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From Transition to Domains of Transformation: Getting to Sustainable and Just Food Systems through Agroecology

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Abstract: The acceleration of ecological crises has driven a growing body of thinking on sustainability transitions. Agroecology is being promoted as an approach that can address multiple crises in the food system while addressing climate change and contributing to the Sustainable Development Goals. Beyond the more technical definition as, "the ecology of food systems", agroecology has a fundamentally political dimension. It is based on an aspiration towards autonomy or the agency of networks of producers and citizens to self-organize for sustainability and social justice. In this article, we use the multi-level perspective (MLP) to examine agroecology transformations. Although the MLP has been helpful in conceptualizing historic transitions, there is a need to better understand: (a) the role of and potential to self-organize in the context of power in the dominant regime, and (b) how to shift to bottom-up forms of governance—a weak point in the literature. Our review analyzes the enabling and disabling conditions that shape agroecology transformations and the ability of communities to self-organize. We develop the notion of 'domains of transformation' as overlapping and interconnected interfaces between agroecology and the incumbent dominant regime. We present six critical domains that are important in agroecological transformations: access to natural ecosystems; knowledge and culture; systems of exchange; networks; discourse; and gender and equity. The article focuses on the dynamics of power and governance, arguing that a shift from top down technocratic approaches to bottom up forms of governance based on community-self organization across these domains has the most potential for enabling transformation for sustainability and social justice.

Keywords: agroecology; food security; food sovereignty; governance; participation; power social transformation; sustainability transitions

1. Introduction

There is growing urgency over the ecological crisis and increasing evidence that our socio-economic systems are fundamentally undermining the functioning of the natural world in catastrophic ways. The latest Intergovernmental Panel on Climate Change (IPCC) report [1] paints a dire picture of the impacts of anthropogenic climate change. Other major reports have drawn attention to other convergent crises, including the accelerating extinction rate of species [2–4], looming water shortages for 5 billion people [5], dangerous degradation and pollution of land and soil and accelerating resource throughputs, and the increasing levels of air pollution and resulting health-related death and disease [6]. Yet, questions of the nature of these changes and how to achieve them require urgent attention.

In this article, we focus on the notion of systems transformation in food and agriculture, and in particular on agroecology as a transformative paradigm. On the one hand, there have been calls for societal transformation based on large scale interventions (e.g., geoengineering), new technologies (e.g., artificial intelligence and blockchain), and expert-led and corporate-led solutions to drive sustainability transitions [7,8]. On the other, there has also been an articulation of the need for bottom up, civil society-led processes of self-organization like agroecology [9,10]. These bottom up transformations mark a departure from transitions driven from the top-down by actors already empowered within the existing political-economic regime.

Over the past five years, agroecology has emerged in the international policy arena as an alternative paradigm for food and farming that can address multiple crises in the food system, contribute to the Sustainable Development Goals and enable a just transition [9–11]. Altieri's commonly used definition of agroecology has been a key reference point as "the application of ecological concepts and principles to the design and management of sustainable agroecosystems" [12]. In the late 1990s, agroecology broadened its framing, moving beyond the farm towards the study of food production, distribution, and consumption. This led to a new and more comprehensive definition of agroecology as "the ecology of food systems" [13]. Agroecology entails a process of continuous transition that does not follow prescriptive rules, but is based on core principles [12,14], values [10], or elements [15] that inform agroecology in the cultural, ecological, and social specificities of place.

Agroecology represents a transformative vision and practice, which puts governance, power, and democracy at the center [16]. Indeed, like other alternative paradigms, agroecology goes far beyond demands for technical change and acknowledges that a range of 'lock ins' to unsustainable regimes will only be addressed by shifts in political-economic power. Agroecology thus emphasizes social and political aspects including autonomy, community-self organization, and bottom-up place-based organizing. Yet many questions remain about alternative paradigms for sustainability, which are contingent on the ability of communities to claim agency and power in transformation processes.

This paper begins by elaborating on agroecology as a transformative paradigm for food and farming. We then introduce the multi-level perspective—an influential framework for analyzing sustainability transitions [17,18]. Next, we describe our study methodology and introduce the notion of 'domains of transformation' as important sites to enable and pursue transformation. These domains are overlapping and interconnected interfaces between two levels in the multi-level perspective—the niche and regime. Synthesizing the literature on agroecology transitions, we present six critical domains of transformation. Our analysis reveals how each domain is primarily determined by governance (especially power), rather than the predominant focus on the technical dimensions of sustainability transitions. We conclude by arguing that shifts in governance away from top down technocratic approaches towards bottom up distributed ones—across these domains of transformation—has the most potential for enabling just sustainability.

1.1. The Increasing Global Prominence of Agroecology as an Alternative to the Dominant Food System Regime

As agroecology has gained prominence in debates over the future of food and farming, it has become increasingly framed in different ways. In some instances, agroecology is being framed more narrowly as a technical approach centered around specific ecological production practices. However, it is becoming increasingly recognized, that the social, cultural, and political dimensions which emphasize community-led governance of transformations are as important as the practices, principles, and science of agroecology [15]. Indeed, these dimensions are articulated by many as the distinguishing feature of agroecology [10]. To make this explicit, the concept of a "peasant agroecology" or a "political agroecology" has been developed. This reflects a paradigm shift that fundamentally challenges the existing cultural and structural power dynamics that underpin the current unjust and unsustainable food system and that puts the self-organization of food producers and food eaters as a means and end for agroecology [16]. In this article, when we use agroecology, we are referring to this political definition.

Agroecology, in its most transformative and political presentation, represents a framework that is centered on the synergistic relationship between people and nature, the agency, knowledge and rights of food producers and other food system actors, and the de-centering of profit, "the" (singular, reified) market, technology transfer and similar elements of "mainstream development" (such as the neologism "climate smart agriculture"), and elite systems of governance. Social movements, scientists, and governments are thus linking agroecology to the notion of food sovereignty, just transitions and other transformative political economy frameworks. In this view, agroecology will only be possible when based on the affirmation of the right to food, the rights of peasants, eaters, and food producers, their cultures and their control over food practice and policy.

Many aspects of what is now referred to as agroecology have been occurring for millennia in traditional and indigenous communities, and have been intentionally advanced more recently through grassroots organizing, science, legislation, policy, and programs. However, only in the last few years has there been a growing emphasis on how to scale-up agroecology to move beyond its marginal-but-widespread existence in the interstices of industrial farming, yet still retain its basis in community self-organization. Initially, there has been a strong focus on how to transition individual farms (e.g., [19]). Gliessman [20] proposed 5 different levels of transitions, which has been widely adopted. However, others have conceptualized the process of scaling agroecology as a rather messy and chaotic, but steady, process that sees agroecology grow from "islands of success" to greater territorial or national spread as well as receiving institutional recognition and support (e.g., [9,21]). These studies have drawn on case-study or multi-case study approaches to articulate different aspects, drivers, dimensions, and qualities that need to be in place in a particular territory in order for agroecology to be nurtured, to grow, to massify, to scale, and to become strengthened on-farm, across and between territories, and throughout the food system. Our study reviewed these different emerging perspectives to develop a framework for conceptualizing agroecology transformations.

1.2. Sustainability Transitions and the Multi-Level Perspective

To contextualize the growing literature on agroecology transformation, we draw from the tradition of research on sustainability transitions from the perspective of socio-technological systems [22–24]. As Hinrichs argues, the futures-orientation and systems-sensibility of the sustainability transitions literature are valuable tools for making sense of processes of food systems change [25]. Within this tradition, sustainability transitions are considered "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" [26] (p. 956). The focus of this field of study is on the dynamics, barriers, and processes that move systems in the direction of sustainability.

Whereas power and governance are not typically the central focus in the sustainability transitions literature [27], our approach is based on the assumption that any transformative system's change will require an analysis of power and governance. Indeed, where sustainability transitions analysis has been applied in the agricultural sector, the emphasis has been primarily on the localization of food systems, organic agriculture, permaculture; very few of these studies put power and governance in the center of the analysis [28]. While the sustainability transitions literature offers useful perspectives and tools, there are very few studies that emphasize transformative changes in governance as a critical determinant of sustainability transformations.

