving wild biodiversity. Furthermore, its procedures for conserving agricultural biodiversity have not been spelt out. Greater attention to the quality of its tree cover and its inland water rather than just concentrating on increases in these areas would also be appropriate from the point of view of biodiversity conservation. Additional discussion of these issues is available in Tisdell (2019).

6. Discussion

A significant limitation of the UN's SDGs is that they lack integration. Furthermore, insufficient consideration is given to the trade-offs likely to be involved in pursuing individual SDG targets. Pursuing some of the targets (for example, substantially raising food production) is likely to require alterations to existing ecosystems and changes in the stock of biodiversity. It is unrealistic to assume that maintaining the status quo in the stock of biodiversity is compatible with satisfying all the anthropocentric targets stated in the 2030 Sustainable Development Agenda. Therefore, it is necessary to take account of these trade-offs and of the opportunity costs involved in the implementation of this agenda. The provision of an extra set of targets by the UN stating how this might be done (that is, a set of guidelines on how to harmonize the targets) would have been of great practical value. Alternatively, some indication of the type of research required to elucidate these trade-offs would have been useful.

Why are the UN's targets frequently vague, presented in a somewhat piecemeal manner, and why are trade-offs not specified? Most likely, this reflects the need for supplying a document which could be agreed to by nations and parties with diverse interests in it. Because the UN is administered by several bodies (many of which have different objectives, not all of which are entirely compatible), this probably influenced the composition (e.g., the piecemeal nature) of the 2030 Agenda for Sustainable Development. Documents of this type play an important role in helping to secure ongoing funding for the bodies operating under the umbrella of the UN, and therefore, each probably looked for support from the 2030 Agenda. After all, the organization of the UN involves a bureaucracy which has an interest in its financial survival, as does each of the bodies operating under its auspices. Hence, it is reasonable to suppose that it takes into account its own interests and political considerations in preparing documents like that drawn up for its 2030 Agenda for Sustainable Development (cf. Svizzero and Tisdell 2016).

The UN was presumably subject to internal organizational constraints in drafting the 2030 Agenda for Sustainable Development and by the need to consider the possible varied political reactions of member states of the UN to its draft. Given all these constraints, it is, therefore, a major achievement for this agenda to have been articulated and accepted by most nations. Although the biodiversity conservation implications of this agenda display inconsistencies and imprecision (as highlighted in this chapter), it does ensure that attention continues to be focused, globally, on the importance of biodiversity as an influence on the sustainability of development. There is a continuing need both to evaluate this diversity from the point of view of its contribution to anthropocentric economic goals and to allow for the felt obligations of much of humankind to conserve the web of life and natural ecosystems, even when doing so is of little or no apparent material economic value to humankind.

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Integrating Environmental Value Systems: A Proposal for Synthesis

Konrad Ott and Karl Christoph Reinmuth

1. Introduction

There is no lack of approaches to the valuation of natural and semi-natural entities in the context of environmental protection issues, especially with regard to biodiversity on the different levels of genomes, populations, species, and ecosystems. With reference to valuations, arguments are made for and against conservation, restoration, sustainable utilization, access and benefit sharing, and other ways of dealing with natural entities. Different, sometimes competing value systems are used, which are based on different presuppositions, but nevertheless can overlap. In the following chapter, some typologies of values (=schematized orderings of types of values) will be subjected to a philosophical analysis, since the lack of systematic unification is a deficit, and an analysis can contribute to a well-founded choice of a value system. A systematic theoretical step towards conceptual unity may open the view to more urgent political questions in an age of unprecedented environmental crisis. This chapter is dedicated to an analysis of existing approaches to evaluation typologies and it identifies avenues for possible synthesis. Another typology of environmental values has been given by Tadaki et al. (2017), distinguishing values (a) as the magnitude of preferences, (b) contributions to goals, (c) individual priorities, and (d) relations. With Tadaki et al. (2017), we share a basic idea: schematic value systems are important tools for the evaluative classification of complex issues. Multi-criteria decision making and environmental impact analysis also rest on value schemes, often implicitly. Value schemes are also part of a scientific ideal of operationalizing concepts and often quantify values in terms of money (monetization). Philosophical considerations, however, must be reflective upon value systems in order to keep touch with underlying questions. In particular, philosophical reflections about the role of values in argumentation, judgement and decision making, about different types of values and their relation to norms and motivation can provide information about which functions value systems must be able to fulfil and which criteria they should fulfil. This chapter analyses approaches to environmental evaluation and presents a discussion of their strengths and weaknesses. It argues that a comprehensive and integrated synthesis of existing approaches is within reach if solutions to philosophical problems related to valuation issues are considered.

The efforts to elaborate such value systems and incorporate them into decision making are also demanded by the Sustainable Development Goals (SDGs), especially SDG 15 ("Life on Land"). For example, sub-target 15.9 calls for the integration of "ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts". Thus, SDG 15 implicitly recognizes the need for evaluation processes. The same holds true for Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). There has been dispute within IPBES for years about limits of and presumptive alternatives to the ecosystem service approach. The conceptual framework of IPBES wishes to include non-Western frameworks into the broad concept of "nature's contribution to people". The value-laden concept of "good quality of life" also refers to evaluations. Other concepts, such as "Mother Earth", "Systems of Life", "Intrinsic Values" and "Living in Harmony with Nature", refer to debates in environmental ethics. Neither SDG 15 nor IPBES, however, reach deeper ethical grounds. This deficit shall be addressed in the chapter in the spirit of IPBES. An ethical synthesis of value systems can and should help the integration of the 'diverse conceptualization of multiple values of nature and its contributions, including biodiversity and ecosystem functions and services' (objective 4, IPBES work programme). The following chapter wishes to contribute to improved evaluations within SDG 15 and IPBES by a robust theoretical groundwork.

This chapter is structured as follows. In the first part, we discuss the axiological concept of value and highlight the role of value systems in valuations and evaluations (Section 2). We then analyse various value systems that have been proposed in the humanities and social sciences for mapping environmental values. There is the Total Economic Value (TEV) scheme, the Ecosystem Service (ESS) approach and various value systems designed in environmental ethics (Rolston 1988; Krebs 1999; Ott 2010; Muraca 2011; Ott et al. 2016). TEV and ESS are often seen as economic schemes, which gives them the general suspicion of "neoliberal thinking" and the repugnant commercialisation of nature on the part of some environmentalists. We will see under which conditions such accusations are justified. While the TEV is clearly economic in scope and method (Section 3), the case is more complex with regard to the ESS (Section 4). Both TEV and ESS are anthropocentric, while all value systems in environmental ethics pay attention to the demarcation problem, considering inherent moral value for natural beings (Section 5). The idea of a uniform ("synthesised") valuation scheme does not require a final and perfect solution to the demarcation problem, but such scheme should not be limited to anthropocentrism. In Section 6, we argue that the categories within TEV and ESS can and should be integrated into the essential patterns of environmental ethics discourse. As we shall see in the next section, valuation schemes can either obscure or reveal underlying philosophical and ethical problems. Our strategy is to use such schemes for revealing.

2. Value Systems and Evaluations

Since ancient times, philosophy has reflected on the status on categories named "values". The philosophy of values has been termed "axiology" since then. Sociology, psychology, history, and economics affirm subject-based axiologies since the beginning of the 20th century. Values are treated as social facts (Durkheim, Weber) from the perspective of observers. The many differences in between values can and should be explained by history, psychology and sociology, while philosophers quest for validity and the (ultimate) grounding of values. Differences between values can take different axiological correlations: peaceful coexistence, indifference, mutual support, respectful tolerance, contrariness, conflict, clash, contradiction. Conflicts over supreme values (nation, religion, socialism, purity of race) may lead to rebellions, civil wars, and revolutions. In Germany, values of natural heritage, unspoiled landscapes, endangered indigenous species, wilderness areas, etc., have enriched the spectrum of societal values since the Romantic movement (Ott 2016).

Nobody doubts that values of environmentalists conflict with those of a liberal consumer culture. According to our modern lifestyles, values of both spheres can be combined. Clearly, beautiful valleys, sparkling waterfalls and a sunset on the beach can be valued as being "good" for naturalists. One can, however, also value a robust car by which one can reach remote sites and can also enjoy a comfortable hotel room with ocean view at the coastline. Most of us value a high-tech camera for spots and sceneries. Economists argue that reasonable utility-functions would combine preferences to different goods and commodity as to maximize the individual good. High-end tourism often combines natural sceneries with luxury accommodation. Such high-end eco-luxury lifestyles, however, look morally repugnant, because not all people can realize them. In such cases, values come under moral attacks. Is it unjust to enjoy a holiday season in the outdoors as long as not all working class people on planet Earth can enjoy paid holidays? It seems fair to say that egalitarian social movements have specialized on grounding such attacks on "privileged" values, even environmental ones. Thus, appreciating values of natural entities does not escape moral critique against unjust privileges. The chapter, however, does not tackle issues of distributive justice.

2.1. Philosophical Axiology

Most contemporary philosophers see individual humans as the grounding "locus" of values. Human agency is intrinsically value oriented. If an agent wishes to reach a goal, she puts a value upon it. To agents, it seems impossible not to value. We will focus on self-conscious agents making value judgements on a daily base. If so, valuing is nothing special, but it belongs, as a mundane practice, to everyday life. Humans enjoy values and they dislike disvalues. Values are perceived, experienced, and expressed from the first-person perspective and such first-person expressions are articulated within cultures via language. Therefore, any ordinary language must include phrases and attributes expressing (dis)values. Such expressions are used in value-judgements. Value-judgements can refer to commodities, artefacts, works of art, aesthetic performances, dishes, hobbies, parties, and so on.

In general, evaluations are carried out in order to establish or determine the (relative) goodness, value, quality, virtue, or correctness of the object of evaluation we call "*evaluandum*". An evaluation should provide correctly substantiated, checkable and (at best) acceptable evaluation statements or value judgements. In the literature, evaluations are assigned various functions (Döring and Bortz 2016; Lumer 1990; von der Pfordten 1993; Scriven 1999). In practice, an evaluation should fulfil cognitive, learning and dialogue, optimisation, decision making and legitimisation functions. One central function of evaluation is to express a value judgment and to show by evaluative reasoning that the value judgement is acceptable (and should be shared). One tries to rationally convince an addressee that the value judgement is acceptable to move the addressee (latently) to act accordingly (Lumer 1990). An evaluation often implies a commitment of how (not) to behave.

Different types of evaluations can be distinguished. The corresponding classifications can be based on the occasions for evaluations, the methods used, the ways in which the results are formulated, the openness to adaptations, etc. It is to be considered that different evaluation types fulfil different functions and can therefore serve different purposes. Sometimes evaluation results are formulated qualitatively and sometimes quantitatively. Thus, marks or points can be assigned, the price can be indicated, or the evaluation result can be formulated with evaluative terms. Often, scales or ranking grades are used. Depending on the scale type, different arithmetic operations and comparisons are permitted. Paradigmatic examples of axiological terms are "good", "bad", "evil", "super", "successful", "un-/just", "suitable", "reasonable", and so on. The term "good" represents a language game of attributions, such as "admirable", "nice", "awful", "tasty", "sexy", "fancy", "gorgeous", etc. Axiological expressions differ from deontic operators which prescribe or forbid different kind of actions. Deontic expressions and operators are, for example, "required", "ought", "forbidden" and "permitted" as well as "duty to", "right to", "in-/correct", "right" and "wrong".

Axiology becomes analysis of value judgements and asks how cultural debates about value judgements are to be performed and substantiated (=justified). All values are in a basic sense "relational" to mindsets, lifestyles, cultures, goods, and rules. Communities endorse shared values as they specify them to rules, rights, and commitments. Peace, liberty, health, safety, wealth, democracy, and decent environments are instances of "our" commonly shared moral values. It can be argued that normative statements (e.g., rules and prescriptions) are often formulated in order to summarise diverse evaluations. If X is good for us, we should act as to protect X. Prescriptive statements mediate between evaluations and rules (norms). According to such an understanding, prescriptions play a central role because they act as a bridge between the axiological evaluations and normative evaluations (Baurmann et al. 2010). Prescriptions ("Let us do something about it!") are formulated because otherwise it is not clear which instructions for action are to be obtained from axiological statements. Prescriptions summarize the efforts of an axiological evaluation—they formulate what should be done in view of the axiological considerations or prescribe the actions to be performed in view of the axiological considerations (or allow and forbid others). A prescription could state that there should be a legal regulation on the matter X (as oil spills, bycatch in fisheries, trophy hunting), but may remain silent on the specific deontic content of such environmental regulation. Grounded and shared values can constitute agreements that regulation is mandatory. Via such reasoning, the realms of axiology and deontology can be bridged discursively. Values span a broad range, starting by simple desires, wishes, and preferences and ending up with moral values such as honesty, peace, democracy, and justice. Moral values require a generic betterness relationship between two oppositional concepts: To all reasonable agents (prima facie and ceteris paribus), peace is better than war, arguing is better than violence, health is better than maladies, wealth is better than poverty, etc. A non-polluted environment is better than a highly toxic one. In environmental valuation, however, such betterness relations are full of vague qualifiers such as "spoiled", "decent", "degraded", "rich and diverse", "impoverished", "original" etc. These qualifiers indicate that a broad and unspecific betterness relation in favour of decent environmental conditions might be of moral value, while specifications remain culturally bounded (Section 6). By moralizing values ("This was a dirty trick!"), we take a turn from the expression of values to deontological validity claims. In his seminal "*Philosophie und Sprache*" (Hönigswald [1937] 1970), philosopher Richard

Hönigswald argued that such a shift can be justified by means of discursive axiological language (see Ott and Surau-Ott 2017). Following Hönigswald, a discourse ethical axiology must distinguish between *attribution* and *grounding*. Attribution means that agents attribute positive and negative values to entities and events. Grounding means that agents present and exchange *axiological reasons* why they attribute values as they do. This implies the distinction between expressive lingual articulation (*attribution*) and well-considered reflective value judgements (*grounding*). Articulation is sincere, while grounding is considered reasoning. In the following, we are concerned with reflected evaluations (as opposed to spontaneous evaluations) or well-considered reflective value judgements (grounding).

Depending on the type of evaluation and the reason for the evaluation, different forms of grounding can be distinguished. Accordingly, different rules of reasoning and quality standards may be relevant and different reasons may be legitimately put forward. Making claims for axiological validity supposes that values can be shared. Grounding values provides chances of values being shared. Shared values constitute particular cultural communities. In axiological grounding, reasoning may refer to substantial cultural traditions (as nature conservation), eudemonic experiences, phenomenological descriptions, psychoanalysis, narratives, history, and even literature and poetry. Axiological grounding does not necessarily have to refer to morals. It can be "deep" without touching morals. To the Neokantian background of Hönigswald, grounding values was a transcendental enterprise ("Wertgeltung"). As we shall see with respect to environmental evaluation, axiological grounding differs from transcendental justification (Section 5). It remains mundane. The phenomenology of nature (Böhme 2016) is helpful in grounding evaluations with respect to nature, because it reveals the perceptions and experiences on which evaluations rest. Sensual mediated bodily perceptions are turned into meaningful experiences with nature. Meaningful experiences are evaluative, and the values can be made explicit. Thus, phenomenology can ground values in a specific way of life. Quite often, a reflective articulation of past experiences presents sufficient grounding. If I say: "I strongly dislike this smell since it reminds me of vomiting in childhood", no further grounding is required (ceteris paribus). The bad memory counts as sufficient reason. We will return to the problem of axiological grounding throughout the following sections. In any case, axiology operates within a range having a contested border zone to deontology (rightness). This borderline region between evaluations, moral values, ideals, obligations, and principles is highly contested even among ethicists. To sum up the point we wish to make: *From an* *axiological perspective, valuation schemes should be conceived as to fulfil the requirement of allowing for both articulation and grounding*.

2.2. Economic Evaluation

Economics assumes that individuals make rational choices according to their preferences. Economic approaches being grounded in a concept of preference are paradigmatic to liberal individualism. A preference is a binary value-judgement ("To me, x is (ceteris paribus) better/worse than y"). An individual agent prefers a state of the world X over Y according to her mental states. Reaching X gives utility (welfare) to the agent. The degree of preference is intensity. Behaviour reveals actual values people really hold. Many, but not all values materialize in commodities (cars, mansions, books, carpets, jewellery, gardens, etc.) which are relatively scarce and have an exchange value signalled by prices. One realizes values via consumption. Economic axiology is liberal, individualistic, flexible, etc. Economists show respect for the many ways in which persons may value commodities, cultural events, and social affairs. Preferences are to count. Economics, however, is disinterested in grounding. Economists assume that people themselves know their real preference best, since they have privileged access to their mental states. Ontogenetic origins, manipulation, advertisement, self-deceit, and indoctrination are abstracted away from economic models. Economics assume authenticity of all or most preferences and they ground their models on such heroic assumptions. To ethics, however, authenticity of evaluations is an ideal, not a given. On a second-order layer, we all should wish that our important values are actually "ours" (Frankfurt 1971). Disregarding such shortcomings, economists apply this general axiological approach to nature, resulting in environmental economics and the TEV-scheme (Section 3) and even the ESS-scheme (Section 4).

After clarifying what is to be understood by the complex term "evaluation", the role of values in relation to *evaluations* can now be analysed. Values play a dual role in evaluations. First of all, they are central to all evaluations, as they guide the selection of criteria and standards and thus also the design and formulation of criteria. In order to fulfil the function of criteria design, one must be clear about one's own values and their strength (or intensity). If nature conservation is important to you and you attach a high value to biodiversity, then you will use appropriate criteria to evaluate interventions in nature. In view of the evaluation functions, in particular enabling decision making, formulating evaluation results is often attempted not only in evaluative terms, but to use "objective" numerical values for the supply of decision bases. Since various aspects of situations can be evaluated in different ways using different criteria, but clear decisions have to be made (e.g., laws have to be given), this way attempts to minimize complexity and to abstract away difficult questions. Many scholars wish to operationalize evaluations. The evaluation *that* X is of value to P remains vague if it is not specified to the question *how much value* does X have to P in relation to many other valuable entities and events. Such specification must homogenize, and, in economics, there is no better homogenizer than money, as specified by willingness to pay (WTP). If a person P values X positively, her WTP should be greater than zero. The epistemic idea to operationalize values numerically in monetary terms deserves reflective scrutiny: May such operationalization open our eyes or may $-numbers blind us against the actual substances of values? How is numerical economic operationalization related to attributing and grounding? What axiological lessons can be drawn from contingent value studies of virtual WTP for nature conservation?

The second function of values is precisely to formulate evaluation results. Since we are talking about reflected evaluations here, one can assume that value statements are the result of well-founded evaluations. One can demand and give reasons for certain valuations and value systems. One can point to missing transparency of evaluations and doubtful consequences. Arguing about values and evaluations is possible. Values and valuations are related to philosophical underpinnings and frameworks. Valuations are associated with varieties of values and major philosophical questions. A philosophically informed analysis can help answer the question, which value systems can fulfil the purposes and deliver appropriate evaluations. As stated above, axiological discourse should give credit to the plurality of value encounters with respect to both attribution and grounding.

The result of this section implies, that all environmental value-schemes should be aware about the deep axiological background within they operate. Environmental value schemes should be able to integrate axiological reflections on the ontology and epistemology of values, such as perception and experience, the status of preferences, clashes of values, second-order preferences, the contested zone of moral values, the many axiological correlations, the role of prescriptions within evaluations, and the distinction between grounding and attribution. Schemes of values as such navigate on a surface over deep water. Such topics kept closely in mind, we turn to the evaluation of nature.

3. Total Economic Value

In environmental economics, the Total Economic Value of Nature (TEV) approach was proposed (see Randall 1987; Pearce and Moran 1994; Plottu and Plottu 2007;

see also contributions in Pushpam 2010). It is based on a preference-based axiology and embedded in micro-economic theory of rational choice. The intensity of the preferences is reflected in the willingness to pay (WTP) for nature conservation or in the willingness to accept (WTA) compensation for a loss of preferred nature. Interestingly, the concept of intensity forms an interface between economics, phenomenology and even morality (Ott 2013). Nature can be a source of both values and disvalues such as earthquakes, pests, infectious diseases, etc. It is trivial to state that nature is not just good for humans. For the rest of the chapter, we keep the dimension of disvalues and disservices closely in mind but focus the benign and beneficial dimension of nature. Nature is conceived being a broad source of utility for humans and "utility" is a generic term for all kinds of benefits, welfare and pleasures that result from it. One can use natural systems as a source of resources and as sinks for pollutants. The "source-and-sink" perspective is common in environmental economics.

This anthropocentric and preference-based TEV approach also distinguishes between use values and non-use values. Use values include, among others, yields (direct use) and tourist areas (indirect use), which can be measured in monetary terms by travel cost analysis.

Option value, bequest value and existence value are categories of non-use values within the TEV and refer to preferences in favour of nature conservation and protection. *Option values* refer to a preference to make decisions from a number of actual future options whose details are uncertain or unknown in the present. If tropical forests and the deep sea are regarded as natural "laboratories" in which many types of biochemical compounds are "tested" by the forces of evolution, humanity has prudential reasons to preserve such environments for future food production, medical, pharmaceutical, or chemical research being grounded in the value of human health. Since humans are omnivores, option values are important for future food security. Perhaps an ecological civilization will shift cultural barriers against certain edible plants and insects. Algae also can have many options that are still unknown. Whatever that may be, members of current generations should keep promising options open. Nature destruction can exclude options before they are identified. Option values of nature are dispositional ones. As such, they are hard to monetize. There are many ways by which nature can be "optional" to humans. Genes, species, and even landscapes are full of options many yet unrealized. Restoring nature should also count as an option. Grounding option values oscillates between generic and specific options. The option value of the sea floor is highly generic, while the option value of some algae species can be specified in terms of food processing. Grounding option values present specific dispositions of how the non-human world might become significant for human intentions. Ironically, there might be economic analogies between option values of nature and the speculative future value of a start-up company at the stock markets. In principle, stock markets value the future, not the present. If this principle is applied to option values of natural assets, value may increase. Licences for exploring some areas (prospecting) may also indicate option values.

Another axiologically interesting category within the TEV is *existence value*. A beloved person is a paradigm case for existence value. The existence value applies to natural entities when an agent evaluates the mere existence of a natural being N without further interest to utilize N. It is perfectly reasonable to say, "It is good to know that there are snow lizards in remote parts of Central Asia." The existence of X is preferred over the non-existence of X: $X > \neg X$. This preference may clash with the opposite evaluation of another person: $\neg X > X$. To some people it would be better if there were no wolves around, while some other people prefer the existence of wolves in a given area. Conflicts over the existence of natural beings will prolong in conflicting prescriptions (regulations), such as licences for hunting wolves. It might be an instance of inconsistency if a person P gives positive existence value to an old tree but gives negative existence value to its leaves in fall. Can P wish to have the tree without its leaves?

As many contingent value studies strongly indicate, the existence value is, to many persons, at odds with the ongoing extinction of many species. It does not even seem inappropriate to place an existence value even onto biodiversity as such. If the WTA or WTP for the protection of an endangered species were US$ 1 per month, however, the existence value of biodiversity could devour all income and wealth ("embedding effect"). Despite this strange effect, it is perfectly reasonable to greatly appreciate a diverse natural world.

Nature's existence values cannot be neglected in monetary terms either. Since affluent people in the North are putting high WTA values to the existence of tropical nature, including crocodiles, tigers, rhinos, etc., the progressive destruction looks repulsive from an economic point of view. WTA, however, remains a virtual payment and does not mobilize real financial assets for protecting nature. There are many ideas regarding how to make real incentives to protect nature out of virtual WTA.

Values of existence are often associated with the slogan "Use it or loose it". The organization of high-end tourism to present the "Big 5" is much more rational than the deforestation of forests to produce charcoal. Tourism is an industry that has specialized in bringing wealthy people to places where they can realize existence values ("I really have seen a lion in the wild!"). When wealthy people accept high travel costs to experience X, X is economically very valuable. In the next section, we will review the parallels with the cultural services of ecosystems.

Existence values can be grounded in many reasonable ways. If a person would mourn over the loss of X and might miss X deeply in her life, she implicitly has given existence value to X. These ways of groundings indicate that WTA is a better measure for existence value than WTP. Grounding existence values touches the problem of *missing* something or missing somebody (dearly). The scheme "P missing X" gives grounding for existence value. Who, however, misses species that have gone extinct? Does anybody miss virtual species which might have existed but have gone extinct before they have been identified by taxonomists?

For many people, a garden with birds, butterflies, bees, spiders, dragonflies and bats is better than a garden with only a few abundant lawn species. Lawn people, however, prefer the non-existence of most plant species in their gardens and act accordingly. Thus, existence value in TEV is just about factual evaluation according to given preferences. On methodical grounds, TEV must be silent on the "goodness" of evaluation or the quality of the grounding. In economics, any person is free to say: "I do not miss anything, if X does not exist anymore". In environmental ethics, however, existence value is more about what environmentally well-informed persons *should* miss and what *should* count as loss (Section 5). TEV restricts itself to social facts, while environmental ethics must go beyond, if the entire ways we value natural beings should be transformed.

Option and existence values become *bequest values* when people want to preserve options and existence for future generations. In economics, bequest values rest upon contingent altruistic preferences. Any person remains free to argue that he has no preference with respect to future affairs which may occur after his maximum life expectancy. The figure of "homo oeconomicus" will support such ignorance because death eliminates all preferences. We will show in Section 5 that TEV does not lay an adequate moral foundation for questions of intergenerational justice.

4. Ecosystem Service Approach

The Millennium Ecosystem Assessment Report introduced the concept of ecosystem services (ESS). It was adopted by the TEEB study (The Economics of Ecosystems and Biodiversity). This anthropocentric concept aims to bridge the gap between nature and human well-being and make the values of nature visible to decision makers and the wider public. Prominent references are Costanza (2008); Daily et al. (2009); Norgaard (2010); Sagoff (2011); Kandziora et al. (2013); Davidson (2013); Chan et al. (2012); Jax et al. (2013); Spangenberg et al. (2014).

ESS takes the form of a cascade ranging from nature to natural capital to a flow of services that offers benefits to people relative to the underlying values. ESS distinguishes between services and disservices of nature, but most ESS studies abstract disservices away. Disservices are, for example, pests, earthquakes, thunderstorms, heavy snow, but also sharks that kill people. Rain (although it is not produced by ecosystems) can be seen as a disservice for tourists, but as an important support service for farmers.

ESS wants to close the gap between nature and man. The ESS scheme mediates between the two abstract poles of nature and culture, overcoming a mere divide (dichotomy). The ESS cascade begins with a concept in which nature is gradually transformed by human action. Nature is not just wilderness. Many managed ecosystems produce ecosystem services. Prudent management can increase the flow of some services, but such an increase often comes at the expense of other services. Thus, many ecosystem services originate from mediations between nature and human labour. The provision services of yields often require agriculture and gardening, even if there are some berries and mushrooms out in the wild.

One should distinguish between stocks and funds of natural capitals. Stocks, such as fossil fuels, can only be consumed away. Consumption diminishes the stock over time. Funds, however, have intrinsic properties to self-increase by proliferation and growth. There are non-living funds (as freshwater cycles) and living funds, such as organisms, species, populations, and ecosystems. Funds equal "renewable resources". The distinction between stocks and funds explains why it is false (non-sustainable) to treat funds as stocks. If funds are treated as being stocks, they are over-utilized. Both stocks and funds yield flows, but details of this fund-flow correlation remain puzzling. A tree stores carbon (regulating service), it produces oxygen, timber and, perhaps, eatable fruits (provisioning service). If, however, the tree is appreciated as being beautiful, is there a series of pictures flowing from the tree to the eye of the beholder? Rather not. If oak trees symbolise my home county, what kind of flow might this be? Both examples indicate that the fund-flow model does not work well with respect to the domain of cultural services. Cultural values are not flows stimulating preferences, but are constituted by axiological-cultural perceptions, by attribution and grounding (Section 2). Here, it must suffice to state that the stock-flow model must undergo modifications to be acceptable to philosophical axiology. We return to this point in the final section.

Moving further along the cascade, it is further assumed that humans are benefitted by such "flows". A service benefits some beneficiaries somehow. Without such benefit, some humans would be worse off. Thus, a service counts as "good". If so, it has positive value (benefit) to someone. To destroy such values implies a loss or a damage being done to somebody else. This value is never isolated from other values but embedded in the entire horizon of values coming in multiple constellations and retreating into a deep background. Thus, the ESS cascade finally immerses into the entirety of cultural values being connected to evaluations, cultural frames, prescriptions and, at least sometimes, to deontic terms.

When using value systems, such as ESS, one should point out that one uses the term "service" as a purely technical term that is established in the sense of "ways in which nature can be useful to humans". Regretfully, the term "services" conveys misleading connotations. Nature does not offer services like a company does. We should not perceive nature in analogy to the service industries, but in its ecological naturalness and its fertility, resilience, diversity and abundance. The "service" terminology has become common parlance worldwide. Even if there are good reasons against such terminology, we should not discard the terminology completely, but integrate the ESS-approach in a broader ethical framework.

The ESS approach distinguishes between *supporting*, *provisioning*, *regulating* and *cultural* services. Each category includes several subcategories. The category of supporting services is controversial. They are basic environmental requirements for services, but not services themselves. They are necessary preconditions for services without being services. Such supportive "services" are ecological functions and structures that sustain the totality of a particular ecosystem (sometimes referred to as "natural integrity"). Supporting services are "primary values", such as exergy, the emergence of productivity and resilience, and fertility as generic disposition of living beings. Since supporting services may include double counting, some scientists abstract them away from the realm of real services. However, some important ecosystem services, such as pollination, are neither provisioning nor regulating or cultural services. If they belong to the category of supporting services, this category should not be fully abstracted away. We may place a high existence value on top predators, but we should remind ourselves that ecological systems are running via the invisible support of small organisms. Supporting services are systemic underpinnings of actual services. As such, they are more basic, but often remain invisible. In economic terms, they are primary values which cannot be monetized. The concept of "ecological integrity" makes good sense if it points to the cluster of supporting services (soil formation, trophic levels, emergent traits, self-organization) which can be studied by scientific ecology.

Provisioning services refer to all species used by humans, including spices, cosmetics, pharmaceutics and medicines. Provisioning services run parallel to the

TEV use values. These are mainly yields that can be measured both physically and in monetary terms. *Regulatory* services also belong, albeit rather indirectly, to the category of TEV use values. They can also be measured in physical terms and by economic replacement costs. A famous example from the Catskill Mountains close to New York city showed that the investment and supply costs for the purification of fresh water using technology were far higher than letting the mountain range do the job. Thus, the mountain range was preserved for its regulatory services on economic grounds. If reed can filter toxic substances from wastewater, it also performs a regulatory service. If the reed will be used to stow walls to secure heating energy, it also provides a supply service. Pollination by bees is far cheaper than by human labour. In this way, the ESS approach can open our eyes to innovative bioeconomic strategies for the multiplication of ecosystem services.

Cultural services are often underrepresented in ESS studies because they are difficult to quantify and monetise. The domain of cultural values encompasses aesthetic values, leisure and recreation, local design and natural heritage, meditation and transformation, and not least the spiritual and symbolic significance of nature. It is widely recognized in the literature that cultural services are highly important to many people but are underrated in many ESS studies. This is an axiological mismatch within ESS. As mentioned above, the stock-flow model misrepresents the axiology of cultural services. Both mismatch and misrepresentation indicate that cultural values stand in need for a better ethical framework (Section 5).

The ESS approach points to the many compromises and trade-offs between provisioning and cultural services in land use. There is a trade-off (conflict) between aquaculture and recreation in coastal zones, a trade-off between blooming meadows and intensive biomass production, a trade-off between rewetting bogs or peat extraction, a trade-off between habitats for endangered species and tourist destinations.

The ESS approach as such is silent on how such trade-offs are to be decided. ESS as such does not include a theory of decision making, conflict resolution, or weighing goods. ESS can, however, identify cases, in which trade-offs are decided against the demands for nature conservation. There are reasons to believe that societal demand for nature conservation has, meanwhile, become higher in developed countries than its supply.

ESS, however, does not provide specific solutions to the interrelated problems of discounting, substitution and compensation. The problem of the marginal destruction of nature also remains unsolved in ESS. It is silent on whether ecosystem services are equitably distributed among different social groups. The distributive justice of ecosystem services opens up a broad field that goes beyond the scope of this chapter. ESS enables the functional substitution of ecosystem services. If a "service" is removed, such loss can be substituted by another service. Substitution of services faces limits in the domain of cultural services. Therefore, ESS requires some additional ideas for the uniqueness of some natural sites ("de re" protection).

To sum up, ESS is not a comprehensive theory of nature conservation. It is rather a schematic tool than a theory. With some caveats ("flow", "service", "monetization"), it fulfils the requirement to allow for attribution and grounding. ESS has one crucial common feature with TEV: it is about factual evaluation only. If people prefer to maximize provision services at the expense of cultural ones, no ESS-experts can reject such a choice as being "wrong". Used in proper ways, however, ESS may be catalytic for environmental axiological discourse, because it stimulates contest over factual evaluations and motivates reflections on the ways we evaluate.

5. Value Systems in Environmental Ethics

Environmental ethics established classifying maps of values and ethical frameworks. After decades of discourse in environmental ethics, some essential (constitutive) ethical frameworks and value types can be identified and differentiated. These generic frameworks and value types have been mapped several times (Rolston 1988; Krebs 1999; Ott 2010; Muraca 2011; Ott et al. 2016). This section is based on these studies and pursues two concerns: It aims to distinguish five major value types and frameworks and to highlight the parallels between these patterns and categories of TEV and ESS. This opens many doors for further reflection on these categories.

5.1. Metabolic and Reliance Values

Human systems depend on and are embedded in natural systems that provide many different resources, goods and services. The direct use of nature for food and shelter is "metabolic" because, as Marx notes, all human societies depend on a continuous metabolism with nature. This general truth about man's dependence on nature is independent of technology and property rights. The categories "metabolic values" or "reliant values" are intended to cover this fundamental dependence. Dependence on nature differs depending on the spatial scale and degree of substitutability. Metabolism should be understood broadly. The metabolic values of nature have been mediated by human work, in particular by agriculture, animal husbandry, mining, forestry and fishing, including aquaculture. The extraction of oil, natural gas and coal provides fuels that are of instrumental value for many purposes. Breeding is a strategy to increase the instrumental values of cows, sheep, rice, and apple trees. The regular supply of fresh water, heating and cooking facilities to almost all members of society has taken many decades even in technologically advanced countries. In (post-)industrial and urbanized societies, such dependence is often overlooked. Full supermarkets are simply a matter of course to many people. Environmental ethics is critical against such forgetfulness and ignorance which rest on Locke's statement that only 1% of economic value directly stems from nature.

Humans have no alternative but to organise metabolism with nature. Social metabolism was intensified from the Neolithic to the great acceleration of the present age. Fundamental Neolithic achievements have paved a long way to the full-grown Anthropocene. Such achievements were permanent settlements, agriculture, ploughs, networks, domestication and breeding techniques, storage, crafts and medicine. Modernity can be understood as a shift from qualitative services to increasing quantities ("more of the same"). It is a clever idea to catch fish via nets, but now the nets have become miles long and deep, catching the marine food web and influencing the development of fish species. As many narratives and figures indicate, the increased metabolism collapses into systematic plundering of our planet's resources. The large-scale industrial metabolism with nature is exaggerated in many respects and for centuries has led to a huge raw material stock and a consumer culture (see Trentmann 2016).

Metabolic and dependency values are conceptually close to "utilization values" within TEV and close to provisioning and regulating services within ESS. The problem with TEV is that only factual preferences of individuals are recorded, regardless of whether these preferences are well informed or not, which can lead to the underestimation of some ecosystem services. The entire cluster of reliance values, direct utility values, provisioning services, etc., apparently just requires simple grounding in terms of (basic) needs, preferences, and demand. Utilization values can be conceived as being demand driven. Such a conception, however, may block a critical reflection upon current consumption patterns (in the Global North) and aspiration levels (in the Global South). The line of reasoning ("reliance values") has been linked to the environmentalism of the poor through concepts of decent livelihoods, especially in the Global South (Martinez-Alier 2002). Many people are reliant upon access to natural resources which might be blocked by property right regimes (as in cases of large-scale land acquisitions, see Voget-Kleschin (2013)). Reliant values open a broad range of questions over environmental distributive justice which are beyond the scope of this chapter (see Ott 2020).

TEV and ESS do not ask for proper attitudes with respect to the many "gifts" of nature supporting metabolism, such as the attitudes of gratitude, frugality, and humility. Environmental ethics should stimulate the idea that grounding such metabolic reliance values should not be demand driven but should become rather virtue based (see end of this section).

The perspective of mainstream microeconomics can underestimate basic dependency values for methodological reasons, too. Economists can admit that primary goods such as oxygen, freshwater, fertile soil, photosynthesis, etc., are, as such, beyond price. The price of planet Earth is infinite, but the economic cost–benefit analysis evaluates local or regional changes at the margin. Thus, it is the method of marginal assessment itself which underrates nature. Therefore, metabolic values are dialectical as they shift between basic dependence on nature, marginal degradation, and substitution processes. Freshwater and fertile soils are paradigm examples for this peculiar dialectic. At the heart of this dialectics is the recognition that humans basically remain reliant upon nature even under recent conditions of almost perfect mastery of nature. Environmental ethics turns the economic perspective of primary values upside down. Each and any part of nature counts as being a parcel of primary values. The flip side of a marginal increase in utility is the marginal loss of primary values. Such dialectics turns into the political economy of strong sustainability (Daly 1996).

5.2. Eudemonic Values

There is now widespread consensus that the distinction between instrumental and inherent value is not a dichotomy if instrumental values are embedded in a certain understanding of a mean–end relation. The recent debate on relational values (Chan et al. 2016) is about overcoming such dichotomy. All values, however, are relational (Section 2). Instrumental values are relational to demands and needs, eudemonic values are relational to ideas about a good human life and to virtues, inherent moral values are relational to criteria of moral considerability. If so, the concepts of values and evaluations imply relatedness. Unrelated values would be "absolute" ones, but we see absolute values as an oxymoron. If so, the term "relation values" is either an analytical truism or it must point to a specific kind of values beyond the instrumental-inherent divide. As Chan et al. (2016) rightly argue, relational values are embedded in practices and traditions, they shape collective cultural belongings ("identities") and they are grounding particular concerns against environmental degradation and the loss of unique sites. If so, we see relational values close to cultural services and overlapping widely with eudemonic values.

Since it is beyond the scope of this chapter to judge all articles on "relational values" (see Knippenberg et al. 2018), we restrict ourselves to the option being opened by Chan et al. (2016) and Himes and Muraca (2018) to conceive specific relatedness in terms of eudemonic values (see also Ott 2016).

Eudemonic values can be seen as a third broad category of values that includes aesthetic, locational, restful, transformative, and spiritual encounters with nature. Reconciliation between man and nature within the paradigm of instrumental rationality will not succeed. Clever animals have only instrumental and at best prudential reasons to protect natural resources. Environmental ethics emphasizes the many ways in which humans are bestowed by nature with types of pleasure, joy, wonder, connectedness, and even bliss and reverence. Eudemonic values give a new perspective on how different people might, could and should shape their lives with and in nature. They refer to outdoor activities that people perform for their own sake, such as hiking, sailing, diving, climbing and even hunting. If you go on a hiking trail for the sake of hiking, you give this activity eudemonic value. Other examples of so-called "eudemonic" values include the beauty of nature, a (deeper) sense of home ("Heimat"), relaxation, joyful physical exercises, biophilic sensations and spiritual encounters with nature. Here, nature reveals itself as an essential dimension of a good, flourishing and meaningful human life. Eugene Hargrove, Allen Holland, Angelika Krebs, and Roger Scruton have also argued along these lines.

The area of eudemonic values resembles the category of cultural services within ESS and it includes the existential value of TEV. It should become clear that some eudemonic values (aesthetic, spiritual, symbolic) would not be sufficiently taken into account by existence values or cultural services. In any case, it is unclear how a spiritual understanding of nature as being "sacred" can be captured by the usual definition of existence value ("value to the mere existence of a natural being N without any further interest to utilize N"). This is also true for biophilic attitudes. With some likeliness, hegemonic concepts of modernity have oppressed biophilic dispositions, while an ecological civilization will liberate them anew. Eudemonic values also make it clear that one could and should restore nature as a joyful focal practice.

5.3. Future Ethics

In connection with questions of distributive justice and the necessary conditions for a good life, responsibility towards future generations with regard to metabolic and eudemonic values is important. Future ethics is about fair legacies at different levels. Most approaches are critical to the promise of a growth-oriented economy that future generations will be far better off than previous generations, as scarcity of commodities is reduced by GDP growth and technological innovation. Overabundance of commodities may coexist with increasing scarcity of nature's values. It seems uncertain whether future humans will simply conform to such situation. They might also deeply mourn the losses, some of which might be irreversible.

Ethical approaches face different problems with future generations. A utilitarian approach to posterity must face the abhorrent conclusion that it would be better to increase the mere number of sentient beings as long as the worst beings still prefer to be alive rather than non-existent. A contractarian approach does not capture the convictions that we owe something to posterity, since we cannot yet make contracts with future persons. If all obligations come from real contracts and contracts are concluded for rational self-interest, contractarian ethics cannot justify binding obligations between generations. Paradoxes of future ethics consist in bringing individuals into existence and controlling population size.

For questions of future ethics, the option value and the bequest value of TEV as well as all service categories of ESS are taken into account. Within TEV, however, the bequest value is nothing more than an altruistic preference that one may or may not feel for one's descendants or for distant future human beings. To economists, saving something for others is a kind of sacrifice. Bequest values are comparable to those of donorship. From natural inclination, the bequest values are mainly dedicated to the offspring, while morality also requires concern for distant and remote future human beings. Within a preference-based approach, it must be accepted that the bequest values decrease with increasing distance in time and space (as is often the case). TEV-scheme cannot see the moral difference between contingent altruistic preferences and mandatory obligations to future generations. Being morally obliged to do x is different from doing x out of an altruistic preference. The resulting action may be the same, but the reasons are different. Ethicists will not like to base future ethics solely on altruistic preferences. If so, TEV is not a suitable framework for intergenerational justice. If so, we need to transform the category of bequest value into a more refined and comprehensive ethical framework, recognizing rights of future persons against present persons.

The moral beliefs behind the "bequest value" of TEV require a deontological interpretation of future ethics. In principle, nobody should live at the expense of others. This principle also holds for distances in space and time. If so, current generations must not live at the expense of posterity in terms of environmental values. If the chain of generations implies a fundamental egalitarianism between generations (no generation is "better" than any other), then one can assume that future generations should have approximately the same living conditions as today's generations. If all people were equal in the present, the standard of comparison would be easy to determine. Since humans are, at present, highly unequal in many respects (salaries, wealth, education), it is almost impossible to apply a comparative standard on a global scale. At the global level, one should rather adopt an absolute standard, which is a moral threshold for a worthy human life; however, it is specified in terms of needs, welfare, or capabilities. Such an absolute standard should be quite demanding in terms of capabilities (Nussbaum 2011). Within an ongoing chain of generation, no generation should come in a situation in which a substantial fraction of humans fall below a demanding threshold line defining a decent human live also with respect to environmental resources. Thus, current generations are obliged to prevent such a situation. This obligation demands cautious foresight independent from contingent degrees of risk aversion.

At a particular level, however, political communities (states, nations) can and should pursue the strategy of bequeathing legacies to future members of a particular state on a comparative basis. They should protect the nature capitals and the natural heritage on their national territory. The conservation, preservation and restoration of nature is never entirely "universal" or "global" but must remain a special and "located" enterprise. Grounding nature's values touches the problem of specific territories which are inhabited by specific people. Inhabitation is full of values ("place making", "coiling the land") which might be shared by particular communities but cannot be as universal as moral rules. Grounding values in specific territories reveals that territories are not just neutral space. Inhabitation values, if grounded, may conflict with cosmopolitan values.

A conflict-laden dialectic takes place here. If intergenerational justice to an absolute standard cannot be limited to future people and should not be ignorant against current poverty and misery, and if some states can ensure a high comparative environmental standard exclusively for their own present and future populations, then the demands of morality and global justice will inevitably exert high pressure on such comparative standards as being "privileges". From the moral point of view, the universal absolute standard seems to override certain comparative standards being enjoyed by some, but not all people. The future world might be highly patchy in terms of nature conservation. Some people will enjoy the results of success stories in nature conservation, while other people have to face results of environmental destruction. On which grounds are the few happy wealthy Norwegians and Canadians entitled to enjoy their sublime landscapes in a world full of slums? Such moral dialectic also points to immigration policy, for wealthy states that pursue ambitious environmental (and social) policies will become attractive destinations for migrants.

The moral tension between absolute and comparative standards makes a brief meta-ethical reflection on the problem of overridingness and a presumed hierarchy of reasons mandatory. Should specific moral reasons to help poor people always "trump" all other kinds of reasons, be they based in values, traditions, loyalties, role obligations, prescriptions, cost estimates, nature conservation objectives, etc.? Are moral reasons to be embedded in other kinds of practical reasons or are moral reasons always to be placed at the very top of a hierarchy of reasons? Embedding moral reasons, however, will bring different results with respect to nature conservation than a supremacy of moral reasons. Just think of curtailing human entitlements in order to safe species from extinction, restrict access to protected areas, or enhance local biodiversity via reforestation at the expense of agriculture. Both TEV and ESS are too schematic to address such peculiar and highly political casuistry.

5.4. Inherent Moral Value

The problem of demarcation concerns the question of how to draw the line between morally considerable beings ("moral community") and other entities, or, to put it otherwise, which entities have inherent (or intrinsic) moral value and which have not, even if they may have considerable instrumental (functional, economic) or eudemonic value. Even if one supposes a broad spectrum of values, discussions about inherent moral values as attributed to natural beings are and shall remain highly important (see Ott 2008).

Moral problems must be solved as well as other problems. If a problem is a real problem at all, solutions must be within reach—and this also holds for moral problems as the demarcation problem. After decades of debate, the demarcation problem seems to be somewhat paradoxical—an essentially controversial search for a "true" solution.

The extent of the solutions to the problem of demarcation put forward so far can be determined as follows: (a) sentimentality, (b) zoo-centrism, (c) biocentrism, (d) eco-centrism, (e) gene-based approaches, (f) (pluralistic) holism. As Ott (2008) has argued, the demarcation problem requires the identification of morally relevant characteristics (properties) attributed to natural beings. In this way, one will not fall victim to the naturalistic fallacy.

Candidates for morally relevant traits are sentience, communication skills (Ott 2015) and openness to a world "outside". The (gradual) ability to communicate deserves special attention (Hendlin and Ott 2016). Western culture has long underestimated the ability to communicate within nature, and it has wrongly silenced nature (Friskics 2001). In nature, however, there is both noise and voice. If animals can give a voice to their mental state, we can and should interpret such voices and translate them, as advocates, into human discourse.

Most scholars would attribute inherent moral values to sentient creatures. If inherent moral values are based on morally relevant attributes (such as sentience or teleonomic structure) and if the most relevant attributes (sensation, communication) are gradual, then it might be permissible to graduate inherent moral values. We should better not homogenize morally relevant traits. The concept of equality could trigger the errors of homogenization of natural beings with morally relevant traits. The principle of equal consideration of each individual sentient member of the moral community makes grading possible. The survival strategies of mice, frogs, turtles, etc., as such (r-strategies) place hardly any value to the individual. This is of some relevance to how we should value such r-species individuals. The moral standpoint does not require all small wild sentient animals to be protected from suffering and premature death. Egalitarian animal welfare activism and the idea of "policing" wild food webs exaggerate sentientism in an absurd way. The egalitarian animal rights movement is completely reversing the way humans have treated animals since the Neolithic Revolution. It is an absurd demand that man should strive to reduce the pain of prey in terrestrial and even marine systems and ideally transform wild nature into a gigantic zoo. An egalitarian sentientism loses contact with human practices such as domestication, animal husbandry, gardening and hunting. Policing wild nature, granting political rights to pets, and the abolition of hunting and domestication present a somewhat weird result of animal rights theory. The result looks strange because it runs counter to how humans interacted with animals since they left the stage of hunters and gatherers. Egalitarians may reply that historical reasons (reasons from traditions) are generally invalid from a right-based moral point of view. Here, we reach the deep question of how morality and history might be correlated within an ethical theory. How much moral content beside transcendental commitments of arguing can and should be safeguarded from the winds of historical change?

Whatever the answer, *equity* is a gradual alternative to equality. Equity means adequacy to the degree to which morally relevant abilities are actually present in a natural being. The faculty to sentience should be coupled with the ability to communicate under the principle of equity. Plants do not communicate with each other, but they transmit signals that are decoded by other plants in the environment. This differs from the gestures with which dogs interact, and such interactions differ from a linguistic interaction between a chimpanzee and a human being. A discursive being would therefore not be equated with a capacity to exchange information on biochemical signals. A principle of equity, coupled with the combined criteria of sensitivity, communication and biological strategies, can provide a solid basis for gradually overcoming anthropocentrism, which is in reflective equilibrium with common intuitions about what we owe non-human beings.

This entire pattern of reasoning about inherent moral value goes beyond TEV and ESS. However, most TEV and ESS scholars acknowledge that the Inherent Value Problem should be taken seriously. Within the TEV, however, it holds that if all people believe that Anopheles mosquitoes are worthless, there is no reason to protect them. If WTP is zero or less than zero, there are reasons to remove such parts of nature. Only if people want to see penguins or observe whales is there a reason to protect these animals. In the case of whaling, however, economists would try to maximize the net present value of whale watching tourism and whale hunting for trade. Rich Norwegians may sometimes like to watch whales, but they also enjoy whale meat in some expensive Oslo restaurants—and they will pay for both. The efficient solution would be to protect the whale populations that live near tourist destinations and kill whales in remote parts of the ocean for luxury food with a fancy smell of decadence. This solution seems clearly cynical to conservationists who may give inherent moral values to whales. To sum up, the problem of inherent moral value in nature cannot be properly addressed within TEV and ESS. Since it should count as real moral problem, environmental ethics cannot be reduced to TEV and ESS. The criteria of sentience and ability to communicate constitute a gradual scale of moral considerability with some leeway to cultural variances (as in case of husbandry and hunting).

5.5. Conceptions of and Attitudes towards Nature

The considerations so far in this section illustrate how diversely nature is valued and how reluctant one should be in view of one's own ignorance to make conclusive and unambiguous evaluations. This is the reason for the fifth set of issues concerning conceptions of and attitudes towards nature. Within environmental ethics we find approaches based on a *non-scientific concept of nature*. Here, nature is conceived as something other than a collection of mere objects that fall under general natural laws. Many thought patterns within contemporary environmental ethics take a critical attitude towards a "purely scientific" interpretation of nature. In this interpretation, nature is nothing more than (a) the subject of scientific description and explanation, (b) a warehouse of resources that can serve as an entrance into industrial production, and (c) a hostile force against human longing for safety, health, and comfort. Within environmental virtue ethics, it is accepted that certain attitudes to and perceptions of nature are morally more appropriate than others. A general attitude of dominance, mastery and control can be rejected for moral reasons. The idea of deep ecology, as conceived by Arne Naess, was to sidestep modern ontology and replace it with "ecosophies". Ecosophies are not in direct competition with science. Ecosophies only assume that nature can show itself in its naturalness in modes and ways beyond scientific observation, data mining, and causal explanation. These ecosophies may have one thing in common: nature reveals itself in different forms in different places for open-minded people. Nature shows up (eventfully) as "physis", "creation", "kosmos", "dao", "wild" or "pacha". ESS can address such revealing of nature within the category of spiritual values, being a sub-category of cultural values. ESS must hold contact with religious studies. Here, monetization clashes with the logic of the sacred. This logic is not just about the strict protection of sacred sites and sacred groves, but goes beyond if entire ways of lives are seen in perpetual spiritual encounter with ancestors, spirits and deities of land and sea. Seen from the category of spiritual cultural values, the entire ESS and TEV schemes look "Western". The ongoing conceptual debate within IPBES is about Western biases within ESS and TEV. And rightly so. Jetzkowitz et al. (2017) have argued that humanities are necessary for an in-depth understanding of the underlying cultural and religious traditions of non-Westerns approaches to the "more than human world". In philosophical terms, cultural traditions have always shaped habits and attitudes. Non-western moral systems are often closer to virtue ethics than liberal Western universalism. In environmental ethics, one should take the bonds between worldviews and virtues seriously. This holds true for debates over SDG 15 and within IPBES.

Environmental virtue ethics requires an appropriate attitude towards oneself, others, time, and natural beings. Environmental virtues ethics evaluates arbitrary characteristics of individual character and bases environmental virtues on moral arguments. The virtue of sufficiency is based on resistance to the consumerist excessiveness of human metabolism. Many (biophilic) virtues are based on eudemonic values. Eudemonic values can have a transformative force, as Bryan Norton argued (Norton 1988). Environmental virtue ethics demands with a future ethical impact the prudential virtues of restraint and care, foresight and precaution. It also means being aware of finiteness and mortality, since the earth belongs to the living in usufruct (Thomas Jefferson). It can also justify the existential attitude of reverence for life, located at the interface between biophilia and biocentrism. Values, virtues, and moral obligations are often expressed in narratives, nature essays, proverbs, chants, and consultative citizen juries. There are valid meta-ethical arguments why not only voices in environmental discourse should be considered that meet Western standards of logical thinking. Eye-opening modes of linguistic articulation, including "thick" phenomenological descriptions, can change attitudes towards natural beings, including landscapes, and sensitize one to the many values of nature. After all, environmental virtues can trigger new maxims such as "leave no trace". Eudemonic-cultural values, strong sustainability and the gradual overcoming of anthropocentrism should shape one's own set of environmental virtues. The spiral-shaped combination of eudemonic-cultural values, strong sustainability, environmental virtue ethics and the recognition of unscientific, spiritual encounters with nature could be described as "deep anthropocentrism", being augmented by some reasonable solution of the demarcation problem. Both TEV and ESS abstract away the problem of virtues, but grounding existence value, cultural services, and bequest value has to remove such abstraction. If so, environmental virtue ethics stays alive in SDG 15 debates.

6. Synthesis of Approaches

In this final section, we will not present a quick "take home message" but remain rigid theoretical grounds. In particular, we will highlight the strengths and weaknesses of the ESS and TEV with respect to axiological discourse about environmental evaluations. We also will correlate ESS and TEV to environmental ethics. Such correlation takes two opposite routes into (1) decision making and economy, and (2) ethics and philosophy. The first route presumes to be of practical relevance for SDG 15 processes, while the second route is about theoretical synthesis.

On the first route, TEV and ESS open eyes for values and services of nature which are hard to ignore by policymakers. ESS values can be combined with TEV values. The combination of provisioning services (ESS) with option value (TEV) gives reason to conserve genes "in situ" (or as second-best solution in seed banks). TEV and ESS can determine through opinion polls how groups of people actually benefit from natural capital, and they can say this in the language of preferences, interests, trade-offs and opportunity costs. Such economic parlance is "lingua Franca" in our commercialized world. One does not conform to this parlance if one makes use of it at some occasions with a "caveat". TEV and ESS can and should give voice to disadvantaged groups in a commercialized word in ways that also can become critical against commercialized mindsets.

TEV and ESS can also point to the many trade-offs in human–nature interactions. Both TEV and ESS can be useful schematic tools designed to make the values of nature visible to people with economic mindsets and decision makers being confronted with economic models (cost–benefit-analysis). TEV and ESS reveal serious trade-offs, while cost–benefit analysis shows simplified solutions in terms of efficiency. Thus, decision makers must become aware that they make "real" decisions, sometimes rigid, harsh, and uncomfortable.

ESS and TEV make the values of nature visible, but they do so for different eyes. The quantification and monetarisation of instrumental values not only highlights the ecological value of nature to policy makers, but also provides information for market-oriented companies. Economic visibility is dialectical in itself. ESS and TEV can make people aware that nature has become scarce in many respects. Recognition of the scarcity of nature, however, also provokes clever strategies in the real economy, including investment brokers, portfolio designers, developers and business consortia, to acquire scarce natural resources through property rights ("assets") and mobilize the return on investments and payments accordingly. Recognition of the scarcity of nature can draw attention either to issues of conservation, restoration and distributive justice (however specified) or to rational, interest-based private strategies to acquire scarce natural resources (land, water rights, concessions, quotas). The business perspective implicitly recognizes the collective scarcity of valuable nature but wants to use ESS privately.

The economic perspectives on the scarcity of nature often become an entrepreneurial perspective: How can an entrepreneur profit from ecological services? How can business models be designed accordingly? How can payments be initiated and managed? Once you have made the scarcity of nature visible, it is difficult to avoid such selfish business prospects for natural values. The large-scale acquisition of land ("land grabbing") is a paradigm case, but one can also think of the acquisition of concessions for timber and fishing, the acquisition of CO_2 credits, the acquisition of beautiful places as travel destinations, and the like. Such acquisition strategies can affect local livelihoods, as a broad NGO discourse shows. They can distribute the benefits of ESS according to the given unequal patterns of purchasing power. Not surprisingly, egalitarian concepts of distributive environmental justice often reject TEV or ESS because of associated business models. Many people dislike the ideas that one may make a profit out of the conservation of nature or that nature's values are traded on markets. Market-based solutions and business-models count as corruption of the "spirit" of nature conservation. Market-based acquisition of ESS is either unfair or corrupt (or both). Thus, there are many warnings that ESS must be safeguarded against neo-liberalism. Warnings against "neoliberal commodification" may, however, also obscure the potential for transitions within environmental entrepreneurship, "green" investments and corporate restructuring.

TEV and ESS are tools and measures that make the values of nature visible. It is inevitable that they will do so for business models, but one should not be afraid of new coalitions between "green" bio-economy and entrepreneurship.

There might be many morally decent ways to make some money with TEV or ESS. Beautiful campsites on Swedish lakes can mobilise the willingness of stressed-out Germans to pay to relax in such an open-air hut. Farmers might specialize in producing agroecological services beyond yields. The same holds for forestry. Why not pay some entrance fee for a land art park presenting sculptures in landscapes? Why not get payments for natural climate solutions with respect to carbon dioxide removal? Why not shift agrarian subsidies to the production of cultural services and existence values? What is wrong with market gardening? Why not support green entrepreneurship politically? Why not stimulate restoration via monetary incentives? If production of ESS would be profitable, ESS might become less scarce in the future. If so, there might be democratising pro-poor "trickle down" effects of ESS. A mere denial of business models may underrate the prospects for innovation (Ziegler 2020).

In view of its internal dialectic of monetarisation of TEV or ESS, the economy can and should take the plunge into critical political environmental economy. To do this, economists would have to think about the scarcity of nature in close connection with environmental ethics, distributive justice and sustainability science. Debates at the interfaces of ethics and economics are about discounting, compensation, replacement costs, the replacement of functions and ("de re") the uniqueness of some special natural monuments (such as the Grand Canyon, Wadden Sea, Great Barrier Reef, and many others). The economic visibility of the scarcity of nature requires economic-ethical disputes over property rights over stocks of natural capital, commons, open access, types of acquisition, kinds of payments, fair benefit sharing, fair burden sharing, and promising business models. On the first route, we reach the basin of attraction called "political economy of nature". SDG 15 and IPBES are committed to inquire this basin of attraction, being full of sharks.

Schemes should not be taken for granted but should be seen as tools and devices for navigating over deep ethical waters. Limits of monetization open the second route of philosophical reflection upon value schemes and upon single categories within. The search for monetization is based on the ideal of operationalization and on the desire to homogenize the multitude of heterogeneous environmental values. Monetization is reductive to one unified measure. Numbers simplify, but both ESS and TEV have intrinsic reasons to withstand its own tendency towards simplification. Environmental ethics wishes to appreciate the heterogeneity of natural values. Appreciating heterogeneity might be an important step on the road of transforming environmental evaluations in the spirit of environmental ethics, as to be found prominently in the work of Holmes Rolston (1988) and Arne Naess (1989).

As we have argued in Section 2, evaluations can be argued with respect both to attribution and grounding. Grounding evaluations of natural entities is at the core of environmental axiology. TEV and ESS are not well suited for grounding as far as they are preference based. It is sufficient for evaluation to state or reveal a preference and declare some WTP or WTA. Such preference-based approaches may disconnect us from a deeper sense of valuing nature—and sharing such grounded values. Both TEV and ESS only point to values which are held by people as matters of facts (actual preferences), but do not allow for a prescriptive approach about values and commitments which peoples *should* hold (Section 5). Preference-based approaches obscure the profoundness of axiological life being connected to the more-than-human world. The following remarks also wish to explain why cultural ecosystem services are not "flows" from stocks of natural capital.

Cultural values overlap strongly with the so-called eudemonic values in environmental ethics. From an economic perspective, the economic value of such cultural services must be measured through travel cost analysis, combined tourism analysis or contingent valuation. Studies can provide useful information to stakeholders and policy makers. If a contingent valuation study shows that most tourists do not like noise on the beach, a destination becomes financially more valuable if noisy vehicles are banned by local authorities. Such useful methods, however, remain at the surface of cultural values. In relation to deeper layers of cultural services, other approaches such as cultural history, literary narratives, landscape painting, poetry, conservation history, cultural anthropology, religious studies, etc., can contribute to a deeper understanding of cultural services being grounded in eudemonic values. Non-Western modes of expression, as in songs, chanting, rituals, and proverbs, or practices such as pilgrimage and feasting should be taken into account. Eudemonic values remain embedded in the particularities of narratives, traditions, and practices (MacIntyre 1984). On reflection, we stand in need to reconcile the universal with the particular within environmental ethics. Universal commitments, as opposition against environmental victimization, obligations against future generations, and protection of sentient beings must be reconciled with particular traditions, cultures and even spiritual ecosophies being embedded in particular worldviews. A spirit of transformation in an age of crisis may not rest solely on universal commitments, but may need stronger bonds of place making, focal practices of conservation, beloved unique landscape, and cultural heritage. An integrated value system is a precondition for such reconciliation.

The TEV categories "option value" and "existence value" can and should be implemented in the ethical argumentation patterns. The existence value falls into the category of eudemonic values and also touches on the virtue-ethical question of what kind of person one wants to be. On a first stage of reflection, a preference for the existence of natural beings opens a path of deep questioning (*sensu* Naess) about being human in a natural world. On a second stage of reflection, one may also cast doubts on the idea that mere existence as such can be of value. If a person wishes to ground an attribution of existence value to a natural entity, such grounding must go beyond the statement "X exists". Grounding existence values must refer to cultural heritage, beauty, transformative value, widening identification, inherent moral value, etc. If so, "existence value" functions as a turn-table: it is an outer frontier to economics but also an entrance doorway to environmental philosophy, asking what kind of preferences we should have with respect to the existence of natural entities. The problem of the intrinsic value of biodiversity, as stipulated in the preamble of the Convention Biological Diversity, has to be grounded at this point. If biodiversity is both about different entities and variability amongst them, the existence value becomes far more profound than a willingness to pay for endangered crocodiles. Which attitudes are appropriate to the many ways by which organisms are capable of existing? Existence is about the "more" within the more-than-human world.

Even the category of option value reveals profoundness on reflection. How can one act in order to preserve and increase good options in the future? Should we create options by interventions or by omissions? Nature can be "optional" in many respects, as in eudemonic options and options for new spiritual encounters with the more-than-human world. Options should not only refer to future resources, but also include future options for people who want to liberate their biophilic dispositions and live as naturalists. A further stage of reflection may reflect upon options as dispositions within a "world". Why do we believe that the natural world we live in is full of options? An (onto)logical analysis of modes of dispositions in nature is still missing. Such analysis might be a common focal research point for logicians, ontologists, and ethicists. Lie (2016) has presented an ontology of dispositions and relational realism which may ground the concept of options values also with respect to long-term responsibility.

The spiritual values of sacred sites as such remain obscure and opaque to scientific and economic methods. Perhaps only phenomenological expressions, such as atmospheres, auras and sacred sites, can be perceived by sensitive embodied spirits and how they form specific moods that come close to such spiritual encounters with nature. When people become radically open to special places ("genius loci", "sacred sites"), it becomes pointless to ask for opportunity costs to replace them with shopping centres. Within ESS, the category of "spirituality" is at the outer edge of cultural services, but it opens a vast array of encounters with nature which are, in fact, alive in many cultures, but should not be downplayed by Western values schemes. There is broad agreement that this category should find a proper place in SDG 15 and IPBES. Environmental philosophy cannot abstain from a philosophy of religion (see for overview Jenkins et al. 2017).

Finally, the two functions of value systems (Section 2) are to be considered in their fulfilment. While value systems such as TEV or ESS can be useful for establishing evaluation standards, values play an important role in specific, complex, grounded evaluations. The axiological grounding of goodness in nature is different from truth claims, moral claims, and sincere expressions of sentiments. As our examples of "eudemonic", "existence", "option", and "spiritual" indicate, rounding value judgements is an immersion into the cultural lifeworld, not just making explicit a contingent mental state. Grounding values means to adopt a commitment to care for something being shared as being "good". Can TEV and ESS be transformed toward such grounding? Yes, in principle, they can. As we argued at the end of Section 4, TEV and ESS can become catalytic for environmental ethical discourse, as presented in Section 5. The identification of factual values may serve as a solid entry point for environmental ethical discourse.

Ethical beliefs are an integral part of our ways of life and judgements should be in a reflective equilibrium with our other beliefs. In order for value systems to perform their functions, they must help set the standards that we want to use—where we arrive at evaluation results that are consistent with our intuitions and where we know that we are valuing something for the best reasons. Well-reasoned evaluations about nature and about man–nature interaction can result if we synthesize ESS, TEV, and the patterns of reasoning within environmental ethics. The result of this chapter indicates that synthesis is within reach. Such synthesis is of high significance to both SDG 15 and IPBES, even if it had been reached on an independent route. To support the implementation of SDG 15 and the IPBS process in the longer run, we wish to have grounded a comprehensive value system being designed for specific evaluations in diverse settings. The reflective route being taken may nourish the spirit of substantial transformation in human interaction with the more-than-human world more than moral postulates. On this reflective route, one may become astonishingly aware that there is so much goodness within nature. Such astonishment looms at the end of the second route and, as always, at the beginning of philosophy (Plato, *Theaitetos*, 155d).

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Can Justice Respect Needs and Nature? The Idea of a Nature-Respecting Sufficiency

Rafael Ziegler

1. Introduction

Imagine a train ride. The passengers rush through the doors of the train. Having passed the threshold to their desired space, they sit down, relieved. Zoosh, chuuggaa chugga, chugga-chuga, choo. The journey starts. Westward. Trains are a 19th century paradigm of innovation and frontiers pushed ever further. They provided images of progress and destiny.[1] This "progress ride" has been accompanied by an increasing standard of living but also an evergrowing economy, disregarding and violating other land users and uses, and undermining the conditions for safe travel. According to the 2019 Global Biodiversity Assessment, all major drivers generally point in a direction of unsustainability (Díaz et al. 2019). It concludes that the Sustainable Development Goals (SDGs), including SDG 14 and 15 for the protection of life below water and on land, cannot be achieved without "transformative change" (Díaz et al. 2019, p. 39). This chapter contributes to this discussion via a focus on the transformation of values. It proposes a nature-respecting sufficiency.

In a move from the train to the automobile and spaceships, popular metaphors are "planetary guard rails" and a "safe operating space" (Biermann and Kim 2020). In the process, the image of the train has changed. It is associated with romantic sounds that are reassuring in comparison to the further accelerated, high-emission planes and rockets that keep on pushing boundaries. The train has become the environmentally friendly vehicle. So when I travelled for the first presentation of this paper, southward from Montreal to New York by train, some people congratulated me for having taken the train (and some, no doubt, thought I was a bit strange and did not have much to do if I could take such a "long" trip). But with a view to history of the progress ride, such praise and change in image is suspicious. Or to explore the image further, having passed the threshold for the train ride, we now increasingly focus on the rails of the train, held together by thresholds, metal or wooden pieces that ensure that the train travels safely. These thresholds become an

[1] See for example John Gast's painting *American Progress* as discussed by Brown (2016).

image for material limits; their disregard derails the train on its journey. As travellers on the "Anthropo-Train", we increasingly insist on limits and boundaries. But is this focus on boundaries enough for the called for transformative change?

This chapter contributes to the values aspect of the seemingly neutral question of environmental limits and boundaries as well as the protection of biodiversity and non-human life on land and in the oceans. Transformation in the view proposed here requires a change in values. For this, the chapter draws on environmental and political philosophy (Taylor 1986; Nussbaum 2006) to propose the idea of a nature-respecting sufficiency. It thereby also shows the contribution of sufficientarianism to sustainability theory and politics, and it challenges the perception of sufficientarianism as a minimalist theory of justice with little regard for inequality and unsustainability. Rather, sufficiency calls for a focus on the resources needed for living in dignity and a justification of resource use above this threshold.

Section two situates the concept of sufficiency in the theory of justice and environmental sustainability. Section 3 turns to the minimum sufficiency threshold, and Section 4 to its upper limits. Section 5 discusses objections, and Section 6 concludes with implications for (sustainable) economy and the technological and social innovations highlighted by the Global Biodiversity Assessment (Díaz et al. 2019).

2. Sufficientarianism

In philosophy and environmental studies, sufficiency is used in different, only partly overlapping ways. In the theory of justice, sufficiency usually refers to a minimum threshold that people are entitled to as a matter of justice (Fourie 2016). In environmental studies dealing with sustainability, sufficiency can refer to a preference of quality over quantity, of virtuous action and social relations over having more. Such eco-sufficiency (Kanschik 2016) articulates specific views of a good life that competes with others. Sufficiency also refers to a concern with environmental limits, i.e., that our consumption and production uses environmental resources and sinks in such a way that the long-term stability of socioecological systems is secured (Spengler 2016). This second "eco" use of sufficiency is directly relevant for intergenerational justice and global justice, i.e., with a view to those already losing their livelihoods in the present due to climate change and the extinction of species.

The double relation between justice and sufficiency is manifest in the uses of enough. As Frankfurt (1987) noted, "having enough" can mean that any more would yield unpleasant results. Perhaps, the chips served on the train are so tasty that you want to have a second bag. You come to regret this directly after, feeling sick. A limit has been reached. Eco-sufficient discourse highlights how consumer democracies are driven by dynamics of marketing and profitability that structurally lead to overconsumption, one of the key indirect drivers of current unsustainability (Díaz et al. 2019). However, as Frankfurt noted, "having enough" can also be used to say that a requirement or standard has been met. In this use, there is no implication that more would be bad. Rather, enough here means that a person has enough to eat, enough access to goods, etc. It is this standard or requirement that is in the focus of the sufficientarian theory of distributive justice.

There is a relation between the two uses. If my over-eating of chips and cake comes at the cost of you or distant others not having any, then there are relations between sufficiency as a requirement and standard and sufficiency as a limit (Spengler 2016, p. 930). The next section will first turn to sufficiency as a standard or requirement, and Section 4 will turn to it as a limit.

3. Sufficiency as a Standard or Requirement

The sufficiency requirement raises a host of questions (Fourie 2016): What is the currency of the standard (resources, needs, capabilities ...)? What is the scope of the associated community ("America first"?, all humans, ... all X)? Are there weighting rules where policies or decisions affect closeness to the threshold or positions below and above the threshold, etc.? How are sufficientarian principles and currencies justified? And related to this last question: is the sufficientarian view itself part of a more general theory or approach also including further values and principles? It follows that there is a variety of sufficientarian conceptions, depending on the respective answers to these questions.

3.1. The Currency of Sufficiency

The position taken here adopts capabilities as the category for evaluating thresholds, i.e., the real opportunities of people to do and to be what they have reason to value.[2] These heterogeneous doings and being are called functionings. A well-known version of such a position is Martha Nussbaum's theory of basic justice that spells out the concept of dignity via a list of central capabilities as entitlements of basic justice (Nussbaum 2006, pp. 76–78)[3]. Sufficiency, as used here, adopts this focus on dignity as a way of selecting capabilities and functionings.

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2 In addition to Nussbaum's theory of basic justice see also (Anderson 2010; Claassen 2017; Nielsen and Axelsen 2017; Ziegler et al. 2017; Drydyk).

3 For a discussion and defense of lists, see (Claassen 2010). There are also other ways of creating lists of central capabilities, and the very idea of such a list has also been criticised. For the purpose of this

3.2. Agency

Central to the capabilities approach is a focus on human agency. This focus originates with objections to theories and policies of development that treat human beings as means rather than ends (Sen 1999). The latter legitimates the priority of economic growth and developmental policies over democracy, education, and culture with the claim that such goods will follow later, once people are affluent enough to "afford" freedom. By contrast, Sen puts the emphasis on an "agent-oriented view" (Sen 1999, p. 11) that highlights the intrinsic and instrumental value of agency for justice and development. An agent is "someone who acts and brings about change, and whose achievement can be judged in terms of her own values and objectives, whether or not we assess them in terms of some external criteria as well ... " (Sen 1999, p. 18).

The focus on acting situates the capabilities approach within traditions of political philosophy that emphasise the need not just to look at formal rights but also at the real opportunity to exercise and enjoy them. Or as Nussbaum puts it, "each person as an end and as a source of agency" (Nussbaum 2000, p. 69). The idea of persons as ends is particularly clear in political agency, and the discussion of values, norms, laws, and policies governing social life. Such agency requires the capacity to reflect, to discuss, to decide, and to bring about—including to decide not to participate (Nussbaum 2006, p. 184f). Thus, agency as used here is very different from the agent in standard economics, who is supposed to act on behalf of a principal.

Elizabeth Anderson has proposed a capabilitarian sufficientarian position called *democratic equality*:

> The fundamental requirement of democracy is that citizens stand in relations of equality to one another. Citizens have a claim to a capability set *sufficient* to enable them to function as equals in society (assuming they have the potential to do so). Democratically relevant functionings include adequate safety, health and nutrition, education, mobility and communication, the ability to interact with others without stigma, and to participate in the system of cooperation. (Anderson 2010, p. 83)

Democratic equality underscores the relation of political agency with other capabilities. In her sufficientarian view, "citizens are entitled to *enough* education, for example, to

article, I bracket both the issue of further refinement of the capabilities list and the philosophical case for proposing such lists.

be able to advance informed claims in public forums, at a level of articulateness that elicits a respectful hearing" (Anderson 2010, p. 83, italics added).

Furthermore, rather than thinking of citizens in terms of representative individuals, the capabilities approach suggests that treating citizens as equals calls for a focus on the diversity of individuals and their contexts. Or in the image: when there is a serious risk that people might not be able to get onto the train, perhaps simply because there is no access for wheelchairs or for strollers, or if some groups are not "supposed" or "expected" to participate in the ride, etc. Nussbaum's list of central capabilities offers a comprehensive starting point for considering the agency of citizens, further thinking about and spelling out such capabilities in context.

3.3. Principles of Distribution

At first sight, a section on principles of distribution seems question-begging. Is sufficientarianism not precisely the view that a minimum threshold is required for justice? That there is really only one principle—that of sufficiency?

Already, Anderson's concept of democratic equality points to a more complicated situation. Democratic equality? How can equality have a place in a sufficientarian approach? Drawing on Nussbaum's Aristotle-inspired capabilities, Nielsen and Axelsen (2017) distinguish three types of capabilities: in relation to biological and physical human needs, in relation to the social interests of individuals, and in relation to their interests as autonomous individuals. The biological category, they suggest, is non-positional: distribution here must only be enough in a minimum threshold sense. If I have sufficient drinking water, it does not really matter very much for my nutritional need if somebody else has 10-times this amount of freshwater. By contrast, the social category is positional: political freedoms, freedom of assembly and of association, require equality. It is not enough for me to have one vote if my neighbour has ten. Here, the principle is equality, underscoring the importance of Anderson's insistence on democratic equality. Their last category refers to quasi-positional capabilities. Rational reflection, imagination, critical thinking, and normative evaluation in their view can be conceived of in terms of a sufficientarian threshold, but there is a need to consider pressures from external factors. "A person's opportunity for getting a meaningful job that is appropriate to her level and type of education is not only dependent on her personal capacities and acquired skills but also on competition from other human agents and social norms" (Nielsen and Axelsen 2017, p. 56).

Sufficientarians should endorse the plurality of capabilities and the respective questions of distributive logic raised by them. However, they should not follow the specific suggestion that the biological category is non-positional. It is true that some aspects depend on personal traits (such as one's metabolism and bodily condition, for example, being pregnant), but much also depends on social and environmental traits. In times of drought, cities in California and South Africa seek to enforce bans on water consumption for green lawns, etc., precisely for this reason. The water consumption of my neighbour affects my capability, and vice versa. Thus, a similar reasoning applies as for the category of autonomous individuals. They are quasi-positional: there are sufficientarian reasons to consider distribution so as to promote and secure the individual capability "from external pressure" (Nielsen and Axelsen 2017, p. 57). In a word, we have to think about the biological aspect of capabilities ecologically. Turning to patiency, it becomes evident how pervasive these quasi-positional reasons are.

3.4. Patiency

Anderson's democratic equality assumes, as she notes, that citizens "have the potential to do so" (Anderson 2010, p. 83). Some members of the community do not have this potential, contingently or permanently. Children have limited or developed capacities for deliberation and acting on reflected goals. A severe accident can prevent a person permanently from such deliberation and action. As Anderson notes, "additional principles must be supplied for such issues" (Anderson 2010, p. 84).

But is this just a matter of additional principles? And of children and future generations? Legal practice in many countries has moved to recognize further non-human animals. Environmental ethics discusses the moral considerability of animals, plants, ecosystems, and entities as such (Gorke 2010). Whatever one's positions in such debates, environmental ethics suggests that the community of justice is larger than the domain of human agents. One way of exploring this point is to consider contingent and permanent *patiency*, understood as the well-being and flourishing of living beings, no matter if this flourishing is based on reflection and deliberation, i.e., political and moral agency.

Dignity is not limited to agency.[4] Rather, we can and should consider the dignity of patients. Partly, this is out of mere self-interest: we are all (potential) patients to some extent and in some contexts. Partly, this is out of consideration for the ends of others. Nussbaum (2006) has recognized this point and proposed a sentientist

4 Sen introduces agency in relation to "the mediaeval distinction between 'the patient' and 'the agent'", positioning his "freedom-centred understanding of economics and of the process of development is very much an agent-oriented view" (Sen 1999, p. 11).

boundary of justice as a realistic utopia for our time. As "realistic utopia" indicates, her proposal is informed by a pragmatic political diagnosis. It is not a systematic implication of a philosophical approach based on flourishing. Her specific boundary proposal has been critiqued as arbitrary and inconsistent (Wolf 2012, p. 52).

