Journal of Agriculture, Food Systems, and Community Development
ISSN: 2152-0801 online
https://foodsystemsjournal.org

COMMENTARY FROM THE U.S. AGROECOLOGY SUMMIT 2023

Reflections on research agendas in agroecology: In search of a practical guide

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Special section of commentaries from the U.S. Agroecology Summit 2023 sponsored by **The University of Vermont**

Submitted February 1, 2024 / Published online April 16, 2024

Citation: Perfecto, I., & Vandermeer, J. (2024). Reflections on research agendas in agroecology: In search of a practical guide [Commentary]. *Journal of Agriculture, Food Systems, and Community Development*. Advance online publication. https://doi.org/10.5304/jafscd.2024.133.006

Dismantling the Capitalist Industrial Food System Should Be a Priority

Food systems are crucial to the stability of our planet's ecosystems and the future of humanity. The industrial capitalist global food system has generated multiple crises that pose a significant threat to the future of our planet. The environmental, health, and social impacts of this system of agriculture are multifaceted and well-documented. Pesticides poison us and destroy the world's biodiversity (Ali et al., 2020; Beaumelle et al., 2023; Beketov et al., 2013; Kumar et al., 2023). Pesticides and fertilizer runoff pollute our water and create dead zones (Craswell, 2021, Diaz & Rosenberg, 2008). Greenhouse gas emissions from the global food system contribute up to a third of total global emissions (Crippa et al., 2020). Land concentration and land grabbing condemn millions to poverty (DeShutter, 2011). Food insecurity persists even as food production continues to increase (Long et al., 2020l; Müller et al., 2021). Not only is our current agri-food system environmentally and socially damaging, but it is also extremely cost-inefficient. Diet-related health problems, for example, overburden global public health systems and affect workers' productivity, costing an estimated 9 trillion dollars annually (Food and Agriculture Organization [FAO], 2023).

These well-documented impacts suggest that continuing business as usual is not an option. What is needed urgently is the transformation of the global industrial food system. This requires a divestment from, and dismantling of, the industrial food system and an investment strategy that priori-

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The U.S. Agroecology Summit 2023, from which this set of commentaries emerged, was supported in part by the intramural research program of the U.S. Department of Agriculture, National Institute of Food and Agriculture, USDA-NIFA Sustainable Agroecosystems Conference, NIFA grant no. 2023-67019-38805.

tizes sustainable and equitable food production practices. Developing alternative systems that operate at the margins of an ever-expanding industrial capitalist system is not a viable solution. It is evident that in order to achieve the transformation of our agri-food system into a just and sustainable one, it is essential to simultaneously disassemble the agro-industrial system responsible for the social, economic, and environmental crises we are facing today, while building sustainable and just alternatives in its place. Today, the largest 1% of farms (>50 ha.) in the world control more than 70% of the farmland (Lowder et al., 2021), and these tend to be managed in a conventional way (monocultures with high agrochemical inputs). Additionally, intensive commodity production continues to expand (Estrada et al., 2019; Meyfroidt et al., 2014). Merely strengthening agroecology and promoting diverse agroecological systems on a small percent of the land not controlled by large farms will not be sufficient to solve these crises. Therefore, the focus should be on a complete transformation of the agri-food system, including land redistribution, rather than just constructing alternative systems that will perform parallel to the agro-industrial ones.

For an effective and truly transformative change, we need to clearly articulate what the old system should be replaced with. Agroecology is emerging as a strong alternative to the discredited industrial agricultural system, and it is gaining recognition from grassroots movements like La Via Campesina to international establishment institutions like the United Nations Food and Agriculture Organization (FAO). However, there are still social, political, and technical barriers that need to be better understood for a full implementation of agroecology. We need to combine our knowledge of basic ecology, local and traditional practices, and socio-political analyses to pave the way forward to complete transformation.

The Quest for Profits and Control

In order to advance agroecology, we must first acknowledge the two primary factors that anchor current agricultural research in the U.S. These factors are the pursuit of profit by the agro-industrial corporate sector and their quest for social and market control. This has been the case for more than 70 years, as Levins and Lewontin (1987) previously elaborated in *The Dialectical Biologist*, and it continues to hold true today, with even higher profits and expanded control (Loyd et al., 2024 [in this Special Issue]; Murphy, 2008). Agroecology can provide the autonomy that farmers need to resist this new form of empire (Holt-Giménez et al., 2021; Van der Ploeg, 2021).

There are many factors that impede the necessary transformation, among them political will and power imbalances. Another factor receiving inadequate attention is system lock-ins—the incentives, policies, and structures that set farmers on a particular trajectory from which it is difficult to diverge. Hence, farmers' needs are determined by the system of production in which they are trapped. Thus, the farmer becomes the agent by which the providers of inputs and the purchasers of outputs benefit from the socialized (and frequently publicly funded) establishment of research. In that way, public agricultural research, indirectly but significantly, serves the needs of capital through the evident goal of responding to the needs of farmers. In fact, the research establishment has been effectively captured for capital accumulation, and this is why only a small fraction of what consumers pay in the supermarket goes to the farmers and farmworkers that produce that food.