Within the sustainability transitions literature, the multi-level perspective (MLP) provides a useful heuristic framework. It has been used to conceptualize dynamics and patterns in socio-technical transitions as "non-linear processes that result from the interplay of developments at three analytical levels: niches (the locus for radical innovations and alternatives), dominant regimes (the locus of established practices and associated rules that stabilize existing systems), and an exogenous landscape" [17] (Figure 1). The MLP encourages a systems analysis that positions agroecology within a wider, overarching socio-technological framework. It provides a relatively simple yet powerful

heuristic framework to conceptualize the complex multiple elements, levels, dimensions, and aspects of agroecology transformations that can be read across the growing number of studies on agroecology.

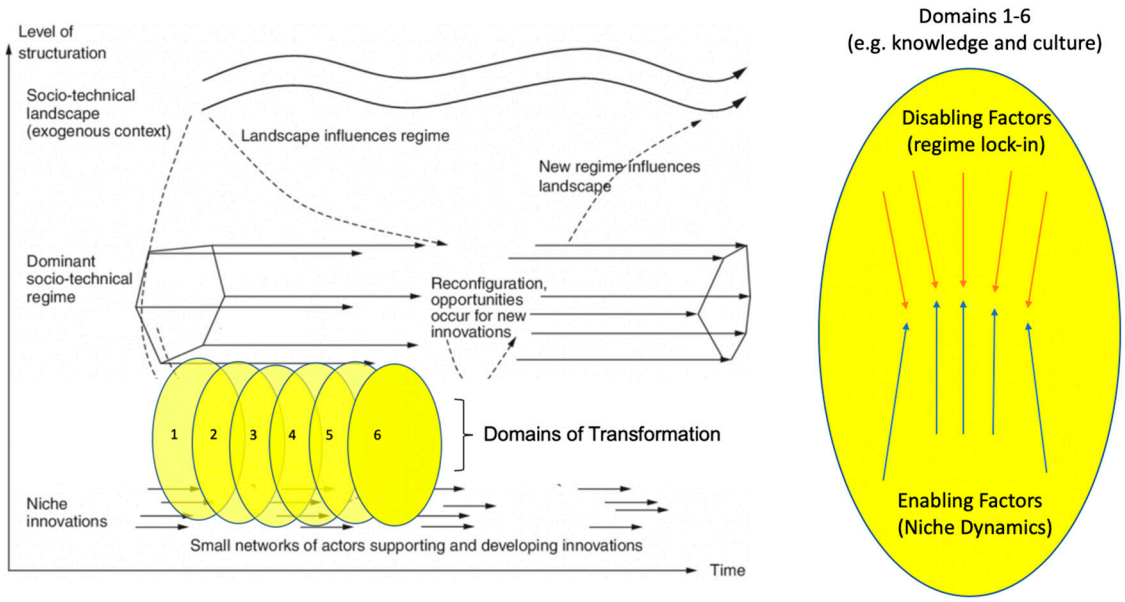

Figure 1. (**Left**) Domains of transformation are depicted here as definable interfaces between niche and regime superimposed onto a simplified version of Geels and Shot's multi-level perspective figure [18]. (**Right**) Within each domain, there are factors, dynamics, structures, and processes that constrain agroecology (orange arrows), and those that enable it (blue arrows). Our analysis examines these dynamics within these interdependent domains of transformation (see Figure 2).

Figure 2. Domains of transformation for sustainable food systems through agroecology. These domains are a determining factor in shaping the depth of agroecological production practices and are influenced by, and in turn influence, processes of governance.

In the MLP, the landscape level represents macro scale, slow moving contextual factors in society that do not necessarily determine change at regime or niche levels, but rather, "make some actions easier than others" [18]. Landscape level changes, such as climate change, political ideologies, societal and cultural values, or periodic geopolitical crises (e.g., the food crisis of 2008) are generally beyond the direct immediate influence of governments or other actors. They are critical factors in sustainability transitions because of their catalyzing role for regime change and for opening up opportunities for alternatives to thrive. For example, Mier y Terán Giménez Cacho et al. [21] note the importance of 'crisis' in their study on the drivers of agroecology. It is important to be mindful of these contextual landscape factors, but it is at the interface between the niche and regime levels where the most immediate possibilities for agency are most salient [29,30].

The regime level involves, "established practices and associated rules that stabilize existing systems" [17,26] where alignments and interdependencies across regime dimensions generate processes of path-dependency or 'lock-in' that enable stability and preserve the status quo. Regimes are resistant to significant change and tend to reproduce themselves while preventing path-breaking innovations. Powerful actors often attempt to resist or appropriate change to maintain the status quo. For example, the co-optation of agroecology has been identified as a risk when governments adopt narrow technical understandings of agroecology into national frameworks [31,32]. The stability of the regime is constituted by a form of structural power that privileges certain actors (those empowered by the regime) at the expense of others. Transitions in this context involve political, economic, cultural, and social struggles of different coalitions of actors, with competing interests seeking to shape both the regime and emerging alternatives. Transformations, in this sense, require a shift in these power relations—empowering different, typically-marginalized actors than those who currently hold power.

Finally, the MLP contains the niche level, which is conceived of as sites of radical socio-technical alternatives that differ in their principles and configurations from the dominant ways of operating. It is important to note that multi-level perspective niches are different from what are often referred to as market niches. Whereas market niches are specialized products or services within capitalist markets, multi-level perspective niches rather reflect radical breaks from the dominant regime. Agroecology, with its emphasis on ecological processes, low external inputs, co-production with living nature, the agency of food producers and eaters, and autonomy from elite and corporate power sharply contrasts with incentives, policies, programs, rules, and norms of the dominant regime; which includes in this case an agricultural or ecological modernization paradigm. Case studies indeed show that in order to survive, mature, grow, and spread, agroecology (as an emerging alternative) generally grows in what are referred to as niches: spaces that are—in a range of different ways—sheltered from the hostile pressures of the dominant regime [30].

The multi-level perspective was originally developed to understand how technological innovation can lead to the consolidation of new commercial products in the corresponding markets. In contrast, agroecology reflects more than a technological fix, but an alternative paradigm and a political challenge to the status quo. From a political economy perspective, the dominant food regime is sustained by powerful capitalist and neoliberal configurations that limit alternatives [33]. In this light, Misra [34] argues that technocratic framings of socio-technological regimes are insufficient, instead choosing to highlight their political dimensions. Giraldo and Rosset [35] articulate the battle for agroecology as 'territory in dispute', characterizing the relationship between institutions in the incumbent regime and social movements advancing agroecology as political struggle with material and immaterial dimensions. From this perspective, the regime is based on the overriding economic and political power of corporate food actors, which are refracted through the uneven structures of patriarchy, caste, class, age, amongst others.

As such, the issue of governance is a critical but often decentered lens in understanding sustainability transitions through the MLP [28]. Governance is understood as the result of numerous interactions among the social actors who, directly or indirectly, shape its content, interpretation, and implementation. Among others, the international experts of the International Panel of Experts

on Sustainable Food Systems (IPES-Food) identified the centrality of power as a key issue that needs to be tackled in order to unlock the large scale potential of agroecology for improved food security and nutrition [36]. Agroecology represents a shift from the status quo, and the actors who hold power within dominant regimes have a vested interest in the status quo and will actively resist agroecology, or try to appropriate the benefits of change [37].

On the other hand, proponents of a political agroecology, particularly amongst social movements, contest the forms of and power imbalance in governance that have come to underpin the dominant regime. They argue for a transformative approach that confronts the fundamental power imbalances that are at the root of the multiple crises in the food system. Rooted in a food sovereignty perspective, food producers and citizens are claiming their right to define agroecology and to claim agency in determining processes of community organization and "development" [10,38]. In this article, we use the multi-level perspective, and develop the notion of "domains of transformation" to better understand how communities can self-organize for bottom-up transformations in food systems through agroecology.

2. Our Study—Introducing Domains of Transformation

Our literature search and review focused on the academic and grey literature that examines transition in agroecology. In order to identify relevant papers, we conducted an extensive search. First, in order to cast a wide net for literature on agroecology and transitions, we conducted a keyword search in an academic database (Scopus) using keywords selected to capture papers on food system transition and agroecology ((agroecology OR agro-ecology OR agroecological) and (scaling OR systems OR transition OR transitions OR transformation OR territory OR territorial OR government OR policy OR institutional OR institution OR systematization OR massification OR spread OR spreading OR amplify OR amplification)). This search identified 2548 documents. Second, we filtered these based on the criterion that the study focuses on transitions to sustainable food systems through agroecology—implying an analysis of the process of upscaling and out-scaling agroecology over time and space in a region, territory, or country that goes beyond the producer/farm level. Next, we supplemented the retained studies by searching the web for relevant grey-literature, including publications that included a systematic approach (i.e., that provided details on their conceptual and/or methodological basis). Overall, this resulted in an initial selection of 54 studies as the starting point for our review.

