Mainstreaming Agrobiodiversity in Sustainable Food Systems

Scientific Foundations for an Agrobiodiversity Index

6

Towards an Agrobiodiversity Index for sustainable food systems

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Measuring

KEY MESSAGES:

- → Agricultural biodiversity is measured in many ways: in healthy diets, sustainable land use, agriculture, climate change adaptation, resilience and biodiversity conservation.
- → Bioversity International proposes the development of an Agrobiodiversity Index that brings agricultural biodiversity data together in innovative combinations across these functions in the food system to give novel insights, help countries identify policy levers, and be usable in real time to guide companies and investments.
- → We welcome input from readers, experts and potential users for the development and utility of the Agrobiodiversity Index for sustainable food systems.

Introduction

"What gets measured, gets managed."

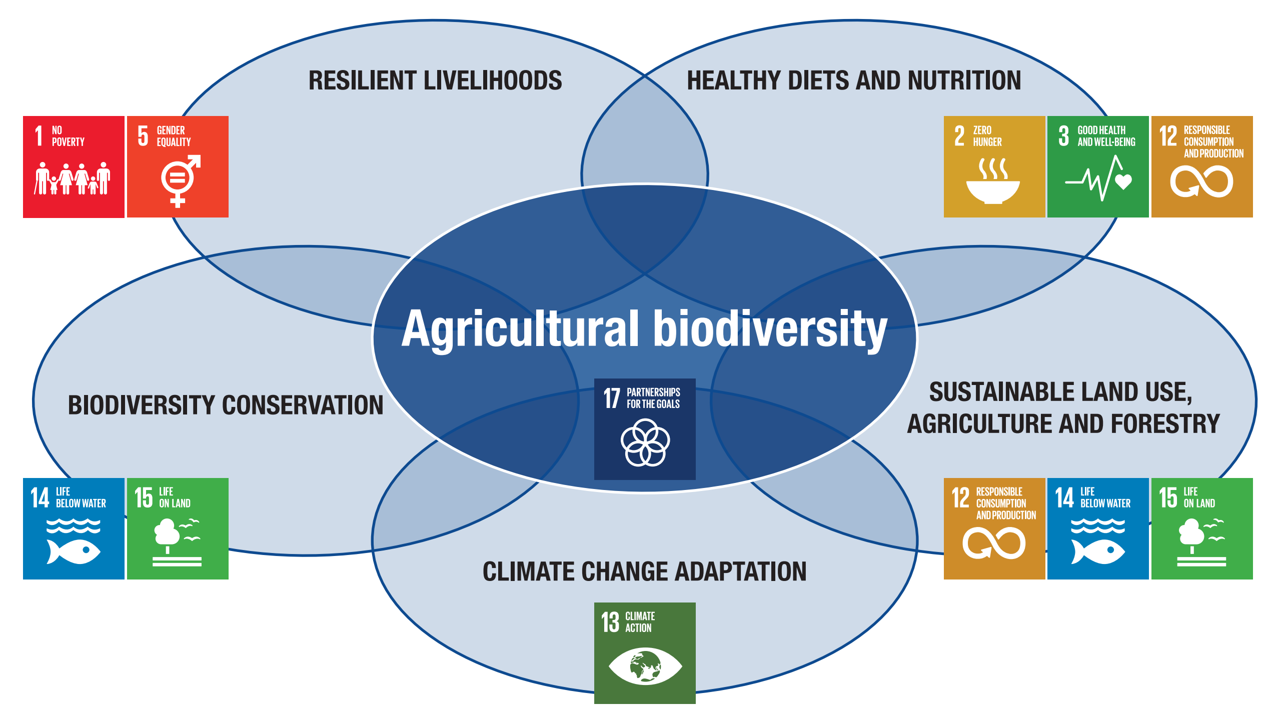
The previous chapters review and summarize the evidence base for how people use agricultural biodiversity to achieve different aspects of sustainable food systems. Agricultural biodiversity is important in four dimensions: in consumption for nutritious diets and human health; in production for long-term productivity, resilience and multiple ecosystem services; in seed systems for access to options that serve diverse needs and help adaptation to changing conditions; and in integrated conservation methods for enabling future uses and insurance against shocks.

