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Developing the agroecological niche in Nicaragua: The roles of knowledge flows and intermediaries

Katharina J. F. Schiller[a,b,1], Laurens Klerkx[b,c], Dennis José Salazar Centeno[d], and P. Marijn Poortvliet[e]

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Supporting transitions to sustainable, resilient agri-food systems is important to ensure stable food supply in the face of growing climate extremes. Agroecology, or diversified farming systems based on ecological principles, can contribute to such systems. Based on a qualitative case study of Nicaragua, a forerunner in agroecology, this paper unpacks an ongoing transition to agroecology, focusing on how the transition has been shaped by knowledge flows and intermediary actors. Using a niche development framework based on knowledge processes, we analyze the growth of the agroecological niche in Nicaragua over three phases of niche development. The findings show how knowledge processes' emphases have shifted over time, as have functions enacted by intermediaries. Dedicated, diversified intermediaries have been key in creating momentum for agroecology, as have individual actors moving between niche and regime. Agency in niche development has come from both niche and regime actors. Finally, we find that Nicaragua's transition to agroecology has been ambiguous: While the niche has succeeded in changing the mainstream selection environment to its favor in some arenas, transition dynamics lag in others. Drawing lessons from this ambiguity, we suggest entry points for broader systems change, such as market stimulation, value chain development, phase-out policies, and supportive policy in related arenas. We also point out possible actions for niche actors such as integration of financial and commercial actors into niches and creation of dedicated market-focused intermediaries. Our results provide evidence of an ongoing transition and action points for supporting niche development in (sustainable agri-food) transitions around the globe.

agri-food transitions | niche development | sociotechnical systems analysis | sustainability transitions | transformative learning

Significance

The global agri-food system is simultaneously a major contributor to, and severely affected by, climate change. Agroecological farming systems can contribute to creating resilient agri-food systems. Based on a multiyear qualitative case study, we use a niche development framework to explore knowledge flows and intermediaries in the emergence of agroecology in Nicaragua. The results highlight diversity within transition processes. In some aspects, change may be substantial and in others not. Agency for transitions may come from both niche and regime actors, and individuals able to move between regime and niche are key agents in fomenting change. We draw lessons for transitions in other areas (e.g., creation of financial- and market-focused intermediaries during the stabilization phase).

The global agri-food production and consumption system (including agricultural production, livestock farming and fishing, food processing, food transport and storage, food retail, and food waste disposal) is already strongly impacted by climate change (1). Simultaneously, it contributes 30 to 34% of yearly anthropogenic greenhouse gas (GHG) emissions, with myriad other negative environmental side effects such as biodiversity loss and soil degradation (2, 3). Sustainability science scholars have shown how ongoing growth of the mainstream global industrial agri-food system facilitates the externalization of ecological and social costs of agri-food production and consumption (4) and how value-shaping processes contribute to creating unsustainable farming systems (5–7). Due to historical and recent developments, the global agri-food system is heavily concentrated, with a few dominant firms along all food chain components (8); its annual value is estimated at $8 trillion (9). It is locked into an unsustainable path due to technologies' socially embedded nature, misaligned institutional settings, infrastructural rigidities, incongruous research and innovation priorities, individual attitudes and culture, and broader political economy factors (10). Its success is contingent on maintaining homogeneous production environments with large-scale commercial farms reliant on large amounts of industrial agri-inputs (11).

In contrast, agroecological agri-food systems aim to optimize ecological processes and environmental and public health and well-being while minimizing socioecological costs of agriculture, e.g., pollution, nonrenewable resource exhaustion, and inequitable social structures (12). While agroecology's contribution to lowering GHG emissions remains under debate, its potential to increase agri-food systems' resilience has been clearly shown (12–15). Agroecology has been mentioned in both sustainability science and sustainability transition literatures as an approach to transform current agri-food systems (4, 16). Agroecological farming systems are based on principles including biodiversity, use of locally produced farming inputs, soil and animal health, economic diversification, knowledge cocreation, and connectivity (12, 17). In broader agroecological agri-food systems, these principles are translated

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[1]To whom correspondence may be addressed. Email: katharina.schiller@isi.fraunhofer.de.

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into certain marketing approaches and value chain configurations (e.g. local food systems) and food system governance (e.g., community-based agriculture) (12). What defines "real agroecology" is however still contested: Although ecological farming practices are widely considered the basis for agroecology, some groups see these practices as sufficient in themselves, without necessitating broader systemic changes (16, 18, 19). Advocates of a holistic agroecology propagate its shared values, community-driven dynamics, and social movement aspects as central alongside its biophysical and practice-related features (16, 18, 19).