To analyze this initial set of studies, three members of the research team each examined this set of papers, distilling the enabling and disabling conditions for food systems transition through agroecology. Through an iterative process (with all five team members) of collective reading, group discussion, and diagramming our emerging analysis across these studies, we developed our analysis. All members of the research team agreed with the framework resulting from the iterative process. The enabling factors (e.g., drivers) and disabling factors ('lock-ins') articulated in the papers were able to be mapped out against six emerging "domains". We then interpreted these emergent categories within the framework of niche-regime dynamics. Based on this interpretation, we developed the notion of domains of transformation: discernible sets of relationships, norms, rules and activities, where enabling and disabling dynamics emerge from niches in relation to the dominant regime (Figure 1).

Within the theoretical framework of the MLP, domains of transformation can be understood as the discrete (yet interrelated) arenas where niche and regime meet, engage in conflict and mutual contestation, and where agroecology—through transformations in governance—can gain strength over regime-driven approaches. In this context, enabling factors represent those that support communities to self-organize in ways that reflect the principles of agroecology whereas disabling factors undermine the agency of niche actors to develop agroecology or that prevent agroecology altogether.

We identified six primary domains (Figure 2) that are critical to consider in the agroecological transformations: (1) Access to Natural Ecosystems; (2) Knowledge and Culture; (3) Systems of Exchange; (4) Networks; (5) Equity; and (6) Discourse. The following sections presents each of these

domains, analyzing how their dynamics can enable or constrain agroecology transformations. Here, the treatment of each domain is succinct and illustrative, rather than exhaustive, and is meant to give a sense of the domains of transformation framework for agroecology as a whole. Subsequent publications will dive more deeply into transformation dynamics within (and between) each domain.

2.1. Domain 1: Access to Natural Ecosystems

Agroecological transformations are closely tied to food producers' need to secure and "access, control, use, and shape or configure land and physical territory consisting of communities, infrastructure, soil, water, biodiversity, air, mountains, valleys, plains, rivers, and coasts" [39]. Secure land tenure and land reform, as well as access to seeds and other elements of natural ecosystems have long shown to be vitally important for smallholder livelihoods and investment in sustainable agriculture, including agroecology [40,41], although these connections are extremely contextual and require gender- and location-specific approaches. Conversely, inadequate and insecure tenure rights for various elements of natural ecosystems increase vulnerability, hunger, and poverty, and the likelihood of conflict and environmental degradation [42] while providing little incentive for farmers, communities, and territorial networks to invest in long-term agroecological approaches.

2.1.1. Enabling Conditions

Evidence to date has indicated positive effects of secure land tenure on the growth of agroecological approaches, as well as on environmental sustainability, efficiency, equality, productivity, income stability, and poverty and hunger reduction [43–45]. However, researchers have found that only land reform that effectively redistributes socio-political power related to land and other resources betters the lives of (marginalized) agricultural producers [44,46]. In terms of suggested processes and policies to support such complex reform processes, the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security [42] provides promising guidelines. Its participatory development process and thoroughly researched proposals have been praised from multiple quarters (e.g., [47]).

The Guidelines notably emphasize the importance of "recogniz[ing] and protect[ing] all legitimate tenure rights, including customary tenure systems and legitimate customary tenure rights that are not currently protected by law" [47]. At the same time, customary tenure systems can leave in place inequalities along the lines of gender and other social divisions [48], which is why the Guidelines' suggested principles and processes incorporate multiple pathways for addressing gender inequality, and other issues, through continuous and participatory processes [42]. Specific principles of implementation of the Guidelines also include non-discrimination, equity and justice (which may require acknowledging difference between individuals and taking positive action), particularly for women, youth, and vulnerable and traditionally marginalized people), and gender equality (see Domain 5—Gender and Equity), including equal tenure rights and access to land, fisheries, and forests [42]. The Guidelines were endorsed by the Committee on World Food Security (CFS), an intergovernmental and intersectoral forum within the United Nations' system, in 2012. Although they are thus an international instrument, they have been used not only to inform global and regional efforts, but extensively within individual countries, and various subnational territories and communities [47,49]. As we will note later in this piece, the "territory" level is increasingly viewed as a key point of interface between different governance regimes and sectors. Thus, even as the Guidelines are an international instrument, many of the important spaces and opportunities it has facilitated have been at national and subnational (territorial) levels [47].

While land issues have been the most studied in this context, secure access to other natural ecosystems is also a key enabling factor for agroecology. More to the point, and in line with our emphasis on changing power relations, as part of food system transformation, it is important to examine which factors enable (or disable) access to natural ecosystems. For example, resistance to appropriative "Western" intellectual property approaches while favoring access to locally-developed

and/or traditional genetic material, open-source intellectual property regimes, and decentralized, participatory approaches to seed saving, selection, exchange, and livestock breeding can be powerful tools to support and enable agroecology. They however often go "against the grain" of dominant intellectual property and industrial farming systems and are often significantly under-resourced [50]. More broadly, approaches rooted in localized, participatory, empowered "commons" regimes offer powerful examples and models [50,51] that are particularly well-suited to the notions of cooperation and community self-organization.

Access to other important ecosystems elements for agroecology includes, but is not limited to, the right to water; ecosystem functions/synergies between wild and cultivated biodiversity; soil and soil quality; pasturelands; fisheries and forests. Here as well, empirical evidence emphasizes the importance of inclusive governance of these ecosystems and their constituent parts and functions, including strong, empowered local governance that prioritizes their interests above those of local and international elites (polycentricity), and customary and indigenous rights regimes [51,52]—though care must be taken in all cases to recognize and address existing inequalities along the lines of gender and other social divisions [47].

2.1.2. Disabling Conditions

Several regime lock-ins pose challenges to agroecological transformations within this domain. For example, in many regions existing inequality and insecurity of land access and control is significant and negatively impacts human well-being and rights necessary for agroecological transformations [53,54]. Vested interests continue to block redistributive land reform despite its documented importance [55], and ignore, marginalize, or subvert customary and collective access regimes. In addition, processes of land fragmentation and declining average farm size in most of the world's less industrialized countries over the past several decades are undermining agroecology [56]. Similarly, dynamics around the phenomenon of "land grabbing" also contribute to significant displacement and land tenure insecurity and disabling conditions for agroecology [57].

As in the enabling conditions, disabling dynamics around the control of water and other resources are quite similar to those facing land. Privatization, displacement, and dispossession of local communities, and excessive control by private interests of water, seeds, breeds, and other material elements of diversity, block the possibilities for community-self organization for agroecology in these areas, decreasing adaptability and resilience [50,58,59]. Other large-scale challenges to ecosystem access and use include armed conflict, climate change, and "financialization" of agriculture [60].

Lastly, while participatory processes such as the Guidelines [42] have great potential as enabling factors for tenure security and thus agroecology, the ability to use such participatory, bottom-up processes varies immensely from place to place, and are under threat in many locations from current political tides [61]. Participatory forums at the global food governance level, such as the Civil Society and Indigenous Peoples Mechanism (CSM) of the Committee on World Food Security face dynamics that decrease participation, popular sovereignty, and the realization of human rights—all disabling factors for agroecological transformations based on community self-organization.

2.2. Domain 2: Knowledge and Culture

In light of agroecology's knowledge-intensive nature, the way that knowledge is constructed, produced, shared, and mobilized is a critical domain in agroecology transformations, [62]. Knowledge and power are intimately linked. Whose knowledges are enabled and valued within socio-technological systems—and who are acknowledged as valid holders and producers of knowledge—shapes the potential of transformations in agroecology. Struggles over knowledge play out across the related areas of research, innovation, education, learning, as well as in agroecological practices and policies.

2.2.1. Enabling Conditions

Agroecological systems are highly diverse, reflecting their economic, ecological, social, and cultural contexts and require intimate, place-based, lived knowledge and wisdom. This knowledge is embodied and reproduced through the traditions, culture, and practices of food producers and indigenous peoples and has developed over time through dialectical human–nature relationships [63]. Knowledge processes that respect and harness the knowledge of farmers, indigenous peoples, and other food producers—and especially the knowledge of women—are essential for agroecology transformations [20,64]. Efforts to sustain and regenerate traditional knowledge systems—including language and practices, ceremonies, oral traditions, and intergenerational elder-youth relations—are critically important.

