PLOS SUSTAINABILITY AND TRANSFORMATION

OPINION

Biodiversity, agriculture and sustainable production: GBF Target 10

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Introduction

In late 2021, a range of experts from around the world were approached to provide expert input to the post-2020 Global Biodiversity Framework (GBF)–the new strategic framework under the Convention on Biological Diversity (CBD) that will guide interventions to conserve biodiversity and ecosystem services for the next three decades.

In this opinion piece, appearing as a companion to other opinion pieces addressing selected aspects of the GBF, we discuss the science behind Target 10 with a focus on agricultural production. This opinion piece is based on analyses that were prepared in support of GBF negotiations provided to governments and stakeholders by the CBD (CBD/WG2020/3/INF/11, CBD/WG2020/4/INF/2/Rev.2 and CBD/POST2020/OM/2022/1/2) and follow-up work (see https://geobon.org/science-briefs/) in the lead-up to the CBD COP-15 held in Montreal in December 2022. This piece is further underpinned by research conducted by several global commissions including the EAT-Lancet Commission [1], the biosphere working group of the Earth Commission [2] and syntheses produced for COP26 [3] and the UN Food System Summit [4].

What is sustainable agriculture?

Much of the highly visible debate on the GBF has focused on avoiding further biodiversity loss through conservation efforts in intact, protected, and wilderness areas. While this focus is critically important, it should be complemented with more ambitious sustainable use of biodiversity in agriculture needed to achieve multiple global goals including food, climate, and environmental security. Target 10 of the GBF refers to lands and waters under sustainable production frequently omitted from biodiversity target-setting due to their transformation from natural ecosystems into agricultural ecosystems. Covering nearly 40% of the ice-free terrestrial land surface (some 51 million km^2), agricultural ecosystems may be considered the world's largest ecosystem but are rarely managed as such. Bending the curve [5] on multiple

Table 1. Food system planetary boundaries, GBF conservation targets and critical SDG's on health and hunger, for example, set an ambitious frame of reference for GBF Target 10 on sustainable production. Super scripts indicated Planetary Boundary (PB), Global Biodiversity Framework Target (GB), or Sustainable Development Goal (SDG).

Control Variable	Example Threshold	Ref.	Plausible Target 10 Contributions and Actions		2020 baseline
			Avoid/Reduce	Regenerate/Increase	
Land for Biodiversity	50 million km^2 (11–15)$^{PB, GB, SDG}$	[1]	Further agricultural conversion of remaining intact ecosystems and wilderness areas.	Sustainable production efficiency within currently converted lands	50 million km^2 land under agricultural production [1]
Biosphere functional Integrity	10–20% (semi)natural habitat per $km^{2\ PB}$	[1,9]	Habitat loss and fragmentation in agricultural lands	Semi-natural and natural habitat within agroecosystems above 20% km^2 threshold.	18–33% of agricultural ecosystems globally have <10–20% per km^2 respectively
Climate	Zero conversion of intact ecosystems and wildernesses	[10]	Avoided conversion and restoration has the potential to store 200–330 Gt CO_2 (5).	Increase production efficiency within currently converted lands.	2.2–6.6 Gt CO_2 e $year^{-1}$ from land conversion
	<5 Gt CO_2 e $year^{-1}$ (4.7–5.4) emitted (1)	[1]	Methane and N_2O emissions from rice and livestock systems.	Increase above and below-ground carbon capture in agriculture.	5 Gt CO_2 e $year^{-1}$
Nitrogen	<90 Tg N application $year^{-1\ PB, GB}$	[1,10]	Increase nutrient use efficiency to reduce inputs and losses to the environment keeping concentrations in water to <1–2.5 mg N L^{-1}	Increase biological nitrogen fixation through leguminous crop cultivation, rotations, or intercropping. Implement biological buffers between terrestrial and aquatic ecosystems.	130 Tg $year^{-1}$
Phosphorus	<8 Tg P application $year^{-1}$ $^{PB, GB}$	[1,10]	Increase nutrient use efficiency to reduce inputs and losses to the environment keeping concentrations <50–100 mg m^{-3}	Implement biological buffers between terrestrial and aquatic ecosystems.	6–12 Tg P $year^{-1}$
Fresh water	<±20% of monthly mean environmental flow or 2500 km^3 $yr^{-1\ PB}$	[1]	Use of nonrenewable groundwater resources; overextraction of freshwater from riverine and lacustrine systems.	Water use efficiency through improved technologies or selected agricultural biodiversity with lower consumptive water needs.	Globally 1400–1800 km^3 $year^{-1}$ though with important regional differences.
Food and nutritional security	±2500 kcal per capita, accounting for waste and loss. $^{PB, SDG}$ Dietary diversity matching national food based dietary guidelines $^{PB, SDG}$	[1,14]	Regionally specific though with global reductions in red meat, calorie-dense ultra-processed foods and sugar [15].	Regionally specific for legumes; global increases in fruit, nut, vegetable and whole grain production and consumption [15]	Nearly 4 billion individuals struggle to access healthy diets.