Agroecology offers both a vision for the future and a practical way for farmers to regain their lost autonomy and become less dependent on market forces that are beyond their control (Lucas et al., 2016). However, as an intellectual field and actual practice, there are gaps in our knowledge. Even though we can easily apply many agroecological practices that have been verified both socio-politically and ecologically, many others remain only "rules of thumb" and require a more comprehensive understanding. This framework cries out for an expanded research agenda in agroecology.

What Questions Should Drive the Direction of Research in Agroecology in the U.S.?

There are six general areas of research we propose should receive special attention: (1) documentation and understanding of current agroecological systems that work well; (2) climate change adaptation

and mitigation; (3) multifunctionality of agroecological systems; (4) complexity of agroecosystems, (5) the intersection of biodiversity and agriculture, and (6) the ecology, management, and preparation of orphan crops.

First, we need to document current examples of agroecological systems that are working well from a productive, ecological, social, and economic perspective, and conduct research to understand these systems. In contrast to the reductionist approach that effectively seeks to solve problems after they emerge, agroecological research should ask, "When a system is working well, what are the characteristics that drive it to do so?" These are the systems that could serve as examples for the scaling out of agroecology (Gascuel-Odoux et al., 2022), yet to do so requires a knowledge of precisely why they are working. Expansion of those successful examples needs to be grounded in concrete knowledge if we are to adapt them to new circumstances and environments. This line of research will require more on-farm research and participatory action research, as well as strengthening a farmer-to-farmer methodology that will facilitate the scaling-out, or massification, of agroecology (Mier y Teran Giménez Cacho et al., 2018; Nicholls & Altieri, 2018).

Second, in the face of evident problems posed by climate change, we need research into the factors and conditions that confer socio-ecological resilience to small- and medium-scale agroecological farms, especially as related to expected new climate regimes (Altieri et al., 2015; Amoak et al., 2022). Likewise, we need more research on how agroecological production can contribute to the reduction of greenhouse gas emissions (Nair, 2012). In these efforts, a deeper understanding of the carbon cycle, the role of microorganisms, and biochemical processes in soils and plants in sequestering and releasing carbon is essential. Likewise, we need a better understanding of how agroecological practices, such as cover crops and intercropping with N-fixing legumes, affect the nitrogen cycle and, more specifically, how these practices can reduce nitrous oxide emissions. This line of research will require the integration of crop and soil ecologists, climate modelers, and social scientists working together in a transdisciplinary fashion.

Third, we need research on the multifunctionality of agroecological systems. We need to better understand the mechanisms that generate synergies and tradeoffs among ecosystem services, as well as socio-economic and political benefits of diverse agroecological systems, to design multifunctional systems. Agroecological planning should have multiple goals, not just productivity. Conventional agricultural research agencies funnel millions of dollars each year into research on how to increase yields of a few crops grown in monocultures. For a true agroecological transformation, more research should be devoted to other benefits of agriculture and yields of multiple crops grown together. We need to redesign agricultural systems all the way up to the global food system (Mason et al., 2021). Intellectually, this requires the integration of diverse kinds of knowledge and a recognition of the inseparability of the natural and the social fields.

Fourth, it is important to recognize that nature is complex, and therefore, any intervention in the rich network of interacting variables is likely to have many indirect and unexpected consequences —there is an inevitability of surprise. The magic bullet, "one problem-one solution" approach should be abandoned. Rather, seeking an understanding of the agroecosystem as a complex system, a challenging goal to be sure, should be a guiding principle. This will require the application of complexity science, including complex adaptive systems, chaos, critical transitions, multidimensionality, and other complexity topics applied to the analysis of agroecosystems and food systems more generally (Vandermeer & Perfecto, 2017).

Fifth, we need to understand the role of biodiversity in agroecological systems. This research area is related to all the previously discussed research foci. Industrial agriculture is the main driver of biodiversity loss. To reverse that trend, we need to design diverse farming systems that maintain biodiversity at local and landscape levels. In this context, farm diversification through genetic diversity, intercropping, and agroforestry is essential. Despite some popular misconceptions, our understanding of the ecology of diverse farming systems remains underdeveloped. How can we encourage synergies and discourage tradeoffs among various crops?

How do nonlinearities in crop-to-crop competition affect production, promote long-term sustainability, and protect against pathogens? A host of such issues are incompletely understood. We also need to better understand the influence of landscape-level diversity on local farms, as well as the role of the agroecological matrix on the conservation of biodiversity at the landscape level (Perfecto et al., 2019). It is important to recognize and understand biodiversity's role in the productivity and sustainability of agricultural systems. As part of increasing agrobiodiversity, we need to better understand processes of seed conservation and dissemination. Furthermore, complicated issues involved with the genetic basis of crop improvement need to be better understood, if for no other reason than to challenge some of the standard narratives about crop improvement.