Supportive dynamics and conditions for the development of agroecological knowledge often exist outside of formal (educational) institutions in the networks, communities, and organizations of food producers. Horizontal processes of adult learning amongst food producers, often at a territorial level, have been central to the spread of agroecology [65–67]. Perhaps the most well-known example is the Paulo Freire-inspired farmer to farmer (campesino-a-campesino, CaC) methodology that originated in the 1980s in Central America. This approach is highly effective, not only in disseminating knowledge, but in enabling farmers to build skills, organizational capacity, and agency in self-catalyzing processes of community mobilization [68]. These horizontal processes can have an intentionally multi-scalar character (e.g., spread from one locality to another and from the local to the international level). For example, La Via Campesina has been developing and systematizing social learning processes, including agroecology schools, in and between different territories and regions of the world [69,70].

Science and research institutions and professionals have been found to be most enabling of agroecology when they are respectful of local, traditional, and indigenous knowledges and are guided by the needs and aspiration of food producers. A growing body of literature charts how participatory and transdisciplinary research approaches [71–73] succeed when they shift power away from professional experts, integrate different knowledges and ways of knowing, and involve strong participation of participants in research processes [74] and in the governance of research [73]. This approach has implications in the area of education, research, and extension with longstanding examples in the use of farmer field schools [75], citizen science, participatory action research, and other forms of participatory research approaches [65,71].

2.2.2. Disabling Conditions

The way knowledge is conceived, produced, and distributed in formal institutions tends to prevent agroecology from flourishing [76]. Research, extension, and education in the dominant regime is characterized by centralized, de-contextualized knowledge production and technology transfer biased towards the knowledge of professionals in the global north [77], profit-led research agendas, reductionist knowledge, and a top-down technology transfer approach [76,78] that undermines alternative knowledges and ways of knowing [39,73].

Science-related policies are largely oriented towards growth and national competitiveness, while in many countries, public sector agricultural research and extension has been substantially scaled back leaving innovation processes largely in the hands of multinational companies. It is often the commercial (productive) potential of knowledge, practices, and innovations that determine their access to support and validation. For example, investment in research on agroecology represents less than one percent of all institutional agricultural research and development in the USA [79]. Agricultural research agendas largely serve high-external input and technology intensive agriculture to market new technologies. The ongoing privatization of research reinforces these trends, along with intellectual property rights that favor private sector research and development including on patents, thereby undermining plant and livestock breeders' rights. These dynamics are tied closely to the imposition and subsidization of agricultural packages that foster economic and material dependence on external knowledge, technology and inputs, undermining the autonomy of producers.

Reductionist approaches focused on indicators, typically used to evaluate and monitor progress in agriculture, are not appropriate for the holistic nature and complex interactions of agroecology, its political-cultural outcomes and its multifunctional benefits [36,80]. They thus serve to further delegitimize agroecological alternatives rooted in community self-organizing. The application of universal production standards (for example in organic certification and regulation) is another example that further erases both diversity and local context and knowledge [81], and can thereby undermine agroecology.

The invalidation and marginalization of local, non-expert, and non-scientific ways of knowing (see also below in domain Discourse) reflect a more deeply rooted coloniality of knowledge where non-western, traditional, and women's knowledge are othered, devalued and in some cases have been systematically erased through waves of epistemicide [82]. This forms a part of what has been referred to as cognitive injustice [83] where modern development has been especially blind to, and damaging of, the knowledge and lives of indigenous peoples, women, and other marginalized actors [63]. Giraldo and Rosset [35] argue how ongoing agricultural 'development' approaches—largely led by actors in the global north and including in the name of 'sustainable agriculture'—continue to dehumanize and disempower communities as targets for expert knowledge and elite, external management.

Finally, agricultural modernization has not only transformed production, but also the associated cognitive frameworks and cultural dynamics of food producers and communities. Decades of dominant, western-science-corporate-led development have depleted traditional ecological knowledge and practice in communities and tied food producers and food eaters into dependency. This transformation cannot be simply addressed through 'micro-' processes of participatory research and development (see examples in Guatemala [84] and in Brazil [85] for analyses of these dynamics). In this context, work in the knowledge domain needs to be connected to a much wider process to confront the material, cultural, and spiritual legacies of colonialism [86].

2.3. Domain 3: Systems of Exchange

Systems of exchange in food systems include the systems and processes by which: (a) agricultural products move from producers to the various users and consumers of these products; (b) the ways food producers acquire production inputs. The existence of appropriate and robust systems of exchange, including different types of markets [21], state provisioning, barter, gifts, and self-provisioning, are all important enablers of agroecology. The extent to which these systems of exchange are accessible, fair, profitable, and fulfilling for food producers is critical for the agroecological transformations. Longstanding traditional systems of exchange and the creative construction of newer "alternative food systems", relations and networks represent a key opportunity for enabling agroecological transformations [87]. Conversely, global food markets, and how they are conceptualized, supported, and 'developed' in the dominant regime, pose a considerable challenge for agroecology.

2.3.1. Enabling Conditions

Agroecology as a polycultural system produces a diverse and nutritious dietary offering [88]. Diverse agroecological production requires systems of exchange that are compatible with diverse, small volume, and locally adapted production and diets. Thus, traditional systems of exchange (e.g., informal markets, barter systems, gifting, and family/self-provisioning) that have evolved alongside the trajectories of traditional communities, ecosystems, and culture are, although undervalued, well suited for enabling agroecological food systems [89]. At the same time, new markets, networks, and economic processes can enable agroecology when they are embedded in local territories, allow for local self-determination and meet the material needs of food producers [90,91].

In addition to the "downstream" side of systems of exchange (i.e., to move goods from producers through to users/consumers), agroecology also requires appropriate upstream systems of exchange so farmers have access to inputs they cannot derive on-farm. This requires a dynamic interdependence within and between territories to exchange inputs including seeds, breeding stock, feed, labor, nutrients,

and tools. These systems of exchange can consist of formal market-based mechanisms, or as importantly, informal relations.

Whether 'upstream' or 'downstream', agroecology is best supported through what has been referred to as "nested" markets: those that emerge from and are constantly re-embedded in democratic social relations [91]. These avoid trading with profiteering intermediaries or "middlemen" and instead value the ecological, social, economic, and political functions and outputs of agroecology that are externalized in price-driven markets. Nested markets also help to thicken networks of solidarity and relations of reciprocity in territories, including between farmers and consumers, between the rural and the urban. Nested markets are spaces where not only products but also cultural traditions, ideas, visions, and knowledge are exchanged [21,91], making agroecology socio-economically and politically viable.

Labelling has been promoted as a mechanism for upscaling and securing markets for 'sustainable' food. While third party labels and certificates have indeed provided important support for the scaling up of different approaches to sustainability in agriculture (e.g., organic agriculture, fair trade), the mechanism is contested. Problems often arise related to the cost for producers to participate in certification schemes, dependency on externally agreed standards, and the locking out of farmers who choose another transition path. Universal labels and standards can serve to de-territorialize production and to reduce citizens to passive consumers in food systems (all they can do is trust a label and buy products, rather than to engage, discern, and participate in the construction of territorial food systems). Labels have some role to play, but a critical question is: Who is responsible for the process of developing, implementing, and controlling standards and who decides which standards are helpful and necessary [92] (p. 17).

One of the alternative, promising initiatives is the development of participatory guarantee systems (PGS); local quality assurance systems, where groups of food producers and food eaters agree on production methods, standards, and processes to self-certify, through democratic processes, in some cases in collaboration with consumers [93,94]. While PGS are relatively new and various issues are yet to be resolved, PGS can challenge the assumptions that underlie third party certification and labelling, such as the prioritization of export-oriented production and the idea that only formally trained experts can make valid assessments of quality.