The evidence combined illustrates that agricultural biodiversity sits at the nexus of different food system components and sustainability dimensions (Figure 6.1). Such a perspective on agricultural biodiversity for multiple goals aligns with one of the core food system principles proposed by the International Panel of Experts on Sustainable Food Systems: "Food systems must be fundamentally reoriented around principles of diversity, multi-functionality and resilience." (1)

Many indicators and methods have been developed and applied to measure the many facets of agricultural biodiversity. For example, metrics illustrated in Table 6.1 inform pathways that connect agricultural biodiversity to diet quality, sustainable agriculture, ecosystem services, the diversity within seed systems, or biodiversity conservation. This variety in measurements is both agricultural biodiversity's strength and its weakness. Its strength because evidence of agricultural biodiversity's contribution to each of these ambitions has been collected and has triggered interest in agricultural biodiversity across sectors, Sustainable Development Goals and Aichi Biodiversity Targets. Its weakness because data, information and metrics are scattered across locations, disciplines (e.g. conservation, ecology, agriculture, markets, nutrition) and scales (from crop varieties and species to ecosystems, entire regions and countries). No coherent monitoring exists, which limits our effectiveness to manage agricultural biodiversity for sustainable food systems.

Starting from the scientific evidence base in the four dimensions described in this book, we are designing an Agrobiodiversity Index, which brings agricultural biodiversity data together in innovative combinations across functions in the food system to give novel insights, which can help countries and companies identify policy and business levers, and guide public and private sector investments.

FIGURE 6.1 – Agricultural biodiversity contributes to multiple sustainability dimensions and development goals



Aichi Biodiversity Target Icons Copyright BIP/SCB

TABLE 6.1 – Illustration of indicators, both existing and proposed, that measure agricultural biodiversity and its contributions to dimensions of a sustainable food system

Agricultural biodiversity contributing to...

			
HEALTHY, DIVERSE DIETS	**MULTIPLE BENEFITS IN SUSTAINABLE FARMING SYSTEMS**	**CROP DIVERSITY FOR SUSTAINABLE FOOD SYSTEMS**	**CONSERVATION FOR USE IN SUSTAINABLE FOOD SYSTEMS**
DIET DIVERSITY • Minimum diet diversity for children and women • % consumption of targeted food groups • Dietary species richness (number of different plant and animal species per person per day) • Grams and dietary energy per capita of different food groups/ items • % dietary energy from non-staples **MARKET/ VALUE CHAIN DIVERSITY** • Prices of principal foods representative of diverse food groups • Ultra-processed food retail (vol/capita) • Fresh food retail (kg/ capita) • Diversity of retail outlets for elements of a healthy diet • Average price of a healthy diet **ENABLING ENVIRONMENT** • Consideration of ABD in a country's National Dietary Guidelines • Food subsidies and public procurement programmes in place that promote ABD for diets/nutrition • Consideration of ABD mainstreaming for diets/nutrition in NBSAPs	**DIVERSITY WITHIN SPECIES** • Varietal diversity of major crops in production systems **DIVERSITY AMONG SPECIES** • Evenness/diversity of production area and yield across crops **DIVERSITY AT FARM AND FIELD LEVEL** • Soil biodiversity in agricultural production systems • Functional trait diversity of crops • % agricultural area under sustainable agricultural practices **DIVERSITY AT LANDSCAPE LEVEL** • Landscape and land-use heterogeneity • Coverage (e.g. extent) of habitat related to particular ecosystem services (e.g. pollinator habitat) **ENABLING ENVIRONMENT** • Policies that explicitly aim to conserve and/or promote ABD • National policies and incentives around multiple ecosystem services in agricultural landscapes	**SEED ACCESSIBILITY** • Information availability • Amount and diversity of seed sources • Proximity of seed sources • Seed price **SEED PRODUCTION AND DISTRIBUTION** • Amount of seed produced and distributed • Range of crops and varieties multiplied and distributed • Number and diversity of seed multipliers and seed suppliers **CROP INNOVATION** • Range of species covered by innovation efforts • (Local) genetic diversity used in innovation efforts • Degree of recognition of farmers as innovators in intellectual property right systems **REGULATIONS** • Extent to which variety registration procedures allow for the release of varieties responding to different environmental and socio-economic conditions • Extent to which seed quality control and certification schemes respond to different types of seed producers and farmers	**ON-FARM CONSERVATION** • Percentage of cultivated land under farmers' varieties/landraces in areas of high diversity and/or risk • Proportion of breeds already at risk that slide a level or more down towards 'critical' status ***IN SITU* CONSERVATION** • Number of crop wild relatives and wild food plants species actively conserved *in situ* • Crop Wild Relative Index based on IUCN Red Listing ***EX SITU* CONSERVATION** • Number of accessions conserved *ex situ* under medium or long-term conditions • Enrichment Index **ENABLING ENVIRONMENT** • NBSAP includes ABD • Farmers and their knowledge recognized and their role explicitly facilitated • Regional, local ordinances to support ABD conservation/use. • Participatory, broad-based development of strategies and implementation plans specifically targeting participation of women farmers

