Mitigating the agricultural drivers of **Nature loss** through **Nature-positive agriculture**

A SYNTHESIS REPORT

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Acronyms

AFOLU	Agriculture, Forestry, and Other Land Use Change
CAP	Conventional Agricultural Practices
CBD	Convention on Biological Diversity
CIAT	International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical)
CIP	International Potato Center (Centro Internacional de la Papa)
CIRAD	French Agricultural Research Centre for International Development (Centre de coopération internationale en recherche agronomique pour le développement)
D4R	Diversity for Restoration
FAO	Food and Agriculture Organization of the United Nations
GMP	Global Precipitation Measurement
IUCN	International Union for Conservation of Nature
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
NBSAPs	National Biodiversity Strategy and Action Plan
NGO	Non-Governmental Organization
NPAPs	Nature-Positive Agricultural Practices
PES	Payment for Ecosystem Services
SAP	Sustainable Agricultural Practices
SDGs	Sustainable Development Goals
TEEB	The Economics of Ecosystems and Biodiversity
WEF	World Economic Forum
WUR	Wageningen University & Research
WWF	World Wide Fund for Nature


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01 INTRODUCTION

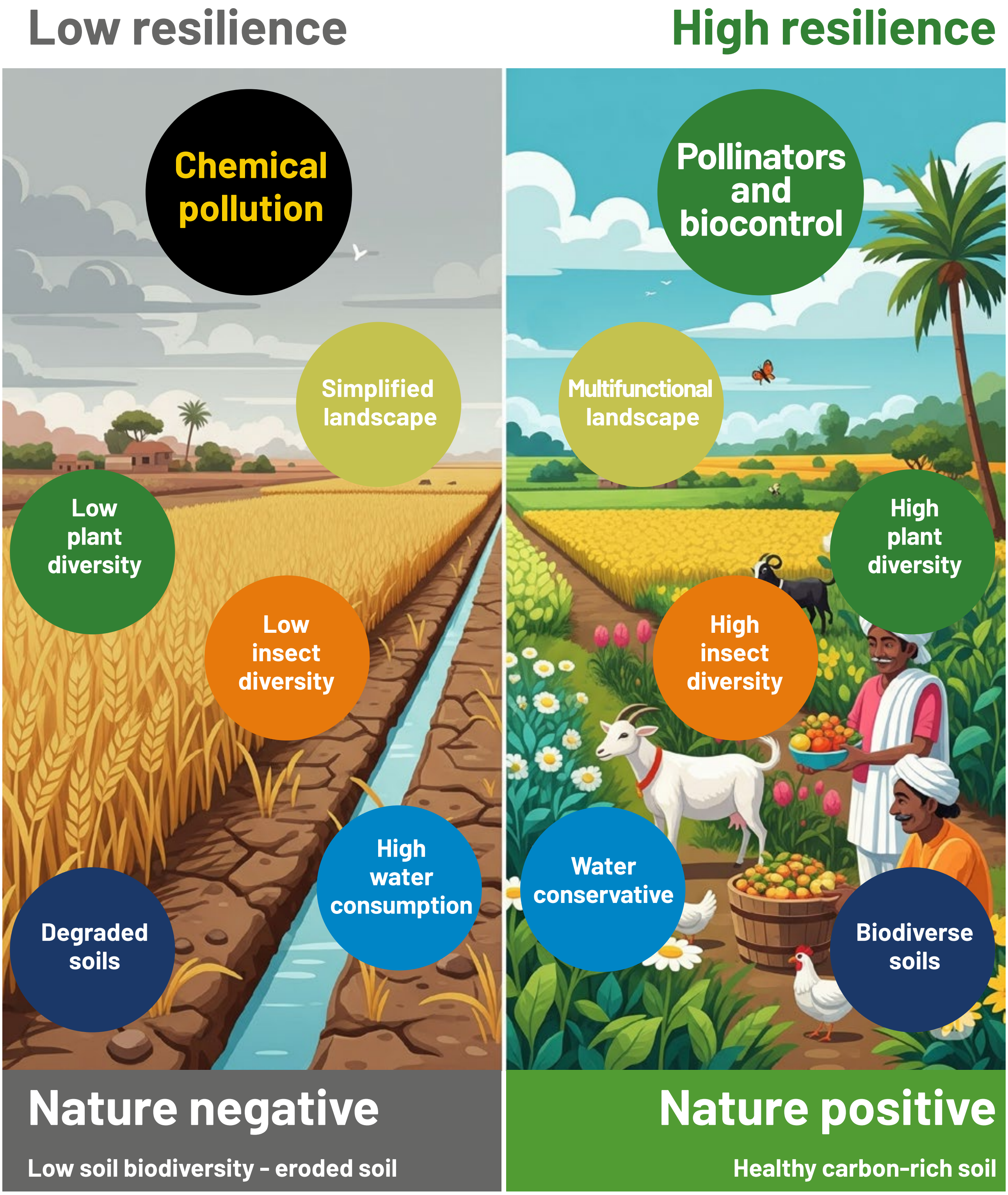
The transition to nature-positive agriculture is critical for addressing biodiversity loss, but also for combating climate change, and for ensuring a resilient food system. A system-level transformation is urgently needed but requires simultaneous actions from stakeholders across both public and private sectors. Catalyzing this transition requires tailored solutions that integrate multiple agricultural practices from field to landscape, enabling policies, and social change.

This report provides a framework for a nature-positive transformation and is intended for policymakers, researchers, development practitioners, and private sector actors working at the intersection of agriculture, environment, and rural development, offering practical guidance and strategic insights to inform decision-making and investment in nature-positive transitions.

Biodiversity underpins the resilience and productivity of agricultural landscapes (Figure 1.1). Diverse species and genetic resources enhance ecological interactions essential for soil health, pollination, pest control, and climate adaptation. Practices such as intercropping, agroforestry, and crop-livestock integration—which enhance biodiversity in production landscapes—increase resilience, ensure healthier diets, and mitigate environmental degradation. Preserving biodiverse landscapes, including forests and wetlands, is not only vital for climate regulation, water cycling, and soil stability, but is also at the heart of resilient agricultural systems.

Agriculture affects biodiversity through land use change, but also through poor management of soil and water resources. Unsustainable practices degrade biodiversity and consequently ecosystem services, leading to reduced soil fertility, limited water availability, and increased pest and disease outbreaks. Transitioning to nature-positive agriculture can break this cycle of diminishing agricultural productivity.

Figure 1.1 - Nature-positive and nature-negative landscapes comparison.



Nature-Positive solution bundles

In this synthesis report, we highlight **nature-positive practices** and a transition pathway that restores ecosystem functions while ensuring economic viability and long-term resilience. The practices are organized in four core management areas: **Sustainable soil and water management**, including minimum tillage, crop rotation, and efficient irrigation; **Integrated pest and nutrient management**, including biocontrol, organic fertilizers, and precision nutrient use; **Diversified agroecosystems**, including agroforestry, silvopastoral systems, and intercropping; and **Pollution and waste management**, including reduced agrochemical use and waste recycling. We highlight the policy and economic enabling environment for nurturing nature-positive transitions, including advisory services, financing, policy incentives, and stakeholder collaboration. We provide evidence that nature-positive practices often result in higher yields and profitability compared to conventional methods. However, initial costs and delayed returns require economic incentives. Policies such as innovative mechanisms for Payments for Ecosystem Services (PES), regulatory reforms, and community-based resource management are essential to foster widespread adoption. Integrating these reforms with national biodiversity strategies enhances scalability and alignment with global goals like the Sustainable Development Goals (SDGs), increasing impact.

The case studies offer valuable lessons and a vision for transition pathways. In Colombia's Orinoquía region, sustainable intensification practices, such as silvopastoral systems and rotational grazing, demonstrate how livestock systems can enhance biodiversity while boosting productivity. Similarly, in Ghana's Kakum landscape, agroforestry, farmer capacity building, and market-based incentives like certification schemes show the potential to harmonize cocoa production with biodiversity conservation. These examples highlight the critical role of enabling conditions, including land tenure security, multistakeholder collaboration, and targeted policy support.

We illustrate how tailored, spatially-explicit guidance can direct investments to maximize biodiversity and ecosystem service benefits while minimizing trade-offs. The report highlights how different solution bundles—combining delivery of different forms of agrobiodiversity at scales from genes to landscapes—can support national biodiversity targets and national biodiversity action plans. Solutions address the core types of agriculture that drive nature loss in highly biodiverse developing countries. We use Colombia as an example.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HARNESSING THE POTENTIAL OF NATURE-POSITIVE AGRICULTURE

2.1 Biodiversity and Agriculture: reversing the negative cycle

Agriculture, as the primary land use, drives global biodiversity loss and the degradation of ecosystem services. Intensive production systems and the expansion of agricultural land have resulted in the overexploitation of natural resources and a reduction in cultivated species. According to the IPBES report (2019), over 75% of the Earth's land surface has been significantly altered by human actions, primarily agriculture, which remains the leading cause of biodiversity loss. The FAO State of the World's Biodiversity for Food and Agriculture (SOWB) (2019) reckons that nearly one-third of fish stocks and one-third of freshwater species are under threat from agricultural practices. According to a Chatham House report (Benton *et al.*, 2021), agriculture contributes approximately 30% of global greenhouse gas emissions, exacerbating climate change and further endangering biodiversity. Similarly, the WWF Living Planet Report (2022) and IUCN data (2024) indicate that the major decline of species populations is largely driven by habitat loss due to agriculture expansion and intensification.

These findings underscore the urgent need to re-evaluate agricultural practices and adopt solutions to mitigate agriculture-driven biodiversity loss. But what is at stake?

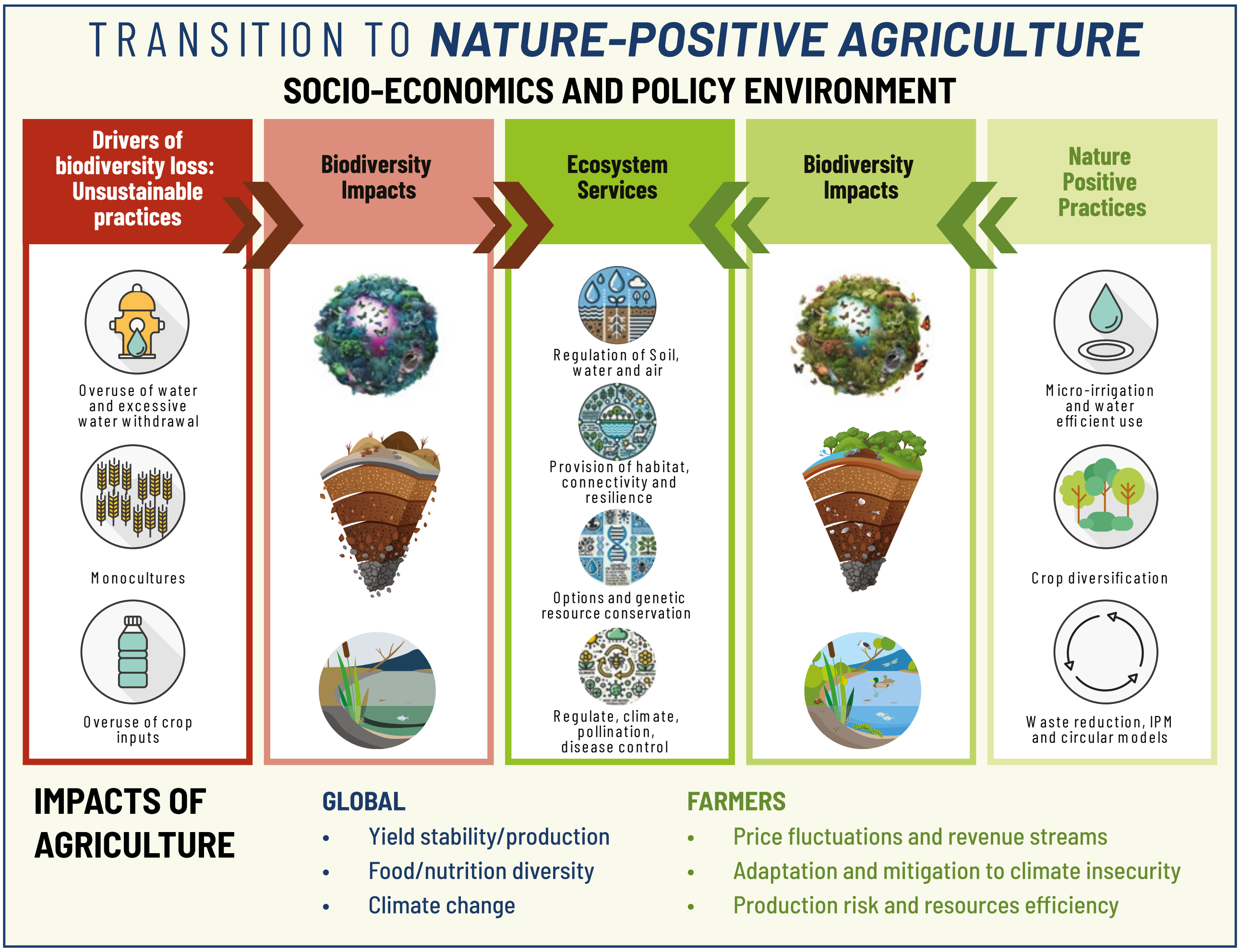
Biodiversity represents the variety and variability of life on Earth, encompassing genes, species, and ecosystems. It forms the foundation of ecological processes essential for agricultural productivity and resilience. When biodiversity declines, these processes are altered, threatening the systems that sustain agriculture and human livelihoods.

Agricultural practices directly and indirectly impact biodiversity functions, influencing agricultural landscapes' capacity to deliver multiple regulatory and provisioning ecosystem services, such as food and water provisioning, water purification, habitat provisioning, carbon sequestration, pest and disease regulation, and soil health and fertility maintenance. Three core management areas—**water management practices** (e.g., availability, use efficiency, and quality), **soil management practices** and **pollution control**—can all enhance or degrade biodiversity and ecosystem functions. When ecosystem services are degraded by unsustainable agricultural practices, the result is soil degradation, reduced water availability, poor pest control, and increased pollution which ultimately creates a cycle of diminishing agricultural output and resilience (Figure 2.1)

The impacts of biodiversity loss are not limited to environmental damage but extend to severe economic and social consequences. Unsustainable agricultural practices that affect biodiversity jeopardize over half of global GDP and the entire gross value added of the agricultural sector (World Economic Forum, 2020). Biodiversity loss undermines food security, intensifies resource scarcity, and exacerbates the effects of climate change, disproportionately affecting the most vulnerable populations. In rural areas, where 75% of the world's poorest populations reside, the degradation of natural resources exacerbates poverty and hinders economic development.