2.3.2. Disabling Conditions

Mainstream food markets generally favor large volumes and standardization, reinforced by policies that emphasize economies of scale, strategic export commodities, and integration into global value chains, which many small-scale farmers cannot (or opt not to) engage in [36,95]. Following the diversity inherent to agroecology, producers using agroecological approaches rarely produce sufficient quantities or uniformity of single agricultural products to solely participate in export markets and global value chains. Efforts to make global value chains more "inclusive" correspondingly tend to benefit only a small number of farmers worldwide, 10% at most, who are well off, educated, strongly oriented toward commercial agriculture, and close to urban areas and to infrastructure [96]. Similarly, international trade has mainly benefited wealthy consumers in high-income countries, while marginalized communities in low-income countries who continue to be unable to afford the diversity available on global markets [97].

Concentration and consolidation of agricultural input markets block agroecological transformations and have been called "one of the most pressing concerns" related to the industrialization of agriculture [98]. Market concentration allows large corporations to make significant profits, while pushing farmers into growing resource-intensive, environmentally destructive monocultures for very low farmgate prices (often below production cost), provoking a cycle of debt, consolidation, and industrialization that does not allow for transition [99,100]. Aided by external input subsidy schemes (e.g., for fertilizer), this dynamic has been repeatedly and empirically observed in farmers'

accelerated and broadened use of fertilizers, pesticides, commercial seeds, non-locally adapted livestock genetics, and imported feed.

2.4. Domain 4: Networks

Multi-actor networks are pivotal in strengthening community self-organization for agroecology. Knowledge, markets, discourse, inclusivity, and production practices in agroecology are all developed through networking and social organization. Indeed, the depth and degree of social organization in networks is key for bringing agroecology to scale [21]. Formal and informal networks for agroecology exist in various forms, such as community supported agriculture or collaborations between groups of agricultural producers and researchers [73].

2.4.1. Enabling Conditions

By mediating collective action and community self-organizing, networks: (i) enable the local adaptive management of multifunctional agroecosystems and landscapes; (ii) coordinate human skills, knowledge and labor to generate wealth and economic exchanges in food systems; and (iii) support the local governance of food systems as well as coordinated action for policy and institutional change at multiple scales [101,102]. The interaction between networks of local organizations create polycentric institutional webs that provide the basis for decentralized governance in and between territories [102,103].

Strong networks for agroecology tend to emerge first as loose, 'endogenous' collaborations for the purpose of isolated experiments, later moving on to serve to aggregate generic lessons from experiments, after which relatively stable networks form. The latter often bring together knowledge from local initiatives and also the participation of some 'external' actors. In agroecology, most networks are driven by civil society actors, such as producer organizations, communities, and social movements. Allies from government, academia, or other sectors often step in to strengthen these networks at a later stage. For example, in Colombia, the inclusion of actors at territorial and national levels (ranging from individual farming families, farmers' associations, supportive Non-Governmental Organizations (NGOs), donors, researchers, and government entities) in aggregating, circulating, and applying generic lessons, was key to effectively help advance agroecology and family farming [24]. Similarly, at the global level, the Nyéléni network brings together a diverse range of food producers, consumer constituencies, and academics around the promotion of agroecology and food sovereignty (see www.foodsovereignty.org).

Involving relative outsiders in a process of social organization can increase the resources available to actors within and between communities (e.g., knowledge, access to other networks, political influence, and finance) [24,36,39]. In turn, this increases the influence of the agroecological niche and its capacity to replicate generic lessons more widely. State actors can be important to include at some point of maturity of a network, especially officials who are favorable to agroecology [24]. However, linking up with public and private sector actors such as those empowered by the dominant regime poses risks. Their agendas and priorities can change the nature of agroecological niche innovations and the endogeneity of networks, thereby marginalizing niche actors and moving away from self-organization. Inclusion of new actors must therefore be done in a way that avoids dependencies which undermine autonomous, long-term, genuine transformation processes in agroecology [21,104,105]. The question of equity related to class, gender, caste, religious, or race divisions also comes to the fore here, as any network needs to decide which actors are allowed "in" or "out" (see below under domain Equity).

Favorable policy arrangements can promote institutional collaboration between state and non-state actors to advance agroecology, prioritizing local needs, community ownership, and territory-based governance [106]. Such policy development for social organization should be based on broad participation that reaches across constituencies, bringing together agriculture, health, environment, and other actors with a stake in food systems [107]. Doing this effectively requires the mobilization of public resources [78].

2.4.2. Disabling Conditions

In many places however, agroecological transformations are limited because regime lock-ins undermine or weaken local organizations and networks for collective action. The dominant regime's interrelated market incentives and policies [36] lock many farmers into individual path-dependencies towards large scale, high-external input dependent agriculture [108,109]. There are also countries where the political context is outright hostile to dissenting social organization and community empowerment. For example, in Uganda, civil society organizations historically have limited capacity or space for political organizing. They fear consequences like deregistration, harassment, and arrest of advocates of agroecology and democratization [23].

Another key barrier to developing effective multidisciplinary and multi-actor networks for agroecology is the compartmentalization of different aspects of the food system in practice, research, and policy. Many institutions and organizations seeking change have been focusing on specific sectors or food system aspects (e.g., technology, seeds, markets, natural ecosystems and functions, health, production, consumption etc.), losing sight of the holistic approach that is at the heart of agroecology. Thus, silos are also created between different approaches and actor groups. For example, some producer organizations take a narrow approach by spreading agroecological production practices while consumer organizations and NGOs tend to emphasize a single issue such as public health. Within agricultural organizations, a strong sectoral focus embedded in highly specialized production can also prevent networking between farmers who produce different products—a requirement for the spread of agroecology. Similarly, scientific networks and producer organizations have difficulty in linking effectively in joint knowledge building. Synergies are often lacking between sectoral policy departments, for example, those related to agriculture, fisheries, forestry, education, health, water and the environment, which equally implies missed opportunities (and, sometimes, obstacles) for effective community self-organization and networking. This hampers integrated and transformative approaches to agroecology and food systems [108].

2.5. Domain 5: Equity

Dynamics of marginalization and inequality, from international policy arenas to the household level, and along the intersecting dimensions of gender, age, class and caste, religion, health, and race, pose a major barrier to the development of sustainable food systems [110]. Since agroecology develops mostly through networking and community self-organizing, as we have seen above, addressing equity at multiple levels is crucial. Gender inequity is a particularly critical barrier in agroecology transformations. Women generally have less access to productive resources and decision making, while still being disproportionately responsible for the household, caretaking, and agricultural tasks. Gender also intersects with almost all other forms of inequity [111]. This section will thus first examine gender equity's connections to agroecology, followed by other forms of equity.

2.5.1. Enabling Conditions

Women often play crucial roles in agroecology as in many communities, they are the guardians of seeds and local breeds, with specialized knowledge and skills for preserving and using them for food, feed, spiritual and medicinal purposes; and they often bring holistic and nutrition-centered views that combine economic, health, environmental, and social needs [64]. Studies have shown that improved gender equality and a stronger position of women can therefore be a driver of improved nutrition outcomes, increased use of diversity, and other aspects of agroecology [88,110,112].

At the same time, since norms and perceptions that shape gender relations evolve jointly with changes in the production system [113], agroecology itself can be an instrument for gender equity and women's self-empowerment. This emancipatory potential is tied to agroecology's emphasis on local and diversified knowledge, skills, and tasks; input-independence; and co-creation. Women's participation in decision making at the household and community level is often both an essential

prerequisite for and a result of agroecological innovation. Thus, agroecology can provide spaces for women and men to work in solidarity and improve equality in decision-making, livelihoods, income, and agency [64,114,115]. A virtuous cycle can be created in which improved gender equity strengthens agroecology, and agroecological approaches strengthen gender equity.

Nevertheless, agroecology does not change gender relations by itself and much of agroecology does not explicitly address how patriarchy and other forms of gender-based inequality can undermine a socially just process of transformation [116]. Explicit efforts must be made to value women's work, empower them politically and address socially constructed gender roles. For agroecology to contribute to gender equity, deliberate, contextualized action and appropriate accompanying interventions are needed, such as women's self-organization, improved access to resources, and education around both agroecological practices and sociopolitical equity [117–119]. Calls are made for governments to support agroecology by prioritizing the implementation of the recommendation on the rights of women living in rural areas made by the UN, including their rights to participate and benefit from rural development, rights to health, education, employment, economic, social and public life, protection from violence, and rights to land and other ecosystem elements [120]. Studies on initiatives that were successful in transforming gender relations in agrifood systems show the key role of iterative, dialogue-based, and women-led experimentation with agroecological practices such as diversification, intercropping, nutrition education, and marketing innovations [100,114,116]. They have developed a useful set of indicators allowing critical analysis of existing gender inequalities and the identification of pathways to reinforce women's empowerment through agroecology to support more equitable roles.