ABD = agricultural biodiversity, NBSAP = National Biodiversity Strategy and Action Plan

What we can learn from agricultural biodiversity data, metrics and monitoring for the design of the index

The importance of agricultural biodiversity data and reporting is increasingly recognized. The Food and Agriculture Organization of the UN (FAO) is publishing a new milestone, the *State of the World's Biodiversity for Food and Agriculture*. There is, however, a gap in terms of tools and approaches for quantitatively synthesizing existing and emerging data into actionable trends, dynamics and summaries. To make measures actionable, we need to know how the diversity is used, how uses are changing over time, and what major enablers and constraints leverage or block the potential of agricultural biodiversity for human and environmental health. For example, we want to know: Is diversity entering the marketplace? Do farmers have access to diverse planting materials? How much diversity is ending up on people's plates?

Learning across agricultural biodiversity measures and monitoring efforts, we can draw several lessons to help guide the design and initial architecture of the Agrobiodiversity Index.

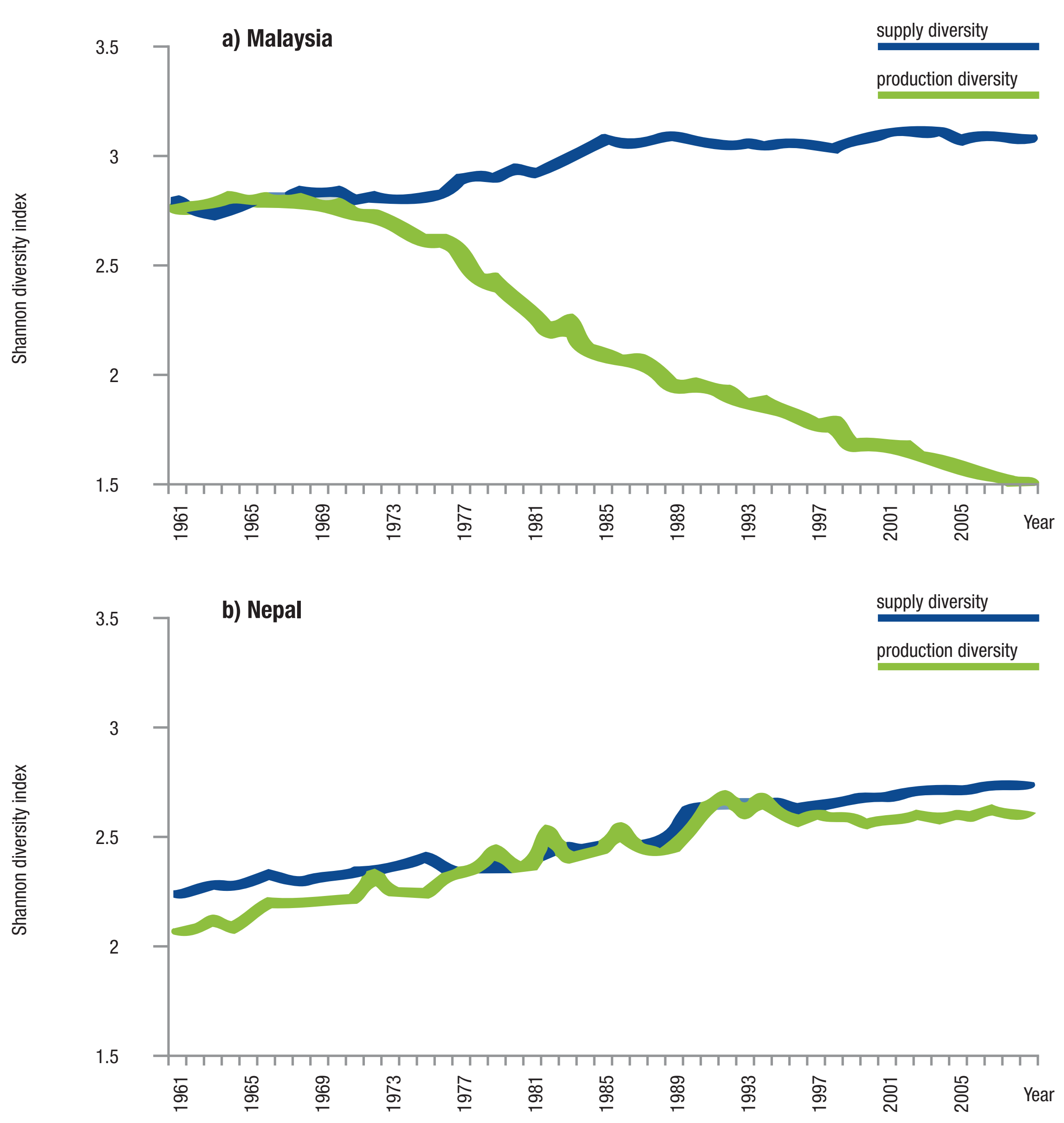
First, agricultural biodiversity is used and measured throughout the food system (Chapters 2 to 5, Table 6.1). Understanding agricultural biodiversity trends across, and interactions among, multiple food system dimensions helps to identify points of constraint, trade-off, synergy or action. For example, if levels of agricultural biodiversity in production are increasing, but diet diversity is not, then there is potential to strengthen local markets for increased access to, and consumption of, food biodiversity. Mobilizing existing databases and applying a consistent set of simple agricultural biodiversity indicators (e.g. species richness, or commonly used measures of diversity, such as the Shannon diversity index[i]) across food system

