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Exploring the "works with nature" pillar of food sovereignty: a review of empirical cases in academic literature

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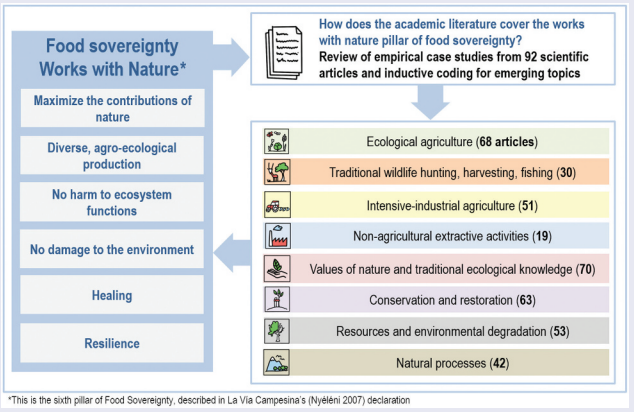
ABSTRACT

Food Sovereignty (FS) is growing in popularity in food-nature academic discussions. This systematic review depicts 1) the level of engagement and 2) the topics related to the "Works with Nature" pillar (WwNP) of food sovereignty present in the academic literature. Most articles engaged with this pillar. Common topics included ecological agriculture practices, rejecting intensive-industrial agriculture and exploring how human-nature values and traditional ecological knowledge are affected. An in-depth engagement with ecological conditions (e.g. biodiversity, ecosystem functions, and resilience) was less prominent. We conclude that a broader variety of topics could be explored to support politically engaged research on the systemic nature of food purported by a paradigm born from grassroots movements.



KEYWORDS

Agroecology; human–nature relationships; systemic approaches; traditional ecological knowledge; biodiversity conservation; values of nature; ecosystem functions

SUSTAINABLE DEVELOPMENT GOALS

SDG 12: Responsible consumption and production; SDG 15: Life on land

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Introduction

Human cultures, societies, and nature are tightly[1] interlinked and co-constructed (Liu et al. 2007; Micarelli 2017; Pascual et al. 2021). From a human-centered perspective, one of the results of our co-existence with other species is the production and harvest of food, which is one of the most important aspects of our survival. At the same time, human relationships with the ecosystems where food is obtained shape our knowledge, defining our species' food cultures and identities (Daigle 2019). In turn, the ways humans relate to and shape agroecosystems affect the conservation or depletion of nature (Perfecto, Vandermeer, and Wright 2019).

The interweaving of food and nature is currently extensively discussed in academia. However, empirical studies are still needed to understand the multidirectional relationships among them (Glamann et al. 2017). Apart from the general lack of empirical research, some authors have argued that socioecological studies, as well as food-nature debates, often focus on a few sociopolitical or ecological aspects. Some examples include utility maximization, governance, land use, or biophysical characteristics (Guerrero et al. 2018). This narrow thematic focus disregards social issues such as power relations, gender, and wellbeing, as well as broader ecological relationships binding humans and other species, which are at the core of environmental and social justice issues of the current agrifood systems (Edelman et al. 2014; Guerrero et al. 2018; Rissman and Gillon 2017). Empirical studies that consider a broader range of parameters involving humans and nature and their contributions to assuring the right to food are still to be pursued (Glamann et al. 2017; Guerrero et al. 2018).

Among the literature discussing food–nature relationships, the existence of agrifood debts, i.e. interregional social–ecological disequilibria in the natural resources consumed, the environmental impacts produced and the social wellbeing attained by populations in regions that play different roles within the globalized agrifood system have been raised and demonstrated (Anderson et al. 2021; Oteros-Rozas et al. 2019; Pascual et al. 2021; Shanahan 2022). There is therefore scope for politically engaged research that critically assesses conventional perspectives on the food-nature nexus (Shanahan 2022).

One critical perspective of the food-nature nexus is Food Sovereignty (FS) (Glamann et al. 2017; Shanahan 2022). This grassroots paradigm was first globally mobilized by La Via Campesina during the 90s. Later, the debates around FS spread into other civil society organizations, farmers' trade unions, governments, international institutions, and academia (de Schutter 2014; Glamann et al. 2017; Patel 2009). In this review, the definition of FS we used is the one proposed by La Via Campesina, as this is the largest peasant movement that keeps redefining the paradigm with its more than 500 representatives of over 2 million members from 80 countries (Nyéléni 2007). FS is

defined as "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (Nyéléni 2007). This definition raises the *where* and *how* food is produced or harvested (de Schutte 2014, putting forward the social-ecological dimensions for just food. Six pillars constitute the basis of FS and are summarized in the FS declaration of 2007 as follows: 1) FS focuses on people and the basic human right to food; 2) FS values food providers; 3) FS localizes food systems; 4) FS puts control locally; 5) FS builds on local knowledge; and 6) FS works with nature. The latter, the *Works with Nature* pillar (from now on the WwNP), is the one that explicitly puts forward food–nature relationships, stressing the need for a sustainable care and use of land, water, and seeds, to preserve biodiversity and the ecosystems' functions that allow the attainment of FS (Jarosz 2014; Van der Ploeg 2014). The goal of working with nature was proposed to be pursued through an alliance with agroecology, considered as being "a way of life, a way of producing food, a science, and a movement to transform food systems for food sovereignty and social, racial, gender, economic, intergenerational, and environmental justice" (Nyéléni 2022).