To reverse the agriculture-driven degradation cycle, the agricultural sector must address the drivers of biodiversity loss, promoting practices that prioritize biodiversity, restoring nature and other ecosystem functions. Below, we briefly summarize the results of a detailed analysis conducted by CGIAR. The study reviewed critical nature-positive practices and assessed their economic viability for reversing the negative impacts of agriculture on nature while ensuring long-term agricultural productivity and ecosystem resilience. By integrating practices such as agroforestry, integrated pest management, and conservation agriculture, agriculture can shift from being nature-negative to nature-positive. This shift creates a positive feedback loop that supports both ecological health and agricultural success.

Figure 2.1 - Examples of agricultural practices that affect biodiversity and ecosystem services, and their impacts on production, nutrition, and climate change.



2.2 Typologies of agriculture driving nature loss

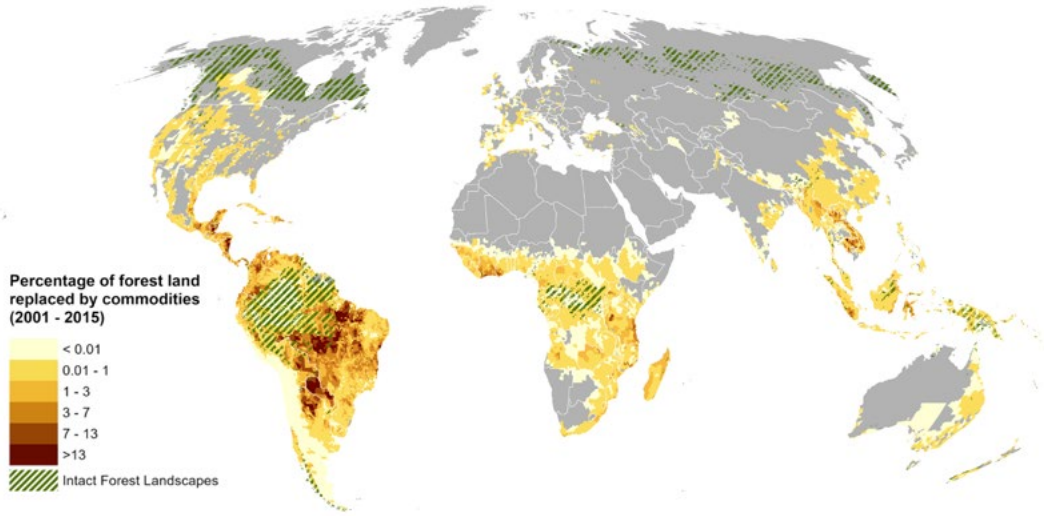
Agricultural expansion for both commodity and non-commodity production has been identified as the primary driver of nature loss. This is followed by agricultural intensification, characterized by high input use and low diversification, as well as unsustainable practices leading to landscapes that are increasingly polluted, degraded, and low in habitat provisioning (Jaureguiberry *et al.*, 2022). We identified four typologies of agriculture driving nature loss. Our aim is to support nature-positive farming and landscape restoration through targeted actions within production landscapes. We match bundles of agricultural solutions to the agricultural typologies. These concepts are explored in a case study analysis in Section 2.4.


Credit: ©2014CIAT/GeorginaSmith

The four types of agriculture are as follows:

Type 1. The "Farms on forest frontiers" category primarily addresses agricultural expansion in forested tropical and sub-tropical regions. It often includes smallholder farmers expanding agriculture for commodity production and farmers engaging in forest clearing as part of shifting cultivation cycles for subsistence or commercial production. This process is frequently linked to intensive production systems, characterized by a lack of effective regulation and poor oversight. The competition between preserving critical natural ecosystems and expanding agricultural land poses significant challenges. Forest ecosystems provide indispensable services, including climate mitigation, to both local and global communities. Agricultural commodity production remains a leading driver of deforestation. Some major agricultural producing countries host vast forest areas, such as Brazil, Indonesia, and the Democratic Republic of the Congo. Global demand for export-oriented or resource-intense commodities like cattle, soy, and palm oil intensifies pressure on forest frontiers in these producing countries. The World Resources Institute reckons that cattle pasture alone accounted for approximately 45.1 million hectares of deforested land between 2001 and 2015, representing 36% of all agricultural-related tree cover loss (WRI, 2024). Oil palm plantations followed, replacing 10.5 million hectares, while soy cultivation contributed to the deforestation of 8.2 million hectares. Additional contributors include cocoa, plantation rubber, coffee, and tree plantations, collectively accounting for around 2 million hectares each. Together, these seven commodities were responsible for 57% of agricultural deforestation during the same period. Tropical forests, in particular, support critical ecosystem services—ranging from carbon sequestration to biodiversity support and water regulation. Deforestation is also affecting intact forest landscapes (Potapov *et al.*, 2017), the last remaining unfragmented forests in the world that are large enough to support native forest biodiversity and have not yet shown signs of human degradation (Figure 2.2). Balancing agricultural needs with the preservation of these critical ecosystems is essential to maintaining global ecological stability and supporting both local and global communities.

Figure 2.2 - Intact Forest Landscapes 2020 (Potapov *et al.*, 2017) and percentage of forest land replaced by commodities considering oil palm, soy, cattle, cocoa and coffee) (Goldman *et al.*, 2020).

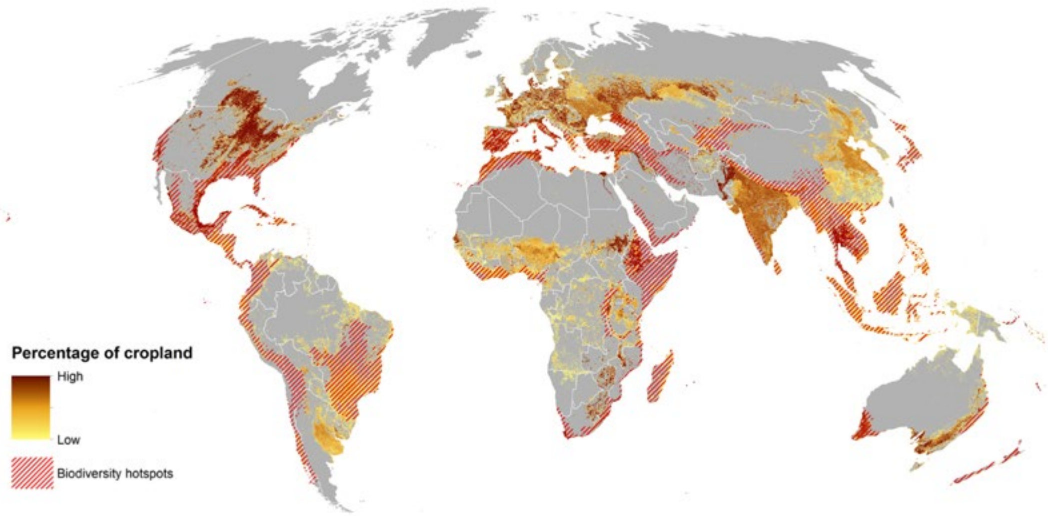


FARMS ON FOREST FRONTIERS: IMPACT PATHWAYS

How does agricultural expansion impact biodiversity? The impacts on nature loss are mainly due to habitat destruction and fragmentation, over-exploitation of wild species, and pollution. These impacts directly and indirectly affect plant diversity, forest-specialist (invertebrate and vertebrate) species through reduced population size and local extinction. **How does this impact ecosystem services?** Agricultural expansion affects the regulating ecosystem services, leading to reductions in habitat connectivity, in water cycling, in carbon sequestration and in provision of healthy soils. The disruption of these services has cascading effects on the stability of ecosystems, reducing their resilience to external shocks such as climate change, which creates negative feedback loops. **How does this impact agriculture?** Biodiversity and ecosystem service losses directly impact agricultural productivity. As regulating services like pollination, pest control, soil fertility and water availability are diminished, agriculture in these regions becomes less sustainable. Global trade and demand in high income, temperate countries—often for foods grown in tropical and subtropical regions—drives agricultural expansion in forested regions. The adoption of sustainable smallholder production using multipurpose, native trees and agroforestry practices can mitigate these trends. Sustainable cocoa and coffee in forest frontiers have substantial scope to drive nature positive transitions.

Type 2. The agrochemical intensive monocultures type of agriculture involves the transition from traditional, diverse cropping systems to intensive, artificial fertilizer-dependent monocultures. This type is widespread in regions focused on high-output, single-crop agriculture, such as the Brazilian Cerrado with the expansion of soy cultivation or the Indian Punjab with rice-wheat systems. Latham *et al.*'s (2014) map of percentages of arable land provides a proxy indicator of these areas, providing insights into global intensive agricultural patterns (Fig. 1.3). In the tropical and subtropical zones, large areas with a high proportion of cropland occur in South and Central America, East and West Africa, and South and Southeast Asia. The environmental stakes magnify in areas where intensive agriculture overlaps with biodiversity hotspots (Hoffman *et al.*, 2016), defined as some of the most biologically diverse yet threatened terrestrial areas (Fig. 2.3).

Figure 2.3 - Biodiversity hotspots (Hoffman *et al.*, 2016) and percentage of cropland (Latham *et al.*, 2014).



AGROCHEMICAL INTENSIVE MONOCULTURES: IMPACT PATHWAYS

How do monocultures impact biodiversity? Monocultures directly erode agrobiodiversity, leading to reductions in crop diversity. The heavy use of agrochemicals—including fertilizers, pesticides and herbicides—results in runoff, leaching, and spray drift. These processes degrade soil health, freshwater ecosystems, and biodiversity. They especially affect insects, birds, and aquatic organisms, with a high impact on coastal and marine ecosystems including through nutrient pollution and eutrophication (Part 2) (Tarigan 2019; Carmona *et al.*, 2020; Carvalho *et al.*, 2021; Raven and Wagner, 2021). **How does this impact ecosystem services?** The loss of biodiversity in monoculture systems weakens critical ecosystem functions such as pollination, biological pest control, and nutrient cycling, creating a need for greater reliance on chemical inputs. This further underscores the need for interventions to reduce the intensity of field-level agricultural homogenization (Carmona *et al.*, 2020). **How does this impact agriculture?** These negative impacts on biodiversity and ecosystem services create a negative feedback loop which ultimately leads to complete collapse of agricultural systems. The spill-over effects of agriculture and the need to reduce the externalities of intensive agriculture in production landscapes while increasing biodiversity remain crucial drivers. Adoption of practices such as zero tillage, integrated pest and nutrient management, diversification of traditional crops and biocontrol have significant mitigating effects.

Type 3. Intensive livestock systems and overgrazing drive environmental degradation worldwide. Overgrazing has significant negative effects on both plant and animal biodiversity (Marques *et al.*, 2019). Figure 2.4 and 2.5 show the global distribution of cattle density (FAO, 2024) and the percentage of forest land converted to cattle farming between 2001 and 2015 (Goldman *et al.*, 2020). The maps highlight how livestock systems encroach on biodiversity hotspots (Hoffman *et al.*, 2016). They illustrate the dual pressures exerted by intensive livestock systems. High cattle densities contribute to ecosystem degradation through soil erosion, vegetation loss, and increased greenhouse gas emissions. Simultaneously, the conversion of forests to grazing land leads to biodiversity loss and reductions in key ecosystem services, such as carbon sequestration. These findings emphasize the need for sustainable livestock management practices and targeted policy interventions to address the environmental and ecological costs associated with cattle farming, particularly in regions where livestock production overlaps with biodiversity-rich ecosystems.

Figure 2.4 - Biodiversity hotspots (Hoffman *et al.*, 2016) and global cattle density (FAO, 2024).

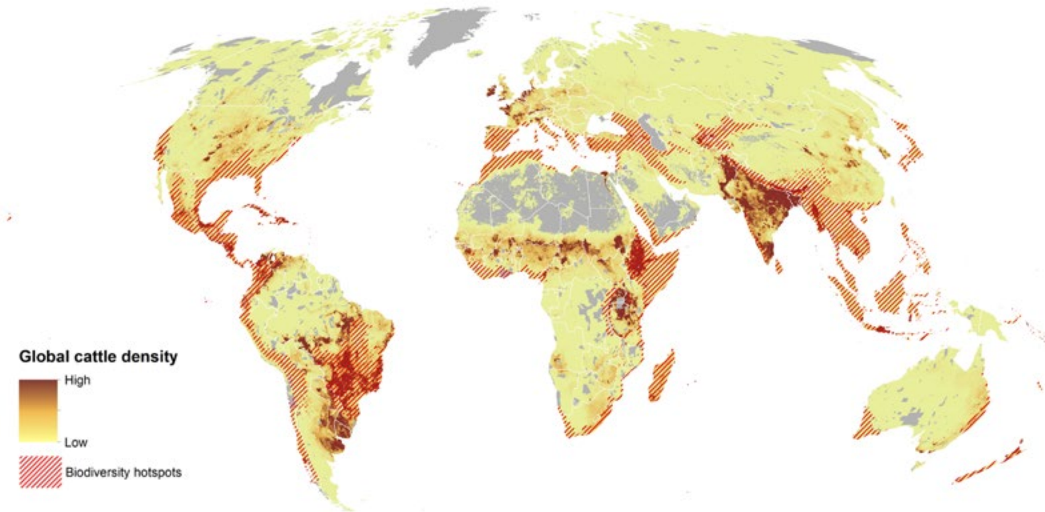
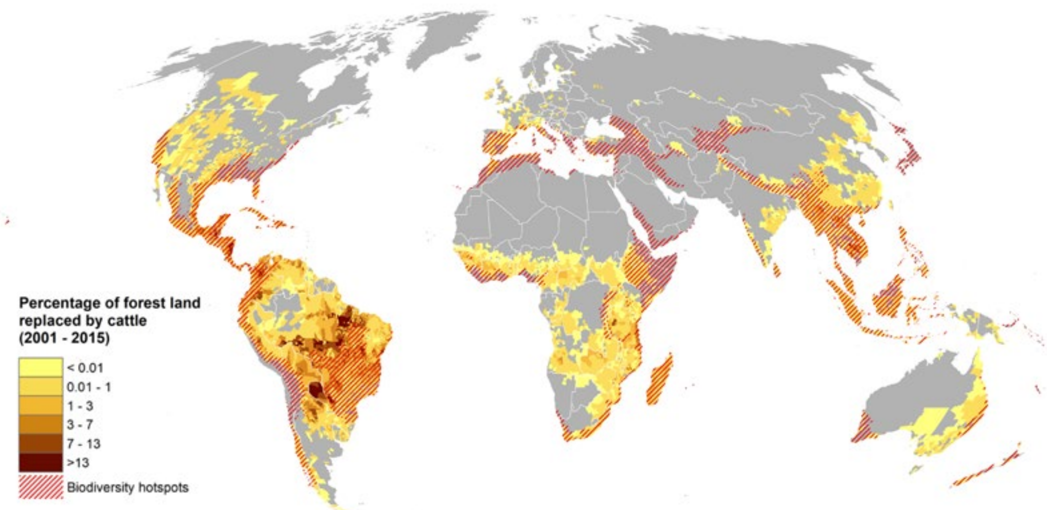


Figure 2.5 - Biodiversity hotspots (Hoffman *et al.*, 2016) and percentage of forest land replaced by cattle (Goldman *et al.*, 2020).