The concept of flourishing at the core of the capabilities approach includes life as such. It is not difficult to identify the functioning needs of humans and non-human lives. As in the case of children, the autonomy-part might be missing or reduced, but this does not preclude the identification of functionings (Anderson 2010, p. 94). The potential to function here is not so much a matter of autonomous choice, but rather of bodily and contextual traits that enable flourishing.

Paul Taylor has recognized this point drawing a distinction of moral agents and moral patients (or, synonymously, subjects, (Taylor 1986, p. 13). "Perhaps the most ethically significant fact about moral subjects," he notes, "is that it is always possible for a moral agent to take a moral subject's standpoint and make judgements from its standpoint about how it ought to be treated. The standard implicit in such judgements is the furtherance or preservation of well-being of the subject, not of the one who does the judging" (Taylor 1986, p. 17). This yields a flourishing test of moral considerability: are moral agents able to identify the good of the subject without reference to any other entity and thus, its instrumental uses for others (Taylor 1986, p. 61)[5].

In Taylor's philosophy, this leads to a normative position that recognizes and respects the flourishing of all life,[6] once we note that our knowledge of the evolution of life places us as living beings among other living beings, who also have their good and who cannot be demonstrated to be inferior to us. Ideas of human superiority (in the Western tradition) are the likely remnants of pre-evolutionary, dualist Cartesian or Christian worldviews. By contrast, the attitude of respect for nature is supported by a worldview informed by evolutionary theory and ecology—as well as by other cultural and religious worldviews, including other varieties of Christianity.

Worldview has implications for our thinking about capabilities. Axelsen and Nielsen claim that some capabilities related to physical needs are non-positional. This argument depends on the assumption that the relevant resources are "freely available". Or, to revisit the example, 120 litres of freshwater per day might be

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[5] As one reviewer pointed out, this also leads to questions about the inclusion of novel entities, in particular due to developments in artificial intelligence. This interesting question is beyond the scope of this chapter, though prima facie Taylor's moral considerability test also applies to such entities.

[6] While I focus on Taylor, there are important further contributions such as (Agar 2001; Varner 1999). For the sake of this exposition of nature-respecting sufficiency, I bracket this intricate further discussion. For comprehensive older and more recent, critical, discussions see (Gorke 2010; Basl 2019), respectively.

fully sufficient for me in the sense that it does not matter if my neighbour uses 240 or 1200 litres etc.; it does not follow that this water is not taken from other beings in a way that harms their good. For example, the growth in consumptive use of water for agriculture and energy is a key cause for the enormous pressure on aquatic ecosystems worldwide (Ziegler et al. 2017, p. 110). The more general point suggested by the example is that it is prima facie not irrelevant what happens above the threshold, i.e., when basic interests have been met. Rather, consumption above the threshold is very likely to interfere with the good of others.

Revisiting the train image, this subsection suggests thinking of the train as a safe travelling space not only for active, "able-bodied" citizen agents, but also for all living beings—a Noah train. Alternatively, we can leave the train to human agents, who as inventors, engineers, entrepreneurs, managers, conductors, and passengers are most directly benefitting and responsible for exploring the frontiers of the blue planet—but note that the environment of the train has significantly changed: it is not just stuff out there, but a living, morally significant landscape. Do not throw your garbage out of the window!

4. Sufficiency as a Limit

The discourse of limits to growth and its revival in national eco-space boundaries and planetary boundaries discussions (Spangenberg 2003; Biermann and Kim 2020) calls for a reduction in production and consumption. "The idea broadly demands that human beings should limit their consumption in order to remain below a level that would be 'too much' in terms of harmful emissions and resource extraction—in other words, to remain below a maximum … " (Spengler 2016, p. 925). The currently most widely discussed limit of this nature is the warming upper limit in climate change policy, that is, an increase of no more than 1.5 degrees Celsius decided on in the 2015 Paris COP21 climate agreement. It is argued for on a number of grounds: moving to an even higher degree of warming would yield unpredictable risk to societies and ecosystems; this would especially harm the global poor, who often lack the technological means for climate adaptation; this would lead to further forced migration with unpredictable consequences for social stability and peace; it would further accelerate the sixth mass extinction of species … to name but the more prominent grounds.

Noteworthy is the specification of environmental limits in terms of resources and environmental goods (CO_2, water consumption, nitrate etc., (Steffen et al. 2015). Moreover, the focus is not primarily on "my CO_2 consumption" in comparison to yours, but on levels that are relevant for the functioning of the system and via this functioning point for individuals; for example, tipping points of the global climate system that, via extreme weather events, undermine secure shelter.

Respect for nature has important implications for thinking about such limits. The notion of relevant harm is extended beyond harm to humans. For example, in climate ethics (Nolt 2011), this extends the community of moral patients that is put at risk via anthropogenic climate change, from changes to habitats and conditions of flourishing that force migration and shift ranges to the extinction of species that cannot adapt quickly enough.

More radically, nature-respecting sufficiency challenges the standard conception of resources and sinks as limits, i.e., as an upper limit that might be reached after considerable economic growth. Any use of resources above the one required for reaching the human dignity threshold is likely to be at a cost to other members of the community and their ability to enjoy a sufficient minimum. I therefore speak of a resource threshold (that complements the central capability threshold). It is a sufficientarian, instrumental consideration in the philosophical sense that the argument is not based on an intrinsic problem with some having more resources than others as such (as in an egalitarian position), but with the effects of high consumption on others.[7] This consideration requires a shift from resource limits to a resource sufficiency threshold as a starting point—whereas simple sufficientarianism, by contrast, is typically associated with distributive agnosticism beyond the threshold. Respect for nature provokes the shift in the burden of justification: as we live in a doubly full world, not only with almost 8 billion people but also myriad other creatures everywhere, there are prima facie no free resources. The key question becomes the justification of consumption and production beyond the resource threshold of living in dignity. Assuming that there are synergetic ways of producing and consuming that do not harm other members of the community or that even improve their positions, there is possible extension (and innovation) beyond the resource threshold—yet, this cannot just be taken for granted.

Instrumental considerations of unequal distribution are not only an environmental matter. Ingrid Robeyns has provided arguments that support *economic* limits (Robeyns 2017b). First, economic inequality undermines political equality. She notes that the financially affluent can use their wealth to buy votes, for agenda-setting, to influence public opinion and for lobbying to undermine democratic policy-making

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7 Holland (2008) calls the environment a meta-capability, in the sense of a precondition that is necessary for central human capabilities. Others have criticised the terminology: the environment is not a capability (see Robeyns 2017a, p. 171).

(for example, via the threat to move production elsewhere). Second, she argues from unmet urgent needs: the financial resource of the affluent could be used to finance the fight against extreme poverty and deprivation as well as collective action problems that require government action. She argues for limitarianism as the view that it is "not morally permissible to have more resources than are needed to fully flourish in life" (Robeyns 2017b, p. 1).

Limitarianism has an instrumentally motivated egalitarian tendency. However, its focus on a "fully flourishing life" indicates a potentially higher level of resource use than flourishing in relation to central capabilities (Robeyns 2017b, p. 24). If the latter is defined relatively generously, the two might coincide; if it is defined very restrictively, there is a space between the resources required for leading a life in dignity and for being rich (in the morally permissible way). Either way, the consideration of resource use with a view to the moral community of all life puts pressure also on economic limitarianism to move the justificatory burden and ask what economic resource use beyond dignity is justified.

To conclude this section on sufficiency as a limit: First, in the environmental discourse, the limit is focused on resources and environmental goods rather than capabilities. Second, the discourse tends to focus on them as part of systems (the climate, the water cycle, etc.). Will a higher absolute level of CO_2 provoke a system imbalance with harmful consequences? How emissions are distributed within the system is secondary for this question. A beneficial implication of this point, at least from a capabilities perspective, is that unequal distribution of resources can be consistent with such limits in consideration of heterogeneity of contexts—say, more energy requirements of somebody living in a cold climate. By contrast, in the economic case, distribution is of primary importance due to the relative power of the rich over the poor. The reason, however, is also systemic. Unequal distribution undermines democratic politics: the rich have too great an opportunity to lobby for their interests, while the least advantaged might be entirely excluded from participating. Third, nature-respecting sufficiency leads to a rethinking of capabilitarian thresholds and resource limits. Rather than asking how much we can maximally produce and consume and stay within a "safe space", it suggests as primary questions: What resources do moral agents need to lead a dignified life? What resource use above this level is justified because it is synergetic with the dignity of all members of the moral community? To be sure, the system questions remain very important here too. However, they are not oriented by a maximization perspective, but by one of enough resources.

There are two advantages of this sufficientarian approach. First, for some systems, it is difficult to define planetary boundaries (see, for example, the difficulties linked to the discussion of a freshwater boundary, (Ziegler et al. 2017); a focus on resource requirements thus suggests a less constraining starting point. Second, some boundaries have been transgressed according to the planetary boundary account: genetic diversity, phosphorus, and nitrogen (Steffen et al. 2015, p. 736). In terms of the resilience concept orienting this account, there is no systemic reason to think that we could simply "move" back to the old, "safe" space. As noted in the introduction, the image of the Anthropo-train continuing its ride therefore rings hollow. In this emerging new social–ecological reality, we can, however, still ask if people's resource needs in relation to central capability are met, if production and consumption respect nature, and how both relate to new system dynamics. This reflects the point that ecosystems are dynamic and do not have a predetermined construction or operating plan (Gorke 2010, p. 142).

5. Nature-Respecting Sufficiency Reconsidered

Nature-respecting sufficiency endorses the "positive thesis" (Fourie 2016, p. 18) of sufficientarianism: "the moral significance of a non-instrumental sufficiency threshold, encapsulating the idea that it is a priority for individuals to reach or not to fall under such a threshold". Spelling out this thesis, however, yields a number of specifications and qualifications. First, threshold does not mean a line limiting a homogenous box, for example, of income. The diversity of all the SDGs in this respect is therefore a welcome feature. Rather, the standard refers to a heterogeneous set of capabilities articulating the concept of dignity that motivates the concern with a threshold. In practice, therefore, it is a demanding process to discuss relevant thresholds across capability categories in context. Second, for some capabilities, i.e., those of political equality, the threshold is intrinsically relational. For other capabilities, based on quasi-positional goods, relations are instrumentally important. Once we accept the attitude of respect for nature, we are living in a full world without free resources. Instrumental concerns are everywhere. This environmental resource point is enforced by the consideration of the negative role of economic inequality for political equality. Third, the style of thinking suggested by nature-respecting sufficiency puts central focus on the specification of a standard of dignity for moral agents, and with it, on distinguishing needs from wants and basic interests from further interests. In this way, nature-respecting sufficiency is a way to articulate philosophically the idea of sustainability, with its discourse based on meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland definition).

Adopting the weak versus strong sustainability terminology of sustainability discourse (Neumayer 2010), *strong* sufficientarianism is based on the recognition that in a full world with almost 8 billion people and a still growing global economy, meeting a threshold of dignity for present and future generations depends on respecting limits and seeing the negative consequences of further growth in production and consumption if non-substitutable natural capital is consumed. *Weak* sufficientarianism holds that technological progress and markets will help us tackle limits and boundaries. Nature-respecting sufficiency seeks to expand the scope of the moral community to include life as such. Thus, it is not only *strong*, i.e., endorsing the idea of environmental constraints to human activity, but also *transformative* of our conception of nature as a resource for us: nature is more than a capital to be preserved or for the "Anthropo-train" to speed on. Nature-respecting, transformative sufficiency is strong; strong sustainability can, but need not, be transformative. Strong sustainability, however, is necessarily drawn to a discussion that sees humans and their economy as part of socioecological dynamics. The planet is not made for humans to exploit and conquer as they please, nor is such conquest without significant risks. Is there a benevolent, slippery slope?[8]

5.1. Standard Objections to Nature-Respecting Sufficiency

According to the arbitrariness objection (Fourie 2016, p. 26f), sufficientarianism is morally arbitrary as there is a continuum of well-being and wherever sufficientarians posit a threshold, the threshold lacks the moral significance claimed by its positive thesis. According to nature-respecting sufficiency, this objection needs to be discussed in two parts. For positional goods, there are non-arbitrary, relational reasons for an egalitarian threshold. If you have two votes, this undermines the value of my vote. For quasi-positional goods, the reasoning is different. It is not based on the idea that well-being somehow suddenly diminishes beyond a threshold. Rather, it is the (potential) harm to others that outweighs the increase in well-being beyond a threshold of dignity. Is this idea still arbitrary in a morally relevant sense? Returning to the example of freshwater consumption, we can note that there is a variety of proposals for what counts as sufficient freshwater per head. Peter

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8 The most elaborate philosophical proponent of strong sustainability, Konrad Ott, suggests to move from anthropocentrism and sentientism to moral considerability based on prehension, which, empirically, he finds most plausible for animals, and hence, speaks of a zoocentrism (Ott 2010, p. 143).

Gleick argues that 50 litres of freshwater per capita per day are needed for drinking and domestic use; Malin Falkenmark, investigating freshwater use of societies with high technological development, argues that 274 litres per day are required; Eran Feitelson combines ideas from both approaches to identify a middle-ground (Feitelson 2012). In addition, a capabilities approach perspective would point to relevant differences in personal and other traits. For example, the freshwater requirement of pregnant and breastfeeding women is higher than those of other people of the same age. These examples and considerations suggest that there is some variety around freshwater resource needs. However, this variety seems more a matter of practical and contextual considerations, and it does not seem arbitrary in a morally significant way (legitimating, say, giving 1000 litres of water to Americans, and 1 litre of water to Mexicans). Thus, nature-respecting sufficiency leaves leeway for specifying a threshold, but not in a morally arbitrary way. The example also suggests that nature-respecting sufficiency can motivate and justify the inquiry into thresholds, but the determination of thresholds requires public debate as well as other disciplines (as in the example hydrology, political science and public health).

According to the indifference objection (Fourie 2016, p. 27), sufficientarians fail to worry about morally significant inequality above the threshold. Provided everyone is above the threshold, it does not, for example, matter if one group is at the threshold and one much beyond that. Again, we need to consider this objection in two parts. For positional capabilities, the objection evidently directly fails. For quasi-positional capabilities, nature-respecting sufficiency considers inequality for instrumental reasons. Again, using the water example, if I use freshwater for a swimming pool and lawn in a dry summer, this contributes to a reduced environmental flow in the river from which the water is abstracted, or contributes to a lowering of the groundwater table, etc.—all with consequences for other species and human neighbours. Thus, the indifference objection here only holds for purely egalitarian reasons. In practical terms, there are ample grounds for not being indifferent.

According to a further objection, sufficientarianism is also problematic below the threshold (Fourie 2016, p. 27f). How should we deal with difference below the threshold, i.e., various groups being not well-off? Should those least well-off be prioritized? Or those that can be made to reach the threshold? My intuition is that those most disadvantaged should be prioritized, say the person with one litre a day over the person with 49 litres a day. However, disadvantage below the threshold is not, even conceptually, a simple matter as there is a variety of types and capabilities of disadvantage. So how do you compare and weigh disadvantage across them? Is disadvantage in health more important than political disadvantage?

Education more important than economic opportunity? Empirical research suggests that disadvantage clusters (Wolff and de Shalit 2007): if you face problems in one capability category, say health, you are likely to also face problems in another one, say economic opportunity. At first sight, this empirical finding makes life easier. If disadvantage clusters, it becomes less complicated to identify socially excluded or marginalised groups and to accordingly prioritize those most disadvantaged. However, empirical research also suggests that supporting such groups yields policy dilemmas. A study of Roma exclusion in Hungary shows that support for excluded Roma is having counter-productive, exclusion re-enforcing effects, if only the Roma are targeted by social policy (Molnár 2017). Other, less excluded groups have to be included so as to improve social ties and avoid further enforcement of Roma exclusion that would be created by a focus on the least-advantaged only. Thus, there might not be a straightforward way of prioritizing below the threshold. However, this point does not depend on a specific moral theory—it is, rather, a challenge that all approaches dealing with disadvantage and social exclusion have to deal with and cautions not to move too quickly from philosophy to policy. Rather, the philosophical contribution here is to motivate the focus on those in need and central capabilities, a small yet still important contribution given that much biodiversity protection in practice depends on the livelihood protection and practices of indigenous people around the world.

Finally, according to the bottomless pit problem, sufficientarianism problematically suggests prioritizing the least well-off, even if this exhausts all of society's resources (Fourie 2016, p. 29). Nature-respecting sufficiency calls for a complete reversal in thinking on this point. The most disadvantaged are not the bottomless pit; the bottomless pit are the affluent in a growth-based world, taking away resources and undermining life conditions for others in the present and future. An Oxfam report estimates that the richest 10% of people in the world are responsible for around 50% of global emissions, whereas the poorest half accounts for only 10% of global emissions (Oxfam 2015).

5.2. Specific Objections to Nature-Respecting Sufficiency: Unliveable and Counter-Intuitive

How can human moral agents, given their bodily condition as heterotrophic beings that, unlike plants, cannot produce their own food via photosynthesis, possibly *not* violate rules of respect for nature? Rules such as non-maleficence (the duty not to harm any entity in the natural environment that has a good of its own), non-interference (the duty to refrain from placing restrictions on the freedom of individual organisms, hands-off policy with regard to whole ecosystems and biotic communities, i.e., providing space for ecosystems due to minimal interference by humans), or restitutive justice (the duty to restore the balance of justice between a moral agent and a moral subject when the subject has been wronged by the agent)[9] are simply not liveable in the world as it is and given the kind of beings we are, or so this objection holds.

A response is priority rules that deal with the inevitable conflicts over resources in a full world (Taylor 1986, pp. 264–305):

1. A principle of self-defence according to which it is permissible to protect oneself against dangerous or harmful organisms by destroying them;
2. A principle of proportionality that gives priority to basic interests over non-basic interests in the case of conflicts;
3. A principle of minimum wrong for the pursuit of non-basic human interests as long as they concern culturally important human interests and as long as they are performed in a way that minimizes harm to non-humans;
4. A principle of distributive justice that demands an equal share in a context where resources are needed to meet basic interests of different parties;
5. A principle of restitutive justice to make up for the harm done under the prior principles—for example, the preservation or restoration of rivers as a compensation for the modification of rivers elsewhere for meeting basic human interests.

The basic move is to enable moral agents to deal with conflicts in a systematic manner. The capabilities approach, via Nussbaum's conception of dignity and central capabilities, offers a way to further spell out the distinction between basic and non-basic interests, which Taylor draws on but does not elaborate further. However, nature-respecting sufficiency suggests more than just filling out open issues. In the sufficientarian perspective, the first two principles seem uncontroversial and the second one, in fact, typical for sufficientarianism. But the sufficientarian approach to distributive justice is different: it demands a *sufficient* share where resources are needed to meet basic interests. In this way, the sufficientarian principle of distributive justice resonates well with the priority articulated in the proportionality principle. On this basis, moreover, the sufficientarian conception suggests an elegant simplification, merging principles one and four in favour of a principle of self-preservation: moral agents are entitled to foster and secure central capabilities for living in dignity.

9 All rules from (Taylor 1986, pp. 172–86).

Take the example of a water dam proposal for energy production. The sufficientarian perspective is not a priori against the dam. Rather, it asks prior questions: what are the energy needs of the community or region; what are the ways to meet them (considering say, also, wind and solar)? And based on this, what is the best way to meet needs while minimizing harm. In practice, this likely requires an energy plan for the region, rather than letting dam construction be guided by economic opportunity and subsequent impact assessment.

But what about the third, minimum wrong principle? In Taylor's philosophy, the principle is there to secure a place for human, non-basic interests that are important for civilized life and that play a central role in their conception of the good life (Taylor 1986, p. 281). Moreover, these interests are to be compatible with an attitude of respect for nature. Taylor thinks, for example, of classical music and the concert halls required for it. In a capabilitarian conception of basic interests, there is a place for culture within Nussbaum's complex conception of living in dignity, with music, for example, via the central capability of play. This suggests that the idea of minimum wrong should accompany the principle of self-preservation as a qualification. Accordingly, the next subsection will further turn to this suggestion and the social and ecological design it calls for.

But is nature-respecting sufficiency not contra-intuitive? Do slime molds have the same standing as humans? The self-preservation principle, valid as such for all living beings, takes some of the apparent counter-intuitiveness away. It is legitimate to meet and secure the dignity of human agents (as is the self-preservation of non-human animals), and on the expansive central capabilities list, this covers considerable grounds of human agency. Interestingly, the principle of self-preservation has a quasi-transcendental justification for humans as moral agents: meeting and securing central capabilities ensures that the conditions of moral agency are met, and thus, of ensuring a precondition of the respect for nature demanded by environmental philosophy.

Still, imagine a case of emergency—a burning house—and stipulate that you are able to save either another human or a mouse trapped in the pantry? Should you not save the human rather than the mouse? Nature-respecting sufficiency can, again, make a transcendental pragmatic appeal to moral agency in response to such cases: if we do not achieve and preserve a threshold for human moral agents, there is not going to be any discussion of morality anyway. A minimalist, i.e., agency-preserving form of "speciesism", suggests a reason why I should save the human. This idea repeats the special, architectonic value of practical reasoning (Nussbaum 2000): practical reason is required for there to be choice regarding any of the capabilities and functionings. Likewise, moral agency is required for there to be any discussion and choice of justice and sustainability. This provides a first reply and helps explain why, in this chapter, I do not use the traditional language of anthropocentric versus (a variety of) physiocentric positions. However, no doubt, more discussion is required on this point.

5.3. Nature-Respecting Sufficiency Ignores Human Ingenuity and Innovation

As noted in the introduction to this section, the emergence of an international sustainability discourse sparked controversy between economists with faith in the power of technology and markets to deal with limits on the one hand, and on the other hand, economists who called for a deeper change in values and the protection of nature. More recently, eco-modernists have revived the case of the technology optimists. As Peter Cannavò writes:

> Eco-modernism is most fundamentally the view that economic growth can be "decoupled" from environmental degradation, through technical ingenuity and the development of substitutes for scarce resources and polluting technologies; ecomodernists also argue that economic growth and prosperity are preconditions for environmental responsibility. (Cannavo 2019, p. 8)

Cannavò notes that writers such as Ted Nordhaus and Michael Shellenberger from the Breakthrough Institute argue against a "politics of limits, which seeks to constrain human ambition, aspiration, and power rather than unleash and direct them" (Cannavo 2019, p. 8). In this view, the sufficientarian focus on thresholds and limits is misguided: wherever challenges emerge, human ingenuity, powered by science and innovation, will come up with new solutions that fix the problem. "If it [climate change] matters, we will solve it" (Steven Pinker quoted in (Davies 2018). This optimism of the eco-modernists takes us to the weak sufficientarianism introduced above. It accepts the importance of a threshold of dignity but views it along with the idea of limits as a signalling device for innovation and markets.

Nature-respecting sufficiency offers three considerations for eco-modernists and related ways of thinking. First, as an environmental philosophy it points to the costs of eco-modernism in the present as we know it. A direct driver of species extinction is the economic exploitation of land and water; moreover, an indirect driver of this is technological innovation (Díaz et al. 2019, p. 5). Either eco-modernists would have to say that this is not a morally relevant loss or, speculatively, that future research and innovation will allow for re-making of lost species and restoring habitats, whenever "we eco-moderns" feel it is important to fix the problem. Thus, the position rests on a gamble on the future.

Second, the gamble of eco-modernism is more general. We do not know what technological change will achieve in the future and what unintended consequences will result from this. As Cannavò notes:

> … such an invasive, physical remaking suggests that humanity, like nonhuman nature, will become raw material for a brave new future, and there are the inevitable questions of who is designing our transformed descendants, who is carrying out the experiments, and who will suffer the collateral damage along the way. Who will be at the mercy of those whose hubris and ambitions demand the reengineering of Earth and humanity? The potential scope of domination by some over others becomes truly sobering. (Cannavo 2019, p. 12)

In science- and technology-oriented discussions of sustainability, the precautionary principle has therefore been invoked: When "human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm" (UNESCO-Comest 2005). The precautionary principle offers an important addition to nature-respecting sufficiency in the context of current knowledge-based, technological innovation for commercial use. It further qualifies the way of thinking about the principle of self-preservation, in addition to the principles of proportionality and minimum wrong introduced above. There is also an emerging research community—responsible innovation—that takes such precautionary concerns seriously and, rather than viewing precaution as a mere "slowdown of progress", reframes the issue as an opportunity for innovation that, from the beginning, reflects on purpose, anticipates consequences, and seeks to be responsive in the process (Owen et al. 2013, p. 34ff).

Third, and beyond a focus on technology in responsible innovation, it is misleading to pit an eco-modernist open future against status quo or past-loving, anti-technology tree-huggers. There is plenty of space to embrace ingenuity and innovation in nature-respecting sufficiency. Notions of well-being and prosperity in the capability approach cover both the multiple realizations of capabilities as well as the material and non-material aspects of this. ". … It is possible to live good lives that are also just and ecologically sustainable, if we understand well-being and human flourishing in terms of human capabilities while giving more weight to the non-material capabilities … If we shift the way we are thinking about well-being towards those non-material capabilities *and* if we think about how we can realise the same capabilities with smaller ecological footprints, then we can still enjoy equal or even higher levels of well-being, while putting less pressure on ecological resources and ecosystems" (Robeyns 2017c, p. 3)[10] None of this precludes human ingenuity. But it shifts the focus from the means—technological novelty for commercial use in the hegemonic conception of innovation—to the ends and a change in practices. Viewed this way, it is unsurprising that the 2019 Global Biodiversity assessment recommends *social* innovation in its proposals for a transformation for sustainability (Díaz et al. 2019, p. 9). However, we immediately have to add that change in practices is not "good" as such either, but rather, calls for ethical discussion of the values and principles animating such change, including an equal consideration of resistance to change, exnovation (or the deliberate divestment from past products, programmes, and policies) and the creative restoration of traditional practices (Ziegler 2020a, see also Zerbe on social agriculture and traditional land use types in this volume).

But does nature-respecting sufficiency, with its emphasis on intrinsic and instrumental reasons for equality, not undermine the entrepreneurial incentives that trigger the search for solutions in response to pressing unsustainability problems, including material gains for those least well-off (Rawls 1999, p. 63)? This frequently expressed concern is at the very least not evident in light of empirical innovation research. For a start, it shows that much innovation is due to tinkerers in households and communities and their "free innovations" (von Hippel 2016), whereas traditional innovation policy in an unequal society tends to reinforce inequality and personal gain is but one motive among many others (Ziegler 2020a, p. 75f). Knowledge-based innovation is consistent with government investing in innovation as a public good—for example, by giving a university resources to investigate technical and social alternative approaches to energy use, without this "more of resources" being linked to an increase in private wealth. Society can provide scientists and innovators with extra means at their disposal to investigate a disease, and reward significant results with prestige. Public-driven innovation missions have been major drivers of significant innovations (Mazzucato 2013). Immediately relevant for the protection of "life on land" (SDG 15) is the large amount of public funding for agriculture; for example, in the European Union, the possibility to shift funding from direct payments to eco-schemes for rewarding multi-functional agriculture and for this to enable coordination and a landscape-level focus (see Lanker et al. this volume).

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[10] A further point that I can only mention here is the importance of human development for tackling population growth. As Sen (1999) has argued, human development and the importance it gives to educational and economic opportunity for women, is in practice also an effective way of reducing population growth

Paludiculture, or the productive use of wet or rewetted peatlands, provides an example for a potential sustainability innovation mission (Ziegler 2020b).

6. Conclusions

"A flourishing life on land is the foundation for our life on this planet," states the introductory sentence to SDG 15.[11] Nature-respecting sufficiency provides philosophical resources to appreciate the transformative potential and philosophical complications of protecting life, land, and waters. It calls for a focus on both agents and patients, and the thresholds and principles required for leading a life in dignity. Its scope is comprehensive, inclusive of all life. It offers one way to spell out a respect for nature in the theory of justice. In Albert Schweitzer's famous words: "I am life that wants to live, in the midst of life that wants to live" (Schweitzer [1923] 1990, p. 308).

As a philosophical contribution, nature-respecting sufficiency does not spell out the threshold values for each capability, let alone measurements or specific policy proposals. It rather provides a style of thinking about sustainability, biodiversity, and SDGs. Public discussion and many other disciplines are needed to spell out thresholds in context as well as economic arrangements that can sustain a sufficientarian ethos in practice.

The justification of nature-respecting sufficiency is complex. The starting point is the dignity of all living beings and their central capabilities. The conception specifically recognizes the role of moral agency via a principle of self-preservation, according to which it is permissible for moral agents to foster and secure their central capabilities. This is accompanied by:

- A principle of proportionality that gives priority to central capabilities over other capabilities;
- A principle of minimum wrong that requires human agents to minimize harm when pursuing their self-preservation;
- A principle of restitutive justice that requires human agents to make up for the harm done under the prior principles;
- A precautionary principle aimed specifically at technological novelty in knowledge-based societies.

For both agency and patiency, the positional and quasi-positional nature of capabilities plays an important role in recognizing intrinsic and instrumental reasons

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[11] For the full text see the website: https://www.globalgoals.org/15-life-on-land (last accessed 2.10.2021).

for a concern with equal distribution. In the background is Taylor's important point that the attitude of respect for life is supported by an evolutionary and ecological worldview and with it, a rejection of human superiority.

This chapter distinguished weak, strong, and transformative sufficiency conceptions. Weak sufficiency treats thresholds and limits as signals for human ingenuity. Strong sufficiency recognizes dignity and basic need thresholds, along with resource limits and sink requirements in a growing, global economy. It remains open to the idea that the world and its natural capital is there for humans to conquer and exploit—even in the absence of it being made for us.[12] If this idea is rejected, it becomes transformative. Nature-respecting sufficiency calls for a change in basic values, to recognize us as one species among others, as moral agents on a continuum of moral patiency. Other environmental philosophy variations of transformative and strong sufficiency are possible and worthwhile exploring further.

While it is thus strong and transformative, the critical discussion of nature-respecting sufficiency showed that the view is not static, pitted against human creativity and innovation. To the contrary, it gives such innovation a distinct focus: the priority principle of self-preservation, accompanied by proportionality, minimum wrong, restitution—and in our knowledge-driven societies—precaution. As a result, it suggests inter alia the importance of complementing technological innovation with a consideration of social innovation (a move made by the 2019 Global Biodiversity Assessment), and to do so in a way that equally considers exnovation or the ending of practices. Again, however, it must be stressed that the role of philosopher here is limited. It proposes a style of thinking rather than solutions. It also helps explain doubts regarding the romantic train and more recent safe operating space metaphors of sustainability. The ultimate challenge is a change in practices and culture, and technological metaphors obscure this point.

A better final navigational metaphor, originating from practice and culture marginalized by "progress", is accordingly: "Walk gently on the earth" (Wagamese 2019)[13]. We both need new practices and technologies, as well as better recognition of old ones and their creative response to current pressures (Díaz et al. 2019, p. 18; Ziegler 2020a). When I travelled northward again from my first presentation of this

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[12] For example, in the planetary boundaries discourse, it might invite the narrative of maximizing growth within limits (Crépin and Folke 2014, p. 58).

[13] Wagamese identifies this as a central teaching of Ojibwe practice, i.e., one of the North American cultures, pushed away and disregarded by "progress" (see footnote one). However, he also stresses the non-parochial, universally shareable (and differently reachable) status of this teaching.

paper, halfway through the trip from New York to Montreal, the atmosphere in the wagon took a distinctly agricultural flavour. A group of Amish people had entered the train, taking the train for two stops, to visit some community members as far as I could tell. They were chatting lively and laughing. As I was looking at them, a boy was curiously looking at me sitting there with my laptop.

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Part 2: Ecosystem Restoration in Cultural Landscapes

Germany's Agriculture and UN's Sustainable Development Goal 15

Ulrich Hampicke

1. Introduction

The Sustainable Development Goal (SDG) 15 within UN's 2030 Agenda for Sustainable Development (UN 2015) demands a transition to sustainable life on land on Earth, including a sustainable use of terrestrial ecosystems, sustainable management of forests, combatting desertification and halting and reversing land degradation and halting biodiversity loss. More specifically, nine targets include the conservation of forests, drylands, wetlands and mountains and the forestalling of poaching, spread of invasive species and land degradation. Although to prevent extinction of species is explicitly demanded in target 15-5, the measures proposed are incomplete. As observed by Tisdell (2021, this volume), habitat loss, being the most important factor, was overlooked. This contribution confirms Tisdell's arguments in adding that restoring and reclaiming habitats is a matter of urgency not only in remaining semi-natural ecosystems worldwide. It is also imperative in the cultivated landscape, notably in efficiently used agricultural environments. Biodiversity losses are not only caused by land degradation, desertification and the like, but also by proper and (from the farmer's point of view) "sustainable" cropping. The problems involved here are given insufficient attention in SDG 15.

This contribution focuses on biodiversity losses. In addition, threats to physical resources such as groundwater and soils are addressed. Although these are less serious than in other parts of the world, industrial agriculture may also conflict with development goals such as SDG 6 (clean water and sanitation), 12 (responsible production and consumption) and 13 (climate action). Of course, any reference to agriculture must take notice of SDG 2 (zero hunger). Some important items of this goal are less pressing in wealthy nations such as Germany. There is no need to further increase crop productivity. Here, target 2.3 (double agricultural productivity) would contradict target 2.4: "implement … agricultural practices that … help maintain ecosystems … and improve land and soil productivity". Socially defined targets such as supporting small-scale food producers, especially women and indigenous peoples, are not relevant in Germany. Notwithstanding, any wealthy country enjoying favorable agricultural conditions has the duty to contribute to global food security. Section 3 describes how this is accomplished in indirect ways in Germany.

The problems addressed apply to Central Europe as a whole; they are very similar or are becoming so in Switzerland, France, Belgium, Poland and other countries. Therefore, in describing the character of the countryside and the history of land use, reference is made to "Central Europe". However, a more detailed and quantitative analysis applies to Germany, due to some peculiarities of its agricultural policy and the availability of statistical data.

Section 2 pictures the historical development of the countryside from prehistoric times to the present in some detail, thereby emphasizing the species richness of traditional land-use in former times (for a comprehensive account, see Leuschner and Ellenberg 2017). Section 3 outlines Germany's industrial agricultural system operating, its general features and productivity, its contribution to food security, its poor management of physical natural resources, its disastrous effects on biodiversity and some of its immanent risks. Section 4 proposes measures conducive to relieving the drawbacks described beforehand, such as abandoning unnecessary production, better funding and planning. It will turn out that although a complete return to traditional land-use is of course impossible, at least the preservation of habitats in sufficient size can be made safe at moderate costs, thereby reducing the danger of species extinction. Section 5 concludes that the problems at hand reflect the poor talent of modern societies to a sustainable management of public goods.

2. History

What is called "Central Europe" in this contribution comprises Germany together with parts or the whole of its surrounding countries. The Alps form a clear barrier to the southern Mediterranean world with distinct ecological conditions and cultural traditions while the gradients to the Atlantic, boral and continental environments, west, north and east, are gentler. Central Europe is that part of the world which, in the absence of mankind, would now largely be covered by deciduous forests, dominated by beech (*Fagus sylvatica*), although this species rose to dominance only a few thousand years ago. Furthermore, it is a part of the world where, due to the action of Pleistocene glaciers not long ago (by geological standards), natural resources such as soils are young and more resistant to mismanagement than, for instance, in the tropics.

The periglacial tundra between the northern and the alpine glaciers used to be roamed by large-deer hunters since immemorial times. The world-wide oldest examples of sculptural art, dating some 30,000 years ago, were found in the valley of the rivulet Lone in southeast Baden-Württemberg. With the retreat of the ice some 13,000 years ago, and vegetation recovering, hunters might have been forced to switch over to fishing and collecting berries, mushrooms and edible plants. Agriculture arrived some 8000 years ago, not gently diffusing but deliberately brought by invaders who left their home territories in southern Anatolia and the "Fertile Crescent" for unknown reasons (Poschlod 2015). The new way of life was adopted by the native people, presumably rather slowly. This not only changed their social life with permanent settlement, surveillance of croplands and stockpiling, but also physiologic changes took place. Gradually, the natives acquired the ability to digest lactose, thus to consume milk products (Haber 2014).

Prehistoric man's impact on the countryside has long been underestimated (Leuschner and Ellenberg 2017). Forests were cleared, less by using primitive axes but rather by fire and farm animals' destructive foraging. The Bronze Age, 3000 to 4000 years ago, saw the transformation of forests into heath, a prominent example being the "Lüneburger Heide" in North Germany. The opening of the countryside provided advantages to plant and animal species adapted to non-forest environments.

Medieval agriculture relied on the small number of crops available since prehistoric times, such as primitive varieties of wheat, other cereals and lentils (Haber 2014). However, the middle ages saw two innovations, one technical, the iron plough, and one social, the three-field system, obliging every farmer to adhere to a strict sequencing of winter cereal, summer cereal and fallow. Medieval agriculture was little productive, unreliable, prone to crop failure and wasting. Reinforced by extreme rainfall events during the "Little Ice Age", soil erosion raged (Poschlod 2015). The poor fertility of the cropland was half-way maintained by a permanent transport of nutrients from the forest, either by deliberate collection of litter or by farm animals' movements. They were driven to what had remained of the forests during the day and brought back to the crop fields in the evening in order to deposit their dung. Contrary to what is often misconceived today, medieval land-use used to be intensive. Like in poor African countries today, every paltry piece of wood was a valuable find used for cooking, every bunch of grass was collected as feedstuff. As a result, open territory with scant vegetation spread, providing optimal conditions for numerous plant and animal species adapted to warm environments, many of them of sub-Mediterranean origin. On its face, paradoxically, wastage furthered biodiversity. The remnants of these biotopes, aptly called semi-cultured landscape ("Halbkulturlandschaft", Wilmanns 1993) and now protected, offer important opportunities for recreation and enjoyment in nature today (Figure 1).

Figure 1. Remnant of semi-cultured landscape, today appreciated for recreation and enjoyment. Chalk grassland "Kleiner Dörnberg" near Kassel, Germany. Source: Photos by the author.

As late as in the eighteenth and early nineteenth century, agriculture became a matter of science and practical improvement. An outstanding personality in Germany was Albrecht Thaer. The former fallow land was now tilled with either food plants like potatoes or sugar beet, or feed, preferably clover (*Trifolium pratense*) or alfalfa (*Medicago sativa*), in order to enhance the nitrogen supply. Animals were fed regularly, feed conserves, mainly hay, provided adequate livelihood during the winter. Excrements were collected, carefully stored and brought to the fields as fertilizer. Compared with today, crop yields and animal performance remained low, but except for rare events such as the "year without summer", following the eruption of Mount Tambora in 1816, crop failures subsided. Biodiversity richness may have declined locally but not in general.

The most important developments in the nineteenth century were the destruction of what had remained as natural biotopes in the countryside, above all, the peatlands, and the dismissal of the semi-cultured countryside. As opposed to today's valuation, heath, barren grassland on limestone and sandy soil—mostly used as commons—were regarded as ugly and as waste lands. Losses became so heavy that around 1900 a conservation movement arose, and the first protected areas were established by private initiatives, such as in the "Lüneburger Heide". Equally important was the taming of almost all watercourses from small creeks to large rivers such as the Rhine (Blackbourn 2008). These activities enhanced agriculturally valuable areas and, transportation on the land being still laborious, facilitated shipping.

Although Justus Liebig propagated the use of mineral fertilizer, it came into use only very slowly until the First World War. The first pesticides appeared, preferably in viniculture, some of them dangerous for their applicants. Agricultural techniques progressed gradually but the system as a whole did not undergo revolutionary changes. In tilling and all other outdoor work, the pace was still given by horse or oxen, countless farm-laborers and maids performed their hard work. Wild plants were tolerated or even utilized in the agriculturally productive areas. Of course, weeds were regulated but never to the point of extinction. A large number of crops, almost all of them fallen into oblivion today—flax (*Linum usitatissimum*), buckwheat (*Fagopyrum esculentum*), poppy (*Papaver somniferum*) and others—offered variety for many concomitant plant and animal species. Permanent grassland used to be colorful and rich in species; a typical meadow—by then regarded as "fatty meadow" ("Fettwiese")—consisted of 40 to 60 plant species, as shown to-day in their scattered remains in plots of twenty-five square meters. Poet Annette von Droste-Hülshoff, in describing her Westphalian mother-country, wrote that " ... every step on its meadows gives rise to the soaring of yellow, blue and milky-white butterflies". It is remarkable that in contrast to most crops and all fruit trees, grassland cultivation made and still makes use of indigenous plants, thus incorporating elements of former wilderness.

Nineteenth-century agriculture shows some resemblance to current organic farming. Primitive and destructive features of medieval land-use were overcome, but modern practices, detrimental to biodiversity and natural resources, were still a long way off. During the first half of the twentieth century, the first tractors appeared and chemical fertilization developed in very modest ways. Yet, by 1950, the open countryside was still more or less resembled the model developed during the nineteenth century. To be sure, natural ecosystems such as peatlands and natural watercourses were mostly lost and the semi-cultured landscape was reduced. However, agricultural biotopes proper continued to be multifarious in every respect. Cereals plus the greater part of their accompanying weeds had been introduced thousands of years ago. All species of fruit trees had been brought by the Romans. American cultures such as new-world beans, potatoes, tomatoes, maize, tobacco and others were introduced during the Renaissance epoch and later. Despite all this, agriculture never gave the impression of being a foreign matter, as in the case of New Zealand where even beetles decomposing the droppings of cattle had to be imported. To the contrary, the traditional Central European countryside was the result of 8000 years of traditions, gentle innovations, adaptation and thus unique in the world. Not least, it used to be aesthetically attractive, as immortalized in many pieces of art. As late as in 1950, nobody had the presentiment that agricultural practices could lead to the extinction of species. Beyond all doubt, it is worthwhile to preserve elements of this unique feature now and for the future.

As for forests, their destructive use in the past has already been mentioned. Remarkably, the area left to the forest today is quite the same as during the middle ages. However, former forest quality was very low, orders from sovereigns for better treatment having been fruitless in most cases. In early modern times—from the fifteenth and sixteenth century onward—various industries such as pottery, glass manufacture and metallurgy of all kind needed heat, which, before the advent of coal, could only be supplied by charcoal (Küster 2008; Leuschner and Ellenberg 2017). Despite the famous call by Carlowitz as early as 1713 to limit wood use to the volume growing up, the recovery of forests was a performance of nineteenth century foresters. Their predilection for coniferous trees, even in regions less suitable for spruce (*Picea abies*), left us with a questionable legacy, all the more so with climate change.

3. Industrial Agriculture in Germany

In this section, the physical structures of Germany's agriculture and food system 2000–2020 are outlined. Second, its performance and contribution to public welfare are appreciated. Third, its negative impact on natural resources and, most particularly, biodiversity is described in detail.

3.1. Physical Structure

A citizen of the 1950s, hypothetically transferred to 2020, would not recognize their agrarian countryside. The outstanding feature of today's agriculture is its high productivity, as compared with the traditional system. Figure 2a (left) shows a rye field as it may have existed 200 years ago, Figure 2b (right) a modern wheat field. Its yield is ten times the yield on the left. Table 1 shows some selected data on former and present productivities. Notice that yields around 1900 in the left column have already been higher than 100 years before.

Figure 2. Former and current productivity of crops. (**a**) Rye field reproduced from around 1800. (**b**) Modern wheat field. Source: Photos by the author.

Table 1. Yield increases in German agriculture.

Yield (Decitons per Hectare)	1900	1950	2012–2015 Average	2015 Peaks
Cereals	16.3	23.2	74.6	120
Potatoes	126.0	244.9	439.5	
Sugar beets	256.0	361.6	711.9	
Milk (kg per cow per year)	2165	2480	7452	13,000–15,000

Source: Adapted from (StJELF 2002, p. XXVIII; StJELF 2016, Tab. 98 and 166, supplemented).

Germany's agriculture comprises roughly 17 million hectares, 12 million for crops and 5 million for permanent grassland. Figure 3 shows production and fluxes of agricultural commodities in Germany. The adequate physical measure is the energy content of every product—one kg of starch contains 17 megajoule (MJ, 10^6 Joule), one kg of plant oil 39 MJ and so on. In the graphic, energy content is the general measure; a detailed description of the calculation is found in Hampicke (2018, in German).

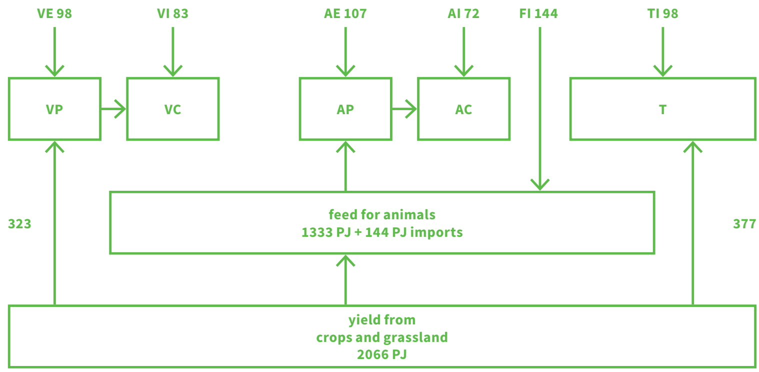

Figure 3. General structure of the German agriculture and food system. All numbers in Petajoule (PJ = 10^{15} J). VP, VC, VE, VI: Vegetable products produced (329 including fruits), consumed domestically (219), exported (98), imported (83), AP, AC, AE, AI: same for animal products (225, 110, 107, 72), FI: feed imports (144), T, TI material used for biogas, biodiesel and bioethanol plus 50 for technical raw materials, imports (98). Source: Adapted from Hampicke (2018, p. 56), simplified.

In 2013, cropland and grassland produced a harvest of 2.066 exajoule (EJ, 10^{18} J). Two thirds or 1.333 EJ were used as feedstuff, enlarged with 144 petajoule (PJ, 10^{15} J) from imports. The second largest share of the overall harvest, 377 PJ, are plants mostly used for technical energy—maize for biogas, the oil of rapeseed for diesel fuel and wheat for ethanol as additive to petrol, and some for raw materials. Vegetable food ranks only third with 323 PJ plus 6 PJ from fruits of which 219 PJ are consumed domestically, that is only eleven percent of the total harvest. Feedstuff produces 255 PJ of animal products—meat, milk and eggs—the ratio of feed energy to product energy being around seven to one due to the animals' energy requirements and for other reasons. The high energy losses in livestock production are well known.

There is much foreign trade in agricultural commodities. In total, 98 PJ in grain, potatoes and sugar are exported, 83 PJ, mostly in vegetables and fruits, are imported. For animal products, the figures are 107 PJ in export and 72 PJ in import. Altogether, Germany shows an export surplus of 15 PJ in vegetable and 35 PJ in animal products.

Given the relatively small area of German agriculture, the output is enormous. Not unexpectedly, adverse side effects on natural resources occur which will be described in the sequel. Striking features of the system are the very high share of feedstuff, the production of technical energy and export surpluses.

3.2. Positive Welfare Effects and Unwarrantable Criticisms

Judging justly, the system's performance in terms of food security has to be acknowledged. It should not be taken for granted that food scarcity used to be a feature only of the distant past and is definitely overcome. Germany contributes in some respect to the world-wide availability of food in that it is self-sufficient and imports products almost entirely from economically well-off countries, for instance vegetables and oranges from Spain. Its exports will be discussed later.

As for product quality, commodities produced in conventional cropping contain residues of chemicals, especially pesticides, for the most part within dosages permitted by regulations. Health risks cannot be ruled out altogether but they are modest as compared with those posed by street traffic, sport activities, alcohol consumption, smoking, unhealthy diet and obesity. It should not be ignored, however, that the latter risks are often run of one's own free will while those from pesticide residues are difficult to avoid.

Some criticisms of modern agriculture are exaggerated. Although its fossil energy requirement is poorly documented, it does not exceed three to four percent of the net energy consumed by the nation. Traffic, often of questionable necessity, needs thirty percent. The reader is invited to consult Table 5 in Section 4.2.1. An often-heard reproach is the energy requirement of mineral nitrogen fertilizer, produced by Haber-Bosch technology. The requirement is around 40 kilojoules per gram nitrogen. Multiplied by 1.7 million tons of mineral nitrogen fertilizer applied per year, this amounts to 68 PJ or 0.76 percent of net energy consumption.

Statistics inform that German agriculture produces 11.5 percent of the nation's greenhouse gases, thus contributing to anthropogenic climate change. Table 2 shows details. Evidently, emissions C are partly avoidable although at some cost. Cropping in peatlands and converting grassland to crop land (D plus E) must be curtailed anyhow for other reasons than caring for climate. There remain emissions of methane (CH_4) from ruminants and nitrous oxide (N_2O) from fertilizers (A plus B). Assuming these emissions and some from C to be unavoidable, agricultural contribution to climate hazards would reduce to some six to seven percent, a very modest share in view of the fundamental necessity to produce food.

Table 2. Greenhouse gas emissions from German agriculture.

Emission Source	Processes	Million t CO_2 Equivalent
A Fermentation	CH_4 emissions from ruminants	24.9
B Soils	N_2O emissions from fertilizers	26.5
C Various	losses of CO_2 from organic fertilizers, application of lime to soils and others	14.6
D Crop soil	using mires for cropping	14.7
E Grassland	conversion to crop land	22.9
Total		103.6

Source: Adapted from WBA and WBW (2016, p. 19).

3.3. Negative Effects on Physical Resources

Although misuse of soils leading to massive water erosion such as in the middle ages is rare, not all soils receive sufficient care. Crop fields in eastern Germany sometimes comprise several hundred hectares. The absence of hedgerows, coppices and other structures facilitates wind erosion. One such event in 2011 produced a dust-cloud leading to a mass accident in a motorway, causing eight fatalities.

Growing specialization results in the separation of regions with excessive livestock rearing, mostly in the northwest, from others confined to cropping. In the latter, mostly eastern regions, soils receive no organic fertilizer, fertility is safeguarded alone by chemical inputs. Although yields still appear satisfactory, consequences in the long run are dubious.

Both shortcomings mentioned could be mitigated within the system given. This is more difficult and expensive regarding the problems addressed in the sequel. Table 3 shows the general nitrogen balance of the German agriculture. Inputs from mineral fertilizer, imported protein feed and other sources amount to roughly 2.6 million tons per year while exports in vegetable and animal products sum up to only 0.9 million tons. The difference of 1.7 million tons per year is lost in the countryside. Almost two thirds trickle with water leakage, jeopardizing groundwater quality. Only 50 percent of 692 measurements in agricultural regions disclose good drinking water quality (less than 25 milligrams NO_3^- per liter), 28 percent surpass maximum permissible loads decreed by European law (50 mg/L), and 22 percent lie in between (BMUB and BMEL 2016). Germany has been sentenced by the European Court of Justice for not realizing the European Nitrate Directive. Until today, the situation would be much worse without the biogeochemical process of denitrification in subsoils. In the absence of oxygen (O_2), some bacteria are able to transform the nitrogen contained in NO_3^- into innocuous N_2. These bacteria consume organic matter diffusely distributed in the subsoil and quit their benevolent activity once this matter together with pyrite (FeS_2) is exhausted. Obliged to prepare for such a future, action re-establishing a controlled nitrogen management is imperative. The deterioration of drinking water, essential to life, cannot be tolerated.

Table 3. Nitrogen budget of German agriculture.

Supplies	Tons per Year
A Leguminous plants symbiotic with N-fixing bacteria	225,000
B NO_x deposition from industry, traffic and other sources	160,000
C Import of protein feeds	450,000
D Mineral fertilizer	1,750,000
Total	2,585,000
E Export in vegetable and animal products	910,000
Losses	1,675,000

Source: A and B adapted from (Bach 2008), D from (StJELF 2016), Table 75, average 2014–2016, C and E from (Hampicke 2018).

Forty percent of the nitrogen losses are transformed into gaseous ammonia (NH_3). German agriculture produces 680,000 tons of ammonia per year (Haenel et al. 2016), a quantity strongly reduced for a long time past had it been emitted by industrial sources. Although part of it subsides to crop fields and meadows these fertilizing, a large share is lost to biotopes which should not be fertilized in this way. Terrestrial eutrophication by ammonia is an important factor of biodiversity decline, in addition to the factors described later. In forests and in the open countryside, nitrophilous plant species profiting from fertilizing suppress and displace many other less competitive species. In forests, species-rich ground vegetation is replaced by uniform stands of blackberries (*Rubus spec.*) and aggressive grasses such as *Calamagrostis spec.*

Agriculture being an open system, it is impossible to avoid nitrogen losses altogether, but the disorganization of the nitrogen circle on the current scale is intolerable. The most important agent is animal husbandry. In regions with excessive livestock rearing, too much manure is deposited in the fields; regulations are lax. Ammonia is emitted from stables, from manure deposits and by inappropriate methods of manure distribution. To a lesser extent, groundwater and atmosphere are also affected by cropping and viniculture. Among mineral fertilizers, urea is increasingly used for its low price. It easily decomposes to ammonia.

3.4. The Extermination of Biodiversity

The strong word in the headline of this section is warranted. Upon meticulous studies of hundreds of vegetation assessments 60 to 70 years old and their comparison with the current situation, a research group at the University of Göttingen concluded that the population sizes of common plant species (not orchids or other rarities) omnipresent in the agrarian countryside for thousands of years have declined to little more than five percent their sizes in the 1950s (Leuschner et al. 2014 and other contributions in the volume). This loss has been aptly called an unintentional large-scale ecological experiment with unknown consequences (Nentwig 2000). The fact that these formerly common plants have still become not rare enough to include them into "Red Data Books" on endangered species misleads to underestimate the consequences of their decline. Butterflies, bees and other insects, depending on these plants, for instance their blossoms, have dramatically declined both in numbers of species and in population sizes (Vogel 2017). While bird populations in forests, at the seashore and even in cities are rather stable, birds adapted to crop fields and meadows, often breeding on the ground, have become rarities or vanished altogether (Hötger et al. 2014).

The reasons are obvious and partly clearly visible: Loss of habitat, ubiquitous eutrophication, exposition to pesticides and others. Let us distinguish four types of biotopes: semi-cultured landscape, grassland, crop fields and structures such as hedgerows, coppices, watercourses and others.

Fortunately, most areas of semi-cultured landscape that survived "cultivation" efforts during the nineteenth and early twentieth century (see Section 2 above) are protected today. Others owe their persistence to military training activities. While the area of these biotopes is less of a problem, their quality is often unsatisfactory. In order to preserve favorable conditions for their characteristic plant and animal species, activities carried out there for thousands of years have to be continued, otherwise coppice and finally wood will invade the areas. A case in point is sheep grazing on barren but species-rich grassland and heather. In some regions, such activities are carried out with considerable success, in others less so. Semi-cultured biotopes and grassland alone, often blending each other, comprise around forty percent of all endangered plant species listed in "Red Data Books" (see Box 1). However, due to conservation efforts, rare species on calcareous soils, among them orchids much appreciated by naturalists, sometimes fare better than sorrel (*Rumex acetosa*) in agricultural biotopes proper. Wet environments may also be qualified as semi-cultured when they interpose between the poor remnants of mires still in a natural state and moist grassland utilized more thoroughly. Plants and animals there, mostly members of "Red Data Books" too, face even worse conditions than those in dry environments.

The area of permanent grassland is diminishing. Daily, almost 70 hectares are withdrawn from agriculture to the benefit of settlements, traffic ways and so on (BfN 2016, p. 80). If cropland was affected, its losses were compensated by the transformation of grassland into cropland so that grassland alone paid the toll. Today, some regulations are retarding the process. A certain portion of grassland must be cultivated intensively, implying high fertilizer input and frequent mowing or grazing, High-yielding milk cows depend on energy-rich feed not producible otherwise. This kind of grassland is worthless for biodiversity, very few plant species are present such as white clover (*Trifolium album*), dandelion (*Taraxacum officinale*) and some grasses (Dierschke and Briemle 2002). None the less, it is still valuable for erosion control and carbon storage.

Box 1. Endangered plant species in Germany.

The Red Data Book on plants (Korneck et al. 1998) designates all species assumed to be endangered or already extinct. Several degrees of threat are distinguished and the species are classified according to the biotopes they live in. So it is possible to assess which biotopes and which kinds of land use contribute most to the threat. In Table 4, four groups of biotopes are distinguished: (1) agricultural areas including the semi-cultured countryside, (2) biotopes often in contact with agricultural activities, such as peatland near moist meadows, (3) forests and (4) others, mostly covering limited areas. In the first two groups, sub-groups are distinguished.

The entry "crop area" comprises all species in cropland-dominated landscapes; weeds proper, dependent on tillage, are much worse off. The relatively favorable situation in productive grassland is due to the fact that till today, only plants resistant to eutrophication and other factors have survived there. Forests appear less beset with endangering, but this is true only for higher plants, the situation for mosses, lichens, fungi and insects is far from favorable. None the less, important conclusions can be drawn. Dry grassland and heather, the semi-cultured landscape, contribute a quarter of all endangered species, agriculture proper together with semi-cultured landscapes contribute nearly half. Add a substantial share of the entry "biotopes in contact or influenced"—peatlands dried, waters eutrophicated and others—then agriculture is contributing directly and indirectly almost two thirds to the process of endangering higher plant species. It is to be assumed that the situation is similar regarding animals.

Table 4. Extinct and endangered plant species according to the biotopes they occur.

Biotops	Numbers of Extinct	Numbers of Endangered But Not Extinct	Percentage of Extinct and Endangered Species per Biotope Type	Share of a Biotope Type of All Extinct and Endangered Species in the Country
Agriculture	**26**	**244**	**27–54**	**46**
- among them				
crop area	13	84	36	7
productive grassland	0	47	25	3
wet grassland	3	103	52	7
dry grassland and heather	9	261	53	26
Biotopes often in contact with agriculture or influenced	**19**	**287**	**11–85**	**22**
- among them				
peatland	3	114	50	6
nutrient-rich waters	3	83	50	6
nutrient-poor waters	4	35	83	2
Forests	**4**	**199**	**13–27**	**14**
Others and alpine	**8**	**168**	**10–56**	**18**

Source: Adapted and compiled by author from Korneck et al. (1998).

Unfortunately, permanent grassland (Figure 4) not confined to these restrictions is losing its species richness by a lingering process. Colorful traditional meadows are replaced by uniform biotopes once the yearly input of nitrogen exceeds 100 kg which is reached easily. Modern techniques add to the impoverishment, mowing with efficient equipment at high speed kills grasshoppers, frogs and hare kids (Oppermann and Krismann 2003; Humbert et al. 2009).

As documented above, the productivity of current conventional crop fields is up to ten times higher than it used to be in pre-industrial agriculture. Stalks of cereals are packed in such a dense way that no living space for weeds would remain even if these had not been eradicated long ago by herbicides (Figure 2b). About 250 plant species in Central Europe are typical for landscapes dominated by crop fields, about 150 depend obligatorily on cropping. This flora element is reduced more than all others, conservation efforts have been neglected for decades and are still insufficient. Due to their poor competitiveness, the majority of weeds are innocuous. They represent interesting plants for various reasons, perform functions in the landscape, not a few are aesthetically attractive and have the potential of becoming ornamental plants (Meyer and Leuschner 2015). Yet, all are unappreciated by the farmer whose ideal—no plant or animal in the field except the crop—has come true frequently.

Figure 4. Colorful meadow in the Alps not yet affected by intensification. Source: Photo by the author.

The dense packaging of stalks in cereal fields offers optimal conditions for fungi causing plant diseases so that fungicides have become indispensable in conventional cropping. Some cultures such as rapeseed are attacked by a number of insects, aphids have to be combated in cereals. So insecticides add to the menu of pesticides regularly applied to crop fields and thus to one third of Germany's area, menacing many species innocuous to agriculture.

As for structuring elements, the main problem is their mere scarcity. For decades, so-called farmland consolidation measures in East and West Germany have eliminated hedgerows, coppices, road margins, terraces and other elements in order to make farming more efficient. During the socialist epoch in East Germany, many small watercourses have been pressed into subterranean tubes. In particular in the northern plains, the landscape was and still is regarded as an opportunity to unfold the capacities of industrialized cropping in full measure, disregarding all other functions and benefits the countryside can bestow, let alone its aesthetics.

Summing up, within a few decades, the colors and richness of biotopes and species developed over millennia have been reduced, and in large regions eradicated almost altogether. Despite the abundance of food and other products brought about by this process and despite it relieving farm people from hard work, the past 60 to 70 years in Central Europe represent an example of non-sustainability, contradicting some of the demands of SDG 15, which urgently needs correction.

3.5. Negative Impacts on Agriculture

Far-sighted agricultural experts increasingly realize the risks farmers incur when they continue the unbalanced way of cropping which has become customary. Crop rotations have become impoverished due to the very small number of economically sound crops with severe risks for soil quality and plant health. Fifty years ago, an expert wrote "the rotation rapeseed—winter wheat—winter barley is to be strictly avoided, diseases both for rapeseed and cereals will accumulate in the soil" (Andreae 1968). Today, this is the standard crop rotation in northeast Germany, the expert's forecast having come true. The overall preference for winter cereals results in upcoming resistance of weeds against herbicides. So, despite heavy spraying, "problem weeds" such as foxtail (*Alopecurus myosoroides*) are becoming serious nuisances. Equally, harmful insects have developed resistance against insecticides, often stimulated by improper and unnecessary spraying.

The situation is aggravated by strict regulations of authorities. A number of pesticides, used for decades, have lost their admissibility or will lose it in the future. One reason among others is the dramatic reduction of insect populations, particularly bees, in recent years. The chemical industry is reluctant in developing new products. Pessimistic forecasts are heard, for instance that rapeseed cultivation will become impossible under these circumstances. The general opinion expressed by experts is that cropping methods must improve substantially in the future.

4. Alternatives

Of course, it is neither possible nor desirable to restore pre-industrial agriculture as a whole. Unfortunately, the discussion is charged with various misplaced arguments expressed even by conservationists. Some argue that valuing the pre-industrial countryside is a purely nostalgic matter, held by people unwilling to accept change.

Colorful meadows, so the argument goes, have not been "natural" in the past but man-made and therefore lack intrinsic value. Commonly, it is added that it is unbearably expensive to conserve what was useful in the past but no longer is, without supporting this assertion by numbers and calculations.

Three aspects contradict such misconceptions: First, to avoid extinction of species is a moral and legal duty. If all species of the traditional countryside, favored by human action or not, were out of danger in other ecosystems or other countries, their disappearance here would be tolerable in terms of sustainability. However, this is far from true. Most endangered species in Central Europe are also endangered in other regions or will become so in the future once land-use methods here are introduced there. As a wealthy nation having signed the Convention on Biodiversity Conservation, Germany cannot shift the responsibility to conserve to other, mostly less wealthy countries. Second, the public strongly welcomes the remnants of the traditional countryside. The scarcity of colorful meadows is regretted, industrialized agriculture or "agro-factories" are of ill repute, also due to their methods of livestock rearing which cannot be addressed in this contribution. Polls elicit a considerable willingness to pay for conservation and the preservation or restoration of a beautiful landscape (Meyerhoff et al. 2012). Third, the costs for the achievement of substantial progress in biodiversity conservation are low in macroeconomic terms, as will be shown below.

4.1. Organic Agriculture

As already mentioned in Section 2, modern organic agriculture is in a way akin to pre-industrial farming, except for the mechanical techniques used. So it is near at hand to suggest replacing conventional by organic farming altogether. Despite the enthusiasm expressed by many devotees, no thorough and quantitative assessment of the consequences has ever been published. Refusing mineral nitrogen fertilizer, at least 25 percent of the cropping area must be left to clover or other plants symbiotic with nitrogen-fixing bacteria. There are two consequences: The area producing food for humans is reduced while feed for ruminants is oversupplied to the point that ecologically valuable grassland runs the risk of becoming abandoned. The modest supply of nitrogen together with the refusal of phosphorous fertilizer easily absorbable by plants results in yields per hectare far below those in conventional cropping. It is doubtful whether the system would be able to meet the nutrition needs even of a frugal actual population consuming less animal products.

Organic agriculture is not rejected in this contribution, to the contrary it is appreciated as an interesting alternative to what is criticized above. Some features, such as its renunciation of pesticides, are strongly welcome. However, rather than adhering to ideological principles almost one hundred years old, it should be open to further development. Perhaps a synthesis of conventional and organic agriculture, in particular avoiding the drawbacks of the former, is the best prospect for the future.

4.2. Remedies

Returning to Section 3.1, we first discuss three measures conducive to practices less injurious to both physical resources and biodiversity in the countryside. They come to the same conclusion: commodity production should and can be reduced. Thereupon, we point to some problems solvable by more generous funding in combination with spatial planning and expedient practices.

4.2.1. Reduction of Agricultural Output

Twenty years ago, prices of customary agricultural commodities were still unsatisfactory so that new assignments for farmers were in demand. With much enthusiasm and much public money, the production of plant material providing technical energy was propagated and necessary equipment was organized. Today, almost twenty percent of the cropping area is used to produce biogas (CH_4) mostly from maize, diesel fuel from rapeseed (FAME) and ethanol as an additive to petrol from cereals and sugar beets. From an engineer's point of view, the biogas system fed with maize is exceptionally cumbersome. After maize is grown, harvested and ensilaged, it is filled into a reactor producing gas which drives a motor generating electric power. Only a fraction of the energy harvested is transformed into electric current.

The agricultural biogas system supplies 4.5 percent of Germany's electricity consumption, FAME and ethanol contribute less than two percent of the energy necessary in transportation. In particular, the biogas system is extremely expensive, its costs are shifted to private households forced to pay high prices for electricity (WBA 2007). Its contribution to climate stabilization is negligible. Table 5 shows that renewable sources supply around fifteen percent of Germany's net energy, the lion's share allotted to wind and solar power. Domestic agricultural plants contribute only negligibly. While biogas production from materials not demanding areas such as old fatty stuff and the like may be sensible, letting agricultural energy production with poor output have 2.3 million hectares must be regarded as questionable policy.

Table 5. Germany's technical energy budget 2018.

	PJ	%
Gross or primary energy	13,106	100.0
from regenerative sources	1804	13.8
Losses in conversion to electricity and other losses	3221	24.6
Non-energetic uses in chemical industry	889	6.8
Net or end energy available for consumers	8996	100.0
from regenerative sources a)	1333	14.8
from domestic agricultural plants b)	max. 150	1.7
Consumption		
Mining and industry	2651	29.5
Traffic	2705	30.1
Households	2291	25.5
Other businesses, trade and services c)	1350	15.0

Source: a) 668 PJ used directly plus electricity produced from regenerative sources, b) around 100 PJ electricity produced from biogas plus FAME and ethanol, c) including agriculture. a) and b) estimated by Hampicke, all other figures from AG Energiebilanzen e.V. (2021), www.ag-energiebilanzen.de, Auswertungstabellen 1990–2018.

Two hundred years ago, David Ricardo (Ricardo 1817) published his famous theory on foreign trade. Every country should export products it owns in abundance or produces more efficiently than others, e.g., wool from England and wine from Portugal. Germany is exporting its scarcest resource—its area. Around one million hectares produce vegetable and animal commodities for export, the area devoted to the latter would be even larger without the feedstuff imports mentioned in Section 3.1. Although a balanced exchange of agricultural commodities may add to overall welfare, net exports (exports in excess of imports) to the extent reached in Germany are questionable (see Box 2). The country is not in need of foreign currency, to the contrary, its balance of trade is too favorable (unfavorable of others). Exports hardly mitigate food scarcity in poor countries but go to solvent consumers, for instance in Russia and China. In some cases, they may even harm domestic production in other countries.

Energy production and net export claim over three million hectares, eighteen percent of Germany's agricultural area of around 17 million hectares. Although "wasted" may be too disparaging an expression, the area is used inefficiently and for the satisfaction of less important demands—in economic terms, it is used inferiorly.

At the same time, area is in urgent need for improving the ecological quality of the countryside; for letting space for structural elements and re-establishing less productive but species-rich traditional cropping and grassland areas. It must be noticed that the energy plant system has been introduced fully by political decisions, in no way by the market. It could be abandoned likewise by a wiser decision which appears not to be impossible in the future. Exports are promoted massively by the government with public money. One objective is to stabilize prices, for instance for hog meat exported to China. More fundamentally, export is promoted in order to grant fodder suppliers, livestock rearers, dairies, the meat industry and traders finding sufficient sales or even the scope to grow facing diminishing domestic demand. In short, three million hectares are used in the first place to the benefit of small minorities and to the disadvantage of the public.

Box 2. Agricultural area exported.

Area agriculturally cultivated in 2013 was 16.7 million hectares (StJELF 2016, table 85). According to Section 3.1 above, total yield was 2.066 EJ. Average productivity was therefore $2066 \times 10^{18}/16.7 \times 10^{6} = 123.7 \times 10^{9}$ J/ha, roughly equivalent to a harvest of 8 tons of grain per hectare.

Annual excess export of vegetable products was 15 PJ. Excess export of animal products of 35 PJ has to be multiplied by seven in order to assess the amount of feed necessary. In total, 245 PJ minus 144 PJ of feed imported amounts to 101 PJ, the entire export surplus to 116 PJ.

Having $116 \times 10^{15}/123.7 \times 10^{9} = 938{,}000$, and given rounded average figures, the area exported is roughly one million hectares per year.

As an aside, the much criticized feedstuff imports, mostly protein concentrates, are re-exported completely in animal products and do not contribute to domestic consumption, as frequently asserted.

The argument that Germany's agricultural imports should be balanced by exports is flawed. First, the figures measure net export, export in excess of import. The area imported is probably overestimated because to a large extent, imports consist of vegetables and fruits, often produced in glasshouses needing only limited area. Second and more important, even a net import of agricultural area would not necessarily deserve criticism. No country has the duty to balance imports and exports of the same class of commodities. It would be perfectly right if Germany balanced its net imports of agricultural products by exports of other, for instance industrial products in rich supply, according to Ricardo.

It is true that some countries (Egypt, Saudi Arabia) are forced to import food. It would be wiser to import from area-rich countries in need of foreign currency rather than from narrow Germany.

The dubiety of Germany's net export can also be expressed otherwise: In years with average yield, about ten percent of cereals are exported. Without export, yield per hectare could be ten percent lower without decreasing domestic provision. Such de-intensification would add substantially to unburden the countryside from stress produced by excessive fertilization and pesticide spraying

Allusion has been made to a third factor conducive to reducing the stress on the agricultural countryside: decreasing demand. A general reason is aging population, aged people eat less. More specifically, not a few people reflect upon their diet. The "German Society for Nutrition", an expert body, recommends a yearly consumption of meat per person of 30 kg for reasons of heath; the present average is 60 kg per year. In total, 35 percent of the average daily energy intake is from meat, dairy products and eggs. A tendency to avoid excessive meat consumption is observed, specifically among younger people. The reasons are health care, the demand for more quality in exchange for quantity and not least ecological considerations. The massive energy losses incurred in feeding animals as noticed in Section 3.1 are becoming aware to increasing numbers of considerate people. Already a moderate reduction in the consumption of animal products results in a multiple reduction of feed demand. Although extreme reorientations, for instance in favor of veganism, will have to be observed in the future as to their durability, the prospects for reducing stress on the countryside on the part of consumers should not be underrated.

4.2.2. Funding and Planning

Of course, many benevolent reorientations cost money which is the very reason for their neglect. This is particularly true when caring for the integrity of physical resources. The reduction of ammonia emissions requires costly investment in stables, among others filters collecting the gas. Equally costly is equipment depositing liquid manure on or beneath the soil surface instead of throwing it in the air as has been practiced for a long time.

Another important case where money alone solves a problem is the care for the semi-cultured landscape. As mentioned in Section 3.4, sheep grazing is obligatory for maintaining barren chalk-grassland. Similar biotopes, too, demand grazing animals, mechanical care by mowing being often less effective in the long run. Table 6 shows that traditional sheep grazing cannot be carried out by receipts from product sales alone, costs are much higher. The shepherd's very important contribution to landscaping requires payments in excess, just as caring for parks in towns requires funding. It is interesting to notice that in the semi-cultured landscape, no conflict with farmers exists and no ideological obstruction has to be overcome. Everybody loves these biotopes, not a few young people are willing to become shepherds. Some funds are operating, but mostly in the short term, discouraging idealistic people to venture upon a risky future.

Table 6. Receipts and costs in landscaping with sheep grazing.

	Euro/ha·Year
Receipts from product sales	231.74
Costs for fodder concentrates, water and other inputs	232.11
Feed	238.30
Work	275.40
Fixed costs for machinery	139.70
Other costs	63,30
Total	948.81
Deficit = funding necessary for landscaping	717.07

Source: From Berger (2011).

Landscape planning is traditional in Germany for decades, university chairs and numerous private firms are active. Its power to enforce its ideas in practice is poor, however. Often plans are produced "for the filing cabinet". Yet, urgent problems call for authoritative spatial planning. The lamentable division of the country into regions rearing far too much livestock and others with only few farm animals has been mentioned in Section 3.3. Even upon an overall reduction of livestock rearing along the lines suggested in Section 4.2.1, groundwater quality can only be safeguarded by a more even distribution of livestock, at the same time providing more soil with organic manure. Lacking instruments to incite farms to agree to such reorientation, techniques are elaborated to condense liquid manure and transport it over long distances. This is fussy and expensive.

Landscape planning is not even capable of safeguarding a sufficient provision of structuring elements in the agrarian countryside. If a motorway is planned, it is built within a few years, a hedgerow, urgently needed against wind erosion, will meet its realization postponed to all eternity.

Paradoxically, the costs for the achievement of substantial progress in biodiversity conservation are low in macroeconomic terms. Table 7 shows a compilation of measures suggested by Hampicke (2014) in a study for a renowned foundation. Comprised are four measures: (1) Safeguarding the ecological quality of the semi-cultured landscape by funding grazing, as already mentioned; (2) de-intensification of grassland providing feed for young cattle not in need of energy-rich grass, as is practiced with great success in the Eifel region in western Germany; (3) low-input cropping in regions with less fertile soil; and (4) provision of a sufficient number of structuring elements in highly productive regions. Around thirteen percent of Germany's agricultural area would be included in such a project, enough to improve substantially the condition of biodiversity. The overall costs are in the range of two thousand million Euros per year, 0.7 per mil (not per cent) of the annual gross national product. A country declaring herself to the Conservation of Biodiversity should be ready to defray this sum, all the more so because it could be affordable by a reorientation of funds already in existence but utilized little efficiently such as the "first pillar" of the Common Agricultural Policy (CAP) of the European Union, comprising around five thousand million euro per year.

Table 7. Suggestion for a program in favor of conservation in German agriculture.

	Area, ha	Euro/ha·Year	Million Euro/Year
Semi-cultured landscape and grassland valuable for conservation	1,000,000	550	550
Restoring 10% of high-productive grassland for young cattle	400,000	1200	480
Setting aside 10% of one quarter of least-productive cropland	150,000	400	60
Structuring elements on 7% of area in highly productive regions	630,000	800	500
Total	2,180,000		1590
Round up for possible underestimates and recent price rises			2000

Source: From Hampicke (2014).

5. Conclusions and Economic Interpretation

The lamentable condition of biodiversity in Germany's rural landscape violates moral and legal duties. German Law of Nature Protection demands the preservation of all wild species. Not only is the situation at variance with the demands of UN's Sustainable Development Goal 15. Furthermore, National and European programs plead for a reorientation. In 2007, the German Federal Government passed a "National Strategy for Biodiversity" (BMU 2007) whose melodious promises remain on paper ever since. As for agriculture, the "Biodiversity Strategy 2030" of the European Union (European Commission 2020) puts in claim concrete targets, among others: reduction of pesticide use by 50%, reduction of nutrient losses by 50% which demands a reduction of application of 20%, establishment of organic agriculture on 25% of the area, reclaiming high-diversity biotopes on at least 10% of the area.

One is tempted to state that the Common Agricultural Policy (CAP) of the European Union has had at its disposal decades in the past to achieve at least some of these goals. Forty years ago, experts gave sufficient advice and presented examples of success (Schumacher 1980). It is easy to demand to dispense with 50% of the pesticide use without wondering about consequences. Doing without 50% of pesticides and leaving everything else unchanged results in confusion. The cropping system as a whole would have to be revised. This is not to say that the targets are not worth aspiring to, but it appears unrealistic to achieve them as soon as 2030, which is in less than ten years.

This contribution shows that considerable improvement is possible even in shorter terms provided there is sufficient political volition. Unnecessary production should cease. The public neither needs energy crops nor excessive export of agricultural commodities, reclaiming three million hectares. Renunciation of both would relieve the stress and open scope for reducing the intensity of cropping and for devoting science and practice to the targets of EU's "Biodiversity Strategy 2030".

A plenitude of agricultural products could be produced, and farmers could enjoy satisfactory incomes—without biodiversity losses witnessed to the present degree. Costs for substantially improving the situation are moderate, funds are available in principle. In a general welfare-economic setting, abandoning uneconomic energy crops even results in avoiding social costs. The general public enjoys beautiful landscapes and regrets biodiversity losses; biotopes as shown in Figure 1 are crowded on weekends by recreationists. Economic studies attest a considerable willingness-to-pay for biodiversity conservation (Meyerhoff et al. 2012).

In the public debate, actors are blamed for being responsible. The government is unwilling to engage in conflicts with farmers, farmers ignore the necessity to conserve, and agricultural lobbyism is too strong, the general public wants cheap food products, and so arguments go on. Although some may be not altogether wrong, they remain superficial.

We have to look for deeper reasons. All agricultural products, some of them supplied in excessive quantity, are commodities, private goods, tradable in the market. All works done in too short supply for the integrity of physical resources and for biodiversity conservation are public goods. A public good is characterized by non-rivalry in consumption and non-excludability. A private good is owned by the one who paid for it in the market. A public good, once it exists, exists for everybody and cannot be traded in the market (we ignore refinements, see Cornes and Sandler 1996).