Because of its strong recognition of the interweaving of food with nature and political engagement for a radical shift of agrifood systems, FS seems like a key paradigm to critically explore food–nature relationships (Shanahan 2022) as compared to other frameworks (e.g. sustainable livelihoods). Albeit this, and similarly to other food-nature lenses (see Glamann et al. 2017), the academic literature around FS seems to have focused on social, economic, and cultural dimensions, and the political implications of agricultural practices (Edelman 2014; Ruelle et al. 2019). In this context, we decided to particularly explore if and how the sixth pillar of FS (WwNP) is being integrated in FS academic literature. This study will contribute to a better understanding of the engagement of FS empirical academic articles with food-nature related topics and explores the themes that are developed in FS academic literature. In a broader sense, the results of this review contribute to discussing the importance of the agency of nature for FS and its indivisibility from it. Given the relevance of context-dependency for all the ecological, sociopolitical, and cultural dimensions of FS, we decided to focus on place-based FS research in particular. This study was guided by the following questions: a) to what extent have empirical academic studies on food sovereignty engaged with the Works with Nature pillar?; and b) which Works with Nature pillar themes are covered in this academic literature?

Methods

We employed a structured method for gathering information from the current available literature on FS (Page et al. 2021; Paré et al. 2015) (Appendix 1). In June 2020, we used the Web of Science database to search for the term "Food Sovereignty" in the titles, keywords, and abstracts of academic publications. We searched for this term only since we wanted to contribute particularly to the scholarly understandings of the WwNP of FS. The term "Food Sovereignty" had to be included in the title and abstract, or the abstract, or title and questions/objectives, or abstract and questions/objectives. A total of 801 publications were initially yielded. The first author read all abstracts and applied three further selection criteria, all of which had to be met to include a paper in the review: a) type of research: only articles with empirical data were considered; b) scale: only "local" studies were considered. By local, we mean region(s) of a country, so that comparisons between case studies could be done; c) Language: initially only articles written in English were searched in Web of Science. We decided to include the literature in Spanish that was yielded by the search in English in order to have a broader coverage of academic publications, given the historical relevance of the FS movement and research in Latin America. Ninety-two articles complied with the screening criteria and were reviewed (Appendix 2), of which six were written in Spanish. The analysis focused primarily on the methods and results' sections of the articles (or results-discussion if no separation was made between these two sections).

We first coded for the field of research the articles were issued, as social, natural, or environmental, multi- or transdisciplinary research. Multidisciplinarity is defined by Paul and Burton (2011) as an investigation with multiple goals resulting from the work of several academic disciplines. We coded an article as multidisciplinary research when at least one of the authors belonged to a research institution or department of a different discipline. We considered the authors of a paper as a social-ecological team, when they included at least one natural/environmental and social/human scientist. We did not differentiate between multi and interdisciplinary research because this difference is unlikely to be distinguished simply from looking at researchers' affiliations. Transdisciplinarity is defined as the most integrative type of research, which involves not only multiple disciplines but also multiple non-academic participants (Paul and Burton 2011). In our coding, the background of one or more authors had to be non-academic (e.g. local-indigenous community member, leader, activist) to be considered as a transdisciplinary article. Afterward, we assessed the two research questions as follows:

Table 1. We defined the different levels of engagement with the works with nature pillar (WwNP) as their description, number of papers assigned to different levels, the percentage (%) of papers in each level, and a respective example of a paper assigned to this level.

Level of engagement	Description	Number of papers	% of papers	Examples of papers
L1. No engagement	Does not mention any aspect related to the EPFS	1	1	(McKinney and Kato 2017)
L2. Mentioned-not studied	The topics that related to the WwNP are mentioned as a buzzword or presented only in the conceptual sections	18	20	(García-Sempere et al. 2019; Mucioki, Sowerwine, and Sarna-Wojcicki 2018; Partridge 2016)
L3. Studied-not central	Themes related to the WwNP are studied in the article but not central to the narrative/analysis of it	29	31	(Clément Picos 2020; Davila 2020; Zhang 2020)
L4. Studied-central	Themes related to the WwNP are studied and are the main or one of the main foci of the narrative/analysis of the article	44	48	(Bhattacharya 2017; Copeland 2019; Gupta 2015; Ruelle et al. 2019; Soper 2020)
		TOTAL: 92	100%	

The level of engagement with the WwNP in the food sovereignty literature

We defined and coded four different levels of engagement of the articles with the WwNP: "No engagement," "Mentioned-not studied," "Studied-not central," and "Studied-central" (see Table 1 for a detailed description). The assignment to any of the levels was based on content analysis and identification of the topics mentioned or assessed in the articles.

The main themes related to the WwNP in the food sovereignty literature

For the second guiding question of this review, we used a code scheme built in MAXQDA 20.4.0. Codification was split between two of the authors (CB and LB), who regularly discussed coding with author JH, e.g. when new topics appeared while coding, in order to adapt the thematic code, as well as to discuss difficulties and interesting findings.

We followed an inductive coding process, but having in mind the topics included in the WwNP of the FS declaration. As in Velten et al. (2015), we referred to an overall topic related to the WwNP pillar as a *theme* and to single aspects inside a theme as *topics* (Figure 1). We built the first codes inductively, by reading one-third of the 92 articles (i.e. 30 articles) and defining the topics that were recurrent across the literature. We then applied the resulting code set to all the articles.