INTENSIVE LIVESTOCK SYSTEMS AND OVERGRAZING: IMPACT PATHWAYS

How do intensive livestock systems and overgrazing impact biodiversity? Intensive livestock systems and overgrazing lead to vegetation loss, soil erosion, and competition between livestock and forests. Additionally, the spill-over of diseases from livestock to wild animals threatens endangered species (Daskak *et al.*, 2000). Global analysis show a positive correlation between numbers of grazing cattle, number of animal disease outbreaks and threatened species (Morand, 2020). **How does this impact ecosystem services?** Overgrazing can be a major threat to tree genetic resources in natural forests (Gaisberger *et al.*, 2020). The degradation of vegetation and soil structure diminishes services like erosion control, soil fertility, and carbon sequestration. The loss of biodiversity also affects ecosystem resilience and climate regulation. The increased production of greenhouse gases (e.g., methane from cattle) especially, exacerbates climate change impacts on biodiversity. In contrast, diversifying livestock, at low density, such as through the inclusion of sheep and cattle, has been shown to promote grassland biodiversity and ecosystem multifunctionality (Wang *et al.*, 2019). **How does this impact agriculture?** The decline in ecosystem services leads to reduced pasture quality and lower livestock productivity, threatening the sustainability of grazing systems. Adopting practices such as food waste-to-animal feed, sustainable manure management and agro-silvo-pastoralism offers important mitigation solutions.

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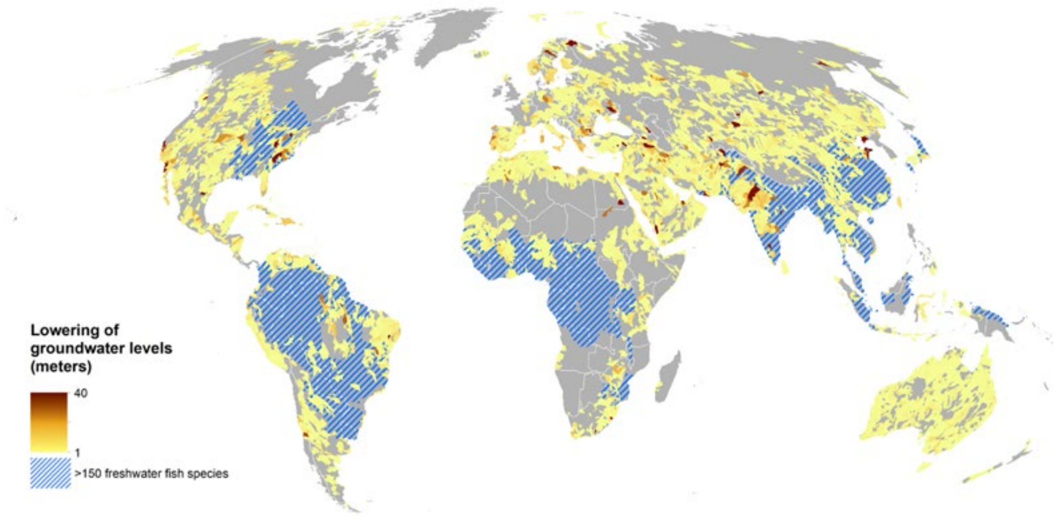
Type 4. Unsustainable irrigation and its impact on freshwater systems. This type encompasses farming practices that rely heavily on water extraction, which affects freshwater ecosystems. Approximately 70% of water withdrawals are linked to agriculture, primarily for irrigation, livestock, and aquaculture. The rest is used for industrial and domestic purposes (Ritchie *et al.*, 2023). Some of the major agricultural production centers that rely heavily on irrigation are found in North India, the Indus River Basin in Pakistan, the North China Plain, and the Central Valley in California (Paria *et al.*, 2021; Liu *et al.*, 2022; Sajid *et al.*, 2024). Figure 2.6 illustrates the lowering of the groundwater level (De Graaf *et al.*, 2019) together with freshwater fish species richness (Abell *et al.*, 2008). Of the countries with significant irrigation schemes, India and Pakistan have the most unsustainable expansion, with 86% (12.1 Mha) and 87% (1.53 Mha) of the gross expansion taking place in areas with freshwater stress (Mehta *et al.*, 2024). Other examples are also cited in the Indus River of Pakistan, where extensive irrigation practices have diminished fish populations (Braulik *et al.*, 2014). High water withdrawals from the Nile and Indus Rivers, primarily for irrigation, have led to saltwater intrusion upstream, affecting estuaries and riverine delta ecosystems (Kidwai *et al.*, 2018). Excessive groundwater withdrawals in arid and semi-arid regions of Africa and Asia—where annual evaporation and transpiration exceed rainfall and surface water storage options are inadequate—have depleted aquifers, lowered water levels in streams and lakes, deteriorated water quality, and led to land subsidence (De Graaf *et al.*, 2019; Jasechko *et al.*, 2024).

Figure 2.6 - Areas with high freshwater fish species richness (Abell *et al.*, 2008) and estimated lowering of groundwater levels (in meters) caused by groundwater pumping (De Graaf *et al.*, 2019).



While this typology illustrates the prevailing types of agricultural-driven nature loss of global importance, it focuses on drivers and impacts directly related to agricultural production, only discussing land use change in the context of intensification. This report does not aim to be exhaustive, nor are the four types mutually exclusive. Yet, this report focuses on the drivers and impacts relating to existing agricultural production and only discusses impacts on land use change in relation to the impact of agricultural intensification on land use change. In the next section, we illustrate how the drivers in water, land and pollution management cause nature loss.

UNSUSTAINABLE IRRIGATION AND ITS IMPACT ON FRESHWATER SYSTEMS: IMPACT PATHWAYS

How does unsustainable irrigation impact biodiversity? Freshwater ecosystems, hosting one-third of all vertebrate species, are particularly vulnerable (Tickner *et al.*, 2020). Excessive water extraction leads to the degradation of freshwater ecosystems, which are essential for many species. Such degradation disrupts species migration and contributes to the accelerated disappearance of these habitats—three times faster than forests. The additional stress from climate change intensifies biodiversity loss in these areas.
How does this impact ecosystem services? The decline in freshwater biodiversity impairs key services such as water purification, carbon sequestration, and habitat provisioning. **How does this impact agriculture?** This loss of ecosystem services reduces the capacity of ecosystems to support agricultural productivity, particularly in arid and semi-arid regions. The depletion of water resources and the degradation of freshwater ecosystems have profound consequences for irrigation-dependent agriculture. Implementing efficient irrigation techniques, promoting water conservation, and integrating ecosystem-based approaches are essential to sustaining both agriculture and biodiversity in water-scarce regions. Different practices have been identified to transform our global food system and reverse trends in biodiversity loss (Benton *et al.*, 2021). These practices focus on reducing pressure on land by promoting dietary shifts and expanding nature protection and restoration efforts, water efficiency use and on transitioning existing agricultural practices toward nature-friendly farming. Such proposed reforms aim to tackle the leading causes of agriculture-driven biodiversity decline.

2.3 Understanding the pathways of agriculture-driven nature loss and their impacts

The typologies provide a series of lenses through which to understand agricultural practices and their impacts on biodiversity. These impacts are shaped by the underlying management practices that constitute the **drivers, nature and extent of biodiversity loss.** We analyzed the drivers of biodiversity loss by looking at soil and water management practices. How do these drivers affect biodiversity and ecosystem services? How are they moderated or exacerbated by climate change?

Agricultural water management

Poor water management practices—including excessive levels of irrigation, groundwater withdrawals, and wetland drainage—are significant contributors to biodiversity loss and ecosystem disruption. Inefficient irrigation methods, such as flood irrigation, lead to waterlogging and salinization, which degrade soil health, reduce agricultural productivity, and disrupt local flora and fauna. Excessive withdrawals of groundwater and surface water for agricultural use reduces streamflow and aquifer levels, destabilizing aquatic ecosystems and decreasing habitat connectivity for species reliant on these environments. Additionally, the drainage of wetlands for agricultural expansion eliminates critical habitats, leading to the loss of species like fish, amphibians, and migratory birds. Excessive drainage also increases risks of flooding and soil erosion in adjacent landscapes.

These impacts negatively affect agriculture by reducing the availability of freshwater resources and degrading the ecosystems that support pollination, pest control, and nutrient cycling. Without sustainable water management, crop yields decline, and farming becomes more vulnerable to climate variability.

Soil management

Soil degradation resulting from unsustainable agricultural practices, such as monocropping, excessive tillage, and insufficient conservation measures, significantly undermines ecosystem health. Monocultures reduce habitat heterogeneity and resilience, limiting soil biodiversity and its capacity to recover from disturbances. Excessive tillage disrupts soil structure and damages microbial communities,

Credit: ©2021 CIAT/Juan Pablo Marin García leading to soil erosion and the loss of fertility critical for sustainable crop production. Land-use changes, including deforestation to expand farmland, further destabilize carbon storage and local food webs, increasing greenhouse gas emissions and contributing to climate change. These effects culminate in long-term reductions in soil productivity and agricultural sustainability.

As soil health deteriorates, its ability to retain water and nutrients is compromised, directly impacting crop growth and productivity. Over time, this leads to increased dependency on synthetic inputs, higher production costs, and diminishing returns for farmers.

Pollution management

Agricultural pollution from excessive fertilizers, pesticides, and poor waste management has severe implications for terrestrial and aquatic ecosystems. Nutrient runoff from fields enriched with synthetic fertilizers causes eutrophication in water bodies, fostering harmful algal blooms that deplete oxygen and threaten aquatic life. Pesticides and herbicides impact non-target organisms, such as pollinators, soil invertebrates, and aquatic species, which are essential for ecosystem functions and agricultural productivity. Improper management of livestock waste releases harmful gases, such as ammonia and methane, while contaminating nearby water bodies with pathogens and excess nutrients. The cumulative effects of pollution degrade ecosystem services and reduce biodiversity, posing long-term challenges for both ecosystems and agricultural systems.

The decline in biodiversity caused by pollution disrupts critical ecosystem services like pollination, natural pest control, and soil regeneration, making agriculture less productive and more vulnerable to external shocks. This dependency on external inputs for productivity also raises farming costs and reduces the resilience of agricultural systems.

All of the core areas of agricultural management, water, soil, and pollution drivers and sub-drivers can be linked back to the four types of agriculture identified in Part 1. An overview of the different management practice areas and respective drivers is provided in Table 2.1.

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Table 2.1 - Agricultural drivers and sub-drivers of nature loss by management area and farm typologies they mostly refer to (Type 1 - Smallholder farms on forest frontiers (expanding agriculture); Type 2 - Agrochemical intensive monocultures; Type 3 - Intensive livestock systems (and overgrazing); Type 4 - Water (over) extractive farming and its impacts on freshwater ecosystems).

DRIVERS	SUB-DRIVERS	DESCRIPTITON/CONTEXT	FARM TYPOLOGIES
AGRICULTURAL WATER MANAGEMENT			
Irrigation water management	**1. Surface (flood) irrigation**	Traditional methods of irrigating agricultural fields by flooding with water; often linked with large (canal) irrigation.	1,4
Practices	**2. Poor scheduling of irrigation water**	Leading to under-/over-irrigation due to insufficient or poorly applied irrigation methods.	1
	3. Poor irrigation water quality	Use of low-quality/marginal water, e.g., brackish, for irrigation/ fertigation.	1,2
Over-exploitation of water resources	**4. Over-abstraction of surface and/or groundwater**	Over-abstraction of water for intensive agriculture or livestock production, where withdrawal exceeds recharge.	3,4
Watershed Management	**5. Wetland drainage and conversion**	Using natural or engineered modifiers to remove water actively; channeling water to lower water level areas; wetland conversion into agricultural land that leads to drainage and destruction of floodplains.	2,4
	6. Poor construction and management of reservoirs	Inadequate construction and distribution, e.g., canal operations for agriculture (illustration not provided)	1,3,4
AGRICULTURAL SOIL AND LAND MANAGEMENT			
Crop management practices	**7. Monocropping and monoculture**	A practice of growing a single crop/species on a specified land, period after period.	2,4
	8. Poor crop selection	A practice of choosing crops that are not well-suited or sub-optimal for local conditions	2,4
Soil management practices	**9. Excessive tillage**	Soil preparation methods that degrade soil structure, including the use of heavy machinery	1,2
	10. Poor Soil and Water Conservation Management	Inadequate or absent of in-situ soil and water conservation measures that expose the soil to dryness and erosion.	1,2
Land use change & management practices	**11. Land Use Change**	Conversion of forests, grasslands, or wetlands into agricultural lands. (illustration not provided)	2,3,4
	12. Shifting cultivation	Clearing forests for temporary crop cultivation and leaving for some time to recuperate (illustration not provided)	1,2
Livestock farming management practices	**13. Poor Livestock Farming**	Practices involving overgrazing, removal of vegetation cover, and stocking density that lead to soil compaction	1,3
AGRICULTURAL POLLUTION MANAGEMENT			
Excessive herbicide and pesticide use	**14. Use of Pesticides**	Untargeted application of chemical compounds to control unwanted plants/weeds	2
		Untargeted application of chemical compounds to control pests (inc. fungicides)	2
Excessive use of nutrients	**15. Fertilizer use**	Application of synthetic and/or organic fertilizer to supplement nutrients on farms	4
Poor Agricultural Waste Management	**16. Poor crop residue and livestock waste management**	Improper handling and use of leftover crop residues and livestock waste in agriculture (illustration not provided)	4

2.4 Nature-positive agricultural practices (NPAPs): delivering ecosystem services for resilience and production

Nature-positive agricultural management practices (from farm to landscape scale) are defined as technologies or approaches that mitigate the negative effects of agriculture on biodiversity. The practices enhance positive impacts on nature, are economically viable, support livelihoods, and include diverse land users associated with the **4 types** of agriculture. We identified 15 detailed sustainable management practices and technologies, hereafter defined as practices. We describe potential solutions for addressing the impacts of agriculture on biodiversity and ecosystem services (Table 2.2).