Jaya Bahadur Thapa and his daughter-in-law, Saraswati Thapa, from Chaur, Begnas, Nepal. Jaya Bahadur and his wife Lal Kumari Thapa (not in the picture) are custodian farmers who specialize in medical plants. They make herbal remedies and powders and also sell saplings of medicinal plants. Sale of their medicinal products is generating a steadily increasing income. They are passing on their knowledge of medical plants and remedies to their daughter-in-law.
Credit: LIBIRD/Sajal Sthapit

dimensions (consumption and markets, production, seeds, conservation) enables trends in these dimensions to be identified and compared (2–4). Two examples can illustrate how useful, novel insights can be drawn from synthesizing publicly available data with a diversity lens.

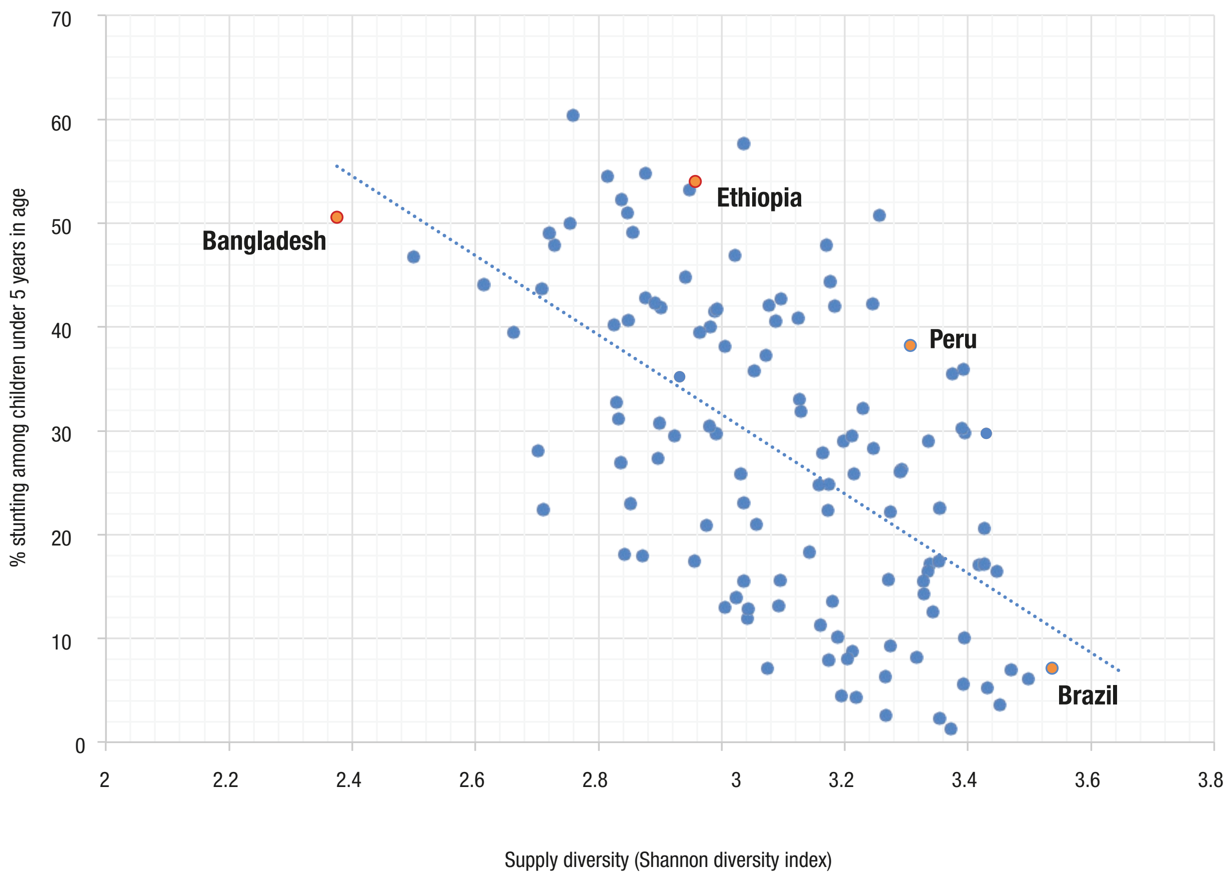
The first (Figure 6.2) compares over 40 years of data on production diversity (i.e. number of species produced in a country) with data on supply diversity (i.e. a measure of the diversity of species available for human consumption in a country, considering production, export, import, feed and waste). In Malaysia, while the diversity in production has dropped drastically through intensification of palm oil production, the diversity in food supply has increased through import of diversified food items. The example illustrates that international trade can provide people with diverse foods to eat, but the drastic reduction in production diversity raises concerns about the environmental consequences as well as the country's dependence on palm oil. In Nepal, on the other hand, production and supply diversity have slowly increased together over time, suggesting that the country is achieving food supply diversity through a system of diverse food production. This indeed reflects Nepal's agricultural and food policy (5, 6), which has been closely integrated with its multisectoral nutrition policy and plan (7). Nepal is still a low-income country with limited international trade and high levels of chronic undernutrition (40% stunting among children under five years of age), despite recent accelerated reductions in stunting (8). A key question here is how Nepal can further climb up the economic development ladder, while smartly managing its production and supply diversity.