The provision of private goods can be left to the market which has been functioning extremely successfully for a long time. So the superabundance of agricultural commodities is not surprising. Public goods have to be provided by collective action. Just as the attempt to supply private goods by collective decisions in socialist systems ended up in overall scarcity, the scarcity of benevolent public goods in the countryside is anything but astonishing.

Elementary economic theory attributes the scarcity of public goods to their non-excludability. Smart consumers acting as free riders, there will be no suppliers because they are unable to recover costs. This is half true at best. In fact, there are three possibilities (Hampicke 2013):

1. No sufficient willingness-to-pay for a public good exists. Consumers are disinterested and would not buy the good even if it was available in the market.
2. Willingness-to-pay exists in principle but is spoiled by free riding.
3. Willingness-to-pay exists, is not spoiled by free riding but is ineffective because of missing or ill-designed institutions capable of bundling individual contributions.

Certainly (1) and (2) are not fully absent in society. However, prevailing opinion in the public and numerous results from scientific studies on willingness to pay for nature conservation indicate that (3) is to blame in the first place. Policy does not ignore its duties, considerable funds are granted in the "Second pillar" of the CAP (see Lakner et al. 2021, this volume). However, oddly enough, strange inconsistencies are observed. As for the management of nitrogen and its damage done to water and atmosphere, policy has been timid for decades, farm lobbyism had and partly still has an easy task in preventing more effective measures. The nearly total failure of landscape planning, equally brought about by lobbying, is particularly regrettable. Add to this well-meaning but ill-considered political decisions such as the furthering of energy plants. On the other hand, payments granted to farms for nature-friendly cropping and grassland managing practices—translating the public concern for conservation into practice—after having operated quite successfully in former years, have mostly degenerated to a system dominated by bureaucracy and unjust sanctions frightening off potential participants.

These are subjected to the control of their activities five times as thorough-going as farmers unwilling to participate in conservation measures. Upon minor irregularities, for instance slightly incorrect documentation of the area involved, they have to pay back the funding they received and face other sanctions in addition. It is a small wonder that the number of farms willing to participate is decreasing. It has been shown that most conflicts arising in this field are caused by unclear regulations and ill-informed authorities rather than by unlawfully acting farmers (Kannegießer and Trepmann 2016). Cases are reported where the financial expenditures for controls exceeded the damage done by mistaken action on the part of farmers almost 60-fold (BfN 2017, p. 34).

Experience shows that farmers are successfully persuaded to cooperate in measures to enhance biodiversity upon two conditions: First, measures must minimize bureaucracy, must recognize the economic necessities of the farm and must be accompanied by the guidance and advice of people in the confidence of farmers. Second, action must be designed long-sighted. Although individual contracts may confine to a couple of years in order to grant flexibility, the general setting demands patience and trust. A case in point is the work done by Wolfgang Schumacher in the Eifel region (west of Bonn) which made his home county (Landkreis Euskirchen) probably the only county in Germany where aspirations of the European Union to stop species reduction have come true. Crop field margins are embellished by weeds no longer in danger of extinction, meadows producing hay for young cattle and other livestock not demanding high-energy feed are colorful (Schumacher 2007).

Society may choose among two alternative designs for agriculture: Either farmers restrict themselves to the maximum production of commodities, thereby regarding limitations protecting natural resources and biodiversity as obstacles for their activity which have to be complied with the least possible. Or they consider the active preservation of the countryside to be part of their business, in a like manner as commodity production, on the condition that a just financial appreciation by society is granted. Unfortunately, the first alternative has gained attraction in recent years, possibly furthered by globalization. Of course, the second alternative is far more promising and would be the optimal way to comply with the demands of SDG 15. To conclude, mismanagement of natural resources and the demise of the traditional countryside are examples of the poor talent of modern societies to design suitable institutions holding trust in public goods.

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Ecosystem Restoration and Agriculture—Putting Strong Sustainability into Practice

Stefan Zerbe

1. Introduction

Although it is undisputed that agriculture is essential for supplying people with food and plant-based resources, today it is one of the most important causes of global environmental problems. The worldwide loss of biodiversity, deforestation, soil erosion, soil salinization, eutrophication of soils and water, and the contamination of soils and water with persistent pesticides are no longer a local problem in agricultural regions but have reached global dimensions (EEA 2016; Tilman et al. 2001; Springmann et al. 2018; IPBES 2019). Along the gradient of extensive towards intensive agriculture, large-scale monocultures in particular, with a high input of fertilizer and pesticides in order to gain maximum yields, are responsible for land degradation and the loss of ecosystem services (Benton et al. 2003; Tscharntke et al. 2005; Olsson et al. 2019).

Ecosystem degradation caused by intensive and unsustainable agriculture is not only a problem for species and habitat conservation and resource protection, respectively, but it can also have significant negative socio-economic impact and is increasingly proven by appropriate studies. For example, Pretty et al. (2003) provided a cost balance for England and Wales on the eutrophication of ecosystems and landscapes, in particular due to intensive agriculture. In their study, they took into account damage to humans and the environment and the associated costs of environmental policy. The costs include, for example, the depreciation of water-related dwellings; the purification of eutrophic water to drinking water quality by the removal of nitrogen, algae toxins, and toxic degradation products; and the depreciation of surface waters for recreation and tourism. Overall, the authors estimate the damage associated with eutrophication of terrestrial and surface waters at 105–160 million USD and the costs of environmental measures and policy, respectively, at 77 million USD per year. The findings of Pretty et al. (2003) indicate the severe effects of nutrient enrichment and eutrophication and that the damage costs are substantial, causing considerable loss of value to many stakeholders in the U.K. Accordingly, the polluters (farmers) do not pay for the damage costs, and these are externalized to society.

Against this background, new approaches in agriculture have to be developed to meet the need for ecological sustainability. The restoration of degraded ecosystems has become a challenge for our societies in the 21st century in order to restore ecosystem services. Walder (2018) rightly states that ecosystem restoration is "one of the most important steps we can take to ensure that people can continue to survive, and thrive, on Planet Earth". In 2019, the United Nations General Assembly declared 2021–2030 the UN Decade on Ecosystem Restoration, thus putting restoration on the global environmental agenda.

All approaches in agriculture that meet the Sustainable Development Goals (SDGs), introduced by the United Nations (UN 2019), should be considered as potential solutions to the global environmental crisis. Ecosystem restoration, in principle, can directly or indirectly contribute to all 17 SDGs with regard to ecological as well as socioeconomic aspects. However, SDG 15 explicitly addresses ecosystem restoration as it states to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (UN 2019). In this chapter, agroforestry systems and social agriculture are discussed as an approach for sustainable land use and ecosystem restoration. The geographic focus will be on Central Europe and, in particular, the mountain areas of the European Alps. These approaches will be discussed on the basis of the principles of ecosystem restoration and strong sustainability. They contribute to the restoration of natural as well as financial, human, and social capital, enhance the multifunctionality of landscapes, and might also prevent or reverse the abandonment of traditional cultural landscapes.

2. Ecosystem Restoration and Strong Sustainability

The international Society for Ecological Restoration (SER) defines ecological restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Clewell et al. 2002). This rather broad and unspecific definition was specified by Zerbe et al. (2009) by focusing on the restoration of ecosystem services and structure against the background of the current ecological and socio-economic conditions. As measures are increasingly applied in the name of "ecosystem restoration" that have led to land degradation, such as, for example, controlled burning, topsoil removal, or the application of pesticides, Zerbe and Konrad (2021) calls for ethical standards in the practice of ecosystem restoration.

In order to assist this recovery of degraded, damaged, or destroyed ecosystems or land-use systems, a broad set of measures are applied, which range from doing nothing (i.e., passive restoration; e.g., Prach and Pyšek 2001; Moral et al. 2007; Prach and Hobbs 2008) up to comprehensive technological measures, often adapted from ecological engineering, for example for the restoration of natural river or coast dynamics by opening or removing dykes (e.g., Roman and Burdick 2012) or changing the hydro-morphology of rivers (e.g., Darby and Sear 2008). Restoration measures also comprise well-known agricultural practices (e.g., mowing, grazing) as well as the practice of habitat management for nature conservation purposes (Zerbe 2019a).

Although the concept of sustainability is increasingly watered down and also overused and abused for non-sustainable action (Ott 2010, p. 164, states "linguistic inflation"), it sets a clear guiding principle for global human society with careful reference to definition and content. Leading the way in global and national environmental policy, the term "sustainability" was coined in 1987 by the so-called "Brundtland Commission" for all land uses and land development (Ott 2010). Development is considered sustainable if it "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). This anchors the principle that people have the right to permanently satisfy their basic needs. Since the environmental conference in Rio de Janeiro in 1992, the idea of sustainable development has been one of the guiding principles of environmental and development policy and has been incorporated into countless documents and statements. As guidance for a global environmental policy, the UN (2019) has formulated 17 Sustainable Development Goals (SDGs).

Following the paradigm that sustainability encompasses the three pillars of ecology, economics, and social affairs ("triple bottom line"), it can be operationalized through capital. Capital, borrowed as an economic term, comprises the physical or natural (e.g., agricultural land), social (e.g., institutions, administrations), human (e.g., education), and knowledge capital (Döring 2004; see also Cirella and Zerbe 2015). Conceptually, a distinction is made between weak and strong sustainability (Neumayer 2003; Daly 2006; Ott and Döring 2007). The main difference between the two concepts lies in the assessment of the substitution possibilities of natural capital. In the concept of strong sustainability, natural capital should be kept constant for future generations (Constant Natural Capital Rule, Costanza and Daly 1992; Daly 1997), whereas in the case of weak sustainability natural capital can, on principle, be indefinitely substituted by other capitals so that utility per capita is not decreasing. With the concept of strong sustainability, natural capital and, thus, also the restoration of ecosystems play particular roles, namely when natural capital can be renewed with the restoration of ecosystems (Aronson et al. 2007; Crossman and Bryan 2009; Gradinaru 2014). For example, Döring (2004) sees investments in natural capital in the restoration of soil fertility, erosion control, the development of near-natural forests, the restoration of fish stocks, the restoration of flowing waters, and the improvement of groundwater quality (see also Döring 2009). Ecosystem restoration, thus, has a direct relation to the sustainable development of nature, environment, and land use and, accordingly, becomes crucial for SDG 15.

3. Combining Tradition with Innovation on Agricultural Land

From the viewpoint of private benefits, extensive traditional agricultural land-use systems may not be able to compete with intensive agricultural land-use systems (e.g., large-scale monocultures with a high input of fertilizer and pesticides). However, by taking all ecosystem services into account and also by balancing costs and benefits not only on the farm but also on the macroeconomic level (e.g., through externalities, negative impact on natural resources), extensive agriculture might turn out to have more benefits for society than intensive agriculture (cp. Oltmer and Nijkamp 2005; Daujanov et al. 2016). Additionally, the restoration of natural capital on agricultural land contributes to sustainability in the medium and long term.

It has been proven by many studies that, in particular, traditional and extensive agricultural land-use systems in Central Europe contribute largely to the biodiversity of our cultural landscapes (Finck et al. 2017; Zerbe 2019a). Additionally, these land-use systems might contribute positively to the socio-economy of a given region. This has been shown, for example, for the nature conservation area of the Lüneburg Heath, a remnant of the heathland formerly widespread in Northern Germany (Härdtle et al. 2009). Tourism is the strongest economic activity in this particular German lowland region with a gross turnover of 1.2 billion euros, more than 32,000 people employed in tourism, income from tourism of approx. 650 million euros, and more than 5 million overnight stays per year (IHK 2016).

In the following, two approaches in agriculture are suggested that

1) can support the restoration of ecosystem services on degraded agricultural land,
2) can contribute to the revitalization of abandoned land in remote areas,
3) can enhance the multifunctionality of cultural landscapes, and/or
4) can integrate ecosystem with social services.

Thus, agroforestry systems and social agriculture are discussed by focusing on their benefits to nature and society.

3.1. Agroforestry Systems

The Food and Agriculture Organization (FAO 2015) defines agroforestry systems as "a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence". Agroforestry can also be defined as "a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels" (FAO 2015).

Three main types of agroforestry systems can be differentiated:

- agrisilvicultural systems are a combination of crops and trees, such as alley cropping or home gardens;
- silvopastoral systems combine forestry and grazing of domesticated animals on pastures, rangelands, or on-farm; and
- the three elements, namely trees, animals and crops, can be integrated in what are called agrosylvopastoral systems and are illustrated by home gardens involving animals as well as scattered trees on croplands used for grazing after harvests.

Agroforestry systems are widespread in the tropics and subtropics, either as traditional types of land use or for intensive agricultural production (e.g., Atangana et al. 2014; Montagnini 2006; Nair and Garrity 2012). However, only relics of traditional land-use systems exist in Central Europe today. For example, extensive orchards are a traditional, multifunctional agroforestry system (Herzog 1998), which is common in the lowlands and the low mountain ranges. Fruit (and timber) is produced on the one hand, and on the other hand it is possible to use the grassland as a meadow or pasture due to the loosely scattered fruit trees (Lucke et al. 1992), often associated with beekeeping (Kornprobst 1994; Traynor 2006). Table 1 shows such traditional agroforestry systems as were once used in Europe. The diverse and multifunctional agroforestry systems in the Mediterranean region that are still used today should not go unmentioned (e.g., Rigueiro-Rodríguez et al. 2009).

Table 1. Traditional agroforestry systems in Europe (compilation from Zerbe 2019b).

Agroforestry System	Examples of Occurrence	Agricultural Component	Forestry Component	Production Service	References
Orchard (in German *Streuobstwiese*)	In the lowlands and lower mountain areas, e.g., in the Oberes Gäu (SW Germany), the Spessart, and Upper Austria	Meadows and pastures; traditionally also arable land	Mostly apple (*Malus domestica*), pears (*Pyrus communis*), plums (*Prunus domestica* s. l.) or cherries (*Prunus avium*, *P. cerasus*)	Fruit and their processed products (e.g., juice), fodder for animals, timber, grain, honey	Herzog (1998), Küster (2010)
Chestnut grove	In many areas of Europe, closely linked to viticulture, e.g., in South Tyrol, in the Austrian Burgenland, and in southwestern Germany	Meadows and pastures	Sweet chestnut (*Castanea sativa*)	Chestnuts and their processed products (e.g., flour, beer), fodder for animals, timber, honey	Conedera et al. (2004a, 2004b)
Larch meadows/pastures	Alps, in particular, in South Tyrol and Switzerland	Meadows and pastures	Larch (*Larix decidua*)	Fodder for animals, timber, larch resin and oil, respectively	Fontana et al. (2013, 2014), Zerbe (2019b)
Tree meadow (in German *Baumwiese*)	East and Northern Europe, Alps	Meadows and pastures	Maple (*Acer pseudoplatanus*), ash (*Fraxinus excelsior*), linden (*Tilia cordata*), and other tree species	Fodder for animals, leaved branches as litter for stalls, timber, honey	Hæggström (1983), Aavik et al. (2008); Kull et al. (2003)
Forest pasture	Widespread in Europe, in particular in Southern Europe	Pasture	Mainly oaks (*Quercus* spec.), also other light demanding tree species	Fodder for animals, timber, tanning agent, honey	Bergmeier et al. (2010), Küster (2010)
Grazed vineyards (*vitipasture*)	South East and Central Europa	Pasture with sheep	Wine (*Vitis vinifera*)	Grapes and wine, respectively; fodder for sheep	Wallis De Vries et al. (2010); Francaviglia et al. (2014)
Walnut fields	France, Netherlands	Arable fields with, e.g., grain and other crops	Walnut (*Juglans regia*)	Walnuts and their processed products (e.g., flour), crops (e.g., grain)	Graves et al. (2007), Rigueiro-Rodríguez et al. (2009)

In the Alps in the montane mountain forest belt between about 1000 and 2000 m above sea level, the European larch (*Larix decidua*) occurs in meadows and pastures, thus forming a traditional agroforestry system. This land-use system that has combined agricultural use with timber production on the same area since the Bronze Age (Gobet et al. 2004) is still found today in Switzerland (Burga 1987), in Austria (Blassnig 2012; Tiefenbach et al. 1998), as well as in North Italy in the Provinces of Trento (Giovannini 2017) and South Tyrol (Fontana et al. 2014). Today, they occur in particular in South Tyrol with the largest larch meadow in Europe on the high plateau of the Tschögglberg north of the city of Bolzano (Figure 1). While the grassland is used as a meadow or pasture, the larches with their summer green needle litter contribute to soil improvement, and the trees can be used as timber. The larch, together with the common yew (*Taxus baccata*), yields the heaviest and hardest timber (Grosser and

Ehmcke 2012). Due to the weather resistance of larch wood, it is an important timber for construction in the mountain areas of the Alps. Larch resin has traditionally been used to make turpentine as a component of folk and veterinary medicine. Larch oil is used today in paints and adhesives and for the production of cosmetic products. The overall ecosystem services of these larch meadows and pastures are given in Table 2.

Figure 1. Larch meadow or pasture on the Tschögglberg near the village of Jenesien in South Tyrol in the spring (Zerbe 2019b).

Table 2. Ecosystem services of larch meadows and pastures (Zerbe 2019b with categorization of ecosystem services according to MEA 2005).

Category	Ecosystem Services of Larch Meadows and Pastures
Provision	Fodder for animals, medical and spice plants, timber for buildings and furniture, firewood, resin, oil, needle litter as natural fertilizer, drinking water
Regulation	Erosion and rockfall protection at slopes, carbon sequestration in above- and belowground biomass and organic soil layer, habitats for plants and animals, water purification
Cultural services	Recreation and tourism, environmental education, environmental research, aesthetics and inspiration for art, identification with home range, bioindication (e.g., with lichens), mythology
Supporting services	Primary production (wood and litter), nutrient cycling, soil formation in the Alpine environment

Today, this traditional land-use system of larch meadow/pasture is under threat of two divergent developments (Fontana et al. 2013; Nagler et al. 2015). On the one hand, farmers intensify land use by cutting the larch trees and transform the agroforestry system into a high-input grassland; on the other hand, the extensive agroforestry system is abandoned. As soon as its abandoned, natural succession leads to the development of a forest with a subsequent loss of biodiversity (Pornaro et al. 2013).

3.2. Social Agriculture

Social agriculture, also known as Social Farming, Green Care, or Care Farming, means all agricultural practices aimed at promoting the rehabilitation, education, health, and integration of various target groups such as, for example, children, elderly people, disabled people, former prisoners, and migrants; this includes pedagogical and nursing services in rural areas, especially for infants and seniors (Di Iacovo and O'Connor 2009; Limbrunner and van Elsen 2013). Historically, farms have always used agricultural labor as an instrument of solidarity, self-support, and social inclusion by providing work for family members of all generations and also including family members with physical or mental disabilities into everyday farm life. Accordingly, social agriculture is a traditional agro-social concept (Di Iacovo and O'Connor 2009), which today is revitalized or institutionalized under different socio-economic conditions (European Communities 2010).

Today, social agriculture is performed by multifunctional agricultural and/or forestry or horticultural enterprises, social cooperatives, or facilities of the public sector that enable people with special needs to develop their own skills and abilities through working with plants, animals, and nature (Di Iacovo et al. 2014; García-Llorente et al. 2016; Nicli et al. 2020). With this kind of cooperation, crafts and social skills should be gained or a recovery process supported. Accordingly, the added value of social agriculture lies not only in the generation of jobs, agricultural production, and health services, but in particular in social inclusion, prevention, education, and improving the quality of life (Di Iacovo and O'Connor 2009; Wiesinger et al. 2013).

Within an interdisciplinary research project on social agriculture in the Southern Alps and adjacent regions, a survey of 22 farms was conducted (Nicli et al. 2020). Semi-structured interviews were carried out to explore whether and how the practice of social farming also met ecological sustainability. We found that all initiatives of social agriculture met the hereby applied criteria for ecological sustainability: (1) organic or ecological farming; (2) activities for nature, resource, and/or cultural landscape protection; and (3) education for sustainable development and environmental education, respectively (Table 3). Those farms which met all three criteria can be considered as best practice for eco-social farming such as, for example, Terre Altre, La Capra Felice, La Pachamama, Santer Farm, and Peintner Farm.

Table 3. Engagement of 22 initiatives of social agriculture, studied in the Southern Alps and adjacent regions, for nature, environmental, and resource protection, respectively; criteria applied are (1) organic or ecological farming; (2) activities for nature, resource and/or cultural landscape protection; and (3) education for sustainable development and environmental education, respectively (based on data from Nicli et al. 2020).

No.	Initiative, Project	Criteria 1	Criteria 2	Criteria 3	Explanation and Specification
1.	Villa Rizzi	x	-	-	Organically certified cultivation of 45 different medicinal herbs and herbs for cooking as well as vegetables
2.	Terre Altre	x	x	x	Biodynamic cultivation of local cereals, fruits, and vegetables, fiber and medicinal plants; beekeeping; preservation of traditional agriculture; various events and courses on biological farming; environmental education and school garden for vegetable cultivation
3.	Cooperativa Samuele	x	-	-	Organically certified viticulture, fruit and vegetable cultivation; beekeeping
4.	La Capra Felice	x	x	x	Certified organic animal husbandry of a domestic goat breed for milk and cheese production; egg-laying hens; vegetables; management of the traditional cultural landscape through grazing; educational offers for school classes
5.	Consorzio delle Valli e Dolomiti Friulane	pt [1]	x	-	Includes 25 small farms; own flock of sheep for milk and meat production; preservation of the cultural landscape and agricultural infrastructure; preservation of local sheep breed
6.	Cadore SCS	x	x	-	Organic cultivation of the Alpine artichoke; landscape management in the alpine mountain range
7.	La Pachamama	x	x	x	Organically certified vegetable, fruit, olive, vine and cereal cultivation; beekeeping; cultivation of old cereal varieties; school at the farm, guided mountain excursions; courses on organic agriculture
8.	Conca d'oro	x	x	-	Organically certified cultivation of vegetables, cereals, fruits and olives; restoration of the traditional cultural landscape
9.	La Costa	x	-	-	Organically certified viticulture and cultivation of vegetables; use of renewable energies
10.	School at the farm	pt [1]	-	x	Consortium of 30 farms with various offers for environmental education and nature experience
11.	Initiative *Mit Bäuerinnen lernen-wachsen-leben*	pt [1]	-	x	Care for children with 120 nannies; employment of senior citizens on the farms; leisure activities in nature and on the farm
12.	Santer Farm	x	x	x	Organically certified apple and vine production; animal husbandry (pigs, goats, chicken, and sheep); school at the farm

Table 3. *Cont.*

No.	Initiative, Project	Criteria 1	Criteria 2	Criteria 3	Explanation and Specification
13.	Vintler Farm	x	-	-	Organically certified vegetable and cereal cultivation; beekeeping; animal husbandry with donkeys and poultry
14.	Vinterra	x	-	-	Biologically certified cultivation of more than 30 different cereals and vegetables
15.	Valentin Farm	x	-	-	Organically certified cultivation of about 60 different apple, berry, and vegetable varieties
16.	Sägemüller Farm	x	x	-	Biodynamically certified (Demeter) farm; cultivation of vegetables, cereals, and potatoes; preservation of endangered cattle breed; restoration of agricultural land after gravel mining
17.	Salewa Garden	x	-	-	Urban agriculture based on the concept of permaculture
18.	Orti Semirurali	pt[1]	-	x	Urban subsistence gardens; beekeeping; events on the concept of sustainability for schools and members
19.	Initiative *Alm-Erleben*	x	-	x	Organic cannabis, saffron, lupine, and poppy production; various pedagogical offers
20.	Peintner Farm	x	x	x	Organic agriculture; animal husbandry of local livestock breeds; seminars on a sustainable and healthy lifestyle
21.	Initiative *Heimstätte Birkenhof*	x	x	-	Biodynamically certified (Demeter) agriculture; cultivation of cereals and vegetables; egg-laying hens; animal husbandry with cows, donkeys, and local animal breeds
22.	Ecological Farm Attendorf	x	-	-	Organic certified cultivation of fruit, vegetable, and medicinal herbs with about 55 different varieties

[1] pt = partly biological, which means not all members are certified organic farms.

4. Discussion

Additional to the overall benefits for society and the manifold ecosystem services they provide, agroforestry systems and social agriculture can considerably contribute to ecosystem restoration. When taking the whole range of ecosystem services into account, these approaches might have a better cost–benefit balance than conventional agricultural systems. For the example of larch meadows in the Alps, two currently occurring developments, the intensification as well as abandonment of larch meadows, were compared. These divergent developments were compared, with respect to their ecosystem services, with existing larch meadows on the basis of interviews with actors and experts and with the help of a multicriteria decision analysis (Fontana et al. 2013). In terms of production services, forest development was ranked highest. Nevertheless, the larch meadows were ranked highest in terms of their cultural and historical importance, biodiversity, aesthetics, and their regulatory capacities (e.g., carbon storage, water balance). In general, traditional agroforestry systems seem to provide, from a qualitative point of view, more ecosystem services than pure agricultural or forestry systems (Figure 2; see also Jose 2009; Schroth et al. 2004). The FAO (2015) highlights the advantages of multifunctional agroforestry systems, which diversify land use, bring social, economic, and nature conservation benefits, and promote sustainable regional development. Accordingly, the restoration of these systems becomes an option for land-use development as well as implementation of the SDGs and, in particular, SDG 15.

Up to now, there have been numerous successful examples from Central Europe and the Alps, which show that the preservation or restoration of traditional land-use systems such as orchards (e.g., Seehofer et al. 2014), heathlands (e.g., Keienburg and Prüter 2006), extensive grasslands (Jedicke et al. 2010), and traditional alpine farming (Blaschka 2015) can combine the objectives of environmental protection as well as the conservation of the cultural landscape with those of sustainable regional development to benefit local communities. Financial support for these initiatives is provided on various levels, from regional towards national and international (e.g., from the European Union) levels (see compilation by Zerbe 2019a).

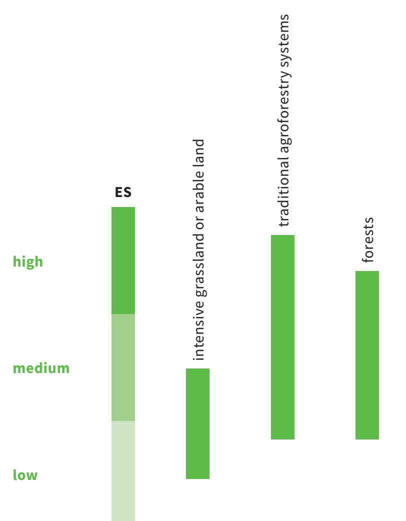

Figure 2. Comparison of the estimated relative number (low, medium, high) of ecosystem services (ES) of intensively managed grassland and arable land and forests with traditional agroforestry systems (Zerbe 2019b).

Our survey of social agriculture in the Alps and adjacent regions has shown that offering social services by farms is also related to responsibility and engagement in environmental services. Accordingly, the investigated farms performed organic or biological agriculture, preserved manifold traditional varieties of agricultural crops, provided environmental education for various groups of people, contributed to management of the traditional cultural landscape, and promoted the diversity of species and habitats on their agricultural land. Some of these initiatives are also actively involved in ecosystem restoration projects (Table 3). Consequently, social agriculture becomes eco-social agriculture (Nicli et al. 2020).

In order to further develop the potential of eco-social agriculture from nature conservation as well as ecosystem restoration perspectives, cooperation between these initiatives (e.g., farms, farm associations, social enterprises) and regional and national agencies for nature conservation has to be promoted. For example, programs for the provision of social services could be linked with those for nature, environmental, and cultural landscape protection. Additionally, cooperation between local, regional, and national institutions must be strengthened by respective policy framework and funding opportunities. The European Union offers a wide range of subsidies (e.g., with the LIFE Program for Environmental Protection, Conservation and Climate Projects (van Elsen and Götz 2000), the European Regional Development Fund (ERDF), the Agricultural Fund for Rural Development 2014–2020 (EAFRD), and of the European Social Fund (ESF; RRN 2017)).

The Man and Biosphere Program, which was launched by UNESCO in 1971, is an intergovernmental scientific program that aims to establish a scientific basis for enhancing the relationship between people and their environments (UNESCO 2019). This program wants to improve human livelihood and safeguard natural and managed ecosystems. Accordingly, biosphere reserves all over the world can be considered as "real-world laboratories" (Zerbe et al. 2020) promoting innovative approaches to economic development that are socially and culturally appropriate and environmentally sustainable.

Case studies of agroforestry systems and social farming initiatives in the Alps and adjacent regions (Tables 2 and 3) should be considered as local contributions of agriculture to a global goal. Worldwide, agricultural lands constitute the largest "anthropogenic biome" (Ellis and Ramankutty 2008), occupying one-third of the global ice-free land area (Ramankutty et al. 2008). Agriculture is a major livelihood for 40% of the world's population. Twenty-five years ago, Daily (1995) stated that around 45% of the terrestrial land surface has a reduced capacity due to non-sustainable land use in the past. With ongoing forest clearing for agricultural land use, in particular in tropical countries, and continuous worldwide biodiversity loss (IPBES 2019) and increasing desertification (Mirzabaev et al. 2019), this situation has not become better in recent decades. Accordingly, agriculture plays a major role in contributing to the

SDG 15. Zerbe (2019a) has shown for the large variety of Central European land-use systems how restoration can be put into practice, comprising grassland, wetlands, forests, arable fields, heathland, rivers and lakes as well as urban environments.

5. Conclusion

The restoration of degraded agricultural land is a worldwide challenge and has to be strongly put forward in the next decade. Those approaches are promising from which the environment as well as the socio-economic systems will benefit. Agroforestry systems and eco-social agriculture are highlighted here because they can meet several objectives of sustainable land use and particularly the SDG 15:

- With both approaches, natural as well as social and economic capital can be restored, thus implementing strong sustainability. Ecosystem services can be coupled with social services on agricultural land.
- Both approaches positively contribute to biodiversity on the species, ecosystem and landscape level. Additionally, they promote agrobiodiversity, e.g., by (re-)introducing local animal breeds and local cultivars or crop varieties, respectively.
- Agroforestry as well as eco-social agriculture enhances the multifunctionality of cultural landscapes.
- The implementation of agroforestry on degraded land and the various environmental and social activities of eco-social agriculture can prevent or reverse land abandonment.

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Forest Landscape Restoration and Sustainable Biomass Utilization in Central Asia

Niels Thevs

1. Introduction

Land use and land degradation are cross cutting issues related to and impacted by many SDGs, like SDG 1 (no poverty), SDG 2 (ending hunger), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production), SDG 13 (climate action), and in particular SDG 15 (life on land) with all its targets. SDG 15 is to protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (UN 2015).

Forest landscape restoration (FLR) has been developed as an approach to restore forests and whole landscapes that interact with forests (Maginnis and Jackson 2005; Mansourian et al. 2005). In the meantime, FLR has become an approach that addresses a wide range of landscapes beyond forests as woodlands and includes restoration approaches like agroforestry (Stanturf et al. 2019). Despite its wide range, Veldman (2015) argues that trees must not dominate restoration approaches, e.g., in grassy landscapes that never had trees.

Under the Bonn Challenge, FLR has gained global attention in forest rich as well as forest poor countries, like the countries in Central Asia. Globally, countries have committed themselves to implement FLR on 350 million ha by 2030 (Bonn Challenge 2021).

FLR, as other restoration efforts, needs to yield income for the people who engage in this and who are affected, in particular for rural communities in poor countries (Stanturf et al. 2019). This is often a challenge, but could be an option as well, as trees do yield biomass, which is a raw material for bioeconomy.

Bioeconomy, if seen solely as the production of renewable biological resources as basis for food, feed, bio-based products, and bio-energy, will not meet the targets of SDG 15 (Heimann 2019). Heimann (2019) analyzed the effects of bioeconomy and so-called sustainable bioeconomy on SDG 15 and found that only sustainable bioeconomy will help in fulfilling SDG 15, while bioeconomy will negatively impact SDG 15. Bioeconomy may allow one to clear forests or other natural ecosystems in favor of intensive biomass production, which is in contradiction to SDG 15.2, which calls for the restoration and protection of forests, and to SDG 15.5, which calls to halt loss of biodiversity and reduce the degradation of natural habitats. Sustainable bioeconomy according to the Global Bioeconomy Summit (2015) optimizes the production and utilization of biological resources, while ensuring food security and protecting ecosystems.

Martinez de Arano et al. (2018) compiled the potentials of ligno-cellulose biomass from forests in southern Europe as feed stock for a wide range of bioeconomy value chains, which does not compete with food production. The applications for that biomass listed there range from bioenergy over textiles (viscose), sugars as chemical building blocks, and lignin, to produce carbon fibers to engineered wood products and house construction.

Central Asia is a region that, after a period of severe land degradation, has recently joined the Bonn Challenge, visible by the Astana Resolution from 2018 (Bonn Challenge 2018) and pledged a total of 2,389,000 ha by today (Bonn Challenge 2021). Like other regions of the world, Central Asia also faces the need to allocate resources to FLR and to generate income in line with FLR to fulfill these pledges. This is a burden and an opportunity at the same time, because this region has space to offer the FLR as well as the bioeconomy. On the other side, Central Asia harbors a large share of the world's winter-cold deserts and is the region with the highest number of closed river basins worldwide. The most well-known of those river basins is the Aral Sea Basin due to the desiccation of that lake. This semi-arid to arid climate adds another obstacle against FLR. Against this background, this chapter will introduce the needs for restoration and protection of landscapes, of FLR and beyond, and introduce examples for biomass utilization as bioeconomy feedstocks that help restore landscapes. These approaches from a vast dryland region as Central Asia may inspire FLR in other dryland regions of the world.

2. Land Degradation across Central Asia

2.1. Central Asia—Geography, Climate, Landscapes

Central Asia, roughly speaking, refers to the land mass stretching from the Caspian Sea in the west into Northwest China and Mongolia in the east, between Siberia in the north and Afghanistan in the south. The boundaries of this region differ from author to author, but all sources include the five countries Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, which share a common history of the Soviet Union, in Central Asia. This chapter, therefore, will refer to those five countries (Figure 1).

Figure 1. Map of the five Central Asian countries with major waters and elevation. Source: Figure by author.

In terms of area, Central Asia is largely dominated by plains and undulating steppe and desert landscapes on an elevation of below 1000 m above sea level (a.s.l.), which cover most of Kazakhstan, Turkmenistan, and Uzbekistan. The southeastern part of that region is dominated by mountains, the Tianshan and Pamirs in Kyrgyzstan and Tajikistan. Very small parts of those mountain ranges are located in Kazakhstan and Uzbekistan. In addition, Kazakhstan shares the Altay Mountains with Russia, Mongolia, and China (ADB 2010).

The climate throughout the region is continental, with cold to very cold winters and warm to hot summers. Average January temperatures are as low as −16 °C in Nur-Sultan, Kazakhstan's capital, −2.6 °C in Bishkek (Kyrgyzstan), 1.9 °C in Tashkent (Uzbekistan), and 4 °C in Tajikistan's capital, Dushanbe. Corresponding average July temperatures are 20 °C, 24.9 °C, 27.8 °C, and 27 °C in Nur-Sultan, Bishkek, Tashkent, and Dushanbe, respectively (Weatherbase 2020). Due to the location far away from any ocean, the climate is semi-arid to arid with an annual precipitation of, e.g., 140 mm in Balkhash at Lake Balkhash in Kazakhstan, 145 mm in Aralsk, close to the Aral Sea in Kazakhstan, and 130 mm in Turkmenabad (Turkmenistan). Precipitation increases in the forelands of the mountains, as illustrated by the annual precipitation of Bishkek, Tashkent, and Dushanbe with 452 mm, 440 mm, and 530 mm, respectively (Weatherbase 2020), and more so in the mountains, with places with annual precipitations of around 1000 mm, e.g., in the mountains northeast of the

Ferghana Valley (ADB 2010; Sakbaeva et al. 2013) and more than 1800 mm in Central Tajikistan (Djumaboev et al. 2020). The precipitation maximum falls in the months March, April, and May for most of the region, e.g., in Bishkek, 40% of the annual precipitation occurs in these three months.

The area outside the mountains is largely covered by zonal vegetation types, which are, from north to south, forest steppe, steppe, dry steppe/semi desert, and desert. The steppes are located in Kazakhstan, whereas Turkmenistan and Uzbekistan are largely covered by deserts. Thereby, it is noteworthy that the deserts of the region, being winter-cold deserts, harbor shrubby vegetation mainly from White Saxaul (*Haloxylon persicum*), *Artemisia* spec., and *Salsola* spec. Many plant species have adapted to use the soil moisture from snow melt and rain fall in spring and finish their annual life cycle in early summer when the soil moisture has been exploited. Woody species are psammophytes and survive the arid conditions in the desert by developing deep roots to exploit a large soil volume for water (Rachkovskaya et al. 2003).

In the mountains and their forelands, the vegetation zones along with increasing elevation are generally: submontane steppes, broad-leaf forests, Coniferous forests (montane forests), alpine shrubs and meadows, and rocks, snowfields, and glaciers. Forests are mainly distributed on northeast, north, and northwest exposed slopes, because other slopes are too dry for tree growth (Orozumbekov et al. 2009). Of course, the spatial pattern of these zones differs according to local climatic conditions, in particular the absence or presence of forests and their vegetation coverage and species composition. The plant species of the submontane steppe behave like the plants in the steppes with regard to water and finish their life cycle early in summer, while the tree species of the mountain forests need a rather continuous water supply over the whole year.

In Tianshan, the coniferous forest zone lies between 1700 m and 3200 m a.s.l. (Scheuber et al. 2000), with *Picea schrenkiana* being distributed from 1700 m to 2800 m a.s.l. and *Juniper* species up to 3200 m a.s.l. Broad leaf forests in Central Asia, except for the Altay and northern part of Kazakhstan, are walnut wild fruit forests or pistachio forests. The former consists of walnuts (*Juglans regia*) and wild fruit trees of the Rosaceae family, i.e., apple (*Malus kirghisorum* and *M. sieversii)*, pear, plum (*Prunus sogdiana*), cherry (*Prunus mahaleb*), peach, and apricot. In the mountains northeast of the Ferghana Valley, these forests form large areas on an elevation from 700 m to 1100 m a.s.l. (Scheuber et al. 2000; Beer et al. 2008). The largest parts of these forests are located in Kyrgyzstan, though small parts are also located in the Chatkal Mountain Range, which is the Uzbek part of the Tianshan northeast of Tashkent. Such walnut wild fruit forests also occur in the Pamirs in Tajikistan, though on higher elevations compared to Tianshan. Pistachio is distributed in lower elevations, below the walnut wild fruit forests (USAID 2001a). In northern Kazakhstan, Aspen and Birch form small forests in a mosaic with steppes in the forest-steppe zone (USAID 2001b).

In the mountains, the precipitation feeds numerous rivers, either directly from rain fall or through snow and glacier melt water. All those rivers, except for the Irtysh River in Kazakhstan, drain into endorheic river basins, i.e., these rivers do not reach the open sea, but end in an end-lake, an inland delta, or simply vanish in one of the deserts. The Amu Darya and Syr Darya are the largest rivers of the region and drain into the Aral Sea (ADB 2010; Djumaboev et al. 2020). The Ili River, with its headwaters in China, drains into Lake Balkhash in Kazakhstan, which today has become the largest lake of Central Asia after the Aral Sea has been desiccating and shrinking (Imentai et al. 2015). The Chui River and Talas River, both shared between Kyrgyzstan upstream and Kazakhstan downstream, each form an inland delta in the Muyinkum Desert in southern Kazakhstan (ADB 2010). Along those rivers, riparian forests and woodlands (Tugai forests) Willow species, *Populus pruinosa*, *Populus euphratica*, Russian Olive (*Elaeagnus angustifolia*), and Black Saxaul (*Haloxylon aphyllum*), as well as wetlands with Common Reed (*Phragmites australis*), form an azonal vegetation (Rachkovskaya et al. 2003). The plant species of the Tugai forests survive the arid climate by exploiting the groundwater (so-called phreatophytes) so that these plant species remain productive during the whole growing season. The wetland plant species depend on high groundwater levels or surface waters to survive. The Tugai forests and wetlands are the most productive natural vegetation types across the whole region of Central Asia (Thevs et al. 2012a). Despite its semi-arid to arid climate, wetlands are significant in that region, as Kazakhstan alone harbors about 2 million ha of reed beds out of 10 million ha globally, which makes it the country with the largest reed bed area (Köbbing et al. 2013) worldwide.

2.2. Land Degradation across Central Asia

Most of Central Asia's population concentrates along the rivers and in the river valleys because there is enough water available for irrigation in agriculture and other human water uses. Therefore, already early in history, Tugai forests and wetlands were reclaimed to give space to cropland and settlements. Though most of the land degradation, the results of which we see today, took place during the past 100 years, which is during Soviet Union times and after the independence of the Central Asian countries (UNECE/FAO 2019). Today, the degraded area ranges from

8% of the total land area for Turkmenistan and Uzbekistan to 60% across Kazakhstan (Mirzabaev et al. 2020).

Starting in the 1960s, huge areas in Central Asia were reclaimed for agriculture. Along the rivers, mainly along the Amu Darya and Syr Darya, irrigated agriculture was expanded for cotton production. After independence, land under irrigation in Uzbekistan and Turkmenistan was further enlarged as wheat production added to cotton to feed the countries' populations. Along the enlarged areas, water abstraction for irrigation increased, which resulted in the desiccation the Aral Sea and degradation of Tugai forests and wetlands. Large areas of irrigated cropland have been degraded by soil salinization.

In the steppe regions of Kazakhstan, from 1954 to 1970, a total of 20.9 million ha of steppe vegetation was converted into cropland, mainly for wheat production, which resulted in humus loss. Due to low yields, many of these areas were not competitive under the market economy after independence and fell fallow. From 1992 to 1998, 19.6 million ha of that cropland was abandoned (Lenk 2005). Today, such reclaimed areas in northern Kazakhstan are cultivated again (Kraemer et al. 2015).

During Soviet Union times, large areas of forests were cleared or degraded, e.g., forest cover in Tajikistan shrunk from 16–18% of the country's surface 100 years ago (USAID 2001c) to 2.9% today (FAO 2015), mainly due to conversion into cropland. In Turkmenistan, from the former Saxaul forest and woodland area less than one third remains today. In Uzbekistan, 81% of the Saxaul forests and woodlands disappeared (Thevs et al. 2013). Saxaul forests and woodlands were logged for fuel and overgrazed. Tugai forests were cleared as well, to give space to irrigated agriculture. The more irrigation took place and the more water was abstracted from rivers, the less water remained for Tugai forests, wetlands, and water bodies. The desiccation of the Aral Sea is the largest example of this cascade of degradation. From the first half of the 20th century until today, 90% of the former Tugai forests vanished in Uzbekistan (USAID 2001a).

During Soviet Union time, Central Asia imported timber and energy sources (coal, oil, gas, electricity) from the Russian SSR. With the independence of the five countries, these imports came to an abrupt end, which resulted in a surge of forest and other landscape degradation. As wood became the main energy source, in particular for rural communities, fuelwood removal was the major driver of forest degradation after independence. Later, during the 1990s, overgrazing and tree cutting for timber became drivers of forest degradation. Today, fuelwood demand does not impact forests in Kazakhstan and Turkmenistan, where gas supply has been substantially improved. In Kyrgyzstan, rural communities use more and more coal and electricity so that the share of fuelwood in the energy mix decreases. Tree cutting for timber and grazing still remain as drivers of forest degradation. Low river runoffs result in water stress for Tugai forests and wetlands and add to their degradation (UNECE/FAO 2019).

Today, 70% of the territory of Kazakhstan is considered degraded to varying extents (UNDP 2015a). Most of those degraded areas are deserts, steppes, and agricultural land and are affected by overgrazing and salinization.

3. Options for Forest Landscape Restoration and Biomass Utilization

3.1. The Need for Restoration and Income Generation and a Focus on Biomass Utilization

From the previous section, it has to be concluded that there is a need for restoration across all landscape and vegetation types of Central Asia, and non-degraded landscapes must be protected from degradation. First of all, landscapes along the rivers and river valleys have to be protected and restored, as most of the population in Central Asia concentrates along rivers and in river valleys. Following the river course from its headwaters downstream, alpine meadows and mountain forests have to be protected from further degradation and restored to firstly buffer rainfall and snowmelt in the mountains, which regulates the river runoff and dampens flood events and secondly combat soil erosion and landslides. Landslides pose a risk to communities. Ongoing soil erosion and landslides result in siltation of reservoirs and water infrastructure (Havenith et al. 2017).

Further downstream, where rivers flow through the steppes and deserts, productivity in agriculture has to be maintained, as this is the basis for a large share of livelihoods in the Central Asian countries. More than half of Central Asia's population is rural, and agriculture is the largest single employer in the countries (Table 1).

Tugai forests and wetlands need to be restored and protected as well, because they are the most productive ecosystems in the region and provide huge amounts of biomass that, currently, is mainly used as fodder—Tugai forests and wetlands are major pasture lands, in particular in the desert region—but offer more higher-value uses, as described in Section 3.3. Furthermore, these ecosystems are hotspots for biodiversity, as reflected in the list of Ramsar Sites of the Central Asian countries.

Table 1. Population (total and rural) and employment in agriculture in the Central Asian countries.

Country	Population in 2018 (FAO 2020)			Employment in Agriculture in 2016 [%] (World Bank 2020)	
	Total [Million]	Rural in [%]	Urban in [%]	Male	Female
Kazakhstan	18.3	43	57	19	17
Kyrgyzstan	6.3	62	38	28	32
Tajikistan	9.1	73	27	45	73
Turkmenistan	5.9	47	53	19	17
Uzbekistan	32.4	49	51	30	27

To protect agricultural productivity as well as Tugai forests and wetlands, reliable and sufficient water supply through reliable and sufficient river runoff from upstream is imperative, as agriculture depends on irrigation. In the course of climate change, substantial reductions of river runoff are expected for the second half of this century, resulting in crop yield losses, as summarized by Reyer et al. (2015). Bliss et al. (2014) for example modeled an annual river runoff decrease by 41% for Central Asia. Djumaboev et al. (2020) claim that the melt water contribution to river runoff dropped by 5% in the Amu Darya and by 20% in the Syr Darya. Against this background, water resources have to be shared between upstream and downstream users, and water must not be wasted to sustain productivity throughout river basins.

Large areas of cropland along those rivers have been degraded through improper irrigation which has resulted in soil salinization (Qadir et al. 2018). This process has to be halted, in order not to further reduce the area of land that has access to irrigation infrastructure and therefore can be productive. Beyond soil salinization, soils need to be protected from erosion and loss of humus to maintain soil fertility and water storage capacity.

In the desert areas, the Saxaul vegetation needs particular attention to be restored and protected, as it prevents wind erosion and is able to provide biomass and fodder in those deserts, if sustainably managed.

All Central Asian countries are net importers of wood (Table 2), with Russia being the main source for those imports.

Table 2. Net imports of sawnwood [m^3], industrial roundwood [m^3] (both coniferous), and OSB [m^3] and total import value of these three products [million USD] to the Central Asian countries as of 2018 (FAO 2020).

Country	Sawnwood Coniferous	Industrial Roundwood Coniferous	OSB	Total Value of Imports
Kazakhstan	315944	122,238	85,285	68.7
Kyrgyzstan	352,000	10,100	26,300	80
Tajikistan	683,000	15,760	550	39.4
Turkmenistan	344,000	12,994	2777	44.2
Uzbekistan	2,744,472	238142	2978	367

It is claimed that economies need to switch from coal, oil, and gas to renewable biological resources to mitigate climate change. In this shift, biomass will gain an increasing importance as a crucial raw material and the demand for biomass will increase (Global Bioeconomy Summit 2015). The countries in Central Asia should increase their wood and other biomass production, in order not to become more and more dependent on costly imports. The basis for such biomass production, e.g., food crops, fibers, or woody biomass, is functioning and non-degraded landscapes. This calls for large scale efforts to restore landscapes and protect non-degraded landscapes throughout the region Central Asia.

These restoration and protection efforts have to be inclusive and must not displace people or compromise their income opportunities. This is particularly important as most people live in rural communities and agriculture is the largest employer (Table 1). Such restoration and protection efforts must not displace ongoing land uses and water competition must be avoided, but income must be generated from restoration and protection efforts.

As biomass utilization will become more important in a general shift towards bio-economy, restoration as discussed further in this chapter should include trees and shrubs for woody biomass, highly productive annual plants for biomass, and fiber yielding plants. As forest landscape restoration has developed into a widely recognized restoration concept which focusses on trees and shrubs, this concept will be further explored.

3.2. The Political Environment for FLR and Other Landscape Restoration

There are a number of restoration concepts and approaches that integrate rural communities and their needs. Sustainable land management (SLM) collects a wide range of land use/land management approaches that also address restoration and protection of landscapes (WOCAT 2020). Forest landscape restoration (FLR) is a concept that takes whole landscapes into account and that has received global recognition under the international Bonn Challenge (IUCN 2020a).

"Forest landscape restoration (FLR) is the ongoing process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes" (IUCN 2020b). Thereby, whole landscapes and not just forests (or areas with forests in the past) are considered for restoration, because forests interact with neighboring land uses and natural ecosystems and because many land uses contain trees (agroforestry). In Central Asia, the concept of FLR comprises a wide range of landscapes, along with the FAO definition of forests, which includes tree stands down to a canopy cover of 10% (FAO 2015). This is also reflected by the pledges made to the Bonn Challenge by Central Asian countries, which amounted to 2,389,000 ha in total (Bonn Challenge 2021). The largest pledge came from Kazakhstan with 1.5 million ha, followed by Uzbekistan with 500,000 ha. Both countries included large areas with Saxaul vegetation into their pledges. The five countries of Central Asia became members of ECCA30 (Europe, Caucasus and Central Asia 30 Million ha Initiative) which aims for FLR on 30 million ha throughout Europe, the Caucasus, and Central Asia until 2030 (IUCN 2020c).

Eventually, FLR and the pledges to the Bonn Challenge refer to trees or woody vegetation in a wide sense. Therefore, steppes and many wetlands will not fall under FLR and the Bonn Challenge. Due to their size and productivity, these areas have to be included in the restoration and protection of landscapes in Central Asia as well.

The countries in Central Asia have all developed and partly adopted national policy strategies that address the landscape restoration and protection needs outlined earlier, as listed by UNECE/FAO (2019).

Kazakhstan adopted the strategy Kazakhstan-2050 in 2012. Under that strategy, the whole economy of Kazakhstan shall move towards a green economy. Conservation and effective management of ecosystems are two parts of this strategy (UNDP 2015a).

Kyrgyzstan has developed a Green Economy Program 2020–2023, within which reforestation, fast growing tree plantations, and general improvement of soil fertility are core points (Partnership for Action on Green Economy 2019).

In Tajikistan, the State Forestry Agency elaborated a strategy for forest development for 2015 until 2030, as part of the National Development Strategy until 2030. This strategy, among other aims, seeks to plant 1000 ha forests annually, rehabilitating 2000 ha forests annually, and support natural forest regeneration on 8000 ha annually.

The National Forest Program 2013–2020 of Turkmenistan (State Committee of Turkmenistan for Environmental Protection and Land Resources 2018) prioritizes the restoration and afforestation of Saxaul forests, in order to combat erosion of deserts and protect settlements. Next to Saxaul, it promotes planting of shelterbelts.

In the National Biodiversity Strategy and Action Plan of Uzbekistan from 2012 (UNDP 2015b), the target was set to reduce the rate of degradation and fragmentation of the most vulnerable natural ecosystems by 2025. Thereby, the focus was laid on Tugai and Saxaul forests. In the mountain forests, degradation must be halted according to that plan as well. Nut and fruit plantations need to be established on a large scale, in order to offer income opportunities for rural communities and to compensate for degradation in the mountain forests. Around rural communities, woodlots and plantations are to be established to cover the wood demand of those communities.

3.3. Options for Restoration (FLR and Others) and Biomass Utilization

A huge number of projects were implemented across Central Asia, which included FLR as well as other landscape restorations, e.g., wetlands, as listed in UNECE/FAO (2019). Most projects focused on biodiversity protection and sustainable pasture/livestock management to reduce grazing pressure and allow, among others, forest regeneration, to combat erosion and reduce disaster risk, enlarge forest areas and increase the number of trees. Some projects focused on agroforestry as an FLR approach for agricultural areas. Some projects are coupled with providing alternative energy sources to reduce the pressure by fuel wood removal. When specific straight forward options for income generation were included, these mostly referred to fruits and other high value food products, medicinal plants, or tourism. An example of FLR that straight forwardly addresses income generation is promoting pistachio in lower elevations in mountains of Uzbekistan (Michael Succow Foundation 2014). FLR examples that aim at producing biomass as a raw material for material use have not yet been explored.

Therefore, underneath a number of FLR and other restoration approaches, ongoing and under development are introduced.

3.3.1. Agroforestry

Agroforestry comprises land use systems that integrate trees and shrubs into farming or animal husbandry. Agroforestry has a long tradition across Central Asia with trees integrated into silvo-pastoral systems, fruit trees integrated with crops, vegetables, or fodder, kitchen gardens, and tree wind breaks (Djanibekov et al. 2016). Thereby, tree wind break is the most widespread agroforestry system across the region in terms of area (Thevs et al. 2017a, 2019). In particular, during Soviet Union times, tree wind breaks were promoted and planted across whole Central Asia (e.g., Albenskii et al. 1972; Kort 1988; Thevs et al. 2019). Tree wind breaks, as other agroforestry systems, qualify as an FLR approach (IUCN 2020b), as they provide many benefits to landscapes to improve current and future biological productivity, which are reducing wind speed, thus reducing crop water consumption, acting as snow trap, combating erosion, increasing soil organic matter through leaf litter, and providing habitat for wildlife (Alemu 2016). Tree wind breaks do not displace ongoing land uses, such as food production, but integrate into such land uses.

The most common tree species used for tree wind breaks were poplars (mainly *P. nigra* clones), throughout the region, elm (*Ulmus minor*), in drier areas north of the Tianshan, and mulberry (*Morus alba*), in the Ferghana Valley and other parts of Uzbekistan, Tajikistan, and Turkmenistan.

All three tree species have been used as raw material, the former two for timber and fuel wood and the latter for silk production and for the wood. Today, most attention has shifted to poplar as fast growing tree in all countries and to mulberry as raw material for silk production mainly in Uzbekistan. These two tree species therefore offer opportunities to address restoration and provide domestic raw material and income opportunities, with a huge untapped potential for further raw material production as feedstock for bioeconomy.

An assessment of Kyrgyzstan revealed (Thevs and Aliev 2017) that a tree wind break grid of 500 m × 500 m across all cropland of the country would harbor 70 million poplar trees, which would cover most of the country's timber demand and a large share of the fuel wood demand. In this assessment, single row tree wind breaks were considered, as this is the type preferred nowadays by farmers. Still, this type significantly reduces wind speed and reduces agricultural water consumption (Thevs et al. 2019). Such single row tree wind breaks do not occupy much space so that there is very limited impact on ongoing land uses. Poplar wood can be used for a wide range of applications, as listed by Isebrands and Richardson (2014) so that an expansion of tree wind breaks would contribute to the raw material basis as needed for a bio-economy.

Mulberry yields the raw material for silk production as a high value product. Silk production has a history of thousands of years and was also promoted during Soviet Union times. Today, mainly Uzbekistan preserved domestic silk production and plans to modernize it, as was revealed by expert interviews in 2019 (Baier et al. 2019). Like poplars, mulberry trees can be integrated into ongoing land use as tree wind breaks. Furthermore, some mulberry cultivars have a certain salt tolerance so that they can be used as tree wind breaks on saline croplands or to restore areas of saline lands.

In the past three years, paulownia has been gaining increased attention as a fast-growing tree with very good timber properties. The timber is light and shows desirable mechanic properties DIN EN 338:2016-07 (DIN Deutsches Institut für Normung e. V. 2016). Currently, there are three plantations and single tree individuals in Kyrgyzstan, and further plantations are in the planning or establishment stage in Kazakhstan, Kyrgyzstan, and Uzbekistan. A group of paulownia trees in Bishkek observed during the growing season 2018 grew from 4.85 m to 7.70 m in height and from DBH of 8.9 cm to 14.6 cm on average (Villwock 2019). Three-year-old trees on the currently largest plantation in Kyrgyzstan, located at Lake Issyk Kul, grew from 2.70 m to 4.40 m in height and from DBH 5 cm to 7.9 cm in average during the year 2019 (Baier 2020). The vegetation period is shorter at Issyk Kul compared to Bishkek. Those trees at Issyk Kul showed a volume increment of 0.01 m^3 per tree compared to 0.004 m^3 volume increment of two-year-old poplars near Bishkek.

Paulownia was reported to have similar effects to poplars when planted as tree wind break, like wind speed reduction by 20–50% and reduction of evapotranspiration of 23–34% compared to open field conditions (Jiang et al. 1994). However, paulownia cannot be used as a tree wind break under very windy climates (Hecker and Weisgerber 2003). Paulownia, in contrast to poplar, cannot endure wet soils (Hecker and Weisgerber 2003). Therefore, Paulownia in combination with crops needs more careful irrigation management, in order to avoid wet soil conditions. Poplars can be easily combined with the widely spread flood or furrow irrigation, as it can endure wet soil conditions.

Whether Paulownia in agroforestry systems should be counted as FLR or not is debatable, as Paulownia is not an indigenous tree of Central Asia, and under humid climate conditions it has been reported as an invasive species. As paulownia needs to be irrigated under the climatic conditions of Central Asia, but cannot endure wet soil conditions, it depends on careful site management, which reduces its opportunities to germinate and recruit outside man-made sites.

Assuming timber yields at least as high as from poplars, paulownia offers similar opportunities to provide biomass as raw material for bio-economy, while providing benefits to landscapes in agroforestry systems and thus not displacing other land uses.

3.3.2. Salt and Water Stress Tolerant Plants for Degraded Croplands and Tugai Forests

Restoration of saline lands with halophytic plants has been implemented in many parts of the world, as e.g., listed by Qadir et al. (2018), including examples for Central Asia. If the resulting biomass is used, it is mainly used as fodder, often with low yields, as restoration is the main focus. Agroforestry was piloted with the tree species *Elaeagnus angustifolia*, *Ulmus pumila*, and *Populus euphratica* on saline degraded lands in Khorezm, Uzbekistan by Lamers et al. (2008). These agroforestry systems were established to yield fodder, fuel wood, and fruits from *Elaeagnus angustifolia.*

Two further promising candidates for restoration of saline lands in river plains are licorice (*Glycyrrhiza glabra*) and Kendir (*Apocynum venetum*). Both plant species are part of the natural vegetation of the river plains and Tugai forests of Central Asia. Both are adapted to the arid climate by tapping the groundwater (phreatophytes) for their water supply. This makes them endure years with low river runoff, as the groundwater layer stores water and acts as a buffer for those plants. Furthermore, both plant species have a certain salt tolerance so that they can be planted on areas which cannot support food production to an economically viable level.

Licorice yields fodder from its leaves, but the higher value biomass are the roots, which are a raw material for medicinal products and for flavors to foods and beverages. As licorice is a nitrogen fixing plant (Fabaceae), it helps improving soil fertility (Kushiev et al. 2005).

Kendir yields bast fibers of a quality similar to cotton and can be harvested as a medicinal plant, which makes it a plant species with the potential to yield high value raw material from places with not many other land use alternatives. Kendir was cultivated until the 1950s in today's Uzbekistan, but abandoned in favor of cotton. Fiber processing after cotton harvest (ginning) is technically easier than the extraction of a bast fiber like Kendir. However after improper irrigation, this has resulted in large areas of saline lands, which do not support high cotton yields anymore. Kendir is salt tolerant, and could be an alternative for those lands, providing a much more valuable raw material than fodder or fuel wood (Thevs et al. 2012b).

3.3.3. Reed as Biomass Source

Central Asia, despite its semi-arid to arid climate, has globally large reed bed areas which yield a huge amount of biomass. Kazakhstan alone harbors 2 million ha of reed beds, followed by Uzbekistan and Turkmenistan with several hundred thousand Hectares each (Köbbing et al. 2013). The Ili Delta in Kazakhstan, which is one of the largest reed bed areas of the region, was mapped through remote sensing (Thevs et al. 2017b), which revealed an area of submerged and non-submerged reed of 85,400 ha and 126,378 ha, respectively, with a standing stem biomass of 869,097 t in the submerged reed beds. The resulting average biomass of 10.1 t/ha is in the range of reed biomasses reported for other reed beds across Kazakhstan (Baibagyssov et al. 2020). This allows the conclusion that there is a huge biomass pool that can be tapped as raw material for the bio-economy, even if only a part of that reed is used, in order to give space to biodiversity conservation.

Reed yields a ligno-cellulose biomass, which can be used as raw material for paper, paper board, and OSB boards. A small factory for OSB boards is being built up in the Ili Delta. Cellulose extraction and the subsequent production of sugars and further chemical inputs are under research, as compiled by Schäpe (2016).

4. Conclusions

Central Asia, despite its arid climate and manyfold land degradation, offers potential for sustainable utilization of biomass as feedstock for different products and value chains under bioeconomy approaches. The options for biomass utilization introduced here avoid or minimize competition with food production. Agroforestry, which includes poplars, mulberry, or paulownia offers timber and silk as high value product. On saline lands, agroforestry offers less valuable products, but still offers options to make use of such lands. Moreover, Kendir and Licorice are plants that yield high value products (fibers, medicine, and flavors) from saline land, which otherwise poses difficulties to grow food crops. Finally, reed in the wetlands of the region yields huge amounts of ligno-cellulose biomass, which can be used as raw material for paper, paper board, and OSB boards. Thereby, the processing of wood and silk as raw materials from agroforestry are well known. The utilization and processing of Kendir and reed though still needs some research to unfold their full potential for high value products.

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The Transition to Sustainable Life on Wetlands: How the Sustainable Use of Peatlands Appears on the Political Agenda

Stefan Ewert and Susanne Abel

1. Introduction

This article deals with the transition to sustainable life in wetlands, a world in the "transitional position between land and water" (Rydin and Jeglum 2013, p. 2). More specifically, we examine peatlands. Peatlands are "the most widespread of all wetland types in the world" (Joosten and Clarke 2002, p. 6). The special characteristic of peatlands explains their importance for sustainability transition: due to a waterlogged, oxygen-poor environment, the rate of decay of dead plants in peatlands is slower than in all other terrestrial ecosystems worldwide (Joosten et al. 2016b, p. 64). Thus, they play a major role in the CO_2 concentrations in the atmosphere. Limpens et al. (Limpens et al. 2008, p. 1381) point out:

> Despite covering only 3% of the Earth's land surface, boreal and subarctic peatlands store about 15–30% of the world's soil carbon as peat. [. . .] These massive deposits are the legacy of peatlands acting as sinks of atmospheric carbon dioxide (CO_2) for millennia, but also illustrate the potential for large CO_2 and methane (CH_4) fluxes to the atmosphere if peatlands were to be destabilized by global warming and changes in land use.

Next to carbon storage, peatlands have multiple other values and functions (Joosten and Clarke 2002, pp. 45–100). Wet peatlands are important for biodiversity protection (Minayeva et al. 2017) and they function as "the kidneys of the landscape" in hydrological and chemical cycles (Fraser and Keddy 2005, p. IX). As such, they play an important role in the storage of water and freshwater quality. Furthermore, they have an archive function—peatlands provide information that is "deposited and stored in the peat profile" (Chapman et al. 2003, p. 525). Sustainable land use is only possible if the peat is conserved in wet peatlands, so that the peatland can provide these ecosystem services.

Today, most human activities in wetlands are based on drainage and cause the degradation of peatlands accompanied by high CO_2 emissions and a loss of mires as living peatlands. Amongst others, forestry, peat extraction and urbanization destroy mires worldwide. However, at least in the non-tropical world, agriculture is the main driver for peatland degradation (Joosten and Clarke 2002, p. 33; cf. IPCC 2007). The only sustainable way of using peatlands is paludiculture, land use on wet and rewetted peatlands (Wichtmann et al. 2016). Paludicultures (Latin 'palus' = swamp) are land management techniques that cultivate biomass on peatlands under conditions that maintain the peat body, facilitate peat accumulation and sustain the ecosystem services associated with natural peatlands. A transition from the unsustainable use of drained peatlands to rewetting and use in paludicultures contributes directly to most of the United Nations Sustainable Development Goals (SDGs), including, amongst others, SDG 6 (clean water), SDG 9 (innovations) und SDG 13 (climate action) (Tanneberger et al. 2020, p. 5). Due to the disproportionately high number of the world's species that live and breed in wetlands, peatland protection is of utmost importance for SDG 15 (life on land) (RAMSAR 2018). Given the fact that agriculture is the main driver for peatland degradation, our article focuses on the question how the agricultural policy can contribute to the transition to sustainable life on (wet-)lands.

For the analysis of political agenda-setting, we focus on the European Union. Europe is one of the world regions with the largest areas of degraded peatlands (Urák et al. 2017). In the EU, agricultural policy is one of the key policies, so that the "EU's Common Agricultural Policy (CAP) is arguably the single most important policy instrument in the context of peatland degradation and conservation across the EU" (Peters and von Unger 2017, p. 10).

The analytical framework of our examination is the Multiple Streams Approach (MSA) by Kingdon ([1995] 2014)). The MSA is a universal theory and key reference in public policy studies (Cairney and Jones 2016). We use this analytical frame in order to understand the emergence of a new approach to sustainable peatland use in the policy discourse. Based on that, we discuss the chances for a large-scale implementation of paludiculture as a form of wet agriculture on peatlands.

2. Theoretical Background and Expectations

John Kingdon's Multiple Stream Approach (MSA) provides the analytical frame of our investigation. Kingdon argues that an idea's time comes when a problem stream, a policy stream and a political stream come together and policy entrepreneurs push this idea on the governmental agenda (Kingdon [1995] 2014).

Since one of the main criticisms of the MSA is the lack of explicit hypotheses and the possibility of falsification, we use the theoretical refining and adaptations of the MSA by Herweg et al. (2015) and integrate their hypotheses into our analysis of the emergence of paludiculture on the political agenda.

The first stream we consider is the problem stream. This stream answers the question "[w]hen exactly [. . .] a problem [is] relevant enough to open policy window" (Herweg et al. 2015, pp. 436–37). According to Kingdon, a problem exists if there is a "mismatch between the observed conditions and one's conception of an ideal state" (Kingdon [1995] 2014, p. 110). Thus, the value-based definition of an ideal state and the intersubjectively shared observation of a phenomenon determine the definition of a problem and the state of the problem stream. The crucial question is to define when exactly the problem is relevant (enough). Herweg et al. (2015) argue that this is the case when the problem puts the policymakers' re-election at risk. Due to the global dimension of the greenhouse gas (GHG) emissions from drained peatlands, we argue that re-election is less important in this case. Instead of this, we consider the problem stream as ripe if there is not only global awareness of a problem, but legally binding mechanisms to deal with that problem exist on a global level and have an influence on policymaking on the political levels below.

The policy stream comprises the ideas for the specific design of the policy field. Analytically, the MSA takes here all proposals into account which are made to reduce the imbalance between the ideal and observed observations. Kingdon calls these ideas and proposals in sum the "policy primeval soup" (Kingdon [1995] 2014, p. 19), and they are discussed, selected and adopted in a community of specialists. Usually, a "large set" (Kingdon [1995] 2014, p. 20) of proposals exists, but, like in a natural selection process, only some ideas survive. Kingdon ([1995] 2014, pp. 131–39) identifies different criteria which determine the success of an idea in the policy stream. These criteria are the technical feasibility, the value acceptability among the specialists in the policy community (including efficiency and cost-effectiveness) and an anticipated positive reaction in the public sphere and among decision makers (cf. Jones et al. 2016, p. 16). The policy stream is ripe "if at least one viable alternative is available" (Herweg et al. 2015, p. 443) to the status quo in order to reduce the mismatch observed in the problem stream.

The third stream in Kingdon's MSA is the political stream. Initially, it flows apart from the work of specialists in the policy stream and the public attention in the problem stream (Kingdon [1995] 2014, p. 145). To understand the stream and its status, Kingdon argues for the analysis of the public mood, the activities of organized interests and changes in governmental and administrative structures (Kingdon [1995] 2014, pp. 146–59).

For examining the political stream, we focus on the EU. The implementation of a sustainable use of peatlands is dependent from the political stream on the levels where the political competencies for shaping and steering the policy field are. As outlined in the introduction, the EU's Common Agricultural Policy (CAP) is a crucial policy instrument for peatland protection. The flow of the political stream within political entities led to the criticism of Kingdon's original MSA to be too unprecise with respect to the different political agents. Consequently, the MSA was extended to political parties and their agenda-setting in the light of the position of interest groups and the chances for re-election (Herweg et al. 2015, pp. 438–41). This theoretical refining is convincing for parliamentary systems. However, due to the crucial role of the EU commission and the interest groups in the EU agenda-setting processes (Princen 2011), we focus on the original characteristics pointed out by Kingdon. In order to refine Kingdon's MSA, we adopt the argument of Herweg et al. (2015) with respect to the conditions and argue that a political stream is ripe if the crucial political institutions perceive the alternative proposal as (a) popular among voters, and if (b) powerful interest groups are unlikely to launch campaigns against it and (c) new key personnel are involved in the agenda-setting on an administrative level.

According to Kingdon, a new idea appears on the political agenda if the three streams are ripe and policy entrepreneurs become active. In times of an open policy window, policy entrepreneurs are key actors who soften up the separations between the streams. Policy entrepreneurs are "advocates for proposals" (Kingdon [1995] 2014, p. 122), and an open policy window gives them the opportunity to promote their policy proposal as a solution to a challenge defined in the problem stream.

3. Materials and Methods

In the 2000s, the MSA became one of the most prominent approaches to analyze public policy (Zohlnhöfer et al. 2015). The empirical material in Kingdon's work was gathered from expert interviews and the analysis of official documents and academic writing (Kingdon [1995] 2014, pp. 4–5). Like Kingdon in his original work, the majority of the MSA studies use documentary analyses and interview methods (cf. Cairney and Jones 2016, p. 44). This qualitative access has proven itself in order to explore a new object of study. To do so, most authors do some conceptual revisions and adaptations of Kingdon's MSA (Cairney and Jones 2016, pp. 45–46). This is also the case for studies in the field of environmental policy (e.g., Brunner 2008). In our article, we follow this methodological path and analyze the policy documents of governmental institutions and policy stakeholders (like interest groups) as well as the scientific literature on the sustainable agricultural use of peatlands. To depict the political stream and the policy window, we analyze all documents of the EU institutions on peatland protection of the last 20 years and examined the publications of the stakeholders addressed to the CAP reforms. Additionally, we conducted five interviews in 2019 with staff on the working level of the agricultural ministries in the German federal states, the Bundesländer. The interviews took place in spring 2019. In the five peatland-rich Bundesländer, there is at least one official for peatland protection in the ministries for agriculture and environment. We conducted semi-structured interviews with these officials and analyzed the interviews with qualitative methods. We use the German Bundesländer as a case study for the agenda-setting on a subnational level. The Bundesländer play a central role in the specification and administration of the European CAP (Ewert 2016). For the implementation of the CAP in Germany, the state ministries are crucial institutions.

4. Results

The MSA is a universal approach in the sense that "policymaking issues that can arise in any time or place" (Cairney and Jones 2016). Due to the global existence of peatlands and the global threat of anthropogenic climate change, the problem stream (Section 4.1) and the policy stream (Section 4.2) also have a global dimension. On the contrary, the political stream flows within political entities. In this stream, policy entrepreneurs in the field of agricultural policy have to be active on different levels, as we demonstrate with the example of the European Union (Section 4.3). We focus on the EU because, on the one hand, the problem of peatland degradation is particularly visible in Europe and, on the other hand, the pressure on the land is high due to high population density (cf. Tanneberger et al. 2020). We show that policy windows regularly open in this policy field, because the CAP functions in seven-year funding periods (Section 4.4). We agree with Brunner (2008) that it is, to some extent, complicated to analyze multi-level game structures with the MSA, but argue that the approach is nevertheless useful to explain the changes in the political agenda concerning sustainable peatland use.

4.1. Problem Stream

We first analyze the problem stream. Regarding greenhouse gas (GHG) emissions in general, there is no doubt that this problem stream is ripe. On a global level, the best evidence for this might be the creation of global organizations and treaties. The foundation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 is only one expression of the problem's recognition (cf. Bodansky 1993). Article 2 sets out the central objective of the convention, the "stabilization of greenhouse gas concentrations in the atmosphere". The assessment of the observable conditions for the UNFCCC is one of the main tasks of the Intergovernmental Panel on Climate Change (IPCC) (Alfsen and Skodvin 1998). The IPCC defines the indicators for GHG inventories (Hiraishi et al. 2014, p. IV) and summarizes the existing data. The IPCC's assessment reports made the mismatch between stable GHG concentrations in the atmosphere (as an "ideal state" in the sense of Kingdon) and the conditions created by human GHG emissions observable. They entered public debates and made clear that climate change is one of the biggest challenges for mankind (Brunner 2008). With the Kyoto protocol, the UNFCCC established a legally binding mechanism to act against climate change on a global level. In terms of the MSA, the problem stream became ripe.

With respect to land use, the IPCC reports pointed out that the agricultural sector is responsible for a substantial part of human GHG emissions (IPCC 2007). The reports already made clear in 2007 that the decay of peat on organic soils drained for agricultural activities is a large CO_2 source (IPCC 2007, p. 36). Subsequently, however, it became clear that the IPCC reporting guidance for the national GHG inventories regarding drained peat soils underestimated the GHG emissions substantially (Couwenberg 2011). While living peatlands under natural, wet conditions are a net carbon sink, drained peatlands are a huge carbon source (Joosten et al. 2016b) and while the peatlands of the world are still the largest terrestrial store of organic carbon (Joosten et al. 2016b, p. 63), agriculture and forestry are the main drivers for the drainage of peatlands (Oleszczuk et al. 2008). Different research activities made the dimension of the problem observable. Joosten et al. (2012, p. C) summarized this research and clarified:

> Fifteen percent of peatlands [=0.45 percent of the Earth's land surface, S.E./S.A.] are drained and used for agriculture, grazing, peat mining and forestry, especially for bioenergy plantations. Including emissions from peat fires, these drained peatlands emit almost six percent of anthropogenic CO_2 emissions. This represents almost 25 percent of emissions from the entire land use, land use change and forestry sector.

Based on this research, the IPCC reviewed the guidelines for reporting GHG emissions from peat soils (Hiraishi et al. 2014). It became obvious that a large mismatch between land use on drained peatlands and the aim of a sustainable use of terrestrial ecosystems exists. The problem was recognized and expressed in figures and it was given scientific and public attention. The Kyoto protocol, which initially did not systematically take the role of peatlands into account, made several adjustments in later commitment periods (Joosten et al. 2016a). In general, the key issue of the discourse on sustainable peatland use is the general challenge of climate change mitigation. Climatic drying and drainage also increase the risk of peat fires that are a further source of greenhouse gas emissions to the atmosphere, as well as causing negative human health and socio-economic impacts (Page and Baird 2016). Wet peatlands are also important for climate change adaptation because of their resilience to gradual, long-term changes in climate and hydrological conditions, but they also respond rapidly to more profound, short-term anthropogenic disturbances (Page and Baird 2016). Drainage of peatlands leads to subsidence. As a result, some areas of peatland formerly drained for agriculture have now been abandoned or put to other land uses. Subsidence leads to high risk of flooding in coastal areas, decreasing agricultural productivity, leading to increased costs for drainage and the reconstruction of infrastructure or developments. With the amendments in the Kyoto protocol, these scientific findings formed the problem stream on a global level.

On an EU level, the current legal framework for the agricultural policy is provided by regulation No 1307 from the year 2013. The problem of the GHG emissions from drained peatlands is not named in the regulation. However, in the present reform discussion of the CAP on a European level, this issue plays an important role (see Section 4.4). In Germany, all current coalition agreements in the peatland-rich Bundesländer mention the need to protect and rewet the peatlands in order to implement GHG emission targets (Ewert and Hartung 2020). Our interviews with the agricultural ministries demonstrate that the Bundesländer have been trying to get the federal ministry of Germany to name the problem and possible solutions in the coming European CAP period (Interview No 1, No 2, No 4 and No 5).

4.2. *Policy Stream*

For the examination of the policy stream, we analyze the literature regarding the alternatives to the unsustainable use of drained peatlands. Within the policy community, there is a consensus that intact mires and bogs are—among other ecosystem services—large carbon stores (Yu et al. 2010; Crump 2017). With regard to the rewetting of drained peatlands, there is a scientific debate on the opposing effects of CO_2 storage and increasing methane (CH_4) emissions. Current research demonstrates that, due to different radiative effects and atmospheric lifetimes of both gases, prompt rewetting has the highest climate change mitigation potential (Günther et al. 2020). However, restoration by rewetting comes into conflict with the existing forms of agricultural and forestry uses of peatlands (Chapman et al. 2003). These conflicts called for a new approach to the wise and sustainable use of peatlands (Joosten and Clarke 2002).

The sustainable productive use of wet peatlands has—on the one hand—a long tradition. One example is the use of reed for construction and roofing. On the other hand, a systematic approach to use peatlands in a way that peat accumulation maintains or starts again is a rather new concept. It is called paludiculture (Latin 'palus': swamp) and defined as "the cultivation of biomass on wet and rewetted peatlands" (Wichtmann and Joosten 2007, p. 24). Since the beginning of the 2000s, the concept has been developed, tested in pilot projects and introduced into scientific discourse (for an overview e.g., Wichtmann et al. 2016; Joosten et al. 2014; Wichtmann and Joosten 2007). This made paludiculture, as an alternative to the unsustainable use of drained peatlands, visible. However, is this policy stream already ripe? To evaluate this, we look at the criteria defined by Kingdon for the success of an idea in the policy stream.