Because agroecological food production and consumption is not measured in most countries (unlike organic food, which follows certification standards and is differentiated in markets), it is difficult to estimate what share agroecology contributes to global food production and consumption. Optimistic estimates conclude that at least 75% of the 1.5 billion smallholders, family farmers, and indigenous peoples producing around 50% of global agricultural output, mainly for local consumption, use ecological methods (20). More conservatively, the international Demeter certification counts around 7,000 producers farming agroecologically on ca. 230,000 ha in 63 countries (21)—clearly a pittance considering the global population's food needs. As agroecology remains a niche product, it seems astounding that supportive policy was passed in a handful of countries, including Cuba, Brazil, El Salvador, France, and Nicaragua. Nicaragua, which has been a vanguard of agroecology since the 1980s (22–26), is a particularly pertinent case to understand the mechanisms behind ongoing transitions from conventional to agroecological agri-food systems.

Transitions from conventional to agroecological agri-food systems are not linear, but rather emergent, context-specific, messy, and contested processes without a fixed end point (16, 19). Such transitions are processes toward a more profound transformation, which may not yet have occurred (27), and involve major shifts in not just technologies and practices but also, e.g., ways of organizing, cultural and market preferences, value chain arrangements, financial setups, power relations between actors, knowledge distribution, and policies (16). Taking a prospective view, we cannot be certain that such transitions-in-the-making will progress to an overall transformation (e.g., complete change to agroecological agri-food systems), but we can identify the emergence of (new) practices, actors, networks, and framings that challenge and disrupt the status quo (28). As the Nicaraguan case is still a transition-in-the-making, we cannot determine full systemic change but instead focus on processes through which emerging (agroecological) practices become more or less translated into mainstream practices (28, 29).

Previous work by the authors has identified knowledge production and distribution as a key factor supporting the agroecological transition in Nicaragua (24) and highlighted the importance of intermediary actors—those who negotiate between the mainstream and new alternatives—in these transition processes (25). Taking this as a starting point, we dive deep into these two factors asking, which knowledge processes enabled the development of agroecology in Nicaragua, and what roles did intermediary actors take in these processes? We unpack the knowledge mechanisms supporting the development of agroecology as an alternative niche, distinguishing between a) different phases of niche development (emergence, stabilization, and diffusion), b) knowledge processes (e.g., knowledge production, circulation, aggregation, and translation), and c) roles of intermediary actors in these processes. Knowledge development is an important element in sustainability transitions (30–34), and intermediaries may contribute to this (35), but there is still limited analysis of this in the case of agroecological transitions [except Steyaert et al. (36), Groot Kormelinck et al. (37), and Iyabano et al. (38)]. This is where the paper aims to contribute.

1. Conceptual Framework: Knowledge Development in Niches and Intermediaries

Our paper uses the MLP (39) as the background framework because it provides an overarching conceptualization of transition processes as involving multidimensional struggles between radical innovations that emerge in niches and the existing sociotechnical regime that is locked-in and stabilized in various ways. These struggles between niche innovations and the existing regime are shaped by exogenous developments in the wider sociotechnical landscape, including macroeconomic processes, ideological developments, and political revolutions.

Agroecology's development in Nicaragua is conceptualized as a sociotechnical niche comprising the central technology (agroecology) and networks of actors interacting and innovating around the central technology.* Niches are spaces where networks of actors colearn, i.e., they experiment together, mutually adapting ecofriendly innovations (39–41). Niches are created when actors converge in response to perceived needs (e.g., environmental, organizational, or market related) that are unfulfilled by dominant regimes or perceived pressures from (unsustainable) regimes and landscapes (39).

Regimes define the predominant "way things are done" and include a complex structure of artifacts, institutions, and agents sustaining existing trajectories of development (42). They comprise a coherent configuration of technological, institutional, economic, social, cognitive, and physical elements and actors with individual goals and values (43). In this case, the regime is represented by the dominant industrial agri-food system. Developments within niches and between niches and regimes occur against a background of broader social, political, economic, and cultural changes outside of actors' reach—the sociotechnical landscape (44).

Using the MLP as a background framework, we use the niche development framework to more specifically guide our analysis of agroecology in Nicaragua. While scholars initially emphasized the role of local projects, pilots, and demonstration projects in the development of new niches (45), Geels and Raven (46) and Geels and Deuten (34) distinguish between local projects with alternative technologies or practices and an emerging community level (what they call "global" levels) of shared rules, including search heuristics, technical models, and abstract theories. This global niche level is influenced by and in turn influences the local niche, with intermediaries translating between them (46). Although the global niche level was originally not conceptualized as having a geographic component, recent work has shown that including the spatial dimensions of global niches can help in better capturing local-global niche cumulation and the mechanisms that condition different transition trajectories (47, 48). For this paper, the global niche level refers to the broader global agroecology movement (16).