The code scheme resulted in two overarching themes. The first theme involved the "practices and uses of natural resources" (Figure 1). We divided this theme into four topics: 1.1) ecological agriculture; 1.2) traditional wildlife hunting, harvesting, and fishing; 1.3) intensive-industrial agriculture; and 1.4) nonagricultural extractive activities (e.g.

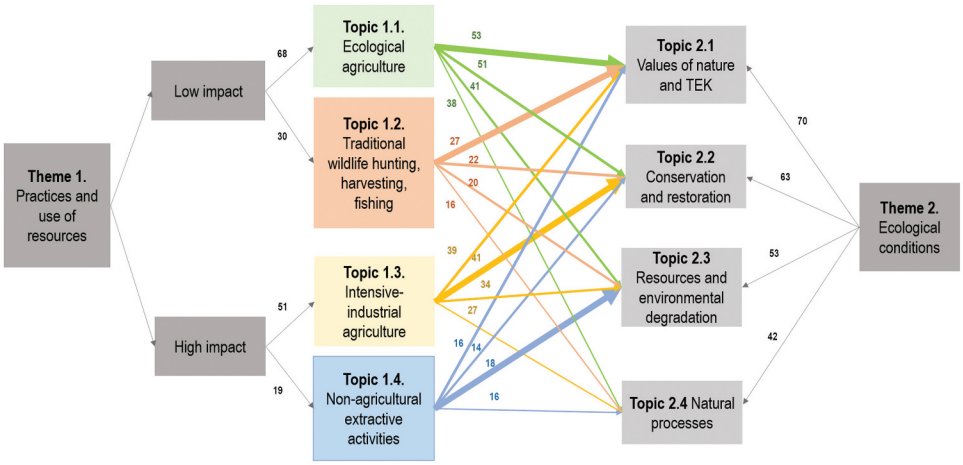

Figure 1. The WwNP themes and topics found in the academic literature; the thickness of the arrows refer to the frequency of topics co-occurrences. The numbers above the arrows indicate the number of co-occurrences between topics of themes 1 and 2.

mining) (Table 2). The second theme includes the social-ecological conditions that are connected to the practices and uses of natural resources from theme 1 (Figure 1). The second theme was subdivided into the following topics (Figure 1): 2.1) values of nature and traditional ecological knowledge (TEK); 2.2) conservation and restoration; 2.3) resources and environmental degradation; and 2.4) natural processes (Figure 1, Table 2). We describe our findings at the topic level. The references used as examples are included in the references section of the main text. The rest of the articles that were reviewed but not included in the main text can be found in Appendix 2.

Results

First, we counted the number of articles belonging to different research fields. Of the 92 articles, 36 were written by multidisciplinary research teams, most frequently of social-ecological teams (22 articles). The second most common field of research of the authors was social sciences (31 articles) followed by natural and environmental sciences (16 articles). The least common teams of researchers were transdisciplinary (9 articles).

Levels of engagement with the WwNP

Nearly half of the articles (44 articles) highly engaged with the WwNP. These articles included themes of the pillar as a central part of their results and discussions (Table 1). Twenty-nine articles (31%) engaged with the WwNP by studying some theme(s) of it, although the pillar was not

Table 2. Description of the topics that were raised in the articles and were coded as part of the results of this review.

Theme	Topics	Description
1. Practices and use of resources	1.1 Ecological agriculture	Refers to various farming techniques involving low environmental impact techniques, e.g. low external inputs, recycling waste, diversification based on local adapted breeds, water and soil fertility management adapted to local bio-physical conditions, mixed crop-livestock-tree systems, local techniques resulting from small-scale, traditional agriculture (iPES-Food 2016; Wezel et al. 2009).
	1.2 Wild-life hunting, harvesting and fishing	Refers to the extraction and use of wild biodiversity as sources of food, nutrients as well as material for housing, shelter, crafts, that are crucial for indigenous and local communities' survival (Somnasang, Moreno, and Chusil 1998).
	1.3 Intensive-industrial agriculture	Refers to the practice of intensive-industrial agriculture. Involving techniques with technical innovations based on the intensive use of external inputs and landscape homogenization (e.g. pesticides, fertilizers, machinery, improved crop varieties, monocrops) (Davies 2015; Jeliazkov et al. 2016; Robinson et al. 2011).
	1.4 Nonagricultural extractive activities	Refers to the practice of human related pressures, that influence the state of planned, wild-life and ecosystems as a whole, resulting from the continuous and excessive extraction of a resource (e.g. mining, logging) (IPBES 2019).
2. Ecological conditions	2.1 Values of nature and Traditional Ecological Knowledge (TEK)	Refers to non-material human-nature relationships. Values of nature refers to values people assign to nature. Values could be instrumental (for humans' sake), intrinsic (for natures' sake) and relational (preferences, principles, and virtues associated with nature-human relationships) (Chan et al. 2016). TEK refers to cumulative dynamic, adaptative complexes of knowledge-practices-beliefs, handed down through generations (sensu Berkes 1999).
	2.2 Conservation and restoration	Refers to the planning and execution of strategies for maintaining or restoring an ecosystem or a resource (e.g. seeds, breeds and plants banks, soils physical, chemical and biological properties, etc.) (Castellini et al. 2021; Nishikawa and Pimbert 2022), in order to provide maximum benefits for present and future generations (Jaisankar, Velmurugan, and Sivaperuman 2018).
	2.3 Resources and environmental degradation	Refers to the loss or reduction of biological or economical productivity and complexity that results from land uses or from a combination of processes, including those arising from human activities and habitation patterns (IPBES 2019).
	2.4 Natural processes	Refers to the processes and relationships between species that do not require humans for them to exist (Govorushko 2012). These include: Ecosystem functions, biodiversity (richness, diversity), land cover, energy cycles, and resilience.

a central focus of the articles. Moreover, 17 articles (20%) mentioned topics of the WwNP, but did not study empirically any themes related to it. Finally, a single article (1%) did not engage at all with the WwNP of FS (Table 1).