As with gender, agroecological approaches can also contribute to addressing other kinds of inequitable social relations. Measures such as those listed by Mora and De Muro [111] help reinforce such a virtuous cycle, including: a greater emphasis on inclusive, people-centered development; better policy monitoring and implementation; decentralization, greater participation and investment in those who are marginalized and excluded; strengthening local capacity, accountability, and transparency of governments; and stronger governance and implementation of the rule of law at all levels. Indeed, the importance of democratic formal and informal institutions to promote equity in agroecological transformations cannot be underestimated. Agroecology and anti-hunger research share a focus on addressing the underlying causes of inequity, and point at the need for transformational changes, including in relation to governance [100,111,121,122]. Over 160 cities around the world have made promising commitments along these lines as part of the Milan Urban Food Policy Pact.

2.5.2. Disabling Conditions

The dominant agricultural development model is "largely gender blind, patriarchal, and indifferent to human rights, including women's rights" [118] as it ignores and undermines the important roles, knowledge, and perspectives of women and other systematically marginalized actors in agriculture and rural communities. Moreover, continued focus on commercialization and large-scale export-oriented agriculture has in some cases led to men migrating to urban areas to find work, increasing the pressure on women caring for their families' health and food security [123]. Intersecting inequities with rurality, peasant status, caste, class, religion, and gender, along with aggressive large-scale land acquisitions worldwide and rising food prices have in many places increased rural women's food insecurity even further. Policy blindness to these inequities and related attitudes support and maintain conditions of inequality and patriarchy [124] within and between communities.

Such persistent inequity, particularly around gender, can become a major disabling condition for community self-organizing processes that drive agroecology transformations (e.g., as reported in [114]). For example, in the Sahel strong correlations have been found between gender inequity and the use of agro-chemical inputs [125], reiterating the ample body of research finding that dominant "Green Revolution"-type approaches have maintained or increased disadvantages for poor (women) farmers and other marginalized groups [126–128]. And in numerous countries, the effective participation of women in agroecological innovation processes has been blocked in a variety of ways, including through

violence—from the symbolic to the psychological and the physical [119]. A virtuous interaction between the agroecological movement and the feminist movement is essential to "de-normalize" gender inequity, as can be seen in Brazil [129].

2.6. Domain 6: Discourse

Discourse, or the ways in which language is used to frame debates, policy, and action, can help or hinder processes of community-self organization and is a critical domain for agroecology transformations [21,35]. Discourse is, for instance, integral to efforts to raise awareness of the validity of different forms of knowledge for research and policy processes [130,131]. These related knowledge processes were outlined in the knowledge and culture domain section of this paper and are closely linked in a broader process of the politics of knowledge of agroecology. However, whereas the section on knowledge and culture focuses on processes of knowledge production and mobilization, this section on discourses examines the discursive frames that are being used to characterize and delimit agroecology and are based in particular political aspirations [132]. In this role, discourse is used as a powerful mobilizing tool for targeted, collective political action in policy arenas, seeking to prioritize particular transition pathways to sustainable food systems, and to undermine others [31,130].

Discourse, knowledge, and power are intimately connected [132]. This means that collective actors, with different positions and power, are drawing on and enacting their power in the negotiation of different discursive framings of agroecology [31,133–135]. There are a number of social actors who play a key role in shaping discourse on agroecology including civil society, governments, Food and Agriculture Organization of the United Nations (FAO) and other multilateral institutions, researchers, media, and the private sector. Thus, although agroecology increasingly constitutes a federating concept for a diversity of these actors, there exist multiple, competing, interpretations of what agroecology is [10,11,134,135].

Actors use a process called 'framing' to convey their interpretation of agroecology where they 'simplify and condense' the complexity of this form of agriculture to emphasize key characteristics that align with their own sensibilities [136]. In order to generate frames, actors selectively draw on and interpret agroecology through their own cultural values, beliefs, and ideologies [137,138]. Frames, therefore, reflect the ideological positions of the actors who create them [136,138]. In this sense, culture is one factor that shapes the emergence of frames. Inversely, new frames can also transform culture when they become widely accepted and acquire cultural legitimacy [136,137].

Given the dynamic and contested framing of agroecology, discourse on agroecology is in constant flux, and these fluid framing processes influence the direction of the agroecological transition, and the capacity of communities to self-organize and shape agroecological transformations [136,137]. The following section outlines some of the enabling and disabling discursive frames for political agroecology and detail the roles of collective actors who utilize them. Perhaps unsurprisingly, it is the frames that explicitly emphasize the agency of communities and food producers as well as the resonance of agroecology with local cultures that are enabling of agroecology.

2.6.1. Enabling Discourse

There are various frames that are supportive of agroecological transformations. First, drawing on local cultural practices, worldviews, and spiritual traditions, social movements [21,139–141], researchers [142], and governments [143,144] have succeeded in mobilizing support for agroecology, presenting it as a culturally appropriate, place-based form of agriculture and food provisioning. This is often accomplished via framings that align agroecology with alternative culturally specific worldviews such as Buen Vivir embraced by indigenous communities in Latin America.

Next, holism is another supportive frame for agroecology. It presents agroecology as a holistic approach that breaks free from sectoral thinking, both within agriculture and in terms of connections with other sectors, such as the environment, food, public health, economy, and social rights, making it the appropriate strategy to address the complex, multiple crises in the world [10,145,146]. In France,

following pressure by civil society organizations, government discourse on agroecology shifted from the 'double' to the 'triple' performance of agriculture, recognizing that beyond its environmental and economic advantages, agroecology is also beneficial to society at large [146].

Third, valuing the role of family farmers and other small-scale food producers in agriculture has been another important frame for agroecology. In this case, institutions and actors recognize family farming, small-scale production, pastoralism, and artisanal fisheries as legitimate, valuable, and viable modes of production [24,147,148]. In Brazil social movement mobilization led to the official recognition of family farming and a subsequent discourse that strongly associated agroecology with family farming [146].

Fourth, a discursive frame that promotes greater participation of different social actors and local communities in shaping the transition to sustainable food systems has been important in some places. The participation frame has helped to amplify the governance dimension of agroecology, and in some cases (e.g., Brazil) has helped to gain significant popular and institutional uptake of agroecology [71,149–152].

Finally, discourse around food sovereignty, autonomy, and rights-based approaches to food and agriculture constitute three key related frames which mainly social movements, but also researchers, states, and intergovernmental organizations, have emphasized towards a wider adoption of agroecology [16,83,102,153,154]. These frames, when used to legitimize and promote agroecology, tend to enable agroecological transformations which foster community self-organization and deepen the radical and political character of agroecology. The successful campaign led by international civil society organizations on the recognition of peasants' rights, adopted by the UN Declaration on the Rights of Peasants, is one illustration of the powerful impact community self-organization can have on framing agroecological transformations.

Discursive processes are an important component of community self-organization in agroecological transformations. When social movements and networks engage in internal debates on the meaning of agroecology, their sequential rounds of sense-making are conducive to the articulation of coherent frames as well as the emergence of new frames [138,154]. These collectively produced frames therefore constitute the discursive packaging of a shared understanding of agroecology by a set of collective actors at a particular time. For instance, in February 2015, the International Forum on Agroecology was organized by social movements to articulate a common vision of an agroecology that is defined and controlled by the people. The resulting declaration thus, "represents the first joint vision of Agroecology from the shared viewpoints of all kinds of small-scale food producing peoples, seen from the perspectives of our social movements" [10]. The event opened a discursive space for dialogue to collectively interpret the meaning of agroecology from the perspective of multiple grassroots constituents [155]. In this context, framing can support community self-organization by mobilizing consensus to enable and sustain ongoing collective action with greater scale and scope of efficacy [20,21,134,135,138]. At the same time, new frames also emerge as a result of contestation between collectives with distinct or opposing interpretations of agroecology shaped by different cultural ideologies, worldviews, and political agendas, seeking distinct policy outcomes [135,136,138].

2.6.2. Disabling Discourse

Several discursive frames are serving to block, constrain or depoliticize agroecology. They maintain existing power relations by de-emphasizing or undermining the agency of communities and food producers. Often underpinned by an alarmist discourse on population growth, hunger, and climate change, powerful frames around the need to 'feed the world' solidify a singular emphasis on productivity [36,144,156,157].