FIGURE 6.2 – Production and supply diversity in Malaysia and Nepal based on FAOSTAT data



Source: Adapted from (9)

FIGURE 6.3 – Comparison of data on supply diversity with data on levels of stunting among children

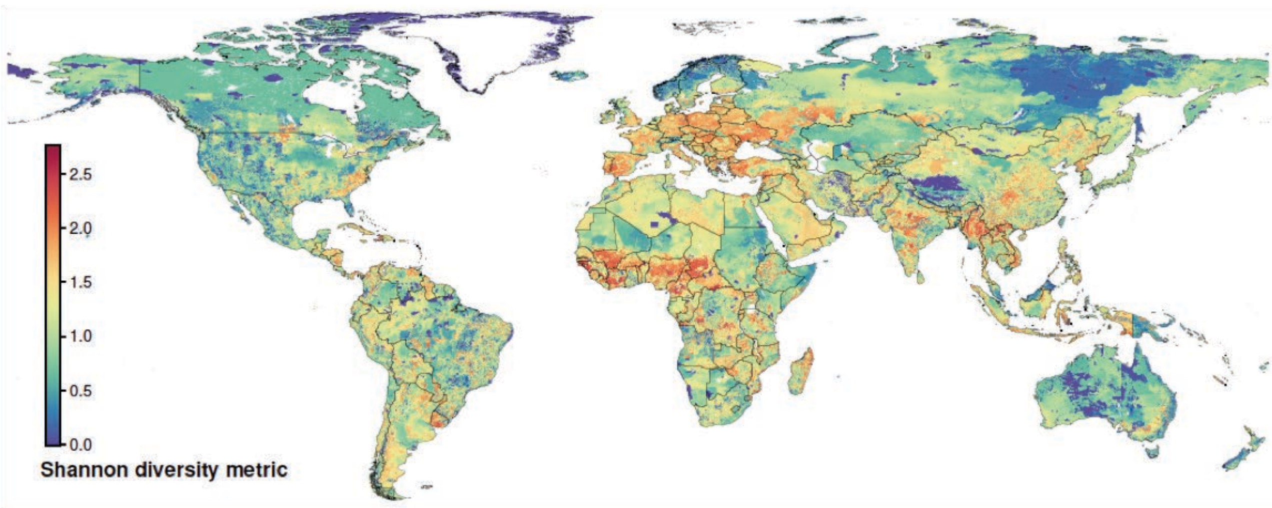


Another example (Figure 6.3) compares data on supply diversity with data on levels of stunting (i.e. low height for age) in children under five years old. Higher levels of supply diversity correlated closely with lower levels of stunting. While this does not necessarily indicate a cause–effect relationship between diversity and the reduction of stunting, it does suggest an interesting and strong relationship which scientists can explore to understand better how to address malnutrition.

Second, it is possible to combine existing crop and livestock data with farming system and spatial modelling in order to generate global agricultural biodiversity maps (e.g. species diversity illustrated in Figure 6.4). Visualizing data in this way helps trigger novel insights into spatial distribution of agricultural biodiversity, and how this is changing over time. The data can be overlapped with other spatially explicit data, for example on Sustainable Development Goals, wild biodiversity or agricultural production.