Main themes and the underlying topics related to the WwNP

We identified two main themes related to the WwNP (Figure 1): Practices and use of resources (Theme 1) and ecological conditions (Theme 2; see Figure 1). The first theme contained four topics that covered low and high impact practices for the production of food: 1.1) ecological agriculture (68 papers); 1.2) traditional wildlife hunting, harvesting, and fishing (30 papers); 1.3) intensive-industrial agriculture (51 papers); and 1.4) nonagricultural extractive activities (19 papers).

The second theme entailed four topics as well: 2.1) values of nature and traditional ecological knowledge (70 papers); 2.2) conservation and restoration (63 papers); 2.3) resources and environmental degradation (53 papers); and 2.4) natural processes (42 papers) (Figure 1).

In the following paragraphs, we describe the topics in detail, as well as the main connections between themes (Figure 1; colored arrows).

Theme 1. practices and use of resources

Ecological agriculture (68 articles) referred to farming practices and diversifying farming activities. The sub-topics mentioned in the articles included practices such as diversification, organic farming, agroforestry, terracing, intercropping, own organic inputs, manual weeding, rotations, manual sowing, mulching, and local seeds use. The most common sub-topic involved diversification, which was raised as a way of assuring additional monetary income and for self-provisioning (Bacon 2015; Calvário 2017; Friedrich, Schneider, and Vogl 2016). Some articles mentioned diversification as a strategy to avoid pests and boost soil nutrients (e.g. Parraguez-Vergara et al. 2018; Quaye et al. 2009). The use of on-farm produced organic inputs (i.e. organic fertilizers and pesticides) was also an important agroecological practice mentioned (e.g. Ngcoya and Kumarakulasingam 2017; Paredes, José, and Acevedo Osorio 2019; Ramírez-García, Sánchez-García, and Montes-Rentería 2015; Schiavoni et al. 2018; Seminar, Sarwoprasodjo, and Kinseng 2018). The occasional use of synthetic fertilizers and pesticides as complementary to organic practices was also brought up (Friedrich, Schneider, and Vogl 2016; Meek and Khadse 2020; Ramírez-García, Sánchez-García, and Montes-Rentería 2015). A reason for additionally using synthetic inputs raised in the articles was high efficiency and low labor effort (Friedrich, Schneider, and Vogl 2016). A second recurrent sub-topic about ecological agriculture was the economic model (subsistence, commercial, or a combination of both). The practice of subsistence agriculture was associated with the family's food self-sufficiency (Isakson 2009; Sunam and Adhikari 2016; Zhang 2020). Subsistence agriculture was mentioned as being at risk of disappearing, mainly because of environmental degradation, its displacement by commercial agriculture, and the lack of support from the state (Louis 2015; Paddock and

Michael Smith 2018; Paprocki and Cons 2014). Commercial agriculture was also often raised as part of ecological agriculture. In this, the cultivation of cash crops and concerns about them were salient topics. Commercial cropping was shown to be in conflict, or displacing food-crops cultivation for self-consumption and as a concern for spiritual reasons (Copeland 2019; Santafe-Troncoso and Loring 2020). For the latter, the risk of *uprooting* people's relationships with their territories was also a concern, for instance in Copeland (2019). Most commonly, case studies indicated that both cash and food crops were grown in combination (Giuliani, Van Oudenhoven, and Mubalieva 2011; Plahe, Wright, and Marembo 2017). Cash crops could involve diversified systems (Seminar, Sarwoprasodjo, and Kinseng 2018; Subejo et al. 2017).

Traditional wildlife hunting, harvesting, and fishing (30 articles), referred to the importance of these activities for people's livelihoods and FS. These practices were often complementary to farming (Thompson, Thapa, and Whiteway 2019; Turner et al. 2020). For instance (Zimmerer et al. 2020), P. 13 mentioned that: "People in Quishqui also depended on foods collected and hunted in the uncultivated areas of their communities." The erosion, abandonment, and the lack of support by governments for gathering, hunting, and fishing activities in people's territories were also raised in the results (Ibarra et al. 2011; Thompson, Thapa, and Whiteway 2019).