Niche development is shaped by its internal growth (i.e., aligning expectations, learning, extending actor networks, and accumulating resources within the niche) (49) and its translation of external stimuli (receiving pressures from regimes to maintain the status quo but also exercising pressure on regimes to change the status quo and making use of "windows of opportunity" afforded

*Since farmers are embedded within wider agri-food value chains and policy and regulatory systems, knowledge development in the agri-food sector takes place in pluralist networks of all kinds of players that influence farmers, including public advisory services, farmer organizations, and agribusiness actors (83–86). These influence the choices farmers make; through their normative orientation and sometimes commercial interest, they also exercise steering on farmers in terms of what technologies and practices they should employ (83–86). Research has shown that social learning processes, which promote innovation and knowledge creation through social interactions, are key in supporting farmers' transitions to more sustainable environmental management (53, 87, 88).

by changing sociotechnical landscapes) (42). During niche development, new knowledge is created by niche actors (34).

Knowledge development—including the creation, sharing, and application of new information and expertise—has both social components (networks of heterogeneous actors who are involved in different aspects in different phases and develop knowledge and learn and unlearn) and cognitive components (abstract theories, models, best practices, guidelines, etc.) (34). Knowledge is developed both to optimize niche practices and to gather evidence to change regime practices (25, 31, 34, 50).

New knowledge is mobilized to interact with the regime in efforts to "anchor" niche elements into regime spaces (25, 50). This occurs through processes such as improving technical performance, supporting lobbying, and supporting standard making (25, 50). New niche practices are institutionalized within the regime through this "anchoring" (25, 50). During these anchoring processes, knowledge is translated interactively between niche and regime elements (34, 50). These interactions may influence the niche's trajectory (34, 50).

Three phases of niche development can be distinguished: emergence, stabilization, and broader diffusion (51). In the following paragraphs, we develop a sociocognitive perspective on how knowledge is created and shared during the three phases. For each phase, we discuss the main subprocesses of knowledge development and the roles intermediaries may play in these. Although presented linearly, it is important to note that the description is stylized and the phases do not necessarily progress linearly. Rather, many subprocesses occur iteratively throughout the phases. Setbacks may occur that may significantly alter the niche's trajectory.

In niche emergence, actors respond to a perceived need or pressure from how the incumbent sociotechnical regime functions and the problems it generates and begin innovating to find solutions. These actors are transformative change agents working intentionally to address a perceived problem; they translate their perceptions of these problems into specific action points based on their previous knowledge, resources, and interests (52). These pressures may be translated selectively, i.e., niche actors may highlight some aspects while ignoring others (42), thereby shaping the direction in which the niche develops. Based on their translations, actors create new artifacts or ways of doing things (34). Actors begin to network, sharing results from their experimentation and from this begin collaboratively creating new knowledge and developing shared expectations (32, 42, 49). They may also be inspired and informed by niche-external information (i.e., from other niches, the regime, or the global niche level) and selectively translate this for local usage (34, 46).

As niches stabilize, local experiments are shared, and locally applicable lessons circulate between actors, stimulating processes of coinnovation, colearning, and coproduction. Actors may define shared problem agendas, collaboratively construct knowledge, and produce shared outcomes (41). To gain human and other resources, new actors are enlisted and networks extended (41). Networks contribute more strongly to niche development if they are broad (involving heterogeneous stakeholders) and deep (actors can mobilize resources) (49). Hence, learning processes involve both knowledge development and aligning heterogeneous elements into working configurations (53). Knowledge, e.g., on best practices, begins accumulating among actors; some (often dedicated) actors begin to collect and systematize this (46). Tacit knowledge begins to be codified into explicit, written recordings (34). Dedicated knowledge aggregation activities include technical model building, best practice formulation, systematization, standardization, and codification (46). Besides the transformation of local experiences into codified knowledge, aggregation includes the creation of infrastructures for knowledge circulation and accumulation (34). Such infrastructures involve fora enabling actors' interactions, both physically and virtually, for exchanging experiences and organizing collective action, e.g., workshops, conferences, or research centers (34).

As niches diffuse more broadly, aggregated local knowledge is translated into generic, translocal knowledge which can circulate both into the regime and the global niche level (34, 46). This translation of local outcomes into generic lessons requires the former's decontextualization (34). As knowledge flows from local niches to the regime or global niche level, this process also happens in reverse: generic, translocal knowledge from the regime or global niche level is interpreted, decodified, and recontextualized for use in local niche practices (42). As illustrated by Fig. 1, these back-and-forth translation processes require dedicated sociocognitive work (34).

Intermediaries broker between niche-internal and niche-external actors and organizations during transition processes, and support knowledge development between niches and regimes or global niches (34, 54). The need for intermediation between niche actors, between niche and regime, and between local and global niche levels varies over the course of transitions (43, 50). Intermediaries' functions in supporting the niche thus may change over time: for example, from supporting experimentation and the articulation of shared expectations during niche emergence, to aggregating knowledge, building networks, and codefining shared problem agendas during