4.2.1. Technical Feasibility

According to Kingdon, a proposal is technically feasible if it is "worked out" and "ready to go" (Kingdon [1995] 2014, p. 131). For paludiculture, the first step is to identify suitable crops. The 'Database of Potential Paludiculture Plants' (DPPP)[1], records the results of pilot projects, etc., and identifies more than one thousand potential plants worldwide (cf. Abel et al. 2013). Based on this, different questions of production, harvesting and utilization have to be analyzed. Several pilot projects and practice examples demonstrate the feasibility of paludiculture (Wichtmann et al. 2016, pp. 21–78). Amongst others, the use of fen biomass in the district heating plant of Malchin from 400 ha of rewetted peatland (Mecklenburg-Western Pomerania, Germany) (Dahms et al. 2012) or the cultivation and use of *Sphagnum* (peat moss) biomass as a substitute for peat in horticulture on 17 ha on a former bog grassland (Gaudig et al. 2018) (see Figure 1). Another example arewater buffalos grazing on around 300 ha of wet or rewetted peatlands (Sweers et al. 2014). The examples were scientifically monitored and the results show that the plant establishment, wet management, harvest and biomass utilization for different value chains (e.g., as fuel, substrate or meat) are feasible on a large scale. The use of wet meadows for hay production or reed cutting for thatching are

1 The DPPP is available online: https://www.greifswaldmoor.de/dppp-109.html.

traditional examples of paludiculture. With modern harvesting techniques, they have developed into a good source of income and have enabled the application of nature conservation measures.

Figure 1. (**left**) Peat moss harvest on rewetted bog grassland in NW Germany; (**right**) wet meadow harvest; Source: Greifswald Mire Centre, used with permission.

4.2.2. Value Acceptability

Kingdon argues that a proposal has to be in line with the values of the specialists in a policy community (Kingdon [1995] 2014, p. 132). Regarding the question of the introduction of paludiculture on organic soils that are currently used for conventional agriculture, the policy community consists of a lot of different agricultural stakeholders. The conventional agriculture on peatlands is based on drainage, agriculture has a 'semi-desert' origin and heritage (Joosten 2014; Joosten et al. 2014). However, in the current discussion on a CAP reform in Europe, COPA-COGECA—as the union of farmers' organizations and a highly influential interest group on a European level—endorses the introduction of paludiculture as an appropriate way to protect peatlands (Copa and Cogeca 2019). Our interviews with representatives of the agricultural ministries in the German Bundesländer confirm that the farmer associations do not oppose the introduction of paludiculture.

Within the topic of value acceptability, the question of the efficiency of the new approach is highly relevant (Kingdon [1995] 2014, p. 136). Within the agricultural sector, with its high level of subsidies worldwide, this question matters maybe even more. Economic studies point out that paludiculture crops can be competitive to other agricultural products, if the entitlement to agricultural subsidies is equal to conventional farming (Wichmann 2017). However, in the European Union, this is not the case. While farmers receive subsidies for drained peatland agriculture, they do not for most of the paludicultures (Joosten et al. 2014, p. 303). The question of the income of paludiculture farming—especially in comparison to farming on drained peatlands—is crucial for its acceptability among farmers. A large-scale implementation of paludiculture could only take place if the income (incl. subsidies) is at least as high as for conventional farming on peatlands.

4.2.3. Anticipated Reaction in the Public Sphere

One can find a lot of examples of the mires' perception as hostile and threatening in different cultures. As Ludwig Fischer has shown for the case of Germany, the discovery of the mire in art and literature in the 19th century was closely connected with the conquer of the mire, and with its scary and hostile nature being transformed by civilization (Fischer 2009). Thus, rewetting projects are often confronted with acceptance problems among local people (Pfadenhauer and Grootjans 1999). Rewetting is perceived as a break with traditions, also because of the great efforts that have been made to drain and reclaim the land for food security, electrification or wealth in general (e.g., Deickert and Piegsa 2016; Varkkey and O'Reilly 2019). People also fear the rising water levels because of wet basements and mosquitos. However, one might expect that the anticipated reaction in the local public sphere is considerably better when the rewetting is connected with an ongoing productive use of the peatland via paludiculture and an awareness of the problems of drainage-based use. The participation of the local people in rewetting projects is the key to the enhancement of acceptance (cf. Pfadenhauer and Grootjans 1999, p. 95; Abel et al. 2019) and paludiculture offers different opportunities for this, especially in terms of the economy and employment.

4.3. Political Stream

The last stream we examine is the political stream. Following Kingdon, we analyze the public mood, the activities of organized interests and the changes in governmental and administrative structures.

4.3.1. Public Mood

Public opinion is the first key pillar of the political stream (Kingdon [1995] 2014, pp. 146–49). Opinion polls point out that, for most Europeans, climate change is one of the most important environmental issues (Eurobarometer 2017, p. 12). Moreover, a large majority demands a stronger EU policy for climate protection.

> More than four in five Europeans (85%) agree that the EU should invest more money in projects and programmes supporting the environment, nature conservation and climate action throughout the EU. (Eurobarometer 2017, p. 98)

Furthermore, a third of Europeans agree that agricultural pollution is one of the most important environmental issues (Eurobarometer 2017, p. 12). These figures demonstrate that the need for a more climate-friendly agricultural policy is clearly expressed by the majority of Europeans.

Other surveys concerning people's preferences towards peatlands show rather heterogenic and complex results. Restoration and nature conservation are commonly accepted by the public, but it was also found that a high value is placed on the agricultural use of peatlands or peat cutting (Tolvanen et al. 2013; Rawlins and Morris 2010). Obviously, there is a mismatch concerning the wish for climate protection or other ecosystem services and the preference for peatland use.

4.3.2. Interest Group and Changes in Their Administration

As already shown, the most influential farmer associations on a European level do not oppose paludicultures, but consent to the view that they help reduce GHG emissions from agriculture substantially (cf. Kingdon [1995] 2014, pp. 149–53). The interviews in the agricultural ministries of the Bundesländer confirmed this interpretation (Interview No 1, No 3). According to Kingdon, another indicator for a ripe political stream is the turnover of key personnel in the government (Kingdon [1995] 2014, pp. 153–59). Currently, there is some evidence that, within the European Green Deal strategy of the European Commission, a "dilution of the sole power of DG AGRI to determine farm policy" is observable due to new working structures (Matthews 2020). This development implies new personnel in the European governmental structures concerning the CAP.

4.4. Policy Windows and Policy Entrepreneurs

According to Kingdon, new ideas and alternative approaches find their way on the political agenda if the three streams are ripe and a policy window opens. Windows open either predictably or rather unpredictably as a result of focused events (Kingdon [1995] 2014, pp. 168–70). Kingdon ([1995] 2014, p. 165) gives the "scheduled renewal of a program" as an example of an open policy window in the first mentioned sense.

In the European Common Agricultural Policy (CAP), such predictable open policy windows are observable every five to seven years. Two European funds, the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD) are the financial sources of the CAP. The European "Multiannual Financial Framework" (MFF) defines the framework for these funds. A new MFF period leads to new EU regulations on the agricultural funds and ongoing reforms to the agricultural policy (Massot 2020; cf. Daugbjerg and Swinbank 2016). In the words of Kingdon: A new MFF period is a "scheduled renewal" of the European agricultural policy program. New EU regulations define a new CAP period with new specifications of new steering mechanisms, adjustments of support, funding tools and so on.

In times of an open policy window, the actions of policy entrepreneurs are a crucial factor in the MSA. Policy entrepreneurs promote their ideas regarding how to deal with the problem defined in the problem stream. The background and the placement of the entrepreneur varies from case to case and Kingdon gives the activities of academics as an explicit example (Kingdon [1995] 2014, p. 180). Regarding the sustainable use of peatlands, Chapman et al. (2003, p. 526) point out the active role of scientists in the policy field, referring to Joosten and Clarke (2002) as "a land-mark book which was the product of a joint effort by the International Mire Conservation Group [IMCG] (a group of scientists aiming to preserve peatlands)". Hans Joosten, the general secretary of the IMCG, describes the work of academics and their achievements as policy entrepreneurs on a global level:

> When—in 2006—experts and advocacy groups for the first time raised the issue of GHG emissions from degraded peatlands at the United Nations Framework Convention on Climate Change (UNFCCC), they met with negotiators, many of whom had never heard of 'peat' in the first place. [. . .] After years of neglect, peatlands have gained the attention that they deserve in the face of their enormous emissions and mitigation potential. (Joosten et al. 2016a, p. 291)

As outlined in Section 4.2, academics developed the concept of paludiculture as a sustainable alternative to the unsustainable agriculture on drained peatlands and emphasize the current practice of farm subsidies as a crucial barrier to the large-scale implementation of paludicultures in Europe. The policy window on a European level opened with discussions and the preparation of a new funding period after 2020. Policy entrepreneurs became active on a European level in order to convince a decision maker in the CAP to put paludiculture on the agenda (cf. Greifswald Mire Centre et al. 2020).

Through the proposals and discussions of the European institutions on the future of the CAP, one can clearly see that the problem of the unsustainable use of peatlands and the solution of paludiculture became part of the agenda. In Annex III of the Commission's proposal for a new CAP period, a new standard for the good agricultural and environmental condition of land (GAEC II) is defined as the "appropriate protection of wetland and peatland" in order to mitigate climate change (European Commission 2018, p. 13). Additionally, a new brochure from the Directorate-General for Agriculture and Rural Development (DG Agri) explicitly takes paludiculture as an example to explain the new possibilities for the member states to use the conditionalities defined in the GAECs for peatland protection (DG Agri 2019, p. 12). As an amendment to the Commission's proposal, the European Parliament calls for an explicit fixation on paludicultures as being eligible for direct payments (European Parliament 2019, amendment 91).

5. Discussion

Paludiculture, as a sustainable way to use peatlands, is on the agenda of the current discussions and proposals on the future of European agricultural policy. The agenda-setting process took place according to Kingdon's theoretical expectations and the refinements by Herweg et al. (2015, p. 443): "Agenda change becomes more likely if (a) a policy window opens; (b) the streams are ripe; and (c) a policy-entrepreneur promotes the agenda change".

On a European level, the window for agricultural policy reforms opens regularly every few years when a new CAP funding period is under preparation. During the current preparation time, the problem of GHG emissions from drained peatlands was already on the global climate protection agenda and found its way into global climate protection agreements and actions due to the activities of scientists. We argue that the problem stream is ripe on a European level because these global initiatives took place and the political levels below became active in putting the problem of GHG emissions from drained peatlands on the European agricultural policy agenda.

In the policy stream, the introduction of paludiculture as sustainable use of peatlands on large scale is a viable policy alternative which fulfils most of Kingdon's criteria for a successful proposal. To follow Kingdon's analogy of the biological evolutionary selection process: like the bottleneck effects in evolution which result in the decline of genetic variability (cf. Nei et al. 1975), one might interpret the question of a sustainable use of peatlands as a bottleneck policy field. The only way to protect peatlands is to keep them wet and to rewet drained peatlands. Moreover, the only way to use peatlands in a sustainable manner for agriculture and forestry is to use them wet. Thus, the concept of Paludiculture had a strategic advantage that enabled its survival in the "policy primeval soup". Yet the crucial question of paludicultures' efficiency, especially in competition with subsidized drainage-based agriculture on peatlands, remains unsolved so far. Here, the policy stream is coupled with the political stream.

On a European level, public surveys demonstrate that a large majority of European citizens support the call for a more sustainable agricultural policy. Politicians with responsibility for the structure of the new CAP might consider these figures as representative of the public mood in favor of the implementation of paludicultures on peatlands. New working structures on a European governmental level integrated new key personnel in CAP decision making and indicate changes in the political stream towards a more climate-friendly farm policy. The initiatives of the European institutions involved in the CAP reforms show that the political stream is ripe to enhance the framework conditions (eligibility for subsidies and other support schemes) for paludicultures.

6. Conclusions

Our analysis has shown that the agenda-setting for the large-scale introduction of paludicultures on peatlands took place on the level of the European agricultural policy. At this stage, two questions remain open, which are connected to some extent. (1) How do the different political levels interact in the agenda-setting process? (2) How does this influence the agenda-setting and the implementation of policies and changes in peatland use towards sustainability?

Brunner (2008) points out the shortcomings of the MSA in the analysis of multi-level politics. For the case of paludiculture, Ewert and Hartung (2020) show that, in Germany, the agricultural administrations in the Bundesländer do not support paludicultures directly via CAP schemes due to their unclear legal status in the European regulations. All our interview partners point out that the sustainable use of peatlands is also on the agenda of the agricultural policy stakeholders in the Bundesländer; however, for its implementation, the stakeholders are waiting for European policy changes (Interview No 1–5). Future research should analyze this interplay more systematically and integrate it into the MSA.

There are already proposals in the MSA literature on how to integrate the decision-making stage into the approach (Herweg et al. 2015, pp. 443–46). In the case of paludiculture, further research is needed to investigate "decision coupling" processes that follow the agenda-setting on an EU level, as well as its implementation on national and subnational levels. John Kingdon's MSA can explain how the time came for the idea of paludiculture and how it appeared on the political agenda. However, the non-formal aspects of policy implementation are beyond the scope of the MSA and the important question of power in the realization of agricultural policy reforms on site (cf. Nuijten 2005) has to be investigated in future research. The transition to sustainable life on wetlands and the sustainable use of peatlands not only needs a political agenda, but also a large-scale implementation on the ground, supported by appropriate funding schemes.

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Part 3: Land Property Rights and Governance

Evolution of the Land Consolidation System in China

Kaiwen Zhang and Rong Tan

1. Introduction

It is widely accepted that fragmented land ownership tends to decrease farmland productivity (Pašakarnis and Maliene 2010; Latruffe and Piet 2014; Jürgenson 2016; Zang et al. 2019). As a result, the concept of land consolidation appeared in the 14th century in Europe (Demetriou et al. 2012; Liu and Zhao 2017). It was originally designed as an agriculture-oriented policy tool and defined as readjustment and reallocation of arable land parcels to improve their quality and quantity (Vitikainen 2004; Pašakarnis and Maliene 2010; Hiironen and Riekkinen 2016; Zhou et al. 2020).

However, this traditional understanding of land consolidation has evolved due to the development of the modern society. Alongside the urbanization and industrialization processes, a large extension of land is in need of urban infrastructure construction and urban planning, which gives incentive to reorganize the rural land (Tan and Zhou 2015; R. Wang et al. 2019). Besides, rural–urban inequity also raises the demand for modernization in rural areas (Crecente et al. 2002; Liu 2014). Furthermore, the protection of the living conditions and ecological environment calls for an urgent care of rural land use (Foster et al. 2003). All these issues can be solved also by means of land rearrangement. In the 1990s, some western European countries started to regard land consolidation as a tool to fulfill public demands (Pašakarnis and Maliene 2010). Then, land consolidation was promoted as an indispensable measure for integrated rural development (Thomas 2006).

Though many developing countries have implemented land consolidation policies, not all of these practices achieved the expected results (van Dijk 2007; Janus and Markuszewska 2017). Policy-makers may face heterogeneous social obstacles such as lack of public participation, overregulation by the government, lack of government capacity, food security issues, or problems related to undeveloped rural regions (Lisec et al. 2014; Djanibekov and Finger 2018; Ahmed et al. 2018; Nguyen and Warr 2020). This makes cross-regional policy comparisons extremely difficult. The literature is clear that certain land consolidation policies can play an important role in the rural society. However, further study is still in need to illustrate the mechanisms of different policies. Then, is it possible to find an effective medium to estimate and compare the economic, social, and ecological functions of multi-purposed land consolidation policies under a similar background in stimulating sustainable development? Interestingly, as a transitioning country, China has experienced a complex situation in land management, and may provide suitable examples.

China has a long history of land consolidation, dating back to the 10th century BC, and land consolidation programs started soon after the funding of the People's Republic of China in the 1950s (Lu 2002; Huang et al. 2011). However, for decades, land consolidation in China was only regarded as an agriculture-focused instrument without considering its social, economic, and ecological functions. For example, in the era of planning economy, farmland consolidation was widely implemented as a supporting policy of people's commune. That is to say, modern land consolidation in China did not exist until the 1980s (Jiang et al. 2015; Long et al. 2019; Zhou et al. 2020). Since the reform and opening in 1978, rapid urbanization and industrialization in China have greatly changed the traditional small-farmer society in rural areas. Thus, land consolidation is no longer a simple agricultural approach, and new technologies and administrative methods have emerged. In the past 30 years, land consolidation in China, guided by the central government and implemented nationwide, has evolved greatly and faced different issues, including food security, rural development, political trade-off, and environmental problems.

The transition of the land consolidation system in China provides insights into the patterns of institutional change and policy performance. During the past 30 years of urbanization, China encountered similar social problems as many other countries, including food security, rural decline, and environmental loss (Liu 2014; Long 2014; Liu and Li 2017; D. Wang et al. 2019). The land consolidation policy was altered over time, whereas the basic institutional framework has remained unchanged. Under these circumstances, the evolution of certain policies reflects not only the purpose of policy-makers but also the response of the society. Hence, different policies can be discussed in the same context, especially to examine their working mechanism and driving force. By illustrating the evolution process of China's land consolidation system and contrasting the motivation, characteristics, and performance of each stage, this study aims at answering the following two questions: (a) how the land consolidation policy worked and performed in China; (b) why the previous system shifted to another one and what the characteristics of the institutional change are.

With these tasks, this research traces back the formation and evolution of the land consolidation system in the past 20 years. The form and method of land consolidation in China varies by region and by time. It is therefore inappropriate to compare local practices directly across time periods. Instead, a temporal-sequence study of country-level policies can abstract the perception and target of central decision-makers. Based on official laws, policies, and reports, this paper adopted a qualitative policy analysis approach. The institutional changes of land consolidation system were identified and characterized to find the internal mechanism of rural land use-related policies.

In an international perspective, it is also necessary and worthwhile to clarify how the Chinese land consolidation system works and why it changed through time. On the one hand, the problems and demands that China faced are applicable to many developing countries, such as agricultural decline and the social-ecological land use problem. The policies implemented in China can serve as a "toolbox" which can be used by policy-makers to formulate rural land plans. On the other hand, the transition experience of industrialization, urbanization, privatization, and marketization in China is also beneficial to other transitioning countries, especially in South Asia and Central and Eastern Europe. With economic growth and social transformation, those countries should tailor their land management policy accordingly. Likewise, the pattern of institutional change in China can also provide a learnable example to avoid social conflict and maintain a sustainable rural development.

2. Literature Review

The function of land consolidation is tightly linked to the arable land fragmentation issue. Many studies pointed out that unfavorable size and unsuitable shape of farmland are detrimental to agricultural production, as they increase the cost of organization and production and decrease the possibility of agricultural innovation (Thomas 2006; Latruffe and Piet 2014; Hartvigsen 2014; Sklenicka et al. 2014). Some other researchers illustrated that the fragmented farmland and property right may be tragic for the commons and reduce the investment incentive of farmers (Zang et al. 2019). On the other hand, some researchers argue that proper land fragmentation can increase the biodiversity and reduce risks for farmers (Ciaian et al. 2018; Ntihinyurwa et al. 2019). However, it is still widely accepted that the land fragmentation issue should be governed especially in developing countries including Central and Eastern Europe, Asia, and Africa (Hartvigsen 2014; Zang et al. 2019), which calls for the implementation of land consolidation.

In land fragmentation research, land consolidation studies mainly focus on the evaluation of procedures and effects. Many researches have primarily concentrated on its influence on agricultural productivity, using a quantitative method. Wan and Cheng (2001) estimated that the exogenous addition of one plot results in a reduction of annual crop output of 2 to 10 percentage points. Rahman and Rahman (2009) analyzed the rice production in Bangladesh by means of the stochastic production frontier framework and indicated that a 1% increase in land fragmentation would reduce the rice output by 0.05%. Hiironen and Riekkinen (2016) estimated the expected cost and benefit of a land consolidation program in Finland which reduced the average production cost by 15% and fulfilled a positive net value. Lai et al. (2015) indicated, through an econometric analysis of north China, that the consolidation of 2.28 plots into 1 plot can increase machinery use by 10% and crop output by 0.5–1%. Most of these studies revealed a positive relationship between land consolidation and crop yield. Colombo and Perujo-Villanueva (2019) indicated that land consolidation brought about a more stable property structure and saved production costs by 5.8% to 15.3% (Colombo and Perujo-Villanueva 2019). Janus and Markuszewska (2019) proved that land consolidation can still improve farmland quality and reduce land abandonment in the long term.

While land consolidation policies have become increasingly diverse, more and more scholars are setting their sight on rural transition and non-farm sector development, especially in Eastern and South Asia. Otsuka et al. (2013) suggested that Asian governments should support land consolidation programs to decrease the average production costs according with wage growth (Otsuka et al. 2013). Nguyen and Warr (2020) used panel data for Vietnam to figure out that land consolidation encouraged more rural labor to participate in non-farm sectors, which stimulate rural development. Many studies in China also presented similar results. Tan et al. (2008) observed that the separate land property right gave rise to rural labor price, and land consolidation may motivate rural resident to move to urban areas. Liu and Li (2017) found that under the trend of urbanization and attendant rural decline, rural workers and immigrants might suffer from limited knowledge and low income, while land leveling and assorted agricultural infrastructure construction projects improved rural conditions and provided more chance in rural area.

Other researchers focused on the social effect of land consolidation programs. In Eastern and Central Europe, communism during the national land privatization process influenced farmers' attitude towards land consolidation (Pašakarnis and Maliene 2010). van Dijk (2007) demonstrated the relationship between personal identity, social emotional bonds, and land property right in Central Europe and pointed out the inadequacy of traditional land consolidation policies. A research in Estonia also supported this view, indicating that land consolidation transactions violated the non-economic motivations of farmers and prevented the conservation of social capital (Grubbström 2011).

Recently, the ecological system is becoming a new perspective of land consolidation studies. A study in Galicia showed that land consolidation which increases the use of fertilizers and pesticides is harmful to the local landscape (Crecente et al. 2002). In recent years, many researches estimated the ecological influence of land consolidation by landscape ecology methods. Guo et al. (2020) indicated the long-term ecological benefit of land consolidation programs based on remote sensing. Zhong et al. (2020) implied that land consolidation programs can improve soil conservation services in Southeast China. Meanwhile, some scholars also argued that the ecological equality in China will degenerate in the overall process, even though restoration approaches of land consolidation can improve the ecological performance in certain periods (Shan et al. 2019). These inconsistent conclusions reflect the diverse ecological impact of land consolidation programs in different natural–social context.

Moreover, the topic of the organization and institution of land consolidation programs is also widely discussed. Lisec et al. (2014) figured out that a better perception of the landowner increases the possibility of land consolidation, which calls for better public participation. Haldrup (2015) introduced an agreement-based land consolidation mode which granted non-state sectors including NGOs and landowners a stronger voice in negotiation in order to satisfy the local interest. Ahmed et al. (2018) indicated that chiefs in Ghana played a negative role in achieving the public interest, going beyond a legal land management system. In Uzbekistan, the cotton production-oriented land consolidation process was controlled by the state, which increased the production risk and reduced farm incomes (Djanibekov and Finger 2018). Zhang et al. (2019b) provided evidence from China to prove that the internal opportunity and ability of farmer decides the performance of land use, while self-organization with sufficient government facilitation can effectively stimulate land consolidation projects. Another research in southwest China introduced a new consolidation method, in which agricultural companies can lease scattered farmlands from farmers and implement land consolidation projects to develop a mechanized agriculture (Zhang et al. 2019a). Besides the discussion of centralization and decentralization, these researches further provide a glimpse into the relationship between local background and institutional arrangement.

Virtually, it can be concluded that land consolidation projects all over the world have experienced three stages, from an agricultural focus to a rural society focus and eventually concentrating on ecosystem conservation. This is apparently according to the demands in different developing countries. However, though the international literature on land consolidation provides a possibility to compare the performance of different policies, it is still difficult to compare cases in heterogeneous backgrounds. For example, weak government power, lack of property right rules, and insufficient technology are the main obstacles in Africa (Ahmed et al. 2018), while East Asian countries are facing the process of urbanization and rural decline (Liu and Li 2017), and South Asian countries are facing the conflict of a growing population and a limited non-farm labor demand (Rahman and Rahman 2009; Nguyen and Warr 2020). Hence, the mechanisms and characteristics of different land consolidation institutions have not been investigated. However, the different stages of development of China's land consolidation policy happen to provide an opportunity for comparing results from different systems.

In the Chinese context, the land consolidation issue has attracted increasing attention in recent years. The related literature is continuously growing. Research has discussed in depth the relative performance of the Chinese land consolidation system mentioned above, including agricultural output (Wan and Cheng 2001; Jiang et al. 2015; Liu and Li 2017), rural development (Tan et al. 2008; Liu and Zhao 2017; R. Wang et al. 2019), soil erosion (Fan 2006; Gao and Liu 2010), and ecological service (Liu et al. 2019; Zhong et al. 2020). Newly emerging local practices have also been introduced, such as collective self-organization and market-led transactions (Zhang et al. 2019a, 2019b). However, most of these studies are limited at the regional level in a certain period and lack a comprehensive investigation at the national level. In other words, after 20 years of implementing a land consolidation policy, it remains to be discussed how the national system has influenced rural land utilization and why this system has been significantly modified. It is vital to clarify the impact by different institutions at different stages, considering the significant institutional changes that occurred in the past. A few studies have tried to identify different stages of the Chinese land consolidation policy (Long et al. 2019; Zhou et al. 2020), but the feature and developing path of each stage remain unclear. This study therefore argues that previous land consolidation studies have focused on the impact on single aspects and may ignore how the land consolidation system itself was planned and transformed.

3. Background and Concept

3.1. Understanding the Modern Land Consolidation System

Land consolidation can achieve several sustainable development goals (SDGs) to face the risks of food, security safety, environment, and poverty (United Nations 2015) (Table 1). Although land consolidation projects always take place in rural areas, they influence both the urban and the rural society (Louwsma et al. 2017; D.

Wang et al. 2019). While clean, safe, and sufficient food provisions are threated by urbanization and industrialization, land readjustment and rearrangement increase the productivity of arable land and contribute to SDG 2 (Zero huger) (Jin et al. 2017). The vitalization of agriculture not only increases the income of farmers, but also promotes an equal distribution of benefits among the relative stakeholders, which supports SDG 1 (No poverty) and SDG 10 (Reducing Inequity) (Pašakarnis and Maliene 2010). Moreover, since land consolidation reshapes the rural society, the rural living environment and social welfare (SDG 3, 4, and 6) improve (Lu et al. 2019). In urban development, land consolidation also provides an economized way of land assembly in order to facilitate peri-urbanization and urban redevelopment (SDG 11) (Louwsma et al. 2017). Notably, a proper land use arrangement can also contribute to SDG 15 (Life on land) by reducing land degradation and conserving biodiversity (Liu et al. 2019).

There are multiple cases to verify the relationship between land consolidation and sustainable development. In Ghana, the government advocated an agricultural reform to combine small parcels into a mechanized farmland, which continuously increased the rural production efficiency and diversity, eradicated extreme hunger, and reduced poverty by half (Ecker 2018). In Vietnam, land consolidation projects encouraged farmers to participate in the off-farm labor market and increased off-farm income, which could contribute to the rural–urban equity (Nguyen and Warr 2020). In Latvia, the implementation of land consolidation projects led to the improvement of the rural living conditions, including less soil erosion, better draining facilities, less air pollution, and better biodiversity conservation (Jankava and Gečaitė 2017). In Western Europe, land consolidation projects stimulated rural recreation and agro-tourism during water governance, serving as an auxiliary approach to developing rural economy and infrastructures (Stańczuk-Gałwiaczek et al. 2018). In north India, land consolidation not only created the conditions for the construction of rural hospitals, educational facilities, and affordable housing, but also protected and restored natural habitats through planning and provided rural public transportation facilities (Munnangi et al. 2020).

Table 1. Sustainable development goals (SDGs) and land consolidation. Source: Own illustration.

SDG	Target	Possible Land Consolidation Activities Contributing to SDG
1	No poverty	Develop mechanized and modernized agriculture to improve rural income; Create rural non-farm sector jobs to increase income
2	Zero hunger	Increase agricultural productivity and diversity
3	Good health and well-being	Provide space for rural public health, transportation facilities construction; Renew rural housing and improve rural landscape;
4	Quality education	Provide space for rural school construction
6	Clean water and sanitation	Demarcate the boundaries of wetlands, rivers, and lakes to conserve natural resources
10	Reduce inequity	Guarantee the welfare and property right of farmers; Vitalize rural industry to reduce the rural–urban gap
11	Sustainable cities and communities	Stimulate peri-urbanization and urban redevelopment; Enrich social capital in rural communities;
15	Life on land	Arrange conservation and restoration projects to protect biodiversity

Therefore, in recent years, the concept of land consolidation has been comprehensively expanded, covering economy, administration, engineering, and legislation (Long 2014; Zhou et al. 2020). Multiple land financing initiatives and the property market expand the possibilities of consolidation programs (Hartvigsen 2014). Besides, the abundant technological approaches, including assessment, planning, construction, and ex-post evaluation, enable land consolidation projects to improve the machinery, ameliorate land production conditions, and conserve the ecosystem (Liu and Zhao 2017; Mika et al. 2019; Shan et al. 2019). Moreover, the diverse legislation and administration modes, such as state-led, market-led, and self-organized, can inspire farmers to participate in land consolidation (Tang et al. 2017; Zhang et al. 2019a, 2019b).

The modern land consolidation system has already been applied all around the world not only to improve agricultural efficiency but also to achieve other goals including agricultural modernization, interregional equity, and sustainability (Long et al. 2019). Even though land consolidation in different regions has diverse purposes, empirical practice shows that it is an effective tool to improve the agricultural output, promote the local economy, and protect the environment. (Demetriou et al. 2012; Janus and Markuszewska 2019; Zhou et al. 2019).

3.2. China's Concerns on Land Issues

As the most populous country in the world, China has a comparatively limited land resource. The arable land area per capita is only one-fourth of the world average. Moreover, the rapid economic growth and urbanization gave rise to the decline of cultivated land and fragmented land holdings (Xu 2004; Lai et al. 2015). Both the expansion of urban area and the blowout of township enterprises created more demands for construction land. As a result, while the urbanization rate grew from 17.92% to 24.52%, 3.13 million hectares of farmland quickly disappeared between 1980 to and (National Bureau of Statistic of China 1987). In addition, the increasing population and the changing diet structure might even exacerbate the existing pressure on food demand (Wang et al. 2018). This phenomenon has soon attracted the attention of the central government, mainly because of the food security issue associated with the shrinkage of agricultural land.

Notably, the decline of arable land is closely related to the Chinese public land ownership system, which is characterized as a rural–urban dual management system (Long et al. 2010; Tan et al. 2011). The government monopolizes the construction land resource in the primary land market, which means the central and state governments are the only legal providers of new urban construction land. Hence, to meet the demands of the rapid economic and urban growth, local governments tend to implement a large numbers of land acquisition programs (Y. Li et al. 2018; L. Wang et al. 2019). In addition, since the compensation for farmers is comparatively much lower than the price of land, local governments as the main operators can obtain an enormous financial income in the acquisition process. As a result, some policy-makers transferred more cultivated land, exceeding the real demand of development, for local governments' interest (Tan and Zhou 2015).

In the pursuit of preventing the over-occupation of arable land, a series of policies were introduced. In 1986, the State Council of China determined "cherishing and rationally using every inch of land and protecting the cultivated land" as a basic state policy (State Council of People's Republic of China 1986) and set up the Land Administration Bureau which is responsible for national land management affairs in China. In June of the same year, the first special law on land, the Law of Land Administration (LLA), was approved by the central government. For the first time, land consolidation was defined as farmland development and reclamation. In 1987, based on these strategy and policy, a land development meeting was held in Liaoning, advocating more land development to maintain the area of arable land, followed by pilots projects carried out by several provincial governments. From then on, even though most of the consolidation processes were still conducted at grassroots level, arable land protection started (Yun et al. 2016).

However, even though the central government had already noticed the advantage of land consolidation in resuming agricultural production, improving agricultural infrastructure, and keeping farmland area, there was no specific law or related department to govern the national land consolidation process. For a long time, land consolidation in the LLA was just a principle definition without any compulsory requirement or practical guidance (Huang et al. 2011).

The public opinion and social problems in the middle 1990s further magnified the government concerns on food security. In 1994, Lester Brown wrote his famous article "Who will feed China" to express his worries about China's food self-sufficiency and the potential global food crisis (see Brown 1994). The aerial picture of 31 main cities in China in 1996 showed that non-agricultural construction land had expanded rapidly, and arable land had been unexpectedly over-occupied. Consequently, the central government was eager to strengthen a centralized control on land.

3.3. The Formation of the Modern Land Consolidation System in China

China's truly modern land consolidation system was established in 1997. After 10 years of practice, over 400 counties had operated land consolidation by the end of 1997 (Land Rehabilitation and Consolidation Center 2014). Considering their comparatively limited scale, these practices did not affect the whole picture of the reduction in arable land. Having said that, local rulers developed some successful strategies and accumulated a lot of experience from them.

Three major events marked its birth. At the administrative level, the former Land Administrative Bureau was reorganized into the Ministry of Land and Resources of China (MLRC), and a specified department for land consolidation was established. The new department, the National Land Consolidation and Rehabilitation Center, which has also provincial and municipal branches, is responsible for all the related affairs, including initiating national land consolidation projects, providing technical guidance for local land consolidation, managing land consolidation and restoration funds, and conducting engineering and technical research.

At the institutional level, the land use planning system, also known as the land use regulation system, was formulated. The beginning of this system was in 1997, when *The Notice on Further Strengthening Land Management and Practically*

Protecting Cultivated Land called for the implementation of a policy that "links the occupation of cultivated land with development and rehabilitation" (State Council of People's Republic of China 1997). In 1998, this *Dynamic Equilibrium of Total Farmland* system was set up. To further illustrate it, it states that the amount of cultivated land transformed into construction land should not exceed the amount of land reclamation in that region. Based on it, China adopted a set of planning policies which constituted a unified and top–down land use quota system (Tan and Zhou 2015). Three main quotas were designed by the central government and allocated to governments at different levels, covering the maximum of construction land, the minimum of cultivated land, as well as the annual amount of land-use change from farmland to construction land (Tan and Beckmann 2010). All of these quotas focused on farmland. To put it in another way, in this nationwide top-down land planning system, the number of farmlands was the crucial factor which strictly constrained urban expansion and rural modernization. As a key part of restoring and even developing new arable land, land consolidation was soon accepted and implemented.

At the legal level, the LLA was amended in 1998. This document stated that "the State encourages land consolidation", and indicated land consolidation as an indispensable part of the land use planning system. The *Land Management Law Implementation Regulations,* amended later, required that "county- and township-level governments should set up rural collective economic organizations to formulate land consolidation programs in accordance with the overall land use planning" (State Council of People's Republic of China 1998). During this period, MLRC established the first batch of land development and demonstration zones in 20 provinces. Therefore, land consolidation has become an important part of the land use planning system and is gradually evolving into a mature administrative system.

Nowadays, land consolidation has been a comprehensive approach to managing cultivated land. Even though different scholars may have diverse definitions, it is widely accepted in the Chinese academic circle that land consolidation is far beyond simple agricultural production (Zhang et al. 2014; Long 2014; Wang and Zhong 2016; Yun et al. 2016). According to the LLA of 1998, land consolidation is defined as

> the governments at the county and township (town) level, who should organize rural collective economic organizations to comprehensively develop farmland, water, roads, forests, and villages, improve cultivated land quality, increase the effective arable land area, improve agricultural production conditions and the ecological environment in accordance with the overall land use plan. (National People's Congress of People's Republic of China 1998, article 41)

Obviously, both researchers and governments notice the social-economic and ecological functions of land consolidation, such as rural growth, environment protection, and sustainable development. There are some key characters of modern land consolidation: multiple elements including administration, economy, law, and engineering transform and optimize local land use, in accordance with multiple goals and land use planning or urban planning.

3.4. Key Factors of China's Modern Land Consolidation System

While the socio-economic environment changed greatly in the past 40 years, land use in China has also faced a significant change, which has diversified the motivation of land consolidation. Besides the traditional aim of food production, there are five main motivations that play important roles in the establishment and evolution of the modern land consolidation system (Table 2).

Firstly, the demand for industrialization and urbanization still exists, and the sufficient supply of construction land is a crucial reason of the economic miracle of the past 40 years (Ding 2003; Liu 2014). Under the red-line control of land use planning in China, the only possible way to provide enough urban land is to dig the potential of rural land (Liu et al. 2014; Tan et al. 2020). It means that land consolidation should not only rehabilitate more arable land but also create more space for urban expansion.

Secondly, the inefficiency of rural land use in China severely restricts the economic development in rural areas. Rural decline is gradually becoming significant worldwide (Liu and Li 2017). According to the China Statistic Yearbook, the housing area per capita of rural residents increased by 38.6 square meters from 1978 to 2017. While the rural population migrates to urban areas, a large number of rural housings emerge and expand, at the cost of reducing farmland (Mullan et al. 2011; Tang et al. 2017). This phenomenon is known as "village hollowing" (Liu et al. 2019). The paradox of extensive construction land and intensive arable land implies that there is a need to rearrange and renew rural land. Besides, agricultural mechanization should also play a vital role in improving farm efficiency and release labors in the first sector (Tan et al. 2008; Lai et al. 2015; Nguyen and Warr 2020).

Additionally, the wealth gap between rural and urban areas is still huge (R. Wang et al. 2019). Likewise, the infrastructure and public services are comparatively insufficient, leading to worse living conditions for villagers. As the physical carrier, the land resource is both the most important resource of rural vitalization and the most valuable asset for economic growth. Therefore, to promote rural–urban integration and realize a sustainable rural development, rural land must be efficiently managed and utilized.

Moreover, the economic and social structures in rural China are being reshaped due to the great transformation in labors, capital, technology, and institutions (Li et al. 2014; Yang et al. 2016). These changes inevitably affect the spatial arrangement of rural land (Long 2014). Consequently, current land property arrangements and land use plans may not be suitable for the demand of a new form of rural living. That is to say, land consolidation can be implemented as a spatial method in the process of restructuring of the rural society.

Finally, degradation of land quality and environment also exists (Foley et al. 2005; Fan 2006; Gao and Liu 2010). Notably, the lack of effective governance on farmland contributes to problems such as soil erosion, pesticide overuse, nutrition imbalance, and pollution, which have long restricted China's agricultural development. On the other hand, land use is also an important factor for the sustainability of the ecological system. For example, the increase in the area of arable land usually comes from the reclamation of unutilized land and will finally affect the local carrying capacity and biodiversity (Zhang et al. 2014). In general, since the governance of land resource will influence the environment in a complex way, comprehensive land consolidation is needed to reduce negative externalities and provide ecosystem services.

Table 2. Key factors of modern land consolidation in China. Source: Own illustration.

Factor	Phenomenon	Requirenment for Land Consolidation
Urbanization	Unsufficient construction land provision	Integrate rural land to expand urban growth space
Rural decline	Ineffective rural land use; Rural to urban migration	Stimulate rural renewal and agricultural mechanization
Rural–urban inequity	Rural–urban wage gap; Lack of rural welfare	Encourage rural land financing and rural non-farm sector development
Social reshape	Modernized rural living	Use spatial planning to fit and restructure a stable rural society
Ecological degradation	Soil erosion, pesticide overuse, nutrition imbalance, and pollution	Reduce negative environmental impact; enhance ecological restoration projects

Thus, the internal driving factor of land consolidation is the demand of optimization, adjustment, and transformation of the rural socio-economic structure during the industrialization and urbanization processes. This transformation in rural China is so significant that numerous social relationships and values have been reshaped. For rural residences, land consolidation may provide an opportunity to embrace modern lifestyles (Long 2014; R. Wang et al. 2019).

Yet, land consolidation today in rural China has not fully achieved its aims; for instance, the concern about the ecological effect of land consolidation is limited (R. Wang et al. 2019). Another example is the quota system. Many people criticize this policy for over-emphasizing the increase in the amount of cultivated land, which makes the number of cultivated area growth become the main or only criterion when evaluating land consolidation (Du et al. 2018).

One possible reason for this deviation may be the Chinese context. The land consolidation system is shaped by the incentives and constraints in the current political structure. Those who conduct local land consolidation projects are usually more interested in economic rewards, and the decision to start a project is based on a financial trade-off. Furthermore, though the central government has strong incentives to guarantee food security and protect the environment, the decision process and vertical regulation are always costly and difficult (Tan and Zhou 2015). Despite this, the hierarchical management system is not always to be blamed, because the current land planning system still establishes a reallocation and monitoring mechanism among multi-level governments and provides essential financial support for rural development. Above all, it is more important to readjust the existing consolidation system to meet the demand in the real world.

4. The Evolution of the Land Consolidation System in China

Though the land consolidation practices before 1997 were mainly adopted at the local level and did not operate as well as expected, it is obvious that the increasing efforts allowed the central government to accumulate experience and confidence. After that, a national land consolidation system was gradually established and was developed in three main steps (Table 3)

Table 3. Main developing steps of land consolidation in China. Source: Own illustration.

Period	Goals	Main Focus	Policy Tools	Result
Exploring (1997–2004)	Food production	Increase farmland area; Reclaim undeveloped land	Dynamic Equilibrium of Total Farmland; Basic Farmland Protection; Extra Farmland Quota (in some provinces)	2200 national investment consolidation projects from 8 batches; Supplemented 1.4267 million hectares of arable land
Developing (2004–2012)	Food production; Rural–urban equity	Maintain farmland area; Improve farmland quality; Rearrange construction land	Dynamic Equilibrium with same quality; High-Standard Farmland; Linkage between Urban Land Taking and Rural Land Giving (LUTRG)	Supplemented 1.484 million hectares of arable land with same land quantity; Arranged 57,360 hectares of LUTRG
Comprehensive Governance (Since 2013)	farmland area; farmland quality social equity eco-system	Maintain farmland area; Improve farmland quality; Rearrange construction land; Ecological protection and restoration	Comprehensive/ Overhaul Land Consolidation; Ecological red line; Urban–rural land property reform	Over 300 pilot projects of overhaul consolidation; 15 provinces finished ecological red line; Over 150,000 villages participated in land reform

4.1. Exploring Period of Land Consolidation (1997–2004)

Consistent with the description in the LLA, land consolidation in this period mainly focused on constructing agricultural infrastructure and promoting the quality and quantity of farmland (Tan et al. 2006; Tang et al. 2019). In other words, the central government aimed at increasing enough arable land by means of reclamation and rehabilitation at first, to cover the decrease of cultivated land

(Liu et al. 2014; Zhou et al. 2020). Low- and medium-yield farmland consolidation, as well as abandoned industrial and mining land reclamation were the main source of increasing cultivated land in that period (Fan 2006). The main reason might be the strong concerns on food security, and most of the land consolidation projects were implemented around crop production. Meanwhile, since 2000, the Chinese government has launched a large-scale national *Grain to Green* program, which aims at controlling soil erosion and land desertification by converting 146.7 million hectares of arable land into forest and grassland (L. Wang et al. 2019; Yan 2019). This ecological restoration program further stimulated the demand of maintaining arable land. It can be assumed that land consolidation from 1997 to 2004 was somehow a continuation of the traditional agriculture-oriented land consolidation practice. However, two main differences distinguish the traditional and modern approaches.

The first characteristic is the national spatial planning system. In 1999, the State Council promulgated the *Outline of the National Land Use Plan (1997–2010)*. Authorized by the newly amended LLA, this outline had unprecedented authority and importance and emphasized the protection of arable land and the practice of the *Dynamic Equilibrium of Total Farmland* system. The primary purpose of this plan was to preserve the 120 million hectares of arable land. This planning and quota system has strong hierarchical characteristics, since it establishes that the central government decides, allocates and monitors land use change as well as the operation process of land consolidation. As a result, a nationwide multi-level system was built, which can better balance the regional supply and demand and provide a public resource for local operators.

Besides, the *10th Five-Year Planning* from 2001 to 2005 that guided all aspects of the national economy was also highly concerned with land rehabilitation and consolidation. In 2001, the *National Land Development and Consolidation Plan (2001–2010)* which advocated to replenish 2.76 million hectares of arable land until the end of 2010 was issued, and then the first batch of land consolidation projects supported by nation-level finance were set up.

Another initiative of this period was the quota incentives of the land planning system. The LLA tried to advocate local land consolidation, but no incentive mechanism was adopted at first. However, in response to the central government advocating on land consolidation, Zhejiang Province created a new construction land quota in its provincial area in 1998. Specifically, when a land consolidation project was implemented and a certain extent of arable land was created, a construction land quota equal to 72% of its area was also created. Therefore, the local government in Zhejiang could convert an extra amount of rural land into urban construction land after land consolidation, offsetting the cost of land consolidation projects by the rent of the additional land. Because the demand of construction land in Zhejiang was abundant, the local government could at the same promote local development and get financial income time by means of land consolidation. In the end of 2003, over half of the new construction land in Zhejiang came from the extra quota system.

Actually, the institution innovation in Zhejiang broke the regulation of the central government. The MLRC first required that the extra quota of municipal government should be taken into account in the total provincial quota, which meant that the extent of cultivated land occupation was still under the cap of central planning. However, later in 2000, several documents such as the Regulation of Land Consolidation extended this quota system to the central level. Therefore, land consolidation projects could exceed the limitation on construction land while in line with the land use planning. The MLRC cancelled all these systems in 2007, but a supplementary system which will be introduced later was issued soon.

By the end of the five-year planning in 2005, China had arranged over 2200 national investment consolidation projects from 8 batches, with a total investment of nearly 29 billion yuan, and a total of 25 billion yuan had been issued. About 1.58 million hectares of cultivated land were developed and reorganized through those projects (Wu 2015).

At this stage, land consolidation plays a very important role in ensuring that the extent of cultivated land does not decrease (Liu et al. 2018). As of the end of 2005, China had supplemented 1.4267 million hectares of arable land, while the area occupied by construction and subjected to disasters during the same period was 1.348 million hectares. All provinces achieved a dynamic equilibrium of total arable land (Fan 2006). During this period, land consolidation effectively realized the core task of arable land protection by mainly reclaiming undeveloped land, while reclaiming constructed land as a supplement (Lichtenberg and Ding 2008; Du et al. 2018). However, despite the fact that the farmland area remained stable, the newly reclaimed and supplemented land had comparatively a low quality and contributed little to crop production (L. Wang et al. 2019).

4.2. Developing Period of Land Consolidation (2005–2012)

With the successful completion of the *10th Five-Year Planning*, the red line of cultivated land in rural areas was effectively protected. However, due to the development and utilization of undeveloped land resources in the past decade, it was increasingly difficult to further reclaim farmland in order to increase its extent (Yun et al. 2016). At the same time, the gap between urban and rural areas had further widened. Therefore, how to solve urban–rural equity problem and realize rural development had become an important issue for maintaining social stability.

Around 2005, the strategy of land consolidation was updated from "number management" to "rural comprehensive management" (Tang et al. 2019). On the one hand, while food security was still one of the core issues, the improvement of rural infrastructure with the main purpose of increasing the quality of farmland and increasing food productivity had gradually become the mainstream. On the other hand, the improvement of rural areas, which includes both agricultural land and rural construction land, had become an important approach to rural land improvement.

In 2004, based on the protection of the cultivated land quantity, China proposed that "the quantity and quality of supplementary cultivated land should be converted into grades, to prevent replacing more with less and replacing the good with the bad" (State Council of People's Republic of China 2004). In other words, after arable land is occupied by urban construction, not only the area of arable land cannot decrease, but also the productivity of arable land cannot reduce. Since 2005, MLRC issued several policy documents, taking the improvement of comprehensive agricultural production capacity as the starting point for land consolidation. Nonetheless, clear requirements and standards of quality-oriented land consolidation were set up, regarding soil, irrigation, spatial distribution, and pollution. To further carry out the practice of preserving and promoting the quality of cultivated land, in 2006, MLRC established demonstration areas for basic farmland protection in 116 counties nationwide. Through the implementation of land consolidation to build "high-standard basic farmland", it achieved large-scale, high-yield, complete infrastructure, and disaster-resistance agricultural goals. Though food production growth still mainly depended on the increase of arable area, quality control remained indispensable (Du et al. 2018). From 2006 to 2012, 1.484 million hectares of cultivated land were supplemented, which corresponded to the amount of farmland occupied by urban construction, and all followed the rule of quality and quantity equilibrium.

Notably, village rearrangement and renewal associated with land consolidation rapidly developed in this period. In contrast, the reclamation of rural construction land had started a little earlier. In 1999, the MLRC formulated a policy of *Land Exchange*, which allowed rural residents to swap the land use of their farmland and housing land without changing the area. Considering the cost of demolition, reconstruction, and reclamation, this policy was rarely implemented. Likewise, in 2000, Zhejiang updated its extra quota system, which originally only allowed farmers to increase cultivated land area by farmland consolidation, to covering construction land reclamation. According to this, if the local government got some increasing farmland through demolition and consolidation of former construction land, it could obtain the same amount of construction land quota and then spend it in urban expansion or trade in quota market. Though Zhejiang was soon ordered to abolish this policy because of the risk of social and political instability, its experience attracted the interest of the central government.

After the State Council proposed in 2004 that “the increase in urban construction land should be linked to the reduction in rural construction land” (State Council of People’s Republic of China 2004), MLRC began to gradually implement the pilot work of a new quota system called *Linkage between Urban Land Taking and Rural Land Giving (LUTRG)* in 2005. Similar to the exploration in Zhejiang, this national system allows local governments to preserve land, cultivate more arable land during the land consolidation process, and use the related profits for local development. Importantly, different from the system in Zhejiang, this LUTRG system should be approved by the central government, thus land use can be vertically controlled. As a result, LUTRG encouraged local governments to improve the efficiency and intensity of land use in rural settlements (Tan et al. 2020).

The LUTRG pilot project achieved very significant results. In 2012, the LUTRG quota reached 57,360 hectares nationwide. Especially, the Chinese government stimulated the domestic economy through monetary policy during the 2008 economic crisis, which indirectly played a strong role in increasing the urban construction land price. The rapid growth of urban land rent had caused a huge gap between agricultural land and construction land prices. As a result, the financial benefits that LUTRG programs could provide far exceeded the cost of adopting land consolidation, which soon became an important incentive for local governments. Discovering this opportunity, many local governments in China began to implement LUTRG to reorganize rural areas. Therefore, the inefficient rural construction land use was improved.

4.3. Comprehensive Period of Land Consolidation (Since 2013)

The report of the 17th Central Committee of the Communist Party of China (CCCPC) in 2007 proposed eco-civilization as a main strategy. As an important approach to optimizing and managing natural resource, land consolidation was also updated to *Comprehensive Land Consolidation*, which was given a rich ecosystem connotation.

This comprehensive concept was raised in 2012 when MLRC formulated the *National Land Development and Consolidation Plan (2011–2015)*. It was defined as a systematic project aimed at improving rural production, living conditions, and the ecological environment by comprehensively consolidating farmland, water, roads, forests, and villages. Moreover, later in 2017, the *National Land Development and Consolidation Plan (2015–2020)* further illustrated the purpose of comprehensive land consolidation including large-scale agriculture, population concentration, industrial agglomeration, and urban–rural integration. Another similar idea is the *Overhaul Land Consolidation*, which emphasizes that land consolidation and rural governance should link together all the factors of a socio-ecological system, reinforcing the diverse actors and intensifying a cross-regional cooperation in resource management. In December 2019, the central government launched a pilot project for *Overhaul Land Consolidation* nationwide and planned to set more than 300 pilot projects in 2020. Another policy design was the *Ecological Redline*, referring to the spatial boundary between natural ecological service functions, environmental quality and safety, and natural resource utilization. Until the end of 2018, 15 ecologically important provinces had already formulated their ecological redline. The remaining provinces were required to complete the redline by the end of 2020. Apparently, the rural society and ecosystem structure are facing a tremendous change under this new round of comprehensive consolidation.

Besides, another main change took place in the rural–urban relationship (Liu 2014). Several reforms of the current rural–urban land dual system were adopted, when a large number of large-scale land consolidation projects were implemented at the provincial level according to the overall reform plan. In 2015, the MLRC launched a new round of urban–rural land property reform, selecting 33 county-level pilot areas throughout the nation for reform of land acquisition, housing land, and commercially used construction land in rural China. So far, over 150,000 villages have participated in the reform, which includes the marketization of the rural property right, the decentralization of land management, the diversification of land use, and the support to rural industry. These reforms have achieved significant success in giving farmers land property rights, coordinating multiple plans, innovating urban–rural market mechanisms, and optimizing the allocation of natural resources (Cao and Zhang 2018; Tan et al. 2020; Xie et al. 2019).

In 2016, the Chinese central government introduced *China's National Plan on Implementation of the 2030 Agenda for Sustainable Development*, which aimed to achieve SDGs through political, economic, social, and ecological construction. In response to the SDG 15 (Life on land), this agenda especially emphasized the *Grain to Green* program and ecological restoration of land. Therefore, against the backdrop of land degradation and ecological loss, comprehensive land consolidation projects were implemented with afforestation, grass planting, and ecological engineering projects such as the prevention of soil erosion. Later in 2017, the Chinese government proposed the idea of *Ecological Redline* which refers to areas in which development is prohibited. Until now, land consolidation has corroborated its sustainable development function of green and clean food provision, rural infrastructure construction, and environmental protection.

Nowadays, land consolidation is more than engineering method for agricultural purpose. First, at the method level, land consolidation involves multi-dimensional governance tools such as economics, administration, and engineering. Secondly, at the institution level, relative formal institutions, for instance the land planning and quota transactions system, have become an integral part of land consolidation, and vice versa. At the target level, land consolidation has a richer connotation in pursuing more non-agricultural and non-economic objectives. Nevertheless, at the spatial level, both urban and rural systems are involved in the implementation of land consolidation.

5. Influence of Land Consolidation

5.1. Food Production

Land consolidation has played a vital role in ensuring China's food security (Lichtenberg and Ding 2008; Zhang et al. 2014; Jin et al. 2017). From 1997 to 2018, China invested 76.17 billion dollars on national land consolidation projects, and 42.7 million hectares of developed farmland (35% of national farmland) were constructed (Bryan et al. 2018). Through land leveling, field roads, farmland irrigation and drainage, and farmland forest network projects, land consolidation increased the potential of farmland production, increased the provision of infrastructure in rural areas, promoted the development of mechanized agriculture, and effectively increased the amount of food while retaining the amount of cultivated land productive forces. Since the implementation of land consolidation nationwide in 1997, while the total area of arable land has gradually decreased because of urbanization, China's total grain output has increased from 504 million tons in 1997 to 664 million tons in 2019, which thoroughly compensated the loss of farmland (Song and Pijanowski 2014). Although the increase is also closely attributed to other relative factors such as technological progress and scientific management, there is no doubt that the land consolidation policy, represented by high-standard basic farmland construction, has huge significance for improving land productivity and realizing a modern agricultural production (Du et al. 2018). As its primary goal, land consolidation has to some extent alleviated the threat of food security resulting from the reduction in the amount of cultivated land and effectively promoted the efficient use of agricultural land and is the fundamental way to ensure national food security.

This is consistent with the SDG of food security. According to the Report on China's implementation of the Millennium Development Goals (2000–2015), China has reduced the portion of malnourished population from 23.9% in 1990 to 10.6% in 2014, halving the population suffering from hunger (Ministry of Foreign Affairs People's Republic of China and United Nations System in China 2015). In 2019, China achieved 470 kg of food output per capita and a grain self-sufficiency rate of over 95% (National Bureau of Statistic of China 2019). As a country with a huge population, China solves the food provision problem for 20% of the international population with only 9% of global arable land, which alleviates the international food provision pressure. Therefore, the land consolidation program has made a remarkable contribution not only to diminishing hunger in China, but also to ensuring global food security.

5.2. Spatial Arrangement

Rural space is the basic carrier of rural vitalization and rural–urban integration development. Currently, land consolidation projects have deeply reshaped the rural spatial structure of China (Long 2014). On the one hand, land consolidation directly changes the spatial arrangement of land use. While the productivity of cultivated land improves, the physical characteristics of farmland is also altered. For instance, intensively organized cultivated land may not only provide a better yield, but also change the terrain and land use, which will affect the lifestyle and human–nature relationship in rural areas. Consequently, in those rural construction land use cases of comparatively higher density which resulted from land consolidation and LUTRG projects, village's spatial forms, farmers' production methods, and lifestyle have also changed dramatically (Lo et al. 2016; Chen et al. 2018).

In this process, land consolidation programs serve as the primary way for contemporary China to solve the problem of inefficient land use in both rural and urban areas. With the help of market mechanisms, land consolidation successfully meets the demand for new construction land of urbanization and industrialization and realize the optimal allocation of urban and rural land. For example, LUTRG, through the transformation and redevelopment of rural residential areas, has concentrated the resettlement of previously excessively extensive rural construction land without threatening the red-ine of cultivated land. Furthermore, the land quota created by means of land consolidation can also supply the necessary construction land for urban development, easing the pressure of urban expansion. Additionally, agricultural infrastructures, health and education facilities, affordable housing, and roads are offered and promoted, which greatly improves the living conditions in rural areas (C. Li et al. 2018). In this way, land consolidation optimizes the allocation of the rural land resource and promotes sustainable development. This rural village renewal along with land consolidation can improve the health, education, and living conditions of rural residents, meeting the SDGs of rural sustainable development.

Spatial changes in rural China are the inevitable consequence of socio-economic development (Zhou et al. 2013). Considering the migration of labor, flow of capital, and spread of technology between the rural and the urban areas during the process of urbanization and industrialization, there is a need for a modern spatial distribution. In certain areas of China, land consolidation projects lead to social conflict, because the over-agglomeration of villages violates the plans of farmers. Rural residents have to live uncomfortably in the new rural communities, while their economic sources and lifestyle remain unchanged, and they suffer from higher costs of production and living (Lo et al. 2016). To achieve the goal of rural development, operators should establish favorable rural production, living, and ecological spaces in the land consolidation process.

5.3. Rural–Urban Equity

As an important policy instrument to promote rural vitalization, land consolidation is essential to improve rural productivity and living standards, which is beneficial for achieving the SDG of reducing the rural–urban gap. For a long time, rural development has been one of the first topics of concern of the Chinese government. A large number of related policies such as those related to rural renewal and new rural construction have been formulated. In fact, the function of land consolidation is highly consistent with the needs of rural renewal, which determines that land consolidation can be implemented as an important work platform for rural development.

The most direct impact of land consolidation is to increase farmers' income and improve the rural living environment (Wu et al. 2005; Du et al. 2018). Undoubtedly, because land consolidation can effectively increase the agricultural production, farmers will also benefit from it and augment their economic income. However, considering that the share of agricultural income in the income of rural residents is decreasing, more economic benefits farmers receive from land consolidation come from quota transactions. Due to the high price of construction land in recent years, the construction land quota generated by the land consolidation project can get a generous return in the land property market. In addition, farmers are property owners of rural land, which means that after deducting the development costs, a considerable portion of the profit from the land consolidation quota transaction will be distributed to villagers or rural collectives. In addition, rural roads, houses, landscapes, and supporting facilities have also been developed and improved during the land consolidation process. For example, high-quality houses with masonry and concrete structures have already become common in rural China.

The land consolidation also brings indirect opportunities for sustainable rural development. In the past two decades, China's rural economy has developed vigorously, with modern agriculture, tourism, and processing industries in rural areas developing especially rapidly. The reason is that the land consolidation policy effectively revitalizes those inefficient rural lands and at the same time allows rural residents to obtain the capital necessary for development through the redistribution of land market revenue. Both of them stimulate the development of rural industries. This is why the land consolidation project is widely supported in rural China. In recent years, the central government has also implemented the land consolidation project as an important way to boost the rural economy and reduce the urban–rural inequality.

5.4. Ecology Conservation

The purpose and function of land consolidation from an ecological perspective have changed significantly over time. If the previous consolidation approaches ignored the ecological impact, the first two stages of the modern land consolidation system in China still put environment conservation and restoration in a secondary position. Consequently, environmental issues including soil erosion, water pollution, and biodiversity decline have emerged (Shan et al. 2019; Zhong et al. 2020; Guo et al. 2020). This caused a confusing paradox: the restoration programs such as the *Grain to Green* sacrificed arable land to improve environmental services, meanwhile land consolidation projects reclaimed undeveloped land to supplement arable land, which decreased the rural ecosystem capacity. This contradiction weakened the significance and effectiveness of the land consolidation system.

In recent years, increasing attention has been paid to the ecological conservation function of land consolidation projects. The relevant comprehensive consolidation framework has also provided solutions to environmental issues linked to land resources utility in rural areas. Due to the relatively short period of policy implementation, the results of these initiatives are still unclear. However, despite this, the approaches for water governance, mine rehabilitation, and farmland ecological improvement in some pilot projects partially reflect the ecological tendency of the comprehensive land consolidation approach. This provides the possibility to conserve and restore the rural environment to meet the demand of SDGs.

5.5. Institutiol Establishment

Land consolidation is an indispensable part of China's land use planning and regulation system. The implementation of nearly every rural land-related policy, whether it is about cultivated land preservation, rural construction land reclamation, or ecological land protection, should be ultimately settled on land. Therefore, land consolidation is an inseparable policy tool to govern rural issues. Actually, since the *10th Five-Year Planning*, the continuous improvement of the land consolidation system has been synchronized with the development of the land control system. The land consolidation management framework including project management, supervision, acceptance, quota control, and market-based transactions has become one of the foundations of China's rural land governance system. More importantly, thanks to the land consolidation project, China's land planning system can introduce a more flexible mechanism of quota market into the hierarchical administrative process. By this mean, the spatial rearrangement and readjustment of cultivated land can be implemented under a cross-regional context, which can better balance and coordinate the multiple demands from different actors. Currently, under the triple requirements of cultivated land protection, economic development, and ecological civilization, the land use regulation system is still the institutional basis of China's land management, in which land consolidation will continue to play an irreplaceable role.

6. Conclusions

Given the goals of sustainable development, this research reveals three main developing steps of Chinese land consolidation system and summarizes its background, characteristics, motivations, and effects. Two main findings result from this research:

(1) The evolution process is conducted in a top–down manner by the central government, while local exploration and pilot projects provide a learning experience for states;
(2) Land consolidation projects can have a positive effect on food production, spatial utilization, rural sustainable development. and ecology conservation, but their details should be handled according to each specific context.

From a traditional agricultural approach to a modern comprehensive system, Chinese land consolidation has extended its multiple goals and introduced diverse methods, which are related to changes in the national interest and focus. The potential crisis of food security in the end of the 1990s urged the Chinese government to put forward land consolidation programs. Later in the early 2000s, the rapid urbanization brought about the imbalanced development between rural and urban regions, which further called for economic and social promotion in rural areas. Recently, the space for urban and rural development further shrank, so it has been necessary to utilize land resources in a more efficient and economical way in place of the extensive land use model in the past.

In addition, in coordination with rural changes during the urbanization and industrialization process, land consolidation projects have been widely implemented to improve farmland productivity, rural infrastructures, construction land supply, and eco-system services. Meanwhile, even if there are still some negative externalities, such as over-agglomeration of rural villages and ignorance of biodiversity, this current modern system is running effectively with respect to food supply, rural vitalization, and urban development. Besides, environmental improvement related to land consolidation projects is gradually beginning to appear.

Additionally, other developing countries can learn from this experience that land consolidation and readjustment can exert a great influence on many aspects of economy and society, from food production to sustainable rural development and efficient urban development. These purposes can be pursued intensively at the same time by land consolidation because of its multifunctionality. Notably, one possible solution is the quantity policy, such as land quota. It can well guide local actors in participating in land consolidation activities to a proper degree, especially when supervision and regulation abilities are limited. Secondly, spatial policies, for example plans by the state or the federal government, can be implemented for issues with strict constraints. This requires a comparatively stronger government, as well as local actors who can express their interest through public participation. However, there is no rule that fits every case. More importantly, because of the the complexity of each situation, all initiatives should be decided carefully, and their side effects such as ecological loss, should be considered.

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Combating Pasture Degradation in Central Asia and the Caucasus—A Review of Approaches †

Regina Neudert

† Section 3 draws on the synopsis part of the author's Ph.D. thesis entitled *Pasture Use of Mobile Pastoralists in Azerbaijan under Institutional Economic, Farm Economic and Ecological Aspects*. University of Greifswald.

1. Introduction

Degradation and unsustainable land use are recurring topics in pastoral systems. Grassland degradation incurs costs of USD 6.8 billion globally, only accounting for the loss of milk and meat production (Kwon et al. 2016). Le et al. (2016) found that, around the globe, 33% of grasslands, 25% of shrubland and 23% of sparse vegetation, which is often used for grazing, are degraded. Thus, globally, grasslands are assessed as the ecosystem type with the most widespread degradation. Improving rangeland management could make a crucial contribution to achieving Sustainable Development Goal (SDG) 15: "Life on Land" for dryland and mountain ecosystems. The topic is especially relevant for goal 15.3: "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world" (UNDP 2020).

Land degradation is commonly understood as a reduction or loss in biological or economic productivity resulting from land uses or a combination of processes involving human activities (UNCCD 1994). Degradation typically is characterized by a persistent decrease in ecosystems to deliver ecosystem services (MEA 2005). Degradation involves reductions in vegetation cover, species changes, erosion or sedimentation, as well as disruptions in biogeochemical cycles in soils (Reynolds et al. 2007). Typically, degradation processes in drylands have multiple drivers producing diverse pathways depending on regions and time periods (Geist and Lambin 2004). While most processes are linear, non-linear, discontinuous processes may also occur (Suding and Hobbs 2009), making it difficult to formulate a clear definition of degradation that is applicable in all cases (Behnke and Mortimore 2016). In Central Asia, drivers of land degradation are mainly salinization, soil erosion and soil fertility depletion in croplands, whereas livestock-induced changes are most frequent for rangelands (Mirzabaev et al. 2016). While the existence of degradation processes in Central Asian rangelands is uncontested, assessments of the extent and severity vary widely depending on the definition of degradation and methods used (Jamsranjav et al. 2018; S. Robinson 2016).

In Central Asia and the Caucasus region (CAC)[1] rangelands are the dominating land use and are thus relevant for achieving SDG 15.3 globally. The enormous importance of rangelands for land use in the CAC region countries is illustrated by their land cover: 56% of the total land area or 78% of the agricultural land is grassland (FAOSTAT 2020). This comprises 22% of the total grasslands worldwide (FAOSTAT 2020). Recent field data on grassland degradation in the CAC region are scarce compared to the Soviet period and often poorly documented, making it difficult to provide detailed and scientifically sound assessments on the current extent of degradation (S. Robinson 2016; Kerven et al. 2012). Based on global remote sensing data, Le et al. (2016) estimate that in Asia, 24% of grasslands, 33% of shrublands and 43% of sparse vegetation are degraded. In addition, in Central Asia rangeland, degradation is estimated to incur the highest costs compared to other forms of land degradation, such as desertification, deforestation and abandonment of croplands (Mirzabaev et al. 2016).

Different definitions for rangelands exist, but most of them emphasize that rangelands are dominated by grassy or shrubby vegetation and primarily support land uses associated with grazing animals (Lund 2007; Briske 2017). In the CAC region, rangelands are typically found in marginal areas, where arable farming is not possible due to cold or dry climate (Khazanov 1984). I define mobile pastoralism as a land use form using different livestock species, ranging from goats and sheep to horses, cattle, yak and camels, and involving nomadic or transhumant mobility between pasture sites (Dong 2016). Grazing areas in the CAC region can comprise steppes and semi-deserts, open areas in the forest zone as well as alpine and subalpine meadows in high mountain regions. Making use of marginal lands under extreme climatic conditions involves well-adapted livestock keeping practices, relatively large herds and special forms of human organization. This characterizes mobile pastoralist systems as closely interlinked social–ecological–technical systems (Scholz 1995).

A crucial aspect for sustainable rangeland management is the governance of rangeland access and use (Herrera et al. 2014a; Bedunah and Angerer 2012).

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[1] I define the CAC region as comprising the post-socialist countries in the South Caucasus (Georgia, Armenia, Azerbaijan) and in Central (Middle) Asia (Turkmenistan, Uzbekistan, Tajikistan, Kyrgyzstan, Kazakhstan, Mongolia) and as a special case, Inner Mongolia, China.

Rangeland governance is a multi-faceted concept comprising regulations pertaining towards rangeland use and the resulting interaction of stakeholders at various levels. This encompasses international and government regulations in addition to the interactions of various stakeholders, community-based management as well as informal norms and practices of interaction between rangeland users (Herrera et al. 2014b). The governance regime has a huge impact on the practices of pastoralism, enabling, enhancing or precluding secure access to rangelands, cooperation among herders, mobility and flexibility in rangeland use. These practices decisively influence direct drivers of rangeland degradation, such as high stocking rates, lacking mobility and lacking maintenance of infrastructure (Mirzabaev et al. 2016). The mobile and flexible nature of pastoralism thus requires balancing the contradicting needs of security and flexibility of access and use, which is known as the "paradox of pastoral land tenure" (Fernandez-Gimenez 2002). Balancing these needs in land tenure is challenging, as it requires a suitable legal framework for rangeland governance complemented by informal norms.

Present-day pastoralism is also shaped by more recent political, social and economic influences. The CAC countries share a common history of socialist influence, trying to deeply transform pastoral organization, land access and management (Verdery 2004; see Shaumarov and Birner 2016 or Robinson and Milner-Gulland 2003 for examples). Large-scale, input-intensive systems of pastoralism with reduced mobility evolved until the 1980s. Starting in most states with the dissolution of the Soviet Union in 1990, the countries are characterized by an ongoing process of post-socialist transition, comprising a deep change in political, social and economic organization and practices (Roland 2000, 2012; for China: reforms in the "post-reform period": Yu and Kasymov 2020) involving for mobile pastoralists a complete reorganization of pastoral groups, operation under the conditions of the market and the reorganization of land access and management. With formal independence or reforms in the political system, each country has begun its individual socio-political transition decisions and processes with regard to the general economy and pastoral land use. These policies are outcomes of complex negotiation and decision-making processes influenced by various stakeholders and interests (Cairney 2019; Kasymov et al. 2016). In pasture governance in many CAC countries, decisive roles are attributed to national level governments and international development organizations (Kasymov et al. 2016; Jaborov et al. 2017). Thus, starting from a similar history of socialist influence, transition policies and trajectories of the individual countries have varied in the last 30 years.

The fact that all CAC countries are characterized by a combination of ecological occurrence of temperate grasslands, heritages of mobile pastoralism, similar socialist influence and now diverging paths of policy making and economic development makes the region an interesting showcase for comparative studies on the impact of different policies in resource governance and sustainable land use. Policies range from a near privatization of pastures to approaches involving open and common access to pastures (Behnke 2008; S. Robinson 2020).

When taking a closer look (or sometimes clearly spelled out by stakeholders themselves or in analyses of policy processes), these policies are motivated by implicit paradigms of how rangelands should be managed and degradation can be avoided. These paradigms are also relevant for general discussions on resource and land governance beyond pastoralism. In this contribution, I review these paradigms and link them to policies of rangeland governance in the CAC countries. In addition, qualitative evaluations of socio-economic and ecological outcomes in relation to the governance regime as provided in the scientific literature are reviewed. Socio-economic outcomes assess the impact that the governance regime has on social organization, mobility and the management of herds. Ecological outcomes target the impact of the governance regime on rangeland conditions, i.e., differentiated use pressure and evidence for degradation.

The analysis is based on a narrative literature review (Galvan and Galvan 2017). The literature on governance approaches for the different CAC countries was acquired by keyword searches in the English-language scientific literature databases Web of Science and Google scholar, combining the keywords pasture, rangeland, mobile pastoralism, governance, land tenure, property rights and degradation with specific country or region names. Due to the scarcity of literature in this specific field, the literature obtained was complemented by snowball searches of citing and cited literature, expanding the literature body also to book articles and reports (Bailey 1978). Priority was given to the most recent and most detailed literature sources, ideally drawing on first-hand or empirical information from the specific countries.

In this contribution, the analysis starts with characterizing forms of pastoralism in CAC (Section 2) and depicting four paradigms of rangeland governance (Section 3). Rangeland governance approaches in the ten CAC countries are reviewed, their relation to the paradigms of rangeland governance is characterized and socio-economic and ecological outcomes are depicted (Section 4). Results are summarized and discussed (Section 5) and conclusions are drawn (Section 6).

2. Forms of Pastoralism in the CAC Region

Pastoralism occurs in many forms in the CAC region. I distinguish pastoralism according to the extent of household mobility into nomadic and transhumant forms, then according migration type into horizontal or vertical types and then characterize agropastoral forms. Forms of stationary livestock keeping and systems dominated solely by enclosed pasturing ("ranching") are excluded, although some traditional pastoral land uses might involve tendencies to stationary livestock keeping or ranching (e.g., in Kazakhstan: Kerven et al. 2016b). The different forms (nomadic vs. transhumant, or horizontal vs. vertical) should be rather seen as dimensions of a continuous space rather than clear-cut classifications (Dyson-Hudson and Dyson-Hudson 1980).

2.1. Nomadic and Transhumant Pastoralism

Nomadic pastoral groups are characterized by extensive mobility. This may comprise migration patterns with up to 1000 km per year, several single moves per year and the absence of a permanent home base for the pastoral household (Dong 2016). In the CAC region, e.g., pastoralists in the desert-steppe in Mongolia covered 1992 in up to 20 moves more than 200 km (Mearns 1993). Pre-socialist movement patterns of Kazakh nomads covered up to 700 km (Robinson and Milner-Gulland 2003). Movements mostly follow a seasonal pattern according to climate and vegetation differences in the region, but exact locations and move timings vary according to the weather conditions in each year. With this land use pattern, nomadic pastoralism is well adapted to variable rainfall patterns, especially under arid and semi-arid conditions, making use of scarce forage resources variable in space and time (Mearns 1993). Nomadic movements in the CAC region are also motivated by low temperatures and snowfall (e.g., Robinson and Milner-Gulland 2003; Mearns 1993). Housing constructions adapted to mobility emerged as yurts or tents in traditional forms (Dong 2016).

Nomadic pastoralism was historically (and partly still is) widespread in Central Asia, especially in Mongolia (Fernandez-Gimenez 1999), China (Inner Mongolia) and high elevations of Tibet (Thwaites et al. 1998; Manderscheid 2001), but also in Kazakhstan (Robinson and Milner-Gulland 2003).

The integration of nomadic pastoral peoples into state structures was historically difficult, having often led to a suppression of mobility and forced settlement (Amitai and Biran 2005). In modern times, there is a tendency towards shorter migration and the transformation of nomadic to transhumant pastoralism (see below) due political changes and the amenities offered by permanent housing locations (such as access to infrastructure: running water, permanent electricity and education; Ehlers and Kreutzmann (2000); Mearns (1993)).

In transhumant pastoralism, the livestock-keeping household has a permanent home base and conducts seasonal migrations to other rather fixed pasture locations (Dong 2016). The pastoral household spends at least one season in the permanent home. In other seasons, the whole household or parts of it live on other pastures. Collective herding practices enable that only a single member of the household or only the livestock under care of another herder is on migration, while the household resides in the permanent home.

More specific classifications of transhumant pastoralism are set up according to the location of the permanent home base in the migration pattern or the number and persons involved in the moves (Beuermann 1967; Ehlers and Kreutzmann 2000).

2.2. *Vertical, Horizontal and Radial Mobility*

Horizontal or vertical mobility can occur in principle with nomadic and transhumant pastoralism. Horizontal migration occurs along climatic zones more or less in a similar elevation and characterized by more southern or northern locations. In the CAC region, horizontal migration occurs mainly in Mongolia and Kazakhstan (Robinson and Milner-Gulland 2003; Fernandez-Gimenez 1999). As horizontal migration involves longer distances, it occurs more frequently with nomadic pastoralism.

Vertical migration allows livestock to use different vegetation zones along an altitudinal gradient in mountain regions. Seasonal pastures are thus mainly characterized by a higher or lower elevation and (sometimes) exposition. While lower elevations are used during the winter months, subalpine and alpine pastures provide seasonal forage during summer. Due to the compact occurrence of vegetation zones along altitudinal gradients, migration distances are mainly shorter (a few to hundreds of kilometers). Vertical migration occurs more often with transhumant pastoralism (Dong 2016). In the CAC region, vertical migration systems occur virtually everywhere, where altitudinal differences exist: in the Caucasus as well as Altay and Tien Shan mountains (Stadelbauer 1984; Mestre 2019; Kreutzmann et al. 2011; Hauck et al. 2016).

A special form of mobility occurs when pastoralism is constrained by key resources, such as water points or wells. In this case, the movement pattern resembles a concentration of livestock and camps under strong resource constraints and a wider dispersion in the surroundings in less constrained seasons. In the CAC region, this mobility pattern occurs among pastoralists in Turkmenistan (Ferret 2014).

Mixed forms of migration may also exist, e.g., nomadic migration patterns in Mongolia.

2.3. Agropastoralism

In agropastoralism or combined mountain agriculture, pastoral groups combine mobile livestock keeping with arable farming, though they still receive a significant part of their income from livestock. While among pastoral groups sowing cereals in winter/spring locations is also conducted for improving the forage base of young or weak livestock (Suttie and Reynolds 2003), agropastoralism involves arable farming for harvesting crops directly for consumption or sale (Kerven et al. 2012).

Arable farming is often combined with transhumant pastoralism and vertical movements. Crops are grown at the permanent home base of the household or at intermediate steps during migration (Kerven et al. 2012; Ehlers and Kreutzmann 2000).

3. Paradigms of Rangeland Governance and Use

This section presents four paradigms of resource use and governance with relevance for rangelands. The paradigms include, in most cases, a characterization of rangelands and explanations for unsustainable use often termed "degradation" or "overstocking". A central part is recommendations for a rangeland property rights regime and how a sustainable management of rangelands can be achieved.

Central for the understanding of paradigms of rangeland governance is the discussion on equilibrium or non-equilibrium ecosystem dynamics in rangeland ecology. Before turning to the governance paradigms themselves, equilibrium and non-equilibrium understandings of rangeland ecology are presented.

The equilibrium model of rangeland ecology rests on the theory of plant succession. It assumes a climax state, which depends on the physical characteristics of a particular site (Clements 1916; Meiners et al. 2015). In grazed rangelands, plant succession is hindered, and instead a subclimax establishes according to the grazing intensity of herbivores (Todd and Hoffman 1999). Range management under equilibrium conditions is aimed at regulating the stocking rate of livestock in order to balance grazing pressure with forage supply in a limited area (Westoby et al. 1989). Thus, degradation occurs on the rangeland plot if the stocking rate is not adapted to the regeneration potential of the vegetation. Large-scale mobility of livestock is not taken into account. To date, this paradigm has been successfully applied in range management in Northern America and Australia, while development measures based on it led to devastating effects in African rangelands (Dijkman 1998).