Sustainable practices help to address the negative effects of agriculture on biodiversity (Figure 2.1). They have a positive influence on the regulating, material and non-material ecosystem services provided by nature. These services include regulating services (e.g., water cycling, pest control), material services (e.g., food and fiber), and non-material services (e.g., cultural and recreational benefits). However, the adoption of sustainable practices must consider the scale of implementation (plot, farm, landscape, or national), the factors influencing their adoption, and their complementarities within a broader strategy.

While the practices reviewed are all technical interventions, their effectiveness lies in being integrated as part of solution bundles rather than as standalone measures. Sustainable practices must be part of a comprehensive strategy that combines them with essential support services such as advisory and extension services, access to financing and insurance, and effective marketing channels, policies and incentives. This enabling environment, which includes the social-economic context and policies is crucial to empowering producers to adopt and maintain sustainable practices.

Without a favorable enabling environment, producers will not be able to take up sustainable practices. Farmers often prioritize practices that generate private goods, where benefits are available only to the individual user (e.g. micro-irrigation). They may minimize broader public goods, where something used by the individual can also benefit others (e.g., multipurpose trees which provide habitat, better downstream water management and food for pollinators). Additional incentives may be needed to encourage adoption of practices that deliver more public-goods (Zander *et al.*, 2024).

The selected practices vary substantially with respect to the actors involved in their application and to the scale at which they mitigate biodiversity losses. Some practices are applied by farmers in their fields, like crop rotation, micro-irrigation, and intercropping. Others, like transforming crop and food waste to animal feed, involve actors from across the food system and require appropriate facilities and processes that go beyond the capacity of any individual farm or household. Table 2.2 shows the practices that individual farmers can adopt at the farm level.

Ensuring a positive impact of the selected practices on biodiversity and ecosystem services at the landscape level often needs appropriate governance and coordination among different actors. Practices with landscape coordination requirements are shown in Table 2.2. For instance, some practices, such as farming with alternative pollinators or enhancing tree cover, require a minimum level of buy-in from farmers. Therefore, their adoption needs to be promoted and incentivized at the landscape level for the practice to deliver the expected biodiversity improvements. Other practices, particularly those related to water management, may require coordination and community control to avoid adoption rates beyond certain thresholds, since exceeding a threshold level may be associated with the opposite results than those originally envisioned. The above examples and the specific issue discussed (adoption thresholds) are not exhaustive of the problem of scale interdependencies for the different practices. Nevertheless, they are indicative of the intrinsic complexities involved in designing locally tailored or contextual guidance for nature-positive agricultural systems.

Table 2.2 - Clusters of nature-positive practices and ecosystem services affected

PRACTICE CLUSTER	PRACTICE	ECOSYSTEM SERVICE AND FUNCTION AFFECTED*																			
		REGULATING										MATERIAL					NONMATERIAL			SCALE	
		HABITAT	POLLINATION & SEED DISPERSAL	AIR QUALITY	CLIMATE	OCEAN ACIDIFICATION	FRESHWATER QUANTITY & FLOW	FRESHWATER QUALITY	SOIL FORMATION & PROTECTION	HAZARDS	PESTS	ENERGY	FOOD & FEED	MATERIALS	MEDICINE	LEARNING & INSPIRATION	EXPERIENCE	IDENTITY	OPTIONS	RM-LEVEL PRACTICE **	LANDSCAPE COORDINATION ***
Sustainable Soil and Water Management	Minimum tillage			■	■	■	■	■	■	■			■						■	■	
	Green manure	■	■		■	■	■	■	■	■	■		■	■					■	■	
Improving soil health and efficient water use	Micro-irrigation				■		■	■	■				■						■	■	■
	Mechanical soil & water conservation						■	■	■	■			■						■	■	
	Crop rotation	■	■		■	■	■	■	■	■	■	■	■	■					■	■	
	Intercropping	■	■		■	■			■	■	■		■	■					■	■	
Integrated Pest and Nutrient Management	Biocontrol	■			■				■	■	■								■	■	■
	Organic fertilizers	■		■	■				■	■	■		■						■	■	
Reducing chemical inputs and enhancing soil and insect biodiversity	Farming with Alternative Pollinators	■	■		■						■					■	■		■	■	■
	Integrated nutrient management	■			■			■	■	■	■								■	■	
	Integrated pest management	■	■		■						■								■	■	■
Diversified and Resilient Agroecosystems	Agro-silvo-pastoralism	■	■		■	■			■	■	■	■	■	■	■	■	■	■	■		■
	Sustainable manure management			■	■				■	■		■		■					■	■	■
	Waste to animal feed	■								■			■	■					■		■

ECOSYSTEM SERVICE AND FUNCTION AFFECTED*																					
PRACTICE CLUSTER	PRACTICE	REGULATING										MATERIAL					NONMATERIAL			SCALE	
		HABITAT	POLLINATION & SEED DISPERSAL	AIR QUALITY	CLIMATE	OCEAN ACIDIFICATION	FRESHWATER QUANTITY & FLOW	FRESHWATER QUALITY	SOIL FORMATION & PROTECTION	HAZARDS	PESTS	ENERGY	FOOD & FEED	MATERIALS	MEDICINE	LEARNING & INSPIRATION	EXPERIENCE	IDENTITY	OPTIONS	RM-LEVEL PRACTICE **	LANDSCAPE COORDINATION ***
Diversified and Resilient Agroecosystems *Enhancing ecosystem services and resilience through biodiversity*	Intercropping																				
	Multipurpose trees																				
Climate-Smart and Resource-Efficient Agriculture *Improving efficiency and mitigating climate change impacts*	Minimum tillage																				
	Green manure																				
	Micro-irrigation																				
	Agro-silvo-pastoralism																				
	Farming with Alternative Pollinators																				
	Crop rotation																				
Pollution and Waste Management *Reducing overall agricultural pollution and managing biomass sustainably*	Biocontrol																				
	Organic fertilizers																				
	Sustainable manure management																				
	Waste to animal feed																				
	Integrated nutrient management																				
	Integrated pest management																				

*From Brauman, K., L. A. Garibaldi, S. Polasky, & M. Verma. 2020. Global trends in nature's contributions to people. *Proceedings of the National Academy of Sciences* 117 (51): 32799-32805. https://doi.org/10.1073/pnas.2010473117
** "Farm-level practice" indicates applicability at the farm level, with adoption being an individual farmer decision. These practices generate ecosystem benefits, which can scale out linearly with higher adoption.
*** The "Landscape coordination" column indicates practices that (1) either cannot be applied at farm level, or (2) practices whose ecosystem benefits are substantially enhanced (beyond linear increase) if they are properly supported and coordinated at landscape level.

2.5 Understanding the economic viability of nature-positive agricultural practices

A systematic review of the literature was conducted to assess the economic performance of sustainable agricultural practices (SAPs), including nature-positive practices using a range of indicators. Existing evidence shows that SAPs are mostly economically attractive compared to conventional agricultural practices (CAPs), although outcomes are highly context specific and depend on temporal scales. Practices such as agrosilvopastoralism, organic farming, crop rotation, mechanical soil and water conservation, improved seed varieties, and climate smart agriculture consistently outperformed conventional practices in terms of profitability and returns on investment. However, barriers such as high initial costs, increased labor demands and longer payback periods for SAPs can hinder the adoption. Furthermore, the economic analyses rarely account for the economic returns associated with environmental benefits, such as increased biodiversity and nature pest control or pollination services, improved soil health, water conservation, and carbon sequestration. Agricultural policies and incentive schemes should consider these types of insights (see below).

The TEEBAgriFood Evaluation Framework (TEEB, 2018) provides a holistic and comprehensive basis from which to assess the entire food system. The framework was applied to four of the NPAPs: a) minimum tillage, b) biological pest control, c) agrosilvopastoralism, and d) micro irrigation. A critical literature review was conducted to identify studies relevant to applying the framework to these practices. The results showed that the practices yield numerous environmental benefits across a wide range of crop types, biomes, and temporal and spatial scales. They suggest that different applications of the chosen NPAPs can be malleable within various agroecosystems. Significant data gaps were identified when applying the TEEBAgriFood Framework to the NPAPs. While the agricultural production cycle was well-represented in the reviewed studies, post-harvest information on manufacturing, processing, distribution, marketing, retail, and household consumption was severely lacking.

THREE TAKE HOME MESSAGES ON ECONOMIC VIABILITY OF PRACTICES

1. **NPAPs offer generally positive economic returns, however, outcomes remain context specific and are influenced by factors such as location, crop type, farm size, and environmental conditions.**

2. **Many NPAPs, such as organic farming and integrated nutrient management, demonstrate potential for long-term yield improvements and environmental benefits like improved soil health, but these benefits may not be captured in short-term studies.**

3. **The TEEBAgriFood Framework is useful in assessing the externalities of food systems, but its wider application is hindered by the lack of information outside of the agricultural production component of the food system.**

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2.6 Summary of policy and investment reforms to support nature-positive agriculture

As outlined above, adoption of innovation bundles that drive nature-positive agriculture requires an effective enabling environment. National policies, programs and strategies aimed at combatting agricultural-driven biodiversity loss are vital. We selected 10 critical policy cases. This group of cases—consistent with the literature on biodiversity policy and governance—was based on the eight criteria[1] (c.f. Jiren *et al.*, 2021; Paavola *et al.*, 2009; Veiga *et al.*, 2016).

We identified six types of agricultural reform associated with nature loss (see box below), which were then categorized to determine: a) the type of nature loss the reform addresses; b) the type of relevant agriculture; c) type of ecosystem.

BOX 1.1 - NATURE-POSITIVE POLICY AND INVESTMENT REFORMS APPLICABLE IN AGRICULTURAL LANDSCAPES

Fiscal: this type of reform refers to the allocation of private or public funds towards biodiversity conservation efforts, including fiscal or monetary policy from a given government. Financial reforms also include private efforts to finance specific biodiversity conservation activities, such as the protection of a specific species or area, and public-private partnerships.

Natural resources: this type of reform broadly considers access to and ownership over natural resources. The most common reform in this category is community-based natural resource management, but it also could involve programs and policies that change land tenure, land use or other human-environmental relationships.

Distributive: these reforms include programs and policies that offer monetary compensation for biodiversity conservation, such as Payments for Ecosystem Services (PES) and cash transfers.

Regulatory: here we are referring to a reform that changes sets of rules or laws to incentivize, control or manage activities. In the context of agriculture and biodiversity, the most common regulatory reforms are changes in laws or institutions that influence land-use and natural resource governance behaviors or practices.

Social: this type of reform includes services offered to groups of people who are involved in agricultural-driven biodiversity loss. Examples include rural extension, education, and stakeholder engagement activities for participatory decision-making.

Institutional: this type of reform indicates a change in the institutional basis for agricultural-driven biodiversity loss, such as the creation of a new national ministry, changes in national development policies, or strategies that integrate existing governmental institutions.

Policy reforms rarely operate in isolation. For example, there are often synergies between regulations, market incentives, or community-based approaches, their coordination mechanisms, and how they strengthen or weaken each other.

[1] The criteria used to identify the policy cases included the following: (1) they originate from developing countries; (2) involve a policy, program, strategy, or investment aimed at promoting or protecting biodiversity; (3) engage the agricultural, livestock, and/or forestry sectors; (4) represent relatively recent reforms (established or revised within the past ~20 years); (5) are relevant to other countries due to their applicability in different contexts; (6) have sufficient available information, including from independent external sources; (7) involve different political or administrative levels; and (8) reflect a diversity of governance models, including participation from both governmental and non-governmental organizations.

To address this, we weighted the trade-offs associated with each approach. They included cost, scalability, reliance on other reforms and/or institutions, and the co-benefits provided for livelihoods. The weighting enabled us to assess critical success factors. In the table 2.3, we provide some examples of policy tradeoffs considering incentives and punitive measures.

Table 2.3 - Agricultural management area, policy type tradeoffs and considerations.

AGRICULTURAL MANAGEMENT AREA	POLICY TYPE	CONSIDERATIONS
Pollution Control (Pesticides & Chemical Use)	**Fiscal** (Taxation & Incentives)	• **Punitive Approach:** Pesticide taxes can reduce chemical use but may increase costs for smallholders. • **Compensatory Approach:** Incentives for sustainable alternatives (e.g., biopesticides) can mitigate yield losses but require government subsidies.
Soil & Land Management (Tillage, Fertilizer Use, Agroforestry)	**Distributive** (Subsidies & Payments for Ecosystem Services - PES)	• **Punitive Approach:** Restricting chemical fertilizer use can improve soil health but may lower short-term yields. • **Compensatory Approach:** PES schemes reward sustainable land practices but require robust monitoring and long-term funding.
Agricultural Water Management (Irrigation, Groundwater Use)	**Regulatory** (Water Pricing, Use Restrictions)	• **Punitive Approach:** Water pricing and abstraction limits can improve efficiency but may disproportionately impact smallholders. • **Compensatory Approach:** Subsidizing efficient irrigation systems encourages conservation but can be costly for governments.
	Institutional & Social (Land Reform, Community Engagement)	• **Punitive Approach:** Strict conservation rules can limit land access, impacting local livelihoods. • **Compensatory Approach:** Land tenure security incentivizes sustainable land use but requires long-term political commitment.

2.7 Country case studies of agriculture and nature conflicts

BOX 1.2 - AGRICULTURE AND TROPICAL FOREST FRONTIERS IN THE ORINOQUÍA, COLOMBIA

The vast Orinoquía region spans 255,000 km^2, 22% of Colombia's territory, 35% of which is forested. Agricultural expansion in the region drives extensive deforestation. In 2018, 34% of the Orinoquía region was used for livestock grazing, with an annual expansion rate of 2% (1,886 km^2/year). The area of monoculture cropland—mostly rice, maize, soybean and sugar cane—has expanded at a rate of 12% a year between 2007 and 2018. In 2018, 3.2% of the region's surface area was used for cropping.

In 2020 alone, more than 171,000 hectares of forest were lost in Orinoquía. This deforestation threatens the region's unique biodiversity, comprising 5,411 species of plants and 3,000 species of animals, including 663 species of fish and 254 mammals. Species like the jaguar (*Panthera onca*) and the giant anteater (*Myrmecophaga tridactyla*) have seen their populations decrease by 30% in the last two decades. The increase of fragmented habitats has led to a 20% decline of the population of the white-tailed deer (*Odocoileus virginianus*). Valuable native hardwood and keystone tree species like mahogany (*Swietenia* sp.)., cedar (*Cedrela* sp.), and abarco (*Cariniana pyriformis*) have seen their populations decline.