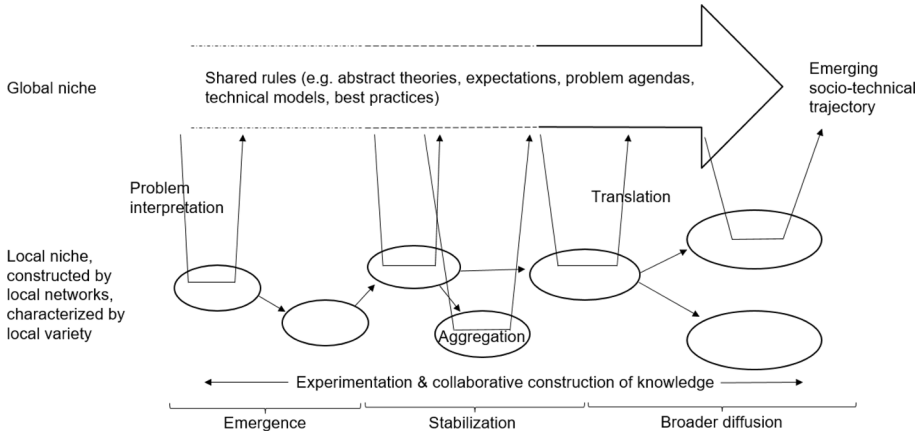

Fig. 1. Interactive knowledge development trajectory carried out by niche [based on Geels and Raven (53)].

stabilization, to translating new, niche-generated knowledge into generic, global knowledge during broader diffusion (55).

2. Research Design

Qualitative data were gathered between 2014 and 2021 using multiple methods. Field studies were undertaken by the lead author and two Nicaraguan research assistants in Nicaragua in 2014 and 2016 to 2018. This allowed extensive data collection, including 27 semistructured interviews; 22 farm visits and walks in two agroecological zones (dry tropics and humid tropics); visits to public, agricultural, and food fairs and markets; participation at 13 workshops and conferences; and personal correspondence and conversations. Besides interviews with a range of stakeholders (farmers, farmers' organizations, national universities, national civil society organizations (CSOs), international nongovernmental organizations (NGOs),[†] government agencies, and national financial institutions), informal conversations with these and other actors informed the understanding of agroecology's development in Nicaragua. Ethical approval was not required for the study by the involved research organizations and funding bodies at the time it was executed. Interviewees were informed of the project background, assured the anonymization of their data, and freely consented to participate. An extensive review of scientific literature, policy documents, and gray literature accompanied the on-the-ground research. The study was part of the international agricultural research and development program Humidtropics[‡], which followed broader developmental goals.

Data collection was guided by the multilevel perspective on sociotechnical transitions and technological innovation systems lens and yielded broad insights into systemic enablers, barriers, and dynamics in niche development. Data from different sources were triangulated and used to elaborate a timeline of niche development, which was subsequently analyzed according to the niche development framework presented above. Key turning points in the niche's development were identified through the formal institutionalization of agroecology into the regime at different levels—among farmers, in the national higher education system, and in national law. The three phases were analyzed according to actors involved, their networks, and types of knowledge processes performed most strongly. Next, the main knowledge processes involved in each phase, and the roles of intermediaries in these, were investigated.

3. Case Study: Findings and Analysis

We describe the case study—the growth of the agroecological niche in Nicaragua—using the three phases of niche development. For each phase, a brief overview of the salient history is interspersed with an analysis of knowledge processes supporting niche development and roles of intermediaries. Key turning points in the agroecological niche's development were pinpointed based on events that formally institutionalized agroecology into the regime.[§] In each phase, knowledge processes and the work of intermediary actors fomented the changes leading to the turning points.

Following the conceptual framework, the agroecological niche in Nicaragua comprises the actors working in support of agroecology in Nicaragua and their artifacts, practices, and resources. The agri-food regime is delineated at the national level and encompasses the actors, networks, institutions, and infrastructures involved in mainstream agri-food production and consumption, which has since the 1950s been based on conventional, industrial agriculture (56). Neither niche nor regime is monolithic but comprises heterogeneous actors following different goals and reacting to different perceived pressures over time.

3.1. Emergence (1986 to 1997). Formalized agroecology emerged in 1986 against the backdrop of the Nicaraguan Revolution, the decade-long popular struggle to overthrow the previous dictatorship, and the ensuing Contra War,[¶] in which Nicaragua became a Cold War hotspot. Although Central American farmers have used agroecological principles for centuries,[#] many agroecological techniques were forgotten with the advent of large-scale plantation agriculture in the 19th and agroindustrial production in the 20th centuries (22). Although monocultural production caused severe environmental degradation and soil depletion, the new Revolutionary government maintained this conventional approach (22, 56). As conventional agricultural inputs scarcened following the 1985 U.S. embargo, the Revolutionary government began searching for local alternatives: Agroecology became of greater interest (22). The National Union of Farmers and Ranchers (UNAG), the mass organization representing medium/large-scale farmers' interests in the Revolution, connected with a Mexican CSO using agroecological practices to combat soil infertility (26). Mexican farmers visited Nicaragua, teaching agroecological practices (such as terracing along contour lines, covering soil with leafy organic cover, and making compost) to Nicaraguan farmers.[‖] In 1986, UNAG formally began promoting agroecology as part of a large-scale program combating soil depletion, with the nascent farmer-to-farmer movement to teach and spread agroecology (23); UNAG's agroecological, farmer-to-farmer, social movement wing is known as PCAC-UNAG[**]. As the Contra War continued during the 1980s, international idealists joined Nicaraguan solidarity brigades, exchanging ideas with Nicaraguans. Concurrently, Nicaragua's environmental movement coalesced, responding to the Revolutionary government's continued environmental destruction and promotion of Green Revolution technologies. Individuals interested in environmental protection began convening in Managua, Nicaragua's capital, in a series of meetings out of which arose the Nicaraguan Environmental Movement (MAN, ca. 1980s to 2000s). MAN's members were instrumental in creating environmental awareness and spreading knowledge on agroecological principles throughout different arenas (57). Fertilized by these national and international exchanges, formalized agroecology emerged as a reaction to three issues: severe environmental degradation; harsh socioeconomic inequalities and economic constraints posed by the Contra War; and the Revolutionary government's continued focus on conventional agricultural approaches (22, 49, 50, 58, 59).