Intensive-industrial agriculture (51 articles) practices included sub-topics such as monocrop production, the use of off-farm inputs, dependence on mechanization for working the land, and the use of GMOs and hybrid seeds. These were often addressed as a matter of concern, especially the use of agrochemicals and GMOs and hybrid seeds was seen in the articles as problematic (Catacora-Vargas et al. 2016; Meek and Khadse 2020). Input prices raised concerns in various articles' results. For instance, Soper (2020) presents the opinion about input prices of a farmer: "Fertilizer always costs $50 a quintal [100 kg], whereas the price of a quintal of potatoes can drop to $1. To buy one quintal of fertilizer, we would have to sell so many quintals of potatoes, we would not make a profit; so I let it go. Now I don't plant potatoes, now we only dedicate ourselves to dairy farming … " (P. 14). Across the articles, the encroachment of agri-corporations in peasants' territories, and a feeling of mistrust toward genetically modified plants and seeds were also prominent. These issues were related to risks toward people's health, livelihoods (by creating dependency), cultures (by interfering in customs and practices in which people share and preserve their own seed varieties) and for undermining women's customary rights, for instance to seeds (Bhattacharya 2017; Gupta 2015; Ritchie 2016). Authors also referred to how the expansion of monoculture aims at supplying urban and global markets instead of local food markets and the subsistence of local communities (e.g. Louis 2015; Misra 2018; Soper 2020). The articles referred to the problem of

low revenues and the difficulties in the cultivation of cash crops in the context of intensive agriculture (Davila 2020; Elkharouf and Pritchard 2019; Manley and Van Leynseele 2019).

Nonagricultural extractive activities (19 articles), especially mining, were considered as important drivers of change affecting people's FS, livelihoods, and cultures (Clément Picos 2020; Copeland 2019; Timler and Water Sandy 2020). The construction of dams (Ibarra et al. 2011; Mucioki, Sowerwine, and Sarna-Wojcicki 2018), water overexploitation, the extraction of timber and other forest resources were cited as well (e.g. Daigle 2019; Thompson, Thapa, and Whiteway 2019).

Theme 2. ecological conditions

Values of nature and traditional ecological knowledge (TEK) (70 articles). This topic was the most frequent aspect raised inside Theme 2 and often developed in depth. We identified two sub-topics of sociocultural aspects related to the ecosystems that illustrate the different ways in which humans relate with nature: values of nature (*sensu* Chan et al. 2016) and traditional ecological knowledge (*sensu* Berkes 1999).

The values of nature were brought up when talking about ecological agriculture and traditional wildlife hunting, harvesting, or fishing. Values of nature were mostly instrumental (for humans' sake). These types of values highlighted in general the potential of cropped and wild biodiversity for providing income or food (Davila 2020; Manley and Van Leynseele 2019). Articles sometimes raised the uptake of monocrops because its practice was perceived as a possibility for a more stable income (e.g. Manley and Van Leynseele 2019). In some cases, instrumental values were related to non-tangible benefits, such as the aesthetic value of a landscape. For instance, Paprocki and Cons (2014) mention: "Residents of Polder 22 as well as those who live outside are acutely aware of both the pleasant aesthetics of this landscape as well as the wide-ranging benefits it affords its residents" (P. 14).

Intrinsic and relational values of nature (the value of nature for itself, and the value of the relationships with nature, respectively) were less present in the literature and were generally identified in case studies involving indigenous communities and ecological agriculture (e.g. Copeland 2019; Coté 2018; Rocha and Simone Liberato 2013). Reciprocity between humans and non-humans was raised for instance in Thompson, Thapa, and Whiteway (2019): "In this worldview, practices include making an offering before harvest for reciprocity, taking only what one needs, and then offering a feast of the first harvest. Reciprocity ensures sustainability and balance, as does speaking to the Anishiniwuk relatives who have hoofs and wings. An Elder stated, 'When I was young, all the animals talked, just like in the cartoons, providing teachings.' Communicating directly with animals provides useful information

to protect both animals and people" (P. 5). Concerns for the wellbeing of the environment were expressed as a consequence of intensive-industrial agriculture (Gupta 2015).

TEK was considered to be integral to ecological agriculture and to the practice of harvesting, hunting, and fishing. Sometimes, TEK was only mentioned as a buzzword (e.g. Rocha and Simone Liberato 2013), while other articles further elaborated on it. For instance, Daigle (2019) develops on how observation is key to TEK and to understand human relationships to other species. In some articles, TEK was at times considered to be eroding because of intensive and extractive activities and participants in articles mentioned an aspiration for its revitalization, for instance, by promoting TEK transmission to younger generations (Coté 2018; Patria 2013; Timler and Water Sandy 2020). In terms of TEK, some articles mention the traditional uses of plants in their territories (e.g. roots, fruits, or mentioned the plant species or the types of plants they select) (e.g. Sowerwine et al. 2019). Sometimes, traditional hunting techniques were raised (Turner et al. 2020). The recipes that used to be prepared with the hunts were sometimes mentioned (e.g. Rocha and Simone Liberato 2013).

Conservation and restoration (63 articles) This topic was mainly related to the conservation of seeds and soils, often as strategies to recover from the negative effects of intensive-industrial agriculture. Seed and soil conservation was also raised as traditional practices associated with ecological agriculture (e.g. Catacora-Vargas et al. 2016). Reforestation and the creation of protected areas were seldom mentioned. The latter were sometimes presented in the articles as impeding customary uses of wildlife (Ibarra et al. 2011). Other articles expressed the recovery of harvested populations since the creation of protected sites (Turner et al. 2020).

Seed conservation is particularly aimed at maintaining culturally important and sacred species, access to good-quality seeds adapted to local conditions, and to avoid spending money on seeds and agrochemicals (Bezner Kerr 2013; Friedrich, Schneider, and Vogl 2016). Sharing among farmers and indigenous peoples was considered an important strategy to promote conservation of seeds, breeds, or plants (e.g. Siebert 2020). Soil conservation and restoration (e.g. Davila 2020; Lucantoni 2020) were mentioned to improve crops and to recover soil fertility or to be damaged by the use of external inputs (Coronel and Tatiana 2019; García-Sempere et al. 2019; Ruelle et al. 2019).