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environmental outcomes from agricultural ecosystems is necessary and possible but requires clear sustainable production targets (e.g Table 1), greater investment in agroecological research and innovation (Box 1), and substantial changes in food consumption, loss, and waste patterns.

Sustainable production practices should be evaluated based on their net positive contribution to downscaled planetary boundaries in addition to total food system productivity and efficiency defined as the number of people that can be fed healthily and sustainably per unit input (6). A diversity of agroecological and complementary production practices, ranging from traditional, to modern, and yet to be innovated, are compatible with Target 10 [7]. Production systems operating without clear environmental objectives are incompatible with global goals on food, nutrition, biodiversity, health and well-being, climate, environmental and livelihood securities [6].

A distinguishing element of the socio-political definitions of agroecology as adopted by the Food and Agriculture Organization's (FAO) 10 Elements of Agroecology ratified by its 194 member countries is that it seeks to integrate and bring sustainability to ecological, social and economic parts of the whole food system. We strongly recommend that Target 10 utilize the framing of the FAO ten elements of agroecology as well as the complementary High Level

Box 1. Empirical and political definitions of agroecology and its contribution to sustainable production

Agroecology has been variously defined as a science, a social and political movement and a practice [8]. As a science, agroecology focuses on the contribution of biodiversity to enhancing the generation of multiple ecosystem services to and from agriculture with the aim of regenerating these services.

Agricultural practices are regenerative if they make a measurable increase in provisioning of diverse ecosystem services. As the environmental performance of agriculture is dependent on ecological functions provided by biodiversity, agroecological practices are necessary to achieve target 10.

As such, *conservation agriculture*, is an *agroecological practice* which aims to support a soil biodiversity capable of *regenerating* soil carbon pools. It is but one of a myriad of agroecological practices capable of regenerating environmental functions in agriculture. Conservation agriculture is compatible with other agroecological practices including crop rotations, field margin buffers, agroforestry to list but a few that farmers often mix, match and adapt according to local contexts and capabilities.

Panel of Experts on Food Security and Nutrition of the Committee on World Food Security report (CFS-HLPE) on 13 principles of agroecology [8] because they are compatible and necessary to achieve GBF objectives.

Ecosystem services from agricultural ecosystems operate at a wide range of scales, depending on the organisms providing those services. Soil nutrient cycling and carbon storage are dependent on soil organisms that have limited dispersal and therefore are primarily controlled by biodiversity dynamics at microscopic to meter scales. Pollination and pest and disease regulation often depend on biodiversity dynamics at scales of tens to thousands of meters. Because Target 10 is supported by processes and actions at these fine to medium scales, the presence of semi-natural or natural habitats embedded in agricultural landscapes at fine spatial scales is required to secure the ecosystem services that support productivity and food security [9]. The additive effects of land use and land use change decisions impact planetary scale processes with farming families and communities becoming critical actors in mitigating global climate change.