In recognition of the ecological imperative to address the multiple crises of the food system, these frames have recently been infused with a discourse on sustainability inspired by revised versions of ecological modernization [135,158]. This forms the basis of calls for high-tech approaches such as sustainable intensification and climate-smart agriculture [134]. Often deployed by the private sector,

scientists, governments, and multilateral organizations, they obscure the wider social, cultural, political, and spatial dimensions of food and agriculture which are at the heart of agroecology [36,156,157]. Instead, these frames reinforce policies that promote technological solutions and global free trade to increase food production and improve nutrition, thereby helping to keep the dominant regime in place [36,157].

Compartmentalized frames that diagnose food system problems in simplistic or reductionist terms constitute additional barriers to scaling agroecology. Presenting malnutrition as a pathological health issue, for example, while ignoring deeper connections between public health, agricultural sustainability, ecosystem health, and democratic participation, is indicative of such a discourse [34]. Fragmented departments in government, academia, and civil society can reinforce compartmentalized visions and discourses [71].

Finally, discursive frames that trivialize smallholders and agroecology can disempower and demobilize social actors, in particular agricultural producers and rural communities, preventing them from launching or expanding agroecological experiments—or from engaging in agriculture at all. Such discursive frames often attribute peasants, traditional rural communities, and traditional forms of agriculture with qualifiers such as 'poor', 'backwards', 'ugly', 'low quality', 'inefficient', and 'unproductive' [154,159], while presenting large-scale producers and industrial forms of agriculture as 'modern', 'productive', 'tidy', and representative of 'good' farming [160,161].

3. Discussion—Shifting Governance across Domains of Transformation: Towards Community Self-Organization

Using the multi-level perspective, we evaluated the enabling and disabling conditions for agroecological transformations. From our analysis within each domain, important questions emerged related to governance processes in agroecological transformations: Which actors are involved? Who has the final control over decision-making processes? Whose perspectives, knowledge, values, and aspirations are embedded in governance, and whose are excluded? Where is 'governance-making' actually taking place? Through which avenues can governance be improved? Whose interests are served and is someone held accountable? These questions shift attention from an analysis of governance per se (where one would ask questions such as: Is governance addressing the relevant issues? Is governance good or misguided?) to the analysis of the actual governance process.

Indeed, governance and power emerged as critical elements in all of the domains and represent a 'sticky' and omnipresent dynamic that will ultimately determine to what extent agroecology will follow a transformative pathway based on processes of community self-organization or one that approximates the power relations, politics, and governance structure of the current dominant regime, which is generally dominated by elite and corporate governance processes. Within each of the domains, the issue of governance emerges as the critical determinant of the nature and strength of agroecology transformations and especially the extent to which food producers and their communities (urban and rural) can develop and reap the multifunctional benefits of agroecology. Governance determines how agroecology amplification is supported and strengthened across sectors, regions, countries as well as its alignment (or not) with wider food, water, energy, trade, and environmental policies.

Each domain of transformation (Figure 2) is shaped by the complex interactions among people and structures that determine how and by whom power is exercised—how decisions are taken and where. Given the often contested pathways and end goals of agroecological transformations, governance processes have to cover issues of equity and efficiency of the allocation and distribution of resources (land, water, genetic resources . . .) and agricultural subsidies; the formulation, establishment, and implementation of food and agricultural policies, legislation and institutions, including for research. Furthermore, advancing agroecology is as much about removing disabling conditions in each domain as it is about enabling them. These decisions are never purely technical nor value neutral. They are fundamentally political choices because 'governance' sets the rules, access rights, economic tools, and accountability mechanisms for all actors involved. These processes determine to what extent

communities can "self-organize" and to what extent the choices available to communities are limited by actors, structures, and processes that are beyond the agency and influence of communities.

The forms of governance that prevail in each of the domains vary from place to place, depending on culture, history, and the balance of social forces in a particular context. In general, however, it is to be expected that both the form and content of governance in a dominant regime will reflect and reinforce the interests of the powerful—be they political parties, elite groups in control of government, influential transnational corporations, or global financial investors. For example, large multinational corporations that increasingly control different links of the global food system (e.g., seeds, livestock and fish stocks, agri-chemical inputs, machinery and tools, food processing, distribution and retail) exert a disproportionate influence on the choice of policies, research, institutions, discourses, markets, and technologies to be promoted [60].

Moreover, the wider social and cultural context—as well as formal and informal rules of power—shapes and conditions any governance system and thus the possibilities for community self-organization in agroecology. Most notably, prevailing normative views on the roles of women, youth, and different ethnic groups deeply influence the extent to which governance processes are inclusive and socially just. For instance, the same discriminatory social and cultural practices that work against women and sustain male privilege in wider patriarchal societies are manifest or latent within governance structures. Women or people from lower castes or ethnic backgrounds often find that rules, norms, cultures, and traditions are heavily biased against them in these governance processes because they have been historically structured around the physical needs, capabilities, and the political interests of men and historically privileged actors (e.g., high caste) who designed them in the first place [162,163]. Many of these aspects constrain the potential for equitable participation in the governance of agroecological transformations (see section on: Domain 5: Equity). Thus, even when 'communities' gain agency to self-organize, if the multiple intersecting dimensions of inequity are not confronted, any benefits within a community will likely follow the same contours of power and privilege. All these dimensions of power and governance permeate and shape the six domains of transformation discussed in this paper. Taking a critical perspective on issues of agency and power is imperative if communities are to gain the ability to self-organize through agroecological transformations.

The territory is increasingly argued to be the decisive level for fostering agroecological transformations (e.g., [164]), being the place and the scale at which actors, new practices, and political agency come together in an intersectoral way and where food producers' strategies can most directly interact with state policies [95]. In the territory, actors are able to work collectively through wider processes of self-organization and can mobilize their agency to shift the rules of the game, to reform institutions, build markets, and foster innovation [107]. The territory is an important point of interface between the top-down provisioning by government programs and investment and the democratic expression of the needs, aspirations, and demands of citizens—and where these two can become blurred through a deepening of democracy and a decentralization of power and governance. Importantly, a territorial approach also allows for cross-sectoral and more holistic perspectives that take into account the interlinkages between the three dimensions of sustainable development (social, economic, environmental). It also emphasizes orientating support structures and resources towards the specificities of place [165] and increases the potential to build and mobilize territorial capital and mechanisms [166] to further catalyze agroecological transformation.

Transition is far more likely in areas where an integrated and holistic approach allows farmers to see beyond their own farm boundaries and that enables learning about how individual land-use decisions are interconnected with dynamics at a landscape level [167]. Indeed, the territorial approach is especially critical in this regard because agroecology is based on ecosystem functions (e.g., pollination, wildlife habitat, watershed management) that are mobilized on a scale exceeding that of the farm or any single parcel of land [117]. Local interactions and collaboration on ecosystem functions between agricultural producers, and other land users in a territory are viewed as key to adequately developing the spatial distribution of agricultural and non-agricultural land use in the landscape. At the territorial

level, actors are able to work collectively and to mobilize their agency to shift the rules of the game, to reform institutions, build markets, and foster innovation [168]. As discussed in the section about the systems of exchange domain above, agroecology emphasizes the localized processing and distribution of foods, where foodstuffs produced via agroecological methods are often ill-suited for undifferentiated export markets and thus undervalued. This situation requires the development of territorial and interterritorial food processing facilities (mills, local abattoirs, community food processing units . . .), distribution mechanisms and markets for agroecologically produced goods.

New territorial institutions and policy are also important to support the territorial approach [78,117,164], in particular new grassroots and alternative institutions that transcend existing regional boundaries. Experiments with new institutional arrangements in existing agroecological innovation niches, such as food policy councils, are providing exemplary developments where territorially based organizations are carving out new strategic roles. For example, bio-districts in Italy are convening multiple stakeholders in a territorial space to advance the local management of natural ecosystems based on the principles of organic agriculture [169]. These new governance initiatives aim to strengthen the inter-linkages between territorial actors, such as farmers, consumers, the touristic sector, municipalities, regional parks, and other local associations to improve local economic, social, and ecological conditions. There are now dozens of bio-districts in Italy, each emphasizing and valorizing particular place-based cultures and mobilizing territorial capital to provide new employment and livelihood opportunities, improve ecological conditions of the landscape, attract people to rural areas, foster the production of territorial (often traditional) products, and enhance biological and cultural diversity. These new institutions and grassroots networks are fundamental to the "thickening" or intensification [78] of territorial connections, relations, and practices, within the context of a multi-scale governance framework (Figure 3).