Based on evidence from rangelands in the Sahel zone, the non-equilibrium paradigm was developed, which emphasizes the influence of abiotic factors on ecosystem states, particularly precipitation, and the limited capacity for internal regulation of those ecosystems (Behnke and Scoones 1993; Ellis and Swift 1988; DeAngelis and Waterhouse 1987). From the perspective of the non-equilibrium paradigm, the equilibrium paradigm of rangeland ecology was criticized mainly for lacking empirical evidence for the existence of equilibrial ecosystems and insufficient recognition of dynamic ecosystem processes (Briske et al. 2003). Instead of a close coupling of livestock and vegetation dynamics as suggested by the equilibrium model, under non-equilibrium conditions, ecosystem changes are driven by periodic and stochastic climatic events. Recurring droughts reduce livestock numbers to such an extent that livestock-density-dependent regulation mechanisms are of minor importance. Thus, under extreme non-equilibrium conditions, livestock-induced degradation processes are irrelevant. Instead, a flexible adjustment of stocking rates to the variable forage supply is recommended in order to improve rangeland management (Scoones 1994; Scoones 1992). The recommendations include temporal and spatial tracking of forage availability with flexible movements and possibilities for the sale and rebuying of livestock in drought events (Behnke and Kerven 1994; Ellis and Swift 1988; Illius et al. 1998).

The comparative testing of equilibrium and non-equilibrium models led to a synthesis of both approaches. Rangeland ecologists now predominantly assume a continuum between equilibrium and non-equilibrium characteristics, which depends on physical site conditions as well as spatial and temporal scales (Briske et al. 2003; Fernandez-Gimenez and Allen-Diaz 1999). Inappropriate rangeland use and degradation may even occur in non-equilibrium systems in key resource areas or following infrastructural developments, such as the provision of water points or external fodder (Illius and O'Connor 1999). The supply of these resources allows the exploitation of previously inaccessible forage, increases livestock numbers and thus can result in deteriorating rangeland conditions (Campbell et al. 2006).

3.1. Classical Economic Theory—Privatization (P1)

Classical economic theory does not distinguish rangelands from other natural resources. Thus, it implicitly draws on equilibrium rangeland ecology, assuming a predictable forage supply and aiming at the regulation of stocking rates. The explanation for unsustainable rangeland management is mainly found in Hardin's often cited "Tragedy of the Commons" (Hardin 1968).

According to Hardin (1968), under a common management, overstocking and degradation are nearly inevitable due to individual interests of herders. To ensure sustainable management of resources, privatization of common resources was recommended. Thus, for decades, private property was regarded as superior for the conservation of resources and agricultural development (Demsetz 1967).

This logic motivated policies of rangeland governance aiming at privatization, e.g., in the CAC region, the de facto privatization with long-term lease contracts under the "household responsibility system" in China (Banks 1997; Bauer 2005).

3.2. Legacy of the Soviet System: Strong State Control (P2)

Under Soviet rule, degradation was a side effect while aiming for maximum production goals. All land and production assets were owned by the state. Management plans on state and collective farms were set up by livestock production specialists (Verdery 2004; Shaumarov and Birner 2016) while local and traditional knowledge was regarded as old-fashioned. The provision of supplementary feed released production constraints, which would have normally limited livestock numbers and their impact on the pasture vegetation (Robinson and Milner-Gulland 2003; Robinson et al. 2003). After initial forced settlements of nomads failed, a system of reduced, regular mobility was allowed on collective and state farms (e.g., in Kazakhstan: Robinson and Milner-Gulland (2003), or in Azerbaijan: Baberowski (2003), Loomis (1989) on various Central Asian states).

For combating degradation, management was carried out according to a scientific-technical knowledge base building on expert studies since the 1920s (Shaumarov and Birner 2016). A fine-scaled monitoring system for agricultural land called "Bonitirovka" was set up, rating the quality and production potential of soils (Gavrilyuk 1974). A remedy for degradation problems caused by intensive use was seen in technical measures, such as winter feeding, rotational grazing, reseeding of pastures or inputs of mineral fertilizers (Liechti 2012; Loomis 1989; Shaumarov and Birner 2016).

3.3. Common Property Scholars: Common Management (P3)

Hardin and the Tragedy of the Commons paradigm were criticized from the 1980s for two major points: First, the narrative mixes common property regimes, where a well-defined user group jointly uses and manages a resource, and open access, where virtually everybody has access and rules are non-existent or not enforced. Second, the narrative refers to a situation without regulations in which individuals follow solely their self-interest. Thus, the possibility of groups to craft and enforce rules is neglected (Feeny et al. 1990).

Common property scholars have been able to show convincingly that a "Tragedy of Open Access" is not inevitable. In contrast, human societies are able to manage resources collectively and sustainably over a long time (Ostrom 1990; Baland and Platteau 1996; Bromley 1992). However, research also showed that not all societies are able to ensure effective mid- and long-term solutions for collective action problems (Kellert et al. 2000). Rather, the stability of common property regimes and the prevention of resource depletion depend on certain factors, which are summarized in the design principles for common property institutions (Ostrom 1990) and their slight modifications (e.g., Agrawal 2001).

For pastures, the boom in common property resource management research induced interest in the "traditional" collective pasture management institutions of mobile pastoralists and a discussion on common property in rangelands in the CAC region (Behnke 2018; Li and Huntsinger 2011; Gongbuzeren and Li 2015). In countries with former socialist influence, a reluctance towards common management approaches is noted since the management by a group is seen as similar to the former collective management, which is associated with negative experiences (Mearns 1996). Although it is often argued that traditional resource management of pastoralists is a common property regime, Ostrom's design principle of "clearly defined boundaries" is violated in many traditional systems. Nevertheless, the mounting evidence for sustainable common property management led researchers and policy makers to recommend approaches of "community-based natural resource management" for pastures (Fernandez-Gimenez et al. 2012; Crewett 2012; Robinson et al. 2010; Ykhanbai et al. 2004).

3.4. New Rangeland Science: Open Property Regimes (P4)

The development of the non-equilibrium paradigm of new rangeland ecology led to a novel view on rangeland management in pastoral systems. In variable environments, herders try to adjust stocking rates to the variable forage supply by using tracking strategies and opportunistic livestock management. These management strategies are enhanced by a high degree of mobility, flexibility in spatial and temporal resource access as well as effective livestock marketing systems that allow the quick destocking and restocking of rangelands. Thus, the sustainable use of ecosystems as well as human welfare are threatened, if a flexible adjustment of stocking rates is hindered by institutional and economic factors (Scoones 1994, Behnke and Kerven 1994).

To facilitate sustainable use, pastoralist rangeland access regimes under this paradigm should be flexible and overlapping to adapt to the unpredictable characteristics of the resource (Goodhue and McCarthy 2000; Scoones 1994). For the CAC region, in addition to rainfall, especially cold temperatures and snowfall (*dzud*) were identified as factors crucially influencing rangeland productivity, accessibility and livestock numbers (Kerven 2004; Fernandez-Gimenez and Allen-Diaz 1999; Robinson and Milner-Gulland 2003; Li and Huntsinger 2011).

This focus on overlapping, open and flexible access rights is in strong contrast to the views held by common property scholars where clearly defined boundaries in a spatial and social sense are seen as crucial for the long-term stability of the common property regime (Ostrom 1990; Moritz et al. 2013). Instead, flexible access, open access or open property regimes are envisioned in which "there is open access to common-pool grazing resources but, and this is critical to note, open access does not mean the absence of rules; instead it refers to the right that every pastoralist has to common-pool grazing resources" (Moritz 2016, p. 689; see also L. Robinson 2019; Moritz et al. 2018).

4. Governance Approaches to Rangeland Management in CAC Countries

In this section, the governance of rangelands in ten CAC countries is reviewed. For each country, I (1) characterize the prevailing forms of pastoralism and (2) provide a short description of the major steps in rangeland policy in post-socialist transition, including the current policy framework for rangeland governance. As an evaluation, (3) the rangeland governance approaches are related to the four broad paradigms in rangeland governance described in Section 3, and (4) socio-economic and ecological outcomes as seen in the scientific literature are briefly characterized. Socio-economic outcomes assess the impact that the governance regime has on social organization, mobility and the management of herds. Ecological outcomes target the impact of the governance regime on rangeland condition, i.e., differentiated use pressure and evidence for degradation.

4.1. Georgia

(1) Forms of pastoralism: On the Georgian territory, steppe areas lying between Greater and Lesser Caucasus facilitate vertical pastoral movements along a steep altitudinal gradient. Stationary and mobile livestock keeping overlaps partly in agropastoral livelihoods (Stadelbauer 1984).

(2) Governance approach: The post-socialist land governance reform process in Georgia started with the dissolution of state and collective farms in 1992. A far-reaching

privatization of agricultural land was initiated, which also allowed the lease of pasture land from 1996. Of the 1.8 million ha of pasture, in 2002, 83,300 ha was privatized, 600,000 leased and 940,600 ha remained in state ownership (Tsomaia et al. 2003).

Between 2005 and 2008, pasture land was planned to be transferred to municipal ownership. However, this process was stopped, and up to 1 million ha pasture land is now under jurisdiction of the Ministry of Economy and Sustainable Development without further provisions for its management and use (as of June 2020). While officially pastures cannot even be leased out, there are exceptions for several municipalities as well as short-term oral use agreements (Gvaramia 2013). In consequence, there is a mixture of ownership structures with private owners (15–25%), municipality ownership (2–5%), ownership by Agency of Protected Areas (APA; 2%) and public property (70–80%) (Mansour and Phulariani 2016).

One major drawback for land privatization in Georgia was the late development of a public registry (starting only from 2004), which, to date, leads to many incomplete processes of land privatization (Gvaramia 2013).

(3) Relation to rangeland governance paradigms: As a general tendency, frequent changes in rangeland governance can be observed with a current intention to privatize rangelands (P1).

In publications on land governance, a variety of positions are articulated. In a quest for further privatization, e.g., a World Bank report (Welton et al. 2013, p. 77) explicitly draws on the Tragedy of the Commons to explain the low quality of pastures and overgrazing. Gvaramia (2013), which is a report of a local NGO, argues that "[i]t is also necessary to privatise animal transportation routes (if not privatised, serious management mechanisms need to be developed)". In contrast, in a report for Swiss Cooperation Office, Raaflaub and Dobry (2015) argue for a balanced approach allowing for cooperatives and user group-based management especially on village pastures.

(4) Reported outcomes: The frequent changes in overall rangeland governance and the management vacuum have created particular insecurity for land users since 2010. Evaluations of pasture quality produce mixed results due to the lack of comprehensive assessments (Mansour and Phulariani 2016). While some publications speak generally of overgrazing and low quality (Welton et al. 2013), others observe underuse and reforestation. A mix of overuse and reforestation processes is most likely, whereas overuse is likely to occur on easily accessible pasture sites and winter pasture areas (Gebhardt 2014).

4.2. Armenia

(1) Forms of pastoralism: Pastures comprise approximately 50% of the agricultural land in Armenia. The land-locked country has predominantly transhumant vertical migration systems along short distances partly combined with arable farming in agropastoral systems.

(2) Governance approach: While arable land was largely privatized based on shares in 1992, pastures remained in the hands of the state and were partly leased out. Between 2003 and 2005, management rights for remaining state land were handed over to local communities. While initially it was intended to give full ownership to local communities (including the right to sell and lease pasture), the government handed over finally only restricted rights in view of concerns about land concentration (Spoor 2012). In surveys, local farmers opposed sales of pastureland (Lerman and Mirzakhanian 2001). The government is working with development support on management schemes and tools for community-based pasture management (Christen 2020).

(3) Relation to rangeland governance paradigms: Armenia aimed at a pro-equality privatization strategy in land governance (Spoor 2012), while for pastures, after an initial search process with strong state control (P2) and intentions of privatization (P1), community-based solutions seem to be in progress (P3).

(4) Reported outcomes: Reports on the levels of pasture degradation or on socio-economic outcomes are scarce. A remote sensing study reports that more than 50% of Armenian pastures are degraded (Tepanosyan et al. 2017). A major issue seems to be the infestation with weeds and non-palatable plants mainly due to insufficient mobility and overgrazing pastures, especially around sheds and water sources (Christen 2020).

4.3. Azerbaijan

(1) Forms of pastoralism: High altitudinal differences on the slopes of the Greater and Lesser Caucasus with steppe and semi-desert lowlands in between allow for transhumant vertical migration systems along steep altitudinal gradients, but also vertical movements of shorter distances in agropastoral systems exist.

(2) Governance approach: In Azerbaijan, agricultural reforms started in 1996 with the privatization of livestock and machinery. Pasture land was not subject to privatization but remained in the hands of collective and state farms. Land access was reorganized in 2000, with the privatization of arable land, while pastures were not subject to privatization. While local village administrations (Belediyye) became responsible for administering village pastures, distant pastures and migration routes

are under district (rayon) administration. Distant pastures can be leased by mobile pastoralists for 25 years, and the individual leased plots have comparably fixed boundaries. By 2007/2008, all available pastures were leased out (Neudert et al. 2015). Contracts can now be obtained under an auction mechanism, while leasers have a primary option for renewal of contracts. Local village administrations have the option to lease parts of their village pastures to mobile pastoralists if these areas are not in use by local village livestock (Neudert et al. 2020).

(3) Relation to rangeland governance paradigms: In Azerbaijan, in post-socialist transition, pasture categories and usage patterns from Soviet and pre-Soviet times were continued or renewed. For distant pastures, the state aimed at an individualization of use with a strong position of the state (P2) but transfer of management rights resembling a near privatization (P1). Pastures in the vicinity of villages remained in common use under local administration (P3), whereas few provisions for effective community-based management were made.

(4) Reported outcomes: The use pressure on pastures in Azerbaijan is comparably high. During the distribution of lease contracts deviations from formal rules, e.g., use of private networks or bribing, occurred. However, during actual use, boundaries are well respected, while mobility is ensured due to the state management of migration routes, and informal cooperation and joint use agreements, which also enable mobility for owners with few livestock (Neudert 2015). Especially on village pastures, overuse is a frequent problem (Neudert et al. 2019).

4.4. Turkmenistan

(1) Forms of pastoralism: Desert and semi-desert ecosystems in Turkmenistan allow for semi-nomadic or transhumant pastoralism governed primarily by well water availability and salinity. The movement pattern is radial around wells, with the concentration of camps around wells in summer and dispersion in winter (Ferret 2014).

(2) Governance approach: In contrast to most other CAC countries, Turkmenistan has retained a comparably low level of privatization and higher state involvement. Reforms began in 1995 with the transformation of state and collective farms into farmer associations (Kerven 2003), while the farm assets remained nearly unchanged. The approach in the pastoral sector is termed "leasehold pastoralism" (Behnke et al. 2005). With lease contracts for state-owned livestock, herders manage the herd in return of a share of the offspring and products as long as production targets are met. Private livestock is allowed and is reported in increasing numbers (S. Robinson et al. 2017b). Rangelands and the associated water wells are state-owned and allocated to

the farmer associations, allowing for some degree of flexibility in pasture and well use. In addition, flexible decisions could be taken by herders with regard to mobility and access of other feed resources (Behnke et al. 2005; Behnke et al. 2016).

In 2015, a new pasture law was passed allowing now for community-based pasture access (S. Robinson et al. 2017b).

(3) Relation to rangeland governance paradigms: Turkmenistan combines a strong position of the state (P2) with regard to land and livestock ownership enabling effective decentralization and flexible decision making for herders. Thus, the rangeland governance resembles an open property regime (P4). With the increasing share of private livestock and a declining management role of the state, a change to towards stronger individual rights with the option of community-based pasture access is underway with the new pasture law of 2015 (P1, P3) (S. Robinson et al. 2017b). Whether the reformed system will be largely individualised or group based will largely depend on bylaws and implementation (Robinson et al. 2018).

(4) Reported outcomes: Based on extensive field research at the rim of the Karakum desert, Behnke et al. (2016, p. 117) conclude that the system is "insufficient to halt the growth in absolute levels of grazing pressure or the loss of vegetation cover around large water points, but they do retard the rate at which larger settlements grow in size, and are sufficient to maintain constant levels of animal performance", thus resembling an ideal free distribution of livestock. However, reports on pasture conditions are contradictory: S. Robinson et al. (2017b, p. 237) report that overgrazing is "perceived to be a serious problem" alongside increasing grazing pressure near settlements. In contrast, satellite imagery studies report a medium to good pasture condition without clear tendencies along transects to wells (Gintzburger et al. 2009), or pasture vegetation rehabilitation around settlements occurring alongside degradation due to the development of biogenic crusts in remote areas (Kaplan et al. 2014).

4.5. Kazakhstan

(1) Forms of pastoralism: The Kazakh territory historically hosted large scale pastoralist movements, which began to decline in length and scope in the 18th century with the establishment of the Russian empire. In the socialist period, collective and state farms with shorter migration cycles and the provision of winter fodder were established (Alimaev and Behnke 2008, Robinson and Milner-Gulland 2003).

(2) Governance approach: In the mid-1990s, the livestock holdings declined dramatically (Robinson and Milner-Gulland 2003), and in 1995, it became possible to lease agricultural land, arable land and pastures, for 99 and later 49 years. While the lease system worked well for arable land, the demand for pastures remained low

and, de facto use without lease contracts was common, as lease processes were complicated and costly. Movements ceased nearly completely particularly in desert regions, while grazing with few livestock took place around settlements (Alimaev and Behnke 2008), and short distance migrations in mountain regions were reestablished comparably quickly (Ferret 2018).

An amendment of the Land Code in 2003 allowed the acquisition of rangelands by purchase in addition to the leasing option, except lands in shared use. Pastures around settlements remain in the hands of local communities and are considered as "commons", as reported by a World Bank document (Schillhorn van Veen et al. 2004). Thus, different access options are available for herders, ranging from private (primarily winter pastures) to communal and open access options (Kerven et al. 2016a, 2016b). A reform of the pasture law in 2017 now formally allows for the creation of voluntary associations of pasture users (S. Robinson et al. 2017b).

A reform of the Land Code in 2016 attempted deeper changes in land access governance with an abolishment of all lease options, effectively allowing only for purchase of land. Following public protests, the reform and all land privatisation and sales were put under a moratorium until 2021 (S. Robinson 2020).

(3) Relation to rangeland governance paradigms: Kazakhstan's land governance initially made no difference between rangelands and arable lands with providing lease options (P2), but differentiated its management regime into several options for different rangeland resources involving privatization, lease and common management broadly dependent on the resource characteristics (P1–3).

(4) Reported outcomes: Several sources note a strong decline in mobility, inducing severe overgrazing around settlements and underuse in remote areas (Kerven et al. 2006). Mobility is re-established predominantly by herders owning greater numbers of livestock and crucial assets, such as trucks and access to wells (Kerven et al. 2006, 2016a; Milner-Gulland et al. 2006). Outcomes of the reforms of the pasture law in 2017 and the Land Code reform in 2016 cannot be assessed, yet.

4.6. Uzbekistan

(1) Forms of pastoralism: Uzbekistan has a history of nomadic pastoralism, while in recent years, desert and semi-desert areas have been used in horizontal transhumant migration systems. In mountain areas, vertical migration systems also exist, although vertical migration has minor importance at the national level (Kerven et al. 1996).

(2) Governance approach: With reforms of farm structures in 1992 and a new Land Code in 1998, the government took a restrictive approach to transition allowing no private ownership to land (Lerman 2008). All land remained state property;

former state and collective farms in arid regions were transformed into agricultural cooperatives in dry areas (*shirkats*, Zanca 2000; Shaumarov and Birner 2016), whereas district governments were mostly responsible for rangelands in semi-arid areas. Pastures can be leased for 49 years by entrepreneurs or agricultural cooperatives, who can allow others to use the land. In fact, land under the jurisdiction of districts is open access (Christmann et al. 2015). As households (*dekhan farms*) are de facto excluded from land lease (Christmann et al. 2015) but hold the greatest share of livestock (S. Robinson 2020), access to grazing land is mostly gained informally (Shaumarov and Birner 2016).

As reported on the website of the International land coalition, in 2019, a new law on pasture management became effective, enabling the development of pasture user associations and measures for improved pasture management and restoration (Yuldashev and Ykhanbai 2019).

(3) Relation to rangeland governance paradigms: Uzbekistan followed a restrictive policy with regard to land ownership intended to avoid land speculation and to preserve pastures as a national source of wealth (P2) (Lerman 2008), but de facto providing no regulation adapted to the resource characteristics of rangelands. The new law issued in 2019 proposed "pasture user associations", a community-based approach to pasture management (P3) (Christmann et al. 2015).

(4) Reported outcomes: Lerman (2008) describes a slight growth in cattle numbers, while abandoned pasture land and a reduction in fodder crops are also noted, implying a higher pressure on some pasture areas. Pasture land seems to be abandoned due to the lacking maintenance of water infrastructure and degradation (Shaumarov and Birner 2013). Christmann et al. (2015) terms the present-day use "unsustainable" and sees the system as being characterized by "the Tragedy of the Commons" and "free riding", as no fees for pasturing and shrub harvesting are collected, and uncontrolled grazing without shepherds occurs. Their work aimed at the establishment of pasture user groups and pasture regeneration.

4.7. Kyrgyzstan

(1) Forms of pastoralism: Rangelands cover approximately 80% of the land resources in Kyrgyzstan. The mountainous terrain allows for transhumant vertical migration and agropastoral systems of short and medium distances (Shirasaka et al. 2016).

(2) Governance approach: In 1998, Kyrgyzstan adopted far-reaching reforms of the agricultural sector, involving a far-reaching privatization of land and livestock. Pastures remained under state control with lease options (Dörre 2012; Undeland 2005). In 2009, Kyrgyzstan adopted as the first state in the Central Asian region

a community-based management approach. After disappointing results with the lease approach in pasture management, the community-based approach was jointly developed by government officials and international donor organizations (Kasymov et al. 2016). Control over pastures was handed from municipalities to pasture user committees, setting up management plans and granting access rights (Kasymov et al. 2016; Dorre 2015). Participatory monitoring approaches are being tested as a basis for informed decisions on pasture management and degradation prevention (Kirch et al. 2016).

(3) Relation to rangeland governance paradigms: From an early approach of strong state control (P2) which was incompletely implemented (Kasymov et al. 2016), Kyrgyzstan soon moved to an adoption of a community-based management approach (P3) with local control over pastures and explicit provisions for user participation.

(4) Reported outcomes: During the initial period of transition, a marked decline in pastoral mobility and overuse of pastures in the vicinity of villages was noted (Farrington 2005). While after 2009, in many places, control over pastures by pasture user committees was established, authors report a gap between intentions and implementation (Kasymov et al. 2016), elite capture (Crewett 2015; Dorre 2015) and lacking acceptance by local pasture users (Shigaeva et al. 2016). However, Kasymov and Thiel (2019) see a declining asymmetry in bargaining power, leading potentially to more equitable outcomes in the future. The community-based approach is evaluated as an improvement compared to the previous lease system; however, it still has shortcomings with regard to facilitating mobility and flexible movements (Mestre 2019; Crewett 2012) and to matching pasture availability with demand (Shirasaka et al. 2016).

4.8. Tajikistan

(1) Forms of pastoralism: Located in the high-mountain region of Central Asia with more than 80% of the country being pasture lands, Tajikistan's environment supports transhumant vertical movements in agropastoral systems (Robinson and Whitton 2010).

(2) Governance approach: Before 2013, there was no special legislation in Tajikistan applying to pasture land, but general land access options were applicable to pastures, including the option for long-term inheritable rights (Halimova 2012). However, no effective governance was established, leaving the pastures de facto open access. A reform in 2013 followed the Kyrgyz model of community-based governance: pastures are owned by the state, while management is delegated to commissions at the district level. Access can be community-based by user associations or individually

based on leases (Jaborov et al. 2017). This leads to a legal coexistence of private and common access options (S. Robinson et al. 2017b).

(3) Relation to rangeland paradigms: Tajikistan first aimed at a strategy of strong state control (P2) while also providing options for the privatization of pastures, which were not implemented (P1). The reform in 2013 generally followed the community-based approach in Kyrgyzstan (P3), but the approach was only adopted incompletely. The weak commitment of the Tajik government and gaps in the legislative framework resulted in a very slow progress of implementation (Jaborov et al. 2017).

(4) Reported outcomes: Lacking mobility and herd sizes led to initially low interest in obtaining private or lease rights for pastures. Declining mobility resulted in an overuse of pastures in the vicinity of villages, whereas remote pastures were virtually abandoned (Robinson and Whitton 2010). The implementation of the 2013 pasture law is uneven, with the creation of pasture user unions and pasture management plans heavily dependent on NGO intervention (Jaborov et al. 2017). In parallel, granting long-term inheritable (de facto private) rights of large plots to wealthy individuals seems to take place, creating a growing number of landless rural households and social tensions (Halimova 2012).

4.9. Mongolia

(1) Forms of pastoralism: The vast steppe and desert areas in Mongolia have hosted nomadic cultures for millennia. Nomadic pastoralism with a combination of vertical and horizontal movements is still common (Fernández-Giménez et al. 2018; Mearns 1993), although there is trend for reduced migration distances and less moves (Chen et al. 2018).

(2) Governance approach: Despite early policy advice to privatize pastures (Murphy 2011), Mongolia maintained state ownership of all pasture land (Fernandez-Gimenez and Batbuyan 2004). A major reform implemented in 1994 allowed the private lease of winter and spring camp sites. Thus, land access is mainly governed through campsite access rather than by rights pertaining to land per se. Local and regional authorities were made responsible for managing grazing pressure and seasonal mobility. Responding to unclear and contradictory issues of the 1994 law, in 2002, an amendment to the pasture law was issued, allowing group ownership of winter and spring camp sites and a consequent local responsibility for grazing management (Fernandez-Gimenez and Batbuyan 2004). Many authors note a strong complement and interpretation of the legal provisions with customary rules (Upton 2009), e.g., pertaining to reserve pastures and irregular long-distance migration in the

case of hazardous weather conditions (Murphy 2011). Development organizations promote actively community-based natural resource management to complement local government responsibilities for grazing management (Addison et al. 2013; Ulambayar et al. 2017). Since 2007, an amendment of the pasture law has been discussed with a central purpose of making provisions for the transfer of ownership and management rights of pasture areas to pasture user groups (Fernandez-Gimenez et al. 2008; Hannam 2014). The law is still in parliamentary discussion (Undargaa 2017).

(3) Relation to rangeland paradigms: Pasture access in Mongolia is mainly governed through campsite access rather than by rights pertaining to pasture per se. Thus, the governance approach broadly reflects open property regimes (P4). With the new proposed pasture law, a shift to more community-based management (P3) is planned. Advantages and disadvantages of common management in comparison to open and flexible access regimes are active discussions (Fernandez-Gimenez et al. 2008; Hannam 2014).

(4) Reported outcomes: The flexible access regulations seem largely conducive with Mongolian customary institutions, though the issuing of lease certificates was reported to not be implemented on large scales (Murphy 2011). Compared to the neighbouring Inner Mongolia, the general rangeland management approach has led to greater mobility and less rangeland degradation (Sneath 1998). Additionally, more recent assessments confirm that severe livestock-induced degradation is comparably rare in Mongolia (Jamsranjav et al. 2018). However, authors note a lack of planning and management resulting in overgrazing and degradation, especially in productive areas (Fernandez-Gimenez et al. 2008; Jamsranjav et al. 2018). Case studies on community-based management approaches showed mixed results (Upton 2009; Addison et al. 2013; Fernandez-Gimenez et al. 2015), although a recent large-scale and representative study could verify improvements in grazing management practices (Ulambayar et al. 2017).

4.10. China (Inner Mongolia)

(1) Forms of pastoralism: With its location on the Mongolian Plateau, Inner Mongolia shares the same ecological system with the Republic of Mongolia. Steppe and semi-desert regions have supported historically nomadic, horizontal pastoral systems. However, in Inner Mongolia, livestock management has been largely changed to stationary systems or systems with reduced mobility (Chen et al. 2018).

(2) Governance approach: The former collective management approach was replaced by the "household responsibility system" or "grassland contracting policy" in the

early 1980s (B. E. Robinson et al. 2017; Li and Huntsinger 2011). The system involved long-term lease contracts to livestock and pasture areas, as well as fencing of rangeland plots (Taylor 2006). While initially a privatization of livestock and grassland to herding groups was possible, the associated settlement of nomadic groups led to an individualization of households, which resulted de facto in a privatization of land and livestock to individual households (Li and Huntsinger 2011).

Since 2000, the existing individual rangeland access system has been complemented by laws and decrees increasingly aiming at a stronger regulation of stocking rates to combat rangeland degradation, e.g., with the "grassland-livestock balance regulation" and "forbidden grazing and rotational grazing program" (B. E. Robinson et al. 2017). Additionally, compensation schemes (payments for ecosystem services) aiming at lower stocking rates on rangelands were set up (B. E. Robinson et al. 2017). Further policies aim to encourage cooperation among herders in anticipation of fragmented family holdings merging into larger holdings (Chen et al. 2018).

(3) Relation to rangeland paradigms: The introduction of the household responsibility system in the 1980s was clearly motivated by the narrative that grassland degradation is caused by a Tragedy of the Commons (Li et al. 2007; Taylor 2006), resulting in an effective privatization of pastures (P1). The policy changes after 2000 are characterized by a stronger position of the state and complementary policy mechanisms, setting positive incentives for grassland conservation based on classical market economic measures of environmental policy (P1, with aspects of P2).

(4) Reported outcomes: The privatization strategy led, until 2000, to an unanticipated extent of rangeland degradation in Inner Mongolia, likely to be caused by fragmentation, fencing and disrupted mobility (Li and Huntsinger 2011) and also associated with adverse social consequences (Yu and Farrell 2013). Incomplete privatization led, on remaining common lands, to severe degradation known as the "tragedy of enclosure" (Williams 1996).

In a review of the scientific literature addressing the impact of government policies published by IIED, Li et al. (2014) find that most authors of the newer literature (2008–2012) evaluate the "grassland contracting policy" in a negative way, leading to adverse changes in environmental, livestock management and social issues. However, some improvements on the socio-economic situation of herders were also reported (B. E. Robinson et al. 2017). While grazing bans and rotational grazing were assessed primarily as positive in combating degradation (see also Li et al. 2012), the policy had largely negative impacts on herders' livelihoods and the pastoral society

(Li et al. 2014). Li et al. (2014) assert that lacking knowledge on pastoralism among policy makers is the root cause for inappropriate rangeland policies.

5. Discussion

This contribution reviewed governance approaches to rangeland management in ten CAC countries and related them to international paradigms of rangeland management as described in the scientific literature and to outcomes with relevance to rangeland degradation. The results are influenced by the methodical approach: only published material in the English language was taken into account. Drawing on local language material or primary data might have led to more detailed assessments of the specific governance approaches in the individual countries, but is beyond the scope of this review. As evaluations of socio-economic and ecological outcomes are based on qualitative assessments by authors of publications, they especially highlight impacts of the governance regime based on authors' perceptions; however, comparisons of statistical or field data may provide additional insights. Table 1 provides an overview of the information presented in Section 4 and facilitates the comparisons discussed in the following.

In the ten CAC countries, diverse forms of pastoralism existed, which were adapted to the ecological conditions in the respective countries; however, these pastoral forms underwent massive changes during the socialist period and in post-socialist transition. Drawing on mobile livestock keeping, pastoralists are able to use variable forage resources in space in time (Scholz 1995). Vertical pastoral migration systems occur wherever mountain environments allow for it in the CAC region. Longer and horizontal mobility forms can be found in Central Asia (especially in Kazakhstan, Uzbekistan, Mongolia and Inner Mongolia).

Ecologically, there is a tendency towards drier ecosystems and to increasing continentality and non-equilibrial ecological conditions from west to east in Central Asia. The measure for climate variability, the Coefficient of Variation of precipitation, typically exceeds 33% under non-equilibrial conditions. In the western part of the CAC region, in Azerbaijan, the Coefficient of Variation ranges between 28% in semi-desert regions and 22% in mountain regions (Peper 2010). In arid and semi-arid regions of Uzbekistan, the indicator ranges between 27 and 34% (Gintzburger et al. 2005), while it is 47–50% in desert-steppe regions and 28% in mountain steppe regions in Mongolia, which indicates the tendency towards non-equilibrial ecosystem conditions in the eastern parts of Central Asia (Fernandez-Gimenez and Allen-Diaz 1999). However, the general east–west gradient is overlaid by elevational differences in mountain regions, which have higher precipitation and mostly lower Coefficients of

Table 1. Summary of forms of pastoralism and rangeland governance approaches in the Central Asia and the Caucasus region (CAC) region.

CAC Countries	Forms of Pastoralism	Rangeland Governance Approaches	Relation to Paradigms of Rangeland Governance	Reported Outcomes
Georgia	Transhumant, vertical pastoralism, partly agropastoralism	Mixture of private, leased and open access plots, frequent changes of management approaches, since 2008 majority of pastures under state jurisdiction, planned privatization	Frequent changes in pasture governance, privatization of pastures planned (P1)	Insecurity of land users, mix of overgrazing and undergrazing
Armenia	Transhumant, vertical pastoralism, partly agropastoralism	Rangelands initially under state jurisdiction, in 2003 transfer to local management, no privatization allowed	Initial policy search process involving strong state control (P2) and privatization intentions (P1), currently common management (P3) as a goal, provisions for community participation to be developed	Mainly degradation due to infestation of weeds, lacking mobility
Azerbaijan	Transhumant, vertical, partly agropastoralism	Distant rangelands under regional government with lease options; village pastures under local (community) management	Lease system with aspects of strong state control (P2) and private management (P1), on village pastures common management (P3) as a goal, few provisions for actual community-based management	High use pressure, degradation on village pastures, mobility enabled
Turkmenistan	Transhumant (historically semi-nomadic) radial pastoralism	Rangelands and partly livestock under state jurisdiction, devolution of management rights to herders, change to individual or community-based lease and management planned	Livestock lease system with strong position of the state (P2) and effective devolution of rights resulting in open property (P4), change to individual (P1) or community-based lease and management (P3)	Contradictory reports on patterns of pasture degradation, mobility enabled
Kazakhstan	Transhumant (historically nomadic), horizontal and vertical pastoralism, in mountain regions agropastoralism	Rangeland initially under state control with leasing options, since 2003 a variety of access options ranging from purchase to community access depending on type of pasture or facility	Initially lease options (P2), later mixture of 3 approaches (P1–3) dependent on resource characteristics	Underuse in remote areas, overuse in accessible areas, insufficient mobility

Table 1. *Cont.*

CAC Countries	Forms of Pastoralism	Rangeland Governance Approaches	Relation to Paradigms of Rangeland Governance	Reported Outcomes
Uzbekistan	Transhumant (historically nomadic), horizontal pastoralism, in few mountain regions agropastoralism	Rangelands under jurisdiction of farmer associations or district governments, in 2019 development of community-based management	Strong position of the state (P2), in 2019 change to community-based management (P3)	Scarce information, most probably underuse of remote areas, overuse in accessible areas
Kyrgyzstan	Transhumant, vertical pastoralism, partly agropastoralism	Initial approach with state ownership and lease options was replaced in 2009 by a community-based management approach	Initially strong position of the state with individual lease options intended (P2), in 2009 change to community-based management (P3)	Initially underuse in remote areas, overuse in accessible areas, still partly lacking mobility
Tajikistan	Transhumant, vertical pastoralism, partly agropastoralism	Initial approach with privatization and lease options, since 2013 parallel existence of individual and group access options	Initially strong position of the state (P2), privatization options not implemented (P1), community-based solutions in testing phase (P3)	Underuse in remote areas, overuse in accessible areas, inconsistencies in legal framework
Mongolia	Nomadic, horizontal and vertical pastoralism	State ownership of pastures, combined with individual and group access options to campsites, promotion of community-based management options	Lease of campsites broadly resembles open property regimes (P4). Planned change to more community-based management (P3)	Overuse in productive areas, social and ecological improvements proven in pilots with community-based management
China (Inner Mongolia)	Historically nomadic horizontal pastoralism, reduced to transhumant or stationary forms	Individualized pasture access and settlement of mobile pastoralists, since 2000 environmental policy based on state regulation and market mechanisms	Clear motivation to privatization related to tragedy of the commons (P1), in 2000 policy change to stronger focus on economic incentives for prevention of degradation (P1, with aspects of P2)	Privatization led to breakdown of mobility and strong degradation, recent social and ecological improvements

Source: Table by authors.

Variation. Thus, in general, most variable climatic conditions, to which nomadic forms of pastoralism are best adapted, can be found on the Mongolian plateau (Mongolia and Inner Mongolia) (Fernandez-Gimenez and Allen-Diaz 1999; Fernandez-Gimenez et al. 2017). While from a cultural–evolutionary perspective, an adaptation of livestock keeping practices and culture to environmental conditions can be assumed, current policy changes seem to be mostly driven by other factors, such as interests of political actors, prevailing narratives of how to achieve growth in the livestock sector and prevent degradation as well as the influence of international NGOs (S. Robinson et al. 2017b).

Current forms of pastoralism are shaped by historical conditions, whereas a tendency towards reduction and regularization of mobility over the last century can be observed. This is most expressed in Inner Mongolia, where an originally nomadic pastoral system was transformed by externally imposed policies to partly settled forms, leading to a livestock keeping system of a completely different character (Wang et al. 2013). This general reduction in mobility can be observed in pastoral systems worldwide (Scholz 1995; Humphrey and Sneath 1999).

In post-socialist transition in all ten CAC countries, similar developments in pastoralism can be observed. Nearly all countries saw a decline in and subsequent recovery of livestock numbers and changes in herd structures, which was associated in many cases with a reduction in mobility. In concurrence with the decline in livestock numbers, a retraction of mobility was observed: the small herds owned by one household were not worth being driven to remote pastures, as enough forage for them was available in the vicinity of villages (Farrington 2005; Robinson et al. 2010; Kerven et al. 2003). In addition to small livestock possessions, the lack of transport means was a contributing factor to decreased mobility.

After the initial decline, mobility patterns started to reverse: wealthier families began again to use remote pastures in order to satisfy the fodder demand of their large herds (Kerven et al. 2003, Farrington 2005, Kerven et al. 2016a, 2016b). In addition, common herding regimes started to emerge, which allowed households with few livestock possessions to participate in mobile pastoralism. Common herding practices may be officially recognized by the rangeland governance regime (e.g., Kyrgyzstan, Turkmenistan) or arise informally in spite of the absence of a legal framework (e.g., Tajikistan, Azerbaijan; Steimann 2011; Watanabe and Shirasaka 2016, 2018; Kasymov and Thiel 2019; Lunch 2003; Robinson et al. 2018; Allahverdiyeva 2017).

In rangeland governance, over the last 20–30 years, search processes for the appropriate regime can be observed, with a diversity of approaches existing today. There is evidence for all four paradigms of rangeland governance, for private, state, common and open property, often combined in hybrid governance regimes. Enabling private or individualized access to rangelands (P1) occurred during the initial transition phase after 1990, providing a legal frame for the privatization of rangelands in Georgia, Tajikistan and Inner Mongolia. However, if individualized access was enabled, de facto distribution of rangelands rarely occurred due to low demand and the decline in livestock and mobility in the initial transition period. Thus, nearly private property rights for pastures are de facto established only in Inner Mongolia and are still planned for Georgia. To avoid a Tragedy of the Commons is clearly spelled out as the motivation for enabling private property rights in advisory documents of international development organizations and the scientific literature. Evidence for this is found for a range of countries, e.g., for Georgia in a World Bank report (Welton et al. 2013), for Mongolia as expressed by the Asian Development Bank and the Democratic Party (Goldstein and Beall 1994 and Sneath 2000 cited in Murphy 2011) or for Inner Mongolia (Taylor 2006; Li et al. 2007). Individualised lease, which resembles privatization if most management rights are transferred, is still a major pillar of rangeland governance in many countries (e.g., Armenia, Azerbaijan, Kazakhstan and Tajikistan).

Whether individualised lease options were implemented depended partly on other factors influencing the demand for pastures and re-establishment of mobility: individualised lease options were rapidly implemented in Azerbaijan due to the dynamic economic development in the country based on the exploitation of oil reserves and comparably scarce pasture resources (Neudert et al. 2015). In contrast, in Tajikistan or Kazakhstan, the implementation of lease options is still incomplete due to the difficult economic environment (Tajikistan) and vast pasture resources in both countries (Kerven et al. 2016b; Jaborov et al. 2017).

Another common approach in the initial transition period was to keep many features of the Soviet style of rangeland governance (P2), which indicates a path-dependency of governance regimes. This is exemplified particularly by the state ownership of rangelands and partly continuing existence of collective farms (e.g., Azerbaijan, Armenia, Kazakhstan, Uzbekistan and Tajikistan). In extreme cases, the state even retained access to livestock, as exemplified in Turkmenistan. In later stages, the approach was complemented by a gradual devolution of rights, either by a change to community-based management (Uzbekistan, Armenia) or to individual users with effective flexible and open rangeland access options (Turkmenistan, where it arose as a side effect of the formal governance regime).

Some countries changed or complemented the initial individual access or strong state control approach in the later stages of post-socialist transition with community-based rangeland management (P3): this is most clearly expressed in the example of Kyrgyzstan, which changed the rangeland governance paradigm from an individual lease to a community-based approach in 2009. Based on the example of Kyrgyzstan, Kazakhstan, Uzbekistan, Armenia and Tajikistan also complemented their rangeland policies with community-based approaches at least for pastures in the vicinity of villages. In many countries, international development organizations played and continue to play a major role in advocating and implementing the approach, e.g., the World Bank and IFAD in Kyrgyzstan (Kasymov et al. 2016), Asian Development Bank, IFAD and World Bank in Tajikistan (Jaborov et al. 2017), World Bank in Armenia (Christen 2020) or diverse donors in Mongolia, among them World Bank and Swiss Development Cooperation (Undargaa 2017). Cases of policy adoption from experience in other countries, e.g., in Tajikistan following the example of Kyrgyzstan (Jaborov et al. 2017), exemplify processes of policy diffusion and convergence in rangeland policies within the CAC region (Busch and Jörgens 2005).

However, as the examples of Azerbaijan and Armenia illustrate, community-based management does not appear spontaneously immediately after handing over management responsibilities to local communities. A legal framework for community-based management must be complemented by the facilitation of community-based decision making supported by tools and trainings for participatory pasture monitoring and the establishment of grazing management plans. Thus, implementing community-based approaches requires supporting measures, well-designed implementation rules and meaningful monitoring of participation activities in the long run (Crewett 2015; Gruber 2010).

The paradigm of open property regimes (P4) is seldom represented in the CAC countries, as it appears as part of the governance regime only in Turkmenistan and Mongolia (Table 1). The paradigm seems most suitable under non-equilibrial ecosystem conditions (see Section 3.4), which are most expressed in Mongolia and Inner Mongolia. Only Mongolia partly followed this approach with the distribution of lease contracts for campsites. In the discussion of the new pasture law where a shift to more widespread community-based management is planned, concerns for flexible access regulations are expressed. As a special case, Turkmenistan was able to complement a system with strong state control with an effective devolution of access rights, thus enabling an open property regime. Moritz et al. (2018) also state that pastoralism in Mongolia and Turkmenistan exhibits features of open property regimes.

As visible in many policy approaches, rarely one paradigm of rangeland management is implemented to the full extent. Rather, approaches are mixed across scales, particularly depending on the type of pasture resource concerned (L. W. Robinson et al. 2017). In many cases, regulations for remote or summer pastures differ from the governance of winter pastures or pastures in the vicinity of villages. Changes and refinements according to types of pastures are also reflected by the time scale. These policy changes and refinements leave the impression of search or trial and error processes to find the appropriate approach for rangeland governance in the respective countries to balance secure rights, mobility and flexibility. These processes are clearly not yet complete.

The review of outcomes, especially on the ecological condition of rangelands, shows a mixed result. The actual extent of pasture degradation in the individual countries is controversially discussed and strongly depends on the different definitions of degradation and methodological approaches used (Jamsranjav et al. 2018; Briske 2017). As irreversible degradation develops over a longer time period, historical use patterns and livestock number should also be taken into account. In the early period of post-socialist transition, an improvement of pasture conditions was noted caused by the decline in livestock numbers followed by an increase in use pressure more recently (see examples of Kazakhstan: S. Robinson et al. (2017a), or Mongolia: Khishigbayar et al. (2015), S. Robinson (2016) for a review for Central Asia). In addition to livestock-induced degradation, climate change may also have negative effects on pasture conditions, altering ecological processes of grassland ecosystems (e.g., in the example of Mongolia: Khishigbayar et al. (2015), Fernandez-Gimenez et al. (2017)).

Recurring patterns noted as problems in rangeland management are overused areas in the vicinity of settlements and underused plots in remote areas. Thus, mobility is a crucial aspect for sustainable rangeland management (Zinsstag et al. 2016; Coughenour et al. 2008). A governance regime can enable or inhibit mobility. This is most clearly illustrated by the example of rangeland governance in Mongolia and Inner Mongolia, where one ecosystem is governed by two very different governance regimes: it was shown that degradation processes are more severe under individualized and settled rangeland management in Inner Mongolia and Russia compared to Mongolia, where pastoralists have maintained at least some degree of mobility (Sneath 1998; Li et al. 2007). In addition, degradation processes were found to be especially severe around enclosures, which are viewed as a threat to the sustainable management of rangelands (Williams 1996; Taylor 2006). Thus, enabling mobility is clearly a crucial aspect in the design of governance regimes for mobile pastoral systems.

However, several examples show that mobility can be maintained under very different access regimes, such as the leasehold pastoral system in Turkmenistan, the strongly individualized lease system in Azerbaijan or the campsite lease system in

Mongolia. Only for a privatized governance regime an example enabling mobility is lacking, but can be imagined theoretically. In addition to ensuring the mobility of livestock owners with formal pasture access, especially in lease system, modes of pasture access for households with few livestock need to be found to enable mobility for all members of the pastoral community. This is frequently ensured with cooperative or common herding regimes. Thus, any access regime should be complemented with formal regulations or informal norms ensuring mobility and enabling cooperative herding agreements.

6. Conclusions

In the context of combating rangeland degradation and SDG 15, this contribution reviewed rangeland governance approaches in ten CAC countries in the post-socialist period and related them to four theoretical paradigms of rangeland governance and socio-economic and environmental outcomes. There is evidence for all four paradigms, private, state common and open rangeland access regimes. Often, actual policy approaches bear evidence for two or three paradigms, or the approach changed during the time period considered. Policy developments show a search process for appropriate rangeland governance regimes, with complete changes of approaches or with gradual amendments and refinements of existing policy approaches, while decisions seem to be strongly influenced by international development organizations in many CAC countries.

Rangeland degradation, though contested in definition and extent, is often associated with lacking mobility, overstocking and lacking maintenance of infrastructure by the publications reviewed. Depending on formal regulations as well as informal practices of herders, rangeland governance regimes can enable or inhibit mobility and flexible movements to react to droughts or severe winter weather. Governance regimes integrating common access to rangelands to some degree and providing legal possibilities for cooperative livestock management and herding also have a greater potential to enable mobility for households with fewer livestock possessions.

Based on this information, the lesson emerges that there is no silver bullet for sustainable rangeland management based on the paradigms of rangeland governance, as often suggested in the theoretical literature or promoted in the early stages of transition by international development organizations. Blueprint or ideologically driven approaches are seldom appropriate. Once a decision for a general approach is taken, it has to be amended depending on the socio-ecological conditions in the country and the practices of the pastoral population. Often trial and error processes are necessary for gradually improving the legal framework and the fit to pastoral practices. Consultation processes with stakeholders seem to be one approach to improve frameworks; however, they can be time consuming, as the example of Mongolia's new pasture law illustrates.

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Impacts of the Land Tenure System on Sustainable Land Use in Ethiopia

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1. Introduction

In most developing countries, land is linked with people's culture, identity, and dignity. This claim is often expressed in the folklore of these countries. For example, in Ethiopian national and heroic songs and poems, land is considered as a dignity (i.e., the honor a person gives to himself) that soldiers are fighting for (Bezu and Holden 2014). Despite their cultural importance, such perceptions and beliefs can also lead to border and land conflicts. Land management is a perceptual concept, and in physical terms, land is nothing but an economic tool. This is linked to Sustainable Development Goal 15 (SDG 15), which is aimed at protecting, restoring, and promoting the sustainable use of terrestrial ecosystems (e.g., lands and forests) (United Nations 2015). Land policy in developing countries affects the development of societies in different dimensions and goes beyond economic and cultural perspectives. Since the period of colonial rule, the Ethiopian land policies have had impacts on resource allocation and agricultural development (Götz 2019; FAO 2008).

Ethiopia's landscapes are very diverse and stretch from deserts to volcanoes and highlands. It has an area of 1,104,300 sq. km, which makes it roughly as wide as France and Spain combined. More than 70% of Africa's mountains are found in Ethiopia. Despite these facts and in contrast to the documentation of the countries origins, little is yet recorded about its land tenure system and other key related issues (Lavers 2018). However, Ethiopia's history has witnessed different rulers during different epochs, and this has brought different land management systems. Ethiopia is the second highest populated country in Africa (Ethiopia Population 2020) with a population of approximately 107.53 million (based on an estimation in December 2018), and the annual growth rate is 2.46%. The key source of the country's economy is farming, which accounts for approximately 50% of the GDP, 85% of total import/export revenue, and more than 80% of total employment (Ethiopian Economics Association 2008; Cochrane and Vercillo 2019). Several theories about the factors affecting living and land management in the East African highlands have been investigated (Fleskens and Stringer 2014). Among the main underlying theories was the prospect of sustainable land use at any given location, which relies on the "development pathways" and can be pursued. In turn, these development pathways rely on factors that determine comparative benefits in various sites, including the biophysical factors affecting agriculture capacity, market and facilities access, and population density (Sreejith et al. 2020).

These factors might affect household choices of livelihoods (e.g., participating in non-farm activities vs. crop production) and land use/management decisions (e.g., cropping patterns, the proportion of on-farm inputs, tree planting, and soil and water conservation measures). All of these decisions and choices will greatly affect the sustainability and productivity, employment, food safety, and welfare of agriculture (Wubneh 2018). In 2015, the United Nations, through the approval of SDGs, adopted an ambitious agenda for simultaneously tackling several major challenges of the 21st century. These goals are focused on eliminating hunger and alleviating poverty while protecting the environment (United Nations 2015). The 17 SDGs and their targets present a new and coherent way of thinking about diverse issues related to development, such as climate change, gender, and hunger. Fu et al. (2019) conceptualized the relationship between three classifications of the SDGs: (a) governance (including effective regulation, equitable rules, and systems, i.e., SDGs 9, 11, 12, 13, and 17) will ensure that (b) essential human survival needs are met (SDGs 2, 6, 7, 14, and 15), while at the same time (c) maximizing expected objectives (SDGs 1, 3, 4, 5, 8, 10, and 16). The current study provides insights into the range of actions regarding the land tenure system linked to SDGs in general and SDG 15 or "Life on Land" in particular at the country level in Ethiopia.

Presently, 40% of the Earth's land surface is already used for agriculture, and arable land tenure will enhance under protectionist paradigms for food security. Many cultivated areas represent high input and intensified landscapes, in which pesticides, fertilizers, and irrigation are used with a severe environmental and biodiversity impact (Leventon and Laudan 2017). Food sovereignty has become an alternative way to achieve local food security, protect biodiversity and the environment, and provide wider social values through non-industrial agriculture methods. The most general definition of sovereignty, as defined by Beuchelt and Virchow (2012), is the right of people to healthy and sustainable food and the right to develop their own agricultural and food systems (Heckelman and Wittman 2015; Suh 2015). Food sovereignty can be formulated as a form of localism, which restores sovereignty over economics (Hess 2008).

In the last decade, the sovereignty and accessibility of food have changed considerably. In 2010, in Ethiopia, about 2.8 million people needed emergency food aid, but at the same time, they had been selling over 600,000 hectares of their land to transnational enterprises, exporting most of their products (Reuters 2011; Green 2011). Although a paradigm has focused on the financial and sovereign aspect of food provision, Ethiopia still has great food insecurity, which is caused by a lack of access to adequate, safe, and nutritious food (WHO 2017; Ruelle et al. 2019). However, Ethiopia needs to fulfill its food security commitments along with broader values (Leventon and Laudan 2017). For example, the threats posed by the commodification of agriculture and global market competition are a factor that can challenge food and existing systems in Ethiopia.

Commodity agriculture is a major contributor to many countries' economies (FAOSTAT 2017). In many countries (such as Ethiopia), commodity agriculture is simultaneously linked to environmental and social challenges to improve agricultural sustainability (Barona et al. 2010; Bowman et al. 2012). Concerning the effectiveness of the sustainability paradigm in recent decades, civil society and voluntary governance mechanisms have become more important (Pye 2019). Integrated food security data will not measure food sovereignty's importance, and data will not take unfair practices and environmental harm into consideration. A large proportion of Ethiopians are subsistence farmers who neglect human rights and environmental protection, since they are deprived of their land, rights, and livelihoods (Jiren et al. 2020). In order to achieve the goal of national food security and reduce the emergency food aid required, rural farms and food sovereignty must improve their revenue with the objective of securing their lands in Ethiopia. Agricultural commodities can also change land use and land tenure in Ethiopia, as in many developing countries. While the commodification of agriculture can lead to the conversion of large tracts of land, price fluctuations after the introduction of a commodity to the market, due to competition in global markets, will lead to the conversion of subsistence land into commercial agriculture in some regions of Ethiopia. This is a serious threat to the sustainability of agricultural systems, food security, sustainable rural livelihoods, and land use conservation in Ethiopian regions (Jiren et al. 2020).

According to Moreda's (2018) finding, the focus on land tenure security, at least in the fields studied, might be misleading. Some existing concerns were also revealed, appearing to threaten landowners' tenure security (e.g., land rights conditions) that may have led to further investment in land conservation activities. The main problem, however, is latent rights with high levels of insecurity and conflict. There is a significant social malaise, unfortunate agrarian structure, and significant pressure for land redistribution due to unsolved land tenure concerns, despite rapid economic development (Ege 2017). As Legesse et al. (2018) demonstrated, land is a fundamental asset of social, economic, and political sustainability, providing ecosystem services, sustainability, and accumulating richness for rural communities in developing nations, such as Ethiopia. Degradation of the land is among Ethiopia's biggest environmental problems. Among the key factors affecting the decision of farmers to invest in land management, for example, may be ownership rights to land. The literature recognizes that land rights play a significant role in land management. Melesse and Awel (2020) demonstrated that in many African countries, agricultural land use and tenure systems are characterized by subsistence production and a system of community land tenure. Tenaw et al. (2009) discussed questions relating to land tenure, land rights, agricultural productivity, and climate change impacts on the north-western region of Amhara. Their findings show that land shortages alone do not affect the production of agriculture; they affect the land tenure structure, the lack of proper land ownership, the lack of enhanced agriculture technology, and climate change. In most Sub-Saharan African countries, including Ethiopia, this is the main issue.

In another study by Ege (2017), land tenure insecurity in the post-certification of the Amhara region in Ethiopia was investigated. The results showed that ownership rights are thought to have improved, but the evidence is weak and contradictory. Land rentals are growing, and farmer insecurity is high. Legesse et al. (2018) looked at the determinants of the decisions of farmers investing in reforestation actions by concentrating on land tenure and property in northwestern Ethiopia. As they showed, land provides ecosystem services, generates livelihoods, and accumulates wealth in developing countries, such as ethics, and is a major factor in social, political, and economic sustainability. Their study found that land safety is among the key factors affecting the decision of farmers to intervene in reforestation. In Ethiopia and Tanzania, Melesse and Awel (2020) examined the tenure of land, gender, and productivity. They were found to be characterized by subsistence production and a communal system of land tenure in many African countries. They also showed that in general, tenure security affects the productivity of households positively and considerably and is marginally significant, especially for female heads of households.

Ethiopia experienced a strong political debate on the relevant land tenure policy based on Chala's (2016) study. Imperial rule fostered an extreme state intervention in complex tenure systems. However, the previous feudal system was actually abolished by Derg, and so, access to land was distributed by peasant associations. By declaring state ownership of land in the Federal Constitution, the incumbent administration changed certain policies of the former regime. The principal source of controversy is the use of land as the instrument for sustainable development by the Ethiopian regimes. Getahun (2019) argued that, in the Derg regime, although it changed the land tenure from heterogeneous to a uniform land tenure system in the whole country, there was unfairness in allocating fertile land to peasants. However, some plots of fertile land were given to some peasants favored by the local state agents, such as by members of land allotting committees. As a result, the Derg regime's land reform failed to maintain tenure security in southern provinces and elsewhere in Ethiopia. Broadly speaking, while the 1995 constitution largely confirms state land ownership as a continuation of Derg policies, some specifications are also provided that seek to take into account the need for rural land and labor markets to rise (World Bank 2013; Wubneh 2018; Tura 2018).

Focusing on one of the main targets of SDG 15, i.e., "promoting the implementation of sustainable management of all types of landscapes", this study aims at discussing the underlying causes of socio-economic and policy-related factors affecting the sustainability of land tenure systems in Ethiopia because the effects of land tenure and land use policies on sustainability and productivity of agriculture, income, food security, and welfare are generally not well understood yet. The aim of this study is also to review and evaluate the performance of land tenure systems in Ethiopia. This study conducted a systematic review to explore theoretical considerations and overviews on current estimates related to land tenure security. The study used major databases (1990 and 2020), including Google Scholar, the Web of Science, and Science Direct. In addition, a comprehensive search was performed to download relevant papers, articles, and FAO and World Bank reports on land tenure system and land degradation in Ethiopia using the following keywords: 1) land tenure insecurity, 2) land use policy, 3) natural resources degradation, 4) land governance, 5) farmers' livelihood, and 6) land use decision making. Moreover, to support the main findings of the current study mainly discussed in the discussion section, other relevant papers were downloaded and reviewed. The systematic review was limited to journal-articles published in peer-reviewed international journals and reports written in English. The collected articles and reports address relevant issues linked to the six keywords and help provide the coherent reviewing role of land tenure institutions and strategies of farmers to secure land use rights. As shown in Figure 1, the data collection process was conducted in three steps. The first step was dealing with the collection of databases. In the second step, the (about 200) relevant articles/reports were downloaded based on the six keywords, as discussed above. In the third step, the most relevant articles/reports (about 100) to the land tenure system and land degradation in Ethiopia were chosen.

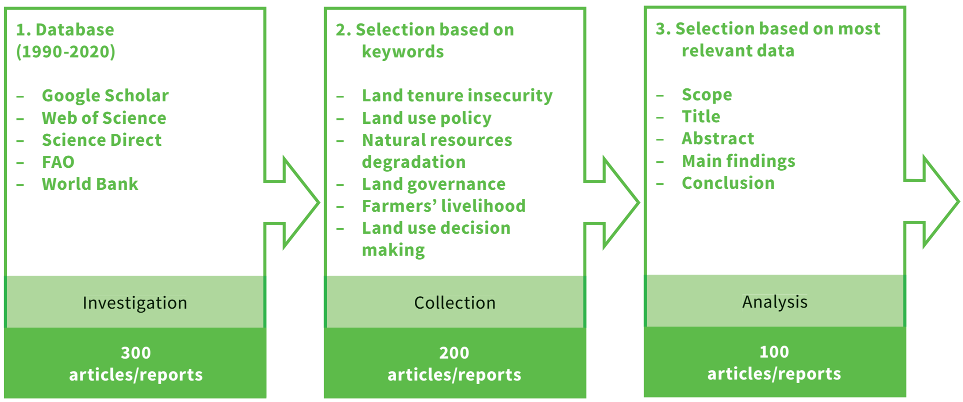

Figure 1. Steps of performing a systematic review and data collection.

2. Ethiopian Experiences in Land Tenure and Land Use Policy Issues

2.1. Land Tenure System in Ethiopia: A Historical Review

It is believed that Ethiopia was founded in 980 BC (Tareke et al. 2002). However, due to the limited availability of information, the history of land tenure and land use policy can be classified into three periods only: the pre-1975, the Derg (1975–1991), and the modern (1991–present) land tenure and land use policies.

The system of land tenure in Ethiopia belonging to pre-1975 was among the most complex tenure systems in the world and has not been studied in detail (Hawando 1997; Fitsum et al. 1999). Among the aspects that created a wide range of land use and ownership are the geographical and cultural diversity and its history (IFPRI 2005). The system's dynamic nature played a critical part in hindering any significant steps towards a substantive reform. Such problems may also have contributed to a number of classifications and methods used to characterize this past system of land tenure. However, the most widely known types of tenure are *rist*/kinship, family, church, and state-owned structures (Melaku 2013). The *rist*/constitution tenure scheme was most common in the northern part of the country, while in most of the country, private tenure was prevalent.

The *rist* scheme was distinguished by the concept of accepting access to land (using and transferring rights without displacement) for all descendants of citizens with a shared ancestor and in an ambilineal manner (the right to inherit land from father and mother). *Gult* is considered as a tenure system, which is often easy to confuse with *rist* as a variant or *rist–gult*. *Gult* is not the right to farm, but the right to tax the profits of property is the main distinction. Less landlessness and tenancy were among the positive qualities for private tenancy in this scheme, while land decline, division of land, and constant land access litigation were among its major problems in the literature (e.g., Chekol 2017; Binayaw 2015). The *rist* structure also became a significant factor mediating the power of peasantry through the government through the elites retaining these rights with its *gult* rights over landholders (Yigremew 2002). In the final days of the Imperial Empire, private tenancy was known as the most dominant system, affecting about 60% of the peasants and 65% of the country's population, and land was sold and exchanged under this scheme. Considerable land concentration, exploitation, and insecurity have categorized the private tenure system, which has led to student movements against the kingship of Derg (Fitsum et al. 1999).

The Derg land reform of 1975 is considered as a revolutionary move that abolished tenant–landlord relations in Ethiopia, mainly recognized by its slogan "*meret le'arashu!*" ("a land must be given to its farmer!"). The reform was intended to fundamentally alter past agricultural relations and land owners, promote agricultural productivity, create jobs, distribute soil, and increase rural incomes (Belay et al. 2014). The right to own land has been vested on the state since the agricultural reform in 1975. Farmers may access land through state-controlled farmers' associations. In peasant associations in which they live, farmers have the open-ended right to use land (the right to use the property of others), but it is subjected to the evidence that they have a permanent natural residence and a capacity for continuous agriculture and fulfilling administrative duties. In 1975, the "Public Property of Rural Land Proclamation" nationalized all rural property and set out to redeploy it to its farmers and organize farmers into cooperatives, thus removing exploitative landlord–owner ties with the imperial regime (Dejene and Teferi 1994; Binayaw 2015; Cochrane and Vercillo 2019).

The collectivization program was intensified by the Derg towards the end of the 1970s with the promotion of state-cooperatives and the establishment of large-scale state farms. State-cooperatives were to be formed through the merging of their land, draught animals, and agricultural machinery by members of a peasant association. Automatically, the head of the cooperative became the head of the peasant organization and was thus able to exert significant political power and control over all members of the association (Kebede 2002). Peasants should formally, at their free will, join state-cooperatives (Dessalegn 2004), but some studies report more vigorous organization implementation (Azeze 2002; Crewett and Korf 2008).

It is not always true that land tenure security can increase productivity in agriculture. A number of studies of African countries in the 1990s officially tested the nature and strength of the relationship between tenure security and farm performance (e.g., Kunz et al. (2016) in Gambia; Higgins et al. (2018) in Ghana, Kenya, and Rwanda; and Delville (2010) in Kenya). Putting a few exceptions aside, land rights have not been identified as a significant factor in determining whether or not farmers make investments that improve land, use inputs that increase yields, obtain credit, or improve land productivity (Lawin and Tamini 2017). Lawin and Tamini (2017) claim that the most pronounced relationships were found in Rwanda, where the right to bequeath was the main factor of some types of land improvement. Rwandan parcels that could not be bequeathed were, under short-term arrangements, mostly rented or borrowed. The research concluded that yields were not affected in any significant way by the presence of land titles. These findings are contrary to the common notion that tenure and titling safety lead to higher yields. All in all, agricultural productivity is affected by many factors that could be beyond the security of land tenure. For Northeastern Ghana, Murtazashvili and Murtazashvili (2016) argue that the focus of politics alone on increasing property security does not lead to increased agricultural production. However, other factors such as a lack of budget, poor soil fertility, insufficient rainfall, outbreaks of pests and diseases, insufficient agricultural land, burning of shrubs, and excessive felling of trees are the most important factors in reducing productivity in agriculture.

In 1991, with the fall of Mengistu's military–socialist Derg, farm collectives were quickly dissolved, and land tenure changed limitedly, to the frustration of several foreign donor agencies. In November 1991, the Declaration of the Transitional Government of Ethiopia on Economic Policy led to the continuation of the Derg regime's land policy. Since the fall of the military socialist Derg regime in 1991, land policy in Ethiopia has been controversial (Chigbu et al. 2019); many case studies have been conducted on the land use system in different parts of Ethiopia. Next, the government launched a land certification program to grant land use rights in order to resolve land tenure issues at the end of the 1990s, while it tried to maintain the ownership of all lands (Fleskens et al. 2014). In 1995, a new federal constitution in favor of public ownership of land was adopted in Ethiopia. By this, the government eliminated land policy as an efficient variable to control and monitor the changing circumstances affecting the rural economy (Ali et al. 2017).

2.2. Recent Changes in the Land Tenure System in Ethiopia

Ethiopia's new land tenure policy continues to be seen as a fundamental concern. Researchers are increasingly arguing about this controversial issue to persuade the government to change land policy. Dejene and Teferi (1994) evaluated the current tenure system by considering the existence of a high level of insecurity regarding land. Land insecurity, in particular, is an obstacle to farmers' interests in the conservation of soil and other natural resources. They concluded that land tenure security should ensure access to land for vulnerable groups, including pastoralists and women.

The backbone of Ethiopia's land economy is smallholder agriculture. With few exceptions, the rights of smallholders' access to land have been largely preserved. However, the conditions and criteria for women and pastoralists' access to land are poor and not properly understood. As a result, access to land by gender, occupational, religious, and ethnic minorities is at risk and must be carefully controlled. Historically, there have been concerns that Derg reforms have eroded the division of resources. Despite the fact that it seems that after the reforms, these efforts to strengthen the rights of women in the land were complementary to the changes that give equal ownership to men and women, some discrimination has subsequently increased since the land reform (Kumar and Quisumbing 2015; Flintan 2010).

Another neglected, but relevant, aspect is land access on behalf of indigenous nomad tribes (pastoralists) and women. The way that nomadic populations (pastoralists) wander from place to place and occupy areas for a limited period of time makes it difficult for them to assert their territorial rights (Gilbert 2007; Abate et al. 2015). The victims of international law are nomads and, therefore, their specific claims need to be recognized. In most societies, such as non-indigenous individuals or minorities, indigenous nomads face double discrimination. Despite the gradual evolution and recent progress in the international land tenure rights of nomads, they are still seen as nomadic societies in their homelands at the national level (Makki 2018; Tamrat 2010).

In Africa, when privatized land tenures promptly fragment pasture and sustain losses in ecosystem service services, intensified livestock production by privatizing is often inconsistent with mobility strategy (Basupi et al. 2017). Greater vulnerability to livestock disease incidences, climate variability, and land degradation can, therefore, challenge the livelihood prospects of pastoralists in communal grazing areas. According to Yang et al. (2020), cooperative grassland management practices have led to considerably higher household incomes, better equality of gender, and more managed grasslands than individuals. Nevertheless, because of their long-term customary activities, many pastoralists chose different grassland management practices. In general, a new reform of rural tenure has enabled pastoralists to choose different pastoral practices, and the promoted, large-scale cooperative pastoral practices benefit the socio-ecological pastoral system. The academic debate has limited knowledge of the historical development, land use patterns of pastoral landscapes, and the way in which historical perspectives are embedded in the political process. The link between several historical factors and the developments in pastoralist landscapes and patterns of land use is less well understood. The sustainability of current rangeland policies depends on this lack of empirical analyses for the evolution of problems in the municipal rangeland (Fernandez-Gimenez 2006; Basupi et al. 2017). In addition, the principles and methods for enforcing the land tenure system were included in the newly drafted Ethiopian People's Revolutionary Democratic Front (EPRDF) constitution. Researchers, such as Bruce et al. (1994) and Dessalegn (2003), argued that the EPRDF's land policy is neither applicable to the agrarian society in Ethiopia nor an incentive for farmers to invest and increase productivity more than ever before. The pro-government advocate Hussein (2001) analyzed the unfair practice of land redistribution in the Amhara region in 1997. He added details on the policy overtones and implementation without the consent of the majority of peasants to participate in the reallocation program. Since 1998, rural land registration and qualification programs have been introduced in different regions of Ethiopia. Protecting land ownership and strengthening land-use practices are the primary objectives of the land registration system. The first phase began in 1998 in the Tigray region, followed by the Amhara region in 2002 and the Oromia region in 2004, respectively. The second phase is underway in all regions of the country. Ethiopia's agricultural land registration system is among the world's largest land registration projects and is fully implemented (Deininger et al. 2008; Tigistu 2011). The land registration system in Ethiopia involves the right (title of registration) with the name of the rightful owner and object of the right. The implementation of land registration is a highly participatory process, with the majority of the land demarcation input from the local community (Tigistu 2011).

In imperial and modern Ethiopia, land use policy, the real source of power, remains at the core of a controversial political debate (Crewett and Korf 2008). There are two antagonistic arguments concerning land ownership rights, which are the basis of the debate. The government of Ethiopia continues to advocate state land ownership, whereby landowners are granted usufruct rights solely (Getahun and Lanen 2015). To protect rural farmers from selling their land to the rich, leaving them without land or a source of livelihood, the right to sell or mortgage the land is ruled out (Crewett and Korf 2008). The government builds its argument on the basis of two principles of social and historical justice: (1) justice acknowledged as egalitarianism, ensuring equal access rights to such land for every farmer in need of agricultural land, and (2) historical justice, providing tenure security to Ethiopian farmers who have experienced land deprivation and land expropriation through different methods during the process (Crewett and Korf 2008; Hussein 2001).

According to Lavers (2018), there are complex and potentially explosive problems with ethnic and religious minority land rights. Pre-revolutionary land tenure systems in most of Ethiopia were the result of conquest land alienation and settlement by northern groups. Therefore, if there is a conflict with the local opinion or tradition, the government must maintain the right to protect ethnic minorities, women, and natural resources (Tura 2018). Lavers (2018), however, states that the truth is not quite so clear-cut. While state ownership of land continues to dominate land tenure, the establishment of ethnic federalism has direct consequences for land governance, particularly in terms of non-indigenous ethnic minorities. In addition, in many parts of the nation, non-customary tenure systems have maintained some influence.

2.3. The Underlying Causes of Land Degradation in Ethiopia

Land destruction was often listed as a major driver of environmental change and had a broad range of environmental and socio-economic consequences, mainly due to deforestation, for agriculture and settlement. Ethiopia experienced major famines in the 1970s and 1980s because of deforestation and subsequent loss of productive capacity (Bai et al. 2008). Ethiopia's annual forest loss rate from 1995 to 2010 was estimated at 141,000 ha, which is approximately an annual decrease of 1.1 percent of the total forest area (FAO 2010). Demand for domestic oil, expansion of farmlands, and overgrazing have been considered as the key drivers of deforestation in Ethiopia (Belay et al. 2014).

There were extreme land cover conversions in the Ethiopian highlands, mainly due to demographic pressure (high population growth and densities) and the resulting increase in food and household energy demand and the subsequent expansion of croplands and destruction of forests (Rosell et al. 2017; Getahun et al. 2013). In the central highlands of Ethiopia, there has been a major expansion of agricultural land and settlements over half of the last century, which has taken place at the expense of forests. Amsalu et al. (2007) recorded an 83% forest loss between 1957 and 2000, and Minta et al. (2018) recorded a 73% reduction in forest cover in the Dendi-Jeldu mountains of the central Ethiopian highlands in 1957 and 2014. Both authors link this forest loss to the expansion of agriculture, pastureland, and settlements as a response to the scarcity of available and suitable land for cultivation. The same trend of deforestation was found in North Central Ethiopia, South Wollo (Rosell et al. 2017).

As a result of both rural–urban and urban–urban migration, population growth in the satellite cities surrounding Addis Ababa has increased in recent years (Lohnert 2017). In particular, the migration of Addis Ababa's urban people, who are finding job opportunities with the industries and developments in the urban fringes, has brought about major changes in land use. This indicates that urban growth and development cause vast deforestation ranges across major urban centers (Kasa et al. 2011; Mohammed 2015). The estimated cost of land loss associated with land use and land cover changes in Ethiopia is estimated at around USD 4.3 billion annually (Gebreselassie et al. 2016). According to Gebreselassie et al. (2016), in Ethiopia, the cost of rehabilitating the degraded land through land use and cover change was found to be around USD 54 billion over a 30-year duration. The land tenure, which will be addressed in the next section, is among many reasons for degradation (Chekol 2017).

As shown in Figure 2, there are three main levels for both land degradation and land improvement. The first level, drivers of land degradation, can be mediated and modified by the second level, the institutional environment. This process will/could lead to land improvement if the third level, land user resource allocation, is considered carefully. Land improvement and land degradation mitigation can result from a behavioral change of land users and their reallocation of resources (e.g., capital or time) to land improvement practices. The entire process will lead to land degradation, unless all these three levels are mediated and modified by a number of institutional programs on land tenure security.

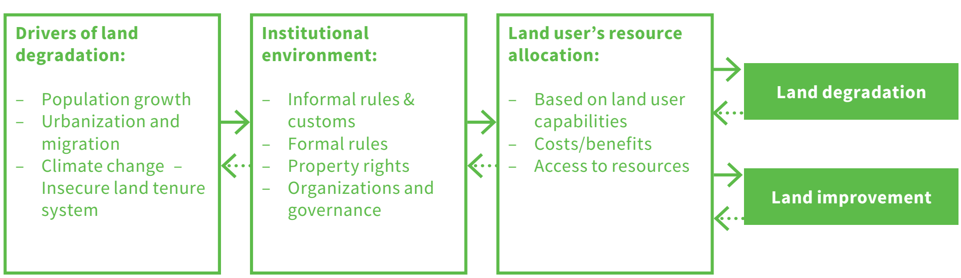

Figure 2. Three main levels of land degradation and land improvement.

3. The Challenge: Impacts of Land Tenure Insecurity on Natural Resources and Land Users

3.1. Land Degradation: Biodiversity Loss

Land degradation has been characterized by a steady decrease in the land's productive potential, which can occur through any combination of related processes, such as soil erosion, soil nutrient depletion, biodiversity loss, and deforestation (Le et al. 2012). Some of Ethiopia's environmental challenges today include the relationship between the environment and development in general, the poor involvement of citizens, and community-based organizations in environmental protection activities (Le et al. 2014). Furthermore, poor land management practices coupled with a lack of understanding lead to the significant depletion of natural resources, such as forest loss, soil degradation, and the scarcity of water supplies (Bai and Dent 2008). Ethiopia has developed a variety of significant policies and strategies regarding the climate. However, the formulation of sound policies and plans alone is not an ideal solution, since the goals can only be accomplished if they are applied correctly (Hansen et al. 2013). While poor policy and strategy implementation remains a major constraint, some other policies and practices hinder the proper implementation of successful and sustainable resource management activities, such as investment policy or regional policies (Le et al. 2014).

As discussed by Gete (2015) and MoARD and WB (2007), despite the fact that tackling land degradation and biodiversity loss through restoring degraded natural resources (e.g., soil and forest) was a priority for the country, organizations dealing with natural resource management were frequently restructured. This process resulted and still results in a high turnover of staff, loss of institutional capacity leading to discontinuity of activities and initiatives, and loss of institutional memory. More importantly, the absence of participation in the management of resources has resulted in the rejection of central government policies, such as settlement and resettlement, reforestation and soil conservation campaigns, and tree cutting prohibition programs (Yosef et al. 2013). In addition, public sector land development efforts have been made with little consideration of traditional land users.

3.2. Soil Erosion: Land Productivity Loss

A key element in soil degradation is the process, which leads to a reduction or loss in the current or future productivity of land and the ability to use it under the effect of different natural or human factors (EPRS European Parliament Research Service). The loss of soil is among the most obvious factors that affect farmers' livelihoods and also indirectly affects the livelihoods of people depending on the production of food by farmers. Soil erosion is highly sensitive to the effects of both human and natural conditions (Pimentel and Burgess 2013). Gully erosion is among the different forms of soil erosion across the globe and has an impact on the productivity of land (Ionita et al. 2015).

Among the major causes of soil degradation in Ethiopia is soil erosion. Berry et al. (2003) mention that the country's annual economic loss derived from soil degradation in the form of soil erosion and nutrient depletion is in the range of 10–11% of agricultural gross domestic product achieved by the country's highlands. Several recent studies (Yesuf et al. 2008; Tsegaye 2019) have estimated the annual cost of soil degradation related to soil erosion and the loss of agricultural and grassland nutrients to be around USD 106 million. The rapid population growth in Ethiopia has led to a decline in the supply of cultivable land and very high soil erosion rates (Essays UK 2013). Generally, the insecure land tenure system and the historic changes in land use in Ethiopia have had a major impact on the country's biodiversity, natural resources, and farmers' livelihoods, which will be discussed in the following sub-section (Tsegaye et al. 2019).

3.3. Impacts on Farmers' Livelihoods: Low Income

Land degradation poses environmental challenges and causes land productivity losses that, in turn, lead to the conversion of high-value biomes, particularly in countries with low-income, where most rural farmers rely on natural resources (Lal et al. 2014). Land degradation caused by an unstable land tenure system has negative implications for the protection of household food and directly reduces rural communities' livelihoods in Ethiopia. The initial effect of soil degradation is lower crop yields, resulting in increased rates of poverty among farm households (von Braun 2013). This poverty leads to less potential for land users to invest in sustainable land management practices and thus higher land degradation rates (Bai et al. 2008). It is important to understand the causes of land degradation and their interactions to determine the correct steps to address it.