Figure 6.4, for example, illustrates how agricultural production in Europe, Africa and Asia is more diverse than most parts of the USA and Latin America. These regional differences are associated with the scale of farms and the type of major crops: large-scale farms are dominant in many parts of the Americas, and in the production of sugar and oil crops (10). The landscapes of these large-scale sugar and oil crop farms are less agriculturally diverse than landscapes with small-scale farms (10). While global analyses may be subject to making some broad generalizations, this does imply that small farms and smallholder farmers play a vital role in maintaining agricultural biodiversity at global to village scales.

FIGURE 6.4 – Global spatial distribution of species diversity of crops and livestock



Source: Adapted from (10)

Third, by considering diversity at different spatial scales, researchers have shown that, while species diversity in national food supplies is increasing (more diversity available to consumers), at global level, food supplies are becoming more homogeneous (less diversity between countries) (11). This has sparked debate about implications and related actions needed for food and nutrition security as well as environmental sustainability.

Fourth, there are still many important data gaps in all four dimensions (consumption, production, seed systems, conservation) and at various levels of diversity (landscape diversity, species diversity, varietal and genetic diversity, functional diversity). Further, many of the data are collected and used only at small scales, often sitting on researchers' and local institutes' desks or on computer hard drives. Biodiversity monitoring increasingly uses crowdsourcing and citizen science (12). Linking high-level monitoring efforts with local crowdsourced agricultural biodiversity information in the index could be a highly innovative development which enables decision-makers to: (1) ground-truth high-level data insights, (2) increase monitoring sensitivity and (3) apply the index at different spatial scales. One potentially very powerful tool that could be used to predict how agricultural biodiversity may change with altered land use and management is the PREDICTS project. PREDICTS is collecting small-scale data from scientists worldwide in order to produce a global database of terrestrial species' responses to human pressures. It investigates how local biodiversity typically responds to human pressures, such as land-use change, different intensities of management within land uses, pollution, invasive species and infrastructure, ultimately combining this analysis with satellite data and improving our ability to predict future biodiversity changes.

Fifth, measurements or scorecard information on drivers, commitments and strategies, which are needed in an enabling environment or a business case for agricultural biodiversity in food systems, are more readily available than measurements on the actual state of agricultural biodiversity. They provide a critical way to identify entry points for action. At the country level, national or company strategies could, for example, include policies and programmes that explicitly commit to managing agricultural biodiversity in conservation and/or production systems, increasing food biodiversity in diets, and providing incentives for growing food items other than major staples. At the company level, such strategies could include, for example, product lines that consider a diversity of varieties or species in their supply chain, land restoration efforts, application of agroecological principles and interventions on production farms, and leveraging benefits from diversified, mixed systems.

What we can learn from other composite indices for the design of the index

There are many composite indices constructed to inform decision-making and different types can be distinguished based on the audience targeted and the type of data used. For example, the Global Biodiversity Outlook, Global Food Security Index, Global Hunger Index and the Environmental Performance Index, all use national datasets, aggregate well-established indicators and mainly target national governments. Some of these focus on measuring drivers (e.g. Global Food Security Index), while others capture outcomes (e.g. Global Hunger Index). Other examples, particularly those assessing issues that are difficult to quantify, like the Corruption Perception Index and the Ease of Doing Business Index, also target national governments and relevant stakeholders, but collect input from a sample of experts or other priority stakeholders using index-specific questionnaires. The Access to Medicine, Access to Seeds, Access to Nutrition type of indices, focus on companies and use company-specific information. Other private sector indices are specifically designed for and used in investment, like the Dow Jones Sustainability Index, which is based on an annual questionnaire completed by the company. These different types of indices indicate that different groups of decision-makers (e.g. national governments, local governments, private actors, NGOs) require different resolutions and time frequencies of index reporting.

Across the broad range of those existing indices, we can draw several general lessons to help guide the process of developing an Agrobiodiversity Index:

First, no index is perfect and there is always space for improvement. Most important from the user perspective is that the index steers progress on intractable challenges. Therefore indices need to be informative, sensitive to relevant change, actionable and inspire communications with other end users (e.g. consumers and farmers).

Second, composite indices emphasize multiple dimensions of a certain issue. While the overall index often serves mainly to attract attention and provide comparisons of performance, analyses of trends in sub-indices allow policymakers to identify entry points for action.

Third, many datasets exist, often collected at great expense and increasingly experienced by users as an overload of information. Indices that aim to prioritize and filter data to make them useful and manageable in decision making, or to score issues that are difficult to quantify, are increasingly in demand, used and referred to.

Fourth, most robust indices are developed, improved and adapted over time through an iterative and adaptive process, engaging end users throughout and adopting lessons learned.