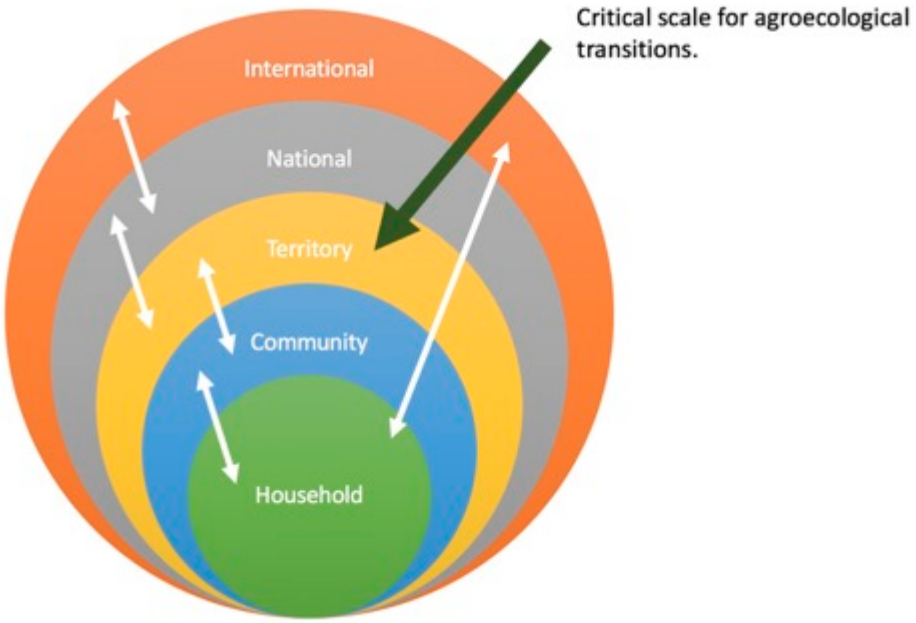

Figure 3. Agroecology should be considered within a multi-scalar governance framework that examines the dynamic relationship between actors, institutions, systems, practices, and policies across household, community, territorial, national, and international scales. At the same time, there is growing evidence of the primacy of the territorial scale for successful agroecological transformations.

In this regard, policy made at other levels (e.g., national, international) should strongly consider the potential for subsidiarity where regulations, laws, guidance, and resources are arranged to enable actors in territories to make decisions on their own agroecological development strategies. For example,

the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests, while formulated at an international level, advocate for local, culturally appropriate decision making.

Finally, it is important to reiterate the complementarity between the domains of transitions. When processes of community self-organization within multiple domains of transformation start to overlap and become 'tied', the opportunities for wider transformation—in a locale, territory, or a country—are amplified. Figure 4 visualizes how the strengthening of community self-organization within the six domains mutually reinforce each other to support the development of agroecological practices and further the transformation of the wider system.

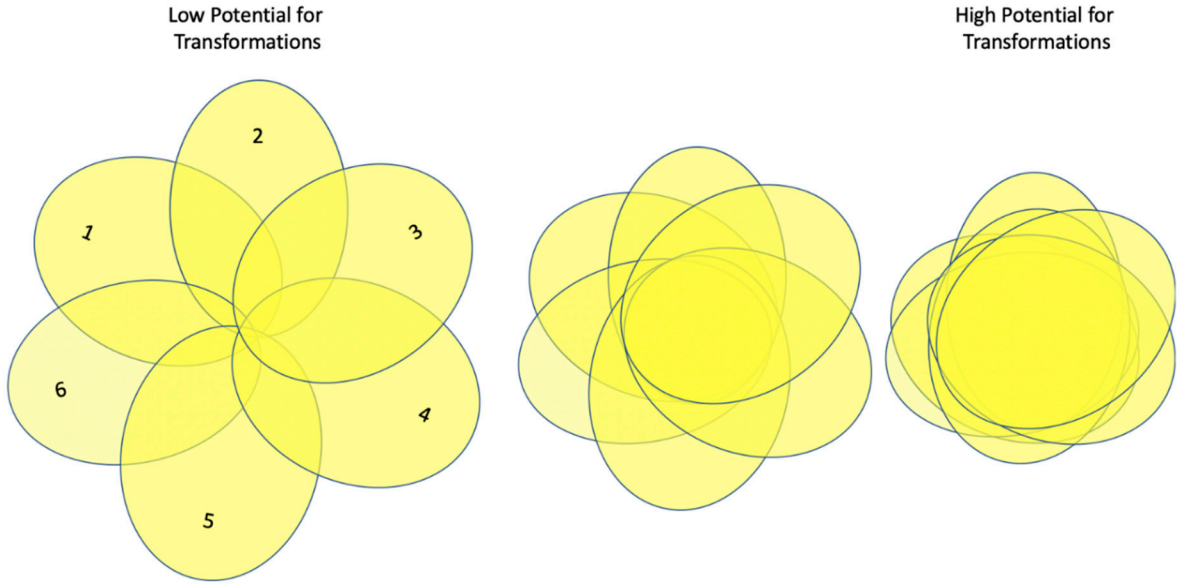

Figure 4. Each of the circles represents a domain of transformation. On the **left** side, the small overlapping space between domains reflects a situation of largely disabling conditions for agroecology. As domains start to overlap and enabling conditions in each domain become more robust and aligned, a greater potential for durable, widespread and deep agroecological transformation ensues (**right**).

4. Conclusions

This paper reviewed the emerging literature on agroecology using (and contributing to) the multi-level perspective on sustainability transitions to better understand how agroecology can be advanced, amplified, scaled up and out through processes of community self-organization rather than top-down elite-driven development. Other studies have largely focused on either the enabling factors/drivers [21] of agroecology or on the disabling factors. Our approach sought to present a framework that is suited for considering these simultaneously in the interface between niche and regime. Further, there have been previous attempts to examine these dynamics within a particular area—for example, Ingram [29] focuses on niche-regime dynamics particularly related to knowledge in agroecology. In contrast, our approach emphasized the simultaneous and synergistic transformations in and across multiple domains. In this way, we conclude that it is essential that intentional processes of agroecological transformations not reduce action to singular domains—such as, for example, creating new markets (a common refrain)—but to consider and support transformations at the intersection of these multiple domains.

Our analysis presents governance—and particularly power imbalances and deficits in democracy—as the key determining factor for transformation across these domains. While agroecology can be advanced through technical means, that would lend itself towards transition processes that leave existing (uneven) power relations intact. Our approach rather concentrates on transformative approaches that put inclusive community-led governance processes at the center. Indeed, where

agroecology has gained traction, it has been in territories where food producers and citizens were able to gain agency in governance across many of these domains [106].

Indeed, as we have seen as agroecology transformations emerge through processes of community self-organization in territories and through the collective agency of food producers and their allies. Thus policy to support agroecology should focus on enhancing endogenous steering of agroecology transformations, or steering from within. Such steering should involve participatory governance processes and can mean a range of actions by agroecological networks, including, for example, adding a new actor, a specific learning process, new linkages, policy-work, or a set of experiments [170]. These actions can take place at multiple scales (e.g., local, territorial, national) and should align with the particularities of place and scale. To support the realization of the transformative vision of agroecology, governments cannot create, insert, control, or manage "niches" in a top–down fashion, as is sometimes assumed, but they can help to open space for experimentation and consider the different roles that policy can play in enabling (or disabling) agroecology.

Our formulation of agroecological transformation reflects not one grand theory of change, but a recognition of a co-evolutionary and adaptive approach that involves, "multiple transformations that will intersect, overlap, and conflict in unpredictable ways" [171] (p. 21). Efforts for agroecological transformation will most likely be met with systemic inertia and intentional, even violent, resistance from regime actors [35]. This underpins the importance of collective action, social movements, and solidarity networks as a means of building and amplifying political power and community agency to advance agroecology transformations. This is easier said than done. But, given the threat of climate change and biodiversity loss, ongoing disempowering dynamics, and continued widespread challenges to food and nutrition security, it appears to be the most viable pathway to agroecological transformation for sustainable and just food systems.

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