Land tenure, as a security feature, has fundamental roles in the livelihoods of farmers. Secure land tenure can provide reasonably good markets with additional benefits and opportunities, including production, input, and financial markets (Baumgartner et al. 2015). Sound land ownership rights broaden the planning scope of agricultural entrepreneurs and make expensive advances in sustainable land management more practical and competitive with significant mid- to long-term benefits (von Braun 2013). It is essential to recognize that a fair and efficient rule of law is a prerequisite for secure land tenure, such that the effect of the rule of law on sustainable land management supersedes that of land-right protection. Therefore, in middle-income and advanced economies, sustainable land management has a positive relationship with land tenure protection (Baumgartner et al. 2015).

4. The Solution: Land Tenure Institutions and Access to Land

4.1. Strategies of Farmers to Secure Land Use Rights: Use, Control, and Transfer

Policies and initiatives aimed at preventing and reversing land degradation have long suffered from the lack of a strong and clearly defined goal for directing action and designing tangible progress. A breakthrough agreement on the concept of land degradation neutrality (LDN) was reached between the parties at the UNCCD in October 2015. The LDN aims to mitigate the projected losses of land-based natural resources and associated ecosystem features and services with metrics that produce alternative benefits through strategies such as soil regeneration and sustainable land management (Kust et al. 2018). The primary scope of land degradation research is currently centered on assessment and monitoring based on various data sources, measures in mitigation and ecological restoration, estimation of key drivers using different techniques at different scales, or simulation of growth patterns and forecasts using quantitative models. Yue et al. (2016) suggest that land use form and quantity should meet human needs and be in accordance with the natural conditions. The work of Kust et al. (2018) indicates that LDN policies need to communicate closely with climate change adaptation plans. Countries have to perform a thorough assessment of land degradation for non-farming land in order to make appropriate and timely land degradation policy decisions.

Regimes regulating tenure rights include access to productive capital. It is essential that land is accessed and managed at the farm level. This is crucial for the livelihood, equity, and productivity of farmlands, especially in rural societies (Lipton et al. 2009). Changing the property right system means either changing the political structure or making substantial efforts by the current regime. Ethiopian agriculture cannot produce enough to feed the country's fast-growing population. A brief historical analysis reveals that up to the end of the 1950s, Ethiopia was self-contained in the production of staple food and net food export (Belay and Manig 2004). More importantly, the development of the Ethiopian economy, in general, and that of the agricultural sector, in particular, have been affected by a range of policy factors, including Ethiopia's top-down approach, insufficient legislation, incorrect priorities, and poorly defined property rights. Highland farmers believe that the adoption of soil conservation measures is a pre-condition to achieve long-term land use certificates in the sloping lands. Another strategy is to buy the farmland through "owner financing". A contract of sale of installments or land is a contract under which the seller of the land (original owner) agrees to pay the selling price to a new buyer. The new buyer enters the ground and begins to pay the seller/owner directly on the basis of an agreed interest rate and other conditions (Belay and Manig 2004).

4.2. Implications of the Land Tenure System in Sustainable Land Use

Land tenure potentially impacts sustainable land use by improving incentives for production and increasing soil and water conservation investments. Thus, changes in access to farm holdings and the ability to exclude others from receiving benefits accruing from land result in resource use changes. This, in turn, affects the demand for labor and capital, productivity, and consequently, income and sustainability (Binayaw 2015). Land use policies are generally considered to have significant impacts on investments, but this might not be a universal formula applicable to all contexts. For instance, in Kenya, Deininger et al. (2006) found no empirical evidence proving that land titling enhances credit markets, land markets, and investments. A secure land tenure system provides countries with a framework to eliminate poverty by ensuring land tenure and ensuring stability on the land market (Holden and Otsuka 2014). Since economic development is among the common goals of many developing countries, such as Ethiopia, one might argue that Ethiopia's current policy of introducing an urban cadastral system is advancing the level of economic development (Adem et al. 2020). Many land use planning programs were introduced in Ethiopia, but with varying degrees of success. Each of these (pilot) projects included cadastral device implementation trials, but these were not complementary to earlier projects. This has resulted in overlaps, redundancies, and ineffective and incoherent cadastral structures across the nation. The persistent absence of a project progress assessment during each process was among the most remarkable characteristics of these projects. In other words, the strengths and limitations of the previous projects are not analyzed regularly, and the methods used in initial projects are not being organized. On the other hand, international organizations should create standards and metrics that can perform these tasks, but such standards are not being implemented. For example, the FIG proposed a set of criteria for developing and accessing the security of tenure (EFQM 2019). As shown in Table 1, the important factors/issues relevant to land degradation and the institutionalization of land tenure include participation, inappropriate land use system, population pressure, and institutional failures. This table shows how these factors lead to land degradation and how they could be avoided using relevant measures (strategies). As an example, an inappropriate land use system (e.g., deforestation, and overgrazing) could be avoided through a forest relations strategy and regulations on grazing management by implementing forestry and plant control policies and legislation.

Table 1. Significant issues and focus areas in the combat against land degradation and institutionalization of land tenure.

Important Issues/Factors	Main Problems	Main Solutions	Measures to Betaken	Responsible Body
Participation	- Lack of a supportive environment - Losing the knowledge - Failure to understand the partnership	- Environment enhancement - Power development	- Building awareness - Making local governance stronger	NGOs (non-governmental organizations), international partners
Inappropriate land use system	- Steep slope farming - Deforestation - Overgrazing - Population pressure	- Property ownership and property use regulation - Forest relations strategy - Regulation on management grazing - Policies on population	- Appropriate land use, forestry, and plant control policies and legislation - Public education - Introducing a population strategy	Regional government, NGOs/CBOs (community-based organizations), development partners
Population pressure	- Uncontrolled growth - The uneducated and motivated women to regulate their own fertility	- Stabilized population growth based on the economic growth - Practiced family planning - Empowering females	- Introduction of a population policy effectively (family planning) - Alternate job chances - Training and empowering women	Governments, NGOs/CBOs, development partners
Institutional failures	- Institutional instability - Resource scarcity - Coordination and integration problem	- Stable institutions, with clear mandates - Suitable resources - Clear integration and collaborative effort	- Creating clear mandated and empowered institution - Fairly sufficient resources - Establishing a system where organizations integrate their activities and organize them	Federal governments, regional states, NGOs, Development partners

Source: Berry et al. (2003).

5. Discussion

5.1. Natural Resource Policies and Land Use Decision Making

The determinants of land tenure include changes in vegetation cover and species spatial distribution, impacts on climate change, the effects of long-term human activities, and land management practices variations (Kakembo 2001). Land tenure is often cited in land transfers and improvements as a way of informally obtaining and owning property by citizens and businesses and improving tenure protection and alternative land usage, as observed in African countries, such as Ethiopia (Mwangi et al. 2018). As stated by Zinda and Zhang (2017), land tenure regimes shape how families use labor and other means of subsistence. Within a given tenure system, existing households with changing trade-offs shift land–labor relationships over the household life cycle. Therefore, the legacies of land distribution after de-collectivization, in particular, secure access to land and restrictions on land transfers, can create separate patterns connecting livelihood strategies to household life cycles in Ethiopia alongside the growing market exchange of labor and production. Land tenure underlies some of the incremental uses of land and includes farmers' shift cycles, turning forests into areas first used for annual and subsequently for perennial crops (Wannasai and Shrestha 2008). Therefore, shifting land ownership in African countries will alter the landscape pattern and ruin mature forests for the production of modern agriculture. According to Gedefaw et al. (2020), land tenure patterns in Sub-Saharan Africa are rapidly changing. They argued that extensive changes in land tenure have occurred in some Ethiopian regions over the past three decades, such as Gozamin. These changes occurred primarily in agricultural lands and then moved to grasslands and forests. Based on the findings of this study, land degradation in Ethiopia has significant socio-economic and environmental tradeoffs, and we need to understand barriers within the social, economic, and political contexts. Kassa et al. (2016) argued that transformation of crop forests and grain-based forests affects biodiversity; soil fertility; soil loss; and economic, social, and cultural conditions of the Ethiopian people. In addition, the loss of natural forest cover in various areas threatens the sustainable agricultural practices and livelihoods of the local community. In another study by Hammad and Tumeizi (2012), it was found that the deterioration of land is a natural and socio-economic cause–effect phenomenon that is common across the globe.

The socio-economic degradation of land in Azerbaijan calls for efforts to improve farmers' awareness of the environment, environmental standards, and legislation, and for the reduction in land mismanagement, diversity of tenure has been observed in common occupation regimes at different land levels in Ethiopia. As a result, it can have different effects on management activities, such as forest cover and land use management. Asaaga et al. (2020) showed that different components of tenure security influence the adoption of non-consistent methods across the various components of tenure security or specific, sustainable land management procedures in African countries such as Ghana. According to the results, in Ethiopia, the relationship between tenure security and sustainable land management investments is also mediated by other important non-tenure factors (including access to credit, modernized agricultural inputs, and targeted extension service support). The results also correspond to and are confirmed in the studies by Kamwi et al. (2017), Walmsley and Sklenička (2017), and Um (2020). These findings, therefore, suggest that Ethiopian land tenure policy will produce a range of positive and negative outcomes relating to investment in land conservation. This indicates the need to think more deeply about prioritizing sustainable land management interventions, especially in emerging areas in Ethiopia.

Overall, these findings are important for redesigning context-specific and appropriate land-use policies to address barriers to Ethiopia's sustainable land management. Furthermore, according to the findings, particular attention should be paid to tangible local incentives for taking action against land degradation. Due to land degradation, consolidating land ownership mitigates certain economic losses and costs (Nkonya et al. 2016). In confirmation of these findings, we can refer to the results of the study by Barbier and Hochard (2018). They believe that land is among the few productive assets that rural poor people own and that nearly all of these households are engaged in agriculture. In low-income countries, such as Sub-Saharan Africa, the rural poor population in agricultural degradation increased over the period 2000–2010. Although degradation threatens the survival of the poor population, this is a complex and economically, socially, and environmentally important interaction. This also limits the impacts of economic growth and economic reforms on poverty reduction.

The erosion of soil is a key cause of land degradation in various parts of the world. This concerns especially developing countries where soil erosion through water seriously endangers farm productivity and food security. In Ethiopia, precipitation is erosive, and soil erosion by water is a major environmental challenge (Fenta et al. 2017). The issue is particularly important because heavy rainfall, steep roots, and agricultural practices that reduce soil protection can lead to potentially high erosion rates (Ebabu et al. 2019). The soil erosion threats and trends were linked to land use and related land tenure practices, such as land fragmentation, especially in agricultural communities. This level of understanding indicates the importance that societies assign to their natural resources in their decision-making processes. The productive land tenure system shows a clear trend for improving resource management. By analyzing the findings of related studies, we learned that the enhancement of forests and the weeding of land biomes have been productive, primarily through participatory community engagement. This underlines the value of collective governance and by-laws that appear to be more effective when implemented and enforced at the local level. These results are consistent and in line with the findings of studies by Ntihinyurwa et al. (2019), Uddin et al. (2018), Terefe et al. (2020), and Sklenicka (2016).

5.2. Land Governance and Land Use Decision Making

Main aspects defining land governance include how land rights are defined, exchanged, and transformed; how public oversight of land use and land management is performed; how state-owned land is managed; and how information on land ownership is collected, controlled, and made publicly available (Hailu 2016). Land tenure, or access and rights to land, is essential to sustain people's livelihoods. The insecurity of perceived and de facto land tenure leads farmers through farming and non-farm job opportunities to explore alternative strategies and avenues for food supply. Therefore, from a political perspective, it is important to emphasize that people's livelihoods must be given priority in land governance, thus extending the current positioning of land solely as a pathway for agricultural or conservation production (Keovilignavong and Suhardiman 2020).

The way land governance is implemented can greatly influence how agricultural and non-agricultural land is used and whether long-term sustainability investments are being made. The land registration and certification of smallholder farms and communal land, for example, can encourage land managers to engage in higher value and more productive land uses (Byamugisha 2014). Secure rights can provide incentives for longer-term investments to enhance land productivity, protect local communities, and safeguard the environment in general (Falk 2016). Likewise, the level of clarity of land tenure on forestlands can affect the willingness of land managers to invest in future forest productivity or conversion to other land uses. Finally, overlapping rights and claims can create conflicts (Hailu 2016) and greater uncertainty for investors (Deininger and Ali 2007). Land management should enable different stakeholders to participate in government decisions and ensure the safety of their livelihoods (Azadi 2020). However, depending on the government's decision-making process, land governance could be poor or strong. So, land governance is a prerequisite in rural areas of developing countries for economic growth and poverty reduction (Bessa and Brunori 2017). In Ethiopia, the government is supporting the gradual reform of land administration and tenure within the country's system of state ownership of land. For example, the last five-year plan committed to scale up second-level land certification in the highlands, and innovative, pilot-level projects of community certification of land, for rangeland communities, for example, are underway (Woldegiorgis et al. 2018). However, gaps in land governance remain. A recent assessment highlights important challenges requiring urgent attention, such as strengthening rights to forest (Okoli 2019) and common lands (Ma Rhea 2018), increasing the effectiveness of rural land use regulations (Van der Sluis et al. 2019), improving public land management (Long and Qu 2018), making large land transfers to private investors more transparent and competitive, and strengthening public provisions of land information (Hailu 2016).

The common land resources grant "common access" to everyone and are used for various economic gains, as the name indicates. They include the communal land, community pastures, forestry, wildlife, wastelands, common dumping, thresholds, banks, and river beds governed by social conventions and legal rules. Forests supply forests. Agriculture and social forestry are also used to support livestock pastures. In general, they represent a large proportion of poor Ethiopian farmers' income, socio-economic growth, and livelihoods. The steady fall in agricultural incomes has caused small farms to become inviable for farming practices. Thus, most farmers use these resources to add to their income. Some farmers depend on them for their livelihoods. Therefore, lands that are used collectively have a great impact on the sustainability of environmental and social systems because they can provide natural resources in the event of various crises and be used as an alternative source when crops are damaged (Dwomoh and Wimberly 2017). Land tenure and environmental conditions are closely related: land tenure can promote land use practices that harm the environment, or it can serve to enhance the environment (von der Mühlen et al. 2020).

The findings of Fonjong et al. (2016) indicate that the government; leaders; and, to a certain extent, elites have played a central role in the formal and informal processes of providing investors with land. Nevertheless, both processes neglect women and communities affected because there are no mechanisms for holding actors, particularly women, to account for their livelihood on land. It is, therefore, essential to have a legislative framework that makes the process transparent and promotes responsibilities and gender inclusion. Given that, in general, insecurity in land tenure is a major limiting factor in Ethiopia and in developing countries for sustainable use, the government has introduced a Rural Land Certification Program to ensure land tenure. As shown by Mengesha et al. (2019), Alemu et al. (2020), and Abi et al. (2018), as soon as their land was certified, the majority of farmers in Ethiopia practiced sustainable land use. Land certification, therefore, makes a major contribution to sustainable land use. Since access to land for developing countries, such as Ethiopia, is a fundamental socio-economic requirement for sustainable agriculture and forestry, tenure security is key to development in poor populations and is essential to achieve sustainable development goals. Therefore, the rights of land tenure as the entry point for the empowerment of the poor should be considered. The security of land tenure is currently applied in Ethiopia with land registration and land certification. This helps improve sustainable land use practices. This enables other countries, particularly developing countries, to learn from this achievement and emphasize land tenure rights for their country's development and sustainability (Rampa et al. 2020).

In fact, property ownership and tenure security are fundamental factors and are a good start for sustainable land management practices. Nevertheless, a policy on land use in order to implement sustainable land use practices should be developed. The land degradation and deforestation problem can otherwise not be resolved (Hendriks et al. 2019). In turn, this could threaten agricultural output and exacerbate the country's poverty situation (Lencucha et al. 2020). Moreover, the experts and local people have a weak tie to the plantations of tree plants. Practices and technology are most often developed using a top-down approach without local citizens being involved. Sustainable land use and sustainable development, in general, cannot lead to this situation (Liu and Ravenscroft 2017). Indigenous local people's knowledge should be integrated with scientific expert knowledge to improve sustainable land use and boost agricultural output (Adade Williams and Shackleton 2020). Most of Ethiopia's legal documents, including the constitution itself, stress the need and value of public involvement in natural resource governance (Gebreamanuel 2015). However, the literature warns that such fundamental freedoms cannot be expected to be followed because the decision-making power of the public is significantly undermined by policymakers. The ECA (Economic Commission for Africa) (2002) reported that current land policies have failed to achieve planned outcomes due to a lack of public participation and interaction, as it is structured using a centralized and top-down approach. According to the relevant studies (Gebreamanuel 2015; Meshesha et al. 2012), these government policies have resulted in a growing degradation of land.

6. Conclusions and Policy Implications

In conclusion, this study proposes some ways to tackle the problems arising from the insecure land tenure system in Ethiopia. The main problem found is the conversion of land classified as forest, protected area, or wetland to other uses affecting the biodiversity and environmental health in Ethiopia. To safeguard land, providing multiple ecosystem services and public goods, the official demarcation, mapping, and registration of public lands must accelerate. This must be aligned with a computerized land information system that supports public access. Performance gaps in allocating land for agricultural investments, a key driver of land use change, must be closed. Notable necessary improvements include increasing the institutional effectiveness of multiple land investment institutions, seeking comprehensive consultations and new benefit sharing models with local communities, and encouraging clear and enforceable land contract clauses to safeguard water, biodiversity, and other natural resources.

The fact that the threats deriving from the commodification of agriculture and the competition from global markets are not mentioned as major challenges for the development of rural communities indicates that the sustainability paradigm is weak. Sustainability pathways and goals set by the UN are a weak sustainability paradigm for a poor, developing country, such as Ethiopia. This is because the UN sustainability pathways fail to consider the peculiarity of the Ethiopian context, where the majority of the population live in poverty (Worku et al. 2018), in rural inaccessible areas (Kea et al. 2018), with low levels of school enrollment (Ramachandran 2017), and very low access to capital (Manlosa et al. 2019) and investments (Haile et al. 2019). Although Ethiopia has enacted laws to achieve a sustainable agricultural market, considerable gaps remain in applying and enforcing these laws within the context of food security and the commodification of agriculture.

More importantly, to achieve more sustainable food and land use, a functioning monitoring system is required to enforce the existing legislative provisions or propose new ones. This, in turn, will require further studies on the current capabilities and practices within governmental structures and the awareness of landholders to apply land laws that support a sustainable food and land use system. The small farmers of Ethiopia play a significant role not only in feeding a large segment of the country's population but also in contributing to food security. There is, therefore, an urgent need to promote strong rural economies in rural areas of the country, empowering and renovating small-scale productive agriculture. This scales down the tide of out-migration from rural regions and creates adequate employment opportunities and strong foundations for food security. In this way, stronger sustainability paradigms, such as food sovereignty or agro-ecology, are more capable of fully addressing the sustainability needs of a developing country, such as Ethiopia. Although Ethiopia has enacted laws to achieve social and environmental objectives, considerable gaps remain in applying and enforcing these laws within the context of land allocation decisions. Expanding access to customized agricultural extension services for female farmers; increasing women's access to key inputs, such as seeds, fertilizer, and pesticides; building women's assets and improving their access to credit; and other gender reforms could support the transition towards a sustainable food and land use system. It is also essential to monitor smallholder commercialization closely in order to detect unintended risks that can lower nutritional outcomes or widen gender gaps within households. Land degradation is a common problem in Ethiopia and has a devastating effect on the socio-cultural and environmental settings of the region. The findings revealed that major causes include rapid population growth, extreme soil erosion, deforestation, low vegetative coverage, and unbalanced crop and livestock production. To manage land loss, conservation policies have concentrated on physical management mechanisms (such as soil erosion) and stable land tenure systems throughout the past. Removing bottlenecks in land administration and strengthening land and resource security can create incentives for more sustainable land and resource management. Improved land administration results in economic and social returns. Future studies on improving low price soil fertility applications and the improvement of environmentally friendly or sustainable farming methods could help in improving land use. Policymakers should consider the above-mentioned points and consider the effective application of the laws.

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New Types of Land Ownership to Sustain Life on Land

Insa Theesfeld and Jarmila Curtiss

1. Introduction

Sustainable Life on Land, the fifteenth UN Sustainable Development Goal, calls for protecting, restoring and promoting sustainable use of terrestrial ecosystems, including agricultural subsystems. Related to agricultural production, Targets 3 and 5 of SDG 15 are particularly relevant. Target 5 regards "taking urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species" (Wood et al. 2018; Blicharska et al. 2019). The need for such action is as critical in Europe as it is in other regions with intensive farming and industrialized agriculture (Dudley and Alexander 2017). Besides the loss of biodiversity, the European agricultural sector faces severe challenges of farmland degradation (Panagos et al. 2018; Panagos et al. 2016; Panagos et al. 2019; EEA 2020). Therefore, in our inquiry into newly emerging organizations governing agricultural land resources, we consider their contribution also to Target 3 of SDG 15, "Combat land degradation, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world".

Various kinds of agricultural farming practices, notably ecological or regenerative farming, but also no-till farming practices and integrated pest management, which emphasize soil protection and the growth of healthy crops with the least possible disruption to agroecosystems, share these target goals as well. However, as these practices come at costs to farmers, they are adopted less broadly than socially desired. Therefore, fighting land degradation and protecting biodiversity in connection with the agricultural use of land have, for a long time, been the subject matter of political debates and interventions (European Commission 2006, 2020). Agri-environmental schemes (AES) under the Common Agricultural Policy of the European Union are an example of such political efforts. Nevertheless, even this most widespread mechanism to encourage farmers with financial compensation to engage in more sustainable practices has been assessed rather critically. Hardy et al. (2020), for example, evaluated the effectiveness of these measures as rather weak as half of the schemes have not increased species richness. To increase their effectiveness, Fleury et al. (2015)

suggested that local collective actions and participative governance are required to complement and support the AES.

The notion of the benefits of a natural resource participatory governance is also supported by the commons literature that points to the particularity of natural resource management. For example, Basurto et al. (2013) referred to natural resource governance arrangements as being responsible for conservation behavior and success. More cooperative forms are thought to be more conducive to sustainable natural resource use. Further, in the area of land tenure, the institutional shift from private (individual) to collective property rights to land has long been asserted as a way of improving incentives to use land in a more societally desirable and sustainable way (Bromley and Hodge 1990). The wide range of land governance arrangements emerging across and within European regions provides evidence of the ongoing institutional shift that may reflect the diverging motives of alternative governance formations. The joint and community-supported land governance arrangements subject to this study could be expected to more likely follow motives such as resource conservation, sustainable management and restoration.

However, cooperative land governance has been discussed in the recent literature as only one potential mode of the ecological transition of land use. Other measures such as knowledge transfer, supporting new entry into farming and farm succession, access to land or changing symbols of farmers' identity have also been pointed to as potential facilitators to achieving the Life on Land SDG. Carlisle et al. (2019), for instance, identified stagnant farm succession and barriers for new entrant farmers who are more likely to adopt agroecological practices with more diversified cropping and livestock systems as barriers to be eliminated. To achieve this, they suggested pushing the role of ecologically skilled farmers and less farming intensity that would reduce the harmful use of non-renewable resources.

The positive role of new entrants into farming for achieving the Life on Land SDG has been highlighted in several other studies. For instance, Zagata and Sutherland (2015) found new entrants into farming to be more interested in and responsive to environmental issues. Correspondingly, they represent a disproportionate number of organic farmers, particularly in Western Europe, where they achieve greater environmental outcomes (ibid.). Another role of new entrants into farming was found in their potential to change symbols and the inherited farming identity (Sutherland and Calo 2020). Farm identity means that farmers want to demonstrate a certain role performance, such as weed-free fields. According to Sutherland and Calo (2020), this kind of inherited farming identity represents another barrier to achieving the Life on Land SDG, as it might hinder the ecological transition of farming. To get rid of such barriers, symbols need to change, and according to Sutherland and Calo (2020), new entrance into farming might be the time to question these symbolic values. There are also several studies supporting that farmers' age relates to views on sustainability (Comer et al. 1999; Vanslembrouck et al. 2002). However, Zagata and Sutherland (2015) questioned the usefulness of concentrating on age (i.e., being young) as a factor of more sustainable farming, promoting the factor of new entry.

Nevertheless, to contribute to long-term sustainability goals, entrant farmers require support mechanisms in order to remain in farming. They need exchange platforms and political market support mechanisms as well as access to land, facilitated, for example, by the cooperative governance forms considered in this contribution (Sutherland and Calo 2020). The role of knowledge as a factor of the adoption and development of more ecological farming practices, particularly for entrant farmers, was assessed by Calo (2018). He pointed out that extension and educational programs for entrant farmers do often not answer to their needs. However, even well-trained and successful farmers with environmental ambitions, such as protecting biodiversity, face structural challenges such as access to land or securing product markets. Thus, to facilitate the ecological SDG 15, educational programs may need, beside mediating entrepreneurial knowledge, to include tools for dealing with the above-mentioned structural challenges. With relevant training, farmers promoting environmentally friendly practices could better enter farming and stay successful in business (Calo 2018).

Despite knowledge transfer, access to land and successful farm succession all being critical conditions for adaptive changes and an ecological transition of land use, without land tenure security, these changes are further unlikely to take place. For instance, Calo (2020) stressed the relation of land tenure distribution and the fight against biodiversity loss. He pointed out that the power to decide on land is inevitably intertwined with the capacity to adapt. This is why a core challenge of meeting the SDG on Sustainable Life on Land is the way land property rights and markets are structured. The socio-legal commitments to private property and the current interest in farmland as a financial asset suggest that a change to more sustainable land use practices will require land governance innovations. Therefore, to understand the progress towards and potentials of achieving SDG 15, it is important to study the emerging forms of land ownership.

In the following, we present unique developments of ownership to land in Germany. In Germany and other European regions, we particularly observe a growth in community- and civil society-supported (community-supported hereafter) organizations of farmland ownership that are mobilizing financial resources for joint land acquisition and promoting delivery of the ecological targets. Some of the endeavors may appear in a way similar to crowdfunding initiatives (Behrendt et al. 2018) or impact investing (Höchstädter and Scheck 2015), where investees do not seek competitive returns on their investments, which, however, result in innovative land governance arrangements. These aim to control resource access, but even more normatively to define the use of land (Bahner et al. 2012; Bahner 2015). Their initiators and supporters often perceive land as commons (Fabjančič 2016; Bahner et al. 2012) and thus ultimately aim at withdrawing land from future market exchange. Their driving belief is that sustainable use of land cannot be achieved when ownership of land is private (individual) and is directly linked to profit- or production-maximizing endeavors (ibid.). Instead, ecologically and socially sustainable use of land is perceived to be best achieved within a "steward-ownership" model with clear criteria and social practices stipulated by a larger community (members or the public). Some community-supported land organizations form in tandem with joint farming communities and aim at environmentally sustainable communal living. Common to all is their self-initiated ecological and also often social value added.

Having described the general impediments to and possible factors of adaptive change and ecologic transition in line with the Sustainable Life on Land SDG, we identified the role and unique potential of the emerging community-supported land organizations, especially if they also adopt the above-described measures such as targeting new entrants into farming or facilitating knowledge generation and transfer. In this chapter, we inquire into the scope of the emergence and diversity of these organizations. In doing so, we respond to the following question: What are the governance interventions of key land commoning efforts in Germany? More specifically, we ask whether such forms of joint farmland ownership are driven by motives congruent with SDG 15 and form governance structures and rules of cooperation with farmers or farming communities that support their achievements.

Based on a German-wide scoping study, we will first introduce the diversity of legal forms of organizations that support such new forms of community-supported land ownership in Germany. This will provide a first perspective on the different legal requirements and opportunities to steer and restrict the property rights to (i) the use of land of the engaged farmers and (ii) the returns of the investees. It will help to assess the formal opportunities to secure ecological farming practices. Second, we will show the geographical dispersion of the partner farms in Germany. This will provide a first indication of the general role such new forms could play as a focal point for social innovation with an ecological impact (Moore et al. 2012; Westley and

McConnell 2010; Kunze 2015). Case studies of two forms of community-supported farmland ownership will exemplify the motives and governance structures for the ecological conditions as well as cost–benefit distribution among stakeholders making such structures possible. We will conclude with opportunities such organizational forms could bear for the fulfillment of SDG 15 and how they can be supported.

2. New Forms of Governing Land Ownership and Use

Community-supported organizations of land ownership can be found in various legal forms under the German business and corporate law. Due to the previously reported organizations' aim to mobilize societal support (Bahner et al. 2012; Rüter et al. 2013), we assumed their broad social outreach and thus active online presence that allowed us to base our scoping analysis on an online search. We created a German-wide sample that covers the wide spectrum of the legal forms and organizational constellations. The online search followed a deeper analysis of the organizations' available documents. Only those organizations were considered in which the providers of financial capital support ecological outcomes without expecting (a) full financial returns or (b) other forms of capitalizing on their investment.

To measure the actual impact on ecology (such as humus content or soil erosion data), a long-term dynamic study with ecological indicators would be needed. However, the static approach at hand allows offering a good indication about the opportunities to shift the agricultural production towards haltering biodiversity loss and sustain soils by certain conditions farmers need to agree on in exchange for receiving the option to lease land plots or to access land through partnerships with community-supported organizations that act as stewards.

2.1. Organizational Diversity and Outreach

There are six different legal organizational forms (excluding the group of "others") of how community-supported organizations of farmland ownership appear in the current agricultural sector (Figure 1). Within the 56 organizations which we studied, we found 31 agricultural homesteads officially registered with a publicly beneficial pursuit under three legal forms. These are publicly beneficial limited liability companies (LLCs), registered associations and foundations. Checking for their outreach, these organizations are represented in rural areas with one homestead location. In contrast, as shown in Figure 2, the BioBoden Cooperative, for example, provides a network of 68 partner farms spread across the whole of Germany.

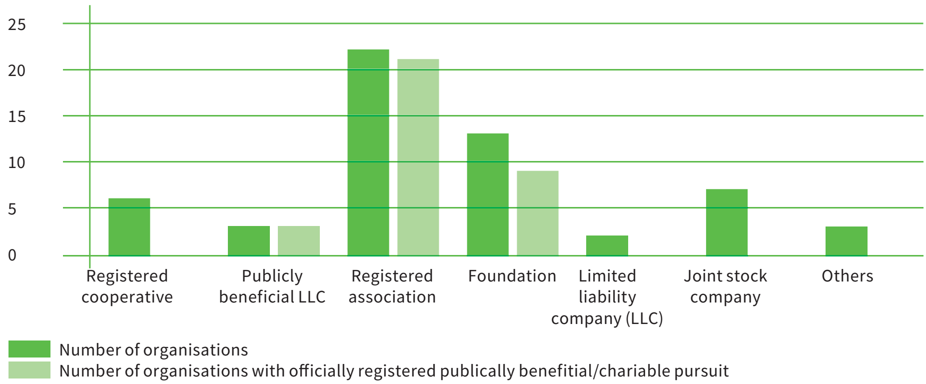

Figure 1. Legal forms of community-supported organizations of land ownership. Source: Graphic by authors.

Depending on the legal form of the organization that constitutes the new community-based land ownership, the individual supporters (shareholders/members/investors) do not necessarily come from the rural areas where the actual farming takes place. People can invest in agricultural land funds, become a member of a soil cooperative, get financially engaged in an association or become a stockholder of a stock company without regional ties. Although we talk about new community-supported organizations of land ownership, the capital providers/supporters do not actually become land owners registered in the German land registry. Formally, the associations, foundations, corporations, partnerships or cooperatives own and manage the land on behalf of the investors and communities.

2.2. Partner Farms and the Ecological Target Delivery

The partner farms, who are supported by such new organizations of land ownership through long-term rental relationships and rental rates often below market rates, have to follow various ecological guidelines, ranging from broad aims of eco-farming to directly specifying production procedures. Thus, de facto the partner farms do deliver the ecological target. By target delivery, we refer to the tenants' contribution to Targets 3 and 5 of SDG 15, primarily to preserving biodiversity and to combating land degradation. The partner farms are mostly individual farms of various legal forms, but also farming communities or farm managing consumer cooperatives.

The spatial distribution of the partner farms exemplified for the registered cooperatives in Figure 2 shows their geographic outreach. The distribution shows a German-wide land governance model with an environmental orientation.

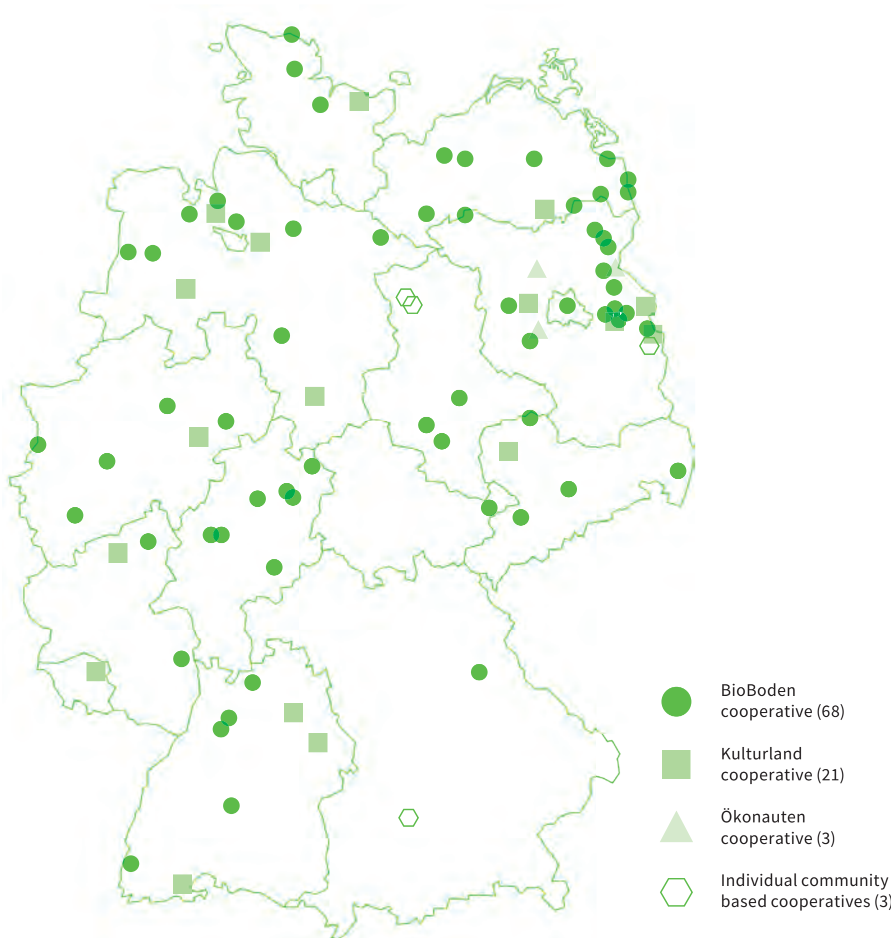

Figure 2. Geographic distribution of partner farms of land cooperatives. Source: graphic by authors created with ESRI Deutschland. **Note:** The individual community-based cooperatives are two consumer group-owned cooperatives, *Kartoffelkombinat* and PlantAge, and the ecovillage community cooperative Sieben Linden.

3. Case Studies of Community-Supported Land Ownership Delivering Ecological Targets

Two case studies will exemplify the new types of governing land ownership, which follow the principle of community-supported organizations of land ownership—*grund-stiftung am Schloß Tempelhof* (a foundation) and *Kulturland Cooperative*. Given the high diversity of organizations of community-supported land ownership as presented in Section 2.1, these two organizations cannot represent typical cases. We, instead, followed a purposive case selection illustrating expansive influential organizational types. We assume these land governance forms will influence the community-supported land organizations' landscape in the future. The case studies are based on qualitative interviews with initiators and active representatives of the organizations as well as on in-depth qualitative research of the organizations' websites and available online documents, such as the statutes and annual reports, and a review of previous descriptive studies.

Both selected cases represent bottom-up self-help initiatives identifying collective land ownership as a means to achieving their ecological objectives. The first case depicts a development where parts of the civil society, based on their motivation to support a fair distribution and sustainable use and preservation of basic natural resources—including land—get engaged. The second responds to developments in the land market and down-stream market segments perceived as threats to more sustainable—organic and locally embedded—farming. The two case study organizations thus differ in their founding sparks. The first stems from a civil society movement forming a community, while the second one was initiated by farmers. Respectively, we will call them "community-initiated" and "farmer-based" organizations.

Another common aspect to both organizations that importantly shapes their mission is their perception of the resource land as an Allmende (Commons) that should not be governed under a private property regime (Netting 1976; Yussefi-Menzler 2015). Recent developments in the land markets denoted by growing competition and soaring land prices prioritized land acquisition in the organizations' development agenda and unveiled the need for innovative instruments to expand their models through broader societal support.

In the following, we present the two case study organizations and the different governance structures they set up to facilitate their partner farms or farming communities to combat land degradation and to sustain biodiversity as well as to gain societal support for land acquisition.

3.1. Community-Initiated Case: Grund-Stiftung am Schloss Tempelhof (Foundation) and Community (Cooperative) Schloss Tempelhof

The charitable foundation *grund-stiftung am Schloss Tempelhof* was established in 2010. Its headquarters is in Kreßberg, located in the Jagstregion, a rural area in Southern Germany, in the state of Baden-Württemberg. It was founded by a community of 20 people organized in a cooperative, *Schloss Tempelhof*, who jointly purchased land and property in the village of Tempelhof for 1.5 million euros in

December 2010.[1] Perceiving land as a commons, the cooperative placed the purchased 32 ha in the foundation *grund-stiftung am Schloss Tempelhof* with the aim to ensure its withdrawal from the land market, and thus to avert future ownership transfer and to promote its long-term sustainable use. The cooperative leased the land back on a long-term basis to retain the user rights. Its 12-member working group for agriculture produces organic food for the community and a contractually linked group of consumers and sells surplus in the local market. Since its establishment, *Schloss Tempelhof* as a cooperative and a self-organized (ecological) village has grown from 20 to 150 inhabitants. Agricultural activity represents nowadays around 30% of its total turnover (Jacobson and Urbain 2018).

The community considers the foundation *grund-stiftung am Schloss Tempelhof*, the owner of the land, as the "guardian" of its visions. It defines the use of land according to socio-ecological criteria promoting sustainability and other broader objectives: "The intention of the Foundation founders is to promote cultural sites, institutions/personalities that/who *protect, preserve and develop our natural foundations of life, our environment with all its creatures*, maintain their health and health of the population, care for people and build up solidarity network structures, which enable and encourage a dignified coexistence of the people in self-determination and self-responsibility. A particular concern of the foundation is *to promote the realization that land is not a commodity*, but a gift from the earth" (foundation's statutes in the version dated 25 May 2015). The foundation fulfills specific ecological objectives of nature protection, including promotion of biodiversity, landscape management, plant breeding or research in areas of soil regeneration and increasing humus content (grund-stiftung am Schloss Tempelhof 2019).

To increase its outreach, the foundation opened up to communities that share these objectives and that want to secure agricultural land for permanent (long-term) use in congruence with the foundation's mission. The foundation offers communities the opportunity to lodge their land in their own foundation fund under the umbrella of the *grund-stiftung am Schloss Tempelhof*. The foundation currently accommodates three funds:

- *Gemeinschaft Schloss Tempelhof eG* (since 2010).

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[1] In view of the German Land Transaction Act, farmers enjoy preemption rights in land sale transactions, while non-agricultural market actors are permitted to acquire land only if no farmer is interested in the land purchase at equal conditions (further more specific regulations apply). The Schloß Tempelhof community was considered an eligible buyer in view of the Real Property Transactions Act, since farming the land was one of the main intended long-term economic activities of the cooperative.

- *Gemeinschaft Sulzbrunn eG* (since 2015).
- *ZukunftsWerk Fliegerhorst Crailsheim* (without agricultural land cultivation) (since 2020).

These communities (cooperatives) transfer their land ownership to the foundation and likewise lease the property back. The lease relationships are regulated by a long-term lease contract for 99 years obliging the communities to use the land in accordance with the foundation's statutes. The communities pay annual rent (*Erbpacht*) that is allocated to their fund within the foundation and that represents financial resources to be used for various charitable projects carried out by the respective communities. The projects relate, for example, to community development, permaculture and soil regeneration, safeguarding biodiversity, sustainable (living space) construction or youth development.

In 2015, the foundation extended its mission and placed a greater emphasis on fundraising for the purchase of land (*Freikauf* of land) (Nelle and Aehnelt 2019). The fundraising activities allow the broader public (society) to support activities and projects of the communities already linked to the foundation as well as the development of other communities with congruent objectives and visions. The introduction of the new objective and the active fundraising tool marks a change in the foundation to an expansive model, in which property is used as a special purpose asset (Nelle and Aehnelt 2019). The foundation's ultimate goal is not to acquire the real estate/land for its own use but to influence the use of the property in the direction of the foundation's mission defined in its statutes. In 2018, the foundation owned ca. 42 hectares of agricultural land and its land value totaled EUR 1,060,000.

The foundation-based land governance structure is schematically illustrated in Figure 3. It demonstrates the above-described interplay between the foundation as the charitable land owner and the cooperatives representing the land tenants. In addition, it illustrates that the governance design allows for mobilizing financial resources from society and the surrounding communities. The SDG 15 Targets 3 and 5 (provision of biodiversity and land stewardship) are thus facilitated by (i) the conditions set in the land rental contracts, as well as (ii) through the societal and community support systems (dark gray blocks). Additionally, community projects related to improving soil conditions and biodiversity are facilitated through the land lease relationship as the foundation returns the majority of the collected land rents to the communities via projects in accordance with the foundation's mission.

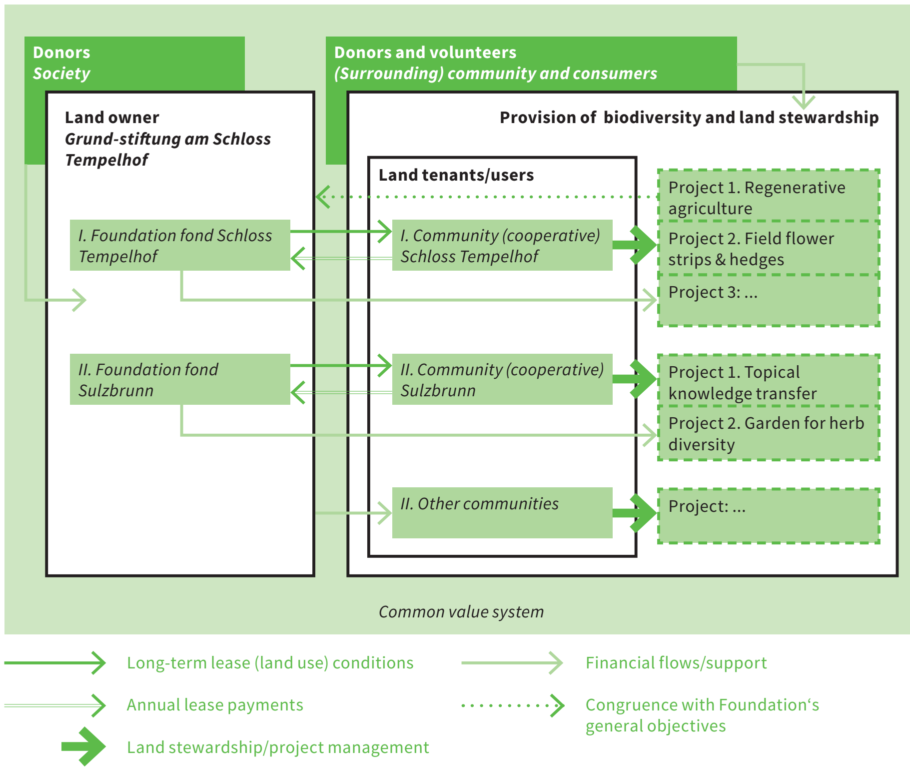

Figure 3. Land governance structure of the *grund-stiftung am Schloss Tempelhof*. **Note:** As of 15 September 2020. Source: Graphic by authors.

Of the total expenditures of EUR 98,000 in 2018, the foundation allocated 48% to projects related to nature protection, permaculture and soil regeneration (regenerative agriculture) (grund-stiftung am Schloss Tempelhof 2019).

3.2. Farmer-Based Case—Kulturland Cooperative

Kulturland Cooperative represents a land cooperative open to members of the public interested in supporting collective ownership of land (land commons) and its environmentally and socially accountable governance. The Cooperative purchases arable land, meadows, pastures, hedges and biotopes and makes the land available to regionally integrated organic farms that produce and regionally market food, as well as offering various social or educational services to the outside community.

It was founded in 2013 by a group of experts—researchers and farm consultants —in response to several impulses: (i) they identified then-observed trends in farmland markets and farm structure development as threatening small-scale organic farming and the sustainability of rural communities, (ii) they observed formations of new organizations of land ownership in Germany and elsewhere and (iii) they were ultimately and most importantly incentivized to action by a concrete case of a farm in need of a prompt response to a sales intent of the leased-land owner. Seeing the last instance as a reoccurring problem of many smaller farms, the founders aimed at establishing a platform that would allow organic and socially accountable farms to secure or extend the farmland in their use as their economic basis and a grounds for social and potentially other public/community-benefitting activities.

Although located in Hitzacker in Lower Saxony, the Cooperative has a broad geographic focus; it supports farms across Germany (see Figure 2). Its agenda is not to acquire land available on the market, but to respond to applications of organic farmers with a concrete land purchase issue. The expansion of the Cooperative is therefore dependent and driven by farmers' interest. As of autumn 2020, *Kulturland* purchased land in support of 22 farms (partner farms hereafter).

The Cooperative was initially soliciting financial support of land purchases mainly from the surrounding community of farms for which the farmland was purchased. Its approach has thus been particularly compliant with consumer-supported farms that are principally characterized by a strong link to and support from the consumer community but have no platform for governing land ownership or its share. As a result, 50% of *Kulturland*'s partner farms are set up as community-supported agriculture (Carlson and Bitsch 2019). In recent years, *Kulturland* expanded its member recruitment to the broader public by designing online crowdfunding campaigns. The crowdfunding tool attracts financial supporters from areas beyond the farms' surrounding communities.

The financial supporters who, through the *Kulturland* model, become land cooperative members are not-for-profit impact investors whose interests lie in contributing to the long-term security of farmland for locally embedded organic production. Although having the option to choose from concrete crowdfunding campaigns, they become cooperative members without any linkage to a specific farm. With a membership share price of EUR 500, the membership is attainable for small investors from the general public. This geographically non-restricted fundraising and low membership share price concept allow for flexible fund acquisition and cooperative expansion. As of July 2021, *Kulturland Cooperative* has 947 members and owns 270 hectares of agricultural land.

Kulturland Cooperative represents in its structure an intermediary between the farms and society. Its role is to bring together the interested parties and carry out necessary transactions related, among others, to farmland purchase, its funding, land use governance and member support. The Cooperative acts as a financier and a guardian organization, ensuring that the partner farms produce ecologically and are regionally integrated. The conditions on partner farms are specified by a land lease contract and include: maintaining organic farming according to EU standards; care/cultivation of nature conservation on at least 10% of the land area; and annual implementation of at least two out of six possible activities for regional integration (open farm, regional product sale, educational work, preservation of biodiversity, cultural events, work with supervised/handicap persons) (Kulturland Genossenschaft 2017). In particular, conditioning land lease to organic farming, maintenance of nature conservation areas and preservation of biodiversity contribute to Targets 3 and 5 of SDG 15.

Due to its main focus on the intermediary function in land acquisition and lease transactions, *Kulturland Cooperative* has the potential to offer a simple and secure long-term land governance structure. The potential simplicity of the land governance is, however, not provided for due to the legal framework of farmland sale transactions in Germany, in which a possible solution for a non-farming community to acquire land is through involving farmers in land purchases. For this reason, *Kulturland Cooperative* establishes limited partnership with each farmer to purchase land. The farmers are the executive party in these legal entities and the *Kulturland Cooperative* is the limited partner providing capital for the land purchase. This is illustrated in Figure 4.

The contract of special limited partnerships between *Kulturland Cooperative* as the financier and the farmers as the complementary parties does not purely represent a formal solution to the state land sale regulations. By consensus, the partnerships set the rules of cooperation between the two parties; the land rental contracts are, however, concluded between the special limited partnership firms and the farms separately. As the general partners of the Special limited partnership, the landlords (farmers) are in fact their own lessors. As long as the farm complies with the above-listed conditions of the rental contract, it can dispose of the land indefinitely (Kulturland Genossenschaft 2017).

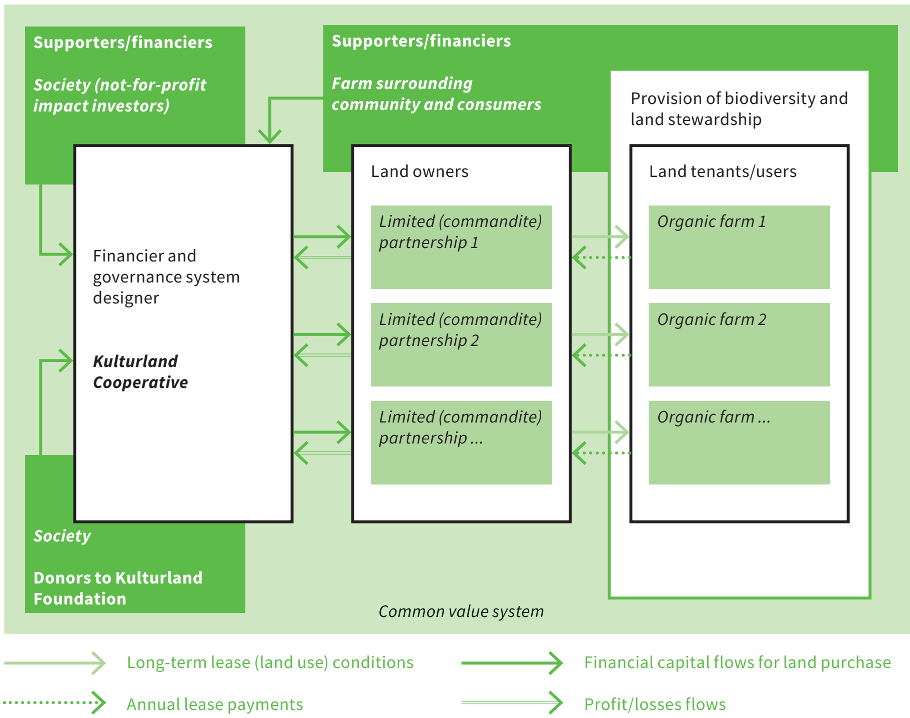

Figure 4. Land governance structure of *Kulturland Cooperative.* Source: Graphic by authors.

3.3. *Comparison of Governing Ecological Targets*

We will compare and analyze the presented cases in two respects. First, we focus on the different governance mechanisms ensuring ecological target delivery. These selected enforcing criteria draw on Basurto et al. (2013), who state that different incentives for conservation are responsible for different governance arrangements of natural resource management with regard to their conduciveness to environmental conservation. As a second criteria to compare the selected organizational forms, we use the mechanism of how supporters get involved and rewarded, as a means for long-term satisfaction with the organization that contributes to its durability.

3.3.1. Regulating Target Delivery—Rental Contract and Foundation Statutes

Kulturland Cooperative, although initiated by a farmer, was set up by a few initiators from the expert/advisor community who designed the land cooperative. The separation between land users and the governance designer (the cooperative), who is the collective owner and steward of the land with a majority of non-farming members, distinguishes this governance model. Its main objective is to secure land for organic farmers across Germany. Other studies have shown that organic farming has been the engine of the sustainable development process, counteracting depopulation and providing a viable economic alternative for rural areas (Zezza et al. 2017). Another objective of the Cooperative is to govern additional environmental and social target delivery. The Cooperative formulates its respective objectives in the statutes; the conditions on land use ensuring the objectives' enforceability are, however, defined more specifically in each individual rental contract, with the farmers managing, individually or in partnership, the leased land. The clarity and enforceability of the rules are important preconditions for the legitimacy and transparency of the organization—necessary conditions for receiving public support and for attracting new supporters. It is the lease contract conditions that regulate the direct target delivery here.

The foundation *grund-stiftung am Schloß Tempelhof* was initiated by the land owner/user community and thus directly reflects the (farming) community's values and objectives. The community of individuals jointly managing the land evolved around one farm and village that greatly contrasts with the mostly individually managed partner farms of *Kulturland Cooperative* spatially distributed across Germany. Due to the uniformity of the land user, the core land financier and the governance designer, there is no issue of legitimacy and the rules of land use and thus ecological target delivery are specified more generally. This is despite the formal separation of land use and ownership as the land was transferred to the foundation. Specific to this land use governance is then the limited option to change the foundation statutes.

Both models contribute to the ecological target delivery also indirectly since they target specific groups of farmers or deliver additional services discussed as important factors of ecological transition in Section 1. *Kulturland Cooperative*, besides securing land of existing organic farms, also facilitates access to land for start-up farms, thus broadening the area on which land and natural resources are used more sustainably than without the collective land acquisition and the related land use conditions. The new entrants' role for the adaptive ecological processes was demonstrated in the previous literature (see Section 1). *Kulturland Cooperative* further provides for long-term tenure security that reduces farmers' risk of loss of investment in environmental practices including soil regeneration. The Cooperative also facilitates crowdfunding for farms' investment projects, designs models for farm succession and offers related extension and seminars to farmers, thus filling in the gap in information transfer and addresses the structural barriers to advancing towards environmental sustainability targets.

The *Schloß Tempelhof* community partnering with *grund-stiftung am Schloß Tempelhof* is also engaged in knowledge generation and transfer. It is active in research of agro-environmental practices, particularly regenerative agriculture, develops information and training material and provides educational seminars.

The selected case studies illustrate that the analyzed land organizations and partnering communities follow the sustainability objectives for agriculture and, for that, combine various means of achieving these targets. They link the land governance arrangements with additional measures to grow to their environmental ambitions.

3.3.2. Acquiring Funding—Investments with Waiving Economic Returns and Donations

The ability to fundraise is an important determinant of organizational sustainability and its long-term success in environmental target delivery. The form and the size of the target delivery support is strongly related to the motivation of supporters and to the origin of the land acquisition funding. The different structures of land financiers thus considerably distinguish the two case studies.

Withholding the land from the farmland market, the aim of *Kulturland Cooperative,* prevents future land value increases, sustaining land rents at a predictable and low level for farmers. The foregone economic returns to capital providers (members) are expected to be compensated by the target delivery by the partner farms. The collected rents are used only for the Cooperative's running cost. Supporters—here members of the Cooperative—participate financially without any expectations on economic returns. The partner farms thus share the costs of target delivery with the Cooperative. This system holds as long as the majority of the members remain with the cooperatives. After five years of membership, the members have the right to withdraw their capital. Should numerous members decide to exit, the Cooperative may be forced to sell some plots and free the land from the conditional use. There are, however, the land tenants who have, based on the rental contract, the right of first refusal of the purchase of the land for the original purchase price, if it were to be sold. Assuming shared values between the cooperative and the partner farms, the continuity of the sustainable use of resources may be secured even then. An interesting development in that respect is the initiative from *Kulturland Cooperative* to form a foundation for members wanting to donate their shares and thus to prevent potential future sale of the farmland.

The foundation *grund-stiftung am Schloß Tempelhof* did not originally have the role of acquiring land. The land was transferred from the farming community that purchased it. The community that acquired and operates the land was the full carrier of the target delivery costs. It formed the foundation to guard the irreversibility of its mission and to generate through rental payments additional funds that would be used only in accordance with the community's objectives. The willingness to absorb the cost of sustainable use of resources and of the delivery of broader societal objectives legitimized the community to donations from society. With the first donations to the foundation, the communities farming the foundation's land started sharing the costs of the target delivery with the donating society.

4. Discussion and Conclusions

Our German-wide scoping study of community- and society-supported organizations of land ownership delivered insights on the large diversity of land ownership arrangements for environmental target delivery—reaching from collective ownership within corporations, partnerships and cooperatives to associations and foundations. These are found linked to unique and innovative forms of sustainable land use governance within partnership arrangements with farms, as shown in the closer investigation using two case studies.

The two examples of the new land governing organizations have shown very distinct possibilities of how to contribute to the transition towards sustainability with the help of community and societal support. Both organizations adopt the right of defining conditions of land use in exchange for long-term tenure and below market price rental conditions for farmers. It is thus the partner farms to these organizations who ultimately preserve biodiversity and combat land degradation, consequently supporting SDG 15.

The relative importance of such new governance forms cannot be expressed in the absolute numbers of partner farms, or the share of cultivated agricultural land, but by their mere existence and their survival that matter for social innovation to start off (Westley and McConnell 2010). Thus, an important criterion of the collective land organizations' success, from the perspective of SDG 15, is the long-term security of their target delivery. This regards the stability of sustainability objectives, a stable and growing supporter base (fundraising) and partnering farmers' viability.

The selected case studies illustrate that the analyzed land organizations and partnering communities follow long-term sustainability objectives for agriculture and, for that, combine various means of achieving these targets. They link the land governance arrangements with additional measures to grow to their environmental ambitions—by supporting farms' viability and succession or through knowledge facilitating the adoption of sustainable practices.

However, we find significant differences in the way the organizations secure their funds and their long-term objectives. While the funds/assets and goals of a foundation are permanently anchored by the law, in the case of a cooperative, they are subject to the amendable statutes. It could be well believed that individuals, who engage with the cooperatives described above, are willing to financially participate without profit, sharing the same long-term objectives as members of a foundation. Nevertheless, the legal form of a registered cooperative principally allows changes under conditions set in the statutes. *Kulturland Cooperative* thus restricts through these conditions the statutes' changeability, as well as lowering the incentives to change the collective land use objectives, potential sale of plots and the right to withdraw membership shares in the early years of membership. Despite the risks of members' mobility, the societal trends suggest sufficient interest in replacing potentially dropping out members in support of a positive sustainability impact.

Achieving stability of conservation objectives requires durable organizations that also need to support social sustainability. Thus, we would like to point out the potential social implications of the new organizations for rural communities and thereby motivate future research. To achieve sustainability goals, the environmental target delivery should not come at a cost to rural communities but rather be aligned with social sustainability targets. The conditions on farmers' partnerships with *Kulturland Cooperative* include items in support of a "regionally integrated organic agriculture". The partner farms thus have to implement annually at least two out of six possible activities for regional integration. These can include open farm days, product sale on farm, educational work, cultural events or work with people in care. These activities are oriented outward toward the local or regional community. Such activities could have an integrative influence on the surrounding community members and groups and thus facilitate local social cohesion as well as increasing trust and solidarity between the farmers and the rural community. The latter may be particularly important in case of new entrants into farming. However, it remains a question whether these semi-occasionally performed activities are sufficient to have such social implications.

A relevant aspect for some of the described farming communities with implications for the original rural community is that they were established by newcomers to the regions. By that, they may be expected to have strongly contributed to the economic value of the acquired local assets as well as the local community's vibrancy. However, getting (mainly urban) people without an agricultural connection involved in the management of land may suffer from the risk of rural gentrification. Studies by Sutherland (2012) and Mamonova and Sutherland (2015) showed that the degree and risks of gentrification depend on who the new acquirers of land are and to which degree they displace native inhabitants in the process of the local establishment. However, to understand these complex social processes and their implications for original rural societies calls for more in-depth research.

According to Target 15 of SDG 15, financial resources should be mobilized and significantly increased from all sources to conserve and sustainably use biodiversity and ecosystems. Thus, if more studies could show that such new community-supported forms of land ownership can implement SDG 15 and that the elaborated governance forms ensure durability, the initiatives would, in line with SDG Target 15, additionally qualify for some form of state support.

Besides financial state support, legal state support in terms of reducing administrative barriers of agricultural land acquisitions for the new governance types of joint land ownership is also an issue. For instance, in order to conform with the Real Property Transactions Act (Hoffmeister 2018)—the most relevant legal ordinance as regards agricultural land transfer in Germany to non-farmers—*Kulturland Cooperative* forms limited partnerships to function as the owner of the land. This results in administrative and other transaction costs for the Cooperative and, at the point of establishment, also the farmer—funds that are, in the case of a foundation, used towards various charitable projects including initiatives supporting SDG 15. As there is no equal treatment of the diverse legal forms allowing community-supported acquisition of farmland, it leads to the distortion of competition among institutional innovations. The possible legal framework amendments restricting access to land to non-agricultural investors and, at the same time, allowing community-supported land purchases are subject to current political federal state-level debates (see, e.g., Rüter 2020; Balmann 2020).

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Part 4: Political and Societal Challenges

Agricultural Policy for Biodiversity: Facilitators and Barriers for Transformation

Sebastian Lakner, Christian Schleyer, Jenny Schmidt and Yves Zinngrebe

1. Introduction

The Common Agricultural Policy (CAP) is one of the largest agricultural policy systems worldwide (Pe'er et al. 2019), with a financial allocation of EUR 58.4 billion in 2019 (EC 2019) and a Producer Support Estimate of roughly EUR 90 billion, outpacing other major agricultural policies (e.g., in the USA (EUR 36 billion) or Japan (EUR 43 billion)) (OECD 2018) in absolute terms. The CAP objectives, first mentioned in the Treaty of Rome of 1957, focused on the increase in productivity, support of farm incomes, and market stability. However, with increasing awareness of environmental challenges and global commitments on biodiversity, climate change as well as desertification at the Earth Summit in Rio de Janeiro in 1992, environmental concerns have increasingly entered the CAP agenda. As the CAP has been reformed every five to seven years, it is reasonable to ask the extent to which reforms have resulted in a coherent policy producing effective and cost-effective outcomes.

This chapter looks at the advances towards this target using the frame of an idealized circular reform process (Figure 1), based on a policy action cycle (Parsons 1995; Zinngrebe 2016). By conducting a formalized evaluation prior to every CAP reform, it might be assumed that experience and a growing body of scientific and local knowledge lead to learning processes in the governance regime (Pahl-Wostl 2009).[1]

Sections 2–5 show and assess issues related to the dimensions of the policy cycle. One of the main questions of this chapter is to elaborate on the past and current status of the CAP and to indicate if the upcoming post-2020 CAP reform will be able to keep up with the challenges for the agricultural sector described in Section 2. In Section 3, we introduce the main CAP instruments supporting biodiversity objectives and give a brief overview on their performance in Section 4, focusing on the case of Germany.

[1] Note that there is already an established evaluation process for the Rural Development Programs (RDP) in Pillar II, put in place since their inception in the Agenda 2000. While having the potential to substantially inform CAP reform at least in this area, the evaluation process itself and the limited uptake of its results have been critically discussed (Dwyer et al. 2008; Poláková et al. 2011).

We focus on policies, instruments, and measures, which aim to halt the biodiversity decline. In Section 6, we draw some conclusions and provide an outlook.

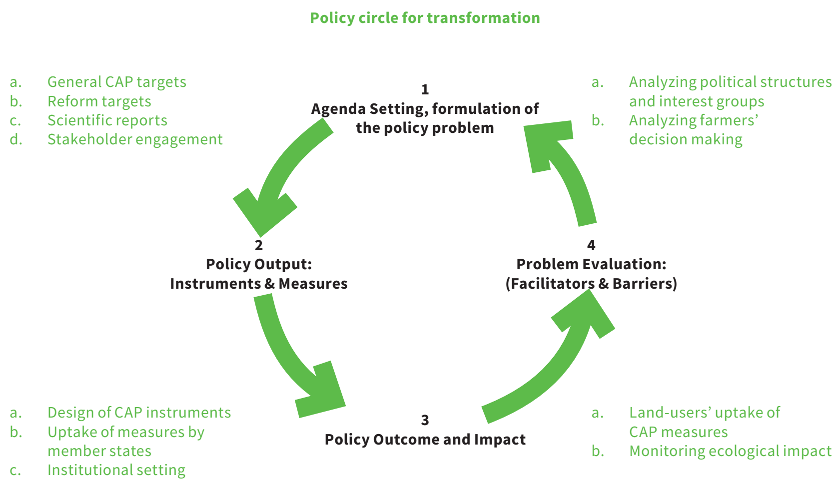

Figure 1. Policy cycle of the EU Common Agricultural Policy. Source: own presentation.

2. Agenda Setting: Formulation of the Policy Problem

Agenda setting for reforming the CAP is determined by a range of aspects, including environmental challenges relevant for and/or caused by agriculture and the uptake of both scientific knowledge and stakeholder and other societal preferences. As a result, targets set by the reformed CAP reflect these insights and, in particular, take into account relevant Sustainable Development Goals (SDG).

2.1. Environmental Challenges

The agricultural sector in Europe is facing a number of environmental challenges, which are already influencing farming practices and agricultural policies; and which will continue to influence the sectoral development and the political transformation of agriculture over the years to come. Most relevant challenges include the decline in farm biodiversity, climate change, and ground and surface water pollution with nitrates and pesticides. This is even more important since agricultural areas account for over 43% of Europe's total area (Eurostat 2020), thus affecting the remaining semi-natural and natural habitats.

Farm biodiversity in Europe and worldwide has been declining for decades (IPBES 2018). This has been illustrated recently in a study on Western Germany (Hallmann et al. 2017). Another study showed that arthropod species richness declined by 34% over the last ten years, and their biomass and numbers declined by 67% and 78%, respectively (Seibold et al. 2019). Furthermore, a report of the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) pointed to land-use change as the most important driver for the decline in terrestrial and freshwater biodiversity worldwide (Díaz et al. 2019). Reports by the German National Academy of Sciences Leopoldina (Leopoldina 2018) and the German Advisory Council on the Environment (SRU and WBBGR 2018) have pointed to the urgent need to react to the decline. On a global scale, Beckmann et al. (2019) have shown that farm intensification is one of the major drivers of biodiversity decline.

The challenges for agriculture posed by climate change are twofold:

First, farms have to adapt to a changing climate. In 2018, for example, a long period of dry weather led to substantial losses in harvests: the yield for wheat declined by 16%, and for rapeseed (25%) and potatoes (26%) the declines were even larger (own calculations). Thus, the issue of adaptation to climate change already plays a major role for farms.

Second, the agricultural sector is a significant contributor to greenhouse gas (GHG) emissions. In Germany, roughly 12% of GHG emissions originate from agriculture and land-use change (UBA 2019). Consequently, the Intergovernmental Panel on Climate Change (IPCC) has pointed out the crucial role of land-use policies (Shukla et al. 2019). Here, the potential of restoring former wet grassland and peatlands and less-intensive forms of land use has been emphasized as being able to substantially reduce GHG emissions from agriculture in Germany (WBAE and WBFP 2016). On a global level, drained peatland takes a share of 1% of agricultural land, changing from a C-sink into a substantial source of GHG (Leifeld and Menichetti 2018). Rewetting peatlands, which have a share of 7% of the agricultural land in Germany, might reduce agricultural GHG emission by 37%. Yet, the implementation of such GHG-reducing strategies may impose high on-farm costs which could, however, be covered by agricultural policies (GMC 2019).

2.2. Scientific Input and Stakeholder Opinions Informing the Reform Process

In comparison to previous CAP reforms, the post-2020 CAP reform process is perceived to be more inclusive with respect to incorporating inputs from the public and evaluating the current CAP (2014–2020), yet still lacking sufficient structure and transparency. Key issues relate to the sequential order of reform elements in the preparation of the CAP proposal, and an unclear or even biased process in taking and processing inputs.

An in-depth evaluation of the current CAP period—the so-called 'fitness check'—has only been conducted many months after the first post-2020 CAP proposal had been published (June 2018) and negotiated in the Council and the EU Parliament (Pe'er et al. 2019). In turn, the new budget in the Multiannual Financial Framework (MFF) 2021–2027 was proposed in May 2018, prior to the publication of the CAP proposal, and thus, as in previous reforms, predetermined the process in advance by fixing, for example, the financial distribution between both pillars and options for potential improvements.

The process of public engagement for reforming the CAP included a public consultation, workshops and a stakeholder conference, and an Impact Assessment (IA). The public consultation process started in early 2017 with a 12-week Online Consultation by the European Commission (EC) to obtain public opinion—in particular, from farmers, citizens, organizations, and other interested parties—on how to modernize and simplify the CAP (Pe'er et al. 2019, SM, p. 46). However, respondents (total: 322,916)[2] represented only a very small (less than 0.01%) and non-random subset of the EU's population (e.g., 45.6% from Germany vs. 6.7% from new Member States (MSs)) who actively chose to participate after being invited. About half of the respondents identified themselves as being associated with farming or forestry. For them, the most pressing challenge of the CAP was ensuring a 'fair standard of living for farmers' (32%). For all others respondents, 'pressures on the environment and on natural resources' were perceived as most important challenge (ECORYS 2017). However, there are methodological concerns (e.g., biased, closed-ended questions often left unanswered) and the raw results have not been made available.

In preparation for the reform, the European Commission (EC) organized a series of workshops as well as a Stakeholder Conference in July 2017. However, the workshops to inform the reform and to prepare the Impact Assessment were organized internally by the EC's Directorate-General for Agriculture and Rural Development (DG AGRI) and it is not clear how participants were selected. Key organizations, such as environmental NGOs and scientific organizations, were not invited to some of these workshops and the conference, while farmer organizations were over-represented. Furthermore, no minutes of the conference were made public.

2 This number includes responses coming from large public campaigns. Only 63,027 responses came from individuals (ECORYS 2017).

As in previous CAP reforms, the EC conducted an Impact Assessment. However, the underlying processes were neither transparent nor inclusive. For example, relevant and important research work, such as the 'fitness check' outcomes of a comprehensive independent literature review (Pe'er et al. 2017b), were largely ignored and the results of the EU Joint Research Centre's (JRC) modelling that were used were not made public. Altogether, it is unclear how different sources of evidence, and types of contribution, were used to develop the proposed post-2020 CAP.

2.3. Reforming CAP Targets vs. Maintaining 'Old' CAP Structure

The original objectives of the CAP formulated in the Treaty of Rome 1957 and repeated in Article 39 of the Treaty of Lisbon 2009—increasing agricultural productivity, ensuring a fair standard of living for the agricultural community, stabilizing markets, assuring the availability of supplies, and ensuring that supplies reach consumers at reasonable prices—are largely insufficient and poorly reflect current European challenges with respect to climate change, nature conservation, and other sustainability issues (Pe'er et al. 2019). Others have already been fulfilled, such as ensuring food security at the European level. Thus, rather than stimulating higher agricultural productivity, the current challenge is to balance productivity with other objectives (Tangermann 2011). On the other hand, uneven distribution of Direct Payments (DPs) among farm size classes as well as among MSs suggests that the CAP instruments in general, and DPs in particular, have failed to reduce disparities and achieve a fair standard of living, and are inefficient in meeting farmers' needs (Deppermann et al. 2016). The chosen instruments do not sufficiently contribute to the targets. Conversely, environmental issues, rural vitality, and inequalities among EU regions are not listed in the original objectives.

During the reform process, sustainability narratives became more prominent; however, whenever it came to budget decisions, 'productivistic' and neo-liberal narratives were rather decisive (Erjavec and Erjavec 2015). The CAP reforms seem to follow a predetermined path, which conflicts with the majority of public inputs, compelling evidence, and published responses on the initial CAP proposal. For example, the 2017 Public Consultation indicates that both farmers and the public perceive the environment-related components of the Rural Development Programmes (RDPs) for public goods as the best instrument to address current challenges (Figure 2), whereas, in the proposed post-2020 CAP, most funding still goes to DPs.

Furthermore, the CAP has little focus on most of the 12 Sustainable Development Goals (SDGs)—ratified by the EC in 2015—relevant for agriculture, including SDG 2 Zero Hunger, SDG 15 Life on Land, SDG 6 Clean Water and Sanitation, SDG 8 Decent

Work and Economic Growth, and SDG 10 Reduced Inequalities (Pe'er et al. 2017b, 2019; Scown et al. 2020). So far, the CAP only substantially contributes to SDG 2 Zero Hunger and SDG 1 No Poverty, in particular through both DPs and RDP payments (ibid.). Yet, both SDGs are not key (anymore) in a European context. Some positive local impacts of some of the environment-targeted CAP instruments such as Agri-Environmental and Climate Measures (AECMs) and Cross Compliance (CC) have been noted with respect to SDG 6 Clean Water and Sanitation and SD 15 Life on Land. However, their budget and extent are too limited to reverse overall trends of environmental degradation and biodiversity loss; and some CAP instruments, such as DPs may have even speeded up the biodiversity decline (Pe'er et al. 2017b). Other crucial agriculture-related SDGs, where various CAP instruments could play an important role, are not—or hardly—addressed, including SDG 12 Sustainable Consumption and Production and SDG 11 Sustainable Cities and Communities. At the same time, several objectives are conflicting with each other and therefore give no clear guidance on how to achieve more sustainable agriculture (Pe'er et al. 2019).

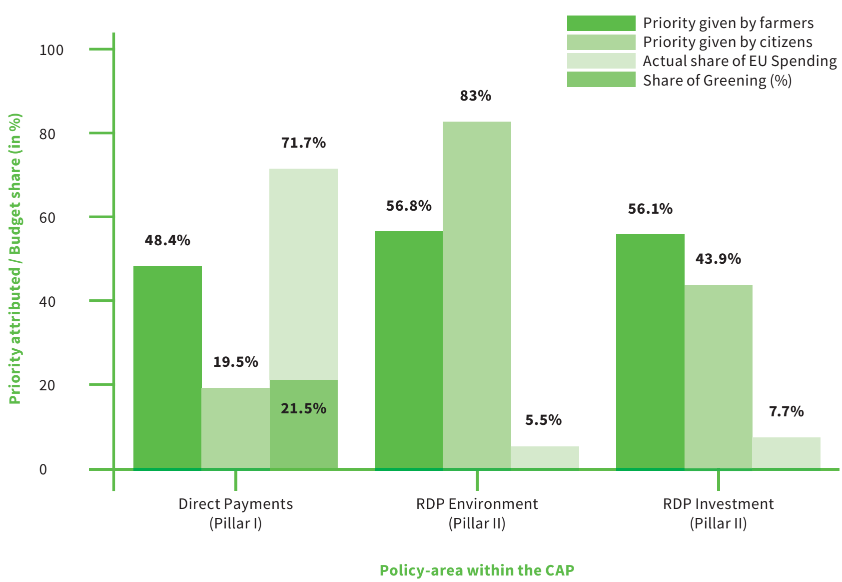

Figure 2. Perceived priorities by farmers and citizens and actual Common Agricultural Policy (CAP) spending. Source: Pe'er et al. (2017b).

3. Policy Output: CAP and Other Policies Relevant for Biodiversity

Apart from instruments and measures directly related to the CAP, in particular Agri-Environmental Programs (AEPs) (today: AECM, CC, and Greening of DPs), there is a wide range of environmental policies which affect agricultural land use, farming systems, and biodiversity. These include the Birds Directive, the Habitat Directive (both building the Natura 2000-network), the Nitrates Directive, the Organic Production Regulation, and the Water Framework Directive (Table 1).

Table 1. A history of environmental policies relevant for agriculture in the EU.

Year	Legal Framework	Main Governance or Policy Level
1975	Less Favored Areas Directive (75/268/EEC); Payments for farming in less productive regions. Today: Areas of Natural Constraints (ANC)	CAP
1979	Birds Directive (79/409/EEC). Today: Natura 2000-network	EU/national
1985	Structural Policy: Special Aids for Environmental Sensitive Areas. Payments for environmental extensification. Today: Agri-Environmental and Climate Measures (AECM) as part of the EU extensification program according to EU-Regulation 4115/88	CAP
1991	Nitrates Directive (91/676/EEC). Organic Production Regulation (2092/91/EEC).	EU/national
1991	Regulation on pesticides use and placing of plant protection products on the market (Regulation 91/414/EEC; 396/2005; 1107/2009).	EU
1992	Habitat Directive (92/43/EEC). Today: Natura 2000-network	EU/national
1992	1./2. Agri-Environmental Programs (AEP) (2078/92/EEC and 1257/1999/EEC). Today: Agri-Environmental and Climate Measures (AECM)	CAP
2000	Water Framework Directive (2000/60/EC).	EU/national
2005	Fischler Reform: Cross Compliance for Direct Payments (GAEC). European Agricultural Fund for Rural Development (EAFRD) (1698/2005/EC).	CAP
2013	Greening of Direct Payments (1307/2013/EC, Art. 43).	CAP

Source: own presentation, based on Hill (2012, 190f.).

The evolution of AEPs within the CAP has its origins in the 1970s, with a substantial development after 1992 when the first AEPs were introduced. Reacting to a fundamental crisis during the 1980s and international pressures, the EU set-up a series of policy reforms, starting in 1992 with the so-called MacSharry Reform. In this and subsequent reform(s), environmental targets and measures were introduced to the CAP-framework. This includes the so-called 'accompanying measures' in 1992 with the EU Regulation 2078/1992 and 1257/1999 (Osterburg and Stratmann 2002), which were later on consolidated as AEPs in the Agenda 2000 Reform. After the Fischler Reform 2005, AEPs were financed through the European Agricultural Fund for Rural Development (EAFRD) (EU-Regulation 1698/2005).

The Agenda 2000 also introduced the two-pillar system: Pillar I includes DPs and market measures. DPs were then granted for production and are currently linked to the farmed area. Pillar II consists of the rural development policies including the AEPs, but also investment programs and rural development such as village renovation or the LEADER initiatives. Linking environmental standards to DPs via CC was introduced as principle with the Agenda 2000 and extended in the Fischler Reform 2005. As another step in this direction, compulsory Greening measures were introduced in the 2013 Reform now linking 30% of DPs to three sets of measures: crop diversification, maintenance of permanent pastures, and Ecological Focus Areas (EFAs). With the reform of 2013, the climate topic was added to the AEPs, now called Agri-Environmental and Climate Measures (AECMs).

Yet, although environmental sustainability narratives gained importance throughout the reform-path of the last 30 years, the designated financial funds remained small (Erjavec and Erjavec 2015). Though fluctuating significantly over the last twenty years, the share of AEPs within the CAP never exceeded 6% (Figure 3). In the current financial period (2014–2020), the AECM spending even slightly decreased by 8.6% compared to 2007–2013 (Pe'er et al. 2017b). Furthermore, 60% of the CAP-budget is still spent on the farm income target, yet failing to reduce disparities between and within MSs and thereby to achieve a fair standard of living (Pe'er et al. 2017b, 2019; Scown et al. 2020). Adding to this, AEPs still have the potential to be improved in terms of effectiveness and efficiency (Batáry et al. 2015).