Expanding sustainable production to all lands in production should not be confused with further expansion of agriculture, whether sustainable or other, into intact ecosystem and wilderness areas. Halting conversion of remaining intact ecosystem and wilderness areas, as contained in Target 1 of the GBF, is an important complement to Target 10. To achieve it, sustainable production must be constrained to currently transformed lands with no expansion into currently intact ecosystems. This same target has been proposed as a planetary boundary [1,10] and a major food system target [11] (Table 1).

The emphasis on production systems in the target formulation is clear. However, many formulations have been proposed of what this means, some with a high degree of overlap, others not. Of the ten elements of agroecology proposed by the FAO, diversity, synergies, efficiency, resilience, and recycling correspond to the ecological principles cited above, and to elements contained within proposed formulations of the target text. Adopting the simplest formulations around efficiency and productivity couched in ecosystem-based approaches, rather than narrow production-focused objectives is recommended. This would be consistent with language elsewhere in the GBF and previous CBD agreements. Explicit alignment of Target 10 with FAO agroecology elements, sustainable foods objectives and relevant Sustainable Development Goals (SDGs) can ensure the target contributes to achieving these goals over environmentally damaging production.

Agriculture and conservation landscapes

The GBF has an explicit spatial planning framing with Target 1 on 100% coverage of national spatial plans within which agricultural ecosystems are embedded (see Ecosystems brief [12]). In these, a minimum of natural or semi-natural habitats covering 10–20% of area at kilometer scales can enhance biodiversity, increase biological connectivity, buffer riverine systems from nutrient losses and pollution from agricultural production, and secure minimum habitat needed for pollination and for pest regulation services' providers. Today, 18–33% of agricultural lands, possibly more, are below this threshold, posing a high risk for food security and compromising the resilience sought by Target 10.

Maintaining adequate cover of habitats with sufficient functional integrity may be done through locally appropriate practices, both traditional and modern, with restoration and regeneration needed where current levels are below the relevant threshold (Box 1 and Restoration Brief [13]). Regeneration in agricultural ecosystems could create 1.2–1.7 M km^2 of natural or semi-natural habitat in agricultural landscapes, and lead to multiple local benefits as listed above. Global benefits may also be significant: carbon sequestration from regeneration of agricultural and restoration of degraded lands may amount to sequestration of 4.3–6.9 $GtCO_2e$ $year^{-1}$ and up to store 10 $GtCO_2e$ $year^{-1}$ by 2100 [1].

Is sustainable production compatible with food security?

A common misconception holds that sustainable production is not compatible with the projected increase in food production needed to feed up to 10 billion people in 2050. Some projections anticipate a 60% increase in agricultural production will be required by 2050 despite only 33% increase in population growth. There are many assumptions embedded in this, most notably income dependent shifts in food consumption that rely on continued reliance on environmentally damaging agricultural practices that have created the current biodiversity, food and climate crises. By contrast, reduction or reversing agriculture's environmental footprint can be achieved through multiple responses. These responses include transformation to agroecological and other sustainability-oriented practices, sustainably closing large yield gaps in some regions especially Africa and transforming demand for food via healthy and environmentally benign dietary choices. These could reduce global land requirements for agriculture by 600 million ha and reducing food loss and waste could reduce pressure by an additional 10 to 20% [4]. Sustainable agriculture is also sometimes cited as underperforming by 20% compared to conventional agriculture, but this is based on analyses of organic agriculture, which represents a limited set of regenerative options and more evidence is demonstrating a comparative and even better performance of alternative systems [7].

There is good evidence that diversification of production systems would not compromise food security [7] and innovations can be expected to increase sustainable food production. Importantly, local and context specific adaptation of sustainable agricultural practices can improve food production while reducing vulnerability to climatic or economic shocks, driving positive change, including increasing socio-ecological resilience.

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