The first actors in the emergence of agroecology were farmers, who identified a local sustainability problem (low yields from soil depletion) and sought answers from their network in the emergent global

[†]Following usage in Nicaragua and Obuch (89), we differentiate between international nongovernmental organizations and national civil society organizations.

[‡]https://cgspace.cgiar.org/handle/10568/35409.

[§]The phases of niche development are based on an in-depth analysis of the knowledge production processes and roles of intermediaries. They do not quite overlap with the phases of change in Nicaragua's government, which are discussed in more depth in terms of shaping agroecology's development in Schiller et al. (25).

[¶]During the Contra War (ca. 1981 to 1990), Nicaraguans who were against the Revolution (the *Contras*) were armed by the United States to destabilize the nascent leftist Revolutionary government. In the countryside, many conservative peasants and those disillusioned with the Revolutionary government's agrarian reforms supported the Contras, while others defended the Revolution (90, 91).

[#]In this sense, agroecology is a "retroinnovation," purposefully reviving historic practices, ideas, and technologies (92).

[‖]For more information on agroecological practices, please see Chapter 3 in Schiller (93).

[**]PCAC: The farmer-to-farmer movement's Spanish acronym, Programa Campesino a Campesino.

agroecological niche (agroecological farmer groups in other countries). Selectively translating external knowledge gained from exchanges with non-Nicaraguan farmer groups, farmers learned new techniques and began experimenting with these on their farms. Through horizontal learning pedagogies, farmers shared learning-by-doing and cocreative processes were nurtured. UNAG was key in supporting farmers' experimentation and first farmer-to-farmer knowledge exchanges and played several unique roles in agroecology's emergence. Although UNAG is associated with the regime (i.e., founded by the Revolutionary government), it was central in creating the emerging niche by formalizing agroecology and the farmer-to-farmer network and movement under PCAC-UNAG. UNAG created space within the regime for the niche and created a first niche actor bringing together local experiments under one organization (PCAC-UNAG). UNAG hence involuntarily became a very specific type of intermediary between niche and regime.

Meanwhile, concerned individuals in civil society identified the same local sustainability problem, among broader environmental degradation issues, and translated it into action at national policy levels, e.g., pushing for the creation of a national institute for environmental protection and, within society, by raising public awareness and creating CSOs (57). During the early/mid-1990s, multiple CSOs were founded that linked agroecological principles to related issues—social justice, women's empowerment, food security, and fair trade (22, 58). CSOs emerged to promote scientific information building on agroecology and link to international groups (e.g., SIMAS, Mesoamerican Information Service on Sustainable Agriculture), connect agroecological actors within Nicaragua (e.g., GPAE, Group for the Promotion of Ecological Agriculture), create value chains for agroecological products, or promote rural development through agroecology (e.g., ADAR, Association for Regional Agroecological Development) (22). Here, individual actors (many members of MAN) played key roles in selectively translating their perceptions of a shared problem (environmental degradation) into spaces for action through the creation of CSOs with different foci. These experimented with agroecology from their perspectives and began creating knowledge around different aspects.

3.2. Stabilization (1998 to 2010). The year 1998 was a turning point for the development of agroecology as it was formally institutionalized for the first time in the national higher education system. The National Autonomous University in León (UNAN-León) began offering an agroecological technician degree. The National Agrarian University (UNA) followed, expanding upon UNAN-León's technical program with an undergraduate degree, and later, postgraduate programs in agroecology (22). Here, niche knowledge was instituted within regime structures by individual change agents (university professors and administrators, several of whom were members of MAN), who translated niche knowledge into academic standards. The universities collected and standardized new local knowledge for diffusion in regime structures through formal educational programs.

