

What do we know about THE FUTURE OF AGROBIODIVERSITY IN RELATION TO FOOD SYSTEMS?

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Key messages

- Agrobiodiversity – the diversity of living organisms that underpin agricultural systems – provides numerous critical benefits, from on-farm crop diversity and genetic resources that allow farmers to adapt crops to changing environments to the provision of ecosystem services such as pollination, disease and pest resistance, soil health, and water conservation. These benefits in turn support resilient livelihoods, food security, and diversified, nutritious diets.
- A number of ex ante theoretical and practical approaches have been used to show how greater agricultural biodiversity is connected to higher production and lower risk exposure, and to assess the role that agrobiodiversity plays in supporting agricultural systems resilience. But little has been done to integrate the measurement of agrobiodiversity into foresight modeling, or to apply foresight tools and methods to study long-term effects of agrobiodiversity on socio-economic or environmental outcomes.
- The recent development of the Agrobiodiversity Index and advances in integrated modeling systems provide opportunities for improved scenario analysis focused on agrobiodiversity and informed by agroecology and agricultural economics theory.

RECENT TRENDS AND CHALLENGES

It is well established that protecting and investing in greater agrobiodiversity is needed to achieve multiple Sustainable Development Goals (Fowler and Hodgkin 2004; Hajjar, Jarvis, and Gemmill-Herren 2008; Wood et al. 2018; Waha et al. 2022), and that this diversity is threatened by many factors, including climate change, socio-economic trends, and management decisions that have led to a global homogenization and degradation of both farmland and its genetic resources (IPBES 2019; Purvis et al. 2019; Landis 2017). For example, it is estimated that up to 22 percent of wild crop species may go extinct by 2055 (Brauman et al. 2019; Jarvis, Lane, and Hijmans 2008), and that over 9 percent of domesticated mammal breeds had already become extinct by 2016 (IPBES 2019).

The magnitude of such threats is undermining the future sustainability of agricultural production and the food security and livelihoods of countless producers and consumers: for example, the loss of pollinators has reduced the value of annual global crop production by an estimated US\$235 to \$577 billion (IPBES 2019; Potts et al. 2016). The large uncertainty inherent in the evolution of global and local drivers of change, and the ensuing challenges, require tools in support of urgent and informed decisions. However, few studies have applied foresight tools to analyze the medium- to long-term effects that investing in agrobiodiversity may have on socioeconomic and ecological outcomes, as well as for adaptation to and mitigation of climate change. Such studies may also be useful to highlight the trade-offs between immediate human needs and the benefits that agrobiodiversity may provide in the long term through the provision of multiple ecosystem services.

LATEST FORESIGHT RESEARCH

A mature literature exists on the farm-level benefits, impact pathways, and nonmarket valuation of agrobiodiversity (Di Falco 2012; Kontoleon, Pascual, and Smale 2009). Linking modeling insights developed at the farm scale with mechanisms and drivers at the ecosystem, national, and global scale remains a challenge, however. A rich literature also addresses the effects that alternative policies or management practices may have on levels

of agrobiodiversity (Petsakos et al. 2023). However, to our knowledge, such studies generally lack a time dimension and consideration of other important drivers of change in food systems over the medium to longer term.

Few studies based on scenario analysis have used integrated models to explore the effects of increased agrobiodiversity on farm productivity, incomes, diets, and ecosystem services (Enahoro et al. 2019, 2023; Kozicka et al. 2020, 2022). These studies commonly link a global partial equilibrium model of the agriculture sector to farm models, environmental simulation tools, and models that analyze changes in ecosystem services.

When agrobiodiversity is studied as a driver of change, it is often represented through proxy indicators. For instance, scenario analysis has been used to explore how agroforestry compares to monocropping vis-à-vis the expansion of agricultural land to accommodate growing demand for animal-source foods in Tanzania (Enahoro et al. 2019; Kozicka et al. 2022). In these studies, the two management systems are mainly distinguished in terms of the biomass they are able to produce to meet livestock production needs (for example, yields of maize in monocropping are double the yields of agroforestry), or characterized through parameters relevant to the delivery of specific ecosystem services (for example, above- and below-ground carbon pools).