Although a fair amount of ecological research has been devoted to biodiversity and ecosystem function, the mechanisms of how biodiversity affects ecosystem function and ecosystem services in agricultural systems have eluded us. A better mechanistic understanding is essential to harness the agricultural benefits of biodiversity, especially in the context of supporting farmers' autonomy from the market forces that keep extracting the fruits of their labor.

Finally, when thinking about farm diversification, we must also pay more attention to the ecology, management, and preparation of the so-called "orphan" or "minor" crops. These crops have received little attention from the agricultural establishment because they do not play a major role in international trade. However, such crops tend to play major roles in regional food security and can have great potential for adaptation to climate change and other extreme conditions (Tadele, 2019; Talabi et al., 2022). Many of these crops have significant nutritional and cultural value, but the traditional knowledge related to their cultivation and preparation is being lost.

Knowledge Gaps for the Implementation of Agroecology

We need to focus on transformation processes within restricted localities: How do we move from the local conventional to locally adapted agroecological systems? The social sciences are clearly important in this applied question. What local impediments do farmers face when attempting to adopt agroecological techniques? The obstacles and difficulties in adopting agroecology vary greatly depending on the specific local context. Therefore, there is no one-size-fits-all solution. However, gaining a deeper understanding of the local conditions, including environmental, economic, cultural, social, and political factors, can significantly help to overcome the barriers farmers may face when implementing agroecology.

There is also a need to understand justice and equity issues related to agroecological transformations, a central socio-political agenda item. In this context, gender plays a major role, as it has been shown to intersect with almost all other forms of inequity (Mora & Muro, 2018). As Rachel Bezner-Kerr and colleagues (2019) have shown for Malawi, feminist concepts of intersectionality and participatory praxis are essential for agroecological transformation and for mobilizing agroecology to promote and protect food sovereignty. Other studies have shown that improved gender equity can result in improved nutritional outcomes, higher use of agri-biodiversity, and other aspects of agroecology (Anderson et al., 2019). Therefore, a research agenda for the transformation of agriculture would be incomplete without a strong gender focus.

We must understand the scalability of agroecology. What is the appropriate planning scale (both ecological and social) for agroecology given different circumstances? Are there essential contradictions between ecological and socio-political referents regarding scale? With respect to diversification (within fields, farms, and landscapes), how do we manage agroecological systems? In particular, the management of intercropping, crop rotations, agroforestry systems, biological control with multiple agents, and soil dynamics and conservation at different scales. These are all things that extant agroecological systems have grappled with and for which at least partial solutions have been found. That is why a strong farmer-to-farmer approach is essential for the transformation process and the scaling-up and scaling-out of agroecology. More than a landscape or regional approach, we need a territorial approach, not restricted to biophysical

factors, but incorporating essential social, cultural, and political factors, which is what "the territory" implies (Wezel et al., 2016).

As we envision more small- and medium-scale diversified farms replacing large-scale ones, we need to consider appropriate technologies. Suitable mechanization technologies and agricultural equipment adapted specifically for agroecological systems should be a focus of research, since easing the work of farmers can address an important barrier for the implementation of agroecology. However, this research needs to be carried out with farmers leading the way. Initiatives of farmer-designers have already proven to be successful at innovations of farm equipment appropriate for agroecology (Salembier et al., 2020). Here, we need to acknowledge and study the obvious benefit for renewable energy use in the small-scale sector (e.g., solar tractors work better on small farms with small tractors). Additionally, we need to harness communication technology to strengthen local and regional food distribution systems.

Conclusion

In all of the above, we must remember that agroecology, in principle, seeks to employ "**gentle, thought-intensive technologies**" rather than a nature-dominating capital and fossil fuel intensiveness. An overall practical guide to such an agenda is to reduce off-farm inputs, harness biodiversity, and let nature work for the farmer. But for that, we need to understand the ecology of the system, a goal that cries out for ecological research as well as the adoption of local, traditional, and indigenous knowledge, and participatory action research. More than anything, we need to promote the interpenetration of traditional knowledges with scientific knowledges.

More research is needed to clarify the path to a sustainable agroecological system. However, the transformation can't wait for complete knowledge since completeness is illusory in agroecosystems, as in all other systems in which knowledge translates into practice. With each advance in knowledge comes a realization that yet further knowledge is lacking. Understanding this truth need not paralyze the practitioner. Taking a cue from traditional farmers, in the face of incomplete knowledge, there are nevertheless "rules of thumb" that anchor the agroecological practices that are already in place. Respecting those rules is essential. Yet, seeking deeper understanding should be part and parcel of an overall research agenda (Vandermeer & Perfecto, 2024).

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