Resources and environmental degradation (53 articles) was often related to nonagricultural extractivist activities. Articles particularly expressed concerns about climate change and extreme weather events, their unpredictability, and their negative impacts on agriculture as well as for finding wild-foods (Jacobi 2016; Quaye et al. 2009; Santafe-Troncoso and Loring 2020; Subejo et al. 2017).

The degradation and loss of cropped biodiversity was commonly mentioned, as well as the decline and depletion of wild fish, birds, and mammals; deforestation; and the loss of cropped varieties (e.g. Jacobi 2016; Misra 2018).

Natural processes (42 articles) included various aspects of environmental and biodiversity characteristics: Biodiversity, land use/land cover, soil/water quality, and ecosystems functions and resilience. These sub-topics were often related or mentioned in the context of ecological agriculture.

Biodiversity or richness of cropped and wild biodiversity was mentioned, and in many cases assessed. Cropped biodiversity assessments were generally present in literature that reported a result from an initiative, institution, organization, or individual about the transformation or application of ecological agriculture practices (Isakson 2009; Ruelle et al. 2019). These articles highlighted that ecological agriculture can result in a high richness of cropped species. On a few occasions, the cropped biodiversity comparisons were made, for instance between different agricultural models (e.g. agroecological vs. intensive) (Catacora-Vargas et al. 2016). When comparing agricultural systems, the names of the plants or the richness of cropped species was only occasionally included (Catacora-Vargas et al. 2016; Manley and Van Leynseele 2019). For a detailed survey of crops, see Zimmerer et al. (2020). Eight articles reported on the *diversity, richness, or abundance of wild biodiversity*. Mainly edible species were mentioned or assessed (Ruelle et al. 2019; Turner et al. 2020). Detailed assessments of wild species were found in Ibarra et al. (2011) and Ruelle et al. (2019). For instance Ruelle et al. (2019) provide lists of cropped and wild species, and calculate diversity indexes for the useful plants. In Ruelle et al. (2019), lists for both cropped and wild species were obtained through interviews and/or questionnaires.

Land use-cover aspects were addressed briefly, for instance by Zimmerer et al. (2020) who assessed the links between the nutrition of small-scale peasants in Peru and their agrobiodiversity. Other biophysical descriptions, such as *soil and water quality*, were assessed in two articles (Álvarez-Salas and Gálvez-Abadía 2014; Lucantoni 2020).

Ecosystem functions were also raised, but none of the articles did empirical assessments of them. These aspects were not core topics in the narrative developed in the articles. *Pest attacks* were mentioned in passing (e.g. Ngcoya and Kumarakulasingam 2017; Lucantoni 2020; Friedrich, Schneider, and Vogl 2016), especially when using mono-cropping practices (e.g. Meek and Khadse 2020). A few articles mentioned *energy cycles'* alteration or improvements. For instance, Ruelle et al. (2019) mentioned how woody vegetation helps maintain moisture and a cool landscape that translates into more biomass. *Pest control and regulation* through predators and other natural enemies were also mentioned in relation to ecological agriculture. Some beneficial pest predators such as insects and frogs were mentioned, for instance by Ngcoya and Kumarakulasingam (2017). Beneficial microorganisms and plants that can

impede pest infections were also raised in Friedrich, Schneider, and Vogl (2016). In the latter study, they observed that "Repellent plants such as common thyme (*Thymus vulgaris*), basil (*Ocimum basilicum*), marigold (*Tagetes erecta*), maize (*Zea mays*), or ruddles (*Calendula officinalis*) were often planted at the edges of the plots to reduce pest infestation or to attract beneficial insects" (P. 6). *Pollination* was mentioned in three articles. This ecological process was said to be important for honey and crops production (Jacobi 2016; Lucantoni 2020; Parraguez-Vergara et al. 2018). Jacobi (2016) reported that "Two interviewees described the importance of agroforestry for pollinators, especially bees. Ecosaf promotes high shares of native plant species, which provide flowers throughout the year. Fruit trees from the Rosaceae family, an important cash crop in the region, flower almost exclusively in September and October but depend mainly on bees for pollination" (P.5).

Resilience was superficially mentioned to highlight how certain practices (e.g. diversification or seed conservation) can contribute to resilience, for instance in the face of climate change (e.g. Bisht et al. 2018; Catacora-Vargas et al. 2016). The articles did not further elaborate on the term. One article used resilience as a framework in the context of FS for a case study in rural Ecuador (Coronel and Tatiana 2019). In particular, a detailed socioecological resilience approach for assessing the responses to climate change was used based on three dimensions: the perception of farmers about climate change; the vulnerability of the farms to these changes; and their capacity to respond and recover to climate instabilities.

Discussion

FS is a paradigm that integrates social and ecological pillars for attaining just food. In this article, we explored how the ecological axis (WwNP) of the FS declaration of Nyéléni (2007) has been integrated into empirical academic literature. A large number of studies strongly engaged with the WwNP identified two underlying themes and eight topics related to it. Here, we discuss the aspects broadly covered in the reviewed articles and then we outline overlooked topics representing opportunities for academic research. Finally, we discuss the role of agroecology for engaged research with the WwNP of FS.