Social conflict, migration and illicit coca cultivation drive forest loss. There is a lack of territorial planning. Perverse policies exacerbate sustainable development problems, impeding public investment in improved infrastructure and economic integration. Conventional agricultural systems lead to soil and pasture degradation and loss of vegetation cover. Monoculture cropping reduces landscape diversity and impacts soil health and biodiversity through intensive use of external inputs, excessive tillage, inadequate fertility management, poor erosion control, etc. The lack of organization among producers limits the transfer of knowledge and application of sustainable technologies, perpetuating the cycle of deforestation and biodiversity loss.

Diverse bundles of nature-positive solutions have been co-developed by local stakeholders and are available for scaling. Conversion programs in the region attend the root causes and aim to transform extensive livestock management and monoculture cropping systems towards more sustainable and productive practices, reducing the pressure on forested areas, increasing tree cover and diversity. These efforts require an enabling environment for the adoption of innovations, such as land-use planning, legal tenure security, producer-level organization, and advisory systems. Concerted multistakeholder platforms for dialogue, planning and articulated action have been essential to advance the transition towards sustainable production and biodiversity conservation. The use of improved forages, rotational grazing, living fences, forage banks, and multi-purpose trees can help land users transition to sustainable silvopastoral systems. There are multiple key lessons to achieve effective synergies between agriculture and biodiversity conservation in the Orinoquía. Land sparing is possible, reducing deforestation and consequent biodiversity conservation through sustainable agriculture. Yet it requires more than technologies and markets. Essential cornerstone conditions include multiscale articulation across sectors, effective knowledge sharing, legal land ownership security, and on-farm income diversification beyond agriculture. Importantly, specialists recognize the need to raise awareness of the potential for bioprospecting and bioeconomic innovations involving local biodiversity.

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BOX 1.3 - COCOA FARMING SYSTEMS, VARIETAL AND SPECIES DIVERSIFICATION, AND CARBON SINKS IN THE KAKUM LANDSCAPE, GHANA

The Kakum Landscape comprises the Kakum Conservation Area and its borderlands, covering a total land area of 360 km2. The conservation area protects the headwaters of the Kakum River and two other streams (Obuo and Nemini), supplying water to Cape Coast. Part of the Upper Guinean Forests, the area is considered a West Africa Biodiversity Hotspot, with over 80 farming communities and an estimated 2000 households within a 5 km radius of the conservation area. Farmers typically maintain about 4 to 8 acres dedicated to cocoa and 2 to 3 acres to food crops. This landscape produces over 50% of Ghana's cocoa. Cocoa accounts for about 57% of all agricultural exports and 25% of Ghana's foreign exchange reserves.

Agricultural expansion, primarily from cocoa production into forested areas, is a leading cause of deforestation. Farmers seek new land to replace ageing cocoa plantations suffering from dramatic yield declines due to soil degradation. Consequently, vast tracts of forests are cleared, generating significant carbon emissions and loss of biodiversity. Many cocoa farmers in Ghana are elderly, often over 60 years old, and are unable to maintain and improve their farms. Their resistance to invest in their cocoa plantations, due to their short time horizon, limits their adoption of modern farming practices and leads to reduced productivity. Concurrently, older trees producing fewer pods and lower-quality beans. They absorb less nutrients, increasingly suffer from diseases, and have reduced pest resistance. This dual challenge—declining farmer productivity and deteriorating tree health—decreased yields, driving abandonment as farmers expand into forested areas. The poor enforcement of forest laws allows for this deforestation to continue almost uninhibited.

The loss of biodiversity is exacerbated by the prevalence of monoculture cocoa to maximize production in the short term. Additionally, misconceptions about associated trees being hosts for pests and about current Ghanaian law, which grants the state ownership of timber trees, has further incentivized the removal of associated trees in cocoa agroforests. Monoculture production not only depletes the soil of essential nutrients but also reduces the resilience of the agricultural system to pests and diseases. It further threatens the long-term sustainability of the land and the surrounding environment. Farmers then combat these challenges with agrochemicals that pollute the soil even more, creating more environmental health consequences. Several management approaches and solutions, led by subnational, national, and international actors, are being undertaken in the Ghana cocoa sector. These approaches could help alleviate the pressure on nature and enhance the biodiversity on cocoa farms. The creation of community resource management areas allow for local management of forests, creating a sense of ownership of the forest by community members. These managed forests improved enforcement of forestry laws. Furthermore, several programs led by the Ghana Cocoa Board have encouraged farmers to adopt sustainable agroforestry practices, The practices include replacement of older trees with disease-tolerant hybrids, hand pollination to increase pod development, and pruning programs to reinvigorate older trees and increase productivity on older cocoa plantations. As the current cocoa plantations become more productive, farmers have less of a desire to expand into forested areas.

Market interventions like certification schemes encourage the use of agroforestry and nature-positive practices. They pay higher prices, ultimately enhancing biodiversity on farms and discouraging deforestation. The provision of crop insurance by the Ghana Cocoa Board encourages farmers to make these investments in sustainable intensification by removing much of the risk from these investments. Additionally, the creation of the 25-year Ghana REDD+ Strategy—by the Forestry Commission and Ghana Cocoa Board, with funding support from the Forest Carbon Partnership Facility of the World Bank—has promoted the adoption of these sustainable intensification practices to reduce carbon emissions.

These programmes promoted in the cacao sector in Ghana provide a lesson on how agricultural production can be enhanced while encouraging forest and biodiversity conservation. Market incentives, such as certification schemes, encourage the adoption of sustainable practices. Several policies and program have shown to be effective and provide opportunities for scaling. These include delegation of the enforcement of forest laws and planning to sub-national actors and community forestry management schemes. These alternative governance strategies give sub-national actors a stake in their natural resources and a motivation to protect them. Additional policy opportunities that show potential include investment in insurance schemes that lower production risks, allowing for investment in sustainable intensification practices. Another opportunity is the REDD+ Strategy, motivating the adoption of agroforestry and other sustainable production practices to meet carbon sequestration goals. As Ghana seeks to align with the new EUDR zero deforestation regulations, traceability, farm mapping and compliance will be critical.


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TAILORING NATURE-POSITIVE AGRICULTURE TO LOCAL NEEDS

03

3.1 Providing local context to guide transitions to nature-positive agriculture

As outlined above, there are complex interactions between ecological systems and a given socioeconomic and agricultural context. When adding cultural and political differences across these contexts, broad-scale generic guidance has limited value. Spatially explicit, local contextual guidance can help better direct funds to agricultural development, natural resource management, conservation, restoration, and reforms in places where they will have the greatest impact. Given the urgency of the problem, there is also a need to prioritize areas and landscapes most likely to achieve the desired biodiversity, food security, economic development, and climate mitigation goals. Planners should minimize negative trade-offs and break landscape degradation cycles in the long-term. Nature-positive transitions of food and land use systems are complex, and investments need careful planning.

For example, investing in restoring vegetation in a production landscape can benefit biodiversity. But it can also lead to a loss of food or income for people in the same location or elsewhere. Spatially explicit and locally contextual models can help identify which interventions will be most effective at achieving the desired multi-objective development outcomes. Models should account for both positive and negative synergies or tradeoffs. To effectively inform local-level nature-positive investments and recommendations in agriculture, a **multi-scale approach** is often necessary, combining data from global, regional, national, and local sources. Such an approach allows for the identification of broad-scale trends and patterns while capturing the unique characteristics of local landscapes and ecosystems. The approach can also provide insights into how local interventions can singularly and collectively contribute to, or detract from, national and global initiatives, such as the Global Biodiversity Framework, the Paris Accords, the SDGs, as well as NBSAPS.

3.2 Existing and relevant datasets

Global-scale datasets can provide a baseline of land use change, climate variability, and biodiversity patterns. For example, [Copernicus Sentinel-2] imagery can be used to monitor land cover changes over time. [NASA's Global Precipitation Measurement (GPM)] mission can provide insights into precipitation patterns and water availability, which are critical for agricultural planning and conservation efforts. These global datasets set the stage by providing a baseline that highlights where significant changes or risks may be occurring.

Regional/national-scale datasets can offer more detailed information on specific geographic areas. For instance, **national land use and land cover maps** can provide information on agricultural land use patterns and protected area coverage. **Regional climate models** can simulate future climate scenarios. Furthermore, **modeled distribution maps** and **hotspot maps** of socioeconomically important tree species combined with remote sensing can identify key areas for protection and restoration.

Local-scale data is essential for capturing the nuances of local landscapes and communities. This may include **high-resolution aerial imagery, soil surveys, biodiversity inventories**, and **socio-economic data** collected by local governments, NGOs, and research institutions. These datasets provide the granularity needed to tailor interventions to the specific conditions of a locality, ensuring that investments are relevant and effective. For instance, local biodiversity inventories might reveal the presence of endemic species that are not visible in broader-scale datasets, guiding conservation efforts that would otherwise overlook these critical areas. However, the effectiveness of global models in guiding nature-positive investments is often hampered by gaps in data availability and quality at the local level. While efforts are being made to enhance global datasets with finer resolution and better accuracy, the current state of data, with its inconsistencies in land use classifications and lack of real-time information, highlights the need for more localized GIS data collection and analysis. Such gaps call for a more nuanced approach, where global models are supplemented with localized data and expertise to ensure that agricultural investments truly benefit both nature and local communities.

Many spatially explicit tools exist to inform integrated food and land use system planning (Table 3.1). Some of these tools can be used to explore risks to food production systems or agricultural value chains, stemming from unsustainable land use (e.g. WWF risk filter, Agrobiodiversity Index hotspot tool, InVEST). Others can be used to identify solutions that can reduce these risks by restoring ecosystem functioning (e.g. D4R). Still others can be used to identify under-performing food production systems in terms of productivity or economic returns. These latter tools enable investments to be targeted to zones of interest (e.g. FAO Hand-in-Hand).

Table 3.1 - Spatially explicit tools for integrated food and land use system planning to achieve harmony between people and nature.

Model/tool	Description	Includes development goals (food and nutrition security, income, productivity)	Includes conservation goals (biodiversity, water, soil health)
WWF Biodiversity/ Water risk filter	*Corporate and portfolio-level screening tool to help companies and investors to prioritize action on what and where it matters the most to address biodiversity risks for enhancing business resilience and contributing to a sustainable future*	No	Yes – biodiversity, water
Diversity4Restoration	*A tool developed to help with decision-making on the use of appropriate tree species and seed sources for tree-based restoration or other tree planting activities,*	No	Yes – biodiversity, soil health, climate mitigation and adaptation
Agrobiodiversity Index (hotspot tool)	*Framework for monitoring biodiversity in food systems where this benefits healthy diets, sustainable production, and biodiversity conservation, based on spatial overlay of agrobiodiversity and food system threat layers*	Yes – nutrition, income	Yes – biodiversity, soil health, water supply
InVEST ecosystem service models	*Models designed to estimate the supply, use and value of ecosystem services, based on land use maps, biophysical and socio-economic data*	Yes – nutrition, economic valuation	Yes – biodiversity, soil health, water supply, pollution
FAO Adaptation, Biodiversity, and Carbon Mapping Tool (ABC Maps)	*A geospatial app that holistically assesses the environmental impact of policies, plans and investments in the agriculture, forestry, and other land use (AFOLU) sector.*	No	Yes - biodiversity, water, climate change adaptation, carbon
FAO Hand-in-Hand initiative	*Geospatial model used to identify areas of high poverty and food insecurity, and opportunities to invest in building operational capacity to boost economic growth and increase food security*	Yes – income, food security	No

Applying risk and solution tools with broad scope—for example by including trends in deforestation next to agricultural land as an indicator of areas with farms encroaching into forest—would provide a means for **generating spatially explicit investment guidance to the World Bank and its partners.**

Specifically, risk tool methodologies can be applied to identify areas where biodiversity loss is increasing due to one of the four main agricultural typologies identified (Section 2.1). The methodologies can employ spatially explicit indicators (Table 3.2). Tools and methodologies can be used to match land-based interventions to at-risk areas according to their ability to alleviate specific or multiple threats. These methods should account for support and barriers created by the local policy and institutional environment (Section 2.6). Note that preliminary assessments using global or national datasets would need validation and improvement using local data and knowledge to ensure accuracy and design of locally appropriate interventions.