Fifth, no examples of indices were found that mobilize recent digital opportunities, such as crowdsourcing, as input of data. This seems like an underexplored opportunity with powerful potential to link the local with the national and global scales.

Perspectives for the Agrobiodiversity Index

Building on the above, we summarize our perspectives for the development of the Agrobiodiversity Index. We start from the demand side. Five user groups have expressed strong interest in the Agrobiodiversity Index:

- National governments: to monitor and manage agricultural biodiversity at national level in order to guide country-specific policies and public investments in sustainable food systems
- Private companies: to monitor and manage agricultural biodiversity at company level to robustly and transparently rate food and agriculture companies listed on stock markets in terms of their commitment to and use of agricultural biodiversity
- Public and private investors: to monitor and manage agricultural biodiversity at project/investment level to guide and track investments in sustainable bond markets
- Farmer and consumer groups: to guide best practices and influence policies and programmes
- Groups developing or maintaining other indices: to include or strengthen an agricultural biodiversity dimension.

The Agrobiodiversity Index must be fit for purpose, easy to use and straightforward to interpret. It can be tailored in different ways to provide the decisionsupporting knowledge that these different user groups need. Contributing data to the index and pulling measurements out should be made easy. For example, investment in lean data approaches (i.e. tailored, focused questions delivered directly to key users through low-cost technologies) can make data collection easier. Sharing data directly in compelling visualizations, scorecards and dashboards in near real time (or at regular intervals) will increase the user-friendliness of the index and more clearly inform decision-making. New institutional, business and innovative financing arrangements can use agricultural biodiversity to connect data for use in risk management.

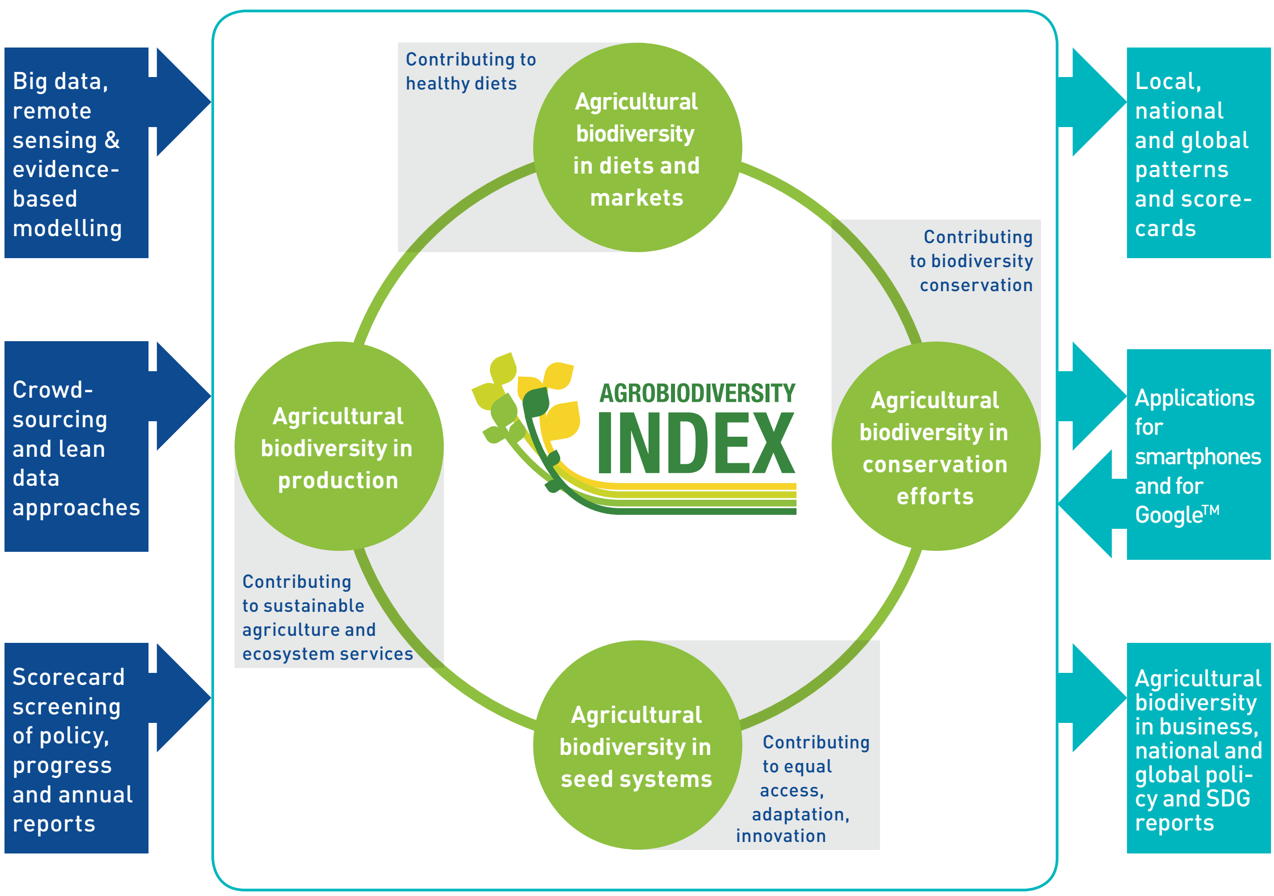
A first step is to combine existing datasets, integrating crop and livestock data for food systems, agricultural biodiversity measures, country and company reports and public data. These high-level monitoring efforts can then be enriched with local crowdsourced agricultural biodiversity data and remote sensing data. An iterative step is to test the Agrobiodiversity Index with multiple users (national governments, investors, companies) by further engaging with stakeholders, pioneering and testing an initial design through use cases. We thereby continuously welcome interactions with readers, experts and potential users for the development and utility of the Agrobiodiversity Index for sustainable food systems.