During the 1990s, the expenditure on AECMs increased (Osterburg and Stratmann 2002), but it stagnated until 2008 due to the Eastern Enlargement of the EU and an increasingly broader scope of Pillar II. Figure 3 shows that the budget-share of AEPs has been varying between 2.3% and 6%, with the dips 2007 and 2015 being mainly due to the switch between program periods, i.e., fading out payments in the 'old' program and still only low expenditures in the 'new' scheme:

In the current CAP (2014–2020), there are three main instruments targeting environmental aspects of agricultural production, which are introduced and discussed in the following: Agri-Environmental and Climate Measures (AECMs), Cross Compliance (CC), and Greening of Direct Payments.

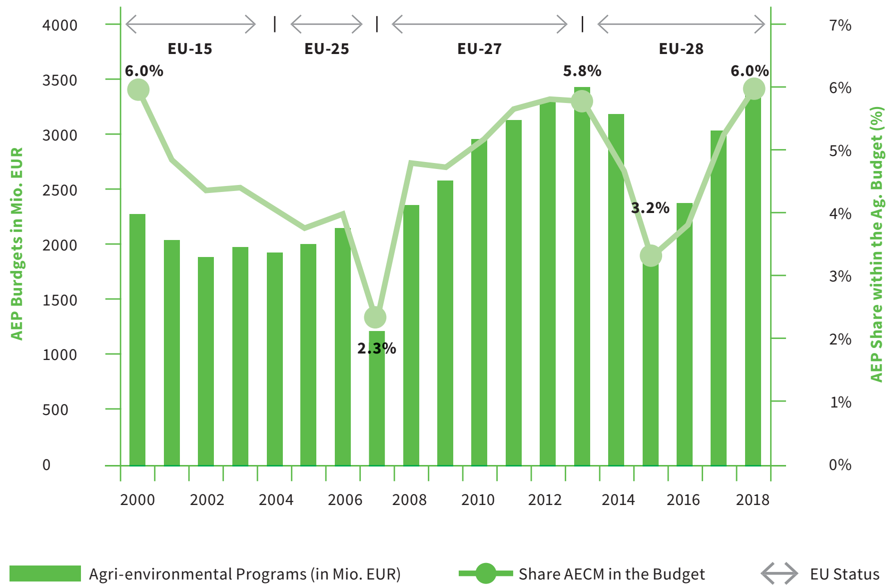

Figure 3. Amount and share of Agri-Environmental Programs in the EU 2000–2018. Source: own calculations; Data from German Federal Ministry of Food and Agriculture (BMEL 2000–2018); div. issues. Values are in Mio. EUR; Note the changing number of EU Members States 2000–2003 EU-15; 2004–2006 EU-25; 2007–2012 EU-27; 2013 ff. EU-28.

3.1. Agri-Environmental and Climate Measures

AECMs are the oldest and most developed environmental instrument within the CAP. Figure 4 displays the specific collaboration in financing and programming between the EU, the national government and, as an example, the federal states of Germany.

The AECMs are jointly financed by the EU and the MSs and formulated and implemented by the MSs or the regions/federal states as part of RDPs. The EU provides the general legal framework (EU regulation 1305/2013), and MSs design and implement the programs. In most cases, the MSs develop national RDPs and the respective AECMs; in some MSs, the regions (France, Spain, and Italy) or the federal states (Germany) are responsible for this. In Germany, the national government offers a co-funding tool (Joint Task for Improvement of Agricultural Structures and Coastal Protection—GAK), adding up to 60% of the costs of the AECMs. The system of co-funding is explained in Figure 4.

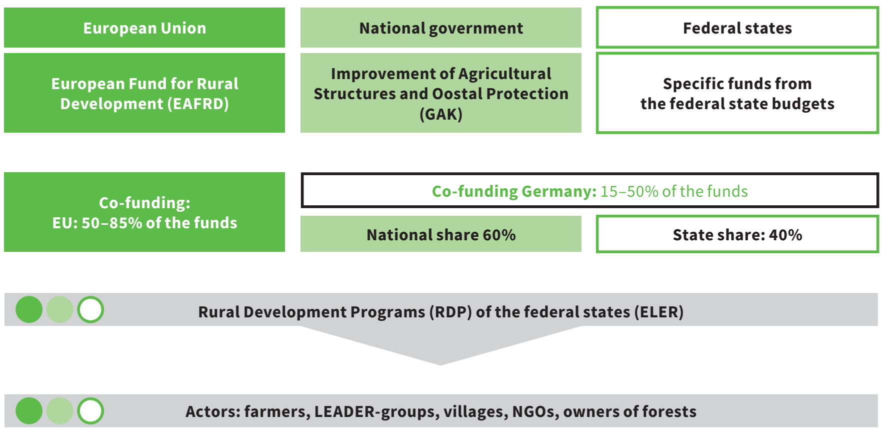

Figure 4. The system of programming and co-funding in Rural Development Programs, using the example of Germany. Source: own presentation.

AECMs are voluntary measures (see Figure 5 for some examples), which remunerate the income forgone for environmental actions that go beyond the CC standard (Section 3.2) and the Greening requirements of Pillar II (Section 3.3). The main approach is to compensate farmers for services as either producing a positive environmental outcome or avoiding a negative externality.

There are different types of AECMs:

- Most AECMs are area based, where farmers carry out a certain measure on a specific plot, whereas the rest of the farmland remains unaffected. Another approach is to support measures on the whole-farm level, for example, if an entire farm switches to organic farming.
- AECMs can target different types of land: arable land, grassland, other farmed land (e.g., permanent crops, horticulture, orchards, wine), and 'non-productive land' (e.g., landscape elements like hedges).
- AECMs differ in terms of their objectives: biotic (e.g., targeting biodiversity), abiotic (e.g., protection of surface waters through buffer strips near rivers and groundwater through less/no fertilizer use in groundwater protection areas) or mitigating climate effects (e.g., through rewetting peatlands).

- While most AECMs are based on concrete farmers' practices, which are assumed to have a positive environmental effect, in the last financial period (2014–2020), the range of available result-based measures has been extended. Here, farmers receive different levels of payments depending on, for example, the number of different endangered species (e.g., four, six or eight) found on their grassland. This approach is often perceived as providing more positive incentives for farmers since it allows them to choose the specific farming activities to increase the environmental 'output' flexibly, yet costs for implementing and monitoring may be higher (Schroeder et al. 2013).
- While some AECMs support specific farming practices (e.g., mowing grassland only after specific dates or establishing flowering strips) other measures limit the use of specified inputs (e.g., chemical fertilizers or pesticides) on certain plots.

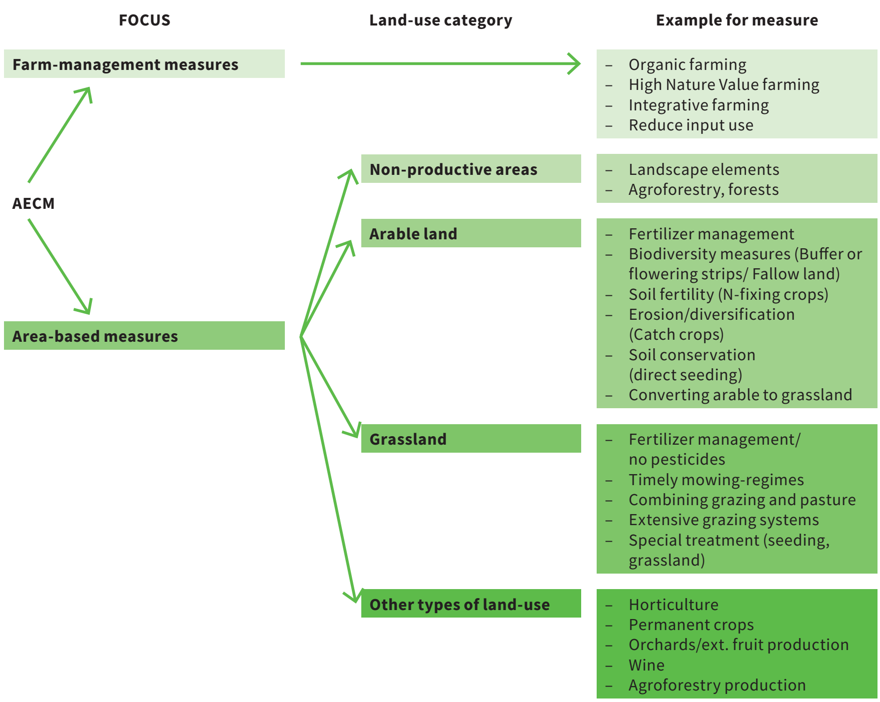

Figure 5. Examples of Agri-Environmental and Climate Measures. Source: own presentation.

The fact that MSs or even regional administrations program their own AECMs leads to a substantial heterogeneity with respect to the range and choice of measures offered and the premium levels. This is due to (a) heterogeneous opportunity costs, (b) different budgetary capacities, (c) high administrative costs (e.g., designing schemes, monitoring, and sanctioning) for which MSs have diverging capacities (personnel, financial budget) to manage, (d) national and/or regional political priorities, and (e) the specific needs of the regional agro-ecosystem. Figure 6 shows the divergence in expenditure per hectare for AECMs across MSs.

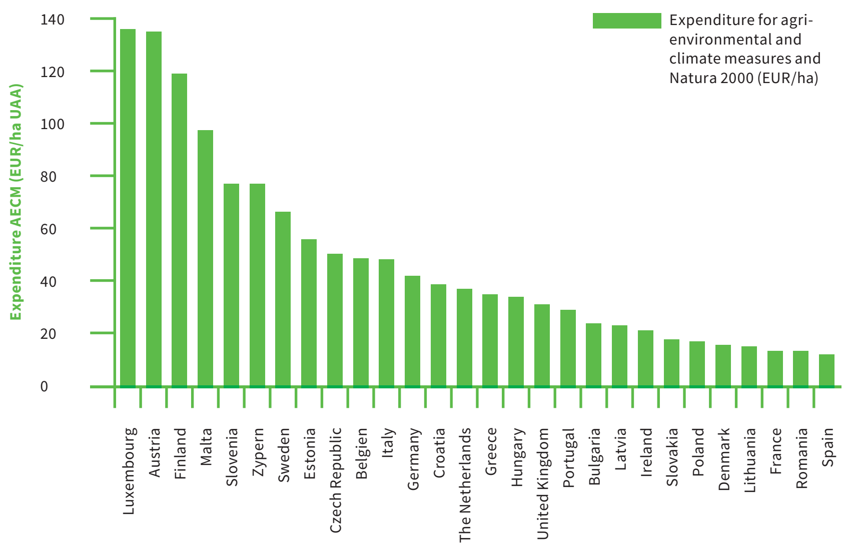

Figure 6. Expenditure for Agri-Environmental and Climate Measures 2014–2020. Source: own calculations, based on EU factsheets Rural Development (EC 2016). Figures include support of organic farms and payments for Natura 2000 areas. Payments for Areas with Natural Constraints (ANC) are not included.

3.2. Cross Compliance (CC)

Cross-Compliance (CC), introduced in 2000, links DPs of Pillar I with environmental objectives, regulations, and good practices for farming and animal husbandry, and food safety (BMEL 2015). The EU sets guidelines that are specified by the MSs (Juntti 2012). As DPs are usually too attractive to forgo, CC is seen as a "de-facto statutory law" (Nitsch and Osterburg 2004, p. 173). Farmers have to comply with Statutory Management Requirements (SMR), for example, avoiding agricultural practices polluting groundwater and to ensure Good Agricultural and Environmental Conditions (GAEC) of their farmed area, like preventing soil erosion and avoiding the deterioration of habitats (Juntti 2012). These standards and regulations were reinforced by CC through a standardized monitoring/control mechanism on 5%

of farms and the possibility to withhold payments if not adhered to; the amount withheld depending on the violation. This way, these standards become effective also in areas with very good *conditions* for agriculture where AEPs/AECMs are usually not applied.

The European Court of Auditors (ECA) 2008 criticized the implementation of CC as not sufficiently effective, as its objectives and the scope were not well defined, and therefore rules were not translated into controllable requirements at the farm level (ECA 2008). To help farmers comply with CC regulations, a Farm Advisory System within the MSs became mandatory in 2007 (Knuth et al. 2018).

As "[t]he use of interconnected resources results in unintended external effects" (Meyer et al. 2014, p. 187), ownership (as the right to use, manage, and gain income from) is linked to certain rights and duties that are subject to (state) authority (Meyer et al. 2014).

3.3. Greening of Direct Payments

The *Greening* of DPs was introduced in 2013 as a means to further deepen the CC standards (Meyer et al. 2014). It aims at 'enhancing the environmental performance' of agriculture by framing 30% of DPs as 'payments beneficial for climate and environment', granted only to farmers who comply with all three greening requirements (EC 2013, verbatim, recital 37).

Crop diversification requires, for farms with more than 30 ha of arable land, the cultivation of at least three different crops, of which the first crop shall not exceed 75%, and the first two crops not 95% of the arable land, respectively. For farms with 10–30 ha of arable land, a minimum of two crops is required, of which the first shall not exceed 75%. Farms with less than 10 ha of arable land, or with a high share of fodder crops on arable land, or a high share of grassland, are exempted (BMEL 2015, p. 37 ff.).

Maintenance of permanent grassland is aiming at protecting environmentally sensitive grassland (e.g., in Nature 2000 areas), which must not be converted to arable land. Conversion of permanent grassland to arable land shall not exceed 5% of the total permanent grassland in a region. Thus, conversion of permanent grassland (>5 years) has to be approved by local authorities (BMEL 2015, p. 42).

Farmers have to provide Ecological Focus Areas (EFA) on 5% of their arable land. They can choose between different EFA options, each related to weighting factors (WF) reflecting the respective ecological impacts. For example, a farmer can register 1.0 ha fallow land (WF = 1.0) equivalent to 3.3 ha of catch crops (WF = 0.3) or 0.5 ha of hedges as landscape elements (WF = 2.0) (BMEL 2015). MSs can pre-select different EFA options, which are then nationally implemented. The choices within MSs are quite diverse; however, especially large MSs provide a broad set of EFA options, whereas small MSs are rather offering few EFA options (Table 2).

Table 2. Number of Ecological Focus Area (EFA)-options implemented in the different EU Member States 2015.

	Number of EFA Options Offered			
	2–4	**5–9**	**10–14**	**15 and More**
Number of MSs	**5**	**9**	**9**	**5**
	AT, FI, LT, NL, SI, ES	CY, DK, EE, EL, LV, MT, PT, SV, UK	BE, BG, HR, CZ, IE, LU, RO, SK	IT DE, FR, HU, PL

Source: own elaboration, based on data from EC (2015: 24) and Pe'er et al. (2017b).

The specific objective of the EFAs was outlined by the EC as to "safeguard and improve biodiversity on farms" (EC 2013, recital 44). While most EFA options are indeed listed as directly affecting biodiversity, the EC admits that catch crops and green cover only do this indirectly. However, any approaches testing the effectiveness of EFAs need to consider specifically their contribution to safeguarding and improving farm biodiversity. With respect to the effects of EFAs on a broader set of ecosystem services, however, some authors come to a more positive assessment (Hauck et al. 2014; Lakner 2018).

Organic farming systems are excluded from the obligation to comply with the Greening criteria (EC 2013). Greening is obligatory. However, in case of non-compliance, about 30% of the DPs can be cut. Consequently, empirical data for Germany in the year 2017, for example, shows that 284.678 farmers did apply for DPs, and only 132 farmers (0.6%) did not receive any Greening-payments, meaning that substantial sanctions lead to zero Greening-payments for these farms (BMEL 2017). Overall, it seems that Greening includes a rather low risk of receiving the maximum level of sanctions.

3.4. Other Policies Protecting and Fostering Biodiversity

Besides the CAP, there are policies from other policy fields also influencing land-use decisions and the maintenance and protection of biodiversity. Here, the so-called Natura 2000-strategy comprising of the Birds Directive (1979) and the Habitat Directive (1991) is the most important; however, pesticide regulations and Water Framework Directive (WFD) also haven influence on biodiversity (see Table 1).

The Birds Directive concentrates on the protection of a list of bird species of European importance. Most of these birds are migratory birds, and the Birds Directive attempts to protect their habitats for nesting and feeding. The Habitat Directive focuses on a number of specific habitats and plant and animal species of European importance, where the MSs have to maintain their 'favourable statuses'. Both Directives are the legal backbone of Natura 2000: a network of sites selected to ensure the long-term survival of Europe's most valuable and threatened species and habitats. Significant parts of this network are supported by AECMs.

There is also a link between the CAP and the EU Water Framework Directive. Introduced in the year 2000, the WFD requires MSs to achieve good qualitative and quantitative status for all water bodies. There is a high coherence in terms of objectives, and some CAP instruments can contribute to the implementation of the WFD: Cross Compliance, statutory management requirements, good agricultural and environmental conditions, and rural development measures. Another relevant water-related EU policy is the EU Nitrates Directive. As part of CC, it does effectively contribute to the reduction in nitrogen fertilizer use across most MSs, influencing not only land-use decisions but also livestock densities. Adding to this, the Regulation on Pesticide Use and the Regulation on Placing of Plant Protection Products on the Market still of 1991 and later years has an impact on the environment and specifically on biodiversity (EC 1991, 2005, 2009).

3.5. Harmful Subsidies within the CAP

Harmful subsidies are subsidies with side-effects on the environment (SCNAT 2020). Within the CAP, only some instruments, in particular coupled DPs, can be categorized as harmful subsidies (Schmid et al. 2007). These are sector-specific coupled payments that are decided upon by the MSs. They incentivize higher production through linking payments with, for example, a number of eligible livestock (Hristov et al. 2020), and they usually lead to a higher local farming intensity than would be the case without coupled DPs. This is because many of the supported production systems are relevant drivers of climate change (e.g., meat or milk production) or input-intensive production, such as protein crops, sugar beet, vegetable production, and horticulture.

Decoupled DPs cannot be regarded as harmful subsidies since they are not linked to production intensity (Schmid et al. 2007). An exception can be perhaps found in Bulgaria, where decoupled DPs are linked to the requirement to reduce landscape elements on supported grassland farms (Trapp and Lakner 2018).

Other CAP instruments, however, may have unintentional impacts. Examples include investment measures (Pillar II) but also sectoral supports such as olives, wine, cotton, and renewable energy as well as support for irrigation and Areas of Natural or other area-specific constraints.

4. Policy Outcomes and Impacts: The Case of Germany

In this section, we analyze the (cost-)effectiveness and impacts of both AECMs and Greening for Direct Payments using the case of Germany as an example for one of the major economies and agricultural sectors among the MSs and because of the availability of comprehensive and detailed data.

4.1. Analysis of AECMs

4.1.1. The Effectiveness of AECMs

There is a broad literature on AECMs focusing on effectiveness towards the maintenance of biodiversity. Despite a large heterogeneity within the objectives, content of the measures, complexity, and payment level, AECMs often have a positive impact on biodiversity.

- AECMs often lead to an increase in species diversity: Examples of good practice have been identified in Germany, Switzerland, and Spain (Kleijn et al. 2006).
- With regards to Natura 2000, studies show that AECMs can contribute to the successful implementation of the Habitat Directive (Lakner et al. 2020).
- AECMs on areas out of production are more effective than in productive regions (Batáry et al. 2015).
- Existing landscape and management types influence the impact of AECMs. Overall, landscape structures can overlay the effects of AECMs. For example, fields with a small size in West Germany have been found to provide a higher biodiversity than larger fields in neighboring East Germany (Batáry et al. 2017). The same can be found for organic farming, which is more effective in intensively used farming systems, whereas, in diverse landscapes, the effect is smaller (Tuck et al. 2014).

Generally, the literature distinguishes between broad entry programs and specific and more advanced programs, often labelled as 'light-green' and 'dark-green' AEPs. A study by the ECA (2011) has pointed out that, especially the specific, dark-green programs are 'effective' and contribute substantially to the conservation of species, whereas the unspecific light-green programs often contribute little to nothing towards the outlined objectives. This finding is confirmed by many studies (e.g., Armsworth et al. 2012). Some studies indicate that the share of spending on effective programs is rather low (Freese 2012). Oppermann et al. (2012), for example, show that of 7.6% expenditures for AECMs, only 1.2% are effective (dark-green). The share of spending for effective AECMs on arable land is even lower, a mere 0.2%. On grassland, 11% of the grassland area is managed by effective AECMs; for arable land, the share is again lower with 0.3% (Oppermann et al. 2012).

4.1.2. Cost-Effectiveness and Administrative Costs of AECMs

Conceptually, the payment level for AECMs is based on the average opportunity costs to the farmers within a region. This leads to a spatially uneven participation behavior since farmers on more favorable production locations have to face higher opportunity costs finally resulting in non-participation, whereas farmers in less productive locations face lower opportunity costs, such that participation is attractive. The spatially uneven distribution is depicted in Figure 7, in a map of the federal state of Bavaria in 2012.

There are also administrative costs involved. In the federal state of Baden-Wuerttemberg, for example, Pillar II (EAFRD) has administrative costs of 32% of the amount of the payments made, in contrast to Pillar I (EAGF) with administrative costs of only 7% (Landesrechnungshof Baden-Württemberg 2015). This is also true for AECMs, however, with substantial variation between different programs and between German federal states. Fährmann and Grajewski (2013) find between 7% and 18% average administrative overhead for AEPs in different federal states. The percentage is also depending on the intensity of regulation. Light-green AECMs are associated with low administrative costs (12%), whereas targeted, dark-green AECMs or conservation programs face high administrative costs (36%); organic farming has low administrative costs of 9% (Fährmann and Grajewski 2013).

The German Scientific Advisory Board on Agricultural Policy, Food and Consumer Health Protection argues that, to a certain extent, administrative costs are necessary means to achieve agri-environmental targets (WBAE 2019). Furthermore, Armsworth et al. (2012) show that higher administrative costs through dark-green AECMs are justified by a much greater increase in biodiversity.

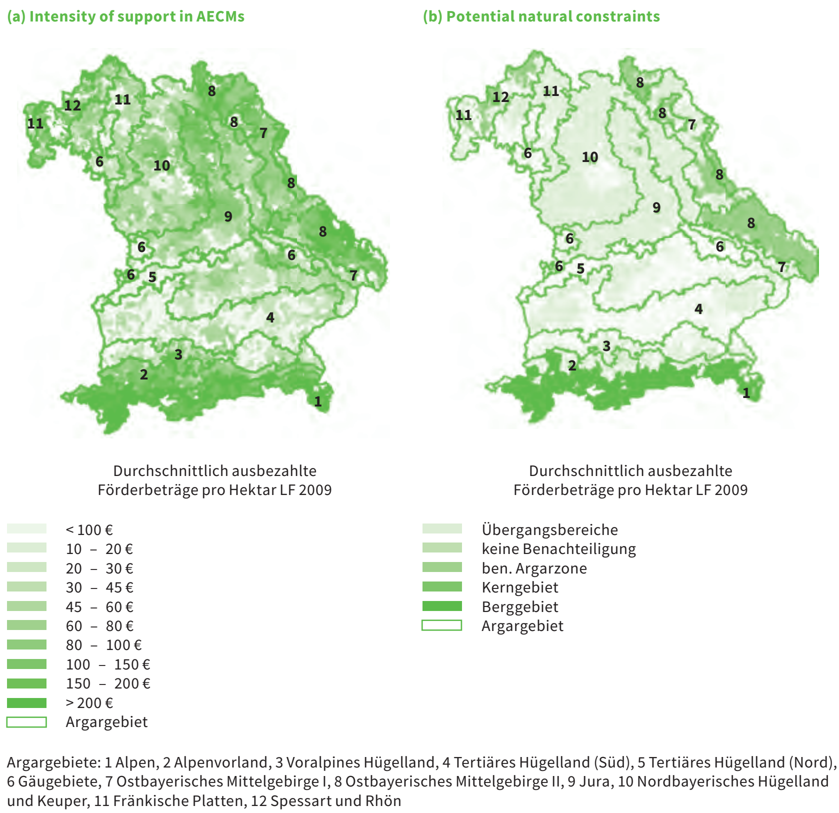

Figure 7. Regional participation in Agri-Environmental Programs (AEPs) and location quality in Bavaria 2012. Source: Wanner (2012).

4.2. Analysis of Greening of Direct Payments

The EC presented a cost estimation for proposed Greening measures within an ex-ante assessment of the CAP reform, assuming even stricter rules of application as formulated in the proposal of 2011 (EC 2011) (Figure 8).

According to this assessment, crop-diversification and maintenance of grassland were presumed to not cause additional costs on 92% and 84.5% of the farms in the EU-27, respectively. Even for EFAs, the assessment predicts no additional costs for 54% of the farms (see Figure 8). Only farms larger than 15 ha have to comply with EFAs, so exemptions reduce the impacts of EFAs. According to an ex-ante study by Pe'er et al. (2014) based on data from Eurostat, 88% of all farms and 48% of the farmed area in the EU were exempted from EFAs. The decision patterns of farmers can be studied based on EU data; however, this is only for the year 2015. More detailed data are available for Germany 2015–2018 (Figure 9).

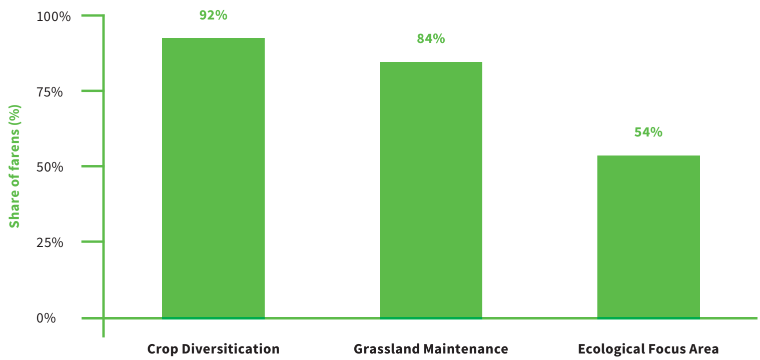

Figure 8. Share of farms with no additional costs due to Greening in the EU-27. Source: own presentation, data from the Ex-ante Impact Assessment (EC 2011, pp. 9, 12 and 17).

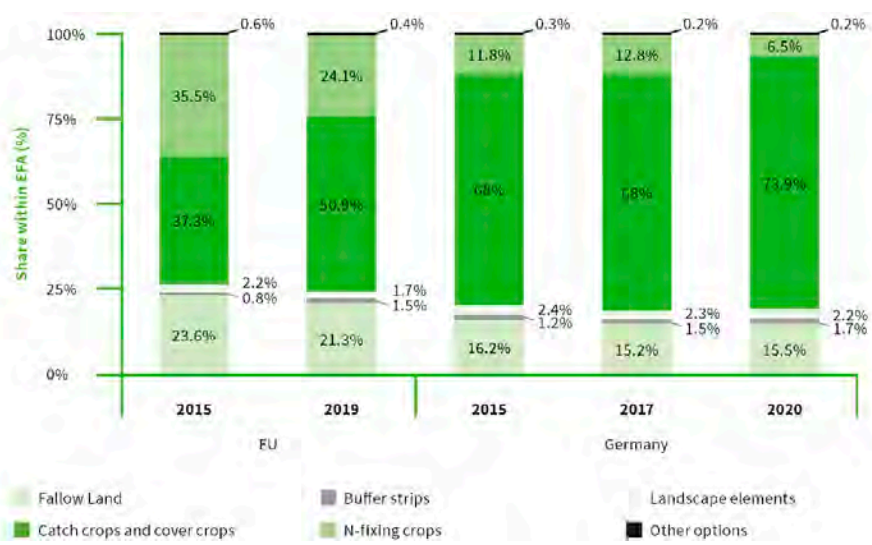

Figure 9. Chosen Ecological Focus Area (EFA) options by farmers in the EU 2015 and Germany 2015–2018. Source: Alliance Environment (2019, p. 33) and BMEL (BMEL 2016–2019). Note: The shares refer to the EFA before Weighting Factors.

The actual decisions of farmers in 2018 in the EU on choosing EFA options show a strong emphasis on production-oriented options such as catch crops (50.9%) and nitrogen-fixing crops (24.1%) (Alliance Environment 2019, p. 33). In Germany in the year 2019, two production-oriented options—with catch crops (73.9%) being the largest and nitrogen-fixing crops (6.5%) the third largest—also took a substantial share of EFAs with 81% of the net area (i.e., the area before applying weighting factors). Among the non-productive options, fallow land takes the largest share, with around 23.6% in the EU and 15.5% in Germany; in turn, buffer strips (1.5%/1.7%) and landscape features (1.7%/2.2%) have only a very low share (Pe'er et al. 2017a).

To analyze the effectiveness of different EFA options, Pe'er et al. (2017b) interviewed 89 ecologists (Figure 10).

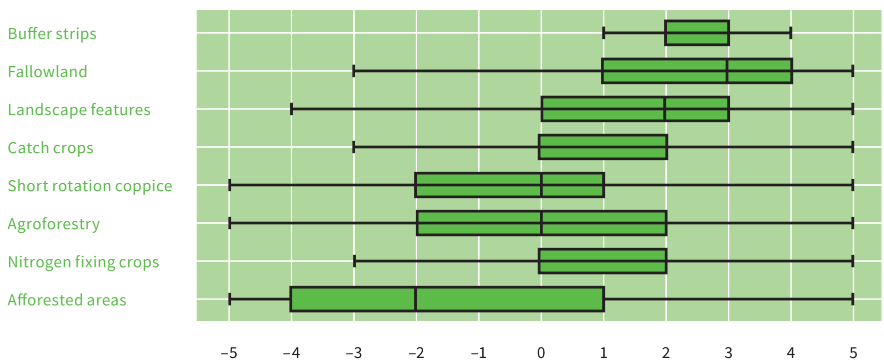

Figure 10. Survey on effects of the different EFA options for biodiversity. Source: Pe'er et al. (2017b); Note: Evaluation from positive (+5) to negative (−5); No. of participants = 89 within EU and Switzerland.

A first group shows a positive median value. The arithmetic mean shows some degree of variation for buffer strips (2.5), fallow land (2.4), and landscape elements (1.7), which are all evaluated as effective. A second group of EFA options show a median value of zero; i.e., they are largely ineffective. Some options show a slight positive arithmetic mean, such as nitrogen-fixing crops (0.7) and catch crops (0.4), which still seem to have a positive effect on biodiversity, whereas agro-forestry (−0.1) and short rotation coppice (−0.4) are neutral to slightly negative. A third group (afforestation areas) has a negative median value and is evaluated as significantly negative, i.e., counterproductive (−1.4). The results of this survey have been largely confirmed by two recent field studies on Greening measures, both concluding that fallow land, buffer strips, and landscape elements are most effective to protect target species of farmland birds or insects (Dellwisch et al. 2019; Ekroos et al. 2019).

The European Court of Auditors concludes that Greening “has led to very limited change in farming practices” (ECA 2017, p. 24).

5. Problem Evaluation

5.1. Farmers’ Decisions on Conservation Measures

The management of agricultural landscapes has strong impacts on biodiversity conservation. There is a broad range of factors determining farmers’ adoption of conservation measures (Figure 11; (Brown et al. 2019)), including structural, financial, ecological, political, and socio-demographic factors as well as farmers’ values and attitudes and policy design features.

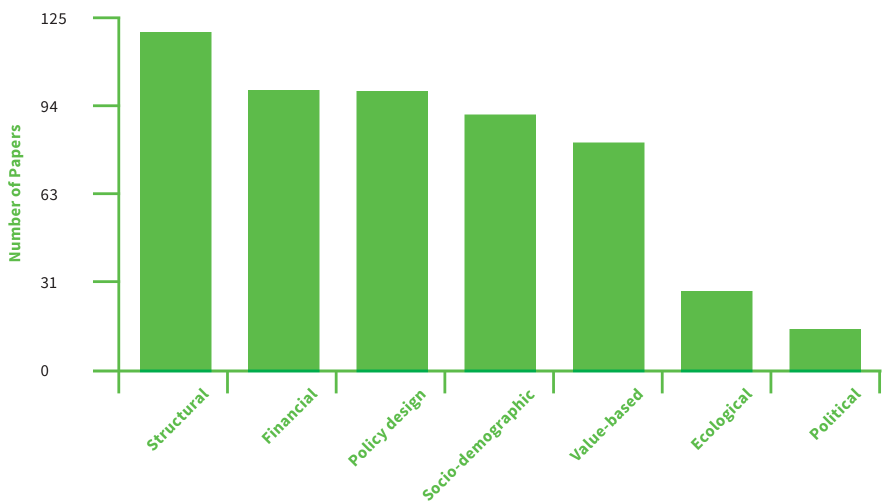

Figure 11. Factors determining farmers’ adoption of conservation measures. Source: Brown et al. (2019).

As structural factors, particularly farm size, production system, and farm location have been shown as influential. Findings on the importance of farm size vary across geographies and production systems (Brown et al. 2019). A positive correlation of farm size with AEMs uptake has been observed (Zimmermann and Britz 2016) and explained with a better education of large farmers (Villanueva et al. 2015). In turn, a specialization in livestock and dairy has been reported as negatively influencing farmers’ uptake of conservation measures in England (Hodge and Reader 2010), while favoring farmers’ uptake in studies from Italy (Borsotto et al. 2008). Literature reports that as farmers specialize in a specific form of farm management, their willingness to adopt AEMs depends on the extent to which conservation practices fit into their technological setting (Vuillot et al. 2016). Furthermore, the geographical location strongly influences farmers' willingness (Zinngrebe et al. 2017). Specifically, areas with high land values are less likely to show strong uptakes of conservation measures (Bartolini et al. 2012).

As a clear pattern in financial factors, higher payments drive farmers' decisions when choosing those EFA options which are least costly, less labor intensive, and leave the largest part of the Greening-payment as 'windfall gain', as shown for the case of cash crops (Lakner and Holst 2015). The positive impact of an economic benefit on farmers' adoption of AECMs was shown, for example, in Germany (Bock et al. 2013) and Italy (Borsotto et al. 2008). The real economic benefits, however, need to prevail when taking into account other costs related to the fear of sanctions, risks of income forgone, and market risks (Prager and Posthumus 2010). There is variation in the role of financial factors depending on the geographical location and the methodology applied (Brown et al. 2019).

As part of the policy design, administrative considerations and farm controls negatively affect farmers' willingness to participate in conservation measures. Furthermore, contract flexibility and taking participatory decisions with farmers increase farmers' willingness to participate (Geitzenauer et al. 2015). What is more, the availability and trust in extension services positively relates to the adoption of conservation measures (Brown et al. 2019).

Socio-demographic factors: while young farmers are more likely to take up conservation measures, the statistical effect of the age of farmers is highly dependent on the social-ecological context (Brown et al. 2019). Some studies find part-time farmers as more likely to engage in AEMs (Vesterager and Lindegaard 2012), while others report a stronger participation of full-time farmers (Matzdorf and Lorenz 2010). Moreover, a stronger focus on productivity is reported to correlate with less AEM uptake (Kvakkestad et al. 2015). Furthermore, the level of education and training might have a positive impact on the adoption.

Values and attitudes of farmers influence their disposition for conservation activities. Production-oriented farm management has a negative effect on farmers' uptake (Breustedt et al. 2013). At the same time, openness and an interest in environmental considerations increase the willingness to participate (Brown et al. 2019). For example, traditional customs, such as the implementation of landscape elements ('Knicks') since the 18th century in the German federal state Schleswig-Holstein, lead to a strong uptake of this measure. Social networks and trust further increase farmers' willingness to adopt measures.

Ecological factors play a role, particularly if a positive effect for landscape and wildlife is perceived (Brown et al. 2019). Visible ecological benefits, such as near water bodies or ecologically valuable areas seem to favor implementation (Grammatikopoulou et al. 2012). Particularly high shares of grassland and a heterogeneity of farm structures are reported to increase farmers' uptake (Matzdorf and Lorenz 2010).

As a last but relevant political factor, distrust in government or in environmental schemes negatively impacts the willingness of farmers to participate in conservation schemes (van Zanten et al. 2014). A misconception of farmers' motivations in political arenas is a potential leverage point for improving the CAP's design and induce more effective implementation (Brown et al. 2021).

5.2. Facilitators and Barriers for a Transition towards Environmentally Friendly Farming

There is clearly a need to improve and increase the uptake of AECMs. The CAP reforms to date have been quite unsuccessful. The established AECMs (together with CC) do not achieve sufficient impacts to halt the decline in biodiversity or to substantially contribute to climate change mitigation within the farming sector. In his seminal paper, Günther Schmitt (Schmitt 1984) has posed the question, 'why is the agricultural policy as it is and not as it should be?'. This question is still highly relevant for the CAP, especially in view of the agri-environmental targets. In this section, we suggest why there is such little progress within respect to the stated agri-environmental targets.

5.2.1. Unclear and Conflicting Objectives

One main obstacle is the vague and contradicting objectives within the CAP. Throughout several reforms of the CAP, the EU added new objectives without adjusting or aligning them. The Treaty of Rome in 1957 defines the original CAP objectives, which were implemented throughout the 1960s by applying market regulations, such as intervention price system and external tariff protection to several sub-markets.

In the Treaty of Lisbon (2009), the EU has confirmed the classic CAP-objectives in Article 39, despite some of them being rather outdated. However, the post-2020 CAP proposal lists nine 'new objectives', of which three are environmental objectives, referring to the protection of biodiversity, climate action, and resource efficiency (EC 2018). While the objectives income (a), competitiveness (b), and market stabilization (c) can still be linked to the 1957 objectives, the environmental (d, e and f) and rural development objectives (g, h and i) cannot. These diverging objective systems are introducing new conflicts between objectives, for example, between competitiveness and environment or between income and environment (Pe'er et al. 2019, SM).

5.2.2. Flexibility Instead of Subsidiarity

The CAP is offering finances and measures for a highly diverse continent, including very different climate zones, heterogeneous production locations, diverse farm structures, and differently developed national economies and farming sectors.

Based on the economic theory of fiscal decentralization (Oates 1997), the EU pursues the subsidiarity principle meaning that policy making takes place at the lowest possible level that can produce effective outcomes. Central solutions seem reasonable if there are (a) economies of scale in the provision of public goods and (b) homogeneous environmental, social, and market conditions across MSs. In turn, decentral solutions enable national and sub-national governments to adjust policies to diverging social preferences and social-ecological contexts. Thus, the appropriate level of subsidiarity has to balance uniform regulation with flexibility to maximize synergies and to account for trade-offs.

In the CAP reform of 2015, the 'trilogue process' (i.e., the negotiation of EU Commission, Council, and the EU Parliament) and the introduced flexible elements have led to a process of watering down of the main reform elements. Here, MSs have often used the top-down flexibilities to implement the softest possible option for their national farming sectors. Since 2005, the EC has continuously increased the use of flexible elements in the CAP (Box 1).

Box 1. Genesis of 'flexible elements' with the CAP.

2005	Different decoupling models of direct payments, differently used within the EU (Fischler Reform 2005)
2009	Regionalization of direct payments, the option to maintain coupled payments within some specific agricultural sectors (Anania and Pupo D'Andrea 2015), (Health Check 2009)
2013	Some flexible elements (Greening, coupled payments, flexible transfer between pillars and options for redistributive payments) (Ciolos Reform 2013)
2020	Full flexibility and national implementation, containing 'strategy plans' with an agreement between EU and MSs on target-oriented implementation (CAP Reform 2021)

However, these flexibilities come with no clear guidelines in programming and no clear outcome indicators for measuring their impact. With respect to Greening, for example, flexibilities have increased the EFA elements, such that farmers had a large choice between elements; however, many options are hardly effective or even counterproductive. Thus, the flexibilities introduced with the Ciolos Reform have undermined and watered-down environmental measures and diluted their effectiveness, still, however, with substantial differences among regions and MSs.

5.2.3. CAP Politics and the Influence of Lobbyism

In the 1960s, Mancur J.R. Olsen introduced the theory of collective action, showing the incentives towards political influence and lobbyism. To attract members, associations have to lobby for political rents for their members (Olsen 1965). The theory further developed by Gary Becker, however, had a more positive view: different stakeholders compete on the political market and create better information for political deciders (Becker 1983).

The CAP can be regarded as a classic example for lobby influences on a specific sectoral policy. From its beginning in the mid-1960s to the 1980s, especially the decisions on intervention prices were taken unanimously in non-public sessions by the council of agricultural ministers in Brussels, at that time far away from any public or media attention and without any minutes (Runge and von Witzke 1987). Here, price-decisions were made like at a 'restaurant table' using a 'menu' meeting the preferences/needs of concrete ministers and national agricultural sectors, whereas costs were ultimately borne jointly by the six MSs (Schmitt 1984).

The role of institutions and the design of decision-making processes can play a decisive role and exhibit a strong impact on today's CAP. As a consequence of the Treaty of Lisbon in 2009, the co-decision-making process was extended and the European Parliament (EP) increased its influence during the 2013 CAP reform process (Fertö and Kovacs 2015). But despite the extended influence of the EP, the farmer-supportive, conservative groups continue to dominate the Committee on Agriculture and Rural Development (COMAGRI) of the EP, resulting in a constrained disposition for reform, while, similarly, DG AGRI dominated the final CAP design despite a consultation with other Commissioners (Knops and Garrone 2015). These findings on the 2013 reform align with the 'old' hypothesis that small interest groups with homogeneous interests (here, farmers associations) dominate political processes compared to larger groups with heterogeneous interests (here, the general public, other sectors).

While new discourses of multi-functionality and sustainability entered the political arena, a 'productivist' narrative continues to dominate political discourse and the resulting policy design (Erjavec and Erjavec 2015). Despite multiple changes in the EU decision rules, with a shift in favor of the European Parliament, the new flexibility introduced by the CAP reform 2013 implies a return to the 'restaurant table game', where MSs can freely choose, for example, between different Greening options, redistribution models, or coupled payments, which can be granted to diverse farming sectors. In most cases, this flexibility is not leading to the provision of more public goods, but rather to more market distorting coupled payments or a watered-down Greening (Alons 2017). Implementation of the Ecological Focus Areas within the Greening obligations showed a strong underrepresentation of ecologically effective measures (Pe'er et al. 2017a; Zinngrebe et al. 2017; Brown et al. 2019).

5.2.4. The Role of Administration for Policy Design

National and regional agricultural administrations play a key role in designing, programming, and controlling the implementation of AECMs. Whether or not an MS or region is offering ambitious or targeted AECMs depends on the available administrative and financial resources. AEPs necessitate between 10% and 35% administrative top-up costs. High administrative costs are a barrier for state administrations to implement complex and, in particular, targeted AECMs (WBAE 2019). This is particularly relevant in eastern MSs, where agricultural administrations are smaller and budget shares for AECMs are lower. In north-western EU MSs[3], about 33.5% of the RDP spending for 2014–2020 is dedicated to AECMs, Organic Farming, and Natura 2000, whereas, in eastern and southern MSs, it is just 19.8%/18.4% (own calculations, based on (EC 2016)). From a farmer's perspective, high administrative burdens are a disincentive to use AECMs, too.

6. Conclusions

We showed that CAP reforms have repeatedly failed to draw on the accumulated knowledge on policy processes and implementation. Consequently, institutional learning along the initially described policy cycle for transformation is disrupted at several levels. Based on the reviewed literature, we conclude that the highly politicized and biased process of incorporating inputs from the public and from evaluation results of previous CAP reforms lacks sufficient structure, transparency, and inclusivity.

The key challenge that remains is how to transform a post-2020 CAP into an incentive framework supporting multifunctionality and the provision of societal

[3] Northwestern MSs: BE, DE, DK, IE, LU, NL, UK, AT, FI, SE; Southern MSs: FR, EL, IT, MT, PT, ES, CY; Eastern MSs: BG, CZ, EE, HR, LV, LT, HU, PL, RO, SK, SL.

services related to the sustainability of agricultural landscapes. In the remainder of this section, we briefly introduce the most recent CAP reform proposal and reflect on its opportunities, potentials, and shortcomings:

6.1. The Post-2020 CAP Reform

The post-2020 CAP reform has four main elements linked to environmental aspects:

1. A set of nine new CAP-objectives is proposed, including three objectives: (c) Climate Action, (d) Environmental Care, and (e) Maintenance of Biodiversity. Given the CAP-budget 2017, so far, less than 20% of the spending relates to environmental objectives, whereas the largest share (60%) is linked to the income objective (Pe'er et al. 2019). Adding to this, some of the objectives are vague and conflicting with each other. Furthermore, the EC has no plan how potential conflicts shall be moderated.
2. A new implementation model for the CAP introduces more flexibility to the MSs, determining their implementation model in the form of a strategic plan. Here, an MS has to describe objectives and deficits using a set of indicators (output, result and impact indicators). It is to be used as a management instrument including documenting results and, if insufficient, adjusting the plan. However, it is unclear on what grounds the EC might reject a strategic plan or require MSs to change its implementation.
3. The new green architecture of the CAP compiles several environmental instruments and measures that already exist, such as AECMs. Furthermore, under the term 'Conditionality', CC now combines elements of Greening within the GAEC, defining requirements for receiving DPs. For example, crop diversification corresponds to GAEC 8 and maintenance of grassland to GAEC 1, 2 and 10; EFAs relate to GAEC 7 (catch crops), GAEC 4 (buffer strips), and GAEC 9 (landscape elements and fallow land). The new GAEC criteria also relate to the Natura 2000 network (SMR 3 and 4, Table 3).

Since MSs choose the set of criteria when implementing the new CAP, the actual impacts of 'Conditionality' are unclear.

The EC proposes 'Eco-Schemes' related to climate and the environment (Article 28), which are yearly AECMs within Pillar I. MSs have to offer these schemes; however, they are voluntary for farmers. The eco-schemes can be cost covering, yet premiums may also contain an income component, thus going beyond opportunity costs. MSs can decide on the funds they want to dedicate to this instrument; yet, a minimum share within Pillar I is discussed.

Table 3. Selected criteria of the good agricultural and environmental conditions.

Criterion	Requirements and Standards	Main Objective of the Standard
Climate action		
GAEC 1	Maintenance of permanent grassland based on a ratio of permanent grassland in relation to agricultural area	General safeguard against conversion to other agricultural uses to preserve carbon stock
GAEC 2	Appropriate protection of wetland and peatland	Protection of carbon-rich soils
Water		
GAEC 4	Establishment of buffer strips along water	Protection of river courses against pollution and run-off
Soil (protection and quality)		
GAEC 7	No bare soil in most sensitive period(s)	Protection of soils in winter
GAEC 8	Crop rotation	Preserve the soil potential
Biodiversity and landscape (protection and quality)		
SMR 3	Birds Directive: Article 3(1), Article 3(2)(b), Article 4(1), (2) and (4)	
SMR 4	Habitats Directive: Article 6(1) and (2)	
GAEC 9	• Minimum share of agricultural area devoted to non-productive features or areas • Retention of landscape features • Ban on cutting hedges and trees during the bird breeding and rearing season • As an option, measures for avoiding invasive plant species	Maintenance of non-productive features and area to improve on-farm biodiversity
GAEC 10	Ban on converting or ploughing permanent grassland in Natura 2000 sites	Protection of habitats and species

Source: European Commission (EC 2018).

4. A Multiannual Financial Framework (MFF) of the EU 2021–2027 was proposed by the EC in May 2018. Since the United Kingdom, one of the net payers to the EU budget, left the EU in January 2020, the proposed MFF contains a cut for the agricultural budget. This MFF proposal was published before the draft of the post-2020 CAP reform, suggesting an asymmetric budget cut of 11% for Pillar I and 28% for Pillar II (Matthews 2018), thus, to some extent, predetermining the CAP reform.

6.2. Potentials and Challenges of the Post-2020 CAP

The new post-2020 CAP gives more responsibility to MSs by using a larger set of flexible elements. This has a number of advantages and drawbacks from an environmental perspective:

- The new green architecture has widened the set of measures and instruments by introducing a wider set of conditionality and rather simple, yearly eco-schemes in Pillar I (Pe'er et al. 2019). This, combined with the established AECMs in Pillar II, provides many options, where MSs can create suites of measures fitting to the national context.
- The top-down approach of Greening, which defined uniform measures for all MSs, had rather limited effects since MSs watered down the EC's proposal (Alons 2017) and the national implementation was often lacking ambition. A more flexible, subsidiarity-oriented approach may better address the MSs needs.
- However, experiences with flexible elements in the past show that lacking environmental ambition and reluctance to change are main barriers for an ambitious implementation. Here, the post-2020 CAP reform proposal does not have clear guidelines and minimum requirements for its flexible elements. The EC has called on the MSs to show 'increased ambition with regard to environmental- and climate-related objectives' (EC 2018, Article 92); yet, it is not clear if this would have any consequences for approving the MSs' strategic plans. Here, the set of indicators for evaluating the strategic plans has been criticized for leaving a broad space for interpretation (Pe'er et al. 2019).
- *The* 'higher ambition' is implemented, for example, using a 'performance bonus' (EC 2018, Article 123). Effectively, MSs might be tempted—unambitiously—to choose simple measures with low requirements and high probable participation rates. Thus, the indicators need to be more precise to avoid MSs using the flexibility to implement only most 'convenient measures' with rather low environmental effectiveness.
- Finally, maintaining many instruments such as DPs and coupled payments signals a business-as-usual CAP reform. DPs as an instrument of income policy are ineffective, distort markets, and lack a clear scientific justification. Coupled payments distort markets and production, and support only some production systems like milk or meat production, which have a strong negative impact on the climate via GHG emissions. Furthermore, the different types of DPs still account

for ca. 38% of the CAP budget; funds are needed to finance agri-environmental policies within the CAP.

Thus, it is unclear whether EC and MSs were able to apply conclusive learning within the CAP-context. The post-2020 CAP reform has some interesting potentials; however, since there are no clear minimum requirements, implementation by the MSs might be unambitious. Here, much will depend on the final decisions of the Council and EU Parliament in 2020, the implementation in the MSs, and the reactions of farmers on the ground.

6.3. Potential Instruments and Approaches for a Transformation

There is a further range of instruments and approaches that could facilitate a transformation towards biodiversity-friendly EU agriculture as elements of future CAP reforms and beyond:

1. Phasing out DPs would acknowledge their poor performance for both income and sustainability aims. Focusing instead on using public money (mainly) for providing public goods, all payments should be made conditional on higher environmental standards. In a transition phase, the flexibility to transfer budgets into Pillar II could be enhanced and at least 30% of DPs ring fenced for effective measures under eco-schemes. A similar approach has been taken for the new post-Brexit agricultural policy in the United Kingdom (DEFRA 2018).
2. Supporting landscape-targeted and coordinated actions among farmers would allow larger-scale goals for biodiversity conservation to be achieved and could be implemented in both pillars. Such a landscape-level perspective would allow for the local targeting of management measures that can achieve a more effective delivery of public goods, such as maintaining water quality (Jones et al. 2017) and reducing fire hazard (Moreira and Pe'er 2018). Successful examples of landscape governance and collaborative implementation of environmental measures, going beyond the farm-based implementation of AECMs, include local initiatives or 'coalitions' in the Netherlands. In order to improve income security and ecological benefits, such approaches should entail longer-term contracts with farmers and groups of farmers. The current CAP allows MSs to support collaborative implementation of greening measures as well, but only two MSs have taken up this option (the Netherlands and Poland). Furthermore, using the management plans for the Habitat Directive might be another opportunity to implement such approaches (Lakner et al. 2020).
3. Supporting innovative and enhancing existing agri-environmental instruments could involve the more widespread implementation of result-based

agri-environmental schemes (Schroeder et al. 2013) and/or the introduction of a points system to increase farmers' benefits proportionate to ambition and/or investments in the provision of a broader range of ecosystem services (Neumann et al. 2017). So far, however, result-oriented schemes have only been implemented in some MSs in an experimental way, yet with both positive ecosystem effects and positive perceptions from farmers' (Schroeder et al. 2013).

In general, the last two approaches (2 and 3) have been considered in the post-2020 CAP proposal: Articles 65 (AECMs) and 71 (Cooperation) allow for the support of collective schemes and result-based schemes, relating to the potential implementation of measures at a larger-scale level, i.e., by groups of farmers. However, Article 71 does not necessarily relate to environmental objectives and may even promote unsustainable farming practices (i.e., homogenization), and Article 65(7) is only voluntary for MSs to adopt. Furthermore, there are no instruments in Pillar I relating to larger-scale implementation, neither as CC mechanisms nor in eco-schemes (Article 28).

In order to address the above challenges and to make the CAP a coherent framework for the sustainable development of rural areas and for achieving the SDGs, in particular SDG 15 Life on Land, the respective political decision-making processes and institutional settings need to be adjusted (Pe'er et al. 2019). Without including other political and other stakeholders in negotiations on budget allocations and policy design, agricultural interest groups will continue to preserve current trajectories and undermine any initiative for sustainable transformation.

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Strategic Engagement in Institutions of Organic Farming in Indonesia

Dimas D. Laksmana and Martina Padmanabhan

1. Introduction

This paper analyzes the institutional aspects of organic farming (OF) in Indonesia, focusing on the dynamic interactions among stakeholders in OF social networks and their engagement with OF government initiatives by using the Net-Map method based on social network analysis (SNA). OF has been promoted by the state as a strategy towards nature conservation and environmental protection. Following the global consensus on the need to transform the current agricultural systems to achieve some Sustainable Development Goals (SDGs), in particular, SDG 15, OF is considered as a promising model of sustainable agriculture (Willett et al. 2019). Therefore, this paper specifically questions how 'sustainable' Indonesian OF is from an institutional perspective. Analysis on sustainability and sustainable development, which are considered as two distinct concepts, should address the specificity of these concepts which are connected to the actors who define them and the subject of the enquiry (Nightingale et al. 2019a). Therefore, following this approach, we analytically show the diversity of views on OF not in order to resolve these differences, but rather to bring these differences to the foreground and to illustrate the various ways people act upon these tensions. We also focus on the ways in which different notions of sustainable agriculture are negotiated through different strategies employed by OF actors. Specifically, we examine how, and to what extent, the development of OF has been supported and/or undermined by the social networks of civil society, government, and the private sector.

Previous studies on SNA and environmental farming practices among cocoa and coffee farmers in Indonesia point out the lack of multi-scale analysis that links local and global social networks (Matous 2015). However, as argued by Neilson and Shonk (2014), a 'value chain approach' to draw linkages between small-holder farmers with global players tends to miss the complexity of micro-level interactions between different stakeholders. With a different take, our paper illustrates the importance of combining analysis on the governance and policies of OF at the national level with the social networks of stakeholders at the local level in understanding the implementation of OF. Therefore, this paper addresses the limited study on OF policies and dynamics between actors in Indonesia (David and Ardiansyah 2016). In addition, the use of Net-Map provides a greater involvement of study participants to interpret the networks they constructed, a feature which reveals insights on their positionality with respect to other actors in the networks. Three research questions were formulated to address the points above:

(1) Which actors influence the institutions of OF in Indonesia?
(2) How do these actors interact with one another?
(3) How do institutional aspects of OF affect the 'sustainability' of OF development?

The paper presents the results of a participatory workshop in Yogyakarta, Indonesia, in 2017 where OF practitioners used Net-Map (Schiffer 2007) to construct the social networks of OF in Indonesia[1]. This research was undertaken as part of the transdisciplinary research project 'IndORGANIC', which explores the environmental, economic, and social potential of OF in Indonesia (IndORGANIC n.d.).

This paper is structured as follows. First, we describe the historical development of conventional farming and OF in Indonesia, with particular emphasis on the interactions between government and civil society. This section identifies the principal OF actors and provides an overview of relevant policies that frame sustainability issues in farming. Second, we review the literature on the application of institutional analysis and SNA for the study of OF in various contexts. Third, we describe how the Net-Map method was used in a participatory workshop to elicit the views of OF practitioners on the current state of OF in Indonesia. Fourth, we analyze the SNA data in the social networks produced by participants in the workshop, and the content of audio recordings made during the workshop. Our interpretation of the data leads us to elaborate different notions of 'sustainability' in OF and to propose three different categories of OF actors, grouped according to their degree of engagement with the government. In the final section, we identify a possible space for negotiation within OF institutions where government and different actors could collaborate in formulating a more coherent policy for OF development. For future research, we identify a need for further investigation on the potential links between OF development and decentralization.

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[1] Please see the Appendix A for social networks created in the workshop, Figures A1 and A2.

2. Study Area

This section specifies historical development of conventional farming and OF in Indonesia, specifically in Java. In addition, it links the government's paradigms and the governance structure in agriculture, which provide insights on the characteristics of the interactions between the government and broader civil society.

2.1. The Historical Development of Conventional Farming in Indonesia

The productivist paradigm, farmers' dependency on the government, and the top-down transfer of knowledge and agricultural inputs are aspects of governance that still persist in the current government's approach to OF. Following the foundation of independent Indonesia in 1945, the government prioritized the increase of agricultural production and food price stability—of rice in particular—in order to achieve national food security (Arifin 2008). These goals were achieved through agriculture policies inspired by a productivist paradigm, whose key components were the intensification and industrialization of agriculture (ibid.). Implementation of these policies involved the creation of top-down bureaucratic institutions that controlled the distribution of agricultural production, managed input subsidies, and claimed to have a monopoly of knowledge on agriculture (Winarto 1995; Sawit and Manwan 1991). In 1960s, as part of the green revolution, the government promoted the use of petroleum-based agricultural inputs and high-yield rice varieties (HYV) in Indonesia. The implementation of these policies in Indonesia is examined in numerous studies, including many that criticize their (intended and unintended) consequences (Fox 1991, 1993; Oka 1997, 2003; Winarto 2004; Winarto 2011; Sawit and Manwan 1991). While the intensification of agriculture enabled the goal of national food self-sufficiency to be achieved in the mid-1980s (Fox 1991 cited in Fox 1993), this success was short lived, undermined by massive outbreaks of the rice pest brown plant-hopper (BPH), which attacked paddy fields throughout the country (Winarto 2011; Fox 1993). Among contributing factors to this agricultural disaster were the bureaucratic inefficiency and centralist control that characterized government during the Soeharto era. All criticism of the government was suppressed, thus, stripping initiative and decision-making power from lower level government officials and civil society (Thorburn 2015). The change of the country's political system from autocracy to democracy during the Reform era in 1998 introduced decentralization, including in agriculture. This important feature of the country's agricultural policy is further elaborated in Section 6. However, overall, the introduction of modern agricultural management during the green revolution period forced farmers to be institutionally, technically, and financially dependent on the government (Winarto 2004, pp. 365–66).

This historical background and institutional context influence the characteristics of the networks of OF actors in contemporary Indonesia, as described in Section 7.

2.2. Civil Society and OF

OF in Indonesia, particularly in Java, emerged as a social movement initiated and spread by non-governmental actors. The Bina Sarana Bakti[2] (BSB) foundation was established in 1983 in West Java to provide an alternative option for farmers locked into a centralized agricultural system that perpetuated their financial and institutional dependency on the state and continuous environmental degradation (David and Ardiansyah 2016). This organization is recognized as being the first to offer training in OF for farmers in Indonesia (Jahroh 2010). Another milestone in the OF movement occurred in 1990, when the Ganjuran Declaration, issued at the conclusion of an international seminar held in Central Java on soil degradation caused by agricultural intensification, called for sustainable agricultural development based on the principles of ecological, economic, cultural, and social sustainability (Utomo 2005). In subsequent years, the World Food Day Secretariat for Farmers and Fishermen (SPTN-HPS)[3], which was founded during the same seminar, continued to promote these principles and spread knowledge of sustainable agriculture.

More recently, numerous organizations and initiatives promoting OF at different scales have emerged in Indonesia. In Central Java, communities of organic market provide space for the exchange of knowledge and transactions of healthy and artisanal food, where ‘self-certification’ of the organic produce is accepted by customers based on trust (Widiyanto 2019). These are community-based grassroots movements initiated by individuals with common aspirations and interests. At a national level, the Indonesia Organic Alliance (AOI)[4] is a long-established organization that has functioned since 2002 as an umbrella organization, connecting different actors involved in OF, and publishing statistics on OF in Indonesia (AOI 2018; AOI n.d.). OF is also supported by international development agencies, such as the international NGO, Rikolto Indonesia, which promotes sustainable agriculture in Indonesia by providing institutional and technical support to farmers (Rikolto n.d.).

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2 Yayasan Bina Sarana Bakti.
3 Sekretariat Petani dan Nelayan Hari Pangan Sedunia.
4 Aliansi Organis Indonesia.

2.3. The Indonesian Government and OF

Government's approach to the development of OF is characterized by productivist and market-oriented agendas, which are exemplified by the following programs and policies. The first government initiative to support the expansion of OF was the "Go Organic" program, launched in 2002, which aimed to transform Indonesia into one of the main producers and exporters of organic food products in the world by 2010 (Ditjen BPPHP 2001). This was supported by the creation of a national standard for OF, based on third-party certification, within the Indonesian National Standard (SNI) certification system (SNI No. 01-6729-2002) (BSN 2002). This SNI and subsequent updated versions of the standard provide guidelines for the regulatory agency OKPO (Competent Authority for Organic Food) and extension workers led by the Ministry of Agriculture (MoA) (BSN 2002; Ministry of Agriculture 2003). The main responsibilities of OKPO are to formulate regulatory policies for the monitoring and development of organic food systems, oversee the establishment of organic food certification bodies, and verify the competence of certification bodies and other entities that perform similar functions (Ministry of Agriculture 2003). All the above standards and regulations cover not only agricultural production but also the activities of other private sector organizations involved in the OF sector, such as certification bodies, suppliers, and retailers (BSN 2002, 2016). While the goal of the "Go Organic" program was not achieved, given that the proportion of organic land is less than 1% of the total agricultural land in 2015 (AOI 2018)[5], the regulatory and institutional structure it gave rise to remains in place. In 2016, the government of President Jokowi launched the "1000 Organic Villages" program with the aim of creating 1000 organic-certified villages throughout the country (Plantation General Directorate of the Ministry of Agriculture 2016). This program was part of the strategy to achieve food sovereignty within the government's wider development agenda (KPPN/BPPN 2014). Despite the government's acknowledgement of the importance of local knowledge and resources, this program still emphasizes the transfer of knowledge, agricultural inputs, and financial support from the MoA to organic farmers (Plantation General Directorate of the Ministry of Agriculture 2016). The top-down structure of the program is apparent from Figure 1.

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5 According to these statistics, organic land includes agricultural land of four different groups: the members of AOI who practice OF without having organic certificate, organic-certified farmers, organic farmers who are in the process of being certified, and organic farmers who are certified by PAMOR which is the Participatory Guarantee System (PGS) in Indonesia.

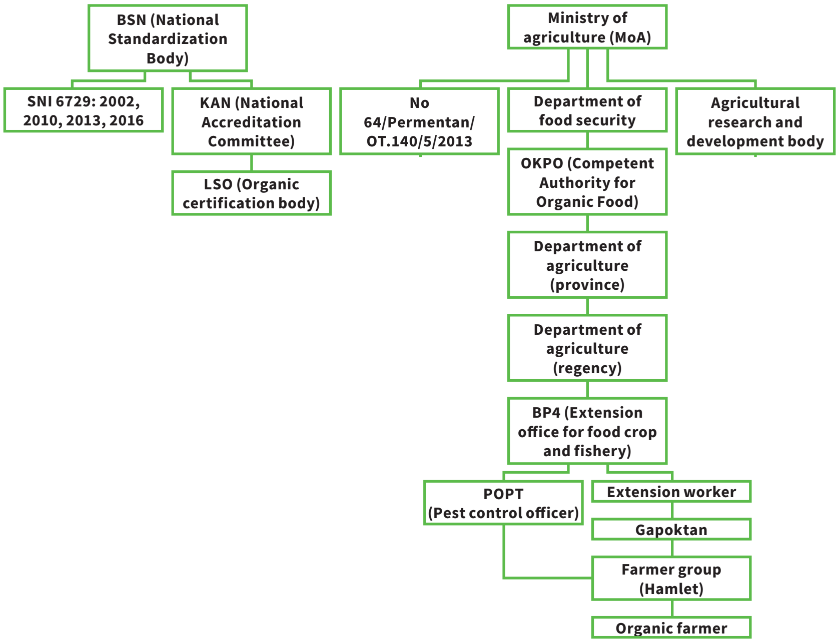

Figure 1. Governance of organic farming (OF) in food crops production in Indonesia (Laksmana and Padmanabhan 2019 based on BSN 2016; Ministry of Agriculture 2003).

3. Theoretical Framework

3.1. Institutional Theory

In this paper, an institution is understood as sets of prescriptions, such as rules and norms, which shape structured and repetitive human interactions. While social interactions are regulated by these rules, the participants and non-participants of these interactions have the possibility to change them (Ostrom 2005, p. 3). Rules in this context are understood in regulatory terms, as something created by an authority (not necessarily conflated with government) that permit or prohibit certain actions (Black 1962, p. 115 cited in Ostrom 2005, p. 17). Conducting institutional analysis is challenging because of the diversity of situations in which preferences are expressed and choices are made, as well as the implicit nature of many of the rules governing their outcomes (Ostrom 2005, pp. 4–5). It is important to select an appropriate level of analysis that gives sufficient information on the specific situation of interest, but at the same time, provides information on outcomes that is generalizable across a range of cases (Ostrom 2005, pp. 5–6). To address these challenges, we follow the theoretical framework by Michelsen et al. (2001) which identifies three levels of the institutional environment that constrain decision-making by organic farmers: macro (rules governing civil society, market, and the state), meso (rules governing farming community, agricultural policy, and food market), and micro (rules governing interaction among actors) level. We analyze Indonesian OF institutions at the micro- and meso-level, with a particular focus on the interactions among actors (individuals and organizations) and the governance of OF. Organizations are associations of individuals who share and participate in the same meaning systems or similar symbolic processes and are subject to common regulatory processes (Scott 1994 cited in Lynggaard 2001). We apply SNA for micro-level analysis to explore the emic perspectives of actors, specifically their perceptions of OF, expectations, and positionality in the networks. Meso-level analysis was conducted by reviewing the literature on the institutions of OF and publications of the relevant governmental agencies. By synthesizing these two levels of analysis, we demonstrate that OF institutions in Indonesia are influenced by the characteristics of the social networks of OF actors that are embedded within the governance of OF. In addition, from the current OF institutions, we draw upon different notions of 'sustainability' enacted by the involved actors. The following sections present the results of the meso-level analysis.

3.2. The Institutions of OF

Numerous studies on OF analyze institutions as determining factors in the development of OF, which is measured variously in terms of the number of organic farmers and farms, market size, consumer demand, and the existence of regulations governing OF (Michelsen 2001b; Lynggaard 2001; Bellon and de Abreu 2006; Sanders 2006; Slavova et al. 2017). Studies characterize OF as fundamentally distinct from conventional farming in terms of values and relations among actors (Michelsen 2001a, 2001b). It is suggested that these distinctions arise as a consequence of the origins of OF, particularly in Europe, in social movements that were critical of the environmental and social impacts of conventional farming (Conford 2001; Tomlinson 2008). Historically, the sustainability of OF is variously rooted in environmental protection, health and food safety, and equity issues related to control over means of production in agriculture (Tovey 1997; Tomlinson 2008; Lockie et al. 2006). Tensions arise when the self-regulatory aspect of OF is undermined by the creation of organic standards, thus, diminishing the importance of individual actors in the OF movement and strengthening the position of government agencies (Michelsen 2001a). Michelsen et al. (2001) propose three types of institutional relationships that may exist between OF and the institutions that govern conventional agriculture: pure cooperation, pure competition, and creative conflict. OF institutions in different countries vary, reflecting their specific national contexts. The OF principles coined by the International Federation of Organic Agriculture Movements (IFOAM) are commonly referred to compare the principles of the global OF movement with national-level organic regulations (Michelsen 2001b; Sanders 2006). However, countries that develop their organic sectors for the export market face the challenge of harmonizing organic regulations with international standards (Mutersbaugh 2004). Harmonization not only poses challenges for the traders and activists involved in the OF movement, but it can also have wider transformational effects, by redefining the meanings of "things", "people", and "social relations" that make up property regimes (Verdery and Humphrey 2004 cited in Aistara 2018, p. 138).

3.3. The Institutionalization Process in OF

The literature on the institutionalization of OF addresses the challenges involved in developing a regulatory framework for OF that is compatible with international standards. Institutionalization is considered in this study as a process in which OF is transformed from a social movement that positions itself as distinct from conventional farming into a branch of agriculture that is embedded in conventional farming. This happens, for instance, through alignment with institutional support structures that enable conventional farming to persist or the codification of organic principles into sets of legally recognized standards and definitions (Buck et al. 1997; Tomlinson 2008). Early studies of the institutionalization of OF were mainly concerned with the reconceptualization of OF within the framework of state agricultural policy (Lockie et al. 2006; Tovey 1997), while later studies focus more on the codification of the principles of the OF movement into national or supranational organic standards and how this process has affected the goals of the OF movement (Michelsen 2001a; Lynggaard 2001). The institutionalization process entails a process of institutional change within OF that can be manifested by the formulation and adherence to new sets of rules and regulations (Lynggaard 2001). In addition, the emergence of new organizations or mergers of existing organizations can be treated as an approximation to institutional change (ibid.). For example, Kaltoft (1999) argues that the creation of national certification and financial subsidies in Denmark led to the dilution of value-laden principles that had underpinned the development of OF as a social movement, and their reduction in OF to a set of technical and quantitative definitions and rules. However, Edwards (2013) argues that the formulation of national standards for OF is part of an institutionalization process that does not necessarily undermine the values of OF as a social movement in Indonesia. Within the OF movement, actors have devised different strategies for adapting to regulatory change without abandoning the values that underpin OF as a social movement (ibid.). Therefore, the introduction of OF regulations does not predetermine subsequent trajectories in the institutionalization of OF. However, regulations do have consequences, as discussed in Sections 6 and 7.

3.4. Institutional Analysis and SNA

SNA is an analysis based on the dyadic relationships between actors in a network. Numerous studies in OF apply SNA in order to examine the network characteristics associated with phenomena such as the commercialization of OF, the participation of individuals in policy-making, adoption of organic practices, the process of knowledge and information production and circulation among OF actors, and OF policy development (Thiers 2002; Mutersbaugh 2004; Bellon and de Abreu 2006; Tomlinson 2010; Wollni and Andersson 2014; Poerting 2015; Slavova et al. 2017). In our research, we used Data Muse to calculate the values for two indices, degree of centrality and betweenness centrality, in order to analyze the relationships and different kinds of flow among the network of OF actors. The actors with high degree of centrality have more links with other actors in the network, while actors with high values of betweenness centrality facilitate flows in the network (Krebs 2004). From these two indices, we can derive a general understanding on structural determinants of influence, the roles of actors, and how the positions of actors in the network relate to their influence (Schiffer and Hauck 2010).

In the abovementioned studies, SNA is usually based on information obtained in semi-structured interviews and surveys where interviewees describe their interactions with other individuals, while the interpretation of the networks is predominantly conducted by analysts. By contrast, in our study, Net-Map was employed to visualize the networks of OF actors and, as further explained in Section 5, this approach enabled us to explore the actors' emic perceptions of the networks that structure their interactions and their own positionalities within these networks. In Section 7, we highlight the influence of the historical coevolution of civil society and government in the area of conventional farming on current OF institutions. Our analysis identifies and characterizes the links among OF actors and shows how these are related to their past positionalities, particularly in relation to the government, and their visions of the sustainability and future development of OF.

4. Research Methodology and Limitations

This section describes the study participants, Net-Map method, and our reflection on the research methodology's limitation. We implemented Net-Map in a participatory workshop held in Yogyakarta in 2017. Out of the 46 people we invited, 28 participated in the workshop. They were mainly from West and Central Java, which are both the primary agricultural production areas in Indonesia and areas which have played an essential role in the historical development of OF, as mentioned in Section 3. The participants came from diverse backgrounds (Table 1). They were identified based on academic papers and grey literature on Indonesian OF and an explorative study conducted in the two study areas before the workshop. Besides, they were selected based on their various forms of involvement in OF. For example, we invited extension workers and staff of the department of agriculture as they monitor and implement OF programs. We also invited NGOs and activists who conduct OF training, thus, are involved in spreading OF knowledge and values. To understand the trade and marketing aspect of OF, we invited organic traders. These categories are based on self-identification.

Table 1. The participants of the workshop from Central and West Java.

Origin Affiliation	Academic	Government Official	Activist	Organic Farmer	NGO	Organic Traders	Total
Central Java	3	2	3	2	3	2	15
West Java	7	2		1	2	1	13

Net-Map is an interview-based mapping tool for visualizing networks that can help people understand, discuss, and improve situations in which different actors can influence outcomes (Schiffer 2007). This method is based on SNA and was developed to address some of the shortcomings of SNA data collection, particularly the interviewees' lack of learning opportunities (Schiffer and Hauck 2010). The Net-Map method encourages participants in the process to discuss and interpret the networks among themselves (ibid.). This method is suitable for application in a variety of intercultural settings and different purposes because of the use of low-tech and low-cost materials and the discussion on the properties of the networks in concrete terms (Birner et al. 2010; Schiffer and Hauck 2010; Campbell et al. 2013; Schöley and Padmanabhan 2016). However, the limitations of the method are the numbers of links can become unmanageably large when working with a large or not very well-defined group of actors and the influence of more powerful actors is a potential source of bias as actors perceived as non-influential might be excluded from expressing their views (Schiffer and Hauck 2010). To overcome the power dynamics among workshop participants, we assigned two facilitators, who can interfere when some participants dominated the discussion, for each group.

The procedure of the workshop is as follows. First, two facilitators familiar with the method divided the participants into two equally sized groups. Each group worked on a large table around which they moved freely. Second, we asked participants, "Who are the important players that can influence organic farming?". We asked the participants to list influential actors and assign them, based on their interpretation, to one of four categories of actors: Non-Governmental Organization (NGO), private sector, government, and community. The names of actors were written on colored cards and placed on the tables. The colors of the cards indicate different categories. Third, we explained to the participants how to describe the links and the direction of the links between actors. We specified four types of links: information or knowledge, marketing channel, agricultural inputs (fertilizer, pesticide, and financial support), and seeds or animals. Participants drew arrows that indicated the links and direction of the links using markers of different colors to connect pairs of actors. Fourth, participants built 'influence towers' by placing plastic cups on the card representing each actor. The height of the tower corresponds to the actor's degree of influence in the networks. Due to time constraints and mental fatigue among the participants, we did not implement the last step of the Net-Map method, which deals with strategizing. In the strategizing step, interviewees are asked to provide actors' perceived goals, which can assist them in deciding on potential collaborations or conflicts that might arise from interacting with particular actors. Finally, Net-Map visualizations of Figures 2–4 were created using Data Muse, open-source software for network visualization and network data analysis[6]. We inputted data for network visualization based on the photographs of the two networks produced at the workshop. The degree of centrality is calculated by Data Muse according to the number of links of an actor divided by the number of links of an actor with the greatest number of links in the network (Freeman 1978). The maximum value is 1, which indicates the greatest number of links an actor has, and the minimum value is 0, which stipulates no link an actor has in a network. Betweenness centrality is calculated according to the sum of the fraction of all-pairs' shortest paths that pass through a node. The betweenness centrality of a node v, for example, follows this formula:

$$C_B(\mathrm{v}) = \sum_{\mathrm{s,t} \in \mathrm{V}} \frac{\sigma(\mathrm{s,t}|\mathrm{v})}{\sigma(\mathrm{s,t})}$$

[6] https://www.datamuse.io/network/login.php#.

where V is the set of nodes, σ (s,t) is the number of shortest (s,t)-paths, and σ (s,t|v) is the number of those paths passing through node v (Brandes 2008). The maximum value is 1, and the minimum value is 0. An actor with the highest degree of betweenness is on the closest links between other actors, so that the actor can control flows in a network. The visualized social networks were supplemented with qualitative analysis of audio recording of the group discussions and information obtained from organizations' websites, booklets, publications, and policy documents.

The Net-Map method assisted us discover nuanced interpretations of the social networks constructed by the workshop participants, which would otherwise not be revealed by the survey method. For instance, the local organic market community is connected to other actors mostly through knowledge/information transfer, since the term market is not limited to a place for selling organic products but also for exchange of ideas, as one participant explained (Section 5). Despite this advantage, there were some problems and limitations in implementating the research method, out of which are related to the points elaborated by Schiffer and Hauck (2010). First, the way the workshop was organized was a potential source of bias in the results. We selected and invited the workshop participants based on our judgment of their knowledge of OF and influence in OF. This selection may have favored certain forms of knowledge or opinions and excluded others. Moreover, the two groups were also formed based on self-selection by participants. To the extent that group formation was based on familiarity among the participants, this could have influenced the discussions' dynamic. In any case, it should be borne in mind that the workshop results provide a snapshot of interactions among a selected group of actors at a particular point in time. As elaborated in Section 6, OF situation in Indonesia is not static, and both actors and the institutional framework are changing and evolving.

Some possibly more fundamental limitations of the method were identified by the participants, who did not merely follow the Net-Map instructions but actively engaged in critical discussions and meaning-making as we proceeded. In particular, crucial discussions took place on the notion of "influence", which was considered ambiguous by the participants. They queried whether it was possible to assign values to the actors' influence based on their actions in the network and pointed out that "influence" was a shorthand term for a set of sometimes incomparable characteristics. For example, how could one compare the influence of organic farmers with that of the MoA? Besides, they maintained that a distinction should be made between "positive" and "negative" influence; however, an actor's judgment in this regard would depend on their positionality concerning the presence of other actors in the network. In other words, both the quantity and the quality of influence reflect the normative stances of actors. For instance, extension workers are influential as they provide technical knowledge and information on the government's programs for farmers. However, they may not be equally influential (quantity of influence) across different actors in the network. Moreover, different actors have different opinions about the standard and usefulness (quality of influence) of the advice they provide. This interpretation implies that, from individual actors' perspective, working closely with "influential" actors does not always help them achieve their goals. As mentioned by Schiffer and Hauck (2010), this issue arose from working with a not so well-defined group of participants, where each individual can have conflicting goals.

However, these critical discussions among participants illustrate one of the strengths of Net-Map. They show the advantages of encouraging participants' active engagement in critically reflecting on and analyzing their positionality concerning other stakeholders in the networks, instead of leaving this analysis to the researchers alone.