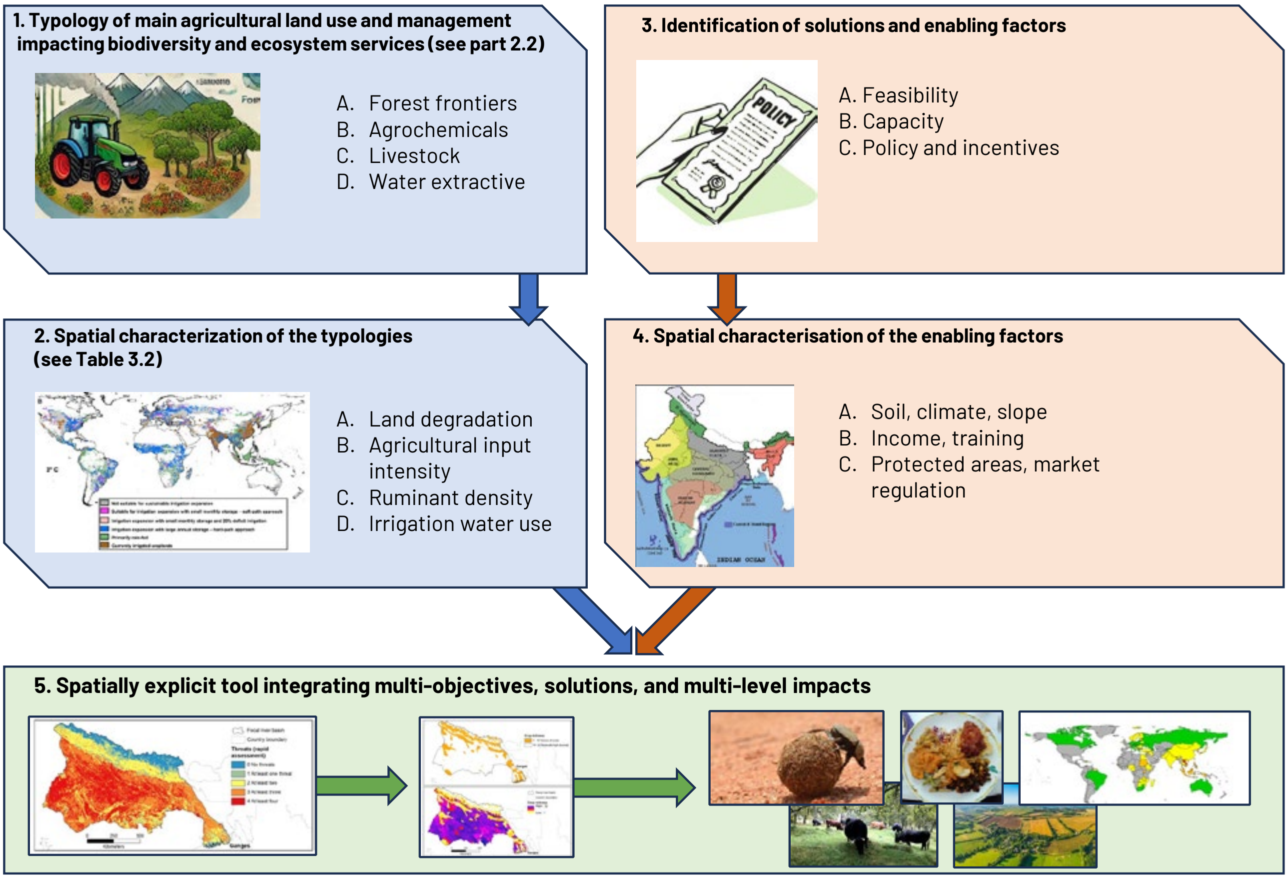
Credit: ©2016CIAT/GeorginaSmith

Table 3.2 - Datasets for identifying agricultural drivers of biodiversity loss

Typologies	Indicators of driver	Potential spatial datasets to use	Temporal and spatial resolution
Farming at Forest Frontiers	Deforestation adjacent to agricultural land	Global Forest Watch (2025)	Original resolution 30 m, often aggregated to 1 km; monthly data 2015-2023
	Trends in natural vegetation cover in ecoregions with agricultural production	Change in share of natural vegetation per ecoregion, from ESA land cover maps (ESA, 2017) and Dinerstein ecoregion boundaries (Dinerstein *et al.*, 2017), potentially disaggregated by protected area and natural vegetation quality	300 m (ESA, 2017) annual data 1992-2023; vector polygons 2017 (Dinerstein *et al.*, 2017)
Agrochemical-intensive monocultures	Crop richness in cropped landscapes	Crop richness per 10x10km calculated from SPAM crop distribution maps (IFPRI, 2025)	10 km; 5-year timesteps 2005-2020
	Tree species and crop wild relatives (CWR) richness on agricultural land	Modeled distribution and in-situ hotspots of socio-economically important tree species and CRW	1 km; 1995 (1981-2010) = baseline, 2025 (2011-2040), 2055 (2041-2070), 2085 (2071-2100)
	Percentage natural vegetation in cropped landscapes	Percentage natural vegetation per 1x1km computed by aggregating ESA land cover maps (ESA, 2017)	1 km; annual data 1992-2023
	Fertilizer use intensity	EarthStat maps of tons per hectare fertilizer use (Mueller *et al.*, 2012; West *et al.*, 2014)	10 km; 2000
	Pesticide use intensity	PEST-CHEMGRIDS (Maggi *et al.*, 2020), showing crop specific pesticide application rates	10 km; annual data 2015-2025
Intensive livestock systems and overgrazing	Ruminant density	Gridded Livestock Density maps (GLW v4) for buffalo, cattle, sheep, goats, pigs and chicken (FAO, 2024)	10 km; 2020
Over-use of agricultural water	Irrigation in water stressed areas	Global maps on areas equipped for irrigation located in water stressed areas (Metha *et al.*, 2024)	10 km; 5-year timesteps 2005-2020

Combining these spatially explicit datasets with assessments of the local enabling environment (based on section 2.3 and 2.4) will contribute substantially to more informed and targeted investment decisions that positively impact on nature (see Figure 3.1 for a schematic representation).

Figure 3.1 - Schematic diagram of the integrated understanding of key drivers and enabling environment (feasibility, capacity, policy and incentives.



3.3 Major benefits for farmers from implementing nature-positive practices

Nature-positive practices contribute to the well-being of farmers in many ways. The practices can provide material benefits (e.g., through increased yields and economic improvements), human health benefits, and improvements to social relations, equity, and job satisfaction.

From a livelihoods perspective, farmers benefit from enhanced yields and productivity gains. For instance, minimum tillage provides long-term yield stability and enhanced economic sustainability (Akpto *et al.*, 2025; Madarász *et al.*, 2025). Green manure can enhance agricultural productivity, particularly in the long term (Fontaine *et al.*, 2020; Haruna *et al.*, 2020). Irrigation can almost double crop yields when compared to rainfed systems, providing additional income (Tsegaye *et al.*, 2025). The use of micro-irrigation improves water use efficiency (Cheng *et al.*, 2021; Wang *et al.*, 2022). Greater yield stability is also brought about through climate-resilient practices, such as soil and water conservation or crop diversification (Rajbanshi *et al.*, 2023).

Greater food security provides health benefits to farmers and consumers, who have improved food access, availability, and stability. Nature-positive agriculture also reduces risk of pesticide exposure, following the implementation of biocontrol approaches and the substitution of synthetic fertilizers and pesticides with organic alternatives. Landscape approaches may require the collective implementation of nature-positive interventions, thereby fostering well-being through improved social relations and participation. Furthermore, the implementation of nature-positive practices has the potential to result in greater fulfillment and labor satisfaction in comparison to conventional farming.

Finally, restoration of degraded lands using nature-positive solutions that combine incentive schemes with locally tailored opportunities for income generation can offer highly scalable solutions. One such nature-positive innovation is the MyFarmTrees platform. The program provides a means to monitor and verify actions made by farmers, such as growing native trees and adopting sustainable agroforestry practices. It can also offers direct digital payments linked to existing policies or financing mechanisms, such as carbon or biodiversity credits. Beyond these features, MyFarmTrees also empowers smallholder farmers to generate incomes for seed collection and tree propagation, scaling nature-positive management and multi-purpose trees beyond one's own farm.

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4. WHAT DO SUCCESSFUL, LOCALLY TAILORED SOLUTION BUNDLES LOOK LIKE?

4.1 Identified solution bundles to tackle agricultural drivers of nature loss

Eight "solution bundles" were identified by linking nature-positive agricultural practice clusters with respective enabling policy reform types. They aim to halt and reverse agricultural drivers of nature loss (Table 4.1). These solution bundles address complementary scales and aims:

- At the farm and landscape levels, implementing economic incentives and regulatory mechanisms can ensure sustainable production through ***improved crop management (S3)***, such as subsidized organic farming. These mechanisms can employ ***improved livestock and pasture management (S4)*** by, for example, subsidizing agrosilvopastoralism or regulating stocking densities and manure management. The solution bundles are primarily suited to regions where agrochemical-intensive monocultures, unsustainable irrigation, and intensive livestock systems and overgrazing prevail as the main agricultural drivers of nature loss.
- At the community level, social, economic, and regulatory reforms can address the co-development of community infrastructure and capacity for clean, resilient, and biodiverse agroecosystems. The solution bundles promote ***water conservation (S5), bio-energy generation (S6)***, and ***multi-cropping machinery (S7).*** They target areas where unsustainable irrigation, intensive livestock systems, and agrochemical-intensive monocultures are the prevailing nature loss drivers.
- At sectoral and national levels, all policy reforms—in particular natural resource rights and institutional reforms—can be deployed to designate areas of ***nature restoration and conservation (S1).*** Reforms can promote ***nutrient-dense and climate-adapted foods (S2)*** supported by farmer intellectual property rights to seeds as well as campaigns to facilitate their integration within markets. They can ***synergistically support nature-positive farming (S8)***, for example, through Payments for Ecosystem Services schemes in combination with reforms removing harmful subsidies for synthetic fertilizers and pesticides. These bundles focus on different agricultural drivers; while nature conservation mechanisms primarily aim to prevent nature loss by farms on forest frontiers, the promotion of nature-positive farming and nutrient-

dense and climate-adapted food largely aim to address the remaining drivers. Institutional reforms in particular present an opportunity to formulate and finance a cohesive cross-sectoral vision for transitioning to nature-positive farming. For example, the creation of National Biodiversity Strategies and Action Plans under the Global Biodiversity Framework addresses the root causes of nature loss.

Table 4.1 - Solution bundles and associated nature-positive agricultural practices and reform types to tackle the key agricultural drivers of nature loss.

Solution bundles	Main nature-positive agricultural practice clusters addressed	Main agricultural reform types addressed	Main agricultural drivers of nature loss addressed
(S1) Nature restoration and conservation investments (e.g., community managed forest programs on sustainable harvesting of non-timber products)	• Diversified and resilient agroecosystem	• Financial • Natural resource rights • Economic • Regulatory • Social	• Farms on forest frontiers
(S2) Promotion of nutrient-dense and climate-adapted crops and livestock breeds (e.g., farmer intellectual property rights to seeds, value chain creation and campaigns to re-introduce neglected, underutilized, nutrient-dense and locally adapted varieties/breeds)	• Climate-smart and resource-efficient agriculture • Diversified and resilient agroecosystems	• Natural resource rights • Regulatory • Social	• Agrochemical-intensive monocultures • Unsustainable irrigation
(S3) Improved cropland management (e.g., minimum tillage, organic fertilizers, intercropping, biocontrol, multipurpose trees)	• Sustainable soil and water management • Integrated pest and nutrient management • Diversified and resilient agroecosystems • Climate-smart and resource-efficient agriculture	• Economic • Regulatory	• Agrochemical-intensive monocultures
(S4) Improved livestock and pasture management (e.g., agrosilvopastoralism, locally-adapted and diverse forages; regulations on antibiotic use, stocking density, manure management)	• Integrated pest and nutrient management • Diversified and resilient agroecosystems • Climate-smart and resource-efficient agriculture • Pollution and waste management	• Economic • Regulatory	• Intensive livestock systems and overgrazing • Unsustainable irrigation
(S5) Rainwater storage infrastructure and conservation technologies / training (e.g., farmer training on efficient irrigation management and mechanical conservation practices)	• Sustainable soil and water management	• Social	• Unsustainable irrigation • Agrochemical-intensive monocultures

Solution bundles	Main nature-positive agricultural practice clusters addressed	Main agricultural reform types addressed	Main agricultural drivers of nature loss addressed
(S6) Bio-energy generation infrastructure and technologies / training (e.g., community managed facility for biogas generation from manure)	• Pollution and waste management	• Economic • Regulatory • Social	• Agrochemical intensive monocultures • Intensive livestock systems and overgrazing
(S7) Development of affordable (green energy) machinery to facilitate multi-crop production (e.g., subsidized mechanical seed drills and harvesters suited to intercropping)	• Diversified and resilient agroecosystems	• Economic • Regulatory	• Agrochemical intensive monocultures
(S8) Synergistic support for nature-positive farming (e.g., Payments for Ecosystem Services to farmers at forest frontiers, financial support for farmers with high transition costs, removal of subsidies for chemical fertilizer or pesticides, public procurement schemes that favor sustainable production)	• Sustainable soil and water management • Integrated pest and nutrient management • Diversified and resilient agroecosystems • Climate-smart and resource-efficient agriculture • Pollution and waste management	• Financial • Natural resource rights • Economic • Regulatory • Social • Institutional	• Farms on forest frontiers • Agrochemical-intensive monocultures • Intensive livestock systems and overgrazing • Unsustainable irrigation

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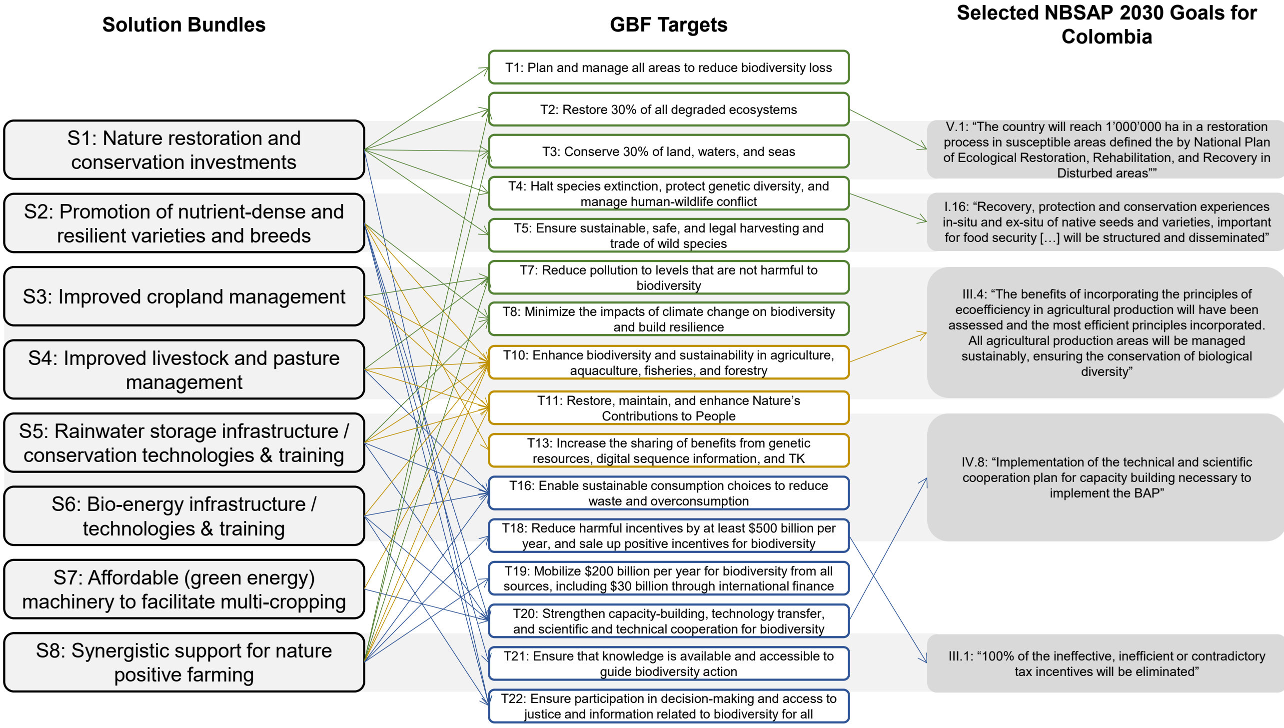
4.2 Guidance for implementing tailored solution bundles in alignment with national biodiversity strategies and action plans: an example case for Colombia

The Convention on Biological Diversity's Global Biodiversity Framework (GBF) outlines 23 Targets to be reached by 2030. Plans to achieve these targets are detailed in national-level strategic documents, such as National Biodiversity Strategies and Action Plans (NBSAPs). Targets and plans draw both direct and indirect linkages between biodiversity action and food system transformation. Figure 4.1 illustrates how the eight solution bundles can be leveraged to achieve targets, providing examples of related goals outlined in Colombia's 2016-2030 NBSAP. Solution bundles 1 and 2, addressing a range of policy reforms at sectoral and national levels, draw the greatest links to targets aimed at reducing threats to biodiversity. For example, Target 4 aims to "halt species extinction, protect genetic diversity, and manage human-wildlife conflict." The target reflects Colombia's goal for the "recovery, protection and conservation experiences in-situ and ex-situ of native seeds and varieties, important for food security [...]." In contrast, solution bundles 5-7 place a stronger emphasis on implementation-oriented gargets. For example, Target 20 aims to "strengthen capacity building, technology-transfer, and scientific and technical cooperation for biodiversity." Bundles 3-4 are centered on Target 10: "Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries and forestry", one of three targets directed at meeting people's needs through sustainable use and benefit sharing. The bundles explicitly address the need for agricultural transformation.