Common topics and strengths

The most common and well-developed topics in the articles included mainstreaming the rejection of intensive-industrial agriculture practices. Another largely covered topic was the importance of ecological agriculture and specific practices in the context of the intensification of the food systems and rural abandonment. The urgent need to reverse the trends of the rapid loss of TEK and values of nature were also dominant topics (Figure 1). Expressions of these

types of distresses and claims for alternative pathways are generally present and considered as political concerns in the arenas of agri-food systems (Walker 2007). FS is a political paradigm, where academic literature also reflected the importance of highlighting peoples' struggles for their right to food, to avert the threats to their cultures and livelihoods (Martinez-Alier 2014; Patel 2009). The emphasis of food-nature political struggles is fundamental in FS research, as they bring into discussion the underlying causes of food-nature issues that often involve the economic models and power relationships that shape food systems toward intensification. The prominence of these topics contrasts with mainstream research that often neglects such struggles as the root causes of food and environmental issues (Shanahan 2022). This paradigm is thus interesting for researchers who feel the need to do engaged political research about food.

The exploration of the multiple ways in which human relate with nature through a plurality of values and TEK was vastly expressed in the literature, being the most prominent and crosscutting topic of theme 2. This was an interesting aspect to be developed in the FS literature. It highlights human–nature interdependencies from a human-cultural perspective, showing the tight coupling of humans with nature in agriculture (Hanspach et al. 2020). In the literature involving values of nature, instrumental values, the value of nature for fulfilling human needs, were the most frequent. Food is in fact a means for human survival. It is consistent then to have found these values more often. Relational or intrinsic values and TEK were less often found in the articles but, when present, they blended with instrumental values and provided information about other types of meaningful relationships that emerge in the agroecosystems beyond profit (Ortiz-Przychodzka et al. 2023) that exist because of food. For instance, Thompson, Thapa, and Whiteway (2019) makes reference to reciprocity, when people made an offering before harvesting certain wild species. This reflected the value of the harvest because it is consumed as food (instrumental value), but also the recognition of the importance of the species' existence with an offering (relational value). This type of research shows the possible contributions of relational and intrinsic values to FS, and reflects the bridges between FS literature and the relational turn in sustainability sciences and studies on human-nature relations in agriculture (West et al. 2020). Furthermore, the mention of TEK topics showed how human-nature interactions can shape knowledges and how these modify in turn the food systems (León-Sicard 2014; Palmieri and Geisa 2019; Perfecto, Vandermeer, and Wright 2019; Ruelle et al. 2019). As mentioned by Ruelle et al. (2019) and Perfecto, Vandermeer, and Wright (2019), the interactions of people with nature involving multiple values and knowledges define their practices and shape the composition and structure of agricultural landscapes. The continuation of the development of such topics will help promote fruitful dialog with the environmental values literature that address how plural values of nature are a constitutive part of FS (Karen et al. 2018).

Less covered topics and opportunities for research

Topics that received less attention were, in theme 1, nonagricultural extractive activities, traditional wildlife, hunting, harvesting, fishing, and, in theme 2, natural processes. The FS declaration of La Vía Campesina makes allusion to the importance of rejecting methods that damage the environment where crops and wild-foods are harvested as well as the importance of ecosystem functions and their contributions to FS (p. 39 Nyéléni 2007). Our results show that in-depth insights on these aspects were present but less developed in depth. It would be interesting to focus on these topics and their consequences for FS in the future, as we suggest in the following paragraphs (for exceptions see Coronel and Tatiana 2019; Ruelle et al. 2019).

An important aspect of the FS paradigm is that it recognizes that food derives from complex systems that depend on the social contexts and the interactions of different species co-existing in agroecosystems (including humans) (Lee 2013; Perfecto, Vandermeer, and Wright 2019; Shanahan 2022). This implies that food does not solely come from the interactions of people with the cropped or harvested species in a certain sociopolitical context, but also from the relations of humans, wild plants, microbes, abiotic components, wild animals, and others (Perfecto, Vandermeer, and Wright 2019). The co-existence of species results in a myriad of ecosystem functions, such as pollination, seed dispersal, decomposition of organic matter, and predation that contribute to assuring the right to food (Maas et al. 2016; Perfecto, Vandermeer, and Wright 2019; Santos, Crouzeilles, and Boelsums Barreto Sansevero 2019). Furthermore, from a human-ecology perspective, it is from the co-existence of humans with other species that the plurality of values of nature, constituting biocultural diversity, emerges and is involved in the conservation of non-human species (Perfecto, Vandermeer, and Wright 2019; Rozzi 2018). Then, all the ecosystem components matter for the re-creation of life (human cultures and biodiversity) and all species (including humans) are important beyond the individual (i.e. the organism itself), but because of the intra and interspecific relations they hold with each other (Odum 1971; Perfecto, Vandermeer, and Wright 2019; Ruelle et al. 2019). The existence of a diversity of species belonging to different functional groups (e.g. scavengers, seed dispersers, farmers) results in different ecosystem functions and cultures, and contributes to making resilient agroecosystems (Ruelle et al. 2019; Sekercioglu 2010). A better understanding of ecosystems is thus not detached from FS and is worth further exploring.