5. Results—OF Actors and Links

Based on the two social networks produced during the workshop, we propose three categories of OF actors based on their different degree of engagement with the government, their positionalities in the network, and the interactions among them. We call these disengaged, partially engaged, and fully engaged groups.

5.1. The Disengaged Group

The disengaged group is characterized by the rejection of interaction with the government. This group is dominated by activists who were inspired by the early pioneers in Indonesian OF. For members of this group, the introduction of organic certification as specified by SNI 01-6729-2002 in 2002 was a decisive moment that altered the aims and the actions of OF as a social movement. In the discussions at the workshop, they expressed the view that the prohibitive cost of organic certificates perpetuates the injustice that prevails in conventional agriculture. This view is aligned with another study that argues for the democratization of third-party certification (Konefal and Hatanaka 2011). As mentioned in Section 1, OF was promoted by BSB and SPTN-HPS as a means of achieving both greater independence of farmers and environmental sustainability in farming. More recently, the introduction of OF certification, envisaged as a way to protect consumers, has raised awareness within the OF movement of the need to take consumers into account, a viewpoint supported by Joko[7], an organic activist, in the discussions at the workshop. However, one initial aim of the OF movement, that to a certain extent is still pursued by activists today, was to create a community. Community in this sense can be understood as a group of people with shared causes or interests, where the roles of those who identify with this group can be quite flexible and interchangeable. The actors in the disengaged group, including Joko, are (also) concerned that the development OF that seems to be following the blueprint of conventional farming towards greater engagement with agri-business:

> So I think it is important to be aware of the State's interpretation of OF, when we talk about Go Organic 2010 program. In the end the aim [of the government] is to develop organic fertilizer industry. (Interview, 9 December 2017)

According to this group, at first, the OF movement was primarily supported by NGOs, whereas it is now mainly driven by market demand. Actors in this group have to adjust to this recent development. They have to either submit to the demands of the market, setting their sights on organic certification and carving out a niche in the market, or to create an alternative system that focuses on the creation of community. This group is exemplified by the local organic market communities (komunitas pasar organik lokal), which are connected to private sector organizations (traders and distributors of organic products), NGOs, and other communities in the network. The term 'local organic market community' reflects the dual purpose of these organizations. As Joko, who was one of the initiators of the local organic market community in Central Java, explains:

> Actually this [local organic market community] can be considered as a community. It's called a market because it's a place where they [people] meet. I try to define them [local organic market community] so that there is an encounter [where people meet to exchange ideas]. (Interview, 9 December 2017)

Figure 2 shows the network connections of the organic market community in Central Java. This actor not only offers a physical space where transactions can take place, for example, as a place where non-corporate farmers (petani non-korporasi) can sell their produce, but also serves as a networking platform for other actors

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[7] All names in this paper are pseudonyms.

with shared concerns about OF (Figure 2). For instance, this actor shares knowledge on nutrition and healthy lifestyle to local consumers, transmits knowledge about agricultural technology to private sector actors, and participates in OF-related research with NGO actors.

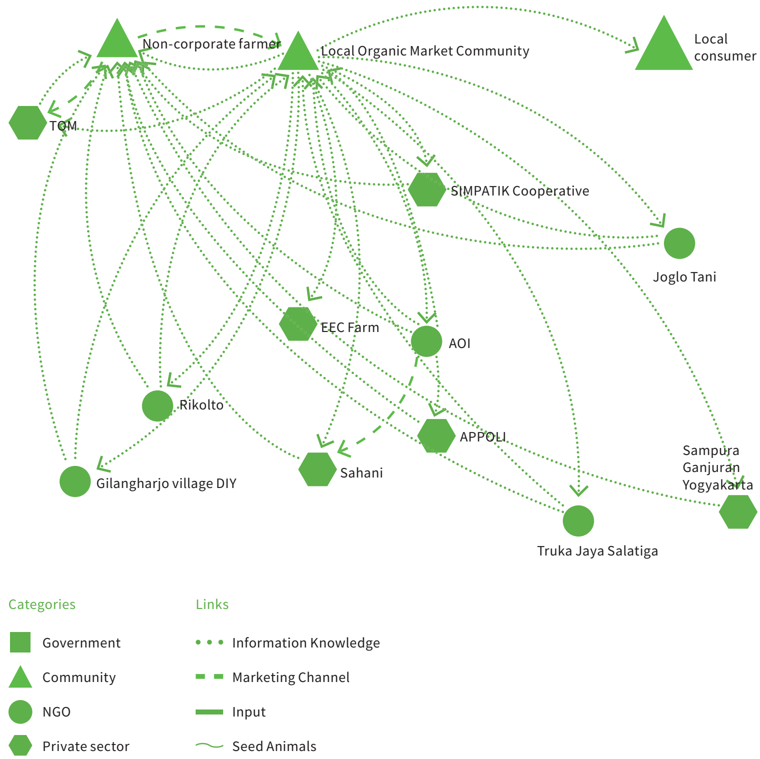

Figure 2. The network of the local organic market community in Central Java. The size of the sphere corresponds to the height of the influence tower (see the text for further explanation). Source: original data by authors.

As shown in Figure 2, this actor has no links with government actors, but numerous links to NGO actors as well as with private sector organizations (degree of centrality score 0.55). In most cases, the links consist of exchanges of information. Apart from providing a market for goods produced by non-corporate farmers, there are no physical exchanges (e.g., of seeds or other inputs) in this network. Another notable feature of the network is the low degree of betweenness centrality (with a score of 0.01); thus, this actor does not facilitate the flow of information between other, otherwise unconnected actors. According to the workshop participants, in this particular network, local consumers have the most influence and non-corporate farmers together with the local organic market community have the least.

5.2. The Partially Engaged Group

The actors who belong to this group are characterized by their strategic adaptation to the government regulations, while retaining certain aspects of OF as a social movement, especially regarding the issue of farmers' independence from the current system of conventional agriculture. They interact with government actors, for example, by accepting government support, as long as this helps them to advance their goals. However, participants at the workshop commented that they are wary of accepting financial support, as this tends to provoke conflict, whereas technological support can be useful. One member of this group, SPTN-HPS, one of the early pioneers of OF in Java (see Section 3), has the degree of centrality score 1.0, with links to all four categories of actors (Figure 3). The majority of links are for knowledge and information transfer, but SPTN-HPS is also connected to other actors through the exchange of agricultural and/or financial inputs and seeds. In these relationships, SPTN-HPS tends to be the provider of information and knowledge to other actors, including other NGOs working on OF-related issues, retailers, village officials, and communities. In addition, SPTN-HPS distributes or sells seeds and animals to both community-based seed banks and distributors of organic products. SPTN-HPS also works directly with village officials to promote the benefits and importance of OF for village development. It, thus, collaborates with government at the level of the administrative units that have direct interactions with farmers as farmlands are predominantly located in rural Indonesia. As a result of decentralization, village governors control significant resources (the so-called village funds) and can influence the direction of agricultural development of the areas they represent. Among the NGOs and communities in Central Java with links to SPTN-HPS are the Young Farmers School (Sekti Muda) and Mursyidul Hadi Islamic boarding school. These two platforms are used by some farmer activists, for example, those who are part of the Indonesian Peasant Union (SPI), to promote OF as part of a strategy to develop young activists and as the starting point for building a grassroots agrarian movement. Totok, who is a former extension worker and is a representative of SPI in Central Java, further explains:

> The Village government is more important [than provincial government], especially after the Village Law was passed, they can use village funds to empower [the villagers]. I have observed several places where OF was developed together with the village governments, because they can take

decisions on their own. In this situation the position of village government is more important than the district government. (Interview, 9 December 2017)

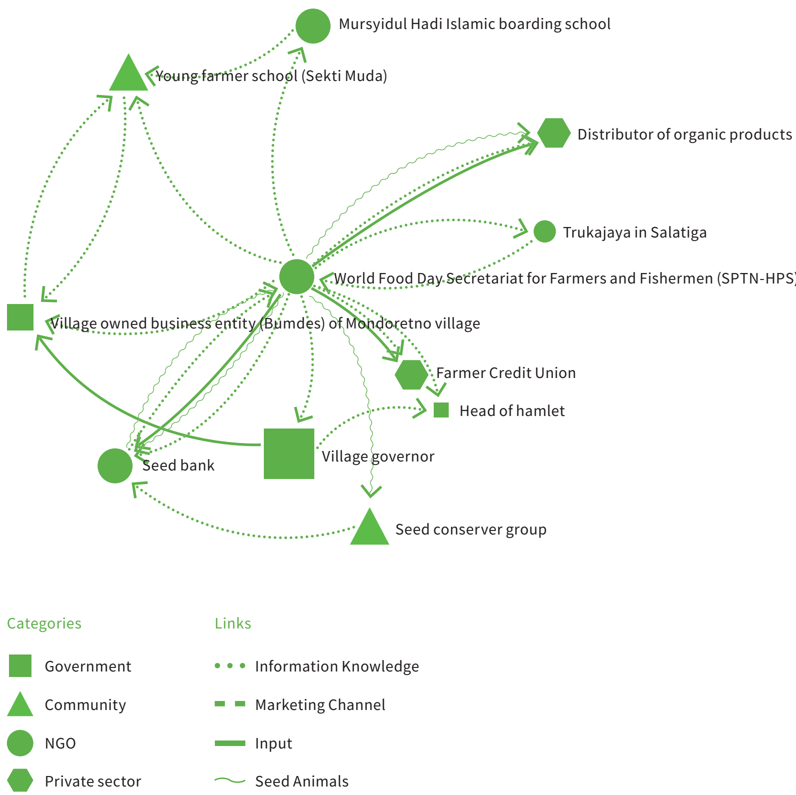

Figure 3. The network of the World Food Day Secretariat for Farmers and Fishermen (SPTN-HPS). The size of the sphere corresponds to the height of the influence tower. Source: original data by authors.

The above statement is illustrated in Figure 3 by the fact that participants in the workshop considered that the village governor had the highest degree of influence in this network. SPTN-HPS has the highest degree of betweenness centrality (score 0.36) in the network, which indicates its important role in the network as a facilitator of information flows between actors that otherwise would not be connected. Due to their influence and centrality in the network, partially engaged actors have the opportunity to disseminate the holistic principles of the OF movement while simultaneously promoting alternative OF systems that are distinct from the government's approach to

OF. Therefore, they are able to operate on two fronts, cooperating with government to promote OF and simultaneously creating an alternative system where they disagree with the government's actions. In this sense, they can influence the government's approach by exchanging information with government actors who share their interest in promoting OF.

5.3. The Fully Engaged Group

In this group, OF actors are characterized by their adaption to the current OF regulations. They generally have links with government agencies, other communities, and actors in the private sector, but no links with NGO actors. They adhere to the status quo and, to the extent that they are successful, provide a justification for the government approach to OF that focuses on building consumer–producer relationships. The creation of a legal framework for OF, with definitions and standards, has allowed actors who do not necessarily identify themselves as belonging to the organic movement to partake in the OF system. In this context, the OF system can be understood as a mechanism for the trade of organic products as premium agricultural products, which protects both consumers and producers from misinformation or fraud through third-party certification as set out in SNI 2016 (BSN 2016). One example of an actor in this group is the farmers' association Gapoktan (Gabungan Kelompok Tani). This is a federation of farmer groups in hamlets that operates at the village level (see Figure 1). In Indonesian agriculture, farmer groups are an official channel for the distribution and dissemination of agricultural subsidies and technical support. Therefore, only farmers who join farmer groups can access government support, though exceptions might exist.

Gapoktan maintains connections with government agencies and other government-sponsored groups with connections to agriculture. Government officials, for instance, public sector employees, often source organic products from farmers, either through formal channels as part of a policy or informally through personal contacts. In Figure 4, these links are observed in the form of inflows of knowledge and information from government actors, such as the regency-level department of agriculture and MoA extension workers. In addition, Gapoktan has a trading relation with the regency-level department of trade, which acts as a trading channel between farmers and customers. Totok, a former extension worker, explains how this works:

> So usually farmer groups [in hamlets] focus more on the technical aspect on the field. Meanwhile, Gapoktan focuses more on administrative issues, for example in connecting them [farmers in farmer groups] with the

government which is one administrative level above [hamlet]. (Interview, 9 December 2017)

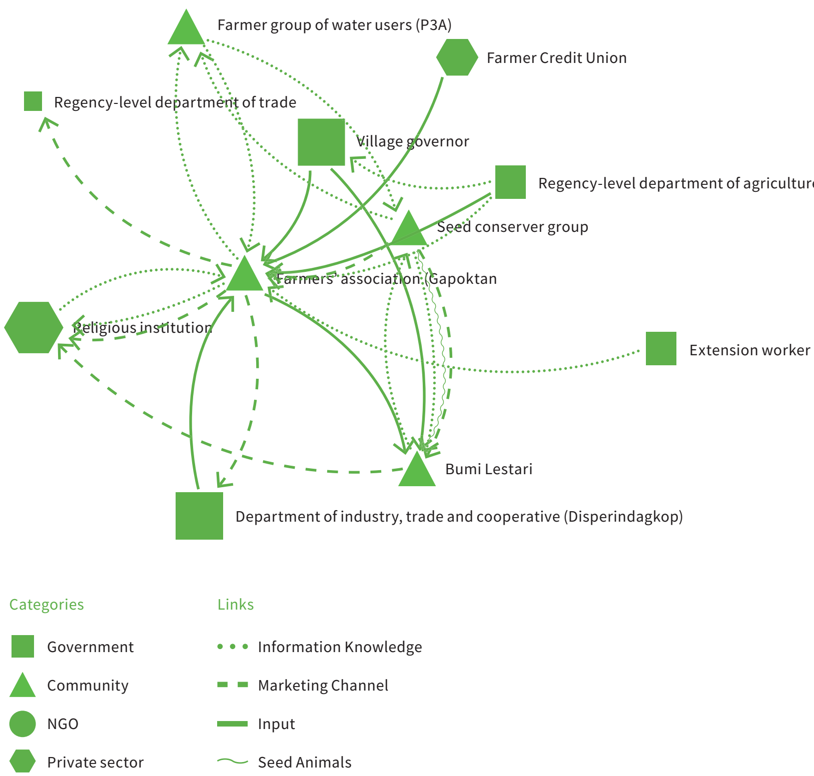

Figure 4. The network of the association of farmers group (Gapoktan). The size of the sphere corresponds to the height of influence tower. Source: original data by authors.

In the network, Gapoktan is connected to other government-sponsored groups, such as Bumi Lestari which is a women's farmer group (KWT) and a farmers' group of water users (P3A) that is responsible for the construction of irrigation channels and drains in and around agricultural fields. These links take the form of exchange of information about government programs and/or distribution of agricultural inputs and financial support. Gapoktan has the second highest score for the degree of centrality (0.89) and a relatively equal number of outflow and inflow links, reflecting its influence in the OF network. It was perceived as influential in the network by the participants, though with a lower degree of influence than village governor. This is probably an indication of Gapoktan's dependence on support from government agencies, as mentioned above. However, Gapoktan's relatively low value of betweenness centrality (0.14) indicates that it does not play an important role as a bridge between actors which otherwise are not connected.

6. Discussion—OF Institutions in Indonesia and Future Implications

In this section, we argue that understanding the emergence of OF institutions, through an analysis of the characteristics of the social networks of OF actors and their relations with the historical development of conventional agriculture, can assist in understanding how the future development and sustainability of OF are perceived and constructed by the related actors. Understanding the interplay between OF as a state policy and as a social movement is crucial for projecting the future trajectory of OF (Michelsen 2001a; Lynggaard 2001).

As mentioned above, since the early 2000s, the MoA has introduced a number of regulations and programs that define, standardize, and set the agenda for Indonesian OF. The Indonesian Standard SNI 6729:2016 on organic farming systems states that one of the aims of OF is to create agriculture that is socially, ecologically, economically, and ethically sustainable (BSN 2016). In addition, organic farming is framed as a strategy for environmental conservation. This approach by the MoA seems to adhere to the OF principles set out by IFOAM and, in Indonesia, the Ganjuran Declaration. Simultaneously, the aim of this national standard to protect consumers and producers of organic products from misinformation (BSN 2016), in a sense, defines OF as a market relationship, distinguishing the different roles of consumers, producers and distributors. This market-based approach has transformed Indonesian OF, which is rooted in the social movements that operated at the grassroots level and emphasized community building. Moreover, closer scrutiny of this policy document reveals that the majority of the information it contains is related to technical aspects in OF, such as the requirement for barriers around organic farms, lists of permitted and prohibited inputs, the conversion period from conventional to organic farming, and other technical measures (BSN 2002; BSN 2016). Therefore, the state has been developing OF following the narrative of sustainable development as ecological modernization, where the invention of environmentally benign technology in OF goes hand-in-hand with economic growth (Nightingale et al. 2019b). Despite the state's recognition of the importance of social, economic, and ethical aspects in OF, they receive much less attention.

Furthermore, the focus on national programs to promote OF recalls the productivist, top-down approach of policies for conventional agriculture, which leads to farmers' dependence on the state. For instance, the targets of the "1000 Organic Village" program are to be achieved through the top-down distribution of agricultural inputs, knowledge transfer, and financial and institutional support for organic certification (Plantation General Directorate of the Ministry of Agriculture 2016). This program views OF as part of the national food sovereignty agenda that leads to food security, an overarching strategic aim of agricultural policy in Indonesia (Neilson and Wright 2017; Schreer and Padmanabhan 2019). On the one hand, the state's orientation in developing OF is technically measurable, for example, through the number of certified organic farms, size of market share, and consumption and production of organic products. In principal, these indicators can be used to assess the sustainability of OF. On the other hand, the diversity of strategies, values, and goals upheld by various OF actors question the extent in which the state's approach contributes to the future sustainability of OF. Moreover, OF is still embedded within the governance of conventional farming (see Figure 1), whereby government agencies take dual roles in developing both organic and conventional farming. Contrary to the European case, where the EU as a supranational entity pushed for the formulation of national OF policies (Slavova et al. 2017), in Indonesia, OF policies emerged from the dominant role played by a national government that views conventional farming and OF as two systems that are not necessarily contradictory, but should be able to exist in parallel and operate side by side.

The need to respond to these inconsistencies in government policy has led to the emergence of three categories of actors within OF social networks. The disengaged group is characterized by its association with the organic movement and its critical attitude towards the government; members of this group have no links with any government actors, as shown in the example of the local organic market community. In particular, they criticize the dilution of OF principles through the focus on standardization and technical definitions, the realignment of OF from community building towards market relationships, and justice issues related to the industrialization of OF, for example, through mechanization and the focus on input substitution (Goodman et al. 1987). They believe that in all these respects, the government's approach to OF perpetuates the existing shortcomings of conventional agriculture. These limitations restrict farmers' initiatives when selecting which farming practices to adopt. They increase the dependency of organic farmers on the state and on policies adapted to the needs of industrialized agriculture—despite the fact that almost two-thirds of farmers in Indonesia are smallholders (Aji et al. 2019; BPS 2018). Therefore, actors in this group consider sustainability in OF should constitute a justice dimension where means of production are not controlled by those who are not directly involved in farming, but rather more independence among farmers in deciding how and what to grow and where to sell. However, actors in the disengaged group do not express their criticisms by advocating for policy changes — as does the Soil Association in the UK, for example (Conford 2001). Instead, they adapt to the policy environment by engaging with retailers directly, while maintaining connections with the NGOs that pioneered OF in Indonesia as a way of upholding the foundational principles of the organic movement. The actors in this group operate in a close-knit network characterized by a large number of links with other actors and low values of betweenness centrality. It should be noted that, in the context of national regulations, which were created to facilitate the trade of organic products, these alternative community-based organic markets are, in principal, illegal (Aistara 2015). While at present, this remains largely a technicality, this legal issue might become a serious problem in the near future if the government increases the monitoring of trade in organic products, or if the definition of 'organic' is made even stricter.

The second group that we identify is the partially engaged group, which is connected both to the OF movement and the conventional agricultural sector, and strategically adapts to the ongoing changes in state policies by maintaining links with government actors. One example is SPTN-HPS, which is one of the organic pioneers in Central Java and was originally supported by the Catholic Church. In the social network, they still maintain this connection with religious institutions, with whom, they exchange information on the philosophy and technical aspects of OF. They also play a supporting role in government-sponsored OF projects, for instance, by offering advice and training to farmers and village governors. The role of SPTN-HPS in promoting OF in government projects might reflect its credibility among government actors, derived from its status as a pioneer of the organic movement. In the network, SPTN-HPS is a central actor given by its high degree of centrality and its links with all four categories of actors. Nevertheless, after their funding from Catholic social and development organizations ended in 2009, SPTN-HPS has been struggling to adapt to changes in OF, as the priorities of organic farmers have shifted, to a certain extent at least, from building a social movement to obtaining certification and markets for their products (Tamtomo forthcoming). The challenge that SPTN-HPS has been facing, could be argued, is connected to the radical aspect of the OF movement that insists on the independence of OF practice from the state and market (Tovey 1997).

One issue on which SPTN-HPS and other members of the partially engaged group, for instance, Sekti Muda and Mursyidul Hadi Islamic boarding school, takes a firm stance is food sovereignty, particularly seed sovereignty, which is defined as farmers' rights to access, reproduce, and save seeds (Kloppenburg 2010). There is insufficient clarity in OF regulations on the issue of what constitutes organic seeds (BSN 2016), while Law No.12/1992, the Plant Cultivation System in Indonesia, makes it illegal for farmers to use non-state-registered seeds (President of the Republic of Indonesia 1992). Thus, organic farmers are liable to be prosecuted for attempting to become more independent by storing and using their own seeds, even though, simultaneously, the state encourages the use of local resources in OF (BSN 2016). Similar to the actors in the disengaged group, the justice aspect in OF is paramount for the sustainability of OF according to them. To address this problem, actors who belong to the partially engaged group consider OF as an entry point for engaging in the critical discussion of the current agricultural system with the young people. They also attempt to take advantage of current decentralized governance structures, using village funds as a resource for developing OF from the bottom-up in a way that engages with the aspirations of farmers.

Decentralization was a significant milestone in the governance of agriculture following the fall of President Suharto in 1998, as mentioned in Section 2. The shift in political power and control over budgets allowed government officials to pursue regional interests (Nordholt 2012; Mietzner 2013; Nasution 2016). In a conversation with Eka Herdiana, a government official at the department of agriculture of Tasikmalaya regency, on December 8 2017, he stated that the regency of Tasikmalaya in West Java decided to emphasize the production of organic rice and this is reflected in the provincial government's budget and active support provided for marketing. In addition, the enactment of Village Law (No 6/2014) gave villages a voice in how village funds were used, and thereby increasing their participation in influencing agricultural development at the village level (Vel and Bedner 2015). Therefore, village-level governance could be a platform where farmers, local grassroots OF movements, and the government meet. Nevertheless, a large proportion of the village development budget originates and requires approval from the central government, and this limits the autonomy that villages have for bottom-up agricultural development (Green 2005). In addition, continuation in village development priorities could also be an issue, as village head is a political position, so that the agenda between village head candidates might differ. Despite competition between government officials at different administrative levels for the exploitation of natural resources and the cases of funds mismanagement in the decentralization process in Indonesia (Tsing 2003; Fox et al. 2005), according to the actors in the partially engaged group, village governments remain important potential cooperation partners, since agricultural areas are mostly located in rural areas. Therefore, on the one hand, the current technocratic and market-driven government policy restricts local OF initiatives; on the other hand, the decision-making process in decentralization offers OF actors the opportunity to influence policy-making and its implementation at local level.

As described above, the disengaged and partially engaged groups adopt different strategies to reconcile the convictions of OF pioneers with government policies and, it could be argued, to overcome the negative stigma previously attached to OF movements (Lähdesmäki et al. 2019). By contrast, there are some actors who make use of the legal framework for OF (i.e., third-party certification and OF standards) as an entry point into the organic market, but do not consider themselves to be part of the organic movement. These actors belong to what we identify as the fully engaged group. In principal, their notion of sustainability is similar to the national government, where OF provides better economic opportunity for farmers in the future. Within the group, the farmers' association Gapoktan is influential in terms of the number of network links to other actors, with whom it exchanges information, agricultural inputs, and seeds. However, similar to the local organic market community, Gapoktan exhibits a low degree of betweenness centrality, which suggests limitations to its influence in the network. Unlike many members of the partially engaged group and all members of the disengaged group, members of the fully engaged group do not consider OF as being opposed to conventional farming, and thereby maintain their dependence on government support for both the production and marketing of organic food products.

7. Policy Implications

We agree that sustainability as a concept loses its analytical rigor when it is used uncritically. The explicit accounts on actors who define it and its definition are prerequisites to address the sustainability of OF. Institutional analysis at the meso level that focuses on the governance of OF highlights the contradiction between centralized governance structures in the agricultural sector and the government's stance that OF should prioritize the use of locally available resources and knowledge. This characteristic can compromise the potential of OF to address the shortcomings in the current agricultural sector, as described above. Institutional analysis at the micro level that focuses on the social networks of organic actors elaborates the multiplicity of perceptions, positionalities, and rationales enacted by different actors. In the context of the pervasive influence of the Indonesian state in regulating OF, our analysis showcases the different strategies based on different degrees and types of interactions between non- and governmental actors. According to this two-level analysis, different notions of sustainability of OF are enacted by different actors. Particular narratives refer to either the justice aspect in sustainability related to the access and control over OF practices promoted by OF activists or on the ecological modernization promoted by the state. Given the influence of non-governmental actors in the networks, the social justice narrative cannot simply be subsumed under the market creation and technological fix narratives. Therefore, the institutionalization of OF in Indonesia, which is illustrated by the creation of OF policies and standards as we argued above, does not completely push the practices and views of OF as social movement to the margin as also pointed out by Edwards (2013). Our findings support the argument that to make progress in SDGs, the implementation and formulation of policies in sustainable agriculture depend on "societal debates and social movements that apply pressure to governments and institutions" (Eyhorn et al. 2019, p. 254).

Despite the existing tensions, we argue there are spaces for negotiation between the civil society and government, which could potentially lead to the formulation of more coherent OF policies that can accommodate the diversity of goals and strategies among OF actors. One option would be to explore the alternative decision-making mechanisms available in the context of decentralization. The aim should be, for each type of decision, to identify the appropriate decision-making administrative level, so that decisions take account of the interests and perspectives of individual actors and help them achieve their goals. Secondly, as farmlands are predominantly located in rural Indonesia, cooperation and coordination between the MoA and the Ministry of Village could help facilitate OF development in a way that captures the aspirations of farmers. Further study of the relation between village governance and OF institutions could contribute to the future development of OF in a form that is not only more inclusive and locally-driven, but also in alignment with current government OF policy, wider sustainable development goals, and the commitment to decentralization.

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Appendix A

Figure A1. The social network that was drawn by participants of group 1 in the workshop.

Figure A2. The social network that was drawn by participants of group 2 in the workshop.

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Biotechnology, Bioeconomy, and Sustainable Life on Land

Justus Wesseler and David Zilberman

1. Introduction

Sustainable Life on Land depends on what people want. Some people have a preference for food products labelled as "organic", while others pay more attention to food attributes (e.g., freshness, country of origin, regionality). Yet for others, food itself is less important than the social aspects of food consumption. Moreover, the cares and concerns that people have are not limited to food. They also care about their family and friends, their work, their social life, and their leisure activities, among many other aspects of life. Their wants and choices are shaped by cultural factors, income, and available time, as well as by the places in which they are raised and choose to live. Their preferences are also influenced by local, regional, national, and international policies, over which they are also willing and able to exercise a certain level of influence (Banerjee and Duflo 2019). All of these factors have an impact on the allocation of aggregate-level natural resources—including land—over time and space. These allocations are not static, and they are likely to change in response to changes in relative prices resulting from new information, as is the case with technological changes generating new information induced by knowledge and ideas generated at home and abroad. The reallocation of natural resources over time and space can be understood as a stochastic process with variations around a trend, with new information inducing changes in both trends and the variations surrounding them. The net present value of this process expresses the value of natural resources by assigning a state-dependent and time-dependent price measured by the owner's opportunity costs for each resource (Zilberman et al. 2018). This can also be calculated at an aggregate level for a sector. An increase in net present value is generally understood to improve sustainability (Arrow et al. 2012) and hence, contribute to the sustainable use of terrestrial ecosystems (SDG 15), but also to SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture). El-Chichakli et al. (2016) have pointed out the importance of innovation in the bioeconomy for reaching SDG 15 and in particular, from advancements in plant breeding. The approach also indicates that a positive contribution will not necessarily always be the case. As opportunity costs need to be considered, tradeoffs—but also synergies—with other SDGs are possible. Ronzon and Sanjuán (2020) assessed the EU Bioeconomy Strategy and already identified a number of potential links with 53 targets distributed over 12 of the 17 SDGs. A positive synergy has been identified with respect to SDG 7, SDG 11, and SDG 15, while a negative one has with SDG 2, SDG 8, and SDG 12.

The generation of new ideas can have an important effect on the allocation of resources, and thus, on trends and variations around them. The importance of these effects has increased when responding to climate change (SDG 13), population growth (Jatana and Currie 2020), and the associated increase in the demand for food, all of which pose challenges to the sustainability of continuing "business as usual". It has been estimated that the agricultural sector alone contributes about 37% to current greenhouse gas emissions, and this contribution is expected to increase to between 47% and 60% by 2050 (SAPEA 2020). Based on projected population growth through to 2050, an increase of about 35% in agricultural production is expected to be needed in order to maintain current consumption levels. Some estimates are even higher (SAPEA 2020).

Achieving such an increase in productivity will pose a challenge in light of climate change and in reaching SDG 15. Cost-effective compliance with the objective of the Paris Agreement (a warming limit of 1.5 °C) will require large-scale land-based mitigation strategies involving bioenergy production and afforestation, which will result in higher food prices (VanMeijl et al. 2018). Compensating for the increase in food prices will require either further increases in productivity and/or a reduction in meat consumption (Doelman et al. 2019). The magnitude of the changes in agricultural productivity and meat consumption that will be required differs widely, depending on the model used and the assumptions made (Rosenzweig et al. 2014; VanMeijl et al. 2018).

In this contribution, we review and discuss recent technical changes in the field of biotechnology from an economic perspective and how they can help to cope with increasing food demand while also contributing to the sustainability of life on land. We pay particular attention to the ways in which these technical changes will be affected by policies at the national and international level.

In the next section, we provide a brief overview of recent historical developments in the political economy of biotechnology and discuss recent major developments and their implications for sustainable life on land. This is followed by Section 3, which focuses on the importance of supply-chain design, and then by Section 4, which addresses the policy dimension. We conclude (Section 5) by mentioning options for policy changes that could enhance the sustainability of life on land.

2. Brief History of Modern Biotechnology, Including Recent Developments

The field of modern biotechnology originated with the development of dDNA technology in the mid-1970s. Early applications were made in various fields, including the pharmaceutical and food-processing sectors. Applications with direct land-use implications began with the development of seeds for plants that can express toxins to protect themselves against pests, as well as for plants that were resistant to broadband herbicides. These traits have since been introduced into major crops, including corn, cotton, canola, soybeans, and sugar beet (ISAAA 2018). These crops are cultivated primarily in the United States and Canada, Brazil and Argentina, China, India, and a few other countries (Brookes and Barfoot 2020b). In recent years, insect-resistant eggplants have been introduced in Bangladesh. Another noteworthy application involves the cultivation of papayas that are resistant to ringspot virus in Hawaii. These crops are often summarized under the term "genetically modified organisms" (GMOs), a legal term used in the European Union (Eriksson et al. 2019).

Several meta-studies have pointed to an average increase in yield, a substantial reduction in the use of herbicides and pesticides, and a substantial reduction in greenhouse gas emissions (Brookes and Barfoot 2020a, 2020b; Klümper and Qaim 2014; Finger et al. 2011; Barrows et al. 2014a, 2014b). The increase in the productivity of land has reduced the pressure on land use. Other countries (e.g., Brazil, Argentina) have also experienced an increase in double-cropping (Zallesa et al. 2019; Trigo and Cap 2006). Brookes and Barfoot (2020a) report an aggregate reduction of 775.4 million kg in pesticide use and a reduction of 2.456 million tons CO_2 emissions over the period from 1996 to 2018, due to decreases in fuel consumption. These figures do not include reductions in greenhouse gas emissions resulting from changes in land use through the adoption of reduced-tillage systems, which can also be substantial. As reported by Smyth et al. (2011), emission savings from the adoption of reduced-tillage systems in Canada's production system for herbicide-resistant canola amounted to about 381,000 to 434,000 additional tons in 2006.

Recent progress in molecular biology has provided opportunities for increasing the scope of plant breeding. New plant-breeding technologies (NPBTs) reduce the time and costs required to develop new plants with traits that protect them against a number of abiotic and biotic stressors, including drought tolerance, pest and disease resistance, and increased efficiency in the use of plant nutrients (Nationale Akademie der Wissenschaften Leopoldina, Deutsche Forschungsgemeinschaft und Union der deutschen Akademien der Wissenschaften 2019). An overview of applications in plant breeding is provided in Table 1. Many more are under development. Such developments can be expected to generate further increases in land productivity, to enhance preparations to counteract the adverse effects of climate change, and to reduce the quantity of pesticides and inorganic fertilizer applied. Taken together, these developments will increase the sustainability of agriculture production and land use by reducing emissions and the pressure on terrestrial ecosystems (Barrows et al. 2014a). Nevertheless, the judgment of the Court of Justice of the European Union (CJEU) in 2018 on the legal treatment of crops developed by using mutagenesis has been interpreted as subjecting crops developed by new plant breeding technologies to the specific EU regulations on GMOs (Purnhagen 2019). This implies that crops developed by those technologies have to follow a lengthy, costly, and unpredictable approval process (Purnhagen and Wesseler 2019; Smart et al. 2017).

New developments in modern biotechnology are not limited to plant production. They have implications for food consumption in general (Tilman and Clark 2014). Advances in biotechnology are being used to grow meat, not only by raising farm animals, but also by growing meat from stem cells in laboratories—a procedure known as "cultured meat" or "clean meat" (Dance 2017). The expectation is that fewer inputs will be needed to grow meat from cell cultures. This is a reasonable expectation, given that the energy needed to keep an animal alive (e.g., for growing a heart, liver, and other body parts) will not be needed, and less land will be required for producing the energy (e.g., in the form of feed and fodder). While the energy use per 1000 kg of cultured meat is comparable to that of beef, the land use and greenhouse gas emissions are more than 10 times less (Dance 2017). Several companies have invested in these technologies, and progress has been made, but it will be many years before the results will reach the market (Thorrez and Vandenburgh 2019). They are nevertheless quite promising from the perspective of both sustainable land use and animal welfare.

Table 1. Current and Potential Applications of new plant-breeding technologies (NPBTs) in Agriculture (Examples).

Plant	Trait
Improved food and feed quality	
Alfalfa	Reduced lignin content
Camelina	Improved fatty-acid composition
Lettuce	Increased Vitamin C content
Potato	Reduced acrylamide formation
Oilseed rape	Improved fatty-acid composition
Soybean	Improved fatty-acid composition
Wheat	Low gluten content
	Improved fiber content
Improved agronomic properties	
Banana	Fungus resistance
Cassava	Virus resistance
Cherry	Virus resistance
Cocoa	Fungus resistance
Flax	Herbicide tolerance
Corn	Drought tolerance
	Fungus resistance
Oilseed Rape	Disease tolerance
	Herbicide tolerance
	Shatter tolerance
Rice	Fungus resistances
	Herbicide tolerance
	Salt tolerance
Soybean	Drought tolerance
Tomato	Bacterial resistance
Wheat	Fungus resistance

Source: adopted from Purnhagen and Wesseler (2020).

Similarly, a number of plant-based meat alternatives are under development, and some have already reached the market. This reduces the amount of land required for final consumer products by substituting plant-based consumer goods for animal-based products by a factor of four or more (STATISTA 2020a). As reported by Curtain and Grafenauer (2019), more than 4400 meat-substitute products were registered worldwide as of 2015, and the market is approaching a value of several billion dollars (King and Lawrence 2019). In addition to its potential to reduce greenhouse gas emissions relative to equivalent meat products (STATISTA 2020b), meat alternatives are expected to enhance human health by reducing the over-consumption of meat (Willett et al. 2019).

Another development involves the production of insect-based protein. This is accomplished either by raising insects directly for human consumption or by converting maggots into protein—either for human consumption or for use as a protein for animal feed (Pippinato et al. 2020). Insects have a much higher conversion rate. Some can be raised on food waste, thereby increasing the circularity of the food system. The production of protein from insects requires less land, as maggots can grow in chambers, requiring much less space per unit of protein. As reported by Akhtar and Isman (2018), compared to the amount of resources required to produce one kilogram of protein from mealworms, beef protein requires more than 100 times more land, more than 150 times more energy, and more than 110 times more water, in addition to producing at least 50 times more emissions of greenhouse gases. The major markets for insect-based protein production are in the Asia Pacific regions, with an expected value of USD 476.9 million for 2018, followed by Europe, with a market value of USD 216.5 million. The insect protein market in the United States is exhibiting the largest compound annual growth rate—about 28% for 2018–2023—followed closely by Europe, with an annual growth of 26% (STATISTA 2020c).

A fourth development that is increasing the sustainable intensity of agriculture per unit of land is the indoor production of vegetables through closed systems or indoor farming. These techniques also enhance the efficiency of water usage, in addition to requiring almost no pesticides and nearly eliminating nutrient emissions into the environment. Indoor vegetable farming increases yields by a factor of 10, relative to outdoor farming (STATISTA 2020b). The use of LED technology to resolve one of the greatest challenges associated with indoor farming is expected to increase both yield and the adoption of the technology (Tibbetts 2019). The worldwide market is expected to increase by a factor of four, from about USD 4.4 billion in 2019 to about USD 15.7 billion in 2025 (STATISTA 2020b).

In yet another development, aquaculture production is increasingly shifting to closed production systems, thereby reducing pressure on coastal regions (e.g., mangrove forests) (Romano and Sinha 2020). Closed and semi-closed aquaculture systems, including recirculating aquaculture systems (RAS), are often combined with closed vegetable-production systems in "aquaponic systems". Although the market is still developing, further growth is expected to be strong in response to the "lighting revolution". The forecasted worldwide market value for 2022 is about USD 870.6 million (STATISTA 2020c). Overall, aquaculture production is expected to exceed capture-fishery production in quantitative terms by 2024 (OECD/FAO 2020), also supported by the recent developments in genetically engineered salmon (Van Eenennaam et al. 2021).

The five developments discussed above are moving food production closer to urban and peri-urban areas, with greater density per unit of land and less release of pollutants into the environment, including the emission of greenhouse gases. Each of these developments has the potential to achieve sustainable increases in food productivity. An overview of expected market values is provided in Table 2.

Table 2. Forecasted market values of sustainable intensification of food production systems.

Production System	Forecasted Market Value (in USD Million)	Year
Cultured meat [1]	214.00–593.00	2027–2032
Plant-based meat substitutes [2]	17,540.00	2022
Edible insects [2]	954.44	2022
Vertical farming [2]	15,700.00	2025
Aquaponic [2]	870.60	2022

Source: [1] MarketsandMarkets (2019), [2] STATISTA (2020a, 2020b, 2020c, 2020d, 2020e).

New developments are also relevant to parts of the bioeconomy that are involved with activities other than processing biomass into food and feed (as discussed above). The bioeconomy is viewed as part of a strategy aimed at sustainable development in general and, in particular, decarbonization and the transition from an economy that relies on non-renewable resources to one that relies heavily on renewable resources (EC 2018). The broad adoption of modern biotechnological solutions combined with taking advantage of new information technologies and applying precision agricultural techniques is expected to increase the input use efficiency of agriculture, in addition to enabling the farming of fine chemicals and biofuels (Zilberman 2014). Many countries have developed bioeconomic strategies involving such conversions, including the production of bioenergy (e.g., biofuels), the extraction of biopolymers for bio-based products (e.g., food wrappings), and the production of textiles and clothing, enzymes for detergents, and many more examples (Wesseler and von Braun 2017). The main expectation is that these developments will reduce the extraction of carbohydrates from fossil resources and contribute to the reduction of greenhouse gas emissions through product substitution. This strategy has received considerable attention in the European Union. Under the new green deal, the EU plans to mobilize investments amounting to about EUR one trillion to develop the EU bioeconomy (EC 2020). Several large biorefineries are under development for the production of bioenergy, bio-based chemicals, and enzymes. A report by Parisi (2018) lists 803 biorefineries, 507 of which produce bio-based chemicals, 363 produce liquid biofuels, and 141 bio-based composites and fibers (multi-product facilities are counted more than once). Germany has the highest number of small-scale biorefineries producing energy in the EU in the form of biogas. Further increases are expected for investments in biorefineries. The economic success of many biorefineries depends in large part on government support. The rise in biogas facilities in Germany was driven primarily by the fixed feed-in tariffs for transferring energy into the grid system, resulting in a substantial reduction in price uncertainty. The future development of smaller and larger scale biorefineries critically depends on government policies (Theuerl et al. 2019) and in particular, on access to advances in biotechnology (Purnhagen and Wesseler 2019).

The United States and Brazil have engaged in a massive effort to produce ethanol as a biofuel. These efforts include the production of ethanol from feed stocks (e.g., corn and sugar cane), as well as the production of second-generation biofuels from grasses (e.g., miscanthus and switchgrass), corn stover and bagasse, and various trees. The production of corn ethanol in the US originally caused a significant rise in food prices and required substantial subsidies. Learning by doing and economies of scale eventually reduced the costs of producing corn ethanol by 45% between 1983 and 2010, while the cost of producing sugar-cane ethanol declined by 75% between 1975 and 2010, thus making these biofuels much more competitive with fossil fuels. The fuel-blend restriction in the US limits the ethanol content of gasoline to 10%, while ethanol provides 30% of the fuel for gasoline cars in Brazil. Corn ethanol production has had less of an impact on land use than was feared. In particular, in 2014, the total crop acreage in the US was only 0.5% higher than it had been in 2008 (Khanna et al. 2021). Furthermore, the introduction of corn ethanol led to a modest reduction in greenhouse gas emissions, as compared to the gasoline it replaced (5–15%), while sugarcane ethanol reduced greenhouse gas emissions by as much as 70% (Hochman and Zilberman 2018). Second-generation biofuels are not yet competitive, especially due to the reduction in oil prices since 2014 and the increased economic viability of electric cars that rely on solar energy. Nevertheless, second-generation biofuels continue to be developed, utilizing recent advancements in biotechnology to target air travel, in which battery use is unlikely to be feasible (Debnath et al. 2019). More could have been achieved, but the use of flex-fuel vehicles in the United States and elsewhere is limited by the E85 refueling infrastructure (Kuby 2019).

Investments in the bioeconomy have not been undisputed. There has been an intense debate about food versus fuel. The conversion of crops that could have been used for food into fuel has been seen as morally unacceptable, given the high level of poverty observed in many regions of the world. This is a somewhat narrow view of the causes of poverty. Although access to food is obviously important, reducing the debate to the provision of food ignores the importance of purchasing power (Sen 1982). It can be extremely misleading to limit the understanding of purchasing power or income to food alone, as it depends on a variety of factors (Schmitt 1989; Acemoglu and Robinson 2012).

3. Developing Supply Chains

Many new technological developments in the bioeconomy require substantial investments, combined with a high level of uncertainty. The supply chains for many products are not yet developed, thus increasing the risk of an individual investor. Public–private partnerships and contracting sales along the supply chain have become important tools for developing new markets. This includes new bio-based products that are associated with positive relative carbon emissions and other environmental benefits (Rahmann et al. 2020).

The introduction of production standards and vertically integrated supply chains has created new market opportunities (Beckmann 2000). Vertical integration has allowed many farmers in Africa, Asia, and Latin America to benefit from export opportunities to the European Union and the United States. In many cases, this involves the export of high-value products, including the sourcing of aquaculture products or vegetables (Reardon and Zilberman 2018).

The development of vertically integrated supply chains has been supported by consumer demand, stakeholder groups, and government policies. The certification of timber products by the Forest Stewardship Council (FSC) has become an important tool for supporting sustainability (Degnet et al. 2020). The Rainforest Alliance and other groups support the production of soybeans without a direct link to the deforestation of the Amazonian rain forest. Other certification schemes support other forms of agriculture (including organic agriculture), with the aim of contributing to sustainable agriculture, resulting in an overall increase in vertical integration (Wesseler 2014). Although many of these initiatives are well-intentioned, their impact on sustainability has been questioned in some cases (Ghozzi et al. 2016).

4. The Political Economy of Biotechnology

Sustainable life on land depends largely on policies and institutions. Policies can directly increase or decrease the price of goods at home and abroad, thereby affecting the allocation of natural resources. In particular, the impact of environmental and food-safety policies on the allocation of natural resources and its related implications for sustainability have been discussed by academics at the level of policy (e.g., Eriksson et al. 2019; Paarlberg 2008).

Concerns about environmental health and food safety have led to the establishment of production standards including procedures, incentives, and regulations that constrain land use (Winston 2002). In general, these measures include a combination of ex ante regulations and ex post liability rules. Ex post liability is understood as liabilities faced by producers in case they do not comply with ex ante regulations. The dependent design of safety policies affects incentives for investment in new food-production technologies. The clarity, severity, and enforcement of safety policies vary across countries. In some countries, they provide clear investment guidance, and in others, they add a layer of uncertainty, possibly curtailing investments. In recent decades, safety policies have substantially increased in importance, becoming non-tariff barriers to trade (e.g., Felbermayr and Larch 2013).

As suggested by Arrow et al. (1996), cost–benefit analysis is crucial for guiding the establishment of safety guidelines. Such analyses require performing risk assessments to estimate the relationship between risks to humans, to the environment, and to human action under alternative regulations and conditions, in addition to evaluating the benefits that the regulations will have for various parties (Antle 1999). Safety regulations are based on tradeoffs. The introduction of transgenics in agriculture benefited the consumers and producers who adopted it. At the same time, it was costly to producers not adopting transgenics and to chemical manufacturers, due to reduced commodity prices. Overall, however, the introduction of transgenics increased social welfare, based on economic criteria (Hochman and Zilberman 2018). In addition to precise and efficient regulations, the implementation of effective safety policies has required effective risk communication and management (Henson and Caswell 1999).

The use of cost–benefit analysis could potentially be constrained by the lack of data on the value of non-market benefits and the cost of regulation. An alternative approach involves the use of cost-effectiveness criteria to establish cost-minimization regulations, subject to an upper boundary of mortality risk (Lichtenberg and Zilberman 1988). The resulting regulations require evaluating statistical life gain (i.e., the value of statistical life; Aldy and Viscusi 2007). This evaluation can be compared to those implied in other regulations, thereby allowing assessment of the stringency of the risk constraint.

Herring and Paarlberg (2016) suggest that Latin American countries (e.g., Brazil, Argentina), which are large feedbox producers (like the US), have applied regulatory frameworks similar to those in the US, while African countries, which have strong ties to Europe, have adopted a strict regulatory environment for biotechnology, even though they also stand to reap significant benefits from such technology (Shao et al. 2020; Wesseler et al. 2017).

Decisions about food safety regulations are inherently political, and the welfare of different groups in society may have different weights, which may be affected by political realities (Swinnen and Vandemoortele 2009). In particular, the economic tradeoff between ex ante regulations and ex post liability (Beckmann et al. 2006, 2010) as well as the decision-making procedures (Smart et al. 2015) can have strong implications for the incentives to invest (Purnhagen and Wesseler 2019). This has been demonstrated by a number of studies that look into the approval process and related costs of biotechnologies in agriculture. Those studies show that the time lengths in approval can differ substantially between regions (Jin et al. 2019; Frederiks and Wesseler 2019; Smart et al. 2017; Smyth et al. 2017) and of course, in many cases, the approval process reaches infinity, i.e., similar to a ban.

In an analysis of the political economy of agricultural biotechnology, Graff et al. (2009) suggest that existing restrictions on the use of biotechnology in Europe reflect the political power of the coalition of a number of farm groups, environmental groups, and chemical manufacturers, as well as the unique political structure of the EU (Smart et al. 2015). The regulatory environment in the US is more receptive to biotechnology, given that many biotechnological innovations have originated in the US, with some traits having been beneficial to US farmers. Wesseler (2002), McCluskey and Swinnen (2004), and Castellari et al. (2018) further suggest that in both the US and the EU, opponents to GMOs have been able to utilize the media to affect consumer preferences, even though consumers stand to benefit from the introduction of genetically modified varieties. Additionally, the semantics being used in the public debate as well as in books, including teaching material, has a further impact on shaping opinions (Aerni 2018). Tosun and Schaub (2017) show that in the EU, the opposition to GMOs includes more active groups and has a stronger network, while the same has also been observed for China (Jin et al. 2020).

While many safety policies are designed by national governments, several international agreements impose additional costs and uncertainty for investors. One example is the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity*. Plant breeders and others have complained that the protocol increases the costs and related uncertainties associated with developing new plant varieties with desirable traits, including drought tolerance, pest and disease resistance, and the efficient use of nutrients and adds to the regulatory burden already caused by the *Cartagena Protocol on Biosafety to the Convention on Biological Diversity* (Deplazes-Zemp et al. 2018). While any international agreement will invoke complaints by some, agreements that increase the costs of investing in sustainable agricultural solutions are of particular concern. New technologies and the benefits associated with them must be weighed against their potential negative implications, particularly those that are irreversible. As stated in Principle 15 of the Rio Declaration on Environment and Development of 1992: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." (United Nations 1992, p. 3)

The presence of irreversible damage does not imply that a technology should be prohibited. As demonstrated by various scholars (Arrow and Fisher 1974; Henry 1974), if an irreversible effect is present, one unit of irreversible costs requires more than one unit of reversible benefits to compensate (Wesseler and Zhao 2019). Unfortunately, many assessments fail to consider the tradeoffs between irreversible damage costs, which are often uncertain, and the benefits foregone by delaying or preventing the introduction of a new technology. Previous studies have indicated that a one-unit increase in investment costs requires more than one unit in benefits to compensate for related uncertainties. For example, as demonstrated by Purnhagen and Wesseler (2019), the marginal effect of an increase in approval costs can be substantial, possibly extending beyond a factor of 10. One prominent and widely discussed example is the regulation of new plant-breeding technologies in the European Union (e.g., Nationale Akademie der Wissenschaften Leopoldina, Deutsche

Forschungsgemeinschaft und Union der deutschen Akademien der Wissenschaften 2019), which has resulted in court cases in which judges have applied an absolute interpretation of the precautionary principle (Purnhagen and Wesseler 2020).

As mentioned previously, many new developments in biotechnology have the potential to provide substantial sustainability gains. Nevertheless, they have been rejected by important stakeholder groups, which also argue that these technologies should be prohibited from entering the market, based on the perspective of sustainability. Such arguments extend beyond the absolute application of the precautionary approach, as the debate concerns the types of agriculture and land use that should be preferable. The line is drawn largely between what is and is not considered organic agriculture. Definitions differ by country and interest group. Referring to the Austrian anthroposophist Rudolph Steiner, groups including farmers market their products under the Demeter® label. While what is and is not considered organic is a policy decision (Castellari et al. 2018), policy choices that favor one over the other are questionable from a sustainable development perspective. In many cases, large-scale applications of organic agriculture as defined by policy makers result in lower yields per unit of land and reduce the total quantity of food available. While one common argument holds that organic agriculture reduces the emissions associated with fertilizers and pesticides, the application of copper sulfate has sometimes resulted in environmental pollution, and the rejection of inorganic fertilizer has led to soil mining in some cases. In other cases, the principles of organic agriculture are likely to yield better results. Policy decisions in these matters can result in a substantial misallocation of resources, thereby endangering sustainable development (World Bank 2010).

5. Conclusions

Modern biotechnology offers a number of possibilities for addressing challenges to sustainable life on land (SDG 15), but there is also a strong link with achieving zero hunger (SDG 2) as achieving SDG 15 depends on the expected increase in population and the related increase in food demand. In this contribution, we have listed several of the possibilities. Many more exist, and some are better developed than others. The promotion of sustainable life on land and protecting terrestrial ecosystems is thus not mainly a technical problem; the major problem is both institutional and political. This has been stressed by several authors before as well (Wesseler and von Braun 2017; El-Chichakli et al. 2016; Zilberman et al. 2018). More specifically, institutional and political environments provide both incentives and disincentives for the private and public sector to invest in the development of solutions. When the obstacles are lower, parties in the private and public sectors are more likely to invest in the development of solutions. Obstacles can be reduced by harmonizing the standards for safety assessments. Examples include the acceptance of animal-feeding trials and nutritional studies across jurisdictions, as well as agreement on the procedures for field trials and the exchange of field trial data for environmental safety assessments. The relevance of harmonization of standards and the related benefits for all has been demonstrated by the COVID-19 pandemic recently. Hence, the positive contribution of biotechnology and the bioeconomy in general will go beyond SDG 15. This has important implications for achieving zero hunger (SDG 2), but also for reducing poverty (SDG 1), promoting sustainable growth (SDG 8), ensuring sustainable consumption and production patterns (SDG 12), and relies on fostering innovation (SDG 9). The UN Sustainable Development Goals initiative provides an opportunity for implementing important policy changes for achieving "decent lives for all on a healthy planet".

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Barriers to Zero Tropical Deforestation and 'Opening up' Sustainable and Just Transitions

Izabela Delabre and Callum Nolan

1. Introduction

International efforts such as the UN Sustainable Development Goals (SDGs), the UN Forum on Forests (UNFF), and the UN Framework Convention on Climate Change (UNFCCC) have sought to engender sustainable use of forests—including tropical forests, the focus of this chapter—through reducing deforestation and encouraging reforestation and afforestation. Ambitiously, the SDGs state that by 2020, we need to "promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally" (UN General Assembly 2015). At the same time, tropical forest governance is increasingly decentralised within government departments, taking on public, private and hybrid forms, and bringing diverse actors and alliances into forest politics that interact across scales and with differentiated effects (Arts 2014). Initiatives for governing tropical forests take multiple forms, including 'zero deforestation' supply chain initiatives, carbon foresy, Reducing Emissions from Deforestation and Forest Degradation (REDD+), legislative frameworks that intend to cut off markets for illegally harvested timber, and emerging landscape and jurisdictional approaches.

These global commitments demonstrate growing recognition of the urgent need to arrest tropical deforestation to avoid 'tipping points' (Walker et al. 2019; Amigo 2020). A tipping point refers to the stage at which forest degradation is such that rainforests can no longer be sustained and shift states to savannah, releasing vast amounts of forest stored carbon with devastating and irreversible repercussions for planetary health (Lovejoy and Nobre 2019; Pereira 2019). A recent study has suggested that such tipping points may be considerably closer than previously imagined, with as much as 40% of the Amazon now at a point at which it could exist as savannah as opposed to rainforest (Staal et al. 2020). However, despite the acknowledgement of the SDGs for 'transformative' change, current trends indicate that the SDG 2020 targets on forests and their sustainable management have not been met. The majority of 'zero deforestation' commitments, made by private companies as voluntary pledges to eradicate deforestation throughout their supply chains (Lambin et al. 2018) also fall short of their 2020 targets (as highlighted in the 'Forest 500' report by Global Canopy that found not one of the 500 most influential forest-risk commodity companies and institutions were on course to do so (Rogerson 2019)). Similarly, the five-year progress review of the transnational multi-stakeholder 2014 New York Declaration on Forests (NYDF) shows large commitments but slow implementation, pointing to another missed target (NYDF Assessment Partners 2019).

Rather than meeting these targets, tropical deforestation continues at an alarming rate, with as much as 12 million hectares of tropical tree cover loss recorded in 2018 (World Resources Institute 2019). On a global scale, tropical forest destruction is driven by an ever-growing demand for commodities such as timber, soybean, oil palm and cattle meat, all associated with forest loss (Seymour and Harris 2019), and the expansion of extractive industries and infrastructure development (Sonter et al. 2017; Bebbington et al. 2018). Tropical deforestation is often facilitated by the violent appropriation of land and the expulsion of indigenous communities (Li 2018), a recent example being the surge of violence against indigenous communities in Brazil (Greenpeace 2020). Furthermore, tropical deforestation has a host of other negative impacts felt across scales. Locally, forest degradation and loss erode vital ecosystem services which provide livelihoods, medicines and food for indigenous communities (Tsing 2004; Li 2015), and globally the felling and burning of tropical forests is a major source of anthropogenic greenhouse gases, emitting more carbon dioxide equivalent than the entire European Union (World Resource Institute 2018). Beyond, and linked to, the commodity expansion driven stressors facing tropical forests, environmental changes such as global warming and biodiversity loss exacerbate degradation, with exactly how and to what extent still relatively poorly understood (Cusack et al. 2016). To that end, we argue that careful attention must be paid to the influences of power and politics in forest governance to imagine opportunities for sustainable and just transitions for forests and their use.

Drawing on insights from political ecology and sustainability transitions research, this chapter discusses the barriers to transitioning to zero deforestation. Exploring the possibilities for a sustainability transition for forests, we argue that careful attention must be paid to the influences of power and politics surrounding drivers of deforestation, forest governance and its outcomes, and the need to challenge orthodoxies around economic growth that currently underpin policy responses. It is increasingly clear that transformative reforms are required, departing from the extant governance milieu of neoliberal solutions. This process is profoundly complex due to the inevitable trade-offs and tensions between the ecological, economic and social aims of transitions to zero deforestation, and the difficulty in challenging the existing power structures that underpin 'business as usual' in forest governance.

2. Power and Politics in Sustainability Transitions

Forest Transition Theory suggests that landscape change is shaped by three distinct processes that occur over time: (1) fragmentation, (2) deforestation and degradation, and then (3) restoration and reforestation; and these three processes correspond with economic development at regional or national scales (Mather 1992). It may be argued that Forest Transition Theory emphasises a natural, unilinear and homogeneous process of 'development' whereby developing countries follow the historical processes of developed countries (Klooster 2003), but the nature of a transition is shaped by situated historical contexts (Rudel et al. 2002). However, the theory remains one of the foundations of current thinking on forest landscape change (Garcia et al. 2020). Given the urgency of addressing the forest crisis, we agree with Garcia et al. (2020, p. 418), who state that "landscapes do not happen; we shape them", and emphasise the role of agency as a key factor and blind spot of current forest policy.

The changes required to halt global trends in deforestation are highly complex and necessitate long lasting reform across social, economic and political spheres. The field of 'sustainability transitions' has increasingly sought to support our understanding of "the complex and multi-dimensional shifts considered necessary to adapt societies and economies to sustainable modes of production and consumption" (Coenen et al. 2012, p. 968). Early literature on sustainability transitions has been critiqued for being overly technocratic and therefore failing to recognise the inherently political, and thus power laden, nature of meaningful change (Meadowcroft 2011; Stevis and Felli 2015). More recent research has recognised that politics and power fundamentally shape the process of sustainability transitions (O'Neill and Gibbs 2020). A multitude of different actors devise, enact, enforce, govern, communicate, shape and resist these processes—including states, international institutions, private actors, civil society and communities. Sustainability transitions are therefore not unilaterally implemented by any one party, but are the product of complex networks of actors, likely to have divergent understandings of what 'success' may look like, and of how it may be achieved (Köhler et al. 2019).

These networks of actors are characterised by an imbalance of power, meaning that powerful actors such as corporations, states and institutions have a disproportionately influential say in setting the transformation agenda (Avelino 2017). Often, elite actors are invested in maintaining the status quo (Routledge et al. 2018), hindering truly sustainable transitions and perpetuating the environmental injustices that blight those less powerful actors such as indigenous communities. Power then in transition studies can pertain to 'power struggles' between incumbent actors and those who are trying to challenge 'business as usual' (Köhler et al. 2019). The results of these struggles impact access to resources and the distribution of the burdens and benefits associated with sustainability transitions (Healy and Barry 2017).

The inherently power-laden nature of sustainability transitions has invited researchers to apply a critical lens to their analysis, asking important political economy questions on who is defining the terms of change, who wins, who loses, how and why (Smith and Stirling 2010; Newell and Mulvaney 2013). These questions expose the injustices that arise, or are reinforced, by transitions aiming to achieve sustainability—most commonly addressed in the literature on 'just transitions'—which have sought to foreground the concerns of marginalised and disproportionately affected actors in transitions (Ciplet and Harrison 2019). Lawhon and Murphy (2012) outline additional critical questions that might further elucidate the impacts of disparate power relations in sustainability transitions such as: At what scale are decisions made? Who is represented in transitions? Whose knowledge counts? What are the intended and actual social outcomes of transitions? Answering such questions enables a root cause analysis of the drivers of, and barriers to, sustainable and just transitions. Next, we unpack some of the barriers to transitioning to zero deforestation to date, considering these critical questions. We do not claim to capture all of the challenges encountered in transitioning to zero deforestation, nor are we dismissive of the efforts undertaken by policymakers, practitioners and researchers in seeking to raise ambition on forest governance. Rather, we attempt to highlight the complexity of the challenges of addressing tropical deforestation and open up discussion on possibilities for transitions.

3. Barriers to Transitioning to Zero Deforestation

3.1. Problem Framing: Contested Definitions of "Forests" and "Deforestation"

Often, forest governance mechanisms are based on technological and market-based solutions to the problem. A case in point is the UN REDD+, in which developing countries receive money from developed countries in order to protect forests. Private governance is also becoming increasingly common, in response to growing public awareness of the extent of private sector-driven deforestation. This has manifested through 'zero deforestation' commitments being made by private companies as voluntary pledges to eradicate deforestation throughout their supply chains, often through the use of certification programmes

(Lambin et al. 2018). Challenges in transitioning to zero deforestation may in part relate to significant differences in how different actors define 'zero' (versus 'net' zero), 'forests', and 'deforestation', as well as differences in implementation mechanisms, and success metrics (Garrett et al. 2019). Definitions of deforestation and zero deforestation used by the private sector, government, and non-governmental organisations, vary and lack clarity on whether they relate to zero 'gross' deforestation (reducing primary forest loss) or zero 'net' deforestation (involving new planting or reforestation to compensate for forest loss), whether tree plantations are included, or how past clearance is addressed (Brown and Zarin 2013; Lambin et al. 2018). Examining discourses of how 'forests' and 'deforestation' are defined highlights how different actors interact and potentially influence the deforestation problem and its possible solutions (Bäckstrand and Lövbrand 2006). How these definitions are then encoded into policies and standards fixes meaning in an inherently political process (Turnhout 2018), where power is exercised by actors to challenge or keep power, thus serving particular interests (Fischer and Hajdu 2017).

This diversity and ambiguity makes it difficult to evaluate progress towards 'zero deforestation', and actors can fill the statements with meaning to suit their particular interests (Beland Lindahl et al. 2016). Through the process of defining forests and deforestation, discourses may be 'closed down' to retain hegemony through the reinterpretation of a problem and how it should be solved, and thus which interests should be taken into account (Fischer and Hajdu 2017). For example, zero 'net' deforestation could be considered well-aligned with corporate interests, as 'business as usual' can continue through a spatial-temporal fix of tree planting, apparently reconciling economic growth and conservation (Harvey 2007). However, alienated communities bear the burden of this appropriation of nature (Fairhead et al. 2012), as their use of land and forests is restricted (e.g., Mahanty et al. 2012) and benefits are captured by the elites (e.g., in the case of REDD+, Sikor et al. 2010).

In attempting to operationalise 'zero deforestation', an important process is making forests or deforestation 'calculable' and 'legible'. In the process of operationalisation, forested and deforested areas are defined using standardised categories and metrics, so that categories are commensurable and their values comparable and exchangeable, including through markets (Turnhout 2018). This process of categorisation involves 'experts' who are tasked with undertaking valuations and assessments as part of land use zoning for agricultural expansion or calculating carbon units represented by forests which obscure their diverse values. This has been at the expense of local communities who frequently recognise the plural values of forests beyond zones labelled as 'High Conservation Value areas/forests'

(HCVs) or areas of 'High Carbon Stock' (HCS) (Cheyns et al. 2020). These technocratic processes of zoning—which allow efficient auditing to take place against certification standards—may obscure the exercise of power by experts, who are influential in defining certain visions of forests and their management.

The definitional problems related to deforestation have persisted for decades, and it is clear that previous accounts of deforestation's impacts have important flaws (Forsyth 2004). According to Hamilton and Pearce (Hamilton and Pearce 1988, p. 75 c.f. Forsyth 2004), "The generic term "deforestation" is used so ambiguously that it is virtually meaningless as a description of land-use change ... It is our contention that the use of the term "deforestation" must be discontinued, if scientists, forest land managers, government planners and environmentalists are to have meaningful dialogue on the various human activities that affect forests and the biophysical consequences of those actions". It is clear that definitions of forests and deforestation continue to be contested, with important implications for how the problem is constructed and its solutions. Although it is unlikely that the term "deforestation" will be discontinued, we argue that the complexity of the term must be recognised. More attention is needed to the nuanced drivers and effects of deforestation, which requires consideration of questions of multi-scalar political economic causes of forest loss, in order to develop appropriate and relevant policies. This may require, for example, contesting problematic assumptions and policy narratives about causes of deforestation which lead to ineffective solutions (Ravikumar et al. 2017).

3.2. Governance across Scales: Translations and Enactments of Sustainable Forest Governance

"Zero deforestation", as encoded into SDG 15, private sector statements, and the NYDF, is a bold statement made by actors at the global level to communicate ambition to protect forests. Although this may be considered "the goal" set by actors at the global level, constituting a process of managing sustainability and brand risks or even as a marketing tool, these ambitious statements reshape and influence relations within global value chains, through consolidations, exclusions, and changing practices. Global strategies are enacted differently and unevenly across geographies, through complex politics of translation as they are refracted and reproduced across local-global sites of negotiation (Merry 2006; Newell 2008). Asserting that deforestation is always problematic through claims of 'zero deforestation' and the targets contained in the SDGs may grant insufficient attention to the complexity of how deforestation is carried out, its variety of purposes and impacts (Forsyth 2004). Moreover, implementation of zero deforestation commitments is incredibly complex due to supply chain structure (Lyons-White and Knight 2018). Issues of leakage when supply chains are 'cleaned up' (or 'deforestation-free' with non-compliant suppliers excluded) mean that deforestation is displaced rather than eliminated (Garrett et al. 2019), and do not address the root causes of deforestation and may be considered a process of 'rendering technical' a complex political economic problem based on inequitable control of forest and forestlands (Li 2011). Myers et al. (2018), based on 742 interviews (in conservation, payment for ecosystem services, and REDD+ projects in Indonesia, Mexico, Peru, Tanzania and Vietnam), found that proponents viewed problems through a 'technical' rather than 'political' lens, which came at the expense of political solutions such as the representation of local people's concerns and recognition of their rights.

Current global sustainable forest governance initiatives are underpinned by the notion of forests as a 'global common good', which may contrast with local understandings of forests and in turn create barriers to transitioning to zero deforestation (Basnett et al. 2019). 'Global' views of legality, such as those defined by the EU Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan, for example, differ from local understandings of legality which are viewed by non-state actors as part of a colonial legacy and imposed upon them (Myers et al. 2020). Global narratives can, in turn, be stabilised within regional narratives, which may not always reflect local realities but still inform policies (Fairhead and Leach 1995).

Measuring, reporting and verification (MRV) systems used to support global forest governance initiatives, while making visible forest loss and regeneration, identify forests as 'pixels' or units of carbon, risks further decontextualising the historic processes of deforestation that were—and are—based on a colonial extractivist mindset that persists in national plans and forest policies (Gupta et al. 2012). Galudra and Sirait (2009) argue that scientific discourse was used by the Dutch colonial administration to justify control of 120 million hectares of land as forest reserves, legitimised by the view that customary systems of land tenure and use were 'inappropriate' and 'destructive'. This pattern of land control endures and remains in policy discourses that emphasise and protect private land rights (Mousseau 2019). Under this form of land control, subsistence and artisanal use of forest resources are often declared illegal, while access is enabled for large commercial timber companies or agribusiness (Munro and Hiemstra-Van der Horst 2011).

Through carbon offsetting, a unit of carbon is disembedded from a locality and its conflicts, and through a process of commodification can be bought and sold in global markets, without challenging current consumption patterns and by allowing economic growth to continue as usual (Cavanagh and Benjaminsen 2014). Private certification has been promoted as an important private forest governance solution, but can reinforce new forms of injustices as it privileges those who can afford to dedicate time and resources to comply with complicated standards (Basnett et al. 2019). According to Sayer et al. (2019, p. 501): "Without an emphasis on integration, wide political and public engagement and greater responsiveness to local needs, SDG 15 risks perpetuating a sectoral, top-down approach". Inadequate consideration of local contexts gives rise to equity concerns and may thus preclude efforts to challenge root causes of unsustainability and deforestation.

Current sustainable forest governance initiatives go further than decontextualising forests and disembedding the local. Initiatives implicitly blame local actors as driving deforestation, while simultaneously focusing on them as the solution, as is seen in the case of REDD+ and corporate deforestation initiatives (Delabre et al. 2020). In the case of REDD+, Skutsch and Turnhout (2020) highlight how the 'communities' narrative may implicitly rest on explanations of the causes of deforestation that have since been discredited, but remains attractive as it focuses attention away from more politically sensitive approaches, e.g., targeting powerful industrial interests, and masking difficult trade-offs. However, such an approach delegates the burden of responsibility to potentially already marginalised communities (Goldman 2001), which may exacerbate existing inequalities and potentially impedes progress against other SDGs. Treating the problem of deforestation as driven by small farmers and actors distracts from attention to the wider political economy of forests and their governance (Ravikumar et al. 2017).

The notion of 'measurementality' places transparency alongside effectiveness and efficiency as neoliberal principles in environmental governance (Turnhout et al. 2012). Despite such emphasis on standardised and 'objective' science-based measurements, the two main global datasets on deforestation are conflicting. Global Forest Watch (hosted by the World Resources Institute) uses satellite images and on the ground observations to detect tree cover, and estimated global deforestation rates as 72.5 million acres in 2017, whereas the UN FAO Global Forest Resources Assessment, based on registered land use and disclosed by governments, estimates annual net loss, once forest regrowth is taken into account, at 8.2 million acres (Pearce 2018). Despite continuing high rates of deforestation in many locations, statistical uncertainties are often not acknowledged, and as a result, some estimates become seen as factual and unchallenged (Forsyth 2004). Furthermore, the use of 'big data' and technologies as industry norms for monitoring and managing deforestation in supply chains brings to the fore a number of challenging questions, some examples of which follow.

Firstly, to what extent are these new technologies for knowing forests legitimate, to whom are they considered legitimate and what are the implications if they fail to gain legitimacy amongst important stakeholders? Secondly, who gains and who loses from the use of these new technologies, what are the power structures and other factors that determine winners and losers, and how might these be dismantled in order to ensure technological advances do not reinforce systems that oppress or harm vulnerable groups? Finally, whose visions of sustainability may be promoted or obscured as measurement is undertaken based on abstracted data, and what are the implications of this?

3.3. Directionality of the Transition: Who Is Represented?

Diverse actors and alliances are involved in the enactment of public, private and hybrid forms of tropical forest governance at global, national and local scales. How these diverse actors perceive forests and their sustainable governance influences their strategies and actions. Different framings of the same problems are often the source of political struggles (Fischer 2003). Thus, who frames the problem of deforestation, and how, is a critical consideration in transitioning to sustainability.

Incumbent actors such as the state, private sector, and powerful NGOs play a disproportionately large role in the directionality of the transition to zero deforestation, and are able to shape particular processes while resisting others. Although on one hand, this multi-actor governance brings diverse perspectives and knowledge and opportunities for dissenting voices to be brought to the table, certain powerful actors may be dominant in setting and enacting (often neoliberal) solutions. If powerful interests and values are over-represented in visioning and framing targets and the means of implementation, this may preclude possibilities for just sustainability transitions, and exclude alternative pathways (Leach et al. 2007).

This can be demonstrated by the different networks and alliances of actors who affect, and are affected by, deforestation and forest governance, who have divergent understandings of what constitutes sustainable land use with important consequences for how tropical forests might be best conserved while obtaining food. These different ideas result in divergent understandings of what 'success' looks like (Köhler et al. 2019). For example, there are disagreements on whether sustainable agriculture should be based on a model of 'land sharing' or 'land sparing' for biodiversity (Phalan et al. 2011), or agroecology or industrial agriculture (McNeill 2019), all of which are context-dependent. This contested discourse reflects both technical issues (i.e., how to assess sustainable land use empirically, and how ecological limits are defined), and political issues (i.e., who benefits and who loses from particular models). In policy fora, agribusiness concerns are frequently rationalised by a narrative of feeding a growing 'global' population based on a model of 'land sparing' that allows continued expansion of commodities, with HCS and HCV areas designated within plantation concessions. These zones are privately conserved by agribusiness, with further implications for their fate and the fate of communities dependent on the resources of these areas.

The SDGs make a normative statement about what a high-level sustainability transition seeks to achieve, but within this high-level agenda are embedded assumptions, politics and trade-offs. Spann (2017) argues that embedded in the SDGs is the notion of 'agriculture for development', premised on a (problematic) structural transformation whereby, over time, countries shift from being agriculturally based to eventually becoming urbanised. Rather than a natural evolution, this agriculture for development model is a political project that negatively affects smallholders and ecological relations (ibid.). Thus, Spann (2017) argues that the SDGs ensure the interests of agribusiness—with whom the SDGs were developed—at the expense of actual (or alternative visions of) sustainable development. This is relevant to transitioning to zero deforestation, given the substantial role of agricultural expansion in tropical forest loss. Thus, the SDGs prioritise a pathway for how land is used for food production, potentially obscuring alternatives that may be more sustainable. Further, this singular pathway neglects attention to governance structures that support continued deforestation, such as harmful incentives, consumption patterns and the fundamental imperative for economic growth, which can be prioritised by states through a process of SDG "cherry-picking" to align with a pre-existing development pathway (Forestier and Kim 2020; Horn and Grugel 2018).

4. 'Opening up' Just Sustainability Transitions for Forests

Key questions need to be asked that relate to epistemological diversity and justice to consider whose knowledge counts in decisions for sustainable development and where forests feature. We suggest that a just sustainability transition, i.e., one that seeks to address both the uneven distribution of burdens and benefits inherent in socio-ecological transitions for forests, and the power imbalances that perpetuate them, requires 'opening up' (Stirling 2008) multiple, alternative visions of sustainable development that do not have infinite economic growth at their core. 'Opening up' examines different framing conditions and assumptions, including marginalised perspectives and considering ignored uncertainties: instead of providing prescriptive recommendations, alternative questions and new options can be considered and governance processes can be better informed, more transparent and accountable (ibid.). A focus on the conditions that create barriers to zero deforestation supports us in unearthing possibilities and spaces for transformation, where power may be redressed through more equitable solutions. A perspective of a just transition based on political ecology supports an understanding of who wins and loses from current governance arrangements and the assumptions that underpin them, and thus supports researchers in imagining what combinations of co-constructed actions are needed.

As part of the process of 'opening up' just sustainability transitions, local actors should be placed at centre stage in decision-making, early on in processes related to land use change, and forest management, rather than rigid tokenistic efforts for consultation following already agreed futures, as has been seen in cases of superficial indigenous 'participation' in Low Carbon Development Strategies in Guyana (Airey and Krause 2017), or in impact assessment processes as part of certification standards in Malaysia and Indonesia (Delabre and Okereke 2020). Decision-making processes therefore need to recognise and be sensitive to diverse forms of agency and resistance, especially of previously marginalised actors (De Vos and Delabre 2018).

Recent conceptualisations of integrated landscape-scale governance arrangements hold some promise in this regard, by emphasising engagement between multiple stakeholders and aiming to disentangle complexity of landscapes, facilitating consideration of different courses of action, and reconciling societal and environmental objectives at the landscape scale (Reed et al. 2020; Sayer et al. 2015). Yet, these landscape-scale approaches may also risk exacerbating existing inequalities encountered in other forest governance approaches in complex political economic contexts and across geographies. Reed et al. (2020) highlight the need for concerted transdisciplinary actions in applying and assessing the effectiveness of landscape approaches, being attentive to power asymmetries in sectorial engagements.

Recognising the root causes of forest loss requires acknowledgement of the unsustainability of land use decisions that prioritise GDP growth, embedded in SDG 8, at the expense of other SDGs—highlighted by Menton et al. (2020) as 'the elephant in the room'. Within a capitalist political economy, neoliberal conservation promises to reconcile unlimited economic growth and forest protection. Recognising this tension highlights the need to develop a more nuanced perspective on the complex drivers of deforestation and thus how problems are confronted. This critical approach requires challenging prevailing political discourses that promise 'win-win' solutions with limited scientific evidence (Reed et al. 2020), or simply blame local people for forest loss (Ravikumar et al. 2017). Redistributing the burden of responsibility for implementing zero deforestation will require targeting actors according to the direct and indirect impacts that their actions have on deforestation and the broader political power they possess (Büscher and Fletcher 2020), pushing for greater accountability for the actions of incumbent actors including companies, states and finance to comply with the commitments they have made themselves.

Following Büscher and Fletcher (2020), we argue that a just sustainability transition for forests requires radical (from the 'roots') shifts in how forests are governed. The concept of 'convivial conservation' may therefore be a helpful imaginary to support human-nature interactions, including conceptualising the diverse and multiple values of forests as complex social-ecological systems (Büscher and Fletcher 2020) that cannot be isolated or disembedded from their social and historical contexts. Shifting away from a 'global transition' to 'zero deforestation', a more sustainable and equitable future may require multi-transition pathways that embrace diversity. Some of these processes of transition may have already started, but as we have discussed, many barriers remain. Despite some shifts in how forest governance is enacted, it is clear that more equitable multi-actor processes will require shifts in power and agency. For example, partnerships between corporations and civil society organisations could be based on stronger requirements for companies, in an action to redress power. Civil society organisations play a role in motivating institutional logics and formulating alternative logics. Rather than being deemed 'too radical' within 'pragmatic' discussions, those civil society organisations play a critical role in pushing the boundaries of the debate (Von Geibler 2013).

Difficult and messy trade-offs are inevitable in implementation of the SDGs, but it is imperative to revisit the problem of deforestation, and to critically analyse the assumptions underpinning current solutions. A coherent, transdisciplinary effort to do so can support in shaping global targets that are appropriate to local contexts, and will be the only way to make transitions both sustainable and 'just'.

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