The complementarity of the solution bundles is further highlighted in the Country Case Study on Agriculture and Nature Conflicts in Orinoquía, Colombia (Box 1.1). Co-developed solutions address the importance of land use zoning. Solution bundles identify target areas for restoration and conservation investments (S1) and tenure security. They promote capacity-building (S5-7) through the creation of multi-stakeholder platforms and knowledge and materials exchange networks. They encourage co-development of on-farm innovations (S3-4), ranging from improved forages to rotational grazing. The spatial tools presented in Section 2 can be strategically operationalized to tailor each solution bundle. They support the identification of areas in need of nature restoration and conservation, addressing threat-mitigating targets. They also identify areas more suitable to sustainable intensification, meeting NCP-delivering targets.

Figure 4.1 - Links between the identified solution bundles, Targets set by the Kunming-Montreal Global Biodiversity Framework (GBF), and selected 2030 Goals in the 2016-2030 National Biodiversity Strategy and Action Plan for Colombia. The GBF identifies three types of Targets: reducing threats to biodiversity (green), meeting people's needs through sustainable use and benefit sharing (yellow), and tools and solution for implementation and mainstreaming (blue).



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CONCLUSIONS AND VISION FOR THE FUTURE OF NATURE-POSITIVE TRANSITIONS

05

The transition to nature-positive agriculture is a pivotal step toward addressing the intertwined crises of biodiversity loss, climate change, and food insecurity. Agriculture must evolve from a system that depletes natural resources into one that restores and sustains them. The evidence is clear: conventional agriculture erodes ecosystem services, reduces agricultural productivity, and jeopardizes human and environmental health. However, nature-positive solutions exist reverse this cycle of degradation without compromising local needs.

Nature-positive agricultural practices as outlined in this report offer proven and feasible pathways to enhance biodiversity, resilience, and productivity. These practices not only mitigate the environmental impacts of farming but also provide economic and health benefits to farmers and communities. Adoption of these practices need to be locally tailored and require an enabling environment, including equitable financial incentives, supportive policies, and community empowerment and engagement. Economic tools like MyFarmTrees and Payments for Ecosystem Services (PES), and regulatory frameworks that incentivize sustainable practices are critical to scaling these efforts.

Localized, spatially informed solutions further enhance the effectiveness of investments by aligning interventions with the specific ecological, social, and economic contexts of each region. The transformation transition to nature-positive agriculture is complex but achievable. It demands coordinated action across sectors, strong policy frameworks, and investment in science-based solutions. By integrating biodiversity into agricultural systems, we can create a positive feedback loop that sustains ecosystems, improves livelihoods, and ensures long-term food security. This transition is not only a necessity for meeting global biodiversity and climate targets but also a cornerstone for building resilient, equitable, and sustainable food systems for future generations.

ANNEX

ANNEXES

ANNEX 1

Table A1 - Links between solution bundles, targets set by the Kunming-Montreal Global Biodiversity Framework, and 2030 goals in the National Biodiversity Strategy and Action Plan for Colombia (2016-2030)

Solution Bundle	Relevant Kunming-Montreal GBF Targets	Relevant 2030 goals addressed in the 2016-2030 NBSAP of Colombia (example case)
Nature restoration and conservation investments (e.g., protected area expansion, community managed forest programs on sustainable harvesting of non-timber products)	• Target 1: *Plan and manage all areas to reduce biodiversity loss* • Target 2: *Restore 30% of all degraded ecosystems* • Target 3: *Conserve 30% of land, waters, and seas* • Target 4: *Halt species extinction, protect genetic diversity, and manage human-wildlife conflicts* • Target 5: *Ensure sustainable, safe, and legal harvesting and trade of wild species* • Target 22: *Ensure participation in decision-making and access to justice and information related to biodiversity for all*	• I.1: "The effectiveness of the National System of Protected Areas will have been assessed as a complete mechanism, ecologically representative and effectively managed, that ensures the conservation of biodiversity and continental, marine and coastal ecosystems, within the framework of rural and urban land-use planning in the country" • I.5: "The country will reach 1,000,000 ha in a restoration process in susceptible areas defined by the National Plan of Ecological Restoration, Rehabilitation and Recovery of Disturbed Areas. The country will have assessed the contribution of restoration processes to the mitigation and adaptation to climate change, and combating desertification" • I.6: "The rate of deforestation will have decreased going from 25,000 ha to 10,000 ha in the deforestation hotspots identified by the IDEAM. The country will assess the implementation of forest governance of instruments by the environmental authorities" • II.1: "100% of regional and local planning instruments are coherent and consistent with the conceptual and strategic guidelines of the PNGIBSE [National Policy for the Integral Management of Biodiversity and its Ecosystem Services], focused on national and local poverty reduction." • V.1: "The main drivers of loss and degradation of forests in the country will have been controlled: the expansion of the agricultural frontier; colonization associated with pastures for livestock production, mining, forest fires, illegal crops; infrastructure (urban centers and road construction) and logging."

Solution Bundle	Relevant Kunming-Montreal GBF Targets	Relevant 2030 goals addressed in the 2016-2030 NBSAP of Colombia (example case)
Promotion of nutrient-dense and climate-adapted crops and livestock breeds (training, nurseries, farmer IP rights to seeds, value chain creation and campaigns to re-introduce NUS and nutrient-dense, local climate adapted varieties/ breeds to fields, meals, and markets)	• Target 8: *Minimize the impacts of climate change on biodiversity and build resilience* • Target 10: *Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry* • Target 13: *Increase the sharing of benefits from genetic resources, digital sequence information, and traditional knowledge* • Target 20: *Strengthen capacity-building, technology transfer, and scientific and technical cooperation for biodiversity* • Target 21: *Ensure that knowledge is available and accessible to guide biodiversity action* • Target 22: *Ensure participation in decision-making and access to justice and information related to biodiversity for all*	• I.16: "Recovery, protection and conservation experiences in-situ and ex-situ of native seeds and varieties, important for food security and rural and local economies in the Amazon, Pacific and Andes will be structured and disseminated." • III.4: "The benefits of incorporating the principles of eco-efficiency based on Gibse in agricultural production will have been assessed and the most efficient principles in these production systems will have been incorporated. All agricultural production areas will be managed sustainably, ensuring the conservation of biological diversity" • IV.8: "Implementation of the technical and scientific cooperation plan for capacity building necessary to implement the BAP"
Improved cropland management (e.g., reduced tillage, optimal and organic fertilizer applications, no chemical pesticides, intercropping and crop rotations, agroforestry systems, flower strips, hedgerows, field margins, biocontrol, green manure, farming with alternative pollinators, INM, IPM)	• Target 7: *Reduce pollution to levels that are not harmful to biodiversity* • Target 10: *Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry* • Target 11: *Restore, maintain and enhance Nature's Contributions to People*	• II.4: "For 2030 environmental responsibility strategies associated with the Gibse [National Policy for the Integral Management of Biodiversity and its Ecosystem Services] will have been implemented in all sectors" • III.4: "The benefits of incorporating the principles of eco-efficiency based on Gibse in agricultural production will have been assessed and the most efficient principles in these production systems will have been incorporated. All agricultural production areas will be managed sustainably, ensuring the conservation of biological diversity" • III.13: "Implementation of projects to reduce pollution, including that from excess nutrients, to levels that are not detrimental to the functioning of ecosystems and biodiversity, especially in marine areas of the Caribbean"

Solution Bundle	Relevant Kunming-Montreal GBF Targets	Relevant 2030 goals addressed in the 2016-2030 NBSAP of Colombia (example case)
Improved livestock and pasture management (e.g., rotational grazing, planting locally adapted and diverse forages, no preventative antibiotic use, landscape livestock grazing quotes and sustainable manure spreading regulations to avoid eutrophication, silvopasture, waste to animal feed, sustainable manure management)	• Target 7: *Reduce pollution to levels that are not harmful to biodiversity* • Target 10: *Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry* • Target 11: *Restore, maintain and enhance Nature's Contributions to People* • Target 16: *Enable sustainable consumption choices to reduce waste and overconsumption*	• II.4: "For 2030 environmental responsibility strategies associated with the Gibse [National Policy for the Integral Management of Biodiversity and its Ecosystem Services] will have been implemented in all sectors" • III.4: "The benefits of incorporating the principles of eco-efficiency based on Gibse in agricultural production will have been assessed and the most efficient principles in these production systems will have been incorporated. All agricultural production areas will be managed sustainably, ensuring the conservation of biological diversity" • III.13: "Implementation of projects to reduce pollution, including that from excess nutrients, to levels that are not detrimental to the functioning of ecosystems and biodiversity, especially in marine areas of the Caribbean"
Rainwater storage infrastructure and conservation technologies/training (e.g., zai pits and organic additions to enhance soil water moisture, solar powered drip irrigation, farmer training on optimal and minimal irrigation requirements, micro-irrigation, mechanical SWC, green manure, intercropping, crop rotation)	• Target 8: *Minimize the impacts of climate change on biodiversity and build resilience* • Target 10: *Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry* • Target 11: *Restore, maintain and enhance Nature's Contributions to People* • Target 16: *Enable sustainable consumption choices to reduce waste and overconsumption* • Target 20: *Strengthen capacity-building, technology transfer, and scientific and technical cooperation for biodiversity*	• I15: "The recovery and maintenance of viable populations of aquatic biodiversity (marine, coastal and freshwater) and associated ecosystem services will have been assessed. Direct pressures will have been reduced on marine and freshwater aquatic diversity, ensuring conservation and promoting sustainable use" • III.4: "The benefits of incorporating the principles of eco-efficiency based on Gibse in agricultural production will have been assessed and the most efficient principles in these production systems will have been incorporated. All agricultural production areas will be managed sustainably, ensuring the conservation of biological diversity" • IV.8: "Implementation of the technical and scientific cooperation plan for capacity building necessary to implement the BAP" • V.1: "Land degradation and desertification will have been controlled, the effects of drought will have been mitigated and sustainable ecosystem management of drylands will be performed"

Solution Bundle	Relevant Kunming-Montreal GBF Targets	Relevant 2030 goals addressed in the 2016-2030 NBSAP of Colombia (example case)
Bio-energy generation infrastructure and technologies/training (e.g., community managed facility for biogas generation from manure, use of crop waste for animal feed)	• Target 10: *Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry* • Target 16: *Enable sustainable consumption choices to reduce waste and overconsumption* • Target 20: *Strengthen capacity-building, technology transfer, and scientific and technical cooperation for biodiversity* • Target 22: *Ensure participation in decision-making and access to justice and information related to biodiversity for all*	• III.13: "Implementation of projects to reduce pollution, including that from excess nutrients, to levels that are not detrimental to the functioning of ecosystems and biodiversity, especially in marine areas of the Caribbean" • IV.8: "Implementation of the technical and scientific cooperation plan for capacity building necessary to implement the BAP"
Development of affordable (green energy) machinery to facilitate multi-crop production (e.g., mechanical seed drills that can plant two or more species in rows or random arrangements, combine harvesters that collect and filter products from multiple crops)	• Target 10: *Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry* • Target 20: *Strengthen capacity-building, technology transfer, and scientific and technical cooperation for biodiversity*	

Solution Bundle	Relevant Kunming-Montreal GBF Targets	Relevant 2030 goals addressed in the 2016-2030 NBSAP of Colombia (example case)
Financial incentives and support for sustainable/ biodiversity friendly farming (e.g., subsidies (PES) to farmers at forest frontiers in exchange for safeguarding and restoring forest, affordable crop failure insurance, financial support for farmers for investments with high upfront costs, removal of subsidies for chemical fertilizer or pesticides, subsidies to cover profit gaps during farm transition from agrochemical-intensive monocultures to alternatives, widespread implementation of public procurement schemes that favor locally and sustainably sourced products).	• Target 2: *Restore 30% of all degraded ecosystems* • Target 3: *Conserve 30% of land, waters, and seas* • Target 7: *Reduce pollution to levels that are not harmful to biodiversity* • Target 10: *Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry* • Target 11: *Restore, maintain and enhance Nature's Contributions to People* • Target 16: *Enable sustainable consumption choices to reduce waste and overconsumption* • Target 18: *Reduce harmful incentives by at least $500 billion per year, and scale up positive incentives for biodiversity* • Target 19: *Mobilize $200 billion per year for biodiversity from all sources, including $30 billion through international finance*	• I9: "The recovery of ecosystem services in strategic ecosystems or priority areas of continental and marine conservation will have been assessed [through PES]." • III.1: "100% of the ineffective, inefficient or contradictory tax incentives will have been eliminated." • IV.4: "The trade-offs identified will be implemented. The valuation of biodiversity and ecosystem services in areas associated with infrastructure and mining and energy activities will be in place. A payment scheme will be implemented for environmental services for the conservation of ecosystems of strategic interest in the 5 biosphere reserves in the country" • VI.3: "The country will include the Gibse in 100% of the related agendas and bilateral and multilateral agreements. The country will have increased 20% the mobilization of technical and financial resources from international cooperation for the Gibse in continental and marine ecosystems."