After Nicaraguan agroecological farms' resilience was demonstrated post–Hurricane Mitch (1998), farmers' interest in agroecology grew (59), and Nicaragua was brought to the international scientific community's attention (22, 60). By the early 2000s, more than 14,000 farmers used ecological methods (61). Collecting findings from local experiments, identifying best practices, systematizing, standardizing, and codifying them into written technical and scientific manuals were important in mobilizing the spread of agroecological practices among farmer organizations and in generating evidence and policy suggestions targeted at national governmental institutions. SIMAS became a leader, collaborating with NGOs, CSOs like GPAE and ADAR, and farmer organizations like PCAC-UNAG to aggregate this new knowledge, e.g., creating technical best practice manuals (57). GPAE, conceived to coordinate between different organizations supporting agroecology and to intermediate between niche and regime (49, 58), has become one of the most important actors supporting niche knowledge flows and pressuring for regime change (57).

Both SIMAS and PCAC-UNAG were instrumental in linking Nicaragua's growing agroecological niche to the emerging global agroecological niche. While SIMAS connected local and global niche levels through participation in international scientific networks, PCAC-UNAG linked them through nascent international farmer-based social movement networks. Through the spread of the farmer-to-farmer program, which became a basis for agroecology's international diffusion (22), and dedicated outreach to non-Nicaraguan farmer organizations, PCAC-UNAG formed roots for what would become international peasant organization La Via Campesina (LVC) (62). Prior to the Rio Earth Summit, UNAG convened a meeting of farmer organizations from Nicaragua, Latin America, and Europe; farmers identified similarities between their struggles, determined joint action, and codified this in 1992's Managua Declaration, one of LVC's founding statements (62, 63). PCAC-UNAG's role in nurturing the emerging global agroecological niche illustrates the feedback between local and global niche levels.

Beginning in 2007, the Organic Roundtable united, in a national first, public (farmer organizations, civil society, research, CSOs, NGOs, and government) and private actors in an effort to synergize their actions supporting agroecology. This laid the groundwork for Nicaragua's largest stakeholder consultation, to formulate the Agroecology and Organic Production Law. During the consultation, the Organic Roundtable facilitated the translation of aggregated niche knowledge into mobile, generic knowledge, enabling the Agroecology Law's formulation in regime language. The Movement of Agroecological and Organic Producers of Nicaragua (MAONIC), a dedicated niche–regime intermediary comprising local- to national-scale farmer organizations, emerged from this process and has since 2009 been arguably the most important player championing agroecology, for example by pushing for final legislation of the Agroecology Law. The construction of dedicated multistakeholder networks bringing together heterogeneous actors was key to agroecology's broader diffusion in terms of both its policy impact and the creation of a dedicated systemic intermediary (MAONIC) able to bridge across large actor networks, take more normative positions, and have legitimacy across both niche and regime contexts (37).

3.3. Broader diffusion? (2011 to 2022). The third key turning point in agroecology's development was its enshrinement into the regime's legal framework through 2011's Agroecology Law (64). The impetus for this had come from intermediary infrastructures and organizations created by farmers' organizations and civil society actors, as detailed above. Since then, several governmental institutions have organized four national congresses dedicated to different aspects of agroecology and so brought together agroecological actors and knowledge from across the country. Although not dedicated intermediaries, these institutions have slipped into intermediary roles (35). Since 2014, the Alliance for Agroecology has united the most important agroecological organizations, including PCAC-UNAG, MAONIC, and GPAE, to continue agroecological knowledge systematization and advocating to mainstream agroecology into national environmental protection efforts (57). Due to efforts by the government, private actors,

and CSOs, market outlets and new forms of commercialization for agroecological products have been created in the larger cities.

The policy change effected by the agroecological niche may be seen as a major step toward broader diffusion of agroecology, given that the niche has succeeded in restructuring the mainstream selection environment—i.e., change the regime's legal framework to be more accommodating. Yet, measured by other indicators, agroecology's diffusion is patchy. An estimated 66% of farmers use at least one agroecological practice regularly and 20% routinely use three or more agroecological practices (59), while 8% of Nicaragua's 261,321 farmers are fully agroecological[††] (65). These numbers highlight that agroecological transitions are processes over long time frames, and farmers may use conventional and agroecological practices in different farm areas, according to their resources and needs (16).[‡‡] Value chain setups have changed over time, e.g., with the advent of (international) supermarkets, but have only sparsely recognized local agroecological production as a food source; financing opportunities for farmers wanting to transition to agroecology (a multiyear process during which yields tend to drop before increasing) are almost nonexistent; the majority of agricultural advisory services remain based on conventional farming; and most of the Agroecology Law's provisions remain to be implemented (23, 59). A decade after legislation, agroecology remains a niche in terms of contribution to urban food consumption and agri-exports; percentage of arable land under agroecological production; percentage of funding for agroecological projects; percentage of national higher education programs, graduates, and research outputs versus other agricultural degrees; and percentage of sales in both farmers' markets and national supermarkets (23, 59).

3.4. Knowledge Flows and Intermediation Across the Three Phases of Niche Development. Five main points can be distilled from the case study's analysis and are synthesized in Table 1. First, regime actors have enacted important changes in the agroecological niche. This demonstrates that agency in transitions comes not only from the niche but also from the regime (66): UNAG has been fundamental in growing the agroecological niche, as have several national universities; in this sense, they act as "regime intermediaries" (cf Kivimaa et al. 55).

Second, knowledge processes' emphases shifted over time. While knowledge development on agroecological practices and the nascent farmer-to-farmer movement was most prevalent in the first phase, knowledge development on agroecology as a science and a social movement strengthened in the second phase. The third phase foregrounded political agroecology. This reflects the development of the global agroecological niche (17) to which the Nicaraguan agroecological niche has contributed.

Third, interactions between the local (Nicaraguan) and global (outside of Nicaragua) agroecological niche have stimulated developments in both. The case study illustrates how practices imported from the global niche level may manifest in the development of a local niche, and how new knowledge developed in the local niche may later contribute back to advancing the global niche. Knowledge from the Nicaraguan niche has been particularly influential concerning the development of the global farmer-to-farmer movement, transnational peasant organizing, and standard setting at a regional scale. This links to ideas of the "glocalization" of systems, in which local practices are informed by (and in turn form part of and inform) the global niche (49, 67).

Fourth, the increase in intermediary actors, particularly dedicated intermediaries, has been instrumental in knowledge processes both in the creation of spaces for interactions and the aggregation of knowledge and its translation to niche-external contexts (regime or global niche level). Intermediaries' diversification—in terms of focus, involved stakeholder groups, and types of intermediation enacted—has increased their effectivity: by creating an "ecology of differently positioned intermediaries" (35), or what also has been called a "boundary infrastructure" (68) that interprets between science, practice, and policy, different actors were able to translate between disparate niche aspects and the regime or global niche level. Furthermore, the findings illustrate that individuals inhabiting both niche and regime spaces are central to translating between these and fomenting change in transition processes, acting as "hybrid actors" (50). This highlights individual change agents' transformative power (69).

Fifth, agroecology has begun to more broadly diffuse into the agri-food regime in some aspects but not all: The transition is, so far, unbalanced. In terms of number of farmers using agroecological methods; knowledge development, aggregation, and translation; and in certain political and institutional formalization processes, niche actors have succeeded in fomenting change. Associated changes, such as market and value chain development, the implementation of agroecological certification schemes, and the creation of financing mechanisms for agroecological farmers have been too sparse. Knowledge creation has supported the progression toward institutionalization of agroecology, e.g., through MAONIC and the Agroecology Law, through the processes described in the case study and through the "cognitive anchoring" (cf Elzen et al. 50) of agroecology—and organic agriculture—into regime structures (25). However, while information on agroecology has been created through the circulation of people, experiences, and more-or-less codified knowledge, this has not (yet) translated into broader regime change. Nonetheless, knowledge and experiences from Nicaragua more strongly informed the development of the global agroecological niche, spurring the creation of LVC.

4. Discussion

Although agroecological policy seems to indicate a major step in the development of agroecology, in that the mainstream selection environment is favorably changed, our analysis shows that this has so far been insufficient to instigate broader regime change. These findings point to a more nuanced view on niche empowerment: Niches may adapt to the mainstream selection environment in some areas while managing to change the mainstream selection environment in others (40). As the government has pledged to revisit the Agroecology Law next year, it remains to be seen to what extent it will be implemented. The ambiguities in the government's response indicate that transition pathways [cf Geels and Schot (70); Geels et al. (71)] may be heterogeneous within regimes, i.e., follow different patterns in different parts of regimes. This implies that agri-food regimes may not be fully locked into unsustainability (cf Conti et al. 10) and that space for change may be fomented in specific regime areas. This suggests that more attention needs to be paid as regard diversity in pathways within regimes [cf Smith et al. (70); Geels and Schot (72); Turnheim et al. (73); Rosenbloom (74); Turnheim and Nykvist (75)].

The findings indicate several entry points for broader regime changes. Market creation and value chain development need to be addressed as arenas of niche development. Focusing on traders—farmers' first contact with value chains—as intermediaries has been suggested (76). Connecting farmers with international markets through agroecological certification standards could

[††]The majority of these are small (<5 ha) or medium sized (<50 ha); many of them produce organically certified export crops; most are members of a cooperative.

[‡‡]Farmers often use agroecology in their kitchen gardens and conventional methods in the fields.

Table 1. Summary of core processes in knowledge development over the three phases of the agroecological niche's development

Phase of niche development	Key types of knowledge processes expected—conceptual	Key types of knowledge processes observed—empirical
Emergence (1986 to 1997)	Individual knowledge development based on interpretations of a shared perceived problem	Problem/issue identification
		Translation to local contexts
	First shared experimentation by stakeholders	Farmers' experimentation with agroecological practices; NGOs' + CSOs' experimentation with scientific and organizational aspects
	Development of shared expectations	
		Observed element of variation:
		Regime actor first to formally institutionalize agroecology through farmer-to-farmer program
Stabilization (1998 to 2010)	Collaborative construction of knowledge, definition of shared problem agendas, and production of shared outcomes	Translation of niche knowledge into regime structures by universities
	Aggregation of knowledge = collection, standardization, and codification of new knowledge in, e.g., technical models or best practices	Aggregated knowledge is mobilized to both optimize niche practices and gather evidence to change regime practices
		Dedicated translation work by intermediaries between niche/regime and local/global niche levels
		Observed element of variation: • Policy formulation as a bottom-up process led by civil society
Broader diffusion (2011 to 2022)	Translation = back-and-forth process of decontextualizing aggregated niche knowledge into generic, translocal knowledge that can circulate into regime and global niche level and recontextualizing generic, translocal knowledge for use in local practices	Agroecology formalized into regime's legal framework
		Observed element of variation: • While niche actors continue working, the legal framework remains to be fully implemented

accompany the creation of locally nested markets that more directly connect producers and consumers (16); the creation of a public certification scheme, as conceived in the Agroecology Law, could make certification accessible for all farmers. Intermediation processes could be expanded to explicitly include financial organizations and market actors along the value chain, with the aim of developing financing and markets in support of agroecology [cf Boon et al. (77); Polzin et al. (78)]. Furthermore, phase-out policies for conventional agriculture are necessary to reshape the agri-food regime into an agroecological one, along with supportive policies in other areas (such as public food procurement) (16).

The case offers lessons for niche actors in other transitions to more sustainable agri-food systems. Although developing knowledge processes and networks are central to creating momentum for transitions, they are insufficient to fully empower the niche. Integrating financial and commercial actors into the niche, possibly during the stabilization phase, could enhance its prospects. The creation of dedicated market-focused intermediaries, who provide a platform for exchange and help align new actors' visions and actions with those of more established niche actors, could facilitate this integration. Analyzing and enacting market formation processes (cf Boon et al. 77), including the development of certification schemes, could help niche actors support the creation of nested markets (oriented toward direct connections between producers and consumers) for agroecological products (16, 77). Actors could leverage links to the global agroecological niche level to explore opportunities for connecting to international markets. This may lead to a more commercial form of agroecology, which may go against or sideline the social values originally propagated by agroecological pioneers; this is a trade-off for many movements that have grassroots origins (cf Smith et al. 79).

5. Conclusions

As agroecology can contribute to more resilient agri-food systems, understanding how transitions from conventional to agroecological regimes unfold is important to learn lessons for supporting such transitions in other places. This paper has examined one of the cases of an agroecological transition-in-the-making at a national level, focusing on knowledge processes and intermediaries as key elements of a niche development framework. It has shown which knowledge process has been enacted most strongly in different stages of niche development and how the functions of intermediaries have changed over time. The results contribute to pluralized conceptions of actors in niche development, (in that supportive actions may be generated by niche and also regime actors; actors' functions in knowledge development change over the niche development phases (echoing Hermans et al. 80)) and point to questions of how intermediaries navigating between niche and regime leverage maximum effect in each without losing credibility in either (50, 81). We found that while particularly intermediary actors have carved out space for agroecology within the regime, this has not (yet) translated into widespread changes. The case shows multiple ambiguities—while both niche and regime actors pushed for change, niche development

has been uneven—and raises more questions, particularly concerning governments' agency as actors in niche development and why agroecology struggles in market arenas. The development of certifications (at a price point accessible for economically weak farmers) for agroecological products is a key first step to increasing the financial viability of agroecology for farmers. For many farmers, agroecology may not be intrinsically value driven (as it may be for proponents of agroecology as a social movement) and therefore needs to give economic and broader well-being benefits for them and their families. These issues point to broader questions of inclusion and power in agri-food systems transitions, which merit more attention from a transition studies perspective (see also Hebinck et al. 82).

Transitions to more sustainable, resilient agri-food systems are ongoing and, if not yet happening, at least beginning to be debated in almost all countries around the globe. Analyzing the processes behind the development of alternative niches can help pinpoint where and how such changes are happening and inform policy and practice supporting transitions to sustainability. Learning from countries that have been forerunners in transitions can enable more diversified and concerted action in other regions.

Data, Materials, and Software Availability. Anonymized dataset data have been deposited in 4TU (10.4121/21378258) (57).

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Author affiliations: [a]Competence Center Policy and Society, Fraunhofer Institute for Systems and Innovation Research (ISI), 76133 Karlsruhe, Germany; [b]Knowledge, Technology and Innovation Group, Wageningen University, Wageningen 6706 KN, the Netherlands; [c]Departamento de Economía Agraria, Facultad de Ciencias Agrarias, Universidad de Talca, Casilla 747-721, Talca, Chile; [d]Facultad de Agronomía, Universidad Nacional Agraria, Managua 11037, Nicaragua; and [e]Strategic Communication Group, Wageningen University, Wageningen 6706 KN, the Netherlands

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