Our results show that conservation-restoration themes in FS tend to focus on seeds and soils. FS strongly supports the need for biodiversity conservation from local perspectives, and puts the livelihoods of the communities at the center of these strategies (Nyéléni 2007). Seeds, soil, their control, and conservation by local people are undoubtedly the baseline for having sovereignty

over the farming systems (Lucantoni 2020; Nishikawa and Pimbert 2022). Still, a wider range of conservation topics could also be emphasized in FS literature, as the sustainability of food systems depends on the maintenance of all the biodiversity of the agroecosystems (Perfecto, Vandermeer, and Wright 2019; Sekercioglu 2010). Conservation strategies for landscapes, water, as well as wild and cultivated species could be further explored in the future (Perfecto, Vandermeer, and Wright 2019). These topics will contribute to emphasizing that food does not depend simply on the management of croplands, but also of the landscapes around them (Cleves-Leguízamo et al. 2017; León-Sicard 2014; Perfecto, Vandermeer, and Wright 2019).

The potential research topics related to the WwNP that we mean to raise do not exclude the political contexts that largely influence agroecosystems and food. For instance, the WwPN research could focus on ecological or conservation dynamics in the context of productivist, technological intensive models of agriculture, power relations, and political contexts in general. This could contribute to discussing the disregard of conventional agricultural lenses for social-ecological topics (Perfecto, Vandermeer, and Wright 2019; Shanahan 2022; Shroff and Ramos Cortés 2020; Turner 2016). The aspects to be explored will depend on the diversity of scholars who focus on FS (Turner 2016) and the contexts being studied, so is not to be defined by just one type of researchers (e.g. agroecologists). Still, a stronger engagement with ecological and conservation topics engaged with the political contexts of the agroecosystems is interesting and could be inspired and linked to agroecological research (*sensu* Pimbert 2018).

Food sovereignty through Agroecology

In its research component, agroecology has greatly advanced in the understanding food–nature relationships (Mason et al. 2020). The use of agroecology as a lens to study the WwNP aspects could add to understanding FS as dependent on sociopolitical forces, but also of complex ecological characteristics in a more structured way (Lee 2013; Walker 2007; Steve, Friedmann, and Howard 2019).

It would seem that only recently agroecological research has begun connecting to FS research (Mason et al. 2020), and, as we show with our results that FS academic literature has not explored various aspects of ecological-ecosystem aspects either. There is scope to explore the interlinking of FS with agroecology as has already been done by some researchers in Latin America. For instance, Gonzáles-Gonzáles et al. (2021) provide case-study examples of agroecological research that considers agricultural landscapes as spaces where food and nature are interdependent. In the same way, Cleves-Leguízamo et al. (2017), propose a methodological tool for planning the use of territories with an agroecological perspective: understanding agroecosystems beyond the plots

and integrating social-ecological components. Perfecto's, Vandermeer, and Wright (2019) book offers an in-depth agroecological perspective, summarizing the importance of biodiversity and ecological functions for FS. More punctual empirical examples can be seen for instance in the work of Ramisch (2005), who studies soil ecosystem behavior in the context of social inequality. Similarly, Turner (1993) showed how livestock populations were determined not only by local bioclimatic factors but also by shifting power relations. Ruelle et al. (2019), with a combination of biological and cultural surveys, showed the importance of biodiversity for providing broader options for preparing, storing, and eating locally meaningful foods. Empirical WwNP research using politically engaged agroecological framework(s) could contribute to strengthening the evidence on how FS "works with nature."

Finally, both FS and agroecology are sensitive to who produces knowledge. Inter- and transdisciplinarity are pursued both by agroecology and FS. Consequently, focusing on narrow disciplinary lenses and modern/Western science as the only valid way of understanding food–nature relationships ought to be avoided. Our results show that the FS literature was mostly written by multidisciplinary research teams. It would be highly beneficial to build transdisciplinary groups in such research fields. Singular disciplines or academic perspectives disconnected from local realities and that do not engage with local actors are unable to provide solutions to complex, multidimensional, and locally rooted food-nature topics (Lang et al. 2012; Paul and Burton 2011; Turner 2016). Fostering a dialog of knowledges ("Diálogo de Saberes") that brings to light the different understandings of food-nature topics would also strengthen FS-agroecological research (Alisha et al. 2021; Delgado and Stephan 2016; Gasche 2010). Transdisciplinary engagements in FS-agroecological literature would allow for responses to the need for a more horizontal discussion of the importance of ecosystems and ecology for sovereign food.

Conclusion

Food Sovereignty is a politically engaged paradigm born from peasant movements increasingly present in academic discussions about the nexus of food and nature. The results of this review reveal that political positions regarding agronomic practices, as well as the importance of TEK and the values of nature, were core topics present in the literature engaging with the WwNP. We highlighted the importance of further pursuing these political and sociocultural perspectives on food–biodiversity relationships. However, a deeper exploration of ecosystem-ecological related topics, or an agroecological perspective *sensu* Pimbert (2018), is relevant for supporting the social-ecological topics relevance for FS (León-Sicard 2014).

Understanding that food originates from the multiple interactions and characteristics of species will allow the further untangling of the complexity of the Food Sovereignty paradigm, which aims to fight not only for our right to food but for the reproduction of life.

Note

1. Humans and other species are part of the same nature (Descola 2012). That means the human species is part of the biodiversity, ecosystems, and nature that inhabit the planet (Descola 2012). For the purposes of this article, although we understand that there is no clear separation between our species and the rest of nature, we will understand nature and biodiversity as the set of non-human living beings. We do this in order to distinguish the relationships that bind humans to other species; which we believe is contained in the message of the FS and notably in the WwNP.

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