REFERENCES

Abell, R., M. L. Thieme, C. Revenga, M. Bryer, M. Kottelat, N. Bogutskaya, B. Coad, *et al.* 2008. "Freshwater Ecoregions of the World: A New Map of Biogeographic Units for Freshwater Biodiversity Conservation." BioScience 58: 403–14. Digital media at: www.feow.org

Akplo, T.M., P.L. Yemadje, L. Imorou, B. Sanni, S. Boulakia, E. Sekloka, e P. Tittonell. 2025. Minimum tillage reduces variability and economic risks in cotton-maize rotations in Northern Benin. Field Crops Research 324: articolo 109795. https://doi.org/10.1016/j.fcr.2025.109795

Benton, T. G., C. Bieg, H. Harwatt, R. Pudasaini, and L. Wellesley. 2021. Food System Impacts on Biodiversity Loss: Three Levers for Food System Transformation in Support of Nature. Chatham House. https://www.chathamhouse.org/sites/default/files/2021-02/2021-02-03-food-system-biodiversity-loss-benton-et-al_0.pdf

Braulik, G. T., M. Arshad, U. Noureen, and S. P. Northridge. 2014. "Habitat Fragmentation and Species Extirpation in Freshwater Ecosystems: Causes of Range Decline of the Indus River Dolphin (Platanista gangetica minor)." PLOS ONE 9 (7): e101657. https://doi.org/10.1371/journal.pone.0101657

Carmona, C. P., A. Azcárate, J. Peco, C. Rota, S. Riedinger, B. A. Sanderson, J. Traba, *et al.* 2020. "Agricultural Intensification Reduces Plant Taxonomic and Functional Diversity Across European Arable Systems." Functional Ecology 34: 1448–1460.

Carvalho, P. C. F., E. D. Souza, and B. Anghinoni. 2021. "Reconnecting Nature and Agricultural Production: Mixed Cropping Systems as a Way Forward to Sustainable Intensification." Boletim de Indústria Animal 78: 1–16. https://www.lume.ufrgs.br/handle/10183/254720

Cheng, M., H. Wang, J. Fan, S. Zhang, Z. Liao, F. Zhang, and Y. Wang. 2021. A global meta-analysis of yield and water use efficiency of crops, vegetables and fruits under full, deficit and alternate partial root-zone irrigation. Agricultural Water Management 248: 106771. https://doi.org/10.1016/j.agwat.2021.106771

Daszak, P., A. A. Cunningham, and A. D. Hyatt. 2000. "Emerging Infectious Diseases of Wildlife—Threats to Biodiversity and Human Health." Science 287 (5452): 443–49.

De Graaf, I. E. M., T. Gleeson, L. P. H. van Beek, E. H. Sutanudjaja, and M. F. P. Bierkens. 2019. "Environmental Flow Limits to Global Groundwater Pumping." Nature 574: 90–94. https://doi.org/10.1038/s41586-019-1594-4

Dinerstein, E., D. Olson, A. Joshi, C. Vynne, N. Burgess, E. Wikramanayake, N. Hahn, *et al.* 2017. An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm. BioScience 67 (6): 534–545. https://doi.org/10.1093/biosci/bix014

European Space Agency (ESA). 2017. Land Cover CCI Product User Guide Version 2. Technical report covering the Land Cover CCI time-series v2.0.7 (1992–2015). European Space Agency. https://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf

FAO. 2019. The State of the World's Biodiversity for Food and Agriculture (SOWB). Rome: FAO. https://www.fao.org/3/CA3129EN/CA3129EN.pdf

FAO. 2024. Gridded Livestock of the World version 4: Global livestock density maps (circa 2020, 10 km resolution). FAO Livestock Systems. https://www.fao.org/livestock-systems/global-distributions/en/

Fontaine, D., J. Eriksen, and P. Sørensen. 2020. Cover crop and cereal straw management influence the residual nitrogen effect. European Journal of Agronomy 118: 126100. https://doi.org/10.1016/j.eja.2020.126100

Gaisberger, H., S. Legay, C. Andre, J. Loo, R. Azimov, S. Aaliev, *et al.* 2020. Diversity under Threat: Connecting Genetic Diversity and Threat Mapping to Set Conservation Priorities for Juglans regia L. in Central Asia. Frontiers in Ecology and Evolution 8: 171.

Global Forest Watch. "Forest Monitoring, Land Use & Deforestation Trends." Accessed September 19, 2025. https://www.globalforestwatch.org/

Goldman, E., M. J. Weisse, N. Harris, and M. Schneider. 2020. Estimating the Role of Seven Commodities in Agriculture-Linked Deforestation. World Resources Institute. https://www.wri.org/research/estimating-role-seven-commodities-agriculture-linked-deforestation-oil-palm-soy-cattle

Haruna, S.I., S.H. Anderson, R.P. Udawatta, C.J. Gantzer, N.C. Phillips, S. Cui, and Y. Gao. 2020. Improving soil physical properties through the use of cover crops: A review. Geosciences and Environment Agrosystems 3(1): e20105. https://doi.org/10.1002/agg2.20105

Hoffman, M., K. Koenig, G. Bunting, J. Costanza, and W. Kristen J. 2016. Biodiversity Hotspots (Version 2016.1). Zenodo. https://doi.org/10.5281/zenodo.3261807

IFPRI. 2025. "SPAM 2020 Version 2: Spatial Production Allocation Model Global Crop Distribution Maps." Global dataset, 5-arc-minute grid (�10 km) for 42 crops. https://www.mapspam.info/data/

IPBES. 2019. Global Assessment Report on Biodiversity and Ecosystem Services. Edited by E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo. Bonn: IPBES Secretariat. https://doi.org/10.5281/zenodo.3831673

IUCN. 2024. The IUCN Red List. Accessed August 2024. https://www.iucnredlist.org/

Jasechko, S., D. Perrone, R.G. Taylor, L.E. Evaristo, and M.F.P. Bierkens. 2024. Global groundwater levels have declined rapidly in dry regions with extensive irrigation. Nature 625: 520–526. https://www.nature.com/articles/s41586-023-06879-8

Jaureguiberry, P., N. Titeux, M. Wiemers, D. E. Bowler, *et al.* 2022. "The Direct Drivers of Recent Global Anthropogenic Biodiversity Loss." Science Advances 8 (45): eabm9982. https://doi.org/10.1126/sciadv.abm9982

Jiren, T. S., J. Leventon, N. W. Jager, J. Newig, B. van Zanten, A. Challis, and J. Schleyer. 2021. "Governance Challenges at the Interface of Food Security and Biodiversity Conservation." Environmental Management 67 (4): 717–730. https://doi.org/10.1007/s00267-021-01432-7

Kidwai, S., M. Saeed, and A. Amjad. 2018. "The Indus Delta—Catchment, River, Coast, and People." In Coasts and Estuaries, edited by Eric Wolanski, Michael Elliott, Donald McLusky, and Tomás Pérez-Ruzafa, 213–232. Amsterdam: Elsevier. https://doi.org/10.1016/B978-0-12-814003-1.00012-5

Latham, J., R. Cumani, I. Rosati, and M. Bloise. 2014. Global Land Cover SHARE (GLC-SHARE) Database Beta-Release Version 1.0. Rome: FAO. http://www.fao.org/uploads/media/glc-share-doc.pdf

Liu, P. W., J. S. Famiglietti, A. J. Purdy, *et al.* 2022. "Groundwater Depletion in California's Central Valley Accelerates During Mega-drought." Nature Communications 13: 7825.

Madarász, B., É.Z. Járási, G. Jakab, Z. Szalai, and M. Ladányi. 2025. Economic comparison of conventional and conservation tillage in a long-term experiment: Is it worth shifting? International Soil and Water Conservation Research 13(3): 501–510. https://doi.org/10.1016/j.iswcr.2025.02.012

Maggi, F., Tang, F. H. M., La Cecilia, D., & McBratney, A. (2020). Global Pesticide Grids (PEST-CHEMGRIDS), Version 1.01 (Version 1.01) [Data set]. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/WEQ9-PV30 Date Accessed: 2026-01-27

Marques, A., I.S. Martins, T. Kastner, M.J. Ramos, G.D. Pereira, C. Moran, L. Krainer, *et al.* 2019. Increasing impacts of land use on biodiversity and carbon sequestration driven by population and economic growth. Nature Ecology & Evolution 3(4): 628–637. https://www.nature.com/articles/s41559-019-0824-3

Mehta, P., S. Siebert, M. Kummu, L. J. W. Beusen, H. Yang, M. Flörke, Y. Wada, H. Biemans, and D. Gerten. 2024. "Half of Twenty-First Century Global Irrigation Expansion Has Been in Water-Stressed Regions." Nature Water. https://doi.org/10.1038/s44221-024-00206-9

Morand, S. 2020. "Emerging Diseases, Livestock Expansion and Biodiversity Loss Are Positively Related at Global Scale." Biological Conservation 248: 108707.

Mueller, Nathaniel D., J. S. Gerber, M. Johnston, D. K. Ray, N. Ramankutty, and J. A. Foley. 2012. "Closing Yield Gaps through Nutrient and Water Management." Nature 490: 254–257. https://doi.org/10.1038/nature11420

Paavola, J., A. Gouldson, and T. Kluvánková-Oravská. 2009. "Interplay of Actors, Scales, Frameworks and Regimes in the Governance of Biodiversity." Environmental Policy and Governance 19(3): 148–158. https://doi.org/10.1002/eet.505

Paria, B., A. Pani, P. Mishra, and B. Behera. 2021. Irrigation-based agricultural intensification and future groundwater potentiality: Experience of Indian states. SN Applied Sciences 3: 1–22. https://link.springer.com/article/10.1007/s42452-021-04417-7

Potapov, P., M. C. Hansen, L. Laestadius, S. Turubanova, A. Yaroshenko, C. Thies, A. Smith, *et al.* 2017. "The Last Frontiers of Wilderness: Tracking Loss of Intact Forest Landscapes from 2000 to 2013." Science Advances 3(1): e1600821. https://doi.org/10.1126/sciadv.1600821

Rajbanshi, J., S. Das, and R. Paul. 2023. Quantification of the effects of conservation practices on surface runoff and soil erosion in croplands and their trade-off: A meta-analysis. Science of the Total Environment 864: 161015. https://doi.org/10.1016/j.scitotenv.2022.161015

Raven, P. H., and D. L. Wagner. 2021. "Agricultural Intensification and Climate Change Are Rapidly Decreasing Insect Biodiversity." PNAS 118. https://www.pnas.org/doi/10.1073/pnas.2002548117

Ritchie, H., and M. Roser. 2023. Water Use and Stress. Our World in Data. https://ourworldindata.org/water-use-stress.

Robinson, T. P., P. K. Thornton, G. Franceschini, R. Kruska, F. Chiozza, A. Notenbaert, G. Cecchi, and M. Herrero. 2014. "Mapping the Global Distribution of Livestock." PLOS ONE 9 (5): e96084. https://doi.org/10.1371/journal.pone.0096084

Sajid, I., B. Tischbein, C. Borgemeister, M. García-Vila, A. Bakhsh, and M. Flörke. 2024. Assessing cotton irrigation scheduling strategies under rotational delivery schedules in Pakistan. Ecohydrology & Hydrobiology. https://doi.org/10.1016/j.ecohyd.2024.04.005

Tarigan, S. D. 2019. "Biodiversity-Based Ecosystem Services for the Management of Monoculture Plantation Landscape Using a Transdisciplinary Approach: A Review." IOP Conference Series: Earth and Environmental Science 325: 012013. IOP Publishing. https://iopscience.iop.org/article/10.1088/1755-1315/325/1/012013 (accessed February 8, 2024).

TEEB. 2018. TEEBAgriFood: Scientific and Economic Foundations. Geneva: UN Environment. https://futureoffood.org/wp-content/uploads/2025/05/Foundations_Report_Final_October.pdf

Tickner, D., J.J. Opperman, R. Abell, M. Acreman, A.H. Arthington, S.E. Bunn, S.J. Cooke, *et al.* 2020. Bending the curve of global freshwater biodiversity loss: An emergency recovery plan. BioScience 70(4): 330–342. https://doi.org/10.1093/biosci/biaa002

Tsegaye, T., J. Haji, M. Sileshi, S. Degefu, and H. Abaynew. 2025. Small-scale irrigation and its impact on technical efficiency and household income among smallholder potato farmers in Ethiopia. Discover Food 5(1): 54. https://doi.org/10.1007/s44187-025-00321-w

Veiga, J. P. C., F. Makishi, M. A. Zacareli, and T. A. H. Terada. 2016. "Multilevel Governance and Sustainable Development: The Case of Biodiversity in the Amazon Rainforest." Review of Social Sciences 1(3): 01–10. https://doi.org/10.18533/rss.v1i3.2

Wang, L., M. Dannenmann, A. Kurganova, S. Butterbach-Bahl, and Y. Kuzyakov. 2019. Diversifying livestock promotes multidiversity and multifunctionality in managed grasslands. Proceedings of the National Academy of Sciences of the United States of America 116(14): 6187–6192. https://doi.org/10.1073/pnas.1807354116

West, P.C., J.S. Gerber, N.D. Mueller, K.A. Brauman, K.M. Carlson, ES Cassidy, P.M. Engstrom, M Johnston, G.K. MacDonald, DK Ray, and S. Siebert. 2014. Leverage points for improving food security and the environment. Science. 345:325-328. https://doi.org/10.1126/science.1246067

Wang, H., N. Wang, H. Quan, F. Zhang, J. Fan, H. Feng, *et al.* 2022. Yield and water productivity of crops, vegetables and fruits under subsurface drip irrigation: A global meta-analysis. Agricultural Water Management 269: 107645. https://doi.org/10.1016/j.agwat.2022.107645

World Economic Forum. 2020. The Future of Nature and Business. New Nature Economy Report II. Geneva: World Economic Forum. https://www.weforum.org/publications/new-nature-economy-report-ii-the-future-of-nature-and-business/

World Resources Institute (WRI). 2024. "Deforestation Linked to Agriculture Indicator." Global Forest Review, updated April 4, 2024. Washington, DC: World Resources Institute. https://research.wri.org/gfr/forest-extent-indicators/deforestation-agriculture

WWF. 2022. Living Planet Report 2022 – Building a Nature-Positive Society. Edited by R. E. A. Almond, M. Grooten, D. Juffe Bignoli, and T. Petersen. Gland, Switzerland: WWF. https://wwfint.awsassets.panda.org/downloads/embargo_13_10_2022_lpr_2022_full_report_single_page_1.pdf.

WWF. 2024. Water Risk Filter tool. https://riskfilter.org/water/home

Zander, K.K., A.G. Drucker, L. Aluso, D.K. Mengistu, C. Fadda, C. Termote, and K. Davis. 2024. Using best-worst scaling to inform agroecological interventions in Western Kenya. Environment, Development and Sustainability. First published online June 28, 2024. https://doi.org/10.1007/s10668-024-05173-5

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