Foresight work looking at changes in the level of agrobiodiversity is also uncommon. In one example, the Shannon Index was used as a measure of change in agrobiodiversity following three possible scenarios of impacts on farming systems in Uganda (Kozicka et al. 2020).

Study results in Tanzania show that, compared to monocropping, agroforestry-based interventions hold promise for mitigating losses to key ecosystem services; in particular, erosion was halved while increasing production of animal-source foods. However, because more agrobiodiverse systems generate lower yields and greater conversion to cropland, some trade-offs may arise between meeting the demand for animal-source foods and maintaining ecosystem services (Enahoro et al. 2019; Kozicka et al. 2022).

The Uganda case study shows that increasing on-farm crop diversity can improve soil and human health and lead to greater socioeconomic system resilience against both climate shocks and damages from pests and diseases (Kozicka et al. 2020; Kozicka, Groot, and Gotor 2019). However,

trade-offs do exist. While greater diversity can boost revenues and could restore dietary vitamin A to close to pre-shock levels, it may also lead to more volatility in revenues.

Similarly, other studies summarize the multiple avenues through which agroforestry interacts with planetary health, note the need for highly context-specific assessments (Rosenstock et al. 2019), and highlight the benefits of agroforestry for household asset accumulation, while also pointing out the difficulties in achieving broad adoption (Hughes et al. 2020).

Crop diversity was the focus of a recent study on durum wheat in Ethiopia, where a GTAP (Global Trade Analysis Project)-derived¹ model was used to test adoption of traditional wheat varieties (TV; those adapted to more extreme agroecological conditions in low-input systems) versus modern high-yielding varieties (MV; those more adapted to high-input monocropping systems) under climate change (Gotor et al. 2024). This study showed that an integrated approach based on the geographically targeted adoption of TV and MV can lead to better adaptation to climate change and boost agricultural production as a result.

KEY GAPS AND OPPORTUNITIES FOR FORESIGHT RESEARCH

There seems to be a lack of research and application of foresight analysis to either the measurement of agrobiodiversity or its role as a driver of ecosystem services and a key determinant of food security and resilient livelihoods. Factors that may contribute to this situation include (1) confusion around the definition of agrobiodiversity; and (2) the difficulty of capturing in foresight models the causal relationships between socioeconomic factors and their impacts on agrobiodiversity. While these difficulties are not trivial, we see three possible ways of including agrobiodiversity in foresight-type scenario analysis.

First, long-run scenario analysis could be used to estimate across geographies and farming systems how agrobiodiversity may be changing as a result of specific policies and management decisions. The recently published

Agrobiodiversity Index (ABDI) (Jones et al. 2021) provides an opportunity for foresight models to systematically measure a broad range of aspects related to agrobiodiversity across both producer and consumer sides of the food system.

Second, agrobiodiversity can be analyzed in terms of the future effects it may have on outcomes, from the provision of ecosystem services to agricultural productivity, incomes and livelihoods, and food security. This area of foresight research is still in its infancy. An additional path may be through development of a feedback loop between a land use change model and an integrated model such as IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade) (Robinson et al. 2015), with possible links to biodiversity models.

And third, foresight tools and methods can be used to explore how major global drivers of change – as well as different policies, technologies, and trends – may affect biodiversity in general. These types of analyses are fairly well established from a methodological standpoint, but the emphasis is typically given to extinction risk, abundance, habitat loss and degradation, and changes in species distributions, especially for vascular plants and vertebrates (Flachsbarth et al. 2015; Leclère et al. 2020). But some such studies and methodologies may offer additional insights into impacts on agrobiodiversity.

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Related chapters on the future of food system drivers and impacts, regional and national perspectives, food commodities, and foresight tools are available in our [Table of Contents](#).

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¹ <https://www.gtap.agecon.purdue.edu>

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