Five years from now, we expect that the methodology for the Agrobiodiversity Index (Figure 6.5) will:

- Combine big data with new crowdsourced data in a georeferenced model
- Provide information on the status of agricultural biodiversity along the food system chain, from genetic resource management, to production systems, to markets and consumption, relevant for countries and companies
- Be used in the design of sustainable investment
- Inform global reports and publications, such as those of the Sustainable Development Goals and the Convention on Biological Diversity
- Increase local and global demand for agricultural biodiversity monitoring and use.

FIGURE 6.5 – Conceptualization of the Agrobiodiversity Index

The Agrobiodiversity Index will draw on input from existing databases, combined with crowdsourced data and a screening of public and private policies and reports on issues connected with agricultural biodiversity's contribution to global goals. Users can consult scorecards, and access and input information through applications. The results from the Agrobiodiversity Index can be used to monitor risk related to poor agricultural biodiversity and report on commitments to global goals.



Conclusion

Diversity is increasingly identified as key to food system sustainability and integrated into the Sustainable Development Goals and the Aichi Biodiversity Targets, but there is no consistent way of tracking it across diets, production, seed and conservation systems.

A recent collaboration between research scientists and influential business leaders identified the top 40 research priorities for managing the complex relationship between food, energy, water and the environment (13). Four of their priority research questions (RQ) identify the role of biodiversity directly at that nexus, and ask how to measure and communicate that complex relationship:

- How can the role of biodiversity on the supply and interdependence of food, energy and water be measured and assessed to enable improved decision-making? (RQ 10)
- How can complex nexus interactions and uncertain outcomes be communicated such that they can be easily understood and applied by non-experts (customers and the public)? (RQ11)
- What common metrics can be devised to enable nexus comparisons to be made to help businesses and investors choose priorities and inform decisions? (RQ12)
- How does the lack of food crop diversity (dominance of wheat–maize–rice) impact upon the sustainability of the food–energy–water–environment nexus and what are the risks to business? (RQ17)

Building on agricultural biodiversity science combined with new innovative approaches, interconnected databases and an active, ground-rooted network, it seems feasible to build an innovative Agrobiodiversity Index and initiate a new global service of agricultural biodiversity tracking that can help answer these questions and move the needle in our food systems.

The Agrobiodiversity Index aims to help guide more sustainable practices, for individuals, communities, governments and companies through presenting food system sustainability data in a digestible form. In our era of data overload, there is a unique opportunity to reach a wide variety of change leaders with newly gained scientific insights. The Agrobiodiversity Index turns the lens around to the consumer, the company, the farmer, government and the globe and asks: 'Why and how is agricultural biodiversity important to you?'

Farmer in Uganda during a baseline assessment study for a project investigating the role of crop diversity in combatting pests and diseases. Here she is sitting with her children in an agricultural landscape belonging to multiple farmers.
Credit: Bioversity International/P.De Santis

Notes

[i] The Shannon diversity index reflects the richness and abundance of diversity in a system. The closer it is to zero, the lower the levels of diversity.

[ii] http://www.predicts.org.uk

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Amaranth plant, Barotse floodplain, Zambia. Amaranth is a versatile and nutritious crop eaten in every continent. Both grains and leaves can be eaten and contain protein and high levels of minerals and vitamins, such as manganese, iron and folic acid. Amaranth grows rapidly and produces many seeds, even under difficult growing conditions.
Credit: Bioversity International/E.Hermanowicz