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THE STATE OF FOOD AND AGRICULTURE

ADDRESSING LAND DEGRADATION ACROSS LANDHOLDING SCALES

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RUSSIAN FEDERATION. Aerial view of cereal fields.

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Food and Agriculture Organization of the United Nations
Rome, 2025

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FOREWORD

Agriculture stands as one of humanity's most transformative achievements. It has enabled the rise of civilizations, sustained growing populations, and shaped the landscapes we depend on today. It is a testament to our collective ingenuity, cooperation and capacity to adapt.

Yet, the very success of agriculture has brought new challenges. The land that has long sustained us is now under pressure. Agricultural expansion remains the leading driver of global deforestation. In some regions, cropland continues to expand at the expense of forests and rangelands, while in others, land is being abandoned due to degradation. Today, nearly 1.7 billion people live in areas where land degradation contributes to yield losses and food insecurity. These impacts are unevenly distributed: in high-income countries, degradation is often masked by intensive input use, while in low-income countries, especially in sub-Saharan Africa, yield gaps are driven by limited access to inputs, credit and markets. The convergence of degraded land, poverty and malnutrition creates vulnerability hotspots that demand urgent, targeted and comprehensive responses.

This year's *State of Food and Agriculture* report focuses on land degradation – a growing threat to agricultural productivity, food security and ecosystem resilience. It presents new evidence on the economic costs of degradation and the potential for recovery across all scales of agricultural production. From smallholders managing marginal plots to large-scale commercial farms operating vast swathes of land, the report highlights how targeted investments and sustainable practices can contribute to land productivity and strengthen the resilience of agrifood systems. The report also provides updated global estimates on farm numbers and land distribution, offering new insights into who is producing what.

Of the approximately 570 million farms worldwide, 85 percent are smaller than 2 hectares, yet they operate just 9 percent of agricultural land. In contrast, farms over 1 000 hectares represent only 0.1 percent of all farms but manage half of the world's farmland. Despite persistent constraints, nearly 500 million smallholders contribute significantly to global food supply. At the same time, larger farms – particularly those exceeding 50 hectares – have a disproportionate influence on land use and food provision, positioning them as key actors in the global response to land degradation. These patterns underscore the need for differentiated strategies that reflect the diversity of land users and their roles in shaping sustainable agrifood systems.

Encouragingly, the report offers a message of hope. Reversing land degradation on existing croplands through sustainable land use and management could close yield gaps to support the livelihoods of hundreds of millions of producers. Additionally, restoring abandoned cropland could feed hundreds of millions more people. These findings represent real opportunities to improve food security, reduce pressure on natural ecosystems, and build more resilient agrifood systems.

To seize these opportunities, we must act decisively. Sustainable land management requires enabling environments that support long-term investment, innovation and stewardship. Secure land tenure – for both individuals and communities – is essential. When land users have confidence in their rights, they are more likely to invest in soil conservation, crop diversity and productivity. Yet, gender disparities persist. In many countries, women remain less likely to hold secure land rights, despite evidence that empowering women leads to better outcomes for households and ecosystems.

FOREWORD

Policy instruments must be tailored to context. Regulatory approaches such as land-use zoning and conservation mandates are essential, but their effectiveness can be enhanced by incentive-based mechanisms and cross-compliance schemes. Agri-environmental payments and conditional support can align private incentives with public benefits – but only if they are economically viable and well targeted.

At FAO, we are committed to supporting Members in achieving Land Degradation Neutrality targets and the Sustainable Development Goals. Through innovation, partnerships and targeted investment, we can transform agriculture into a force for regeneration – delivering on the Four Betters: better production, better nutrition, a better environment and a better life – leaving no one behind.

In 2025, FAO is reaffirming its commitment to sustainable land management. This edition of *The State of Food and Agriculture* is part of this commitment to provide a comprehensive evidence base to guide policy, investment and action at all levels.

The land has sustained us for millennia. Now, it is our turn to care for it – wisely, justly and together for a better food-secure future for generations to come.

Qu Dongyu
FAO Director-General

METHODOLOGY

The preparation of *The State of Food and Agriculture 2025* began with the formation of an advisory group representing all relevant FAO technical units as well as a panel of external experts, which assisted the research and writing team. A virtual inception workshop took place on 28 January 2025 to discuss the outline of the report. The preparation of the report was further informed by four background papers that provided novel evidence and insights based on state-of the art data and empirical analyses prepared by FAO and external experts. The first draft of the report was presented to the advisory group in advance of a workshop held both virtually and in Rome from 2 to 3 April 2025. Based on guidance emerging from the workshop, the report was reworked. The revised draft was sent for comments to the advisory group, the senior management team of FAO's Economic and Social Development stream, and to other FAO streams and the FAO Regional Offices for Africa, Asia and the Pacific, Europe and Central Asia, Latin America and the Caribbean, and the Near East and North Africa. Comments were incorporated in the final draft, which was reviewed by the Director of FAO's Agrifood Economics and Policy Division, the Chief Economist and the Office of the Director-General.

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ABBREVIATIONS

ACYG	all-cause yield gaps
CBD	Convention on Biological Diversity
CEDAW	Convention on the Elimination of All Forms of Discrimination against Women
CML	Institute of Environmental Studies
CropPI	Crop Productivity Index
DiD	difference-in-difference
DiDC	difference-in-discontinuity
DIYL	degradation-induced yield losses
EUDR	European Union Deforestation Regulation
FAO	Food and Agriculture Organization of the United Nations
GAEZ	Global Agro-Ecological Zoning
GGW	Great Green Wall
GMT	global mean temperature
HICs	high-income countries
IIASA	International Institute for Applied Systems Analysis
ILUP	integrated land use planning
IR	inverse farm size productivity relationship
LDN	land degradation neutrality
LICs	low-income countries
LINEQ	Global Database of Land Distribution and Inequality
LMICs	lower-middle-income countries
LUCC	land-use and land-cover change
MODIS	Moderate Resolution Imaging Spectroradiometer
NTFPs	non-timber forest products
SAFER	Land Development and Rural Settlement Agency
SDGs	Sustainable Development Goals
SLM	sustainable land management
SOC	soil organic carbon
TFP	total factor productivity
UMICs	upper-middle-income countries
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
VGGT	Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests
WCA	World Programme for the Census of Agriculture

GLOSSARY

Convention on Biological Diversity (CBD). An international treaty adopted in 1992 with the aim of conserving biological diversity, promoting the sustainable use of its components and ensuring the equitable distribution of its benefits.

Deforestation. The conversion of forest to other land use independent of whether this process is human-induced or not.[1] Many technical and scientific studies equate deforestation with tree-cover loss, without considering land-use criteria. The approach used in this report encompasses all tree cover and counts non-permanent tree-cover loss (e.g. clear-felling or temporary forest fire damage) as deforestation.[2]

Dietary energy. The energy provided by food and drink, measured in kilojoules or kilocalories (often referred to as calories), that the body uses to maintain basic physiological functions, health, and physical activity. Dietary energy requirements vary by age, sex, body size, and activity level, and are higher during periods of growth, pregnancy and lactation to support healthy development and maternal well-being.[3]

Economic loss. The reduction in economic value resulting from land degradation, encompassing both direct losses in the form of reduced agricultural output and land devaluation, and indirect losses associated with increased costs.

Ecosystem functions. The biological, chemical and physical processes within ecosystems, such as nutrient cycling and carbon sequestration, which underpin ecosystem structure and resilience.[4]

Ecosystem services. The direct and indirect benefits people derive from ecosystem functions, including supporting (e.g. soil formation), regulating (e.g. flood management, climate regulation), provisioning (e.g. food, water, timber) and cultural (e.g. recreational, aesthetic) services.[4]

Externality. A positive or negative consequence of an economic activity or transaction that affects other parties without being reflected in the price of the goods or services transacted.[5]

Food security. A situation in which all people at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.[3]

Forest degradation. The long-term reduction in the overall supply of benefits from forests, including wood, biodiversity and other products and services.[6]

Green revolution. A period in the mid-twentieth century characterized by a dramatic surge in the production of staple food grains, notably wheat and rice. This revolution was driven largely by the widespread introduction and adoption of genetically improved, high-yielding crop varieties in developing countries.[7]

Healthy diets. Healthy diets comprise four key aspects: diversity (within and across food groups), adequacy (sufficiency of all essential nutrients compared to requirements), moderation (of foods and nutrients that are related to poor health outcomes) and balance (of energy and macronutrient intake). Foods consumed should be safe.[3]

Institutional failure. The failure of institutions – governments, markets, private property and communal management – to provide the necessary framework for development. From a sustainability perspective, institutional failure is defined in terms of the inability of institutions to conserve resources.[8, 9]

Land abandonment. The cessation of human use and management of land. In the context of agricultural land, this refers to land that is no longer actively used for productive purposes such as crop cultivation, livestock grazing and forestry.[10–12] This distinguishes it from land that is temporarily fallow or under rotational use, where future reactivation is planned or expected.

Land cover. The observed physical cover on the Earth's surface, including vegetation (natural or planted) and human-made constructions.[13]

Land degradation. Commonly referred to as a negative trend or a long-term decline and/or loss in the land's capacity to provide ecosystem functions and services. While there is no global consensus on how land degradation should be defined or measured, FAO defines it as a reduction in the capacity of land to provide ecosystem goods and services to its beneficiaries over a period of time.[14, 15] For the purposes of this report, land degradation is measured by expressing indicators for tree-cover loss, soil erosion, and below- and above-ground carbon via a debt-based approach (see "Land degradation debt"), and using these indicators in combination to monitor and assess progress in land degradation neutrality.[16]

Land degradation debt. A quantitative assessment that represents the total human-induced deterioration of land accumulated over time. It is determined by calculating the discrepancy between the present value of land degradation indicators and their baseline values under native ecological conditions, thereby differentiating anthropogenic impacts from natural degradation.[16]

Land degradation neutrality (LDN). A state whereby the amount and quality of land resources necessary to support ecosystem functions and services to enhance food security remain stable, or increase, within specified temporal and spatial scales and ecosystems.[17]

> **LDN response hierarchy.** The strategic order of actions – avoid > reduce > reverse – endorsed by the UNCCD to achieve LDN, prioritizing the prevention of new degradation, minimizing ongoing degradation, and restoring degraded land only as a last resort. This approach reflects the principle that avoiding or reducing land degradation is more effective and cost-efficient than reversing it.[18]

Land tenure. Social contracts that define how individuals and groups access, use and control land. Land tenure can comprise both formal (written) and informal (unwritten) rules that specify who can use the land, for how long and under what conditions.[19]

Land use. The various ways in which people organize, manage and utilize land.[13]

Land-use change. The conversion of land from one use to another due to human activities. Transforming a forested area into agricultural land or urban settlements would constitute land-use change.

Land-use policies. Frameworks that guide how people use and manage land for different activities.

> **Cross-compliance or conditionality.** Policy instruments that make incentives, such as government support payments, conditional on farmers' adherence to specific regulations or standards, such as environmental protection, animal welfare and sustainable land management practices.

> **Incentive-based policies.** Instruments that use financial rewards or leverage market mechanisms to correct market failures and encourage the voluntary adoption of sustainable land practices. Examples include payment for ecosystem services and conservation tenders.

> **Regulatory policies.** Legally binding rules and standards imposed by governments to control land use and mitigate negative environmental impacts, often through mandates and prohibitions. Also known as command-and-control policies.

Macronutrients. Nutrients that provide energy and volume in our diets, and which are required in large amounts to maintain bodily functions and carry out the activities of daily life. There are three broad classes of macronutrients: carbohydrates, proteins and fats. They are a main source of dietary energy, which is measured in calories. Obtaining sufficient energy is essential for everyone to maintain body growth and development, and good health. In addition to providing energy for activity and growth, each macronutrient has very specific functions in the body and must be supplied in sufficient amounts to carry out those functions.[3]

Market failure. A situation in which the allocation of goods and services by a free market is not efficient, often leading to a net loss of economic value to society (i.e. the full benefits of the use of social resources are not realized). The many types of market failure include demerit goods, externalities, market power, missing markets and public goods.

Native conditions. The pre-agricultural state of soil defined using estimates of native soil organic carbon stocks and natural erosion rates, representing baseline soil health prior to human cultivation.[16]

Production. In the context of agriculture, the total quantity of agricultural goods produced.

Productivity. A measurement of performance that can be defined as the ratio of outputs to inputs.[20]

Shared Socioeconomic Pathways (SSPs). Scenarios that explore how global society, demographics and economics might evolve over the twenty-first century, influencing greenhouse gas emissions and climate change.

Sustainable land management. The use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions.[21]

Total factor productivity. A measurement of the total outputs of a sector relative to the total inputs of land, labour, capital and materials.[22]

United Nations Convention to Combat Desertification (UNCCD). An international treaty adopted in 1994 to combat desertification and mitigate the effects of drought. The convention promotes sustainable land management and aims to achieve land degradation neutrality by avoiding, reducing and reversing land degradation, particularly in arid, semi-arid and dry sub-humid areas, through both national action and international cooperation.

United Nations Framework Convention on Climate Change (UNFCCC). An international treaty adopted in 1992 to address climate change by stabilizing greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the global climate.

Yield. In the context of agriculture, the output produced per unit of land.

Yield gap. The difference between the maximum attainable yield for a given crop in a specific environment and the actual yields currently achieved by farmers.

> **Agroecological yield gap.** The difference between the maximum attainable yield for a given crop under specific agroecological conditions, such as local climate, soil type and water availability, and the actual yields currently achieved by farmers.

> **Statistical yield gap.** The difference between the attainable yield achieved by the best-performing farmers under similar real-world conditions, accounting for socioeconomic and institutional constraints such as market access and input availability, and the actual yields currently achieved by most farmers.

Yield loss attributable to land degradation. The portion of the yield gaps directly caused by land degradation.

CORE MESSAGES

1 Land is a finite, essential, non-substitutable resource that underpins food security, livelihoods, biodiversity, and mitigation of and adaptation to climate change. Yet, land degradation – driven by intensifying pressures – is now a pervasive and silent global challenge, eroding productivity and ecosystem health in countries of all income levels.

2 Land degradation – driven by human activities such as deforestation, overgrazing and unsustainable farming – refers to a persistent decline in land's ability to sustain ecosystem functions and services. Its impacts range from subtle productivity losses to complete agricultural abandonment – reinforcing the urgent need for sustainable land management or restoration.

3 Around 1.7 billion people live in areas experiencing sizeable degradation-induced crop yield losses. Middle-income countries are the most affected, accounting for nearly 1 billion people. In high-income countries, intensive input use sustains yields but masks degradation and increases environmental harm.

4 Farm size strongly influences land management and food production strategies, as well as farmers' ability to address land degradation. Of the world's 570 million farms, 85 percent are smaller than 2 hectares (ha) and cultivate just 9 percent of farmland, while the 0.1 percent of farms over 1 000 ha control nearly 50 percent. Medium-sized farms – those between 2 ha and 50 ha – play a particularly important role in Africa and Asia, where they manage about half of all agricultural land.

5 The vast diversity in farm size underscores the need for scale-sensitive approaches to land degradation, food security and sustainability. Smallholder farmers working under resource constraints and on marginal lands require targeted support to sustainably intensify production.

6 Closing yield gaps, especially in socioeconomically vulnerable hotspots in sub-Saharan Africa and Southern Asia, without further degrading land, depends on access to appropriate technologies and extension services, secure tenure, and inclusive financing, alongside enabling environments that break unsustainable patterns.

7 Tackling land degradation at scale hinges on engaging large commercial farms, whose management decisions shape most of the world's agricultural land. Effective policies, environmental compliance and incentive schemes that reward ecosystem stewardship are essential to align productivity goals with long-term sustainability.

8 The viability of farms of all sizes is central to ensuring food security. Medium and large farms produce, respectively, 26 percent and 58 percent of the kilocalories provided by crops globally; they play a key role in global trade and supply chains. On the other hand, smallholders, while producing just 16 percent globally, are vital in low- and lower-middle-income countries, where they account for about 60 percent.

9 Restoration strategies must be tailored to the severity and context of land degradation. Severely degraded areas may require transformative interventions, while land still in production can benefit from improved management practices.

10 Agri-environmental policies aimed at improving land use and management are expanding globally, but their adoption remains uneven. While high-income countries have implemented a wide range of regulatory and incentive-based approaches, low-income countries face constraints in deploying such measures; this highlights disparities in policy priorities, institutional capacity and access to resources.

11 Regulatory measures consistently improve land conditions across all land cover types; on the other hand, agri-environmental payments are particularly effective on forest lands and croplands – but they require funding. A combination of both approaches generates the greatest potential to align private incentives with public benefits for reversing land degradation.

12 Land degradation is neither inevitable nor irreversible. Strategic investments in people, institutions and land-friendly practices can transform agriculture from a driver of degradation to a source of restoration, strengthening agrifood systems and safeguarding the natural foundations of human well-being.

EXECUTIVE SUMMARY

Land is the foundation of our global agrifood systems, supporting over 95 percent of food production while providing essential ecosystem services that sustain life on Earth. As a finite resource, it faces unprecedented pressures from competing demands including urban expansion, biofuel production, and changing consumption patterns driven by rising incomes and shifting diets. This critical resource underpins not only food security but also biodiversity conservation, climate regulation and the livelihoods of 892 million agricultural workers globally.

The expansion of agriculture has fundamentally transformed land-use patterns across the planet over the centuries. In the twenty-first century, between 2001 and 2023, global agricultural area decreased by 78 million hectares (Mha) (–2 percent), with cropland area increasing by 78 Mha and permanent meadows and pastures decreasing by 151 Mha.

These changes exhibit significant regional variations. Sub-Saharan Africa witnessed cropland expansion of 69 Mha accompanied by 72 Mha of forest loss, while Latin America saw 25 Mha of cropland growth alongside 85 Mha of deforestation. Agricultural expansion remains the primary driver of global deforestation, accounting for nearly 90 percent of forest loss. In this century, another important aspect to consider is that approximately 3.6 Mha of croplands are abandoned annually, with land degradation likely playing a significant role in these losses.

Human-induced land degradation represents a growing threat to agricultural productivity and food security. This long-term decline in land's capacity to provide essential ecosystem functions results from complex interactions between environmental pressures and human activities including deforestation, overgrazing, and unsustainable farming practices leading to nutrient depletion and salinization. Today, this degradation manifests across all agricultural landscapes, creating a spectrum of impacts from subtle productivity declines to complete agricultural abandonment.

This troubling pattern unfolds within a wider context of systemic strain on agricultural production systems. Despite remarkable productivity gains that have quadrupled global agricultural output since 1961 with limited land expansion, worrying trends have emerged. Total factor productivity growth, which reflects technological advancement and efficiency improvements, has declined since the 2000s, particularly in the Global South where some countries show negative growth rates. This decline, coupled with persistent yield gaps between potential and actual production, threatens future food security and may drive further agricultural expansion into fragile ecosystems.

The international community has recognized land degradation as a critical challenge, with over 130 countries committing to Land Degradation Neutrality under the United Nations Convention to Combat Desertification (UNCCD). Achieving this goal requires balancing degradation with restoration to maintain the total stock of healthy land. However, although restoration investments offer returns far exceeding costs, most benefits accrue to wider society well into the future, while costs fall on individual landholders today. This creates a misalignment between private incentives and public goods that necessitates supportive policies and public investment.

Land-use decisions emerge from a complex web of drivers operating at global, national and local levels. Global markets and trade allow countries to draw on resources from exporting nations while transmitting consumption impacts across borders. At national level, policies, infrastructure and institutions shape the context within which farmers operate, while local decisions reflect farmers' available resources including land size, capital, tenure, and access to inputs and information.

The heterogeneity in land management affects degradation of croplands in major ways. This matters for food security because croplands produce the vast majority of global calories and proteins.

However, understanding the true impact of land degradation on food production requires sophisticated analysis. This report presents new evidence establishing a causal relationship between historical land degradation and current yield losses on croplands, isolating the specific impacts of degradation from other factors affecting agricultural productivity.

The human toll of land degradation on croplands is sobering: approximately 1.7 billion people worldwide live in areas experiencing yield gaps linked to human-induced land degradation. The largest affected populations reside in Eastern and Southern Asia regions that have accumulated a substantial degradation debt and also have high population densities. Remarkably, reversing just 10 percent of human-induced degradation on current croplands could restore production sufficient to feed an additional 154 million people annually. However, these figures represent only a fraction of the true cost. First, these estimates overlook the role of degradation in land abandonment. Research suggests that restoring abandoned croplands to productive use could potentially feed between 292 and 476 million people. Second, the estimates exclude impacts on pasturelands and the broader ecosystem services that benefit society at large, making land degradation a challenge requiring collective action for the provision of these public goods.

The relationship between land degradation and agricultural productivity varies dramatically across regions and income levels. In high-income countries with intensive agricultural systems, the per hectare production losses from degradation are particularly severe, though often masked by heavy application of synthetic fertilizers and other inputs. This compensatory strategy creates a troubling paradox: while maintaining high yields in the short term, it generates diminishing returns, increases production costs, and often exacerbates the underlying degradation through soil acidification, nutrient imbalances and pollution. Furthermore, threshold effects associated with land degradation may lead to land abandonment in areas with a long history of intensive agricultural systems.

In stark contrast, most of sub-Saharan Africa exhibits relatively low degradation-induced yield losses, not because soils are healthier, but because other constraints – including limited access to inputs, mechanization, credit and markets – dominate as causes of yield gaps. This finding carries crucial policy implications: while avoiding land degradation remains important, addressing these constraints would have more immediate impact on closing yield gaps in these regions. However, this must be done carefully to avoid repeating the unsustainable intensification pathways that have led to costly degradation in today's high-input agricultural systems.

The convergence of land degradation, poverty and food insecurity creates particularly concerning vulnerability hotspots. Analysis reveals that the most severe overlaps occur in Southern Asia and sub-Saharan Africa, where degraded lands coincide with high poverty rates and childhood stunting. Overall, 47 million children under five years of age suffering from stunting live in hotspots where stunting overlaps with significant yield losses from land degradation. These hotspots represent a convergence of environmental degradation and human deprivation that demands urgent and targeted responses.

The path forward requires navigation of complex trade-offs between agricultural intensification and environmental sustainability. Historical debates between land sparing (intensive agriculture on smaller areas) and land sharing (wildlife-friendly farming over larger areas) have evolved towards recognition that both approaches have merit depending on context. Recent research demonstrates that improved crop technologies actually reduced global cropland by 16 Mha between 1961 and 2015 – challenging narratives about the negative environmental impacts of intensification. The most promising solutions combine strategies that enhance productivity while maintaining ecological integrity, requiring careful policy design that aligns economic incentives with environmental goals.

Beyond croplands, degradation affects all agricultural systems, undermining livestock production in rangelands and – through forest loss driven by agricultural expansion – disrupting climate patterns and biodiversity. The interconnectedness of these systems means degradation in one area cascades into other areas, creating feedback loops that amplify impacts. Nearly 90 percent of global deforestation stems from agriculture, with cropland expansion and pasture creation the primary drivers, highlighting the urgent need for integrated landscape management approaches.

The findings underscore that land degradation is not an inevitable consequence of agriculture but rather the result of specific management choices and policy failures. Addressing this requires recognizing the challenges farms face in tackling land degradation and food security, and the underlying drivers. Both the incentive and the ability to invest in reducing, reversing and restoring degradation on croplands – while improving productivity – can differ significantly depending on farm size, land conditions and socioeconomic factors.

Farm size, while not the only factor influencing land management and food production, shapes all other determinants in important ways. Larger farms often have more resources to invest in advanced technologies that optimize input use and productivity – but which can exacerbate land degradation. However, these farms may also have greater incentives to maintain land quality, if it is clearly linked to long-term profitability. Conversely, smaller farms often contend with more vulnerable land conditions, and struggle with limited resources and multiple market constraints. Understanding these dynamics is essential for designing effective policies that enable all farmers to contribute to both food security and environmental sustainability, ensuring that the land that feeds us today remains productive for generations to come.

Of the world's roughly 570 million farms, 85 percent are smaller than 2 ha yet cultivate only 9 percent of farmland, while the 0.1 percent exceeding 1 000 ha command about half of all agricultural land – a disparity that shapes strategies for land degradation control, food security and long-term resource governance. Regional patterns deepen the contrast: Latin America and the Caribbean host just 3 percent of farms because holdings are generally large; in Asia and Africa, smallholders dominate numerically, but farms of 2 to 50 ha work around half the farmland; and in Europe, the Americas and Oceania, farms exceeding 1 000 ha control the greater part of farmland.

Despite facing persistent constraints including limited access to land, credit, inputs, technology and markets, the world's 500 million smallholders make remarkable contributions to global food supply. The crops produced by these farmers contribute approximately 16 percent of global dietary energy, 12 percent of proteins, and 9 percent of fats derived from crops. Their contribution is particularly significant for certain crop types: farms smaller than 5 ha produce almost 50 percent of global stimulants, spices and aromatic crops, while contributing between 20 and 30 percent of cereals, fruits and vegetables. This production profile reflects not only their importance to local agrifood systems and dietary diversity but also their role in high-value crops that can enhance rural livelihoods.

The dominance of large-scale operations in globally traded commodities underscores their outsized influence on food availability and their critical responsibility for sustainable land management. Large farms, particularly those exceeding 50 ha, dominate global production of cereals, pulses, sugars and oil crops – commodities that form the backbone of international trade and urban food systems. These operations produce more than 55 percent of global crop-derived nutrients, with the largest category (>1 000 ha) accounting for nearly one-sixth of global food energy from crops. This concentration is most extreme in Northern America, where these mega-farms produce almost half of the region's crop-derived dietary energy, driven primarily by industrial agriculture in the United States of America.

Farm size patterns are evolving differently across regions, defying simple narratives of consolidation. While average farm sizes have increased in Latin America, Europe and Central Asia over the past two decades, they have decreased in most of Asia and continue to shrink in sub-Saharan Africa. High-income countries show increasing polarization, with both mean and median farm sizes growing but the gap between them widening, indicating greater inequality. In Africa, the persistence of very small farms combined with poor soil fertility creates a double poverty trap: farmers can neither produce enough for household needs nor invest in restoring soil productivity, perpetuating cycles of degradation and food insecurity.

The intersection of farm size with land degradation reveals complex patterns requiring nuanced policy responses. All farm sizes face similar levels of accumulated soil organic carbon debt, yet the impacts and response capacities vary dramatically. Large farms in intensively cultivated regions of Europe and Northern America show the strongest causal relationship between historical degradation and current yield losses; the extent of land degradation is masked by heavy input use that maintains productivity at increasing economic and environmental cost. Conversely, smallholder-dominated regions in sub-Saharan Africa exhibit large yield gaps driven more by resource constraints than by degradation per se; still, degraded soils may respond poorly to inputs when they do become available.

Climate change adds another layer of complexity to these challenges, with differential impacts across farm scales. Under projected warming scenarios, smallholder farms in tropical regions will face disproportionate exposure to heat stress, dry spells and extreme precipitation events. Medium-sized farms may experience the highest exposure to combined stressors, while large farms in temperate regions might benefit from reduced frost days.

Moving forward, policies must navigate the tension between supporting smallholder livelihoods and addressing the global environmental impacts of large-scale agriculture. With large farms controlling most agricultural land, they bear primary responsibility for implementing sustainable land management at scale. Yet the sheer number of smallholders and their vulnerability to both degradation and climate change demand targeted interventions that enhance productivity without repeating the unsustainable intensification pathways observed in high-income countries.

Success requires recognizing farms of all sizes as complementary components of agrifood systems, each facing distinct challenges and opportunities in the quest for land degradation neutrality and food security. Only through differentiated approaches that account for scale-specific constraints and potentials can agriculture meet growing food demands while preserving the land resources upon which future generations depend.

Addressing land degradation requires recognizing that it is not an inevitable consequence of agriculture. With thoughtful stewardship and regenerative approaches, farming can become a force for avoiding, reducing and reversing degradation while maintaining productivity. Tenure security emerges as a fundamental enabler of sustainable land management.

Secure land rights reduce uncertainty and encourage long-term investments in soil conservation and productivity improvements. However, significant gender inequalities persist, with women in 43 out of 49 countries with available data less likely than men to own or have secure rights to agricultural land. When women do have secure land rights, evidence shows increased investment in soil conservation, greater crop diversity and improved household food security, highlighting the critical importance of addressing these disparities.

Enabling environments are the foundation of sustainable land management, not guarantees. Secure and enforceable land tenure, along with transparent and well-functioning land markets, empower land users to make long-term investments in land quality, adopt sustainable practices, and access credit, insurance, and extension services. However, enabling environments alone are not sufficient. Land degradation persists even in contexts with strong enabling environments, underscoring that the alignment of private incentives with public benefits is not automatic.

A range of policy instruments exist, each with distinct strengths, limitations and implementation requirements. Policies are categorized into three broad types – regulatory, incentive-based and cross-compliance (or conditionality).

- *Regulatory policies* are often the most direct means of addressing land degradation. These include land-use zoning, deforestation bans, and soil conservation mandates. While effective in setting clear behavioural expectations, regulations can be costly to enforce, particularly in areas with many smallholders. Moreover, if poorly designed, they may create perverse incentives, such as regulatory avoidance by fragmenting landholdings.
- *Incentive-based policies* – such as payments for ecosystem services – offer financial or market-based rewards for sustainable practices. Such schemes are typically voluntary and flexible, making them attractive to land users. However, they often entail high transaction and monitoring costs, and their effectiveness depends on the level of compensation and the ease of participation. Larger farms may find it easier to engage with incentive-based schemes due to economies of scale, while smallholders may require additional support to overcome administrative and financial barriers.
- *Cross-compliance policies* link government payments to adherence to environmental standards. Widely adopted in high-income countries, conditionality ensures that public funding supports responsible land stewardship. Its success depends on the balance between compliance costs and the value of financial incentives provided, as well as the robustness of monitoring and enforcement mechanisms.

Since the twentieth century, countries have implemented an expanding portfolio of policy approaches related to agriculture, land use and the environment. A notable surge in public policy adoption occurred after 2000. Regulatory instruments have formed the backbone of these efforts, typically preceding the introduction of incentive-based approaches and cross-compliance policies. Over time, the policy landscape has evolved from a predominantly regulatory focus to a more diversified mix that increasingly incorporates both incentive-based mechanisms and cross-compliance schemes.

The ongoing United Nations Decade on Ecosystem Restoration has increased awareness of the public good nature of actions to address land degradation and provided impetus to governments around the world to pledge sizeable investments to accelerate progress towards land degradation neutrality. The growing commitments have contributed to the diversification of policy instruments supporting sustainable land use and management. Despite the increasing adoption of agri-environmental policies globally, their distribution remains highly uneven across regions. A significant concentration is observed in high-income countries. In contrast, low-income countries have implemented fewer agri-environmental measures, highlighting a disparity in priorities and resources that could be allocated to incentive-based schemes.

Given resource constraints, matching interventions to land condition and farm structure is key. Land degradation is not uniform. Even within a single farm, land parcels may vary in condition, requiring differentiated responses. The "avoid > reduce > reverse" hierarchy promoted by the UNCCD as a strategic framework for intervention is a useful way of approaching the challenges of land degradation. The main premise is to pre-emptively *avoid* degradation on healthy, productive lands, *reduce* degradation, halting its progression through improved land management practices, and finally, *reverse* degradation on severely degraded land, which often requires transformative measures such as change in land use, ecological restoration, and long-term investment.

The choice of intervention must reflect both the severity of degradation and the potential for recovery. For example, lands operating near their biophysical yield potential may respond well to incremental improvements, while severely degraded or abandoned lands may require complete shifts in land use.

In terms of impacts on land degradation, land-use regulations consistently emerge as effective instruments for improving land conditions. Agri-environmental payments also show positive impacts, though with greater variability. They are particularly effective in forest conservation and contribute to improved cropland conditions globally. Overall, approaches that combine regulatory and incentive-based instruments offer strong potential to improve land conditions. Their effectiveness depends on careful tailoring to land cover types and local contexts. In croplands, for example, regulations can be complemented by payments supporting biodiversity in non-productive landscape features such as hedgerows. Ultimately, a context-specific approach that strategically combines policy instruments while considering economic and institutional capabilities is crucial for achieving meaningful improvements in land conditions worldwide.

The way forward. The evidence presented in this report underscores the urgency of reversing land degradation to safeguard food security, sustain livelihoods and preserve the ecological functions that underpin agrifood systems. Yet, the path forward must be as diverse and dynamic as the landscapes and land users it seeks to support.

Align global and local action. Land degradation must be understood within the broader context of land-use decisions – shaped by local choices and global drivers such as trade, climate change and demographic transitions. Farmers, as private actors, make decisions primarily based on productivity and profitability. This means that efforts to promote sustainable land management must consider the economic realities they face – including the time, labour and financial costs of implementation – and ensure that these do not outweigh the expected benefits. Land degradation intersects with climate change and biodiversity loss, making it central to the Rio Conventions (UNCCD, UNFCCC, CBD). Translating global commitments into local action requires institutional coherence, political will, and long-term financing.

Recognize the diversity of land users. The diversity of farm sizes and structures must be embraced as a central axis of policy design. Smallholder farmers, who often operate under resource constraints and on marginal lands, need targeted support to sustainably intensify production. Closing yield gaps without further degrading land calls for access to appropriate technologies and extension services, secure land tenure, and inclusive financing mechanisms. In places where accumulated land degradation is not the primary constraint, strengthening enabling environments will be key to breaking path dependencies that have led to unsustainable intensification. At the other end of the spectrum, large-scale commercial farms – though fewer in number – manage most of the world's agricultural land and have a disproportionate impact on land systems. These farms must play a leading role in achieving land degradation neutrality by complying with environmental regulations, adopting sustainable land management practices, and participating in incentive schemes that reward ecosystem stewardship.

Differentiate restoration strategies. Severely degraded areas may require transformative interventions, including land-use change or long-term fallowing, while land in agricultural production can benefit from improved management practices that enhance productivity and resilience. This calls for a nuanced policy mix that combines regulatory frameworks with incentive-based mechanisms, underpinned by robust monitoring systems and adaptive governance. Tailoring interventions to the specific needs, capacities and responsibilities of different land users is essential for equitable and effective progress.

Strengthening land governance is critical. Well-defined tenure rights – both individual and collective – are non-negotiable for sustainable land management and livelihoods. Inclusive governance structures are also essential to manage trade-offs, which are often unavoidable in land systems. Win–win scenarios are rare; thus, enabling environments must support transparent decision-making and equitable outcomes.

Scale what works. Encouragingly, sustainable land management and land restoration efforts are already underway in many parts of the world, demonstrating that solutions exist and can be scaled. These efforts show that reversing degradation is possible when the right enabling conditions are in place. However, land degradation must still be addressed within the broader context of global sustainability goals. While land is foundational to national food security and development strategies, it is also central to the global challenges of climate change and biodiversity loss. Governments and international bodies are increasingly aligning efforts; however, progress is hindered by weak implementation, limited coordination and insecure land tenure. Strengthening institutional coherence and political will is essential to translate global commitments into local action.

Investing in people, policies and practices to respond to land degradation challenges. The costs of inaction are rising, but so too is our capacity to respond. Land degradation is not an inevitable consequence of agriculture. It is the result of specific land use and management choices, policy failures and misaligned incentives. But it is also reversible. With the right mix of policies, institutions and investments, we can transform agriculture into a force for regeneration – restoring degraded lands, enhancing food security and nutrition, and securing the ecological foundations of our agrifood systems. By investing in people, policies and practices that value land, not only as a productive asset but as a cornerstone of human and planetary well-being, we can chart a path towards a more sustainable and equitable future. ■

BURKINA FASO
Mitigating desertification: farmers prepare for the next rainy season by digging mid-moon dams to save water.
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CHAPTER 1
LAND AT THE CROSSROADS OF GLOBAL CHALLENGES

KEY MESSAGES

➔ Land is the core resource of agrifood systems. It underpins food security, biodiversity, livelihoods, ecosystem services, cultural heritage, and mitigation of and adaptation to climate change.

➔ Land is a finite resource, increasingly stressed in both quantity and quality. Competing demands – ranging from feed, fibre and the production of biofuels to the expansion of urban areas – require that agriculture be efficient and productive, but degradation further strains land's potential.

➔ Human-induced land degradation is not a new phenomenon; it dates to the beginning of agriculture. However, its accelerated pace and intensified impacts make addressing land degradation and related abandonment more urgent than ever.

➔ Action against land degradation can be costly. While it brings private benefits to land users, most benefits are enjoyed by the broader society. This makes such action a public good, requiring public policies and investment.

➔ Farmers' ability and their incentive to adapt to and restore land depend on farm size, land conditions and socioeconomic context. Tailored solutions that align incentives with public benefits are essential for progress towards sustainable production.

Since the invention of agriculture 12 000 years ago, land has played a central role in sustaining civilizations. As the fundamental resource of agrifood systems, it interacts with natural systems in complex ways, influencing soil quality, water resources and biodiversity, while securing global food supplies and supporting the achievement of the Sustainable Development Goals (SDGs). Biophysically, it consists of a range of components including soil, water, flora and fauna, and provides numerous ecosystem services including nutrient cycling, carbon sequestration and water purification, all of which are subject to climate and weather conditions. Socioeconomically, land supports many sectors such as agriculture, forestry, livestock, infrastructure development, mining and tourism. Land is also deeply woven into the cultures of humanity, including those of Indigenous Peoples, whose unique agrifood systems are a profound expression of ancestral lands and territories, waters, non-human relatives, the spiritual realm, and their collective identity and self-determination.[1] Land, therefore, functions as the basis for human livelihoods and well-being.[2]

At its core, land is an essential resource for agricultural production, feeding billions of people worldwide and sustaining employment for millions of agrifood workers. Healthy soils, with their ability to retain water and nutrients, underpin the cultivation of crops, while pastures support livestock; together they supply diverse food products essential to diets and economies.

Currently, more than 95 percent of the global food supply is grown or raised on land.[3] In 2022, the agricultural sector also employed 892 million people worldwide (accounting for 26.2 percent of total employment), with an additional 13 percent of the global workforce engaged in non-agricultural agrifood systems jobs, providing livelihoods, generating incomes and supporting food security.[4]

Land also plays a critical role in maintaining the ecological balance and providing indispensable ecosystem services for agrifood systems. Forest lands and wetlands regulate water cycles, prevent floods and recharge aquifers, ensuring that agriculture has access to a reliable supply of water. Healthy soils store vast amounts of organic carbon, mitigating the impacts of climate change, while also serving as reservoirs of biodiversity, housing countless organisms that support nutrient cycling and pest control. These services are essential for both food production and environmental sustainability.[2, 5]

Yet, land is a finite resource. Various demands – driven by policy decisions, market trends and consumer preferences – add significant pressure to already scarce land resources. These include demand for biofuels, which requires large areas of land for crops, often competing with food production. Emissions trading schemes also influence land use, prioritizing carbon sequestration projects like reforestation over other uses. Additionally, the growing need for feed crops further strains land resources. Urbanization exacerbates these pressures by converting agricultural and natural lands into urban areas, reducing the availability of land for food production and other essential uses. At the same time, urban lifestyles and rising incomes are reshaping consumption patterns, with demand growing for more diverse and resource-intensive diets, including higher consumption of meat, dairy and processed foods.[6, 7] Balancing these competing demands is essential to ensure land remains able to support sustainable food production and maintain ecosystem services.

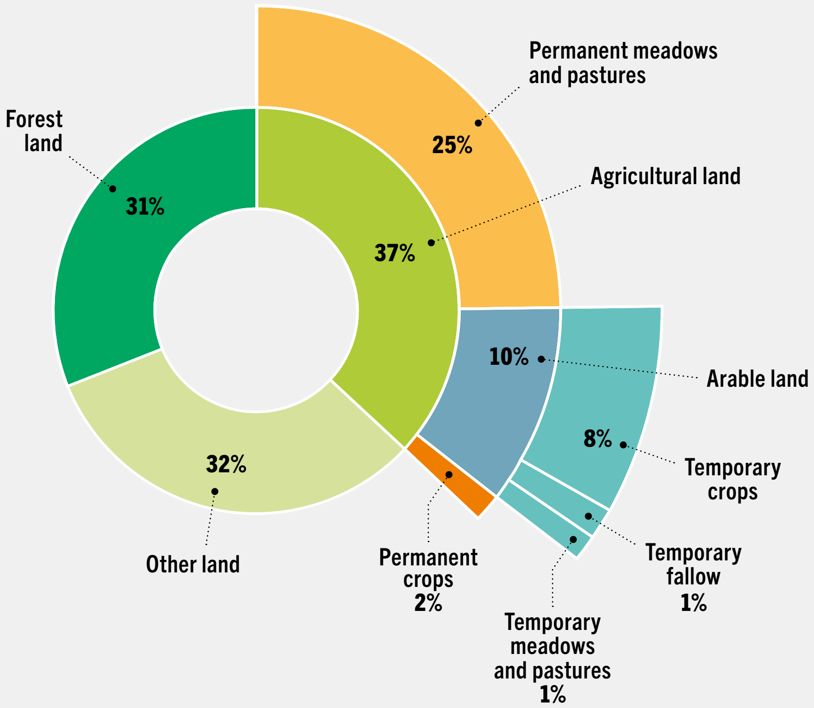
The expansion of agriculture and the accompanying growth of the human population have long exerted pressure on land systems, triggering changes over time that result in land degradation.[8–12] These cumulative impacts have compromised not only the productive capacity of land but also its ecological integrity and the many services it provides. As a long-term trend driven by unsustainable agricultural practices, land degradation exerts significant stress on agricultural production systems, undermining their stability, increasing their vulnerability and reducing their resilience,[13, 14] ultimately jeopardizing food security and livelihoods.

Today, nearly all inhabited parts of the world are subject to some form of human-induced land degradation,[15, 16] with producers largely bearing the immediate burden of impacts on croplands. For example, they suffer revenue losses as a result of low yields or of costly compensation measures; the latter include soil amendments with inorganic and organic fertilizers and agricultural lime, some of which may not be accessible to all. However, the impacts of land degradation extend beyond producers, as society at large bears the externalized costs through climate change, loss of biodiversity and ecosystem services, and diminished future agricultural potential, making land degradation a problem that requires both local and global solutions.[17] Nonetheless, land degradation is not an inevitable consequence of agricultural production. When managed sustainably, agricultural systems can maintain – and even enhance – land health, supporting productivity while preserving ecosystem functions. ■

TRENDS AND CHALLENGES IN AGRICULTURAL LAND USE

Understanding contemporary agriculture requires an examination of key trends and challenges in how land is used globally. These range from large-scale shifts in land cover type to the structure of farm holdings. The way humanity organizes, manages and utilizes land – land use[18] – has undergone significant transformations, accelerated in particular by the invention of nitrogen fertilizer in the early twentieth century and the introduction of new agricultural technologies during the green revolution.

FIGURE 1 WORLD AGRICULTURAL LAND AREA BY MAIN CATEGORY, 2023



SOURCE: Authors' own elaboration based on Figure 1 in FAO. 2025. *Land statistics 2001–2023*. FAOSTAT Analytical Briefs, No. 107. Rome. https://doi.org/10.4060/cd5765en

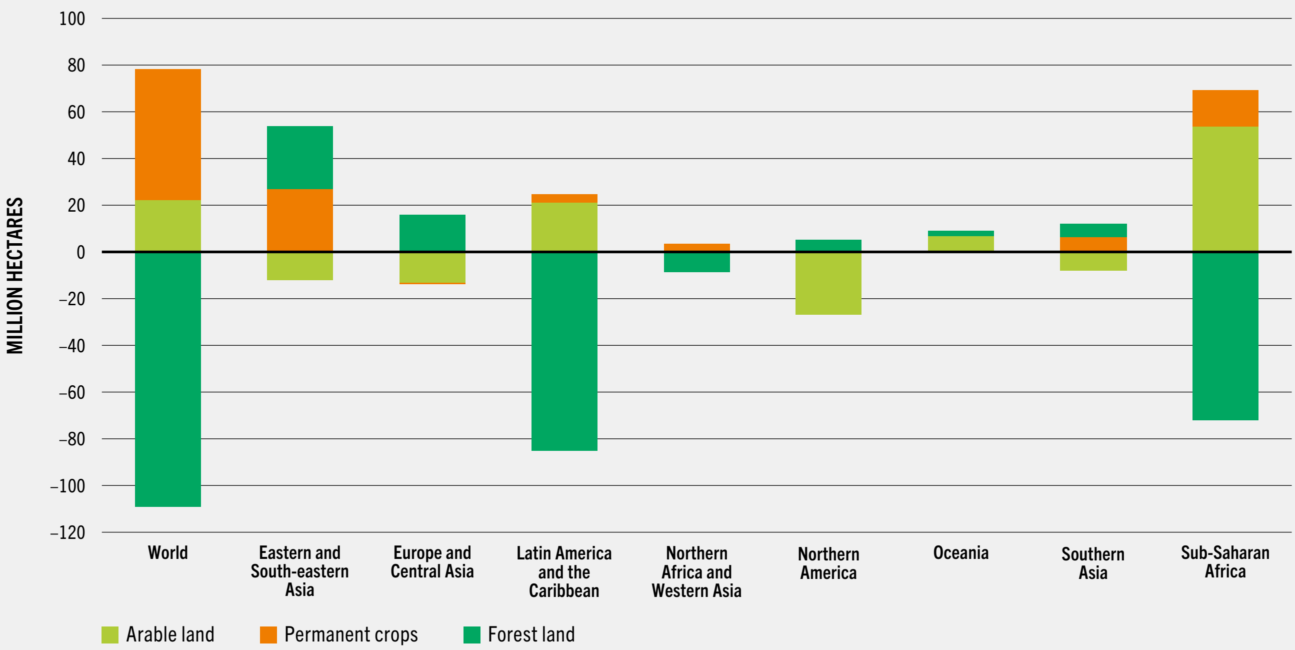
https://doi.org/10.4060/cd7067en-fig01

Shifting patterns in agricultural land use

Globally, agricultural land, encompassing both croplands and permanent meadows and pastures, spans nearly 4.8 billion hectares (ha), representing more than one-third of the world's land area.[19] Figure 1 presents the world agricultural land area by category as of 2023 and shows that only 12 percent of the total land area (i.e. arable land and permanent crops) sustains global crop production. Permanent meadows and pastures make up one-quarter of the total land, while forests cover one-third. Between 2001 and 2023, global agricultural land area experienced a net decrease of 75 million hectares (Mha) (–2 percent), with cropland area increasing by 78 Mha and permanent meadows and pastures decreasing by 151 Mha. However, the changes in land use were not geographically uniform.

Figure 2 presents the net changes in cropland – encompassing arable land and permanent crops – against changes in forest land. In general, in regions with cropland expansion, deforestation was also observed. Notably, in sub-Saharan Africa, cropland expanded by 69 Mha while 72 Mha of forests were lost; similarly, in Latin America and the Caribbean, an expansion of 25 Mha of cropland coincided with deforestation spanning 85 Mha. Globally, forest area declined by 109 Mha. Conversely, regions that saw a decrease in cropland, such as Eastern and South-eastern Asia and Northern America, recorded afforestation.

FIGURE 2 LAND-USE CHANGE IN CROPLAND AND FOREST LAND BY REGION AND SUBREGION, 2001–2023



NOTE: World totals reflect the net change in cropland (arable land and permanent crops) and forest land.

SOURCE: Figure 6 in FAO. 2025. *Land statistics 2001–2023*. FAOSTAT Analytical Briefs, No. 107. Rome. https://doi.org/10.4060/cd5765en

https://doi.org/10.4060/cd7067en-fig02

Remote sensing evidence further reinforces this link, showing that agricultural expansion – particularly cropland development – is the primary driver of global deforestation. Nearly 90 percent of global deforestation is driven by agriculture. Of all agricultural activities, cropland expansion is the single largest contributor, accounting for almost half of the total deforested area, followed by livestock grazing. While the former was the main driver in Asia and Africa, the latter was the largest contributor to deforestation in the Americas and Oceania.[20] These findings underscore the central role of agriculture in shaping land-use change and the urgent need to balance food production with forest conservation.

The above-discussed trends in land use highlight broader changes in land cover – the physical cover of the Earth's surface including natural or planted vegetation and human construction.[18] Between 1992 and 2019, natural and semi-natural types of land cover lost over 20 percent more area than they gained, mostly due to conversion to cropland, as well as desertification and urban expansion.[21] In the twentieth century, approximately 400 Mha of land were abandoned globally, including not only areas affected by land degradation but also those left idle due to socioeconomic shifts such as rural depopulation, changing labour markets, and evolving land-use priorities.[22] Globally, the majority of remaining natural land cover is located in close proximity to areas of intensive land use, increasing the risk of habitat fragmentation in areas rich in ecosystem services that underpin agricultural productivity.[23]

Farm structures and their implications

Beyond these large-scale changes in land use and cover, the structure of agricultural production itself varies significantly worldwide, particularly concerning the size of landholdings. Farming operations encompass a wide spectrum of land sizes, frequently referred to as small, medium and large. The distinction is important because farm size influences not only how land is managed, but also the adoption of agricultural technologies and the ecological outcomes of farming practices. Smaller farms often encounter constraints in accessing mechanization and inputs,[24, 25] and present greater diversity;[26] larger farms, on the other hand, may contribute to landscape homogenization with implications for biodiversity and ecosystem services.[27]

When attempting to define farm size categorization, it is best to consider landholding size relative to the full distribution of holdings in a given country; what is considered small in one country may be perceived as large in another. In this regard, SDG Indicator 2.3.2 defines small-scale producers using nationally relevant distributions. Farmers located in the bottom 40 percent of the national distribution of physical land size (and/or livestock herd size) and in the bottom 40 percent of national total on-farm revenue distribution are considered small-scale producers.[28]

Adopting such a relative national definition of small-scale or large-scale producers is relevant for national policymaking. Depending on the distribution of land, livestock heads and revenues, thresholds that identify small-scale food producers might be 2 ha in one country and 50 ha in another, or annual revenues of USD 1 500 in one country and USD 250 000 in another.[28, 29]

While this country-relative approach captures national distributions, a globally consistent threshold is also useful for identifying common resource constraints and scale-specific technological interventions. Farms under 2 ha face similar challenges – such as limited mechanization, restricted input access and weaker market participation – regardless of national context. This makes the threshold highly relevant for global agricultural development strategies. At the other end of the spectrum, the definition of a large landholding also varies significantly by region, with 50 ha or 100 ha usually used as the lower threshold.[30–32] The thresholds cited in Chapter 3 of this report consider holdings between 2 ha and 50 ha as medium-sized, while those exceeding 50 ha and 1 000 ha are considered large and very large, respectively. Almost 500 million farms in the world cover less than 2 ha, falling within the category of smallholding, while very large farms control vast areas of farmland.[33]

Although farm size is an important element in the link between land degradation and agricultural production, it cannot capture the full diversity of farming systems. Tenure security, market access, gender dynamics and agroecological conditions all play pivotal roles in shaping agricultural outcomes. To understand the development, characteristics and heterogeneity of farming systems, with the goal of eventually guiding policies, research and policymaking rely on many different farm classification systems.[34] Box 1 presents a brief overview of different types of farm classification and their uses.

The farm size-based classification used in this report highlights vast disparities in land use and farm structures across regions. This underscores the need for context-specific agricultural policies that can address the varying challenges to technology adoption, resource access and environmental management to ensure sustainable agricultural productivity growth. ■

UNDERSTANDING LAND DEGRADATION

Land degradation refers to a long-term decline in the capacity of land to provide essential ecosystem functions and services. While definitions vary, they all consistently highlight persistent negative trends in biological productivity, ecological integrity and value to humans – driven by both natural processes and, increasingly, human activities.[2, 3, 15, 43–45] This report focuses on human-induced land degradation due to its significant implications

BOX 1 BEYOND FARM SIZE: MATCHING POLICY WITH FARM CLASSIFICATION

Categorizing farms according to a single dimension, such as land size or revenue, risks occluding broader structural and environmental determinants from view. Above all, the choice of farm classification should be guided by the specific research questions and policy objectives at hand. Aligning classification design with the stage of the policy process under discussion strengthens the link between research and intervention. Failure to do so may result in typologies that lack transferability, validity or acceptance among stakeholders, particularly if they are seen as unfair or overly reductive.[34]

Tenure-based classifications may be relevant when considering outcomes linked to land degradation, because tenure security impacts land management and investment decisions. Farmers with secure tenure are more likely to invest in soil conservation practices and long-term land improvements, as they can be more confident that they will reap the rewards of their investments.[35]

Market-oriented classifications, which distinguish between farms producing primarily for subsistence needs and those producing to meet commercial demand, are also useful. Farms integrated into commercial value chains typically have greater access to inputs, credit and extension services, and may therefore be better positioned to adopt sustainable practices that reduce land degradation.[36]

Gender-based classifications can illuminate important inequalities in access to land, resources and decision-making power. For instance, female-headed households often face greater constraints in accessing land and credit, but are also found to employ distinct and often more conservation-oriented land management strategies.[37]

Holistic classifications, integrating a range of biophysical and socioeconomic factors – such as land quality, degree of mechanization, market integration and value of productive assets – may enable researchers to acquire deeper insights into the determinants of land outcomes.[38] These may be data-driven, combining cluster analysis, machine learning or other statistical methods to group farms or regions based on multiple variables simultaneously.[39] Such multidimensional frameworks must strike a balance between comprehensiveness and parsimony: while richer classifications can capture the full complexity of farming systems, they may become unwieldy for broad application and policy communication.

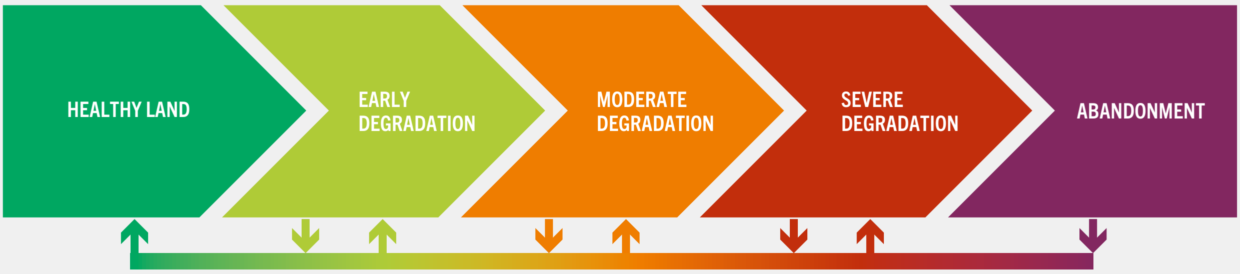
Farm size-based classifications, such as the one adapted in this report, are generally used as a practical approach to capture multiple overlapping dimensions of vulnerability and capacity, which are relevant to land degradation. For example, insecure tenure, market constraints, subsistence farming strategies and female management are all associated with smaller farm sizes.[40–42]

for agricultural productivity, food security and socioeconomic stability – especially in regions heavily reliant on farming.

Land degradation is rarely the result of a single factor. Instead, it arises from a complex interplay of environmental, socioeconomic and institutional pressures acting at various scales. Natural biophysical processes such as soil erosion, salinization, waterlogging and the depletion of vital soil organic matter are key drivers – often intensified by climate variability, including extreme weather events such as droughts and floods. However, human activities including deforestation, overgrazing, unsustainable cropping and irrigation practices are increasingly responsible for accelerating these processes.[3, 46, 47]

Importantly, land degradation occurs along a spectrum, resulting in increasingly severe impacts – from subtle declines in ecosystem function to the complete loss of agricultural viability and abandonment. Figure 3 illustrates this continuum, highlighting key stages and a tipping point where land may fall out of productive use. For example, degradation-driven

FIGURE 3 SPECTRUM OF LAND DEGRADATION AND RESTORATION PATHWAYS



SOURCE: Authors' own elaboration.

land abandonment occurred in the Costa de Hermosillo in Mexico, where seawater intrusion associated with extensive use of irrigation caused widespread salinization and crop loss.[8] The figure also emphasizes that land restoration is possible at any stage; however, while restoration may improve land conditions, it does not always result in land that is fully restored to native conditions or returned to agriculture.

Understanding this progression requires clarity around related concepts. While soil degradation refers to specific processes such as nutrient depletion, salinization, and the loss of soil structure and biodiversity,[48, 49] land degradation includes all negative changes affecting the broader natural resource base that supports agriculture, livestock and forestry.[50] Similarly, desertification is not a separate phenomenon but a manifestation of land degradation in arid, semi-arid and dry sub-humid regions.[51] Recognizing these distinctions is essential for accurately diagnosing degradation processes and implementing effective land management strategies.

Disentangling land degradation from other causes of land abandonment is complex, as it is often intertwined with economic, social and environmental factors. Nonetheless, land degradation undeniably plays a significant role, as evidenced by historical events of abandonment such as the Dust Bowl in the United States of America during the 1930s and the salinization of irrigated agricultural areas around the Aral Sea. Globally, approximately 3.6 Mha of cropland were abandoned annually between 1992 and 2020, and it is legitimate to assume that land degradation played a sizeable role in this abandonment.[52]

While land degradation leading to the abandonment of degraded croplands and pastures can have a major impact on food security and the environment, the less visible degradation of croplands poses a similarly direct and growing threat. This report introduces analysis on cropland degradation – reflecting croplands' central role in food production and the spectrum of degradation illustrated in Figure 3. At the same time, it maintains a broader perspective that considers degradation across other land-use categories based on the latest literature. Degraded croplands suffer reduced productivity, directly impacting the cropland base that supplies two-thirds of global caloric intake.[53] Indirectly, cropland degradation also drives agricultural expansion into meadows, pastures and forests, that is, landscapes that support diverse food production systems. Addressing degradation of croplands can generate positive spillover effects for these other land systems, facilitating synergies across multiple SDG targets.

Crucially, land degradation is not a predetermined outcome of agriculture.[8] With thoughtful stewardship and regenerative approaches, farming can become a force for avoiding, reducing and reversing land degradation, not only on croplands but also on other types of land, balancing productivity with the preservation of ecological integrity. ■

RESPONSES TO LAND DEGRADATION: FROM ADAPTATION TO RESTORATION

Despite ongoing land degradation in many areas, farmers are striving to adapt and continue producing. The extent of this adaptation is influenced by available resources, supportive national policies (or lack thereof) and the overall global context such as population and income growth, markets, and climate change. Understanding the historical responses to these challenges can offer valuable lessons for future resilience. Box 2 provides historical insights into how agronomists and farmers have responded to land degradation over time.

While adaptation to the effects of land degradation is necessary to improve productivity, it is not sufficient from a long-term societal perspective. As degradation persists, agricultural systems must shift from short-term coping strategies to long-term solutions that restore and protect land. This transition requires supportive policies and investments to align incentives, including through secure land tenure and functioning markets. Yet, in many contexts, weak institutions, lack of or misguided incentives, and limited access to knowledge and resources hinder sustainable land use.[63] Strengthening governance and environmental regulation is therefore essential to enable responsible land management and reduce future degradation.

Farmers respond to land degradation in different ways – some strategies aim to compensate for declining land health, while others seek to restore it. In many cases, farmers adopt intensification practices to maintain yields, using inputs such as improved seed, fertilizers, irrigation and machinery. These can help offset productivity losses, but often come at a cost, straining farm incomes and introducing environmental externalities such as nutrient runoff and greenhouse gas emissions. Such intensification when implemented unsustainably can lead to further degradation and even land abandonment. In some cases, population pressure and the inability to sustain production on degraded croplands drive expansion into forests and other natural areas, contributing to broader land degradation through land-use change. Alternatively, when used appropriately, inputs can support restoration, particularly as part of integrated approaches that improve soil health and sustain productivity over time.[64] ■

SUSTAINING AGRICULTURAL PRODUCTIVITY GROWTH

Despite complex challenges affecting agricultural production that could jeopardize food supply, the Malthusian fears – based on the theory that population growth will outpace agricultural production – have not materialized. This is largely because increases in global food production have consistently kept ahead of global population growth, especially after the industrial revolution.[65] The remarkable quadrupling of global agricultural output between 1961 and 2020, achieved with a mere 8 percent expansion in agricultural land,[66] represents a significant productivity improvement. Food insecurity today is largely driven by distributional issues affecting access, utilization and stability rather than by global food availability. Historical progress in agricultural productivity growth has been fundamental to food security, poverty reduction and economic development, although patterns have varied considerably across regions.

BOX 2 HISTORICAL CONTEXT OF LAND DEGRADATION RESPONSES

Over the last century, agriculture has continually evolved in response to the persistent challenge of land degradation. Each approach introduced – from Steiner's biodynamic agriculture in the 1920s, emphasizing spiritual and ecological harmony,[54] through to nature-positive farming in the 2020s, focused on restoring biodiversity and ecosystem services[55] – reflects progressive shifts in scientific understanding, ecological integration and ambition.

Early efforts in the 1920s–1950s, such as organic farming and soil conservation techniques in response to the Dust Bowl – a period of severe dust storms and agricultural collapse in the United States of America caused by drought and over-planting, -ploughing and -grazing[56] – were aimed primarily at protecting soils from immediate erosion and fertility loss.[57, 58] From the 1970s onwards, agroecology broadened this perspective, explicitly integrating ecological principles into farming practices, based on an understanding of farms as ecosystems of soil, plants, insects and people.[59]

By the late 1990s, conservation agriculture, a suite of practices including reduced tillage, soil cover (cover crops or mulching) and crop associations (rotations or intercropping), had gained momentum to curb erosion and rebuild soil. Its principles – disturb the soil as little as possible, keep it covered, and rotate crops – echoed the lessons of the Dust Bowl. However, approaches to conservation agriculture and the resulting outcomes differ by region: for some, it implies resource-conserving, low external input agriculture; for others, it is applied in the context of highly industrial agriculture.[60]

Agronomists have also grappled with how to increase yields for a growing population without further degrading land. The concept of sustainable intensification was introduced in the 1990s to describe boosting agricultural output on existing land while improving environmental outcomes. The approach emphasizes desirable results in terms of both more food and improved ecosystem services; it does not predetermine technologies, species mix or particular design components.

By the 2000s, climate change had emerged as a new threat, with agriculture identified as a significant source of greenhouse gas emissions. The Food and Agriculture Organization of the United Nations (FAO) launched the concept of climate-smart agriculture in 2010, uniting sustainable practices under a framework to boost yields, build resilience and reduce greenhouse gas emissions.[61] This climate-smart approach built on prior knowledge – from soil conservation to agroecology – recognizing that healthy, biologically rich soils are more resilient to climate stressors. It also highlighted the importance of integrating locally relevant evidence into broader policy coordination, rather than relying on a general list of "good practices".

In the 2010s, regenerative agriculture gained momentum based on a vision of farming that actively restores soil carbon, biodiversity and water cycles. Initially introduced in the early 1980s, it aimed at not just sustaining but also renewing farm resources and enhancing productivity. This evolving concept incorporates elements of previous efforts into an approach that is knowledge intensive, rather than chemical and capital intensive.[62]

While each of the above approaches builds on previous practices, they differ in scope, level of scientific sophistication, and the interpretation of challenges faced and the associated constraints. Each new term and practice – organic, agroecological, conservation, climate-smart and regenerative – adds a chapter to the same story: the ongoing quest to harmonize agriculture with the natural systems that sustain it. They all aim to advance the integration of agricultural productivity goals with environmental and social objectives. However, despite notable successes at local scale, global land degradation remains a pressing issue, with almost 30 percent of rainfed and 50 percent of irrigated croplands still affected.[15] The effectiveness of newer approaches in fully resolving this issue remains open to debate – only time will reveal whether they are adopted by farmers and what their long-term impacts are.

The evolving, yet fundamental contribution of land

Historically, increases in agricultural output beyond land expansion have relied on two main pathways: increasing inputs (e.g. labour, capital, irrigation, fertilizers, pesticides) per hectare of existing agricultural land; and enhancing the overall efficiency of resource use. The latter pathway is captured by total factor productivity (TFP), which reflects the combined impact of technological advancements, better management practices and more efficient allocation of all inputs, including land. It represents the average productivity of all inputs used to produce all agricultural commodities. Growth in TFP reflects the overall rate of technological advancement and efficiency improvements in the agricultural sector.

As farming systems evolve through innovation, the relative importance of different production factors often shifts. Labour may become less intensive as mechanization increases, or land use might become more efficient with improved crop varieties and management practices. These changes in relative factor shares demonstrate how aggregate TFP growth represents not simply doing more with the same resources, but often transforming how those resources are utilized and combined in the production process, possibly reflecting a change in the mix of commodities produced. Yet, land remains the foundation upon which all agricultural productivity rests, even as its relative contribution to output growth has evolved.

When analysing productivity trends in agriculture, net agricultural area and yield growth provide direct metrics, but improvements in yield depend on complex input interactions. Biophysical inputs such as seed, fertilizers, pesticides and irrigation combine with investments in labour and capital to determine productivity and efficiency. This interplay is essential to understanding the role of land in agriculture. Enhanced yields may stem from input intensification, technological innovation, improved management or combinations thereof. Therefore, yield growth may simply reflect more intensive use of fertilizer, machinery or labour.

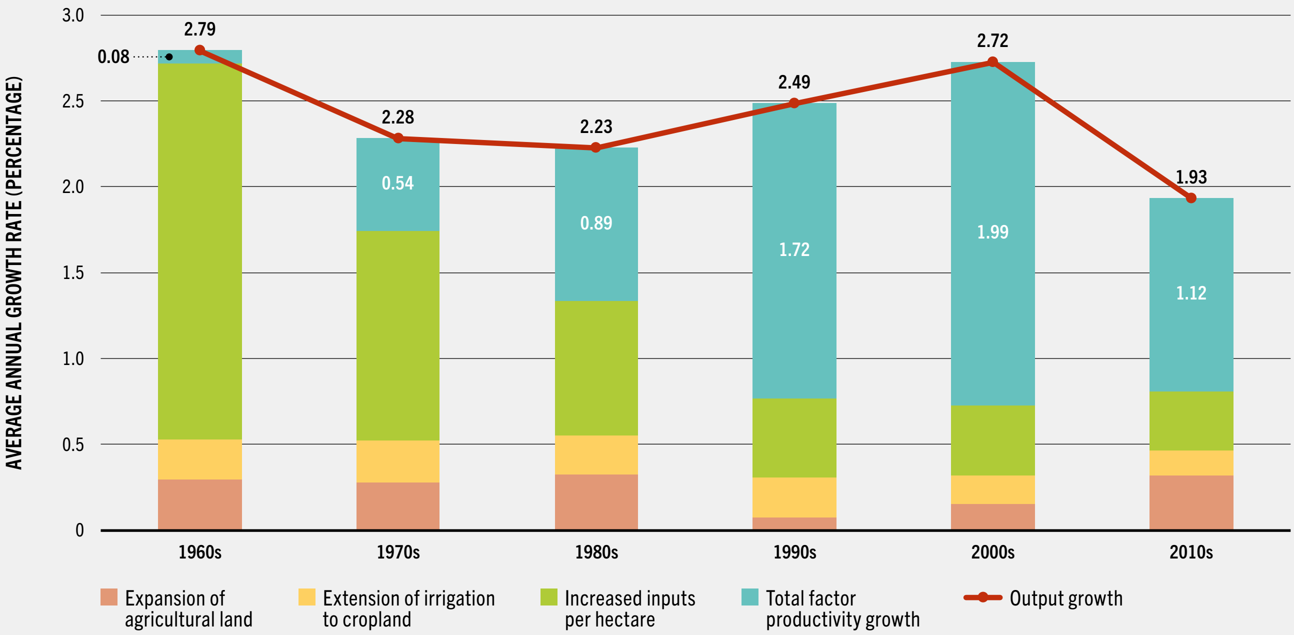
As Figure 4 illustrates, net land expansion has played only a minimal role in global output growth. However, the figure masks significant regional variation; indeed, cropland expansion is of particular significance in the Global South.[67] While input intensification was the dominant driver in the 1960s, this has gradually given way to TFP improvements as the primary engine of agricultural output growth. The visible decline in the global TFP growth rate since the 2000s has been particularly pronounced in the Global South, including negative TFP growth rates in several African countries. This trend reflects cropland expansion into less productive lands, land degradation, and the impacts of climate change. The importance of reversing this decline in TFP growth has critical implications for food security and natural resource degradation.[67] Key factors in achieving this goal include increasing investment in agricultural research and development,[68] addressing climate change,[69] and improving market infrastructure, trade flows and macroeconomic stability.[70]

Total factor productivity gains generally raise returns for land, labour and capital, but the most significant gains often accrue to landowners and capital owners. Globally, labour has been increasingly substituted by capital (as the labour force declines), though the average number of workers per farm is very similar across the globe, reflecting capital-intensive and labour-intensive agriculture on large versus small farms, respectively.[67] Farm workers may or may not benefit from increased TFP growth, depending on wages and the availability of employment opportunities in other sectors. When these are lacking due to slow rural transformation, multiple factors including small farm size, abundant labour and low TFP growth can combine to create poverty and food security traps.[71] Differences in the growth of non-farm sectors and population dynamics, therefore, can create very different patterns of economic growth and inequality.

Yield gaps persist despite past success in yield growth

Global historical trends demonstrate significant yield growth – defined as increase in output per unit of land – driven by both input intensification and TFP growth. Nevertheless, yield gaps persist,

FIGURE 4 SOURCES OF GROWTH IN WORLD AGRICULTURAL OUTPUT BY DECADE, 1961–2020



SOURCE: Adapted from Figure 18 in Fuglie, K.O., Morgan, S. & Jelliffe, J., eds. 2024. *World Agricultural Production, Resource Use, and Productivity, 1961–2020*. Economic Information Bulletin No. 268. https://doi.org/10.22004/ag.econ.341638

https://doi.org/10.4060/cd7067en-fig04

threatening the future potential of agriculture. Yield gap is the difference between the maximum attainable yield for a given crop in a specific environment and the actual yields farmers are currently achieving. Even with past successes in yield growth, substantial yield gaps across many regions and crops indicate significant underutilized potential of existing agricultural land. Importantly, these gaps are driven not only by biophysical but also by socioeconomic and institutional constraints. High fertilizer prices, low crop prices, limited access to credit or insurance, and tenure insecurity can disincentivize farmers' investments in inputs and technologies to close this gap.

The quality and health of agricultural land directly influence the effectiveness of all other inputs and the potential for TFP improvements. As global agriculture faces mounting pressure from land degradation – including soil erosion, salinization, compaction and organic matter loss – the sustainability of productivity gains becomes increasingly precarious. These degradation processes undermine the biophysical capacity of land to support future output growth; if left unaddressed, this could create a troubling feedback loop where productivity declines may prompt further land expansion into fragile ecosystems and remaining forests. The trend observed in Figure 4, indicating a recent increase in land expansion alongside decreasing growth rates of both TFP and agricultural output, serves as an early warning. Policies to reverse this trend and expand the production frontier through innovation may be constrained by biophysical limits in parts of the world with already small yield gaps. Closing existing yield gaps therefore remains critical to maintaining growth in agricultural output supply at historical levels.[72]

Addressing this challenge requires agricultural policies that recognize land as a complex, living system underpinning the entire agricultural enterprise, coupled with broader environmental stewardship. Future productivity improvements will depend not only on technological innovation and input optimization, but, critically, also on approaches that maintain and enhance fundamental qualities of agricultural land that make all other productivity gains possible. This understanding of the underutilized potential represented by yield gaps, alongside the threats posed by land degradation, provides a critical backdrop for the discussions in subsequent chapters. ■

WHAT DRIVES AGRICULTURAL LAND USE AND MANAGEMENT?

As human-induced land degradation is a consequence of decisions regarding land use and land management, it can be helpful to deconstruct the numerous drivers that influence these decisions at local, national and global levels. Agricultural land use refers to whether a piece of land is used for crops, pastures or forests. Land management, on the other hand, refers to how the activity within a given land-use category will be implemented (e.g. through adoption of sustainable practices or otherwise).

Figure 5 shows the web of drivers that can incentivize or constrain sustainable land use and management decisions. These drivers are grouped at global, national and local levels for the sake of simplification, although they interact dynamically. For example, climate change – a global driver – interacts with national and local drivers to influence both land-use and land management decisions. When yields on existing croplands decrease due to higher temperatures or erratic rainfall, farmers may resort to converting forests or grasslands into cropland, contributing to degradation due to land-use change; alternatively, they can decide to use sustainable land management technologies such as agroforestry to maintain soil moisture and fix nitrogen to boost yields despite climate change. Conversely, unsustainable forms of land use and management at local or national level can increase carbon emissions, further exacerbating climate change globally.

Global influences on local decisions

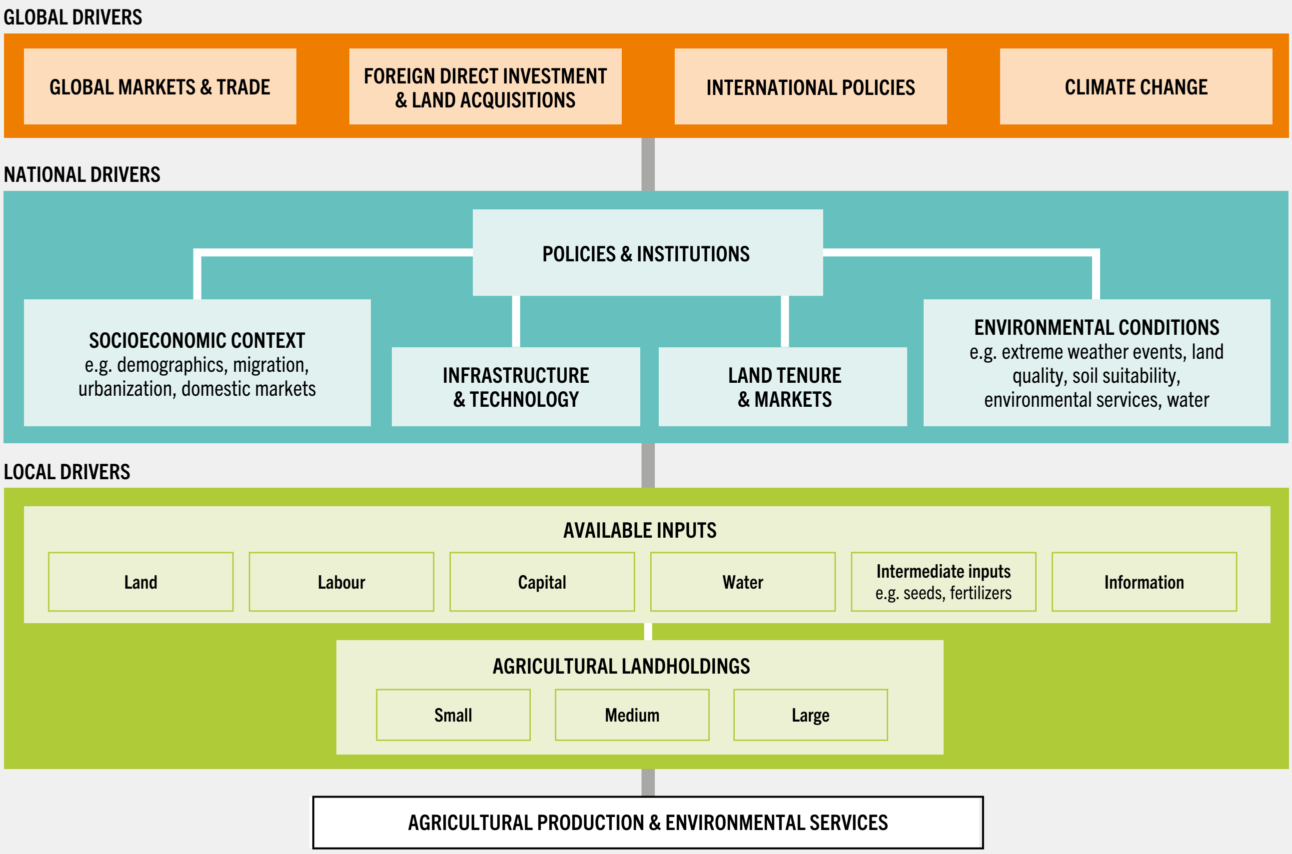
Global drivers of land use and management are felt locally, influencing the agricultural context in which farmers make their decisions through several mechanisms. Global markets and trade comprise one such mechanism: they allow countries to draw on the land and other resources of exporting nations to meet their food needs, acting as a virtual land trade. Many countries depend on trade because of natural resource constraints.[73] Trade also expands the impacts of national dietary transitions, as changing consumption patterns in one region influence production systems in another.[6, 74]

Foreign direct investment and land acquisitions also influence decisions on how land is used and managed. Foreign direct investment involves companies establishing or acquiring operations abroad to expand long-term business interests. Land acquisitions refer specifically to the purchase or long-term lease of land for agricultural, commercial or industrial purposes, often leading to shifts in land use. Both mechanisms can lead to significant shifts in land-use patterns.

International policies and agreements shape land use by promoting shared goals and coordinated action. For instance, under the United Nations Convention to Combat Desertification (UNCCD), 131 countries are working towards achieving land degradation neutrality by 2030 – some through formal commitments with national targets, others by developing strategies and assessing their land conditions.[75]

Climate change is another global driver that alters weather patterns, growing seasons and land suitability, often leading to land degradation.[2] In response, farmers adapt by changing production practices, crops and inputs, as well as increasing area planted.[76] Innovations for adaptation (e.g. climate-resilient crops) and mitigation (e.g. improved livestock management) shape decisions across the globe. Beyond impacts on how land used for food production is managed,

FIGURE 5 DRIVERS OF AGRICULTURAL LAND USE AND MANAGEMENT



NOTE: The depiction of small, medium and large agricultural holdings is conceptual; specific definitions used elsewhere in this report are small (<2 ha), medium (2–50 ha) and large (>50 ha).
SOURCE: Authors' own elaboration.

climate change increases demand for land for biofuels, renewable energy and carbon capture sequestration affecting land use.

Although these global drivers may appear a long way from farm-level decisions, they can result in locally experienced sustainability stressors including land degradation.[77] For example, international trade is estimated to account for 21–37 percent of global land use and 17–30 percent of biodiversity loss.[78] While trade enhances global resource use efficiency, rising demand for resource-intensive exports (e.g. oilseeds, beef)[6] may lead to local resource depletion.[79] The growing disconnect between the consumption of food and the land from which it comes, exacerbated by global trade, presents a new challenge to the sustainable management of land systems.[80]

National contexts shape farmers' options

At the national level, policies and institutions – or the absence thereof – shape the overall context in which land use and management decisions are made. Government agencies such as ministries of agriculture, environment and forestry, land registration offices, urban planning authorities and enforcement bodies (for land inheritance and environmental regulations) play key roles, with often overlapping mandates. These institutions shape the overall socioeconomic context of land use and condition access to infrastructure and technology. They implement policies that can directly influence land use (e.g. conservation programmes, urban development), land management (e.g. input subsidies, extension) and land distribution (e.g. land titling, tenure reforms), or indirectly affect investment incentives through land, credit and insurance markets. Furthermore, they influence the response to extreme environmental conditions.

Socioeconomic context

The socioeconomic conditions of a country play a critical role in shaping land-use decisions. Demographic trends, including population size, age and gender distribution, migration, and urbanization, influence both labour availability and land pressure. Global population growth rates have shown a sharp decline – albeit with significant regional variation – which may reshape pressure on natural resources.[65]

Recent socioeconomic trends represent a departure from historical patterns. While population growth has long been a key driver of global food demand and land pressure, economic development and rising per capita incomes are now the main drivers.[6, 74, 81] Slowing global population growth, combined with rising economic growth, incomes and urbanization, is shifting food demand towards more resource-intensive foods such as meat, dairy and processed foods.[6, 7, 74]

In particular, urbanization affects land-use decisions through multiple pathways. There are both indirect impacts through changing diets (mentioned above) and direct impacts through demand for land with implications for land availability, prices and land-use dynamics along the urban–rural continuum. Box 3 presents evidence from France that proximity to intermediate and large cities is associated with higher agricultural land prices.

Domestic markets, such as those for food, agricultural inputs, credit and insurance, also shape land-use decisions by creating incentives or disincentives for producers. When markets are imperfect or missing, decision-makers face constraints that reduce production efficiency.[88–91] Moreover, producers are less likely to adopt sustainable land management technologies that can maintain or improve soil health, creating a vicious cycle of low yields, land degradation and agricultural expansion.

Infrastructure and technology access

Infrastructure plays a foundational role in supporting agriculture by providing essential services such as roads, irrigation systems, storage facilities and internet connectivity. These elements improve farmers' access to markets, reduce production and transaction costs, and contribute to greater productivity and sustainability.[14, 92] However, the expansion of infrastructure can also have unintended consequences: in some cases, it may encourage unsustainable intensification and lead to land degradation.

Similarly, access to technology offers significant potential to optimize land management. Innovative tools and practices can enhance input use efficiency and boost productivity, helping to make agriculture more sustainable. For technology to be effective in this role, it must be accessible, inclusive, and adapted to local conditions, in addition to suitable for farms of all sizes.[25]

Policies and institutions play a crucial role in enabling these advancements. By supporting investments in agricultural research and development, and by ensuring that technologies are widely available and beneficial to diverse stakeholders, they help lay the groundwork for agricultural growth and structural transformation.[67]

Land tenure and land markets

Land tenure, encompassing both formal regulations and informal rules, defines how individuals and groups access, use and control land.[93] Secure land tenure reduces risk and uncertainty, encouraging investment in land productivity and the adoption of sustainable practices.[35, 94–96] In some contexts, informal and customary tenure arrangements, particularly over communal lands, can also support the »

BOX 3 INFLUENCE OF URBAN PROXIMITY ON AGRICULTURAL LAND PRICES IN FRANCE

Land prices are a critical factor in land-use decisions, reflecting both expected returns from land-based activity and underlying land scarcity. Yet, due to limited data availability, these prices are often represented by proxies such as market accessibility or are omitted entirely from analyses.[82] Reliable, spatially explicit farmland price data remain rare, especially in rural and low-income regions. Even in high-income countries, research typically focuses on either urban or rural land markets, overlooking transitional zones such as city fringes where both markets interact. Public land transaction data, when available, are often aggregated or commercialized.[83]

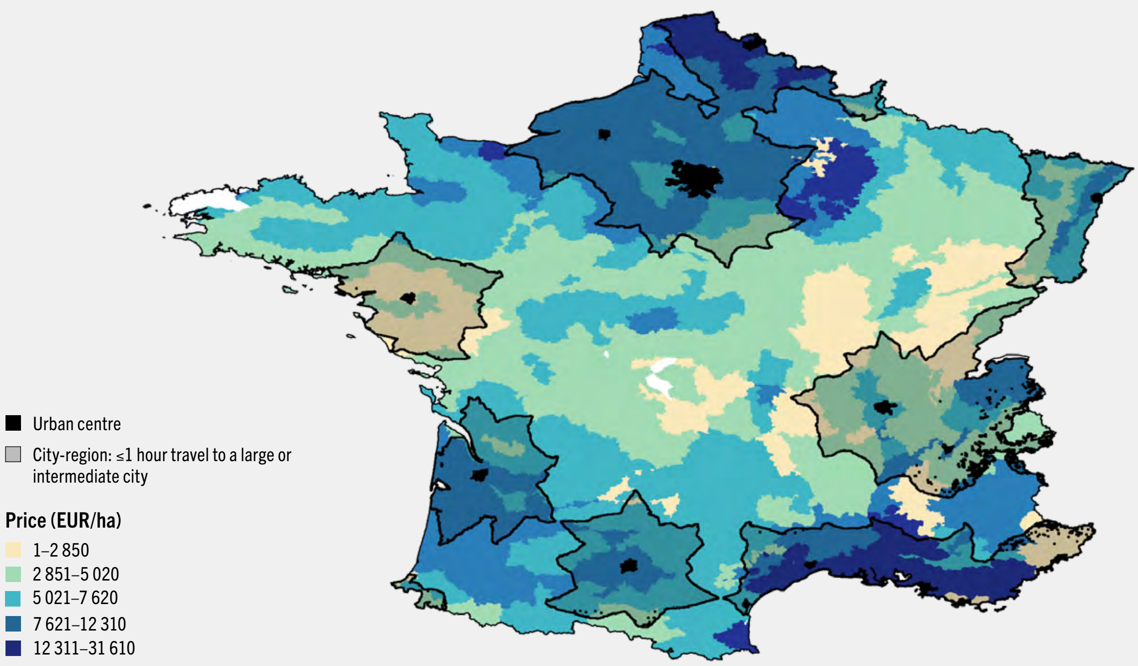
France stands out as a rare exception. Its Land Development and Rural Settlement Agency (SAFER) publishes the *Les Prix des Terres* map, providing open access, spatially explicit farmland price data at the subnational level, disaggregated by land use (e.g. arable, pasture, vineyard).[84] It also reports the number of land acquisitions at the commune level, enhancing transparency on both prices and market activity.

Overlaying such price data with a spatial dataset that defines city-regions, particularly the framework developed by Cattaneo *et al.*,[85] can shed light on how proximity to urban areas of different sizes affects farmland prices. Research suggests that farmland near cities tends to be more expensive due to improved market access, healthy soils and the potential of land conversion for high-value residential or commercial uses.[86, 87]

Exploratory regression analysis at the agricultural region level controlling for departmental fixed effects* finds that farmland closer to intermediate and large cities is, on average, EUR 1 230 more expensive per hectare.** This is a meaningful increase when compared with departmental averages, which range from EUR 2 370 to EUR 15 590 per hectare. Furthermore, half of all departments have prices below EUR 6 000 per hectare, making a EUR 1 230 difference equivalent to an increase of more than 20 percent.

While many factors influence land values, ranging from land quality, local market and economic conditions to regional land-use regulations, the analysis suggests a correlation between urban proximity and higher farmland prices. Future research can build upon this analysis by incorporating place-specific data and narratives to provide more grounded geographic insights into city-regions and land prices.

FIGURE AGRICULTURAL LAND PRICES AND PROXIMITY TO CITY-REGIONS



NOTES: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. * The department level in France is an administrative division below the regional level. ** Estimate significant at 95 percent confidence level.

SOURCES: SAFER. 2025. *Le prix des terres* [*Farmland prices*]. [Cited 22 April 2025]. https://www.le-prix-des-terres.fr; Cattaneo, A., Girgin, S., de By, R., McMenomy, T., Nelson, A. & Vaz, S. 2024. Worldwide delineation of multi-tier city-regions. *Nature Cities*, 1(7): 469–479. https://doi.org/10.1038/s44284-024-00083-z

» protection of ecosystem services; this is especially so where Indigenous Peoples and other traditional communities have a long-established relationship with land and place a high value on its sustainable use and preservation.[97] However, when such tenure is not formally recognized, it can expose communities to socioeconomic and environmental risks, and lead to conflict.[98, 99] Box 4 describes the importance of land tenure and governance for sustainable land management and food security.

Closely linked to tenure systems are land markets, which influence how land is allocated and used. Both rental and sales markets shape the type and intensity of agricultural management practices, as well as the conversion of agricultural land to other uses (see Box 16 in **Chapter 4**). Transparency in land rights and markets conveys clear price signals, facilitates the efficient allocation of land to more productive users, and encourages investment in sustainable land management. Conversely, poorly functioning or opaque land markets can hinder these transfers, weaken credit and insurance systems, and ultimately erode incentives for sustainable land management.[88, 100, 101] Thus, the structure and accessibility of land markets are integral to the broader dynamics of land governance and sustainability.

Collective and customary land rights are essential for Indigenous Peoples as they reflect deeply rooted cultural, spiritual and biocentric relationships with land and ecosystems. These customary systems, often operating through collective tenure arrangements, enable Indigenous Peoples to contribute to "overcoming the combined challenges of climate change, food security, biodiversity conservation, and combating desertification and land degradation".[2] When customary rights are not formally recognized, displacement and dispossession can lead to environmental degradation.

Gender inequalities in land rights, access to resources, and decision-making further complicate these dynamics. Women often face weaker tenure security than men, limiting their ability to invest in long-term land improvements. In Malawi, for example, short-term informal tenancy contracts and gender-biased customary inheritance practices have reduced investments in soil conservation.[102] Similarly, in Ghana, complex land tenure arrangements tend to increase women's tenure insecurity, undermining women's ability to adopt both short- and long-term land conservation practices.[103]

These challenges are reflected in global data. Women are less likely than men to own land, particularly agricultural land. In 43 out of 49 countries with data on SDG Indicator 5.a.1, men in agricultural households are more likely than women to own or have secure rights to land. In nearly half of these countries, the gender gap in landownership exceeds 20 percentage points. Surveys on tenure insecurity perceptions consistently show that women report higher levels of tenure insecurity in cases of divorce or death of a spouse.[104] Although sex-disaggregated data on the share of land owned by women (jointly or individually) compared to men are limited, evidence from six sub-Saharan African countries shows that women own less land and are less likely to be sole owners.[105] Furthermore, case studies also show that female farmers tend to access lower-quality land than their male counterparts.[106]

Despite these disparities, evidence from several countries indicates that strengthening women's land rights can lead to more sustainable land management. In Benin, for example, land formalization increased long-term investments and decreased the difference between male- and female-headed households' use of fallowing to restore soil fertility.[107] An impact evaluation of Rwanda's pilot land regularization programme revealed a significant improvement in women's land access, including inheritance rights; the programme also boosted soil conservation investments, especially among female-headed households previously subject to greater tenure insecurity.[108]

Beyond legal access, women's ability to manage land sustainability is shaped by structural inequalities that limit their decision-making power, increase their labour burdens, and influence their knowledge and preferences. These challenges can undermine soil health.[109] Yet, when women own land, crop diversity and household food security improve significantly, as demonstrated by evidence from Ecuador

BOX 4 LAND TENURE ENABLES LAND STEWARDSHIP AND FOOD SECURITY

Tenure rights shape access to land, investment choices and agricultural productivity. Secure tenure rights – whether of individual holdings or community-held areas – can play a key role in stimulating investment in adoption of sustainable land management practices, while maintaining the collective resource management systems that underpin food production. Conversely, when land rights are unclear or contested, holdings and communities may face restrictions on land use, displacement, or reduced long-term planning capacity, all of which can negatively affect food security. While tenure security alone does not guarantee food security, it is an essential enabler, especially when combined with broader supportive economic, infrastructural and environmental conditions.[113, 114]

Globally, pressures on land resources are estimated to undermine the well-being of over 3.2 billion people.[115] Land consolidation and fragmentation are placing particular strain on the rural poor in low- and middle-income countries, threatening their access to land and livelihoods. In this context, secure tenure rights play a crucial role in protecting farmers from displacement and ensuring continued access to productive land, thereby bolstering food security.[97] Research also shows that secure tenure can contribute to dietary diversity and improved nutrition. In Uganda, for example, the dietary diversity of women of reproductive age was positively correlated with tenure security.[116] Secure land tenure is also linked to greater private investment and can facilitate access to credit and insurance, though this also depends on broader institutional capacity.[117]

Global governance of land tenure is evolving to address these challenges. The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT), adopted by the Committee on World Food Security in 2012, offer a widely recognized framework for improving tenure governance, focusing on transparency, equity and the protection of vulnerable groups.[93] However, implementation remains uneven. Encouragingly, integration of the VGGT into the United Nations Convention to Combat Desertification (UNCCD) and its Land Degradation Neutrality (LDN) targets in 2012 marked a critical step in embedding tenure into land degradation policy. This process has been advanced by a joint FAO-UNCCD initiative which produced a technical guide to support application of the VGGT in the context of LDN implementation, promoting tenure-responsive land restoration and sustainable land governance.[115, 118] In 2024, land tenure was further adopted as a headline indicator under Target 22 on traditional knowledge at the Sixteenth meeting of the Conference of the Parties to the Convention on Biological Diversity, institutionalizing land tenure within biodiversity strategies and monitoring frameworks.

Building on this momentum, FAO is preparing a new report, *The status of land tenure and governance*,[119] which will synthesize current evidence, identify key trends and challenges, and outline strategies to strengthen governance and secure tenure rights. The report will highlight the role of collectively managed lands held by Indigenous Peoples and other communities with customary tenure, which cover vast amounts of land. Despite their social and ecological importance, most of these lands remain without legal recognition. Protecting these rights is essential not only to preserving biodiversity and mitigating climate change, but also to ensuring food security and livelihoods.

and Peru.[110, 111] These benefits are even more pronounced when women from low-income farming households are actively involved in decision-making, as observed in Burkina Faso, India, Malawi and the United Republic of Tanzania.[112]

Nevertheless, women's land rights remain weak in many countries, despite their recognition in international frameworks such as the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) and the SDGs (Targets 5.a and 1.4). Box 5 examines the legal barriers that continue to restrict women's land rights and limit their ability to benefit from land-based opportunities.

Environmental conditions

Farmers' land management decisions are strongly shaped by local environmental conditions. Factors such as climate, land quality, soil suitability, ecosystem services and water availability play a fundamental role in determining agricultural productivity. In response to increasingly frequent extreme weather events and slow onset changes, many farmers are in need of adaptation strategies, barriers to which may exacerbate land degradation.[2]

National agri-environmental policies and regulations can support land-based adaptation by promoting sustainable land management practices. These policies not only influence domestic agricultural outcomes but can also have cross-border effects through international trade. However, if trade-offs are not carefully evaluated, such policies may inadvertently encourage unsustainable intensification, leading to maladaptation and long-term environmental degradation including through land-use change.

Local drivers reflect farmers' resources

At the local level, farmers make decisions based on the available resources synthesized in Figure 5 (green rectangle). Landholding size is not only an indicator of resource endowment; it also shapes access to and use of agricultural inputs such as labour, water, seed and information. These determine farmers' capacity to adopt sustainable practices or, conversely, the likelihood of resorting to methods that may lead to land degradation. In many low-income countries, limited access to fertilizers, irrigation, improved seed varieties and mechanization further constrains these decisions. While land management is a local activity, the availability of these inputs is heavily influenced by national and international contexts.

The interplay between global, national and local drivers creates a complex web of influences on land use and management decisions made by farmers. National policies and institutions shape the availability of resources and incentives, while international agreements and global markets establish broader frameworks and trends. Climate change and markets traverse these levels, impacting land management practices and sustainability. Ultimately, farmers navigate these multifaceted influences to make decisions that balance productivity and socioeconomic needs, but which may fail to capture the full benefits to society of environmental stewardship. ■

LAND'S ROLE IN A SUSTAINABLE FUTURE

Land is the foundation of food production, and its management plays a critical role in ensuring global food security. The way land's productive potential is managed directly affects the availability and stability of food supplies. As the global population grows and dietary patterns shift towards more resource-intensive foods, sustainable land management becomes increasingly important.[6, 74, 81] While food availability and stability are closely linked to land, achieving comprehensive food security also requires attention to access and utilization. Within the context of building resilient agrifood systems, sustainable land management is not only an agricultural concern – it is a development priority that underpins efforts to meet rising food demand, protect ecosystems and achieve the Sustainable Development Goals.

As pressures on land continue to rise, there is increased awareness that land is a finite resource. Unlike other production factors, the amount of available agricultural land is limited.[72, 128–131] This inherent characteristic creates unique challenges for ensuring food security and sustainable development, as increasing demands place ever greater stress on existing land resources.

The need to address these complexities underscores the broader, foundational role that land plays in achieving sustainable development. Land is essential for food production, biodiversity conservation and climate resilience, and it underpins multiple SDGs. It is the silent partner in attaining No Poverty (SDG 1), the buffer for Climate Action (SDG 13) and the very foundation of Life on Land (SDG 15). In terms of SDG 2, land is not just the means to achieving Zero Hunger, it is about cultivating improved food security and nutrition through sustainable agriculture (Box 6). Moreover, land is central to building Sustainable

BOX 5 LEGAL BARRIERS TO WOMEN'S LAND RIGHTS: GAPS, IMPLICATIONS AND OPPORTUNITIES FOR REFORM

Despite growing recognition of the importance of equality between men and women for land governance, legal protections for women's land rights remain limited and uneven across countries. SDG Indicator 5.a.2 evaluates whether laws guarantee women's rights to own, use, inherit and register land, and whether they ensure women's participation in land-related decision-making. Among 91 reporting countries, only 26 percent score high on legal protections, while 49 percent have few or no measures aligned with international standards.

Legal gaps are widespread across all components of the indicator, underscored by a clear lack of enabling provisions – such as those supporting positive measures to promote gender equality in land rights – or provisions that strengthen women's rights and participation in family and customary land matters (see figure). Thirty-eight percent of countries lack adequate legal provisions to ensure equal inheritance rights for men and women, and boys and girls, with many of these gaps rooted in religious or customary laws.

In many contexts, discriminatory practices persist despite formal legal recognition of women's rights. For example, in 44 percent of countries, husbands can sell jointly owned land without consent, and only 31 percent of countries require joint registration of land. Among the countries recognizing customary tenure, 44 percent do not prioritize gender equality when customary law conflicts with women's rights. For instance, in Iraq, traditional community tenure systems typically allocate land rights to male relatives, excluding women without male advocates.[120, 121] In Indonesia, young women are not only ineligible for customary land allocations, they are also often barred from inheriting land from their parents despite being more active in farming.[122]

Although measures such as quotas, tax incentives for joint land registration, and access to finance and extension services can strengthen women's land rights,[123] they are rarely adopted. Only 29 percent of countries have quotas, and few allocate funding to support women's landownership.

Implications for policy

Closing legal gaps is only the first step. More and better data are needed to support legal reforms and inform the design and implementation of policies and programmes seeking to advance women's land rights. This is particularly important given the rapid transformation in land tenure systems, as well as gender roles and responsibilities within the family unit, underway in many regions.[124] A more detailed and comprehensive review of relevant policies and programmes will be available in FAO's forthcoming report, *The status of land tenure and governance*.[119]

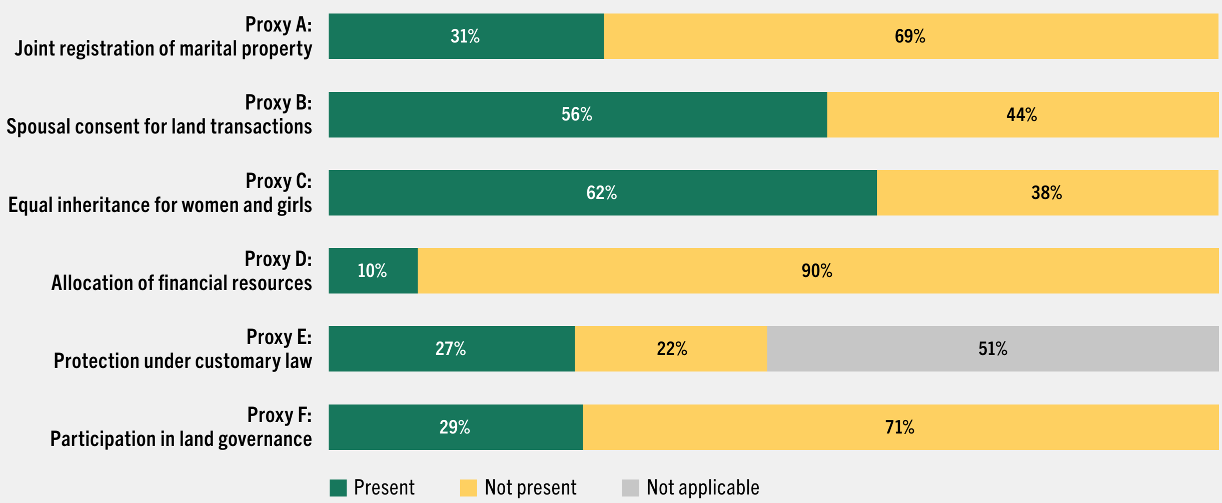
Legal protections must be backed by financial resources, strong enforcement mechanisms and efforts to shift discriminatory norms and practices.[125] Raising awareness of legal land rights is a critical complement to gender-responsive land reforms, with evidence demonstrating that it can directly influence sustainable land use. In Ethiopia, awareness of tenure security, transfer rights and gender equality significantly boosted the adoption of soil conservation, tree crops and legumes.[126] Similarly, a study from Uganda found that land rights awareness had a strong effect on tree planting and soil conservation, especially among female-headed households.[127]

Cities and Communities for the growing population (SDG 11).

Recognizing this, land degradation has moved steadily up the international agenda over the past two decades. The most prominent global commitment is enshrined in SDG Target 15.3, which calls on members to "combat desertification, restore degraded land and soil, and strive to achieve a land degradation-neutral world" by 2030. This target builds on the UNCCD, the only legally binding international agreement focused specifically on the preservation of land and soil. Under this agreement, over 130 countries

BOX 5 (Continued)

FIGURE SHARE OF SDG 5.A.2-REPORTING COUNTRIES WITH LEGAL PROVISIONS ALIGNED WITH THE INDICATOR'S METHODOLOGY AND CEDAW STANDARDS



NOTES: CEDAW = Convention on the Elimination of All Forms of Discrimination against Women. Data cover 91 reporting countries. Of these countries, 51 percent reported that "protection under customary law" is not applicable, indicating that customary laws and tenure systems are not legally recognized, in line with the SDG 5.a.2 methodology.[125]

SOURCE: FAO unpublished data based on officially submitted SDG Indicator 5.a.2 assessment as of 30 July 2025.

https://doi.org/10.4060/cd7067en-figB05

have engaged in a Land Degradation Neutrality (LDN) target-setting framework, committing to balance degradation with equivalent restoration so that the total stock of healthy land is at least maintained.[45]

As of 2020, 115 countries had submitted quantitative, area-based restoration commitments to at least one of the three Rio Conventions – the United Nations Convention to Combat Desertification (UNCCD), the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) – or to the Bonn Challenge and related regional initiatives. Many countries have made overlapping commitments under multiple frameworks, often with variations in restoration type, scope and definition. As a result, national targets may be misaligned across conventions, which hampers strategic planning and implementation. In many cases, commitments are qualitative or non-specific, and they tend to lack geographic targeting, making them difficult to monitor or evaluate. More precise, measurable and transparent restoration commitments are needed to enhance credibility, effectiveness and accountability. Differences in reporting approaches also make it difficult to compare restoration goals and progress across countries and frameworks.[132]

Achieving LDN is not only environmentally sound but also economically beneficial for society. Investments in land restoration efforts are estimated to bring returns that far exceed the costs, though the benefit–cost ratios vary depending on cost definitions and time frames.[17, 45] In the short term, opportunity

BOX 6 MEASURING SUSTAINABLE PRODUCTIVITY GAINS: SDG INDICATORS 2.3.1 AND 2.4.1

The Sustainable Development Goals (SDGs) provide a framework for achieving food security through sustainable agriculture, one which protects natural resources and supports inclusive development.[138] The Food and Agriculture Organization of the United Nations (FAO) is the custodian agency for SDG Indicators 2.3.1 and 2.4.1, which track agricultural productivity and sustainability based on farm-level data collected through agricultural surveys and censuses.[139]

SDG Indicator 2.3.1 focuses on small-scale food producers, measuring agricultural output per labour unit.[28] It supports the target of doubling by 2030 the productivity and incomes of smallholders – particularly women, Indigenous Peoples and family farmers. Smallholders are central to agrifood systems, particularly in Africa and Asia, but often record low levels of productivity due to limited resources, poor access to technologies and lack of training. Improving labour productivity among smallholders is essential for tackling rural poverty and hunger. Solutions include better access to improved seed, machinery and high-quality inputs, often combined with sustainable practices covered by SDG 2.4.1.

SDG Indicator 2.4.1 measures the share of agricultural land managed sustainably across environmental, economic and social dimensions.[140] These dimensions encompass soil health, efficient water use, biodiversity conservation, land productivity, decent employment and secure land tenure. Only farms meeting minimum thresholds across all dimensions are considered "productive and sustainable". This comprehensive approach ensures that productivity gains do not come at the expense of the long-term health of ecosystems or the well-being of rural communities. This indicator serves as a guide for governments, helping them to identify gaps and target investments in areas where sustainability is lagging. Viet Nam's successful integration of SDG 2.4.1 into its 2020 Mid-term Rural and Agricultural Survey, involving over 33 000 households and 22 000 ha of agricultural land, demonstrates a practical and scalable approach to monitoring and promoting sustainable agricultural practices.[141]

Together, these indicators promote an integrated vision: SDG 2.3.1 focuses on productivity gains, while SDG 2.4.1 ensures these gains are sustainable and equitable. They emphasize that success in agriculture means not just more food, but better food, produced with fewer environmental costs and greater social benefits.

costs may lower the net benefits, but over a 30-year horizon, returns remain clearly positive. Given that most long-term returns – such as carbon sequestration, biodiversity protection and regional food security – are public goods, whereas opportunity costs and investment risks are borne by individual landholders, private incentives often fail to align with the broader public benefits of restoration.[17, 133] This misalignment means land degradation has negative externalities, supporting the case for public or international cofinancing to ease the burden of early-stage investment. Moreover, the investment required to restore all degraded land worldwide is equivalent to just 0.03–0.27 percent of global gross domestic product, which is a comparatively small outlay for outsized gains in productivity, livelihoods and resilience.[134, 135] These dynamics vary by land size: larger landholders are more likely to pursue complex, high-cost restoration with delayed returns, while smaller landholders tend to adopt simpler, lower-cost practices with more modest societal gains.[136] Without corrective policy mechanisms, most land users have limited incentive to invest in sustainable land management or restoration at a scale needed to achieve global LDN goals.

Assessing incentives in terms of farm size and productivity may result in overlooking the significant contributions of Indigenous Peoples' agrifood systems and practices, including hunting and gathering, fishing, shifting cultivation and pastoralism. These practices are deeply rooted in territorial and cultural contexts. They are essential for the conservation of biodiversity and contribute to food security, nutrition and resilience. Indigenous Peoples hold the right to free, prior and informed consent,[137] which is fundamental for land-related policy discussions, particularly those concerning land degradation neutrality and restoration efforts.

Scaling up global action against land degradation will require economic instruments and inclusive governance arrangements that internalize public benefits, reduce risk to landholders, and mobilize sufficient upfront finance. Ultimately, effective land restoration depends not only on technical knowledge, but on aligning economic incentives to support long-term stewardship.

Despite growing recognition, land degradation is often overlooked. Unlike climate-related disasters that generate visible and immediate shocks, land degradation is typically slow moving and unfolds over large areas, making it less likely to capture public or policy attention. This absence of clear "before and after" events also complicates causal analysis, as the impacts are diffuse and accumulate gradually over time.

By emphasizing sustainable land management as a foundation for production, this report highlights the need to engage with farmers at all production scales to avoid, reduce and reverse land degradation. This approach fosters Decent Work and Economic Growth (SDG 8) by securing agricultural livelihoods and creating green jobs, while contributing to Reduced Inequalities (SDG 10) by improving the conditions for marginalized land users. Finally, the focus on boosting land productivity while enhancing sustainability contributes to SDG 12 (Responsible Production and Consumption). Achieving these outcomes requires the creation of enabling socioeconomic and political environments. These environments should support the adoption of sustainable land management practices, notably secure land tenure, inclusive policies, and access to resources and services. Coordinated action to manage land for food security, urban growth and ecosystem conservation can create resilient agrifood systems that safeguard resources for future generations. ■

STRUCTURE OF THE REPORT

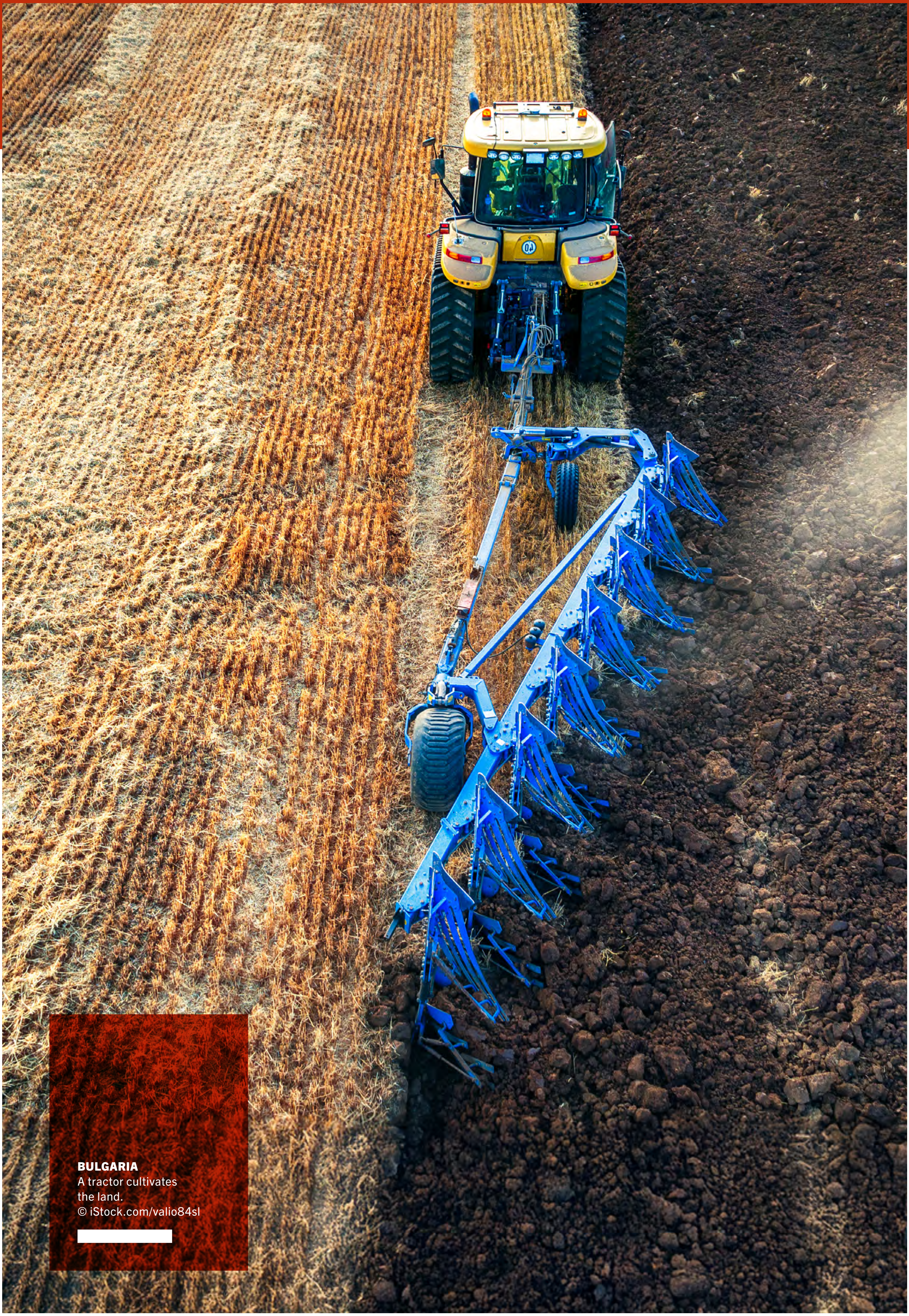
With its central theme, "Addressing land degradation across landholding scales", this edition of *The State of Food and Agriculture* contributes to the knowledge needed to achieve multiple SDGs and their targets.

Chapter 2 documents the challenges to agricultural production and food security posed by cropland degradation, establishing a causal link between long-term land degradation and crop yield loss globally. It identifies vulnerability hotspots where yield losses driven by degradation and pervasive yield gaps overlap with population density, food insecurity and poverty.[142] By highlighting distinct historical agricultural intensification patterns that have led to long-term accumulation of cropland degradation and sometimes abandonment and extensification, it establishes a basis for identifying policy entry points to decrease pressures on land while ensuring progress towards multiple SDG targets.

Chapter 3 provides an overview of the global distribution of farms, farm sizes and food production. Understanding the distribution of farm types operating croplands is critical to designing policies for sustainable agrifood systems transformation.[143, 144] Production structures and incentives of large-scale farms are fundamentally different from those of smaller farms; farms of different sizes interact in complex ways. Combined with the dynamic nature of change in farm size, effective policy design relies on up-to-date information on global farm size distributions. Chapter 3 provides this information, expanding and improving on previous literature using novel data and methodological advancements.

Chapter 3 also provides an up-to-date assessment of the global diversity of agricultural production systems. It documents their contribution to the global production of crops that provide essential dietary energy and macronutrients; this is a first step in identifying policy entry points for safeguarding production and diversity.[30, 144, 145] Based on an understanding of who produces what and where, it connects landholding scales to differentiated exposure to global challenges including land degradation, yield gaps and climate change.

Chapter 4 builds on the global insights from earlier chapters by exploring how policies can be tailored to the diverse landholding and degradation patterns documented in this report. It also outlines how different policy instruments – regulatory, incentive-based and cross-compliance approaches – can be applied to avoid, reduce and reverse land degradation, with attention to their suitability across land conditions and farm structures. The chapter draws on evidence on the impacts of more than 4 500 existing agri-environmental policies worldwide in improving the conditions of croplands, grasslands and forests.[146] It highlights how, by strategically combining policy instruments and recognizing the fundamental role of economic and institutional capabilities, it is possible to address land degradation and maintain agricultural production. ■



BULGARIA
A tractor cultivates the land.
© iStock.com/valio84sl

CHAPTER 2
LAND DEGRADATION AS A CHALLENGE TO PRODUCTIVITY

KEY MESSAGES

➔ Securing long-term food security requires a thorough understanding of how land degradation contributes globally to reduced food production across croplands, grasslands and forest lands. As croplands account for the vast majority of global dietary energy, addressing degradation and the associated yield loss on these lands is essential to improve productivity.

➔ Around 1.7 billion people globally live in areas experiencing yield gaps linked to human-induced land degradation.

➔ Most people affected by yield gaps live in regions characterized by smallholder agriculture and acute socioeconomic vulnerability. These hotspots, concentrated in Southern Asia and sub-Saharan Africa, represent a troubling convergence of degraded land, low agricultural productivity and human deprivation.

➔ While the effects of land degradation on yields are masked by intensive input use in high-income countries, this strategy is costly, produces diminishing returns, exacerbates degradation and causes environmental externalities.

➔ Cropland abandonment is occurring around currently cultivated areas, especially in high-input regions where degradation has already caused substantial yield loss.

Healthy land and soils are the cornerstones of agricultural productivity and provide vital ecosystem services. Yet, these precious resources, which can take decades or even centuries to develop,[1] can become degraded with alarming speed. As soils evolve, so too do the intricate communities of plants and microorganisms that make nutrients more accessible.[2] This delicate, long-term development stands in stark contrast to the often rapid processes of degradation.[3]

Today, land degradation is a global phenomenon, affecting countries across all income levels and manifesting in diverse landscapes – from croplands and grasslands to forests. The decrease in land's capacity to provide ecosystem services, including biomass production, climate regulation, water purification and nutrient recycling, can significantly undermine agricultural productivity, representing a serious threat to food security and nutrition.[4]

While the specific drivers and expressions of degradation vary, unsustainable land management practices are a common underlying cause. Understanding the impacts of land degradation on agricultural productivity – and how these impacts may be temporarily masked by increased input use – is essential to inform efforts to avoid, reduce and reverse land degradation. ■

LAND DEGRADATION IN DIFFERENT PRODUCTION SYSTEMS

Land degradation manifests in different ways across land-use systems, with distinct challenges arising depending on the practices applied and the environmental conditions. In croplands, degradation is driven predominantly by nutrient depletion resulting from continuous cropping, decline in soil health due to unsustainable agricultural practices, salinization in areas reliant on irrigation, and soil erosion primarily from water and wind.[5, 6] Additional pressures include soil compaction from heavy machinery, pollution from over- or misuse of agrochemicals, and monocropping and monoculture, which further impair soil structure and biological activity. These activities reduce soil cover and increase runoff, leading to the loss of fertile topsoil, while also decreasing biodiversity, diminishing agricultural productivity and compromising the long-term viability of soil and land.[7–10]

Pastoral rangeland systems experience degradation primarily through loss of vegetation cover caused by overgrazing, resulting in soil erosion and compaction. In many of the world's rangelands, livestock levels are at or above the land's capacity to sustain animal production, leading to overgrazing and long-term declines in both plant and animal production.[5] This can contribute to desertification and bush encroachment, where woody plants and shrubs invade areas typically dominated by grasses and herbaceous plants.[11] This shift in vegetation can reduce biodiversity, alter ecosystem functions and decrease land productivity, particularly in arid and semi-arid regions where the land is more vulnerable to such pressures. The degradation of rangelands compromises the ecological balance, but also impacts the livelihoods of communities dependent on these areas for grazing, potentially exacerbating conflicts over resources.[12]

Forest systems face their own set of challenges, most notably deforestation, which involves the conversion of forested areas to other land uses.[13, 14] Additionally, forest degradation – characterized by a long-term decline in the overall supply of benefits from forests (i.e. wood, biodiversity, and other products and services)[15] – poses a significant global threat, due to its impact on biodiversity and the forest's capacity to store carbon. The loss of forest cover can lead to soil erosion, reduced water quality and altered climate patterns, further exacerbating land degradation.[16–19]

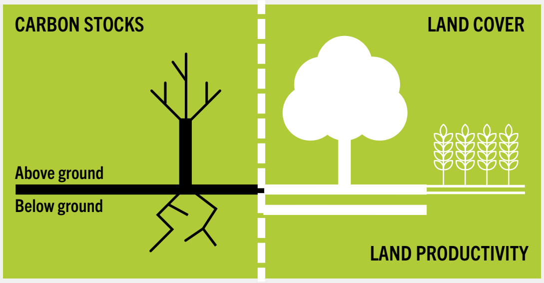
The interconnectedness of the above land-use systems means that degradation in one area can have cascading effects in other areas. For instance, deforestation, which contributes to broader patterns of forest degradation, is often a consequence of agricultural expansion. The Global Forest Resources Assessment 2020 remote sensing survey found that cropland expansion explains almost 50 percent of global deforestation, with the creation of new pastures accounting for an additional 38.5 percent.[20] In turn, unsustainable practices on converted land, such as monocropping and overgrazing, can strain the capacity of the remaining forested areas to provide ecosystem services. Furthermore, changes in climate patterns, influenced by large-scale deforestation and overall land degradation, can negatively impact the productivity and stability of both croplands and rangelands.[21] ■

MEASURING LAND DEGRADATION

Land degradation is one of three interconnected global challenges cited by the United Nations Rio Conventions, but it is less well understood than both climate change and biodiversity loss.[22] This is due in part to its multiple definitions, as well as to the many different approaches to measurement. For example, there are disagreements over how to define baselines, which makes it challenging to agree on the extent of global land degradation across different biomes.[5] This complexity is compounded by the use of varying indicators to measure land degradation by different working groups and intergovernmental panels within the United Nations system.[23]

Despite these challenges, the critical importance of addressing land degradation is widely recognized. It forms the basis of SDG Target 15.3, which aims to "combat desertification, restore degraded land and soil, including land affected

FIGURE 6 KEY INDICATORS OF LAND DEGRADATION TRACKED BY SDG TARGET 15.3



SOURCE: Authors' own elaboration based on United Nations. 2020. SDG 15 - Life on land – SDG 15 Targets. In: *Space4Water*. [Cited 2 March 2025]. https://www.space4water.org/taxonomy/term/16

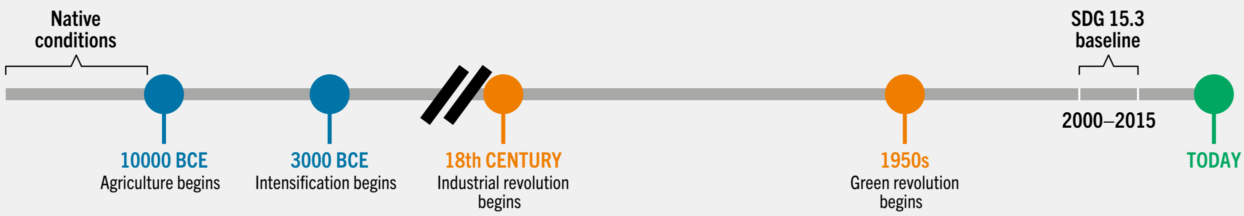
by desertification, drought and floods, and strive to achieve a land degradation-neutral world". Furthermore, there is clear consensus that avoiding, reducing and reversing land degradation all play a highly synergistic role in achieving the majority of the SDGs.[5]

Three specific sub-indicators are used for the purposes of reporting on SDG Indicator 15.3.1 (Proportion of land that is degraded over total land area): 1) trends in carbon stocks (above and below ground); 2) trends in land cover; and 3) trends in productivity (Figure 6). A significant negative change detected in any one of the three sub-indicators – using a specific threshold or statistical decreasing trend – is used to define land as degraded.[24] Trends in carbon stocks (identified by measuring soil organic carbon [SOC] above and below ground) reflect slower changes that suggest a trajectory over time; trends in land cover address land conversion; and trends in productivity capture relatively fast changes in land-based natural capital.[25] In recognition of the difficulty in measuring these biogeochemical processes, which are largely context-specific, the SDG reporting guidelines provide a wide variety of options for locally calibrated measurements.[24]

A truly holistic approach to assessing global trends in land degradation would capture all physical, chemical and biological processes that lead to degradation. One way to express land degradation in a globally consistent way is in terms ofland degradation debt.[23] A debt-based approach is based on the difference between each land degradation indicator's current value and the conditions that would be observed without human activity. It is thus possible to distinguish between human-induced degradation and natural degradation and quantify the former. While reversing all human activity is neither feasible nor preferable, the quantification of the global total cost of human-induced land degradation is a first step to identifying and prioritizing activities that can move the needle towards land degradation neutrality objectives.

The choice of baseline is crucial, as it determines whether a specific piece of land is classified as degraded. United Nations Convention to Combat Desertification reporting guidelines for SDG Target 15.3 require the use of a baseline period that covers the years from 2000 to 2015, against which reporting periods are compared.[24] However, the use of native/natural conditions as the baseline provides a more long-term understanding of global historical land degradation and highlights the importance of more ambitious goals for restoration.[23] Areas where land has been degraded for a long time, due to unsustainable agriculture or other human activity, would otherwise remain undetected, introducing bias into global efforts to achieve land degradation neutrality. Furthermore, using the native/natural state as a baseline is also perceived to be fairer, as countries where the ecosystems were transformed centuries ago can be identified and incentivized to set more ambitious restoration goals, which would not be possible with a recent baseline.[5] Figure 7 illustrates the concept of baselines in relation to agricultural history. ■

FIGURE 7 AGRICULTURAL HISTORY IN RELATION TO OPTIONS OF LAND DEGRADATION BASELINES



SOURCE: Authors' own elaboration.

HOW LAND DEGRADATION AFFECTS FOOD PRODUCTION

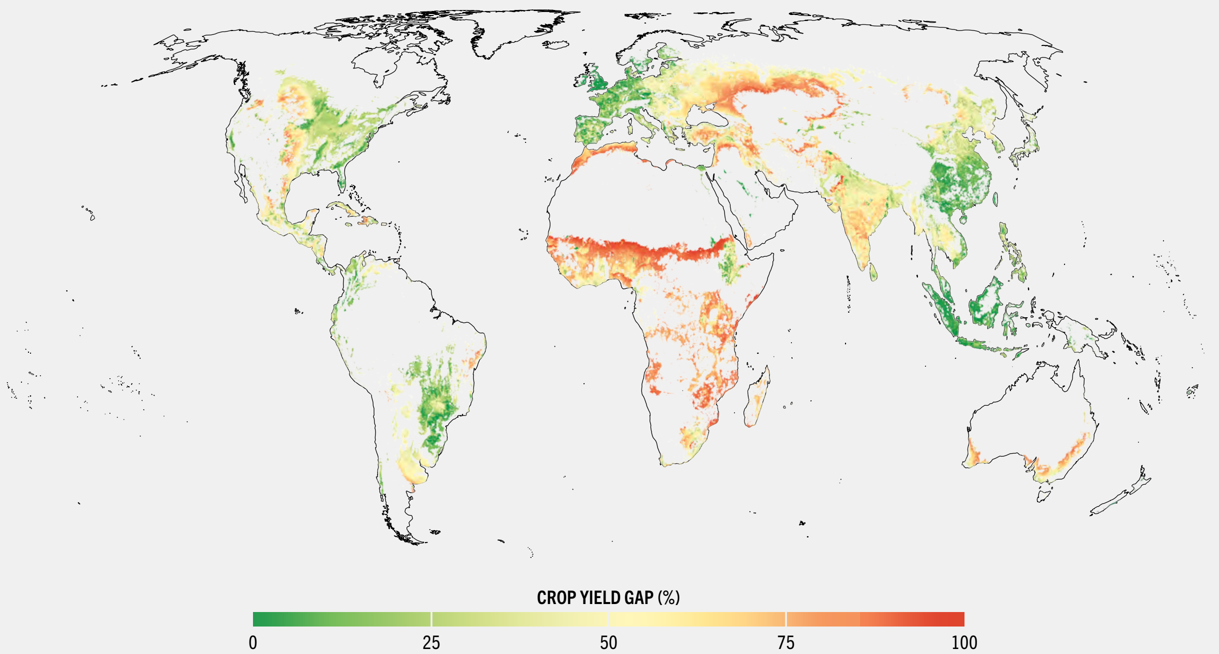
Understanding how land degradation affects food production is critical to global food security. However, assessing the causal linkages in this relationship can be a complex process: evidence is often contradictory, with studies reporting effects that range from negligible to severe.[26, 27] References to positive correlations between high yields and land degradation can even be misinterpreted as a causal relationship.[28] Isolating the direct impact of land degradation on agricultural productivity can also be challenging due to numerous confounding factors including the interplay between environmental and management practices. This report presents new global evidence on the causal relationship between cropland degradation and yield loss. It explores the underlying pathways that contribute to this relationship – pathways that may need to be avoided in the future to effectively address land degradation and achieve food security goals.

While land degradation occurs across all types of agricultural land, findings related to croplands provide important information on how to ensure sustainable food production and reduce pressure on natural ecosystems – both of which are fundamental to achieving food security. Croplands account for nearly one-third of all agricultural land, and form the basis of food provisioning and of regulating and cultural services.[29, 30] Accordingly, croplands produce the vast majority of global kilocalories and proteins. Cereals alone contribute about 43 percent of global caloric intake, with vegetables, fruits, and roots and tubers adding another 15 percent, and sugar crops providing an additional 8 percent.[31] Additionally, one-third of all croplands are used to grow animal feed, indirectly contributing to protein availability in addition to the plant-based proteins directly consumed by humans.

Cropland expansion has accelerated in the twenty-first century, significantly affecting forest loss, wildland fragmentation and pasture conversion – a trend in direct conflict with SDG 15.[32] The contribution of these biomes to food security complements the central role of cultivated crops in nutrition, particularly for forest-dependent and pastoralist communities.[33–35] Furthermore, on average every year nearly 4 Mha of cropland are being abandoned, possibly due to degradation, leading to losses in production.[36] Addressing degradation in croplands, and its implications for yield gaps and land abandonment, would therefore relieve pressures on other types of land cover.

For land that is currently in production, yield gaps are key to understanding the impact of land degradation on crop production (see **Chapter 1**).

FIGURE 8 AGROECOLOGICAL YIELD GAPS FOR TEN MAJOR CROPS, 2020



NOTES: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. Agroecological yield gap data are based on the GAEZ v5 2020 attainable yields, actual yields and cropland layers available in: Fischer, G., Nachtergaele, F.O., van Velthuizen, H.T., Chiozza, F., Franceschini, G., Henry, M., Muchoney, D. & Tramberend, S. 2021. *Global Agro-Ecological Zones v5 – Model documentation*. Rome, FAO. https://doi.org/10.4060/cb4744en; FAO & IIASA. 2025. Global Agro-Ecological Zones version 5 (GAEZ v5). [Accessed on 27 June 2025]. https://data.apps.fao.org/gaez/?lang=en. Licence: CC-BY-4.0.

SOURCE: Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

They represent the difference between the maximum attainable yield for a given crop in a specific environment and the actual yields achieved by farmers. Figure 8 shows the global distribution of agroecological yield gaps for 2020, drawing on FAO's latest Global Agro-ecological Zoning (GAEZ v5).[37] These agroecological yield gaps measure the difference between actual yields and attainable yields based primarily on environmental conditions for ten major crops: barley, cassava, maize, oil palm, rapeseed, rice, sorghum, soybean, sugar cane and wheat. Together, these crops account for over 80 percent of all harvested food energy and more than 60 percent of global harvested area.[38] The data underlying the figure are in broad agreement with statistical yield gaps, which use attainable yields from the best-performing farmers under real-world conditions and account for additional socioeconomic and institutional constraints.[39]

To inform effective policies, it is essential to distinguish between: 1) all-cause yield gaps (ACYG) – which reflects the combined effects of diverse biophysical, management and socioeconomic constraints; and 2) more specific degradation-induced yield losses (DIYL) – which refer to the portion of yield gap directly

BOX 7 DEBT-BASED APPROACH TO ASSESSING HUMAN-INDUCED LAND DEGRADATION

Land degradation debt can be defined as the difference between the current values of specific indicators – soil organic carbon (SOC), soil erosion and soil water – and their values without human activity. The process used to model the counterfactual values applies recent advances in remote sensing, machine learning and computational resources, to separate human-induced change from natural degradation processes.[23] This is achieved by modelling each degradation indicator to proxy baseline conditions using the following historical benchmarks:

- **Soil organic carbon:** native SOC.[41]
- **Soil erosion:** land cover in protected areas.[42]
- **Soil water:** long differences based on the European Space Agency Climate Change Initiative's Soil Moisture dataset.[43–45]

Regardless of the differences in historical benchmark, each debt measure captures the effects of human activity on agricultural land compared to native/natural conditions. These data are fed into a machine-learning model that incorporates environmental drivers of change to isolate the native/natural state of land in the absence of human interference. The counterfactual soil organic carbon is modelled under a prehistoric "no land use" scenario representing pre-agricultural conditions (~10000 BCE), while other environmental drivers of soil organic carbon remain unchanged.[41] These values are then compared against estimates of current soil organic carbon taken from the FAO Global Soil Organic Carbon Map (GSOC Map),[46] to quantify human-induced losses of soil organic carbon, or SOC debt.

For soil erosion, a machine-learning model is similarly trained using data from protected areas, where land cover is assumed to be relatively unaffected by human activity, thus approximating vegetation cover in historical times. See the rationale and limitations of this common approach in Hengl *et al*. (2018).[47] The model learns how native land cover relates to environmental predictors (e.g. temperature, rainfall). It then applies this relationship to all regions to estimate what the land cover would be in the absence of human land use. This estimated counterfactual land cover is used as the main input in the soil erosion model (with all other soil erosion drivers held constant) to simulate natural erosion rates without human-induced changes. These are then compared with current soil erosion rates[42] to quantify human-induced erosion, or soil erosion debt. Further details can be found in Wuepper *et al.* (2021).[23] The maps in the figure illustrate two examples of this method showing the components of the SOC and soil erosion debt calculations for Ethiopia and the United States of America.

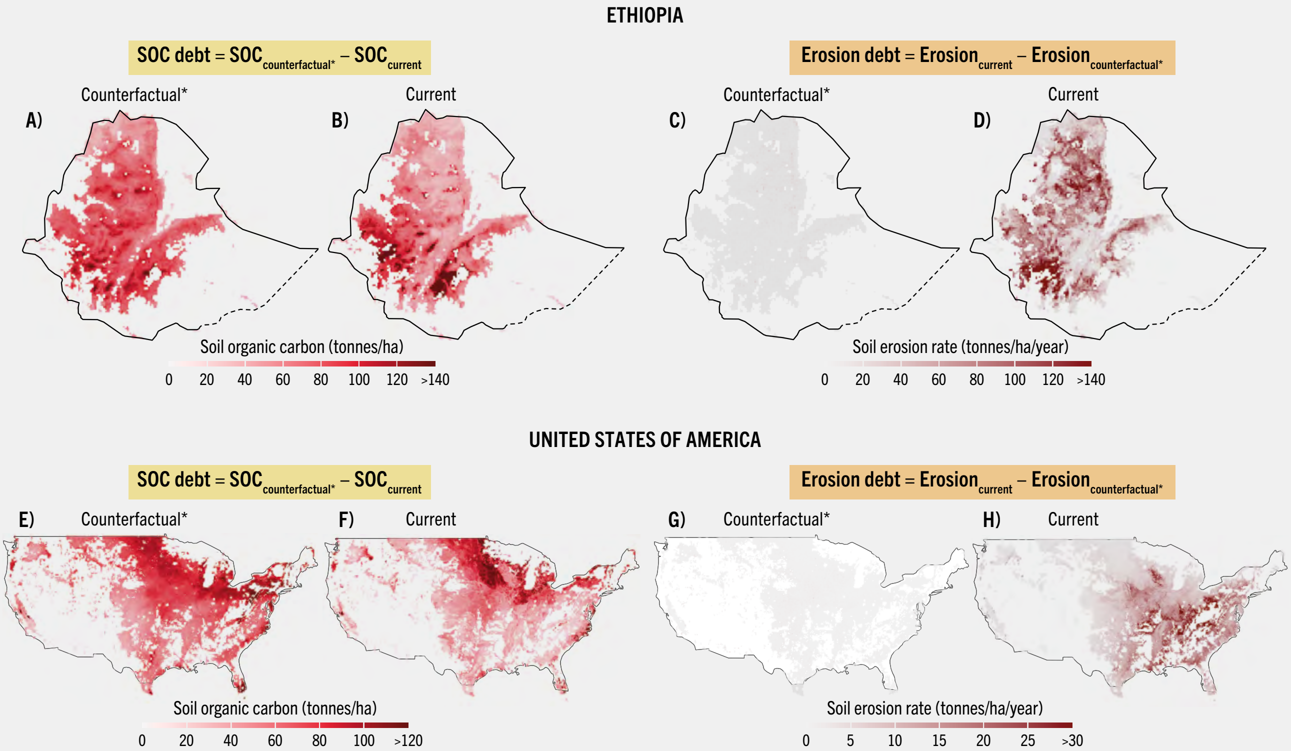
Importantly, this approach does not assume that historical land conditions were optimal for agriculture. Rather, using a historical benchmark provides a reference point to track changes over time and evaluate the long-term impact of human-induced land degradation on current crop yields. This enhances comparability across regions and facilitates the assessment of restoration opportunities. Furthermore, land degradation is treated as a continuous variable, eliminating issues associated with arbitrary thresholds.[48]

attributable to land degradation due to human activity. While isolating the precise contribution of degradation to ACYG is analytically complex, examining its magnitude and spatial patterns in relation to indicators of land degradation can provide insights into how much agricultural potential is being lost. However, establishing a causal link between land degradation and yield gaps is highly challenging, due to the gradual, cumulative and context-specific nature of degradation processes.

If land degradation indicators and ACYG are mapped together, the results show that yields are higher (and hence yield gaps smaller) in areas with higher land degradation. This is because cropland degradation is strongly correlated with intensive agriculture.[40] However, land degradation is only one of many factors that can impact yields. To isolate the impact of land degradation on yield gaps, it is necessary to control for the impacts of other factors, including management choices (input use), agroecological

BOX 7 (Continued)

FIGURE COUNTERFACTUAL AND CURRENT LEVELS OF SOIL ORGANIC CARBON AND SOIL EROSION RATE: ETHIOPIA AND THE UNITED STATES OF AMERICA



NOTES: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. SOC = soil organic carbon. Data were resampled to ~10-km resolution and the data range was clipped at the 97.5th percentile to enhance contrast. * Counterfactual values of SOC and soil erosion rates are estimated using various machine learning models to isolate the native/natural state of the variables without human interference.

SOURCE: Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

conditions (soil type, climate, topography), and socioeconomic and institutional characteristics.

The use of a debt-based approach to measure land degradation helps to capture and isolate the impacts of human activity on land degradation indicators (Box 7). This approach has revealed that, compared to native/natural conditions, global tree cover had fallen by 30 percent, carbon stored in biomass had decreased by 20 percent (average for above- and below-ground carbon) and soil erosion had increased almost fourfold due to human activity, as of 2010.[23] The consequences of these changes for global food security take the form of increasing yield gaps, where a 10 percent increase in land degradation debt is associated with an approximately 2 percent increase in average statistical yield gaps for circa 2010.[40]

Estimating the extent of DIYL on croplands relies on a wide range of global databases and state-of-the art analysis methods. By accounting for input intensities, as well as many other factors that affect yield gaps, this approach isolates the true biophysical yield penalty caused by land degradation, which is often masked when inputs fully or partially compensate for its effects. Box 8 provides further detail on this methodology. »

BOX 8 ESTIMATING THE CAUSAL LINKS BETWEEN HUMAN-INDUCED LAND DEGRADATION AND YIELD GAP AT THE GLOBAL LEVEL

The causal relationship between land degradation and yield gap, referred to here as degradation-induced yield losses (DIYL), is analysed using cross-sectional geospatial data and a control-on-observables regression approach. A global dataset at 10-km resolution is employed, consistent with yield gap measurements. The empirical method employed follows Hadi *et al*. (2025).[40]

A causal forest model – a modern causal machine-learning method[49, 50] gaining traction in applied economics[51–53] – is applied to estimate how yield gap changes with land degradation in each grid of the latest global cropland map. The model is set up to quantify the percentage change in yield gap per 1 percent increase in land degradation indicators defined in Box 7, allowing for assessment of the total impact of soil organic carbon debt, soil erosion debt and soil water debt on current yield gaps.

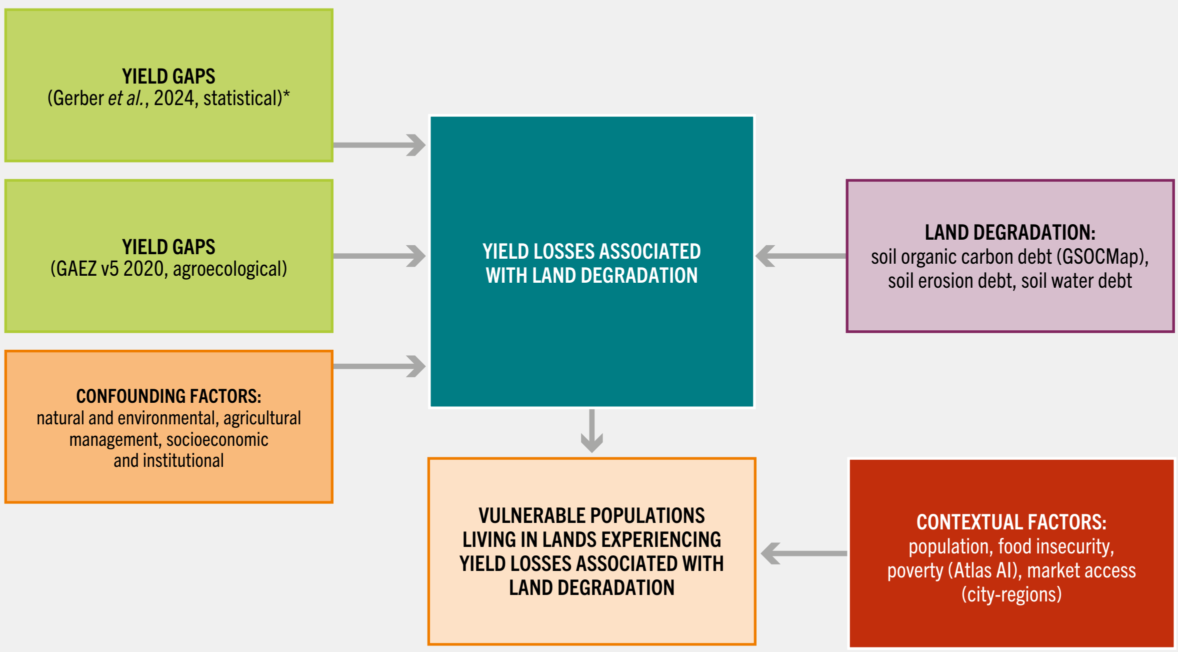
To help ensure that the estimates are robust, the model controls for a wide range of factors (see Table A1 in Hadi and Wuepper [2025]).[39] These include the following:

- **Natural and environmental variables:** climate conditions (e.g. temperature, precipitation, solar radiation), soil properties and topography.
- **Agricultural management features:** fertilizer and pesticide use, irrigation, farm machinery and agricultural employment.
- **Socioeconomic and institutional factors:** gross domestic product, human development index, road density, travel time to cities, access to electricity, mobile phone subscriptions, property rights protection, environmental policy stringency and enforcement, and corruption perception.

The magnitude of the estimated impacts of land degradation on yield gap (i.e. DIYL) is then overlayed with gridded data on socioeconomic factors (e.g. population, poverty, stunting), to identify vulnerability hotspots.

The approach demonstrated here improves upon previous methods[54–56] for measuring land degradation, with a focus on croplands. Earlier studies identified degraded land based on observed negative trends in satellite-measured vegetation indices or net primary productivity over recent decades, accounting for only a limited set of confounding factors (e.g. rainfall, fertilizer use). Others relied on criteria such as slope, soil quality (using only soil water as a proxy) and rainfall. In contrast, the present model identifies degraded land using a more comprehensive and direct representation of degradation processes on croplands and, thanks to the causal forest model, isolates the impacts on latest yield gaps.

FIGURE CONCEPTUAL FRAMEWORK FOR ESTIMATING DEGRADATION-INDUCED YIELD LOSSES



NOTE: * Gerber, J.S., Ray, D.K., Makowski, D., Butler, E.E., Mueller, N.D., West, P.C., Johnson, J.A. *et al.* 2024. Global spatially explicit yield gap time trends reveal regions at risk of future crop yield stagnation. *Nature Food*, 5(2): 125–135. https://doi.org/10.1038/s43016-023-00913-8

SOURCE: Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

» The identification of the causal links between land degradation and yield gaps allows for the estimation of the extent to which yield gaps have already widened specifically due to degradation, as well as facilitating the identification of areas where they are mainly driven by other factors. Crucially, this analysis also facilitates the assessment of socioeconomic vulnerability hotspots, thus linking SDG Target 15.3 more directly to food security outcomes under SDG 2, as well as to poverty (SDG 1) and livelihoods (SDG 8).

Costs of land degradation: global losses in provisioning services from croplands

The global cost of land degradation has been quantified by a number of studies, and it varies significantly according to the ecosystem services and biomes being assessed.[30] It depends on the baseline used, as well as on how ecosystem and provisioning services are valued. Including all costs of land degradation – from those due to decreased production borne by private land users, to those arising from lost ecosystem and cultural services borne by society at large – a global study found that the annual cost of land degradation is about USD 300 billion. More than three-quarters of these costs are attributed to land use and land cover change (LUCC), and the majority of the costs globally are borne by the public rather than by private land users.[30] While this observation makes addressing land degradation partially a public good, understanding the incentives of land users is critical to facilitate action to address degradation for both private and public benefits.

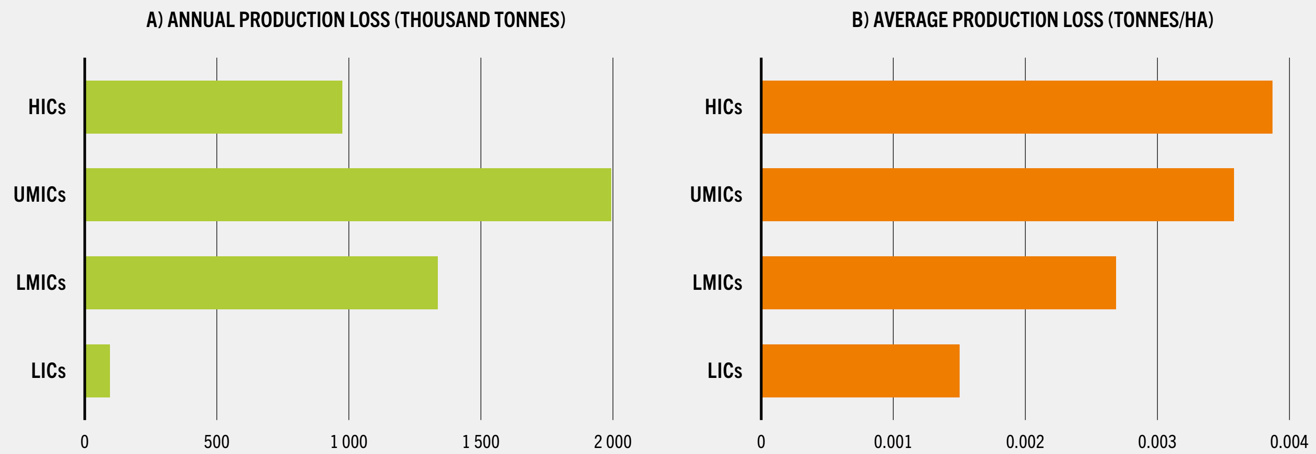
The extent to which land degradation affects crop production, yield gaps and land abandonment has direct implications for the availability dimension of global food security. For hundreds of millions of farms that depend on crop production, it also has an important impact on livelihoods. This section, therefore, focuses on the costs arising from losses in cropland provisioning services; it uses the model described in Box 8 to assess the causal land degradation–yield loss relationship. This chapter later examines the prevalence of land abandonment in cropland areas to understand yield loss in relation to land that was in production at an earlier point in time.

Reduced yields decrease overall crop production, and hence the availability of dietary energy, potentially exacerbating undernutrition in vulnerable populations. Additionally, these losses have direct economic implications, as reduced agricultural output leads to declining revenues for farmers and national economies; if not addressed, this can lead to other forms of degradation driven by LUCC or land abandonment.

The estimated causal relationship between land degradation debt and yield gaps is stronger in high productivity regions of Western Europe, Northern America and South-eastern Asia. This suggests that intensive use of agricultural inputs (i.e. fertilizers, pesticides, improved seed, machinery and irrigation) over long periods can compensate for the impacts of land degradation on yield gaps. It is well established that some indicators recommended by UNCCD to monitor changes in land productivity fail to capture the effects of land degradation in these production systems because of this masking effect.[56] The methodology used in this analysis overcomes this challenge by controlling for a comprehensive set of variables that affect yield gaps (including input and machinery use), highlighting significant DIYL in today's high-input agricultural systems. The DIYL are relatively low in sub-Saharan Africa, Central Asia and Southern Asia, where large yield gaps are driven primarily by causes other than the debt-based land degradation indicators used here, for example, salinization and other types of land degradation, or lack of inputs, technology and information. Converting the estimated DIYL expressed in crop production volumes into dietary energy needed per person per day reveals that, globally, reversing just 10 percent of human-induced degradation debt could restore 44 million tonnes of production and feed an additional 154 million people annually.

The losses associated with each 1 percent increase in land degradation vary markedly by country income group (Figure 9). Panel A shows total annual production losses (in thousand tonnes) and Panel B presents the average production loss relative to harvested crop area (in tonnes per hectare). The largest absolute losses occur in upper-middle-income countries (UMICs) with approximately 2 million tonnes

FIGURE 9 ESTIMATED ANNUAL AND AVERAGE PRODUCTION LOSSES DUE TO LAND DEGRADATION BY INCOME GROUP



NOTES: Panel A shows the total annual production loss for each income group associated with a simulated 1 percent increase in land degradation. Panel B shows the average national per hectare production loss for countries within each income group associated with a simulated 1 percent increase in land degradation. Country income groups are classified as low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) and high-income countries (HICs), according to World Bank definitions for the reference year of the data. Losses are calculated based on estimated yield declines under degradation, applied to national crop production for the year 2020. Crop-level harvest area is from FAO & IIASA. 2025. *Global Agro-ecological Zoning version 5 (GAEZ v5) Model documentation*. [Accessed on 27 June 2025]. https://data.apps.fao.org/gaez/?lang=en. Licence: CC-BY-4.0.

SOURCE: Authors' own elaboration based on Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig09

per year, reflected in Panel A. This is followed by lower-middle-income countries (LMICs) at about 1.3 million tonnes and high-income countries (HICs) at nearly 974 000 tonnes. Low-income countries (LICs), located primarily in Africa, incur the smallest total losses by this measure.

Degradation-induced yield losses relative to each country's harvested cropland area show a pattern that diverges from total losses (Panel B). The largest losses per hectare are seen in HICs and they decrease progressively across UMICs, LMICs and LICs. This gradient reflects the intensive nature of agriculture in HICs, where land degradation has a more pronounced impact per unit area on yield gaps. In such agricultural systems, the productivity impacts of land degradation are difficult to measure because high rates of synthetic fertilizer application partially offset the impacts of soil fertility decline.[56] The costs of such compensatory actions increase over time as land degradation worsens, and can represent a significant cost to farmers even in places where availability and affordability are not an issue.[57]

A key insight emerging from the above analysis is that DIYL are relatively low in most of Africa, indicating that persistently large yield gaps are primarily driven by other reasons in addition to land degradation. In sub-Saharan Africa, yields are generally low due to very limited overall input use[58–60] and low agricultural mechanization rates[61] – a consideration accounted for in the causal analysis. Improving these factors would have a more immediate impact on closing current yield gaps in this context.

Latin America and the Caribbean has absolute production losses driven by land degradation that are much lower than in Asia and Northern America. Regional average losses per hectare (in terms of production and revenues) driven by degradation, however, are high in this region; this is to be expected given that more than two-thirds of its countries are UMICs that tend to partially offset land degradation impacts on yield gaps through input use (Figure 9, Panel B). Although fertilizer application rates in Latin America and the Caribbean are significantly lower than in most parts of Asia, yield gaps are smaller, indicating more efficient use. Nevertheless, the region has pockets (eastern Brazil; central parts of Argentina and the Plurinational State of Bolivia; central and eastern parts of Mexico; and the Caribbean) characterized by large yield gaps that seem to be driven by other factors (e.g. access to inputs and mechanization), as in Africa.

The efforts to address these factors need to avoid unsustainable intensification pathways comprising continuous cultivation, monocropping and overuse of chemicals, which have led to the costly accumulation of long-term degradation debt observed in intensively cultivated regions of today. ■

SOCIOECONOMIC VULNERABILITY HOTSPOTS

The socioeconomic impacts of yield gaps will likely be concentrated in poor and food-insecure regions of the world, heightening the implications of documented losses for global food security.[62, 63] Strategies to address the interconnected drivers of land degradation would benefit from a better understanding of these socioeconomic vulnerability hotspots, where DIYL and ACYG overlap with poverty and food insecurity. The increasing availability of global geospatial data on population structures and socioeconomic indicators facilitates the assessment of such hotspots to identify potential policy entry points.

Populations exposed to degradation-induced yield losses and all-cause yield gaps

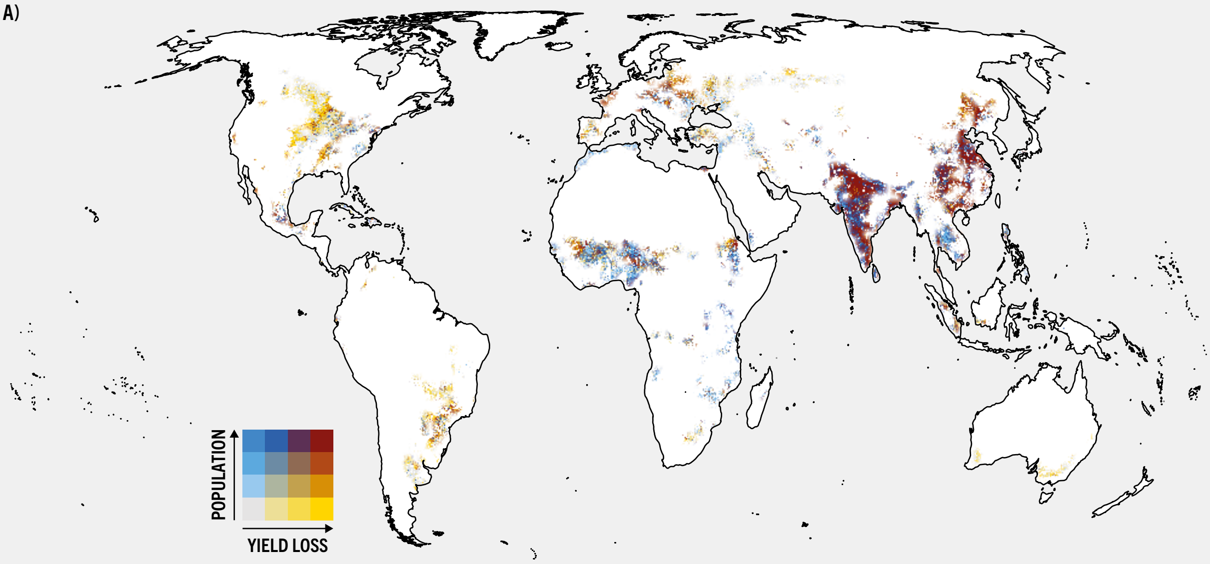
Population hotspots exposed to DIYL and ACYG are shown in Figure 10. Panel A indicates the global distribution of the 1.7 billion people living on land presenting a strong causal link between human-induced cropland degradation and yield loss. The largest affected populations are in Eastern and Southern Asia. Directly addressing the causes of degradation indicators measured here (increases in SOC, erosion and water debts) would decrease yield losses for 1.1 billion people, even if other drivers of yield gaps (e.g. inputs, technology) remain unchanged. Where food insecurity is high, interventions to close yield gaps to increase local food availability and to address other pillars of food security are of particular importance.

The relatively small yield gaps observed in parts of Asia reflect a partial masking of the impacts of land degradation linked to the widespread implementation of intensive agricultural practices. The most important of these practices is excessive use of chemical fertilizers – a key driver of soil degradation. Application rates in many cropping systems significantly exceed the recommended sustainable amounts. While it may make perfect economic sense for private landholders to overapply fertilizers (especially in cases where affordability is not an issue or input subsidies are in place), this practice leads to serious soil health issues, including deep cumulative acidification, salt buildup, poor nutrient use efficiency (often just 30–40 percent), and diffuse pollution from nitrogen and phosphorus runoff.[64, 65] These types of degradation outcomes are not measured herein; however, if addressed, they would bring private long-term benefits. The exception is pollution, which constitutes an environmental externality, hence mostly public benefits if addressed.

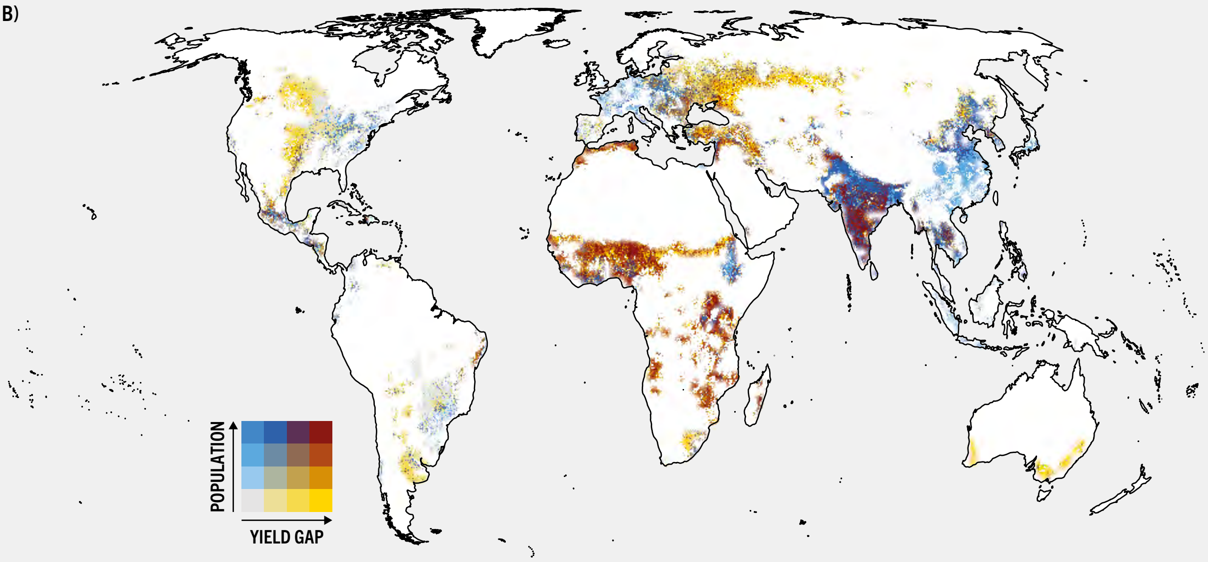
Smallholders that have access to fertilizers are likely to disproportionately overapply them. This tendency is a result of limited access to complementary fixed inputs (e.g. quality seed, machinery), but it is also a risk-averse strategy adopted to safeguard yields in the face of limited capacity to absorb economic or climatic shocks.[64, 66, 67] Such unsustainable intensification »

FIGURE 10 POPULATION HOTSPOTS EXPOSED TO DEGRADATION-INDUCED YIELD LOSSES AND ALL-CAUSE YIELD GAPS

A)



B)



NOTES: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. Panel A indicates populations exposed to degradation-induced yield losses. Panel B indicates populations exposed to all-cause yield gaps.

SOURCE: Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

» can be addressed by optimizing fertilizer types and amounts, improving nutrient use efficiency, and shifting to precision or integrated nutrient management. Adoption of these approaches would reduce yield gaps and improve resilience, while simultaneously reducing the environmental burden of degraded soils.

Panel B of Figure 10 shows the population exposed to all-cause yield gaps. The difference between the two panels is particularly notable in sub-Saharan Africa, due to the region's very high exposure to ACYG. However, in most cases, cropland degradation is not the underlying driver of yield gaps. As discussed above, a variety of factors – including limited use of modern inputs and mechanization, lack of locally adapted agricultural technologies, and market imperfections impeding adoption – drive yield gaps in the region.[58–61] To close yield gaps in sub-Saharan Africa and in other regions facing similar challenges, it is necessary to address these issues while ensuring no worsening of land degradation. For example, fertilizer subsidies should be designed so as to avoid overuse.[66]

Poverty and stunting under yield gaps

In the absence of high-resolution global poverty maps, the background paper for this report uses georeferenced well-being indicators, drawn from Atlas AI, for 40 countries of sub-Saharan Africa and Southern Asia.[a, 68] Figure 11 shows the overlap between populations living below the moderate poverty line (3.20 purchasing power parity dollars, 2011) and DIYL (Panel A) and ACYG (Panel B). The most significant situations of DIYL overlap strongly with poverty in the Indo-Gangetic Plain, making this region a primary hotspot for prioritizing land degradation interventions as part of combined efforts to achieve SDGs 1, 2 and 15. In sub-Saharan Africa, such hotspots include parts of Eastern and Western Africa.

The significant overlap between poverty and all-cause yield gaps, documented in Panel B of Figure 11, once again highlights the importance of primary drivers of low yields other than cropland degradation debts in sub-Saharan Africa.

Hadi and Wuepper (2025)[39] also identify that among the 1.7 billion people living on land with significant DIYL, 47 million are children under 5 years of age suffering from stunting – a key indicator of SDG 2 to end all forms of malnutrition. Overlaying land degradation-related yield losses with gridded stunting data reveals yet another type of socioeconomic vulnerability hotspot. Populations most affected by stunting in these hotspots are concentrated in Southern and South-eastern Asia, and in North-East Africa.[39] ■

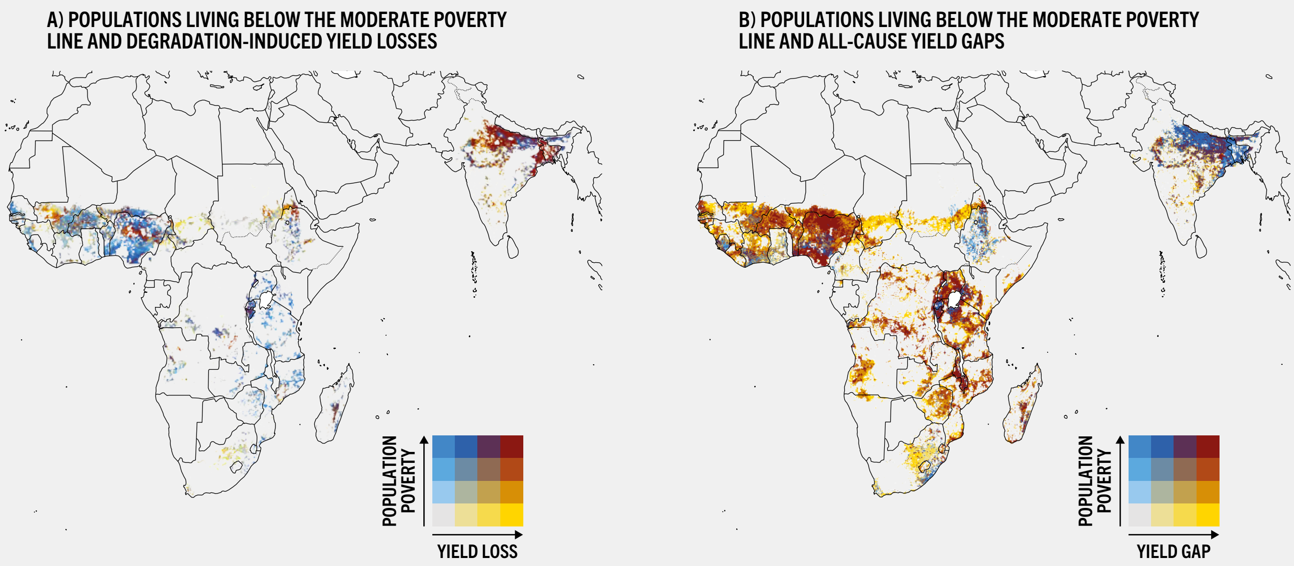
CLOSING YIELD GAPS FOR FOOD SECURITY AND ENVIRONMENTAL SUSTAINABILITY

The findings presented above clearly highlight the importance of agricultural intensification in closing yield gaps. However, historical examples also reveal the long-term consequences of this strategy for land integrity and ecological functions. If intensification processes repeat the historical unsustainable pathways, accumulation of degradation debt will eventually catch up with land users and negatively affect yields, or may even result in land abandonment. Given that most of the global cost of land degradation is borne by the broader society (in terms of lost ecosystem services and environmental pollution), efforts to close yield gaps for food security will need to balance private benefits (from degrading practices) and public costs.

Global agricultural production can increase in two main ways: by expanding the production frontier or by closing existing yield gaps. While policies that promote innovation and push the production frontier are essential – especially to reverse the recent slowdown of total factor productivity growth in agriculture – they may offer diminishing returns in regions already operating close to their biophysical yield potential. Therefore, closing existing yield gaps, especially in areas still far from their productivity potential, is vital for sustaining long-term growth in global food production.[69]

a See the Atlas AI FAO documentation: https://faodocs.atlasai.co/economic%20well-being/spending/#poverty-estimates

FIGURE 11 POVERTY, DEGRADATION-INDUCED YIELD LOSSES AND ALL-CAUSE YIELD GAPS FOR SUB-SAHARAN AFRICA AND SOUTHERN ASIA



NOTE: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

SOURCE: Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

Failure to do so has significant implications for environmental sustainability. When yield improvements fall short, food demand has often been met by expanding farmland into previously uncultivated areas – a process known as agricultural extensification. While this approach can increase food supply, it also reduces land available for conservation and wildlife habitats.[70] Such increases in land degradation through LUCC further add to the costs of degradation borne by the consumers of ecosystem services off the farm.

There is ongoing debate about which agricultural practices best manage the land and ecological footprint of food production. Researchers have long examined the environmental trade-offs between two main strategies: high-yield agriculture with a small footprint (land sparing) versus wildlife-friendly, lower-yield farming over larger areas (land sharing).[70, 71]

The land-sparing approach is based on the idea that increasing yields through innovations – such as high-yielding seeds – can reduce the need to convert natural ecosystems into farmland.[72, 73] If the land saved is restored or protected in large habitat blocks (e.g. woodlands, grasslands, wetlands), this can support conservation objectives.[74] However, land sparing does not automatically result in nature conservation. For spared land to contribute meaningfully to biodiversity, formal protection through targeted environmental policies is required.[70, 75–77]

In contrast, land sharing integrates biodiversity-supporting practices within agricultural landscapes. These include crop rotation, intercropping, agroforestry, conservation agriculture and mixed crop–livestock systems, which would also decrease land degradation.[73] Although often perceived as lower yielding, many of these systems bring both private benefits (i.e. yields) and public benefits (i.e. ecosystem services).[78, 79] A synthesis of over 5 000 experiments found that crop diversification enhances yields, biodiversity, and key ecosystem services such as water quality, pest control and soil health. Agroforestry, which prevents soil erosion and fixes nitrogen, demonstrated particularly high benefits – including a 35 percent increase in crop production.[80]

As in most initially polarized debates, research has evolved towards a more nuanced understanding. Both land sparing and land sharing have roles to play; trade-offs are bound to exist in land-use decisions and need to be carefully managed.[81, 82] Box 9 provides a brief overview of the debate on land sparing vs land sharing.

In practice, trade-offs vary significantly across different environmental and socioeconomic contexts. The impact of yield improvements on land use also differs by scale. For example, the green revolution was found to be much more land sparing at the global level than at the local level, underscoring the importance of incorporating international trade into such assessments.[88]

For policymakers, the challenge lies in identifying where these trade-offs can be minimized. Some areas may be more suitable for intensification to close yield gaps, while others may benefit more from strategies focused on sustainability and biodiversity conservation. This calls for an integrated approach to decision-making, one that combines insights from natural sciences and economics to align ecological needs with economic incentives.[89, 90] ■

BROADER DEGRADATION PROCESSES AND LAND ABANDONMENT

Developing such an integrated approach hinges upon understanding the broader land degradation processes and incentives that drive them. Although there is no agreement on how to measure all land degradation processes on all biomes, overlaying eight different methods reveals a broad agreement on the extent of global land degradation.[91] Globally, LUCC generates most of the ecosystem services lost due to degradation and is mainly driven by conversion of forest land to grazing land in Latin America, grassland to cropland in sub-Saharan Africa, and grassland to barren land in Asia.[63]

The incentives driving these transitions differ in practice, but at their core lies the fact that private economic incentives do not align with the values of ecosystem services. For example, most farmers facing large yield gaps on their cropland and lacking the ability to restore land quality would not value the ecosystem services lost by converting forest land or grassland into cropland. Indeed, most of the deforestation linked to farming is associated with small-scale farming in Africa and large-scale farming in Latin America and South-eastern Asia.[92]

If degradation on existing croplands is left to continue over long periods of time, land abandonment can also ensue as part of LUCC. Though abandonment is mostly driven by socioeconomic drivers – as in the case of the vast areas of cropland in Central Asia abandoned after the collapse of the former Soviet Union[93] – it is also incentivized by cropland degradation and yield gaps.[94] For example, a study in southern Chile found that declining soil quality was a leading driver of cropland abandonment.[95] However, a recent study found that lands abandoned since 1992 and considered suitable for recultivation had the potential to feed between 292 million and 476 million people.[36]

Figure 12 shows the overlap between croplands abandoned from 1992 to 2015 and the latest global cropland layer used in this report. It is evident that cropland abandonment is happening in »

BOX 9 FROM TRADE-OFFS TO SYNERGIES: RETHINKING LAND SPARING VS LAND SHARING

Proponents of land sparing emphasize that yield increases should be achieved through sustainable intensification, which aims to boost food production on existing farmland without causing additional environmental harm.[83] Critics, however, raise the Jevons paradox, which suggests that efficiency gains lead to higher production and consumption, potentially encouraging cropland expansion, given that enhanced productivity can make cultivation more economically attractive in these areas.[84, 85]

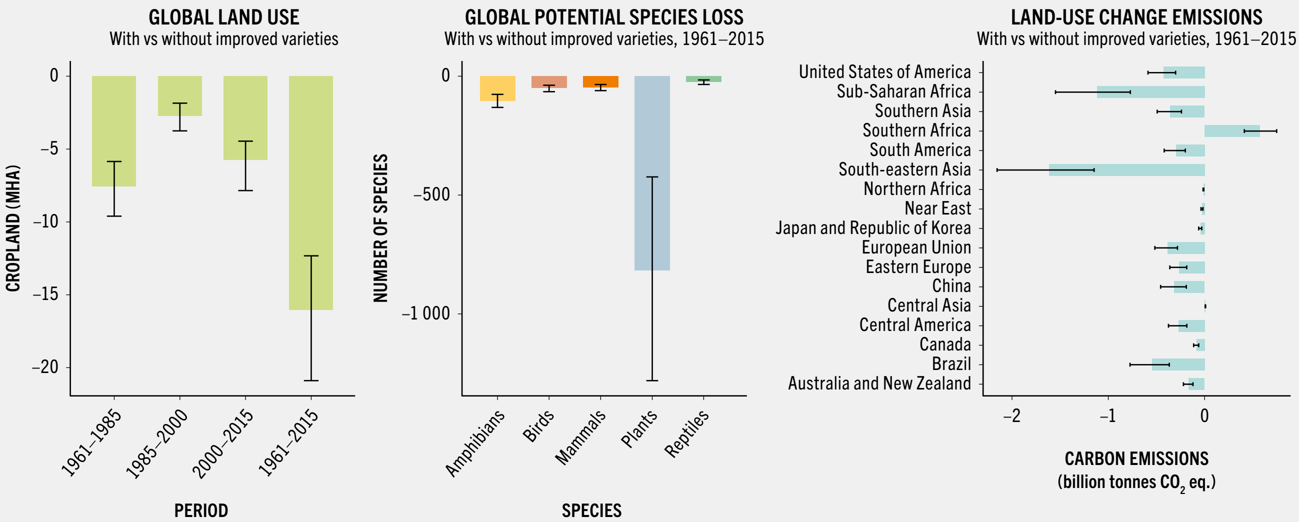
However, a global study by Baldos *et al.* (2025)[86] found that improved crop technologies actually led to a reduction of 16.03 million ha of cropland between 1961 and 2015. This reduction resulted in gains in terrestrial carbon stock and prevented the extinction of around 1 043 threatened animal and plant species (see figure). While some regions did experience cropland expansion due to higher crop profitability, supporting the Jevons paradox, other regions saw slower expansion due to market-mediated spillover effects, leading to overall environmental benefits. These context-specific outcomes suggest that the impacts of improved crop technologies are complex and context-dependent.

Some experts argue that the sparing vs sharing debate misses the mark. Baudron *et al.* (2021),[87] for instance, criticize its reliance on yield–density trade-offs, arguing that the debate underplays synergies between agriculture and biodiversity and that producers may also prioritize aspects other than yields, including income generation, labour productivity, risk mitigation, and cultural and traditional values. Finally, they suggest that farm profitability may be a more comprehensive indicator, because increases in yield do not always result in increased revenue.

Similarly, Kremen (2015) challenges the binary framing and proposes alternatives that combine aspects of sharing and sparing.[70] Examples include large habitat blocks surrounded by diversified farming systems designed to support biodiversity and sustainable food production.[71] These intermediate approaches aim to create multifunctional landscapes that balance high agricultural productivity with biodiversity conservation.

In summary, the debate on land sparing and land sharing underscores the need for a nuanced approach to agricultural practices. While high-yield farming can potentially free up land for conservation, it requires effective policies to ensure environmental benefits. Conversely, integrating biodiversity-friendly practices within agricultural landscapes can enhance ecosystem services, but private incentives need to be aligned with public benefits for successful implementation. The most promising solutions likely include a combination of strategies across space that reconcile agricultural productivity and environmental sustainability at the systems level.

FIGURE EFFECTS OF IMPROVED CROP VARIETIES ON CROPLAND EXPANSION, BIODIVERSITY LOSS AND TERRESTRIAL CARBON EMISSIONS



SOURCE: Baldos, U.L.C., Cisneros-Pineda, A., Fuglie, K.O. & Hertel, T.W. 2025. Adoption of improved crop varieties limited biodiversity losses, terrestrial carbon emissions and cropland expansion in the tropics. *Proceedings of the National Academy of Sciences of the United States of America*, 122(6): e2404839122. https://doi.org/10.1073/pnas.2404839122

https://doi.org/10.4060/cd7067en-figB09

» the vicinity of current croplands. This pattern is particularly visible in areas of intensive agriculture where land degradation was found to cause significant degradation-induced yield losses. When land is abandoned after falling out of productive use, reclaiming and restoring it can be very costly, often requiring government intervention, as in Uzbekistan.[96] Consequently, the pressure increases to produce more from existing cropland, highlighting the importance of addressing the degradation–yield gap nexus. ■

CONCLUSION

This chapter examined the ways in which land degradation affects global agricultural productivity, with profound implications for environmental sustainability and socioeconomic well-being. The impacts of accumulated land degradation, relative to conditions that would likely prevail in the absence of human activity, undermine the capacity of land to support sustainable agricultural production, and lead to growing yield gaps and increased vulnerability. A comprehensive approach to assessing land degradation – including indicators measuring changes in soil organic carbon, soil erosion and soil water – within a debt-based framework helps to distinguish between human-induced and natural degradation, offering a clearer picture of the land's health and its potential for productivity.

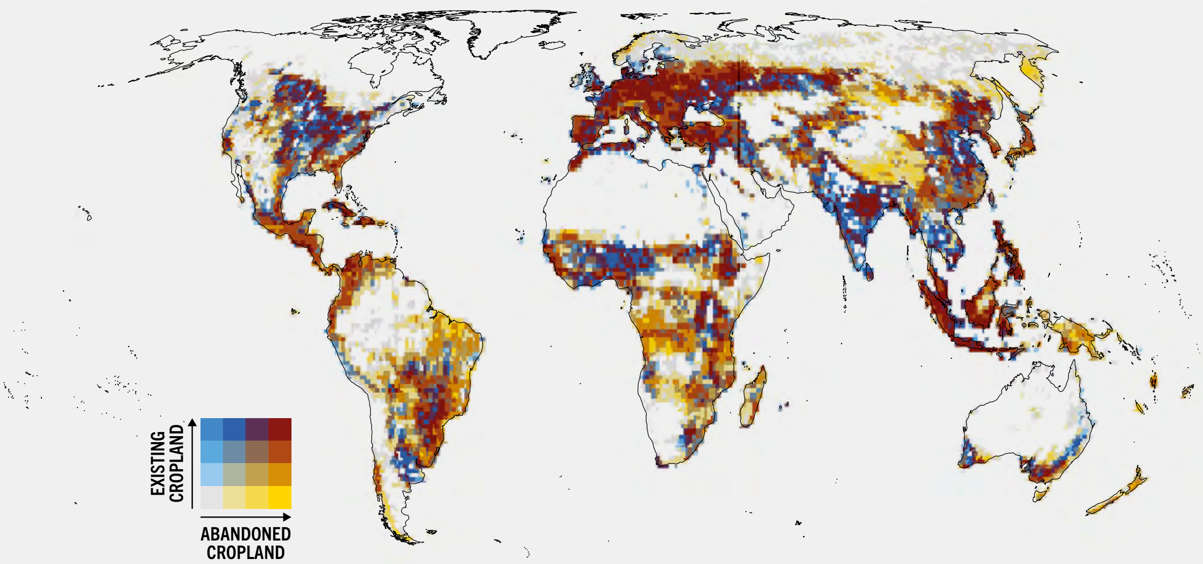
Assessing the causal linkages between land degradation and yield gaps requires consideration of multiple factors, including management practices, agroecological conditions and socioeconomic circumstances. While establishing a direct causal link is challenging, the costs of degradation in terms of larger yield gaps – manifested in the loss of potential calories, revenues and production – are clear. Around 1.7 billion individuals live in areas where crop yields have been significantly impacted. Reversing just 10 percent of this degradation could restore sufficient production to meet the annual caloric requirements of 154 million people.

These figures understate the true scale of the impact of land degradation for three reasons:

- First, they relate only to cropland and exclude pastureland. However, the degradation of pastureland negatively affects both human and animal health, reducing income and productivity for dependent livelihoods, and potentially increasing the risk of conflict.[12]
- Second, they quantify the impacts on provisioning services derived from land that are mostly borne by private land users, and these only constitute a small share of the total cost of global land degradation. Other effects of cropland degradation not measured here, including decreased carbon sequestration, intensified biodiversity loss and increased pollution, impose much larger costs on the global community. Many people outside degraded croplands depend on the ecosystem goods and services those lands provide, making action to address degradation a public good.[30]
- Third, most of the global cost of land degradation is attributed to LUCC (not quantified here). The costs of the yield losses on cropland quantified herein, combined with the possibility that they could lead to land abandonment, in conjunction with population and market pressures, can incentivize LUCC if not addressed.

The findings in this chapter underline the contributions of historical land degradation to crop yield gaps across all levels of economic development. In intensively managed agricultural systems in high-income countries, per hectare production losses due to historical land degradation are particularly high. This likely reflects the long-term consequences of intensive agriculture including monoculture, and excessive use of synthetic fertilizers and heavy machinery. In other words, current practices are maintaining high yields in these regions by increasingly compensating for the negative effects of land degradation. However, while agricultural intensification can mask yield gaps temporarily, it cannot indefinitely prevent productivity losses if land degradation continues. Thus, while the private benefits of compensatory practices may exceed private costs, farmers implementing these practices face increasing overall costs and are contributing to the intensification of land degradation.

FIGURE 12 HOTSPOTS OF ABANDONED CROPLAND (1992–2015) AND EXISTING CROPLAND (2020)



NOTES: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. Abandoned cropland aggregated at 1° resolution is sourced from Næss *et al.* (2021), which mapped cropland abandonment based on the European Space Agency Climate Change Initiative Land Cover annual product. Existing cropland in 2020 is sourced from GAEZ v5 cropland share dataset at 10-km resolution (FAO and IIASA, 2025) and resampled to match the 1° grid of abandoned cropland data.

SOURCES: Næss, J.S., Cavalett, O. & Cherubini, F. 2021. The land–energy–water nexus of global bioenergy potentials from abandoned cropland. *Nature Sustainability*, 4(6): 525–536. https://doi.org/10.1038/s41893-020-00680-5; FAO & IIASA. 2025. Global Agro-Ecological Zones version 5 (GAEZ v5). [Accessed on 20 February 2025]. https://data.apps.fao.org/gaez/?lang=en. Licence: CC-BY-4.0.

The relatively weak causal relationship between land degradation and yield loss, observed across the African continent, should not be interpreted as evidence that soil health interventions are not beneficial for closing yield gaps in this region. Rather, it indicates that other constraints – for example, unavailability of inputs and labour, poor infrastructure, and lack of access to markets, credit or information – are equally or more important than biophysical land degradation in terms of causing yield gaps. Nonetheless, soil health matters in its own right; it therefore remains a fundamental component of agricultural productivity, particularly in predominantly low-input systems, where soils respond poorly to increased input use. Given the very high current yield gaps, doubling crop yields in Africa would have a substantial impact on local livelihoods, even if the contribution to closing the global yield gap is relatively modest.[97] Accordingly, the findings presented here suggest the need for a holistic assessment of the complementary factors, in addition to land degradation, that constrain yield gaps in this region.

Such an approach would also address poverty and food insecurity challenges in the Indo-Gangetic Plain and parts of sub-Saharan Africa. Closing yield gaps through sustainable management of croplands would improve not only livelihoods but also ecosystem services, and create positive spillover effects on other types of land cover.[79, 86] This would significantly decrease the global costs of land degradation, which are mainly driven by changes in land-use and land-cover, including conversion of forest land to grazing land in Latin America and the Caribbean, grassland to barren land in Asia, and grassland to cropland in sub-Saharan Africa. The costs of these transitions are borne by society as a whole, while the incentives of private land users are driven by the value of provisioning services (crop yields), making land degradation a global problem that requires both global and local solutions.[30]

Given the need to promote sustainable land management in areas with both small and large yield gaps,[98] it is essential to understand the decision-making processes of the full range of farming systems, whose day-to-day land-use decisions affect global outcomes. Farms of all sizes contribute to global food production and land degradation to a varying extent. Accordingly, the global distribution of farm sizes is subject to scrutiny as part of the discourse on the future of farms (especially smallholders), food production and food.[99]

The following chapter presents the latest estimates of the global distribution of farm sizes, using data from the most recent available agricultural censuses; it explores the extent to which farms control global agricultural land and contribute to food production. It also highlights the particular challenges farms face in addressing land degradation and food security, and the underlying drivers. Farmers' incentives and their ability to invest in reducing and reversing land degradation and ultimately restoring land – while improving productivity – can differ significantly depending on farm size, land conditions and socioeconomic factors. Larger farms often have more resources to invest in advanced technologies that optimize input use and productivity, but may also exacerbate land degradation. However, these farms may also have greater incentives to maintain land quality if clearly linked to long-term profitability. Conversely, smaller farms often contend with more vulnerable land conditions, and struggle with limited resources and multiple market constraints. These interact with socioeconomic and environmental conditions in different ways to shape incentives for addressing degradation. Farm size, therefore, while not the only factor influencing land management and food production, shapes all other determinants in important ways. This feature is assessed systematically using the most recent data and methodologies in the next chapter. ■

AFGHANISTAN
A farmer uses certified wheat seed to cultivate his land.
© FAO/Hashim Azizi

CHAPTER 3
GLOBAL LANDSCAPE OF FARMS AND FOOD PRODUCTION

KEY MESSAGES

➔ There are approximately 570 million farms worldwide. While about 85 percent of these farms are smaller than 2 ha, they operate only 9 percent of agricultural land. Meanwhile, farms covering over 1 000 ha account for just 0.1 percent of the total number, yet operate half of all agricultural land.

➔ The distribution of farm sizes varies significantly across regions. In Africa and Asia, medium-sized farms cover about half of available agricultural land; in other regions, the majority of farmland is located on farms larger than 1 000 ha.

➔ Despite persistent constraints that limit their productivity, the almost 500 million smallholders worldwide are important contributors to global food supply, producing around 16 percent of dietary energy, 9 percent of fats and 12 percent of plant-based proteins.

➔ Large farms exceeding 50 ha have an outsized influence on global agricultural land and food provision, hence are uniquely positioned for driving solutions to land degradation.

➔ As agrifood trade increasingly connects distant regions, it is crucial that policies and organizations for sustainable agrifood systems consider the global impacts of land use across farms of all sizes, including medium- and large-scale operations that manage the majority of the world's farmland.

Human-induced land degradation and the resulting yield losses are ongoing issues that undermine the ability to produce food sustainably. These challenges are intertwined with socioeconomic vulnerabilities and pressures on land to meet increasing demand for land-based products and ecosystem services. Understanding the challenges faced by those who manage agricultural land is therefore crucial to designing effective policy solutions that promote sustainable land use and ensure long-term food security.

Effective policies to sustainably increase agricultural production require a comprehensive knowledge of the people responsible for land management. This includes understanding who land managers are, the scale at which they operate, their contribution to global food production, and the obstacles they face in increasing productivity while managing land sustainably. Improving knowledge of these key areas will enable policymakers to better assist those responsible for the primary production stage of global agrifood systems. ■

WHO IS MANAGING AGRICULTURAL LAND? FARM SIZE AND LAND DISTRIBUTION

Understanding the distribution of agricultural land – including both croplands and permanent meadows and pastures – by size is essential to address land degradation and yield gaps, while promoting sustainable agricultural practices. Farms of varying scales often encounter unique challenges related to market constraints that affect land management and sustainability outcomes.

Smaller farms continue to face enduring barriers such as limited access to land, credit, inputs, technology, information and markets, often combined with poverty and food insecurity. These can compel survival-driven decisions that degrade land. When smallholders lack resources to invest in sustainable practices or struggle with the threat of food insecurity, they may resort to production practices such as continuous farming without restoring soil fertility (with organic or inorganic fertilizers), leading to nutrient mining.[1] They may also apply fertilizers (when available) inefficiently, resulting in nitrogen pollution,[2] or expand cultivation into ecologically fragile areas. In addition, smallholders may find it costly to participate in certification schemes that increase incomes and incentives for sustainable land use. As a consequence, many such schemes are dominated by large-scale producers.[3]

Despite managing most of the world's farms, small-scale farmers and their households make up a disproportionately large share of the 2.3 billion people experiencing moderate or severe food insecurity as of 2023[4] and the majority of the world's poor.[5–8] Increasing their competitiveness and productivity would therefore have an immediate impact on poverty and food insecurity. Indeed, the Sustainable Development Goals aim to double the labour productivity and incomes of small-scale food producers by 2030 to end hunger, achieve food security and promote sustainable agriculture.

Large farms manage the majority of agricultural land and account for the bulk of global cereal, oilseed and livestock production, ensuring stability in food supply chains, export markets and urban food systems. Accordingly, they have very different incentive structures. On the one hand, large farms benefit from economies of scale, face much lower market constraints, and can optimize production through the use of technology; on the other, they often specialize in monoculture and intensive systems that may also increase land degradation and reduce crop diversity.[9] Depending on the value chain, large-scale farms may dominate sustainability certification schemes, while at the same time leading to agricultural land expansion and the social exclusion of smallholders.[3] Given that large farms operate the majority of the world's farmland, the impacts of their decisions affect much wider areas of cropland and food availability, not only locally but also globally.

Recent studies indicate that the constraints limiting agricultural productivity vary depending on the scale of operation. When scale-dependent constraints are addressed, including those that prevent the efficient allocation of land and labour across farms of different sizes, there is significant potential to increase overall agricultural productivity.[10–12] However, in sub-Saharan Africa, these challenges have shown little improvement, with smallholder total factor productivity decreasing over the last decade. In parallel, the adoption of sustainable land and water management strategies has also declined, despite exposure to land degradation.[13, 14] Given the multiple challenges to rural transformation combined with population pressure in this region – the only region where the population is projected to increase over the next few decades – farm sizes are at the core of the dual challenge of food security and land degradation.[15]

Addressing differentiated pathways to land degradation by farm size therefore requires targeted interventions based on an understanding of how farms and farmlands are distributed worldwide, and of the specific dynamics at play. For instance, smallholders may contribute more to agrobiodiversity, rural employment and climate resilience, while larger farms provide high levels of output, underpinning commercially viable food

TABLE 1 GLOBAL DISTRIBUTION OF FARMS, AREA OPERATED AND DIETARY ENERGY PRODUCTION

Farm size category (ha)	Total farms (millions)	Total area operated (million ha)	Share of farms (%)	Share of area operated (%)	Share of dietary energy (kcal) produced (%)
<1	422.5	156.7	72.6	5.5	9.9
1–2	73.5	101.9	12.6	3.6	6.3
2–5	58.3	169.4	10.0	5.9	9.3
5–10	14.8	99.1	2.5	3.5	4.9
10–20	5.7	75.6	1.0	2.6	4.5
20–50	3.6	107.8	0.6	3.8	7.6
50–100	1.6	105.5	0.3	3.7	7.3
100–200	1.0	132.9	0.2	4.6	9.5
200–500	0.7	200.2	0.1	7.0	11.5
500–1 000	0.3	182.5	0.0	6.4	11.6
>1 000	0.3	1 529.8	0.1	53.5	17.6
Total	**582.1**	**2 861.5**	**100.0**	**100.0**	**100.0**

NOTES: The figures on the number of holdings and total area operated are based on the latest available national data from 131 countries and territories reported between 2006 and 2023. The total number differs from the total number of farms projected to 2025, in accordance with the expected decline in the number of farms globally. Data in the last column on the share of dietary energy produced cover 77 countries and territories that have production data by farm size. See **Annex 1** for the list of countries and territories.

SOURCES: Authors' own elaboration based on Lowder, S., Arslan, A., Cabrera Cevallos, C.E., O'Neill, M. & de la O Campos, A.P. 2025. *A global update on the number of farms, farm size and farmland distribution – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-14. Rome, FAO; Arslan, A., Ranuzzi, E., O'Neill, M., Ricciardi, V., Lowder, S. & Vaz, S. 2025. *Revealing complementarities across farm scales in global food production – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-13. Rome, FAO.

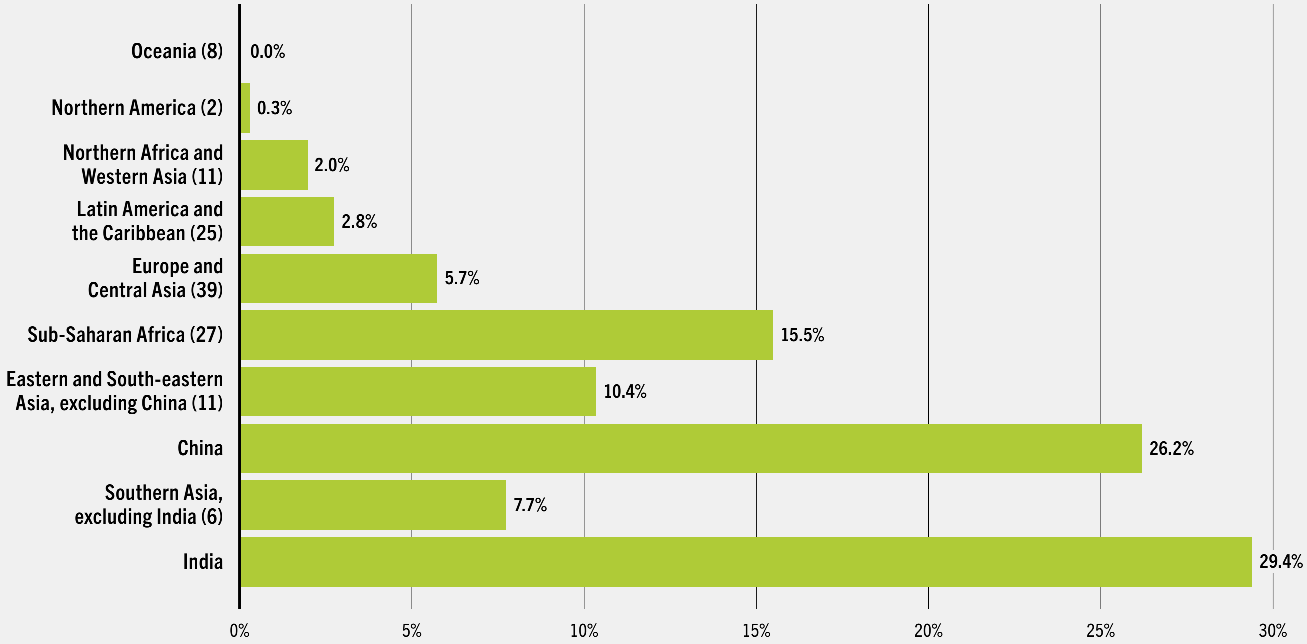
production. A systems approach to understanding the interactions among farms of different sizes can uncover levers to enhance positive spillover effects for improved and sustainable land use and productivity enhancements.[16, 17] Recognizing and addressing these interdependencies is critical to achieving global food security in the face of growing population demands and climate change.

Globally, farm sizes and production are unevenly distributed

The number of farms worldwide is continuously changing, based on multiple drivers (e.g. income, land availability, demographic change)[18] and their distribution across different farm size categories. Understanding this trend is an essential component of designing and targeting policies to address challenges to agricultural production and land degradation. Farm size is strongly connected with multiple dimensions of food security. Furthermore, the discourse regarding the future of farms – including land and labour productivity, income and poverty, as well as interactions between other economic sectors and agriculture – is linked to farm size.[19] Based on the most recent data available from agricultural censuses and surveys, and projections accounting for the main drivers of global farm numbers,[18] this report estimates that there are just over 571 million farms globally in 2025, spread across 131 countries and territories.[20]

Table 1 presents the distribution of farms and agricultural land across farm size categories, along with the contribution of farms of each size to global dietary energy production. The total number of farms in the table is based on the latest available national data sources before projections to 2025, therefore differs from the total above. The gradual decline in the total number of farms is expected based on the historical patterns captured in projections. Estimating the distributional dynamics within countries, however, is not possible without further data and assumptions; hence the farm size and area distributions in this chapter are based on the year in which each country collected its data (spanning 2006–2023). This constitutes the most consistent and up-to-date picture of

FIGURE 13 DISTRIBUTION OF 571 MILLION FARMS BY REGION, 2025



NOTES: The bars show each region/country's share of the world's farms (based on projections from 131 countries and territories). The numbers in parentheses are the number of countries and territories in each region. For the list of countries and territories covered, see Annex 1 of Lowder *et al.* (2025).

SOURCE: Authors' own elaboration based on Lowder, S., Arslan, A., Cabrera Cevallos, C.E., O'Neill, M. & de la O Campos, A.P. 2025. *A global update on the number of farms, farm size and farmland distribution – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-14. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig13

how the number of farms, agricultural land, and agricultural production are distributed globally.

It is important to emphasize that the production estimates presented here pertain exclusively to cropland area, which is a subset of the broader agricultural land used by farms globally. They do not include ivestock, fisheries and other kinds of non-crop agricultural production.

The findings underscore the dominance of smallholder farms (<2 ha) in terms of numbers, as well as the disproportionate share of agricultural land controlled by farms exceeding 50 ha globally (accounting for around 75 percent). Detailed data on agricultural production from croplands available for 77 countries show that these larger farms produce more than 55 percent of crop-derived dietary energy globally.[21] Among them, farms over 1 000 ha account for more than 50 percent of agricultural land and produce about 18 percent of all dietary energy from crops (see **Annex 1** for country-specific data).

However, the global numbers in Table 1 conceal significant differences across regions and income groups. This chapter uses the most recent data and methodologies to provide a detailed understanding of these indicators, which are critical to the collective achievement of the 2030 Agenda for Sustainable Development.[22]

Farm distribution patterns vary across regions

Of the estimated 571 million farms globally, China and India host around half. The rest of Eastern and South-eastern Asia accounts for 10 percent, and Southern Asia for 7.7 percent (Figure 13). In sub-Saharan Africa, 27 countries

BOX 10 ESTIMATING GLOBAL FARM SIZE DISTRIBUTIONS

Analysis of farm size distribution relies on three main approaches: direct observation from survey data,[26] analysis of aggregated census data[24] or downscaled Earth observation data, in which satellite measurements of field sizes are calibrated with national data.[25] All of these methods come with strengths and limitations.

Reliance on survey data can limit the scope of a study, as coverage is necessarily constrained to a subset of countries and territories with recent farm size surveys. Additionally, the surveys used may not be nationally representative, and their sampling frames may systematically exclude certain categories of holdings.

Use of official data from agricultural censuses allows for broader geographical coverage but comes with its own drawbacks.[20] Census data are almost always processed to prepare publicly available tabulations at aggregate levels, preventing direct computation of key distributional measures such as the median or inequality indices. Furthermore, the land size categories used in census tabulations often vary across countries and over time, complicating cross-country and intertemporal comparisons of farm size distribution. Finally, many countries go decades without conducting agricultural censuses, leading to reliance on outdated data.

To tackle these challenges, Cabrera Cevallos *et al.* (forthcoming) developed LINEQ: Global Database of Land Distribution and Inequality, a comprehensive resource providing harmonized estimates of farm size distributions and land inequality.[27] The database applies advanced interpolation techniques to census tabulations from the World Programme for the Census of Agriculture, reconstructing the full underlying distribution of farm sizes as a generalized Pareto curve.[28] This enables the estimation of key distributional measures while ensuring consistent farm size categories across all countries and time periods.

To enhance coverage, LINEQ also integrates nationally representative surveys, particularly to fill gaps in sub-Saharan Africa, where census data are often scarce. This combined approach allows for a more comprehensive and globally comparable dataset, covering 178 countries and including 593 censuses and 32 surveys. Of the countries covered, 131 have reported detailed data on farm size distribution since 2006, and these form the basis of most of the analysis in this chapter.

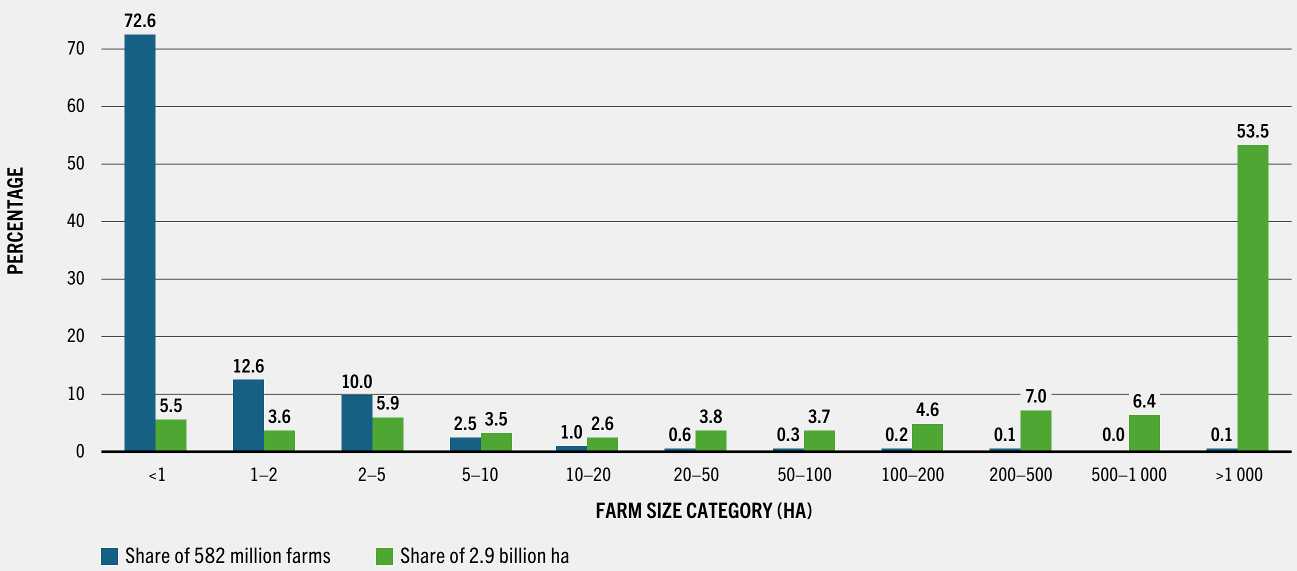
host 15.5 percent of the world's farms. In contrast, farms in Latin America and the Caribbean tend to be larger but less numerous, making up only 3 percent of the global total.

Some 6 percent of the world's farms are located in 39 European and Central Asian countries, while Northern America accounts for only a negligible share, reflecting the large farm sizes in Canada and the United States of America compared to Europe. Similarly, the share of farms in eight countries of Oceania is also negligible, due to the very large but very few farms in Australia and New Zealand, as well as the small number of farms located in the region's small island states.

If historical structural transformation pathways were to unfold everywhere, there would be a decrease in the share of agriculture in the economy and labour force, accompanied by farmland consolidation and urbanization.[18, 23] These pathways might differ across regions, however. The total number of farms in the world is projected to decrease by 50 percent by the end of the twenty-first century. At the same time, the number of farms in some regions is projected to increase significantly, particularly in sub-Saharan Africa, representing a deviation from historical pathways.[18, 22]

While the total number of farms is indicative of the location of farming activity in the world, understanding how global agricultural land is managed also requires information on the scale of farming operations. Consistent and up-to-date data on a large set of countries on this topic have been scarce, leading researchers to rely on outdated datasets and simple projections,[24] or on downscaled large-scale earth observation data, which introduce substantial uncertainties.[25] Such

FIGURE 14 GLOBAL SHARE OF FARMS AND AREA OPERATED BY FARM SIZE



NOTES: The figure is based on the latest available census data from 131 countries and territories reported between 2006 and 2023. The total number of farms differs from the total number of farms projected to 2025, in accordance with the expected decline in the number of farms globally.

SOURCE: Authors' own elaboration based on Lowder, S., Arslan, A., Cabrera Cevallos, C.E., O'Neill, M. & de la O Campos, A.P. 2025. *A global update on the number of farms, farm size and farmland distribution – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-14. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig14

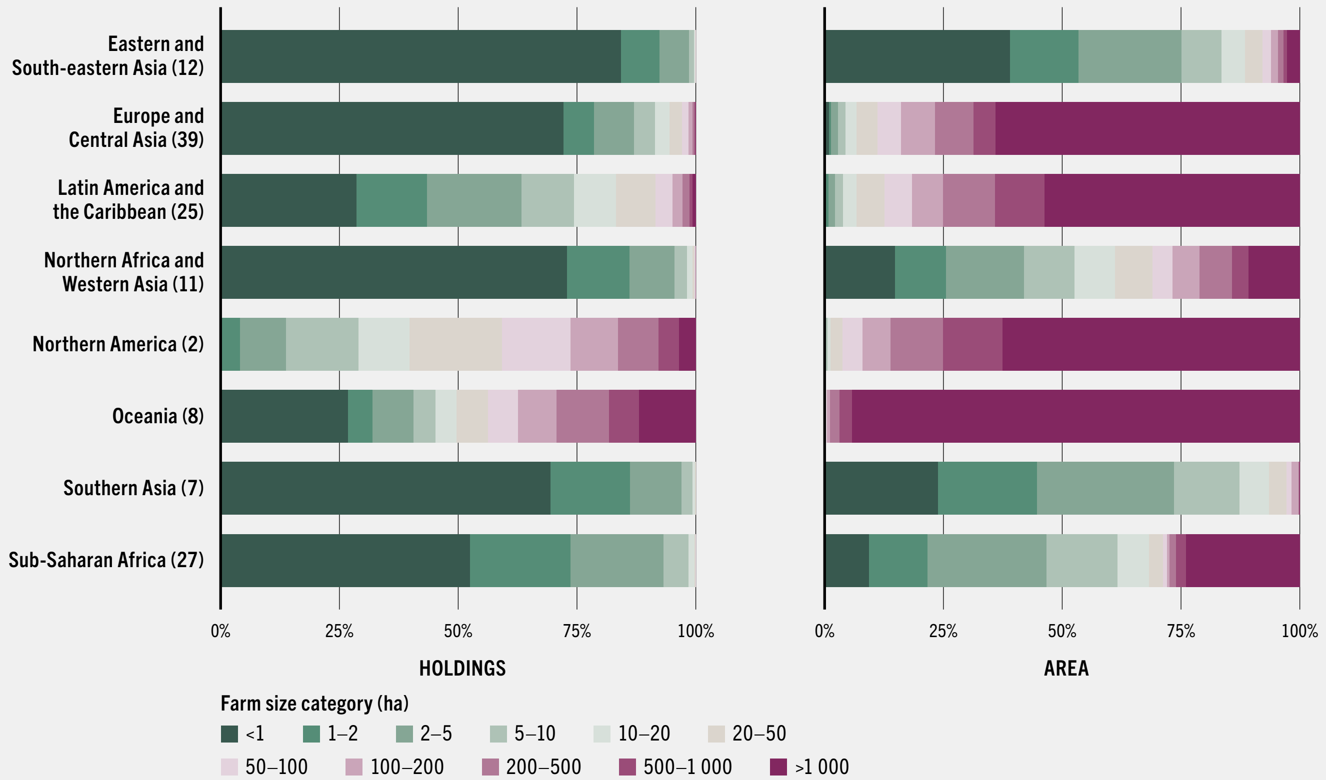
information is essential for efforts to develop the necessary context-specific balance between improving the livelihoods of rural producers and meeting the changing food demands of an increasingly urban population, while simultaneously addressing land degradation.[19]

To bridge this gap, a new database curated by FAO leverages the latest methodological advances to estimate comparable full farm size distributions from (sometimes limited and incomplete) official census data (Box 10).

The global distribution of farmland by size reveals three key insights (Figure 14). First, smallholder farms (<2 ha) are vast in number, estimated at around 500 million; they constitute approximately 85 percent of all farms worldwide, yet collectively occupy a much smaller portion of the land, spanning only about 9 percent of global agricultural area. In contrast, medium-sized farms (2–50 ha) represent a more balanced share, accounting for around 14 and 16 percent of the number of farms and the agricultural area operated, respectively. Finally, farms classified as large (>50 ha) make up less than 1 percent of all farms but cover a substantial 75 percent of agricultural land. This concentration is even more pronounced within very large farms exceeding 1 000 ha, which, despite their tiny number (290 000), operate on more than 50 percent of global agricultural land (equivalent to 1.5 billion ha). These very large farms cover vast areas of farmland in five countries: Australia, Russian Federation, United States of America, Brazil and Argentina – listed by extent of agricultural area.

The stark contrast between the high prevalence of smallholdings and the limited number of very large operations underscores a critical policy dichotomy. On the one hand, these figures supply evidence of the need to support the livelihoods of the vast number of smallholders reliant on land; on the other, improving the sustainability of land management practices

FIGURE 15 PROPORTION OF HOLDINGS AND AREA OPERATED BY REGION



NOTES: The figure is based on the latest available census data from 131 countries and territories reported between 2006 and 2023. The numbers in parentheses are the number of countries and territories in each region.

SOURCE: Authors' own elaboration based on Lowder, S., Arslan, A., Cabrera Cevallos, C.E., O'Neill, M. & de la O Campos, A.P. 2025. *A global update on the number of farms, farm size and farmland distribution – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-14. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig15

is paramount for the minority of farms that steward a disproportionately large share of global agricultural land. Given this unequal farmland distribution, tackling large-scale issues – for example, land degradation, the concentration of agricultural production, and the environmental impacts of monocropping – demands targeted strategies for the largest farms. Conversely, supporting smallholders remains essential to positively impact the practices and livelihoods of the greatest number of farmers.

However, the picture of farm size distribution is not uniform worldwide, with both numbers and sizes varying significantly and distinct patterns emerging across regions. As shown in Figure 15, agricultural systems in Asia and Africa are composed primarily of numerous small-scale holdings. At the same time, around 50 percent of agricultural land is operated by farms that range between 2 ha and 50 ha in both regions. In comparison, Europe and Central Asia, Latin America and the Caribbean, Northern America, and Oceania display a broader distribution of farm sizes, along with very concentrated farmland distributions. Northern America stands out with the lowest share of smallholders and a balanced distribution of farm sizes, although more than 60 percent of all agricultural land is operated by farms exceeding 1 000 ha.

FIGURE 16 PROPORTION OF HOLDINGS AND AREA OPERATED BY COUNTRY INCOME GROUP

NOTES: The figure is based on the latest available data from 131 countries and territories reported between 2006 and 2023. The numbers in parentheses are the number of countries in each income group. Country income groups are classified as low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) and high-income countries (HICs), according to World Bank definitions for the reference year of the data.

SOURCE: Authors' own elaboration based on Lowder, S., Arslan, A., Cabrera Cevallos, C.E., O'Neill, M. & de la O Campos, A.P. 2025. *A global update on the number of farms, farm size and farmland distribution – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-14. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig16

Farm distribution differs across country income groups

Farmland distribution is highly correlated with income groupings (Figure 16). In low- and lower-middle-income countries, agriculture is driven predominantly by a large number of smallholders. Taken collectively, these smallholders manage a significant proportion of the land, despite the small size of their holdings. Farms larger than 10 ha are rare in these income categories.

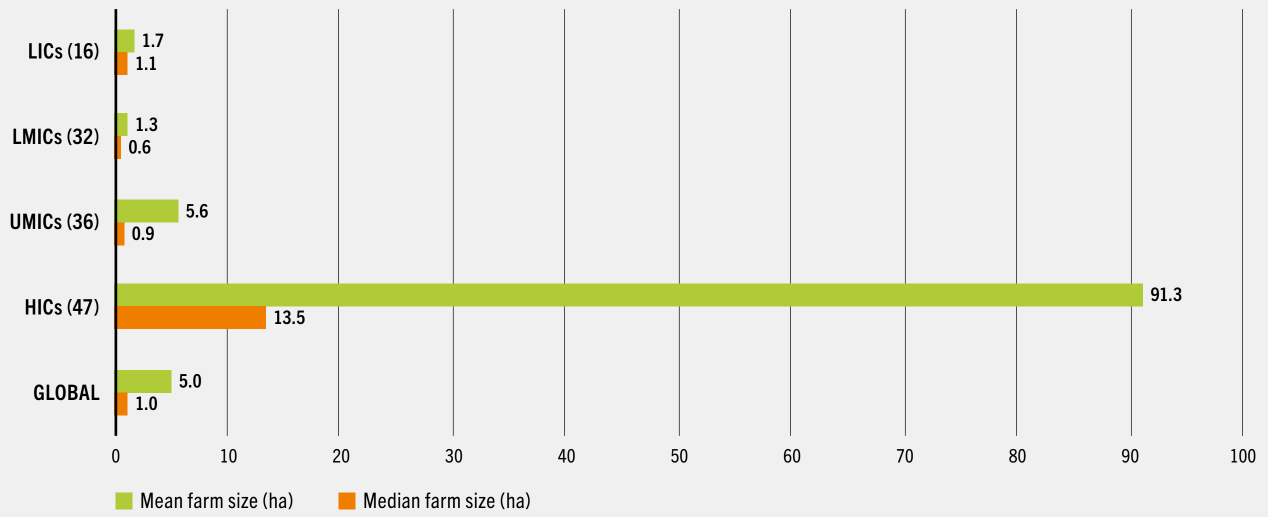
In upper-middle-income countries, while smallholdings account for the largest proportion of farms, their share of the land is significantly lower, with very large farms of 1 000 ha or more covering more than half of the farmland.[b]

High-income countries, in contrast, exhibit a broader range of farm sizes. Nevertheless, here too, land management is dominated by very large farms, which cover a clear majority of agricultural land. This pattern highlights a fundamental shift from smallholder-dominated farming in lower-income economies to the dominance of large-scale agricultural operations in higher-income economies.

This trend suggests that in countries with higher income levels, farmland tends to be more concentrated among large farms, while smallholdings are less common. This observed tendency towards consolidation – where farms become larger and fewer – aligns with expectations based on conventional theories of how economies develop and transform. However, these expectations are not fully supported by detailed assessments at the country level, as patterns differ significantly. Increasing evidence shows that structural transformation does not

b The distribution for UMICs with 90 percent of farms smaller than 2 ha largely reflects the situation in China, where a large share of the world's farms are located and where most farms are smallholdings.

FIGURE 17 MEAN AND MEDIAN FARM SIZES BY COUNTRY INCOME GROUP



NOTES: Data cover 131 countries and territories with farm size distribution information from 2006 to 2023. Country income groups are classified as low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) and high-income countries (HICs), according to World Bank definitions for the reference year of the data. Farm sizes are weighted by the total number of agricultural holdings in each country to ensure equal weight for each farm in the group mean and median values.

SOURCE: Authors' own elaboration based on Lowder, S., Arslan, A., Cabrera Cevallos, C.E., O'Neill, M. & de la O Campos, A.P. 2025. *A global update on the number of farms, farm size and farmland distribution – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-14. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig17

necessarily lead to land consolidation in many places.[29] Instead, trends in average farm size over time, for select countries, show that population density seems to explain changes in average farm size (one aspect of farmland distribution) better than economic growth.

Farmland patterns are changing over time

Globally, farmland distribution patterns evolve, albeit slowly, with farm sizes exhibiting divergent trends across regions. Before examining these trends, it is important to note the distinction between mean (commonly referred to as "average") farm size and median farm size, as these convey different information about the typical farm and inequality. While the mean farm size is frequently used in discussions of trends, it can be heavily influenced by extremely large or small holdings and may not accurately represent the size of a typical farm. The median farm size, on the other hand, provides a better picture of the typical farm, as the size falls exactly in the middle of the distribution. Comparing the mean to the median can therefore serve as an implicit indicator of farm size inequality.

Looking at the trends, farm sizes present divergent trajectories globally. As economies have grown and structural transformation unfolded, operated farm sizes have increased in most regions (especially in the twentieth century), albeit with notable exceptions. More recently, in the last 20 years, mean farm sizes have continued to increase in most of Latin America and the Caribbean and Europe and Central Asia, while decreasing in most of the rest of Asia. However, this decrease has since slowed compared to the period from 1960 to the early 2000s.[23, 24]

In sub-Saharan Africa, farm sizes in general have historically become smaller in tandem with population growth, with some recent exceptions. For instance, in Ghana, the United Republic of Tanzania and Zambia, farms in the middle of the distribution (5–100 ha) have increased in size due to growth in investments by urban-based professionals or wealthier rural residents. Nevertheless, smallholdings continue to make up the overwhelming majority of farms, even in these countries.[26]

BOX 11 LAND DISTRIBUTION: QUANTITY VERSUS QUALITY?

While land area remains the most common metric for assessing distribution, differences in land quality are equally important for understanding inequality in agricultural potential and economic outcomes. Land value, which can serve as a proxy for productivity, offers useful insights. Recent studies have shown that land inequality appears more pronounced when both size and value are considered, with larger landholders often owning higher-quality, more productive land.[30] While developed countries regularly monitor land prices through registries and surveys, such data are scarce in many developing regions, especially for agricultural land. One approach that addresses this gap is to standardize land area using observable farm-level characteristics or geospatial data which reflect land quality and productivity.

Earth observation data can be used to develop a Crop Productivity Index (CropPI) as a proxy for land quality.[31] CropPI combines real-time environmental data (temperature, water availability and soil conditions) with crop-specific requirements to assess the suitability of local conditions for agricultural production. This enables estimation of the natural productivity potential of land across both spatial and temporal dimensions.

Standardizing land by its potential productivity generally leads to an increase in measured inequality. In several African and Latin American countries, for example, the share of high-quality land operated by the top 10 percent rises, while the share held by the bottom 40 percent typically declines, when compared to the equivalent shares of non-quality-adjusted land.[27, 32] This pattern highlights a concentration of high-potential land among fewer landholders.

The difference between mean and median farm sizes is significant globally. Across the 131 countries included in the farm size distribution analysis, mean farm sizes are two to seven times greater than median farm sizes across all income groups (Figure 17). This difference is largest in UMICs and HICs, pointing to higher levels of inequality in this group.

Using data from 43 countries that have conducted at least two censuses since the 2000s, a recent analysis of managed agricultural land by size shows that the mean farm size differs notably across country income groups, and that HICs and UMICs have experienced significant increases in both mean and median farm sizes (Table 2).[20]

Despite limited data availability for LICs and LMICs, the sample presented reveals meaningful trends. Globally, more than half of the countries in the study experienced an increase in both mean and median farm sizes between 2000 and 2020. This upward trend is driven largely by HICs, of which 22 out of 29 reported an increase in the mean, and 19 reported an increase in the median. In contrast, the limited data for LICs and LMICs suggest an inverse trend, with both indicators generally declining over the same period. Additionally, the difference between the mean and the median is significantly more pronounced in UMICs and HICs, indicating more unequal distributions. Notably, only a small number of countries across all income groups showed no significant change, reinforcing the point that the observed trends are, in most cases, statistically meaningful.

These findings suggest not only growing disparities in average holding sizes across countries but also widening gaps within them – particularly in HICs. At the same time, it should be noted that land area is only one dimension of farm distribution. Differences in land quality also shape productive potential and economic outcomes; when land is assessed in terms of quality or value, even starker disparities may emerge. New approaches using geospatial data and environmental indicators are beginning to shed light on this dimension of inequality (Box 11). ■

TABLE 2 CHANGES IN MEAN AND MEDIAN FARM SIZES FROM THE 2000s TO THE 2020s BY COUNTRY INCOME GROUP

Income group	Indicator	Latest value	No. countries with		
			Increase	Decrease	No significant change
LICs	Mean	1.34		2	
	Median	0.91	1	1	
LMICs	Mean	1.09	2	4	
	Median	0.57	2	4	
UMICs	Mean	3.30	2	3	1
	Median	0.70	1	4	1
HICs	Mean	73.43	22	6	1
	Median	13.40	19	9	1
Global	**Mean**	**3.49**	**26**	**15**	**2**
	Median	**0.87**	**23**	**18**	**2**

NOTES: The table presents mean and median farm sizes by country income group using data from 43 countries that conducted agricultural censuses in both the World Programme for the Census of Agriculture (WCA) 2000 and WCA 2020. Farm sizes are weighted by the total number of agricultural holdings in each country to ensure equal weight for each farm in the group mean and median values. Income group classifications correspond to the status of each country at the time of its most recent census. Country income groups are classified as low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) and high-income countries (HICs), according to World Bank definitions. Changes in median farm sizes were categorized as increases, decreases or no significant change based on bootstrapped confidence intervals.

SOURCE: Authors' own elaboration based on Cabrera Cevallos, C.E., de la O Campos, A.P., O'Neill, M., di Simone, L. & Fahad, M. (forthcoming). *Divide in the fields: A study of global agricultural land inequality*. FAO Agricultural Development Economics Working Paper. Rome, FAO.

WHICH FARMS PRODUCE THE BULK OF FOOD?

Understanding which farms produce the bulk of the world's food is central to shaping effective agricultural policies and research. Given the vastly different shares of global land operated by farms of different sizes documented above, determining how much of the world's food is produced by each size category is critical to designing sustainable agrifood systems policies. Farms of different sizes have complementary roles to play in meeting the demand for land-based agricultural products while conserving ecosystem services.[33]

Thus far, most research on global food production by farm size and the future of farming has concentrated on smallholdings and family farms. This emphasis is driven partly by the SDGs, as many related indicators focus on the role of smallholders in sustainable development.[9, 24, 25, 33] Smallholders tend to grow a more diverse range of crops and non-crops,[34] with most of their crop production consumed as food; in contrast, larger farms tend to produce crops for animal feed and processing.[9] This difference in categories of food produced at varying scales adds to the complementarity of different types of farms within an agrifood system.

While some of this research adopts a systems approach and assesses the contributions of larger farms, the onus of the discourse on the future of farming and farm sizes remains on smallholders. This section expands the literature by addressing data and methodological challenges to examine how farms across 11 farm size categories contribute to the global production of crops supplying a significant share of dietary energy (including from macronutrients).

Diversity of global agricultural production patterns

The latest analysis – based on a comprehensive assessment of direct measurements of production on croplands, drawing on 77 agricultural censuses and nationally representative surveys – shows

FIGURE 18 SHARE OF DIETARY ENERGY, PROTEINS AND FATS SUPPLIED BY CROP PRODUCTION BY FARM SIZE

NOTES: Data cover 77 countries with crop production information from 2006 to 2023. Country level data are available in the Supplementary data at https://doi.org/10.4060/cd7067en-supplementarydata

SOURCE: Authors' own elaboration based on Arslan, A., Ranuzzi, E., O'Neill, M., Ricciardi, V., Lowder, S. & Vaz, S. 2025. *Revealing complementarities across farm scales in global food production – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-13. Rome, FAO.

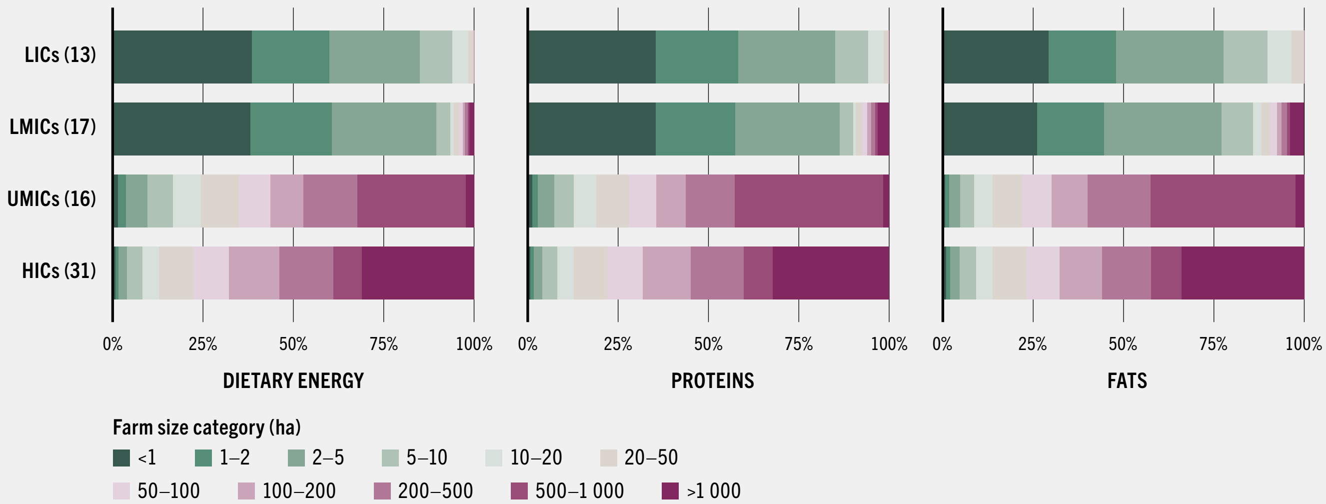
https://doi.org/10.4060/cd7067en-fig18

that crops produced by smallholder farms supply globally 16 percent and 12 percent of crop-derived dietary energy and proteins, respectively, in addition to 9 percent of fats.[21] These figures reflect only the production of crop-derived nutrients, and therefore exclude the dietary contributions of livestock, fisheries, forestry and other sources of nutrition. The results of this assessment are illustrated in Figure 18. The figure also addresses the limited spatial coverage of Africa, South-eastern Asia and Eastern Asia, as well as associated methodological challenges in previous literature,[9] which decrease the share of food production previously attributed to smallholders. Regardless, considering the multitude of constraints that smallholders face in accessing resources such as land, finance, inputs, information and technology, their contribution to global food production remains remarkable. Moreover, given the sheer number of smallholders in many developing countries, they remain critical to local food availability and improved incomes and livelihoods and play a vital role in inclusive rural transformation.

Globally, however, larger farms play a leading role in food production, reflecting their dominance over the control of land. Farms between 2 ha and 50 ha produce crops accounting for around one-quarter of all dietary energy and macronutrients assessed, while those larger than 50 ha are responsible for approximately 60 percent. The largest farm size category (>1 000 ha) is responsible for almost one-sixth of the dietary energy and macronutrients derived from crop production globally.

The contribution of farms of different sizes to crop production varies significantly by country income level (Figure 19). In HICs, farms larger than 1 000 ha account for about one-third of all dietary energy supplied by crops, underscoring the dominance of large-scale commercial agriculture. In contrast, in LICs and LMICs, the vast majority of crop production comes from farms smaller than 5 ha, highlighting the critical role of smallholder farmers in these regions.

FIGURE 19 SHARE OF DIETARY ENERGY, PROTEINS AND FATS SUPPLIED BY CROP PRODUCTION BY COUNTRY INCOME GROUP AND FARM SIZE



NOTES: The figure covers a total of 77 countries reporting crop production information from 2006 to 2023. The numbers in parentheses indicate the number of countries in each income group. Income groups are from to the World Bank's categorization for the reference year of the data. Country income groups are classified as low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) and high-income countries (HICs), according to World Bank definitions. The cropland area covered by these data is about 850 million ha, corresponding to 54 percent of global cropland area in 2022.

SOURCE: Authors' own elaboration based on Arslan, A., Ranuzzi, E., O'Neill, M., Ricciardi, V., Lowder, S. & Vaz, S. 2025. *Revealing complementarities across farm scales in global food production – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-13. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig19

At the regional level, a particularly striking trend emerges in Northern America, where the only country included in the dataset is the United States of America; farms larger than 1 000 ha produce almost half of the country's crop-derived dietary energy supply (Figure 20). This pattern reflects the dominant role of large-scale farming operations in national and global food supply chains.

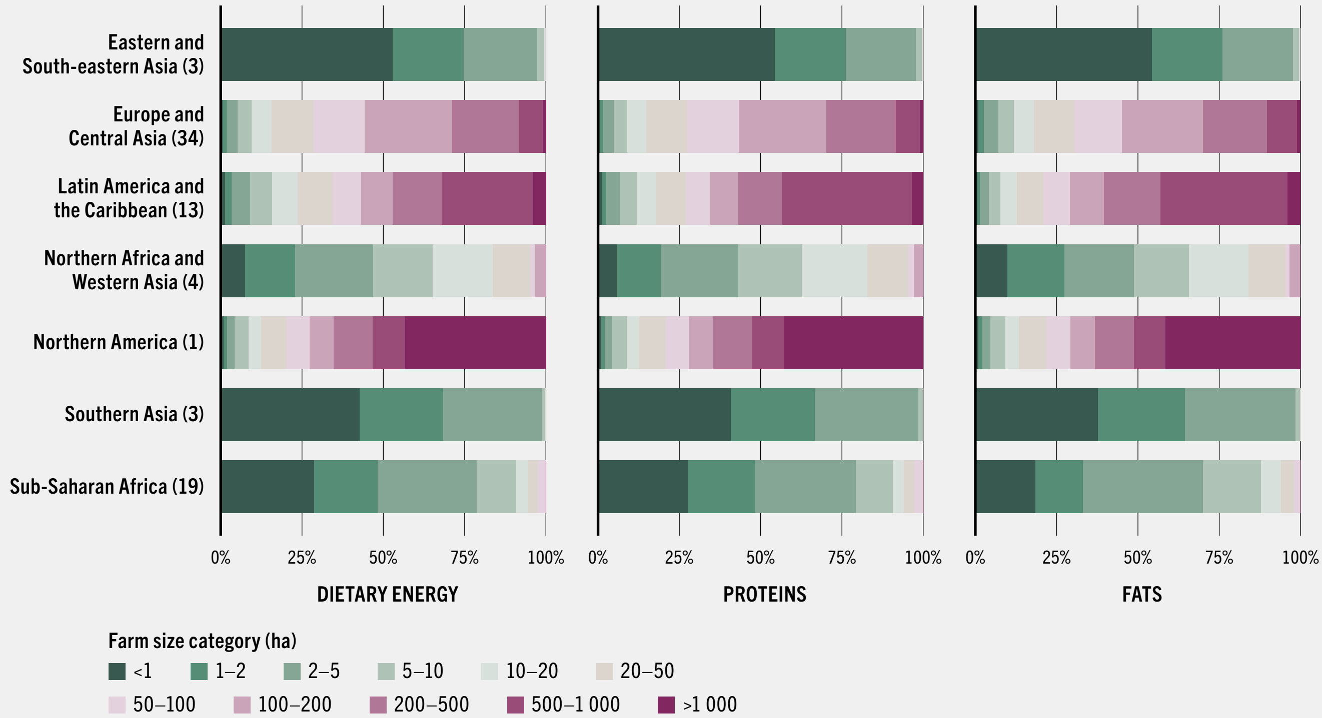
A similar, though less extreme, concentration is observed in Latin America and the Caribbean, where farms greater than 500 ha also account for a substantial share of crop-based dietary energy production. This pattern is strongly shaped by Brazil, the region's agricultural powerhouse, where commercial farming plays a leading role alongside a large base of small and medium-sized farms.

In contrast, this degree of concentration is not observed in Europe and Central Asia, where farms in the 100–200 ha range contribute the most to dietary energy production. This reflects the region's distinct agricultural structure characterized by medium-sized farms rather than the vast expanses of farmland seen in the Americas.

In sub-Saharan Africa and South-eastern, Eastern and Southern Asia, small farms under 5 ha continue to play a crucial role, producing the bulk of food supplies. This trend highlights the persistence of smallholder farming as the backbone of food security and livelihoods in these regions, emphasizing the need for policies that support their productivity.

The above global assessment is a first step in understanding how farm size relates to overall nutrient availability. While proteins and fats

FIGURE 20 SHARE OF DIETARY ENERGY, PROTEINS AND FATS SUPPLIED BY CROP PRODUCTION BY REGION AND FARM SIZE



NOTES: The figure covers a total of 77 countries reporting crop production information from 2006 to 2023. The numbers in parentheses indicate the number of countries in each region.

SOURCE: Authors' own elaboration based on Arslan, A., Ranuzzi, E., O'Neill, M., Ricciardi, V., Lowder, S. & Vaz, S. 2025. *Revealing complementarities across farm scales in global food production – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-13. Rome, FAO.

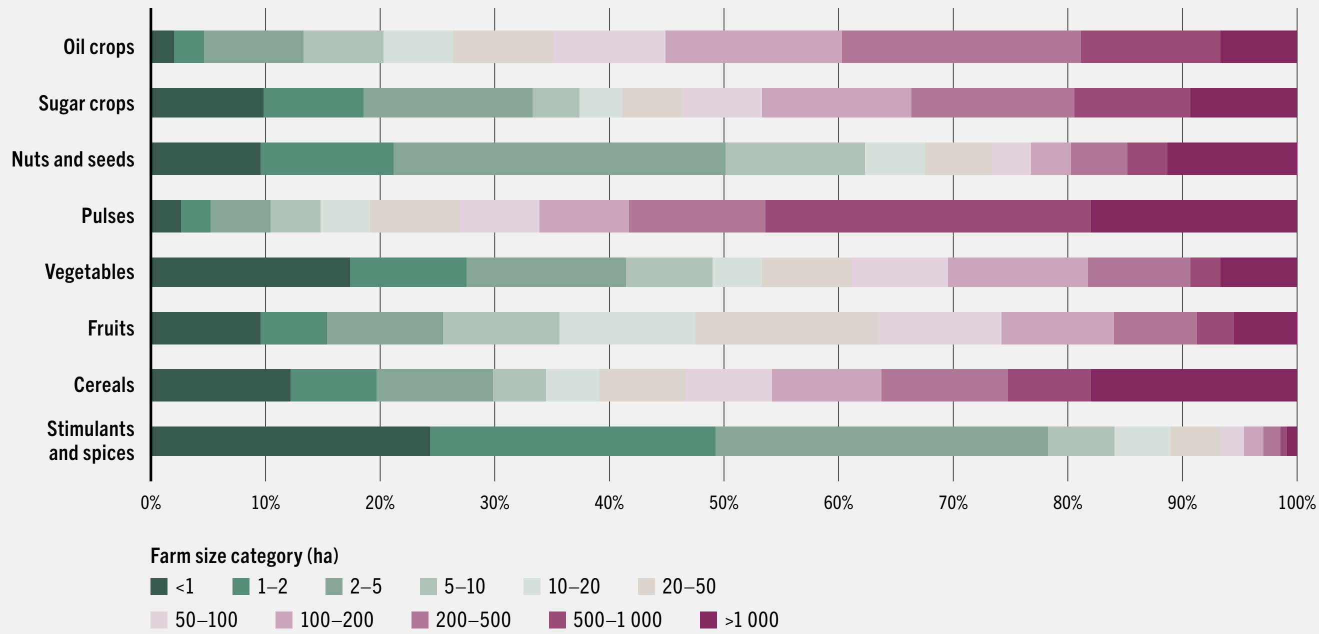
https://doi.org/10.4060/cd7067en-fig20

are significant sources of energy in diets, a more complete understanding of which types of crops are grown is needed to guide policy. Figure 21 shows the relative contributions of farms of different sizes to global food production by crop group. Smallholders' contribution to the production of cereals, fruits and vegetables is around 20–30 percent. Farms smaller than 5 ha produce almost 50 percent of the global output of stimulants, spices and aromatic crops. Despite their minimal contribution to caloric intake, these are high-value crops that boost smallholder incomes. For example, in northeastern Madagascar – the global centre of vanilla production – such crops significantly enhance smallholder livelihoods through increased income and asset ownership.[35] There is also growing evidence that herbs and spices add to overall human health and wellness thanks to a variety of beneficial properties.[36, 37]

Farms greater than 50 ha dominate the global production of cereals, pulses, sugars and oil crops. These commodities are highly traded globally, reflecting larger farms' better integration into global supply chains.[9, 25] In addition, the consumption of whole grains, pulses and seeds is associated with improved health and a reduced risk of chronic diseases.[38–40]

Micronutrients are essential for human health and well-being. How their production is distributed across farm sizes can inform nutrition-sensitive agricultural and land-use

FIGURE 21 **CONTRIBUTION OF DIFFERENT FARM SIZES TO GLOBAL DIETARY ENERGY PRODUCTION BY CROP GROUP**



NOTES: The figure covers a total of 77 countries reporting crop production information from 2006 to 2023. The bars represent the total dietary energy derived from the production of each crop group, broken down by farm size category. This figure does not distinguish between the end uses of crops – that is, whether they are consumed as food (and in what form), used as animal feed, converted to biofuels, or otherwise processed. According to FAOSTAT Supply Utilization Accounts, across the countries included in this dataset, 18.5 percent of crop-derived kilocalories are used for livestock feed, highlighting the indirect contribution of the crops assessed to animal-based protein production.

SOURCE: Authors' own elaboration based on Arslan, A., Ranuzzi, E., O'Neill, M., Ricciardi, V., Lowder, S. & Vaz, S. 2025. *Revealing complementarities across farm scales in global food production*. FAO Agricultural Development Economics Working Paper 25-13. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig21

policies. Small farms account for 20 percent of vitamin C and 17 percent of vitamin A global production, reflecting their significant role in the cultivation of fruits and vegetables. Interestingly, farms ranging from 2 ha to 50 ha are the top contributors to the global availability of these two micronutrients, producing 28 percent of vitamin C and 25 percent of vitamin A. Meanwhile, the largest farms (>1 000 ha) account for more than 17 percent of the global production of several essential minerals including iron, magnesium, potassium and zinc.[21] This reflects their leading role in cultivating nutrient-dense staples like grains and legumes, which are among the richest dietary sources of these essential micronutrients.[41, 42]

It is important to note that the above figures illustrate the contributions of different farm sizes to the production (i.e. availability) of assessed food and nutrient components, which combine with access, utilization and stability of consumption to determine food security outcomes. Given that agrifood trade increasingly connects producers to consumers living in distant locations – increasing the physical and mental detachment of food from land – the contributions of different farming systems to consumption can differ significantly from their contributions to production. Box 12 highlights how farms of 2–20 ha in several regions make a major contribution to food consumption due to reliance on international trade.

»

BOX 12 FOOD PROVISIONING WITHIN A GLOBALIZED AGRIFOOD SYSTEM

The contribution of small- and large-scale farmers to food provisioning has been the subject of global data collection and modelling efforts.[9, 24, 33, 43] Within this context, the importance of farms at different scales tends to be assessed in terms of their contribution to domestic food production in each country. However, this does not accurately reflect their role in food consumption, given countries' reliance on imports from and exports to countries with different farm size structures.

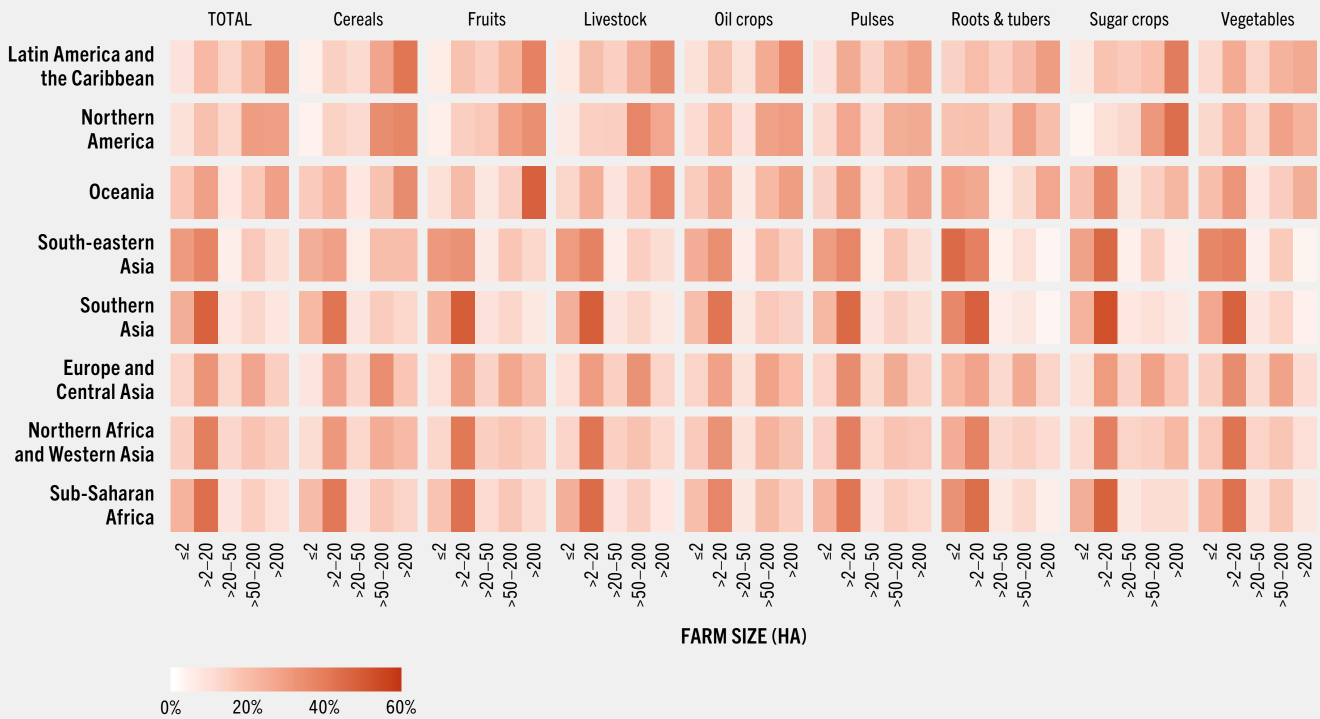
New research combines country sector-specific agricultural production patterns[44] with agrifood trade data[45] to quantify the global dependencies of nations on farmers across the food supply chains of 200 countries.[46] From a consumption perspective (Figure A), farms larger than 2–20 ha make a major contribution to food consumption in several regions, satisfying over 35 percent of food demand in sub-Saharan Africa, Northern Africa and Western Asia and South-eastern Asia. In sub-Saharan Africa and Southern Asia, these farming systems contribute 43 percent and 48 percent, respectively, to regional food needs. In contrast, farms larger than 200 ha contribute more substantially to food consumption in Oceania (29 percent), Latin America (29 percent) and the Caribbean (34 percent). Regional reliance on farmers also varies by food group (Figure A).

The study also investigates discrepancies between the consumption- and production-related roles of small- and large-scale farms in national food provisioning. The large differences reported highlight their diverse roles in meeting national and transboundary food needs. These patterns are illustrated in Figure B, which presents regional averages of farm contributions to food consumption and production.

Farms larger than 200 ha contribute comparatively less to regional consumption than to production in Latin America and the Caribbean (–7 percent), Northern America (–9 percent) and Oceania (–7 percent). In Northern America, overseas dependencies on smaller farms are manifested in demand for pulses, vegetables, and roots and tubers. Conversely, farms of 2 ha or below contribute significantly less to consumption than to production in South-eastern Asia (–7 percent), Southern Asia (–3 percent) and sub-Saharan Africa (–6 percent). In these regions, food consumption is also met by imports of grains and oil crops from farms larger than 50–200 ha.

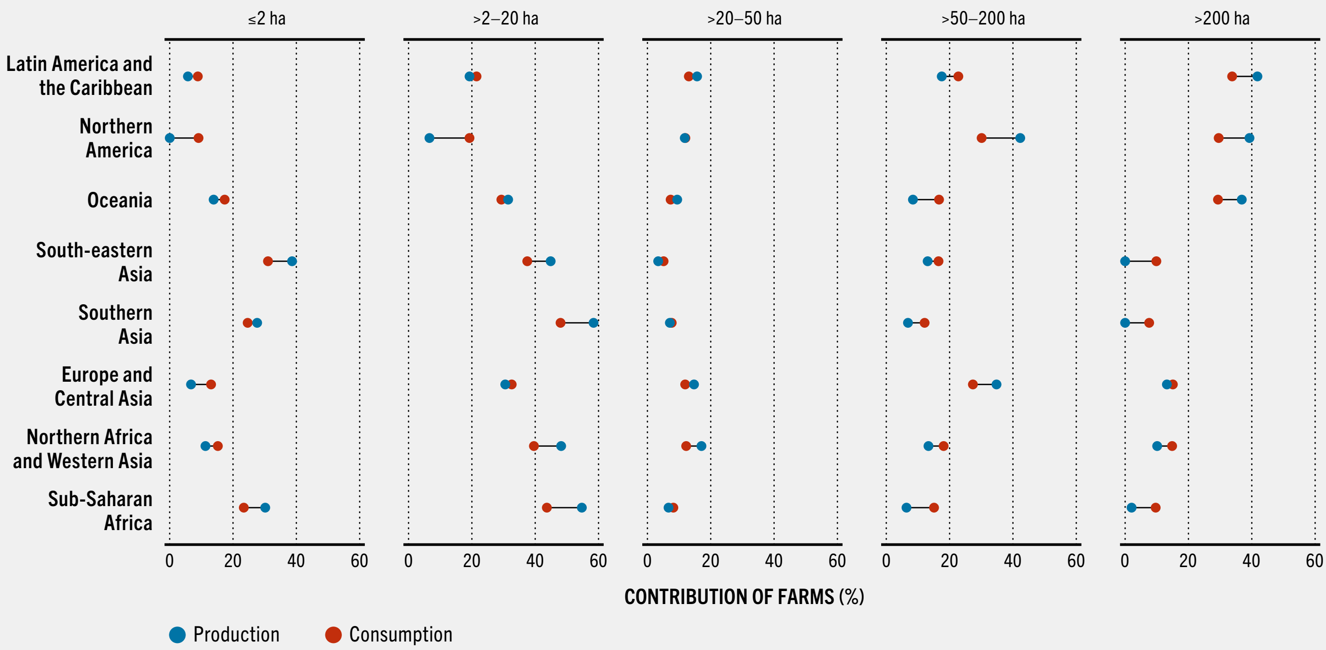
These findings highlight the need for a global supply chain perspective to better understand the role of farms in regional food provisioning. Continued improvements in the mapping and traceability of output from farms is needed to this end. Further integration of production microdata into global agrifood system models can help assess how small- and large-scale farmers differ in the environmental risks they face – and those they drive – and in their roles in sustainable food transition.

FIGURE A CONTRIBUTION OF FARMS TO REGIONAL FOOD CONSUMPTION BY FARM SIZE AND FOOD GROUP



BOX 12 (Continued)

FIGURE B AVERAGE CONTRIBUTION OF FARMS TO REGIONAL FOOD PRODUCTION AND CONSUMPTION



NOTES: "Production" refers to the contribution of farms to domestic agricultural production (including exports and excluding imports). "Consumption" refers to the source and farm patterns of agricultural output destined for regional consumption (domestic and non-domestic).

SOURCE (text and figures): Adapted from Taherzadeh, O., Cai, H. & Mogollón, J. (forthcoming). The hidden role of small-scale farmers in global food security. *Nature Food*. https://doi.org/10.31235/osf.io/ajnsk

» The above results refer to the total amount of land-based agricultural production and not to a measure of productivity. Understanding whether certain farm size segments are inherently more productive than others is critical to the design and targeting of effective policies to meet food security and land degradation neutrality objectives.

The relationship between farm size and productivity has been studied extensively for over 50 years. The question of whether smallholders are more productive than larger farms informs thinking about the role of small farms in the agricultural transformation process, particularly in low- and middle-income countries, where small farms account for a large share of the farming sector.[47–49] If small farms are more productive, then they merit supportive policies to increase food production; such support must go beyond welfare and distributional concerns that may also be addressed through smallholder-focused development strategies. However, if small farms are less productive than larger operations, and if returns to scale translate into broader and faster growth eventually benefiting all rural households, then a strategic orientation to support land consolidation may be warranted.

Increased production on a given size of land also has implications for land degradation: on the one hand, it may decrease pressures for agricultural extensification (land sparing); on the other, it may increase land degradation and externalities through unsustainable intensification. Understanding whether productivity differs

BOX 13 REVISITING THE INVERSE FARM SIZE PRODUCTIVITY RELATIONSHIP

The inverse relationship between farm size and productivity – the finding that smaller farms often achieve higher yields per hectare than larger ones – has been a longstanding puzzle in development economics. First identified by Sen (1962), the relationship challenged classical assumptions about economies of scale and shaped decades of policy advocating for smallholder farming, especially in low- and middle-income countries.[50, 53]

Early studies attributed the inverse relationship to labour supervision advantages: small farms rely on family labour, which is more motivated and better supervised than hired labour.[54, 55] These findings led to widespread support for smallholder-oriented development strategies.

In recent years, however, this consensus has been increasingly questioned. Some studies have shown that when medium- and large-scale farms (typically >10–20 ha) are included, the relationship becomes U-shaped or even positive.[12, 56, 57] Others point to systematic errors in measuring farm size or production: yields tend to be over-reported on small plots and under-reported on larger ones, skewing the relationship.[58–60]

Crucially, the inverse relationship often disappears when broader productivity measures are used. While early literature focused on land productivity (i.e. yields), more recent work uses total factor productivity (TFP), which accounts for land, labour, capital and technology. Studies show that using TFP often reveals no inverse relationship – or even reveals a positive relationship – between farm size and productivity.[61, 62] A meta-analysis of nearly 1 000 studies further confirms that the inverse relationship is not universal and varies depending on how productivity is measured. Over time, as data quality and methods have improved, evidence for the inverse relationship has become less frequent.[63]

In summary, while the inverse relationship was long seen as a stylized fact, newer evidence suggests that it is context-specific, shaped by measurement and methodology, and advises caution against using this relationship as a causal link to guide policy.[64] This evolving understanding has major implications for agricultural policy, land use planning and strategies to sustainably close yield gaps in different farming systems.

systematically among farms of different sizes – and the underlying reasons for this variation – is thus a first step in characterizing land degradation pathways that are potentially scale dependent to guide relevant policies.

Box 13 synthesizes the latest knowledge on the relationship between farm size and productivity, known as the inverse farm size productivity relationship (IR). The IR literature tries to unpack the reasons for the longstanding empirical observation that, in many developing countries, smaller farms tend to have higher productivity than larger farms. However, the accumulated evidence challenges this once conventional wisdom. After accounting for the multiple reasons for observing an inverse relationship – for example, scale-dependent market imperfections, measurement error, choice of productivity indicator and methodological issues – no systematic productivity differences have been found to exist across scales. This means that if they had access to the same resources, smallholders would exhibit the same productivity levels as larger farms, based on the use of a broad range of indicators. Nevertheless, most small farms remain constrained by multiple market and institutional failures, leading to large yield gaps that need to be addressed sustainably.

While this body of evidence may appear to challenge the rationale behind strong policy advocacy for smallholder farming in developing countries,[50, 51] small farms continue to warrant policy support for reasons beyond purely productivity-based arguments. The market failures that explained the inverse relationship in the early literature still ring true in many instances, disproportionately affecting smallholders. Smallholder agriculture continues to play a vital role and will remain an important source of livelihood and food security for rural households in developing rural economies. Addressing constraints to improving the livelihoods of smallholders, within an inclusive rural transformation framework,[52] thus remains essential to achieving both sustainable productivity and land degradation neutrality targets.

Policies and interventions towards these goals would be more effective if based on an understanding of whether and how land degradation pathways differ by farm size. This would have significant impacts on the livelihoods of smallholders, which number around 500 million, as well as on most of the world's agricultural land, which is managed by large farms. Addressing the challenges to sustainable production across scales without repeating the historical patterns that led to the relationship between human-induced land degradation and yield gaps (documented in **Chapter 2** of this report) is critical to meeting the goals of the 2030 Agenda. ■

CONNECTING PRODUCTION SCALE TO LAND DEGRADATION AND YIELD GAPS

Building upon the analysis of farm and production distribution by scale (presented earlier in this chapter) and the examination of land degradation and its impact on yield loss relative to native conditions (detailed in **Chapter 2**), this section explores the key issue of how agricultural production scale relates to the incidence and implications of land degradation and yield gaps. Evidence presented so far suggests that regions dominated by large landholdings often exhibit smaller yield gaps, as these farms benefit from economies of scale, advanced technology and optimized resource use. However, these same regions also display the strongest causal relationship between land degradation and yield gaps: given that production systems in these areas are already highly optimized, any decline in land quality can have a disproportionately large impact on yields. Moreover, intensive production practices commonly used in large-scale farming can accelerate processes such as soil nutrient depletion, erosion and other forms of ecological stress.[65] Conversely, smallholder-dominated regions with limited access to inputs, credit and infrastructure tend to experience wider yield gaps. Yet, in certain contexts, smallholders have managed to narrow these gaps through targeted increases in input use or improved agronomic practices.[66, 67]

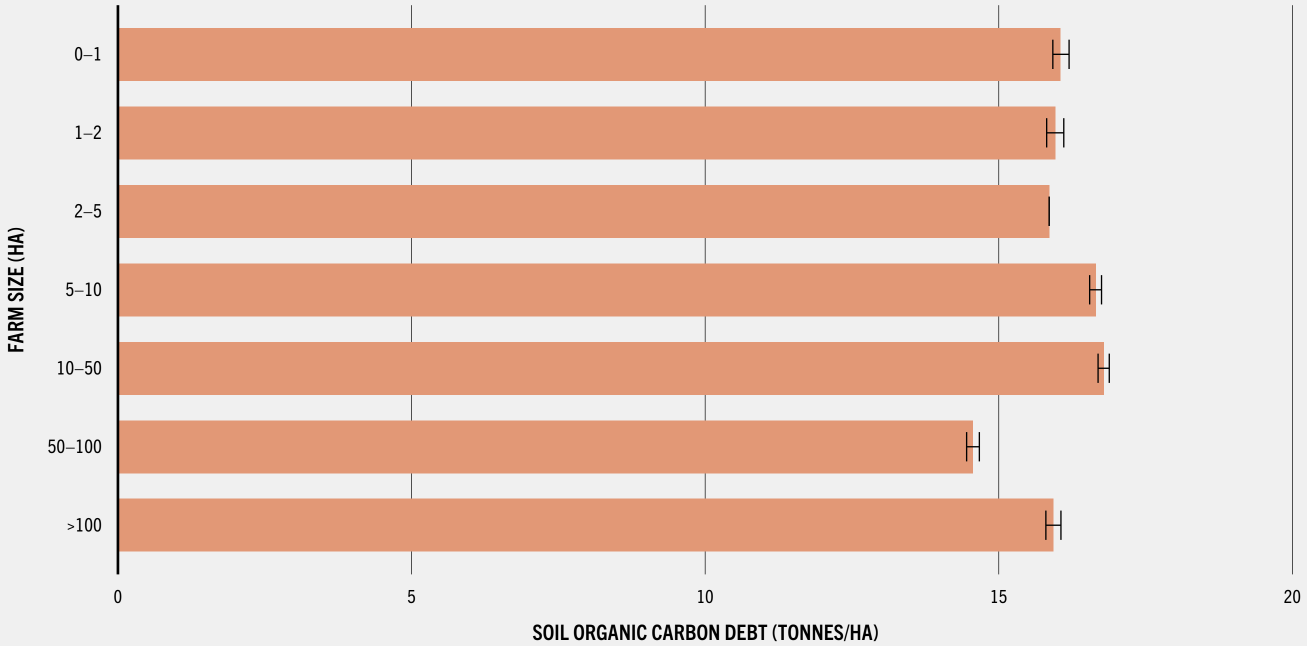
Quantifying how land degradation varies by farm size globally is challenging due to data limitations: comparing quantitative data on long-term degradation and yield loss across specific farm sizes over time would require data on the historical evolution of farm scales, which is not documented spatially. This lack of historical information hinders the ability to link farm size to current degradation status, which reflects cumulative impacts of the specific and evolving scales of production that have shaped the land over time.

Nevertheless, combining a widely used map of global field sizes,[68] calibrated with the data on current farm sizes from 131 countries presented above, with the current soil organic carbon debt used in **Chapter 2**, reveals interesting insights (Figure 22). Farms of all sizes have to deal with similar levels of SOC debt accumulated since the invention of agriculture. However, given uncertainties in the spatial mapping of all farm sizes, the figure conceals important heterogeneities that need to be assessed at high resolution to guide locally specific policies. In the rest of this section, broad inferences are drawn by comparing observed patterns of cropland degradation in regions presently characterized by different dominant production scales.

Exposure to land degradation and yield gap

At the global level, land degradation affects countries at all levels of economic and human development.[69] The map presented in Figure 23 shows that some of the most degraded areas in the world – measured by SOC loss relative to the native conditions (see **Chapter 2**) – are located in high-income countries with large farm sizes.

FIGURE 22 AVERAGE SOIL ORGANIC CARBON DEBT BY FARM SIZE



SOURCE: Authors' own elaboration based on Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

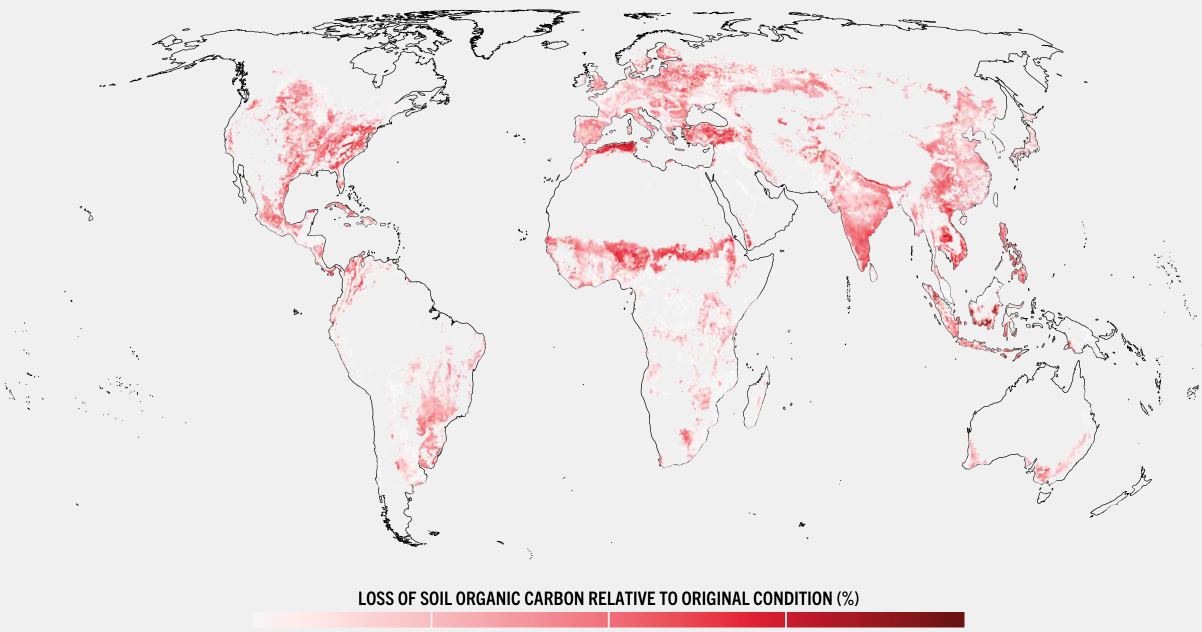
https://doi.org/10.4060/cd7067en-fig22

Other highly degraded areas are observed in regions where farm sizes are much smaller, including South-eastern and Southern Asia, as documented above. In these regions, the impacts of land degradation on human well-being are more pronounced due to overlaps with poverty, low institutional capacity and weak social safety nets.[69, 70] To the extent that farm holding sizes are correlated with these socioeconomic indicators, understanding how exposure to cropland degradation and yield gaps varies by farming scale can contribute to developing policies to improve both land conditions and human well-being.

Combining the understanding of farm size distribution across regions with the yield gap map in **Chapter 2** (see Figure 8) provides insights into how farms of different sizes are likely to overlap with current yield gaps. Very low current yield gaps in regions with large farm sizes (Europe, United States of America and parts of Brazil) again point to the capacity of larger farms – especially in temperate or well-irrigated regions – to push yields closer to their agroecological ceilings, using inputs, machinery and modern management. Yet, because other yield determinants (e.g. water, nutrients, technology) are already close to optimal in these highly productive areas, land degradation has a disproportionately large impact on yields, amplifying its causal effect on yield gaps.

Sub-Saharan Africa presents the largest yield gaps and also has a high share of smallholders (75 percent); despite this, 75 percent of the land is managed by medium-sized farms (>2 ha). Conversely, Eastern, South-eastern and Southern Asia all have smaller yield gaps. In these regions too, the majority of the farms are smallholdings,

FIGURE 23 SOIL ORGANIC CARBON DEBT, PERCENTAGE OF NATIVE CONDITION



NOTE: Refer to the disclaimer on the copyright page for the names and boundaries used in this map.

SOURCE: Hadi, H. & Wuepper, D. 2025. *A global yield gap assessment to link land degradation to socioeconomic risks – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-16. Rome, FAO.

with the difference that they also manage most of the agricultural land (>50 percent). Small-scale farms in Asia seem more able than African farms to compensate for the impacts of land degradation on current yields, largely through increased input use.[71] At the same time, these regions also have the highest proportion of populations vulnerable to yield loss from long-term land degradation, underlining the importance of addressing accumulated land degradation for production. In contrast, small farms in Africa tend to have larger yield gaps that are more attributable to resource constraints, including low input use and mechanization rates, which need to be addressed to increase production sustainably.

In other words, regions with large farms, irrigation infrastructure and access to fertilizers tend to approach their yield ceilings, while smallholder systems in Africa, Asia and Latin America remain below potential. These global differences also reflect variations in water and nutrient access, market and infrastructure linkage, and farming practices.[72] Box 14 highlights the important scale dependencies in terms of exposure to water stress that add to the difficulty in addressing yield gaps, especially in smallholder systems.

In fact, small farm size combined with poor soil fertility among the poorest households represents a double poverty trap in Africa: they can neither produce enough for household needs nor restore the productive capacity of the soil.[15] At the national level, such small farm sizes present a barrier to achieving greater food self-sufficiency as households have few incentives to invest in agriculture, leading to stagnation in agricultural

BOX 14 SCALE DEPENDENCIES IN EXPOSURE TO WATER STRESS AND WATER CONSUMPTION

Water is essential for agricultural production and comes in two forms: irrigated water from rivers, lakes, reservoirs and underground sources, otherwise known as blue water, and rainwater used directly by crops, referred to as green water. Agriculture is the largest consumer of both blue and green water globally.[73] However, overuse of water resources has led to a worldwide water scarcity problem. Currently, more than 3 billion people live in water-constrained agricultural areas[74] and 40 percent of global cropland is affected by reduced availability of water.[75]

Small-scale agriculture is more vulnerable to water scarcity than large-scale agriculture.[34, 76, 77] A recent study covering 55 countries found that approximately 68 percent of harvested areas in small-scale agriculture are located in water-scarce regions, compared to 43 percent in large-scale agriculture.[77] This higher exposure is due in part to the fact that small-scale agriculture is often situated in dry climate zones. However, even within the same climate zone, small-scale agriculture still faces greater water scarcity issues than large-scale agriculture.

Despite the higher exposure to water scarcity, small-scale agriculture uses much less blue water than large-scale agriculture.[77] This is true in both water-abundant and water-scarce regions. Small-scale agriculture has less access to irrigation, which partly explains its lower blue water consumption. Additionally, small-scale agriculture tends to focus on food crops, which generally require less water than non-food crops.[9, 33, 77] Beyond differences in types of crop and irrigation access and use, the fact that the majority of small-scale agriculture is located in dry climate zones, while more large-scale agriculture is located in fully humid regions, can further explain smallholders' limited access to irrigation.[77]

Moreover, insecure land tenure can discourage smallholders from investing in irrigation systems,[78] while limited extension services and technical support further hinder smallholder adoption, reinforcing their reliance on rainfed agriculture.[78, 79] However, green water productivity on small farms is often low. More productive utilization of green water, by alleviating soil fertility stress, would enable small-scale agriculture to increase its nutrient production by more than 70 percent, even in water-scarce regions.[77]

SOURCE: Su, H., Foster, T., Hogeboom, R.J., Luna-Gonzalez, D.V., Mialyk, O., Willaarts, B., Wang, Y. & Krol, M.S. 2025. Nutrient production, water consumption, and stresses of large-scale versus small-scale agriculture: A global comparative analysis based on a gridded crop model. *Global Food Security*, 45: 100844. https://doi.org/10.1016/j.gfs.2025.100844

productivity (referred to as the African Food Security Conundrum). This pattern also has implications for land degradation on both cropland and other types of land cover through land abandonment and extensification, creating a vicious cycle.

Exposure of cropland to climate change

Climate change – the quintessential threat multiplier – is expected to severely impact food security through its complex interactions with land degradation, water stress and productivity, exacerbating livelihood vulnerabilities, particularly for small-scale producers and rural communities. Rising temperatures, altered precipitation patterns and extreme weather events endanger ecosystem stability and reduce agricultural resilience.[80] This is particularly the case in low-latitude regions (including sub-Saharan Africa and Southern Asia), where climate change is expected to negatively impact crop production and significantly reduce the variety of crop types that can feasibly be cultivated on existing cropland.[81] These regions are heavily reliant on smallholder farming, making them particularly vulnerable to climatic disruption. With 3 °C of warming above pre-industrial levels, farms of all sizes in these areas will face heightened exposure to heat

BOX 15 EXPOSURE OF GLOBAL AGRICULTURAL LAND TO FUTURE EXTREME WEATHER

Increasing weather extremes are wreaking havoc on livelihoods, food security and nutrition, not only in farming communities but also across the world. The ramifications of weather extremes are profound, significantly diminishing global agricultural output[93] and undermining the stability of global agrifood systems.[94]

In a 3 °C warmer world (from pre-industrial levels), 25 percent of agricultural land will face over two months of extreme heat, up from 16 percent (in a 1 °C warmer world), but frost exposure will decline from 7 percent to 5 percent of global agricultural land. Exposure to prolonged dryness and extreme precipitation will likely remain unchanged.

Shared Socioeconomic Pathways (SSPs) are scenarios that explore how global society, demographics and economics might evolve over the twenty-first century, influencing greenhouse gas emissions and climate change. Under the "middle of the road" pathway (SSP2-4.5), crop- and pasturelands will experience different weather shocks of varying magnitude and extent. Pasturelands will undergo more heat stress and prolonged dryness, while current croplands will face more combined heat and precipitation extremes.

Given the current geographic distribution of farms around the world, with smaller farms located predominantly in the tropics, small, medium and large farms will face different levels of exposure to weather shocks under a 3 °C global mean temperature (GMT) scenario, compared to 1 °C GMT (see figure). Panel A shows exposure to conditions that are too hot and too dry (measured by days above 35 °C and the longest dry spell), while Panel B shows exposure to conditions that are too cold and too wet (measured by days below 0 °C and maximum five-day rainfall).

Notwithstanding the potential evolution of underlying farm size distribution over the coming decades, this analysis shows that farms below 2 ha and those between 2 ha and 5 ha, in both cropping and pasture systems, will face more intense downpours compared to their counterparts. Cropland and pastureland exposure to prolonged heat stress and severe downpours is hump-shaped: medium-sized farms experience the highest exposure to heat stress and dry spells, while smallholders experience the greatest exposure to severe downpours. Additionally, on average, medium-sized pasture farms experience nearly double the increase in exposure (over eight additional days) to heat stress compared to small farms. Large farms (>50 ha), which predominate in the extratropics, will benefit most from a reduction in frost days, predicted to decrease from an average of seven to eight days to just four days during the growing season.

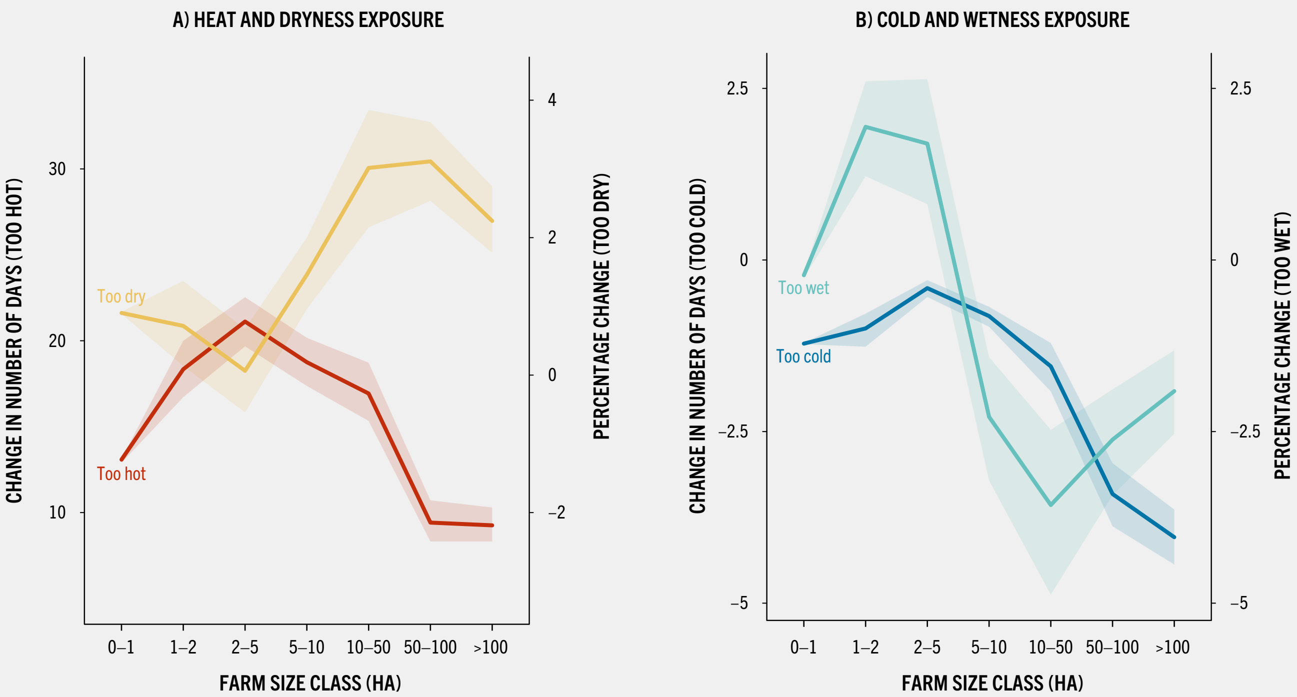
The diversity of farming systems documented here have varying sensitivities and capacities to adapt to weather extremes. As climate change progresses, these systems will face different combinations of weather-related challenges, requiring targeted and context-specific adaptation strategies. The projected rise in agricultural areas exposed to multiple, overlapping weather extremes underscores the urgent need for more holistic and integrated approaches to adaptation. Without such measures, the impact on land productivity, food security and livelihoods could be severe.

stress, dry spells and heavy downpours (Box 15).[82] Furthermore, the decline in crop diversity is especially concerning for smallholders, who depend on diverse cultivation for resilience as well as nutrition.[9, 81, 83] At the same time, climate change threatens the availability of livestock production by reducing feed productivity and quality, compromising animal health and increasing mortality from extreme weather events.[84–87]

Beyond extreme events, climate variability and uncertainty are also emerging as drivers of land degradation. Unpredictable rainfall and temperature patterns and shifting growing seasons may prompt farmers to adapt agricultural practices, including in ways that may unintentionally degrade land. For example, shortened fallow periods, deforestation, and heavy fertilizer and chemical use to secure yields can undermine long-term adaptation.[88–90] Similarly, subsistence smallholders may

BOX 15 (Continued)

FIGURE CHANGE IN FUTURE EXPOSURE TO EXTREME WEATHER DURING THE GROWING SEASON BY FARM SIZE



NOTES: The panels show cropland exposure to weather extremes by farm size under 3 °C global mean temperature (GMT) relative to 1 °C GMT. Panel A covers heat stress (days >35 °C) and dry spells (longest period with <1 mm rainfall). Panel B covers cold snaps (days <0 °C) and excessive rainfall (maximum five-day total). The ribbon around the lines indicates confidence intervals, estimated using 1 000 bootstrap samples for each farm size category and weather extreme.

SOURCE: Bajaj, K., Mehrabi, Z. & Ramankutty, N. 2025. *Exposure of global agricultural lands to extreme weather using CMIP6 projections of future climate.* Unpublished.

respond to extreme heat by extensification,[91] potentially contributing to land degradation due to land cover change. Furthermore, the link is bidirectional: degraded land is more vulnerable to climate variability[92] and less responsive to inputs,[1] creating a vicious cycle of risk to soil health and livelihoods.

The differences in exposure levels documented in Box 15 can function as both the cause and the effect in different production systems that lead to scale-dependent degradation pathways. Closing the yield gaps in many smallholder-dominated regions may present significant opportunities for improving productivity through intensification; however, such efforts must strike a balance between boosting short-term production and achieving long-term soil health as well as land degradation neutrality goals. Strengthening farmers' knowledge, particularly on sustainable land and risk management practices, and addressing enduring constraints to adoption and tenure security are therefore essential to support adaptive responses that safeguard rather than compromise land quality. ■

CONCLUSION

The diversity of global farm structures shaped by day-to-day land-use decisions at vastly different scales is striking. While more than 85 percent of the world's farms are smaller than 2 ha, more than half of global agricultural land is managed by farms exceeding 1 000 ha. The contributions of these diverse decision-makers to the global production of food and land-based ecosystem services also vary across country income groups and regions.

This chapter highlights the contribution of different farm sizes to the production of crops that supply a significant share of dietary energy globally. Key findings reveal that smallholder farmers, despite their limited land share and the multitude of constraints they face, remain vital contributors to global food supply: they produce a significant proportion of the dietary energy derived from crops, including from macronutrients such as fats and proteins, particularly in low-income regions. Meanwhile, medium- and large-scale farms produce more than half of the global food supply from crops. Although fewer in number, these farms dominate land use and thus bear a greater responsibility for addressing land degradation and sustainable management at the global level.

Policies to achieve the interconnected goals of ending poverty, achieving food security and improved nutrition, and promoting sustainable agriculture and land degradation neutrality, need to strike a balance between livelihoods and scale. This is easier said than done, as land-use decisions often entail trade-offs between people or places across spatio-temporal scales.[95] The regional variation in farm size distribution and the associated challenges underscore the need for nuanced, context-specific policies that target sustainable land management as well as land degradation – through both local-level measures and landscape-scale planning.

Future research could benefit from exploring alternative farm classification systems that better capture the complexity of degradation patterns and their socioeconomic drivers. These might include classifications based on market orientation, tenure security, or frameworks aligned with the SDGs that consider both relative farm size and revenue. Such approaches could improve the targeting and effectiveness of policies addressing land degradation and sustainable agriculture.

The next chapter presents a global synthesis of the effectiveness of agri-environmental policies aimed at improving land conditions and provides a framework to guide differentiated policy and investment approaches for different farm size and land degradation profiles. ■

SOUTH SUDAN
Investing in soil health: building dykes at the site of the Aweil Rice Scheme under the FAO Hand-in-Hand Initiative.
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CHAPTER 4
POLICY OPTIONS FOR SUSTAINABLE LAND USE

KEY MESSAGES

➔ Well-designed and enforceable tenure rights and transparent land markets are the foundations on which to build sustainable land management, but policies and regulations are needed to align incentives for private productivity with public benefits from ecosystem services.

➔ Restoring severely degraded land that requires a break from previous land use will be very different from reducing or reversing less severe land degradation on agricultural land through management practices, requiring different targeting, financial resources, monitoring and enforcement.

➔ Land-use regulations to improve land conditions across croplands, grasslands and forest lands, when appropriately enforced, tend to outperform incentive-based conservation schemes, which show mixed results.

➔ Combining regulatory and incentive-based approaches is often more effective than pursuing either approach exclusively, especially when addressing degradation challenges on agricultural land that requires diverse management practices.

➔ Policies and interventions aimed at reducing land degradation need to be targeted based on an understanding of how land is being degraded and the opportunity space of who manages the land, be they small or large producers.

Enabling the sustainable use and management of agricultural land while maintaining sufficient productivity to ensure food security requires consideration of the multiple causes of land and ecosystem degradation, which are exerting increasing pressure. Drivers at local, national and international level interact and influence the land-use decisions of producers (see Figure 5, **Chapter 1**). At the local level, resource endowments, including landholding size, drive access to inputs. At the national level, socioeconomic structure, including demographic and urbanization dynamics, domestic markets, infrastructure and environmental conditions, combine with policies and institutions to (dis-) incentivize land degradation. In parallel, international drivers of global trade, investments, climate change and associated commitments provide a wider context, creating both challenges and opportunities for policy interventions.

Unfortunately, institutional, policy and governance responses to address land degradation are often reactive and fragmented. Although land degradation is a central theme of three intersecting global challenges identified by the Rio Conventions (UNCCD, UNFCCC and CBD), national action plans remain siloed.[1] Interventions typically target only specific and visible drivers of land degradation, failing to harness complementarities across objectives.

However, a wide range of practices already exist to improve land conditions, which need to be scaled up before implementation becomes too costly.[2]

This chapter synthesizes policy interventions for sustainable land management, focusing on limiting land degradation, with a view to maintaining agricultural production while reducing environmental impacts. Based on the evidence presented in **Chapter 2** and **Chapter 3**, this chapter aims to provide insight into tailoring policy options based on the evidence presented on land degradation and the current distribution of farm sizes and yield gaps, highlighting the importance of context in designing effective interventions. ■

FOUNDATIONS OF SUSTAINABLE LAND MANAGEMENT

Secure and enforceable land tenure, together with transparent and well-functioning land markets, provides the institutional foundation for sustainable land management. These elements enable land users to make long-term investments in land quality, adopt sustainable practices and access credit, insurance and extension services. In their absence, land users – particularly smallholders, Indigenous Peoples and women – face increased risks of dispossession and exclusion from policy benefits, and inevitably rely on short-term land-use strategies. These dynamics can accelerate land degradation and undermine the provision of ecosystem services.[1, 3]

Tenure security has been shown to increase the likelihood of adopting sustainable land management practices, but only when rights are legally recognized and enforceable. In the Brazilian Amazon, for example, deforestation declined significantly only after Indigenous Peoples' land rights became legally enforceable following full demarcation and certification.[4, 5] Similarly, in Western Africa, formal titling reduced annual forest loss through increased on-farm tree planting and fallowing – an important way of restoring soil fertility.[6, 7]

Transparent land markets – including rental markets – can also improve land-use efficiency and sustainability. In Ethiopia, land certification facilitated more efficient land allocation through rentals, increasing productivity by up to 43 percent.[8] Box 16 illustrates how land market development is evolving in sub-Saharan Africa, where rental and sales markets are expanding rapidly but remain shaped by broader rural transformation dynamics. However, formalization must be approached with caution. Without adequate safeguards, it can reinforce existing inequalities and encourage speculative land acquisition rather than productive use.[9] Effective tenure systems must therefore include clear rules, equity safeguards and enforcement mechanisms that recognize overlapping and seasonal claims, especially in communal and agropastoral systems. [10]

Digital tools can support these efforts by accelerating the mapping and registration of land rights, improving transparency, and enabling bundled services such as land-based insurance and targeted financial products.[11] Nonetheless, tenure reform alone is not sufficient for supporting sustainable land management. It must be embedded within a broader enabling environment that includes inclusive governance, equitable market access and strong institutions (Box 17).

While secure tenure and transparent land markets are essential foundations for sustainable land management, they are not sufficient on their own. Land degradation continues to occur even in contexts with strong enabling environments, highlighting that the alignment of private incentives with larger public benefits is not automatic. Without deliberate policy interventions, market failures, power imbalances and short-term economic pressures can still drive unsustainable land use and management. Therefore, enabling environments must be complemented by targeted measures that realign incentives and strengthen accountability to facilitate global, national and local action to address land degradation. The resulting overall benefits – derived primarily from ecosystem services in addition to provisioning services – far exceed the costs. Only through this broader systems approach can the full potential of tenure reform and land market development be realized. ■

BOX 16 LAND MARKET DEVELOPMENT IN SUB-SAHARAN AFRICA

Land rental and sales markets are expanding rapidly across sub-Saharan Africa, where most smallholder farming continues to take place on customary land with limited market exchange. The empirical literature shows that in the early 2000s, land rental among smallholders nearly doubled in Malawi and tripled in Zambia.[12]

These changes have been associated with broader trends in rural transformation, including institutional changes, which in turn respond to broader demographic and economic forces such as population growth,[12–16] migration, urbanization, and related shifts in the distribution of income and power across society.

Evidence on the economic and social impacts of land market participation in smallholder systems is nascent, given their early stage of development. Such markets can facilitate aggregate productivity increases – by transferring land from less productive to more productive users – as well as improve rural equity outcomes by equalizing factor ratios. Recent examples of such evidence include studies of smallholder land market participation in Ethiopia,[8] Kenya,[17] Malawi,[12] Uganda,[17] the United Republic of Tanzania[18] and Zambia.[12]

A longstanding policy concern is that the expansion of land markets may worsen inequality.[16, 19–21] The "commodification" of land – transforming it into a tradable asset – along with the shift towards individualized tenure, may enable more powerful actors, both local and external, to displace poor residents via distress sales or coercion, a phenomenon often referred to as "land grabbing". Land markets may also promote commercial agriculture and value chain concentration, excluding poorer farmers and increasing disparities.[22] Additionally, commodification may erode communal rights to land and shared cultural heritage, weakening community institutions that support welfare outcomes.[23]

As land markets continue to develop, it will be important to monitor who gains and who loses – in both the short and the long term – to better understand the impact on smallholder productivity, welfare gains, incentives to invest in sustainable land management, and the region's ongoing rural transformation.

BOX 17 BEYOND TENURE: KEY ENABLERS OF SUSTAINABLE LAND MANAGEMENT

While secure and enforceable tenure and transparent land markets are foundational, their effectiveness at supporting sustainable land management depends on a broader enabling environment that shapes land users' incentives and capacities. Key complementary enablers include the following:

- **Market access.** Reliable access to input, output and financial markets strengthens the economic case for long-term investments in sustainable practices. In particular, smallholders who are more risk averse and have shorter planning horizons tend to face enduring market constraints. Different forms of contractual arrangements (e.g. contract farming, cooperatives, vertical integration schemes) can reduce uncertainty, improve returns and help smallholders achieve scale to facilitate the implementation of land degradation neutrality initiatives.[10, 24, 25]
- **Institutions and governance.** Strong institutions are critical to creating an enabling environment for sustainable land management. The rules and structures that govern how land is accessed, used and transferred – such as land registries, inheritance systems, and both formal and informal dispute resolution mechanisms – shape incentives and determine outcomes on the ground. Where institutions are weak or fragmented, even well-designed policies may fall short of their full potential. Institutions that are designed with local conditions in mind also facilitate sustainable management of common resources, particularly in Indigenous Peoples' territories and common lands, where locally grounded systems often outperform top-down approaches.[26, 27]
- **Inclusive agrifood systems transformation.** Structural challenges such as land fragmentation, demographic pressures and limited off-farm opportunities constrain how farmers use and transfer land, often forcing smallholders to overwork marginal plots and limiting the adoption of sustainable practices.[28] Youth- and gender-sensitive policies, social protection and rural employment strategies are essential to reduce land pressure and support intergenerational land transfer.[29, 30] Social pensions, for example, can reduce reliance on land as old-age security, encouraging land rental and more efficient land use.[31]

Together, these enablers create the conditions for land users to adopt sustainable practices, reduce degradation and contribute to land degradation neutrality.

AVOID, REDUCE AND REVERSE LAND DEGRADATION

Given that land degradation is already widespread across diverse landscapes and farming systems, the challenge now lies in how to respond effectively across landholding scales and degradation gradients. As discussed in **Chapter 2**, unsustainable intensification and rising trends in land abandonment are a warning sign: the viability of agricultural production is at stake. Yet degradation is not uniform. Even within a single farm, land parcels may vary in condition, requiring tailored responses that reflect both the severity of degradation and the potential for recovery.

Land degradation often stems from a misalignment between private incentives – both economic and sociocultural – and the public value of ecosystem services. This disconnect has led to scale-dependent pathways of degradation (Box 18). As discussed in **Chapter 2**, most of the global cost of land degradation is borne by the broader society due to the loss of ecosystem services, including biodiversity, regulating services and carbon sequestration. Addressing the misalignment requires action across a spectrum of land conditions. On land currently used for agriculture – including permanent meadows and pastures, arable land, and permanent crops – degradation can be masked by input intensification, where productivity can still be restored through improved management practices; yet such practices have diminishing returns in places that are already operating close to their biophysical yield potential. In contrast, severely degraded or abandoned lands demand more transformative approaches, such as land-use change and ecological rehabilitation.

To guide such efforts, the UNCCD promotes a hierarchy of responses – avoid > reduce > reverse – which together form the foundation of land degradation neutrality strategies.[32] This hierarchy reflects both the urgency and the cost-effectiveness of different interventions. Avoiding degradation on healthy, productive lands is the most efficient strategy, as it prevents the loss of ecosystem services before damage occurs. Where degradation is already underway, efforts must focus on reducing or halting its progression through improved land management. In cases where land has been severely degraded or abandoned, more transformative measures are needed to reverse damage – often involving land-use change, ecological restoration and long-term investment. In these cases, lands have exceeded thresholds for viable use without intervention.

Figure 24 illustrates how the avoid–reduce–reverse framework aligns with the condition of land, distinguishing between agricultural land where degradation can still be managed – albeit at increasing cost as degradation progresses – and land that has crossed viability thresholds and requires a fundamental reset in management strategy. This conceptual progression helps clarify where incremental improvements are sufficient and where more systemic change is needed.

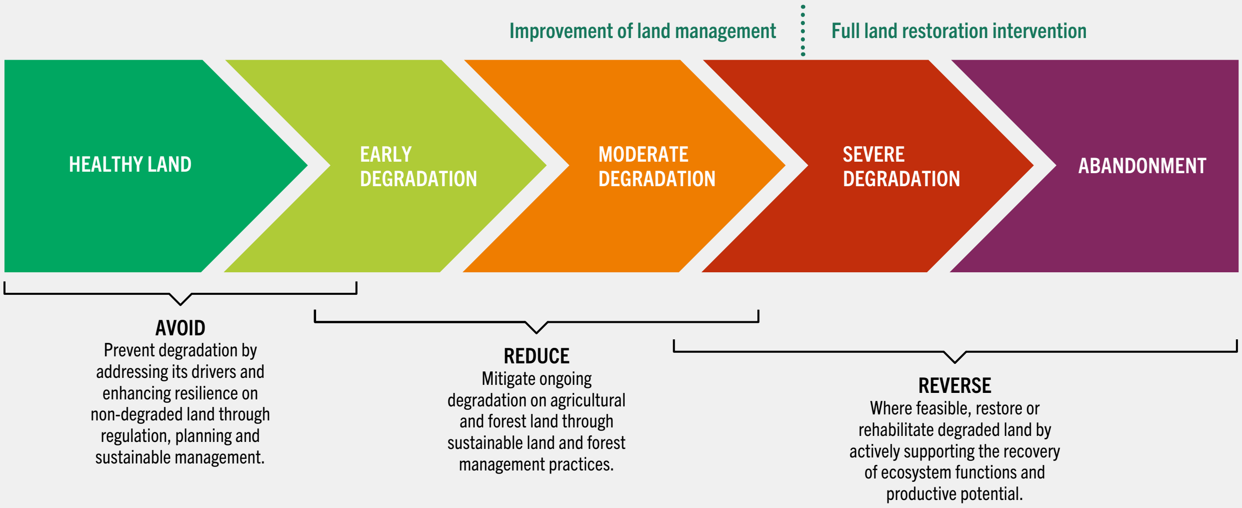
While the avoid–reduce–reverse framework provides a useful foundation, effective implementation also requires differentiated strategies that consider the degree of land degradation (e.g. whether sustainable land management or land-use and land-cover change is needed) and reflect the diversity of land users and production systems. Designing tailored approaches also requires an understanding of various types of policy instruments along with their management and monitoring burdens, as well as financial needs. These are discussed in detail in the next section. ■

TAILORED APPROACHES FOR HETEROGENEOUS LANDSCAPES

The diversity in agricultural landscapes often features a mosaic of land parcels ranging from healthy, productive lands to severely degraded or even abandoned areas. This variability, combined with the wide range of farm sizes managing the land, demands a tailored policy response – one that matches the type and intensity of intervention to the condition and use of the land.

»

FIGURE 24 STRATEGIC RESPONSES ACROSS LAND DEGRADATION STAGES: FROM IMPROVING LAND MANAGEMENT TO FULL-SCALE LAND RESTORATION



SOURCE: Authors' own elaboration based on Figure 7 in Orr, B.J., Cowie, A.L., Castillo Sanchez, M.V., Chasek, P., Crossman, N.D., Erlewein, A., Louwagie, G. *et al.* 2017. *Scientific Conceptual Framework for Land Degradation Neutrality. A Report of the Science-Policy Interface*. Bonn, Germany, UNCCD. https://www.unccd.int/resources/reports/scientific-conceptual-framework-land-degradation-neutrality-report-science-policy

BOX 18 CONTEXT MATTERS WHEN TRYING TO REVERSE SCALE-DEPENDENT PATHWAYS OF DEGRADATION

All agricultural land today exhibits some degree of degradation, and this should be considered by policymakers. However, degradation is shaped by historically diverse trajectories of agricultural development, production systems, and varying levels of intensification across regions.

Two contrasting extremes have emerged for degradation on croplands. At one end, in systems with a history of intensification, degradation tends to be largely masked by further increasing input use, making it more difficult to detect despite its severity. These systems are dominated by medium and large landholdings, with farms larger than 1 000 ha controlling most of the land.

At the other end, many agricultural systems have not benefited from intensification, particularly in large parts of Africa where low-input, low-output smallholder farms dominate. Productivity has remained stagnant; cropland degradation may occur, but it is not the main obstacle to reducing yield gaps.[28, 33] The widespread low-input, low-output nature of smallholder farming in these areas presents a major challenge. Past historical intensification pathways are an option for closing yield gaps; however, limiting land degradation through more sustainable means is needed for long-term viability.

Between these two extremes lie agricultural systems that have experienced intensification relatively recently. These systems – predominantly in Asia, the region home to the smallest farm sizes globally – have seen increased input use starting in the middle of the twentieth century, but often without proportional gains in productivity. This has led to the accumulation of more severe land degradation impacts than in non-intensified systems, but without the productivity gains observed in areas with high levels of intensification. Input use thus only partially masks the effects of land degradation. It has led to heterogeneity in yield gaps, which are sizeable in some areas (though generally still lower than in non-intensified systems), and low in others.

Furthermore, in countries where degradation is occurring in rangelands and forests, additional layers of contextual information will be needed in order to design regulations and incentive-based schemes. In rangelands, tenure and property rights are important factors determining what is viable and effective. Similarly, for forest areas, the drivers of land-use change and who is involved must be considered.

Landholders along these various pathways may co-exist within a country, forming a specific mix in terms of land size distribution, resources and production systems. Therefore, policymakers will need to take into account all these factors when designing regulations or incentive-based schemes.

» Table 3 provides a framework for distinguishing interventions related to land management practices from those aiming to change land use. Interventions to incentivize sustainable land management practices are appropriate for lands in the earlier stages of the degradation continuum (Figure 24), as their focus is on avoiding and reducing degradation. Land-use change interventions, on the other hand, are primarily implemented on lands that are severely degraded or abandoned with a goal to reverse the degradation process. As discussed throughout this report, most of the global cost of land degradation (78 percent according to Nkonya *et al*. [2026][34]) is associated with LUCC. Therefore, it is not sufficient to implement only policies aimed at incentivizing sustainable land management – it is critical to complement them with LUCC policies.

Policy interventions are classified according to three distinct approaches adopted to change the behaviour of land users: regulatory, incentive-based and cross-compliance (also known as conditionality). Each approach has distinct interactions with prevalent farm size structures. Table 3 outlines how these interactions and the management burden, monitoring requirements and public financing needs vary depending on the type of policy instrument and whether it is related to land management or land-use change.

Regulatory policies

Regulation is the earliest form of environmental policy, introduced to correct market failures, such as externalities caused by land degradation (e.g. biodiversity loss, water pollution, loss of cultural services). "Command and control" measures – regulations – set specific legal limits, standards or mandatory practices to curb land degradation.[2]

Examples of regulations include deforestation restrictions,[35] requirements for soil conservation, and bans on harmful agricultural chemicals.[36] In Kyrgyzstan, for instance, Law No. 15 (2007) imposed a five-year ban on the harvest and trade of protected forest species such as walnut and juniper, backed by enforcement provisions including confiscation and legal penalties.[37]

However, the scope of these regulations varies significantly. In some countries, such as the United States of America, environmental regulations often apply only to farms above certain size thresholds, particularly in livestock operations, where compliance is triggered by animal unit counts. This approach can unintentionally incentivize smaller-scale operations to remain just below regulatory limits to avoid compliance – a phenomenon known as regulatory avoidance.[38] Such dynamics can undermine the effectiveness of environmental policies and should be carefully considered in regulatory design.

Incentive-based policies

In the last two decades, incentive-based environmental policies have become more common, complementing regulations.[39, 40] Incentive mechanisms offer financial or market-based rewards for actions that generate environmental benefits (e.g. improved on-farm biodiversity, reduced erosion).[41] Examples include payments for ecosystem services, conservation tenders, and green credit lines.[2]

Canada's 2 Billion Trees programme provides long-term funding to support voluntary afforestation and reforestation efforts that align with biodiversity and climate goals.[42] Similarly, China's restoration of the severely degraded Loess Plateau shows how incentive schemes can drive large-scale ecological recovery, even in densely populated, smallholder-dominated regions (Box 19). Such schemes are typically voluntary and flexible, but they still face potential challenges such as leakage – the displacement of harmful activities to other areas.[43]

Monitoring incentive-based schemes can be costly and complex, requiring significant institutional capacity, especially across large or fragmented farming areas.[44] Farm size can influence participation, as engaging fewer but larger farms can simplify implementation and reduces transaction costs. For example, in Iowa in the United States of America, adoption of improved soil and water conservation practices was accelerated by large-scale farmers' repeated face-to-face interactions with conservation professionals at the United States Department of »

TABLE 3 LAND MANAGEMENT VS LAND-USE CHANGE INTERVENTIONS BY TYPE OF POLICY INSTRUMENT

	LAND MANAGEMENT	LAND-USE CHANGE
REGULATORY		
Does farm size matter?	Regulation may apply across the board or only to farms above or below a certain threshold. Applying a threshold may affect incentives, leading to regulatory avoidance.	Regulation (e.g. land-use zoning or deforestation bans) tends to be applied across the board, because exemption of one farm size category leads to leakage. On small farms, land-use regulations may impose a proportionately higher burden.
Management burden	Burden falls on landholders to provide proof of compliance with regulations.	Burden is low because parties can rely on high-resolution earth observation and remote sensing data to resolve any dispute.
Monitoring requirements	Field-level checks can be resource intensive. Monitoring performance using outcome indicators is more challenging than monitoring the application of regulated practices.	Cost of monitoring is low with high-resolution earth observation data.
Financing needs	Public financing requirements are low and mainly for enforcement. Cost of applying regulated practices is borne by landholders.	Public financing requirements are low and mainly for enforcement. Cost of forgone land-use options is borne by landholders.
INCENTIVE-BASED		
Does farm size matter?	Smaller farms often have limited capacity to develop proposals and do the paperwork associated with contractual arrangements.	Large farms are likely to more easily incorporate land-use change for restoration purposes on part of the farm. On smaller farms, land-use change might affect overall economic viability depending on the level of incentive.
Management burden	Transaction costs are typically high, associated with agreeing on contracts for specific land management practices. Targeting participants based on the effectiveness of proposed actions and available budget requires effort on the part of the government.	As for land management practices – with the difference that, when the incentive is set-aside land, the contractual arrangement is simpler, because there are fewer land management practice options to consider.
Monitoring requirements	Field-level checks can be resource intensive and ensuring additionality is not always possible. Monitoring performance using outcome indicators is more challenging than monitoring the application of incentivized practices.	Cost of monitoring is low with high-resolution earth observation data.
Financing needs	Incentivizing uptake is costly in terms of public financing. It depends on the degree of financial incentives provided and the private benefits of land management practices received by the landholder. If these are sizeable, cost sharing between public financing and the landholder is feasible.	Compensating land rental value is costly in terms of public financing because it typically involves public funds. Costs are very high in the case of long-term land restoration projects – often cofinanced with donors or the private sector.
CROSS-COMPLIANCE (CONDITIONALITY)		
Does farm size matter?	Farm size matters as a function of the overlap of 1) who the regulation applies to, and 2) how payments to landholders are distributed.	On small farms, land-use regulations may impose a proportionately higher burden; therefore, they would need to receive substantial payments for cross-compliance to be effective.
Management burden	Release of payments is contingent on compliance with regulations; therefore, in principle, the additional burden for landholders is zero because this burden is already considered. Conditionality on compliance may result in an administrative burden, requiring systems integration.	As for land management practices.
Monitoring requirements	Monitoring of regulation- and incentive-based systems already in place might need to be aligned to make cross-compliance effective. Additional monitoring requirements are likely to be marginal.	As for land management practices.
Financing needs	Needs are minimal as interventions leverage existing programmes.	As for land management practices.

BOX 19 CHINA'S LOESS PLATEAU: REVIVING ECOSYSTEMS AND RURAL LIVELIHOODS

The Loess Plateau in north-central China spans approximately 640 000 km^2 across multiple provinces.[49] Its fine, silty soils, steep slopes, and high wind exposure make it acutely vulnerable to erosion. This natural fragility was compounded by a tripling of the population between 1949 and 2000, which placed mounting pressure on land resources. Widespread deforestation, overgrazing and land clearance during this period led to the large-scale loss of topsoil and widespread degradation.[50] By the late 1990s, around 47 percent of the plateau's land area was moderately or severely eroded, with average annual soil loss estimated at 3 720 tonnes per km^2.[51] Such extensive degradation not only undermined local agricultural productivity but also contributed to broader environmental crises, such as intensified flooding from excessive sediment deposits in the Yellow River.[50]

In response, the government initiated a series of land and water management programmes to reduce erosion and stabilize rural incomes. These efforts culminated in the Grain for Green programme, launched in the late 1990s and still ongoing. The programme provides compensation to farmers who cease cultivation of low-productivity, erosion-prone land and allow it to revert to forest or grassland. Compliance is ensured through a multilayered inspection system involving routine monitoring by village officials, formal evaluations at township and county levels, and occasional random audits by higher authorities.[44] This structure likely entails significant administrative costs and reflects the high degree of state capacity required for implementation at scale.

Since its inception, Grain for Green has expanded to become the world's largest reforestation initiative, increasing tree cover on the plateau by 41 percent.[52, 53] Soil and water conservation efforts between 1975 and 2015 are estimated to have enhanced ecosystem service values while simultaneously improving local grain yields.[54, 55] Nonetheless, concerns have emerged regarding the impact on water resources. Large-scale afforestation, particularly using fast-growing non-native species, has reduced surface runoff and soil moisture, contributing to forest decline and placing strain on water availability.[56, 57] These outcomes highlight the need for ecologically balanced and hydrologically sustainable reforestation strategies. Nonetheless, the restoration of the Loess Plateau demonstrates that ambitious, incentive-driven ecological programmes can produce significant environmental and socioeconomic benefits, provided that implementation is context-sensitive and long-term trade-offs are managed carefully.

» Agriculture. The bias towards large-scale farmers was justified there, as they operate around 90 percent of cropland area, providing significant scope for conservation.[45] Such bias in other places where most farmland is operated by smallholders would need to be avoided during design and implementation.

Incentive-based measures that include results-based payments – which link financial incentives not only to the adoption of certain management practices but also to measurable biodiversity outcomes – are more effective in delivering actual environmental benefits. Although these programmes tend to have higher monitoring costs, they are increasingly used in biodiversity conservation on European farmlands, where cost-efficient monitoring and verification methods have provided large-scale conservation benefits.[46] Ensuring additionality of benefits from incentive-based schemes can be challenging, as some participating farmers might adopt conservation practices even in the absence of incentives, adding to the monitoring costs.

Sometimes, incentive-based mechanisms both complement regulations and strengthen environmental outcomes. The European Union's agri-environment-climate measures and eco-schemes, for example, provide voluntary payments for environmental practices that go beyond regulations, such as maintaining hedgerows or managing species-rich grasslands.[47] Other examples include eco-certification schemes that avoid or reduce degradation (e.g. forest-friendly, shade-grown production) and

BOX 20 COMBINING PRIVATE INITIATIVES WITH REGULATION TO ADDRESS DEFORESTATION: THE SOY AND BEEF MORATORIA IN BRAZIL

Since the mid-2000s, land-use governance in Brazil has integrated regulation with private sector initiatives. Among the most prominent non-state interventions are the soy and beef moratoria – voluntary agreements developed under pressure from civil society and implemented through supply chain mechanisms. The Soy Moratorium, launched in 2006 by major traders after Greenpeace's "Eating Up the Amazon" campaign, prohibits the purchase of soy grown on land deforested after July 2008 in the Amazon biome. Similarly, the 2009 cattle agreements require slaughterhouses to stop sourcing from properties linked to illegal deforestation. Although these moratoria are not formal public policies, they have become central components of forest governance, complementing legal instruments such as the Forest Code and environmental licensing.

During the period from 2005 to 2013, Amazon deforestation declined by approximately 70 percent.[58] However, the specific contribution of the soy and beef moratoria remains bounded by their spatial scope and implementation context. Evidence indicates that soy producers largely complied with the moratorium, and that major slaughterhouses adjusted their sourcing practices in line with the cattle agreements.[59, 60] Nonetheless, more recent evidence suggests these outcomes were spatially limited, with a cross-country review finding no consistent reduction in soy or pasture expansion patterns in response to deforestation regulations outside the Amazon biome.[61]

Within the Amazon, pasture expansion slowed in regulated areas, coinciding with a shift towards intensification. This trend, however, has its own implications: intensified grazing systems may accelerate pasture degradation and soil exhaustion.[62] Moreover, these localized improvements in the Amazon were likely offset by leakage to less regulated biomes such as the Cerrado. Modelling suggests that domestic leakage may have offset up to 50 percent of avoided deforestation from soy supply chain interventions.[63] These findings indicate that while voluntary market-based interventions have been locally effective, their limited overall impact could be enhanced through regulatory harmonization and broader shifts towards sustainable land use and management practices.

commodity round tables mostly implemented through public–private partnerships.[48] Brazil's soy and beef moratoria illustrate the benefits as well as the limitations of these private sector initiatives combined with regulation to address deforestation (Box 20).

In Mato Grosso, Brazil, environmental reserve quotas use a market-based system to help landowners meet legal conservation requirements. Landowners with more native vegetation than required by law can sell forest credits to others who need to meet their conservation obligations. This creates a financial incentive to preserve and restore forests by reducing the economic cost of setting land aside for conservation. These examples show how policy frameworks can encompass both regulatory and incentive-based approaches.

Cross-compliance policies

Cross-compliance policies make government payments to farmers conditional on their adherence to environmental standards – in practice functioning as a conditional subsidy. A recent scoping review provides strong evidence that cross-compliance incentives lead to positive environmental outcomes.[64]

This approach is most prominently adopted in the European Union and the United States of America. In the European Union, cross-compliance is embedded in the Common Agricultural Policy, whereby farmers receiving payments must comply with standards relating to environmental protection, animal welfare and plant health.[47] This system, known as "conditionality", ensures that public funding supports responsible farming by making adherence to basic good practices a prerequisite for financial support. In the United States, a similar approach – "conservation compliance" – was introduced in the 1985 Food Security Act. To qualify for federal support (e.g. commodity payments, disaster assistance, subsidized crop insurance) farmers must meet specific environmental requirements.[65] Enforcement relies primarily on self-certification, supplemented by field inspections.

The effectiveness of these policies depends on how farmers weigh the costs of compliance against the direct payments they receive. When subsidies are large and compliance costs manageable, farmers are more likely to adopt conservation practices. However, if compliance is expensive or payments low, the environmental impact may be limited.[66]

To ensure outcomes, the design of such policies must factor in the economic trade-offs faced by producers. These are likely to differ by farm size, as compliance costs may be less affordable for smaller farms in the absence of financial and technical support. Effective cross-compliance depends not only on the environmental objectives but also on aligning financial incentives so that conservation becomes a rational choice for farmers, regardless of farm size.

Recent studies suggest that for greater effectiveness, policies need to be clearly communicated and aligned with actual environmental outcomes; in addition, there needs to be a clear line between legal obligations and payments for public goods.[67]

Evolving use of agri-environmental policies

Since the beginning of the twentieth century, countries have implemented a growing portfolio of these policy approaches to avoid, reduce and reverse land degradation. The ongoing United Nations Decade on Ecosystem Restoration has increased awareness of the public good nature of actions to address land degradation; moreover, it has provided impetus to governments around the world to pledge sizeable investments to accelerate progress towards land degradation neutrality.[68] The growing commitments have contributed to the diversification of policy instruments supporting sustainable land use and management.

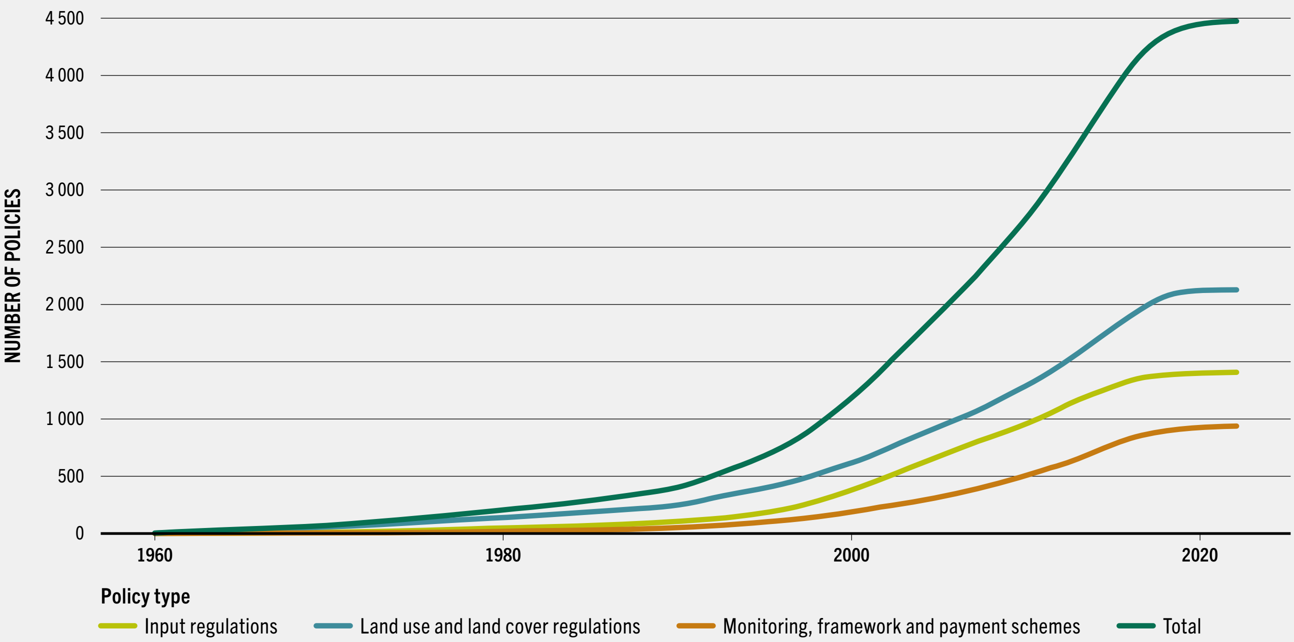
Figure 25 illustrates the evolution of agri-environmental policy use since the 1960s, with a notable increase in public policy adoption after 2000.[42] Regulatory instruments form the core of these policies. In the figure, countries' use of regulations targeting input use (green line) correspond to the land management practices detailed in Table 3; policies addressing land use and land cover (blue line) align with the aspects of land-use change under "regulatory" in the table. Over time, the policy landscape has diversified, shifting from a predominantly regulatory approach to one that increasingly incorporates incentive-based mechanisms including cross-compliance schemes (orange line).

Despite the increasing adoption of agri-environmental policies at the global level, their distribution remains highly uneven across regions. A significant concentration of these policies is observed within European Union Member States, which consistently report the highest number of agri-environmental initiatives per country. In contrast, African countries have implemented fewer such policies over the same period, highlighting a disparity in policy engagement and environmental support mechanisms across continents. ■

OPERATIONALIZING LAND DEGRADATION RESPONSES ACROSS DIVERSE FARM STRUCTURES AND CONDITIONS

Effective implementation of land degradation responses depends on both the condition of the land and the type of farm structure. In practice, this means distinguishing between areas where land remains under active use but requires improved management, and areas where degradation is so severe that a complete change in land use is necessary (Table 3). In both cases, policies must be realistic for farmers to adopt and feasible to implement at scale, striking a balance between short-term profitability and long-term sustainability to ensure uptake and impact.[64]

FIGURE 25 GLOBAL INCREASE IN SELECTED AGRI-ENVIRONMENTAL POLICIES, 1960–2022



NOTES: The figure includes national and subnational policies mainly funded by national governments. European Union policies are counted as one policy for the European Union, not as 27 separate policies.

SOURCE: Figure 1 in Wuepper, D., Homma, K., Dureti, G., Schioppa, A. & Clemence, S. 2025. *Policies that improved land conditions – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-15. Rome, FAO.

https://doi.org/10.4060/cd7067en-fig25

Where land remains in use but shows signs of degradation, the focus is on improving land management practices. These may include soil and water conservation, agroforestry, and reduced tillage. Regulatory measures can promote adoption, but their effectiveness depends on farmers' capacity to comply. Incentive-based schemes can help offset opportunity costs and provide technical support, particularly for smallholders, and their outcomes can be further enhanced through cross-compliance. However, efforts to promote sustainable land management can be costly to implement and monitor, especially in areas with a large number of small-scale farms.[48, 69, 70]

The burden of implementation varies by farm size. Smallholders often experience the added burden of lacking the livelihood security or financial margins needed to adopt sustainable land-use practices such as fallowing to reduce nutrient mining. Larger farms, by contrast, benefit from economies of scale and are often better positioned to meet compliance or reporting requirements.[71, 72] Policies and institutions may be biased towards larger farms, reinforcing disparities.[73, 74] For an example of how regulatory burdens can fall unevenly according to farm size, see Box 21, which documents the potential impacts of EU Deforestation Regulation going beyond national and EU jurisdictions. To ensure equitable outcomes, enabling measures such as secure land tenure, access to extension services and support for farmer cooperatives are essential.

In severely degraded or abandoned lands, the objective is to reverse degradation through intensive restoration efforts. These areas require »

BOX 21 DIFFERENTIAL IMPACTS OF DEFORESTATION REGULATIONS BY FARM SIZE

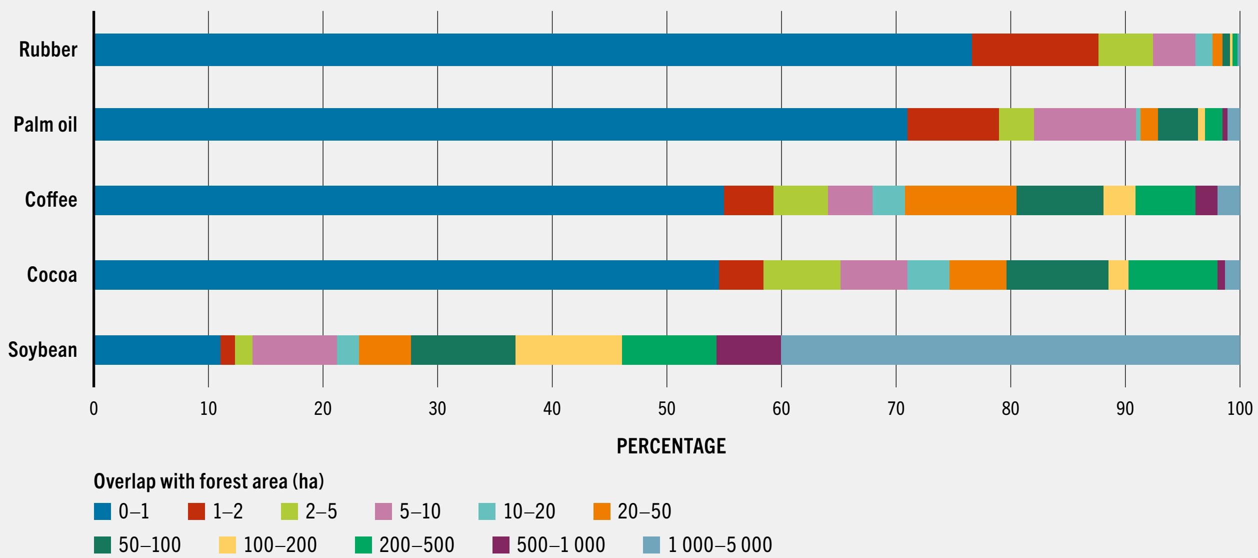
Agriculture is the leading driver of tropical deforestation, a trend that continues to grow, posing severe threats to the climate, biodiversity and ecosystems.[75–78] Forest loss also endangers the food security of the 1.6 billion people worldwide who live within 5 km of forests.[79] A major obstacle to reducing deforestation lies in understanding the diverse farming activities within forested landscapes. Existing agrifood system models have attempted to quantify the extent and sources of deforestation linked to crop and livestock products, yet they fall short of attributing forest loss to individual farms. This gap hinders the development of targeted interventions.[80]

A new study led by researchers at Leiden University's Institute of Environmental Sciences (CML) addresses this issue by combining spatially modelled field size data with data on forest cover and crop yields.[81–83] The study assesses the contribution of small-, medium- and large-scale farmers to agricultural production in forest-dominated areas. It finds that roughly one-third of farms intersect with forested regions, and that smallholder farms are the most prevalent farm type in these landscapes. This finding reflects the recent assertion that smallholders (albeit defined differently) are responsible for most global deforestation – although in South America and Asia, there are areas where large-scale farming is the main driver of deforestation.[84]

These insights are crucial for shaping effective deforestation policies, including the European Union Deforestation Regulation (EUDR). The EUDR will require cocoa, coffee, palm oil, natural rubber, cattle (beef), soybean and timber products and their derivatives to be free from deforestation.[85] To comply, farmers must submit geolocation data; non-compliance means they risk exclusion from international markets. The CML study applies the EU Joint Research Centre's forest map to identify high-risk farms, countries and commodities within this regulatory framework.[81]

Smallholder farmers account for the largest share of forest-dominated land used to produce several forest-risk commodities (see figure), including rubber (88 percent), palm oil (79 percent), coffee (59 percent) and cocoa (58 percent). In contrast, large-scale farmers dominate soybean cultivation in forested areas. These findings highlight the importance of understanding the types of farms that will be affected by policies. If smallholders are disproportionately affected, additional measures may be needed to address the limited technical and financial capacities of small-scale farmers, including support for data collection, certification and compliance. These are critical to ensure that forest conservation initiatives do not come at the cost of smallholder livelihoods.

FIGURE PRODUCTION OF EUROPEAN UNION DEFORESTATION REGULATION-LISTED CROPS OVERLAPPING WITH FOREST AREAS, SHOWN BY CONTRIBUTION BY FARM SIZE



SOURCE: Çelik, A., Flach, R., van Bodegom, P., zu Ermgassen, E. & Taherzadeh, O.A. (forthcoming). *Small-scale farmers critical to curbing deforestation linked to forest-risk commodities*. Institute of Environmental Sciences, Leiden University, Kingdom of the Netherlands.

BOX 22 THE GREAT GREEN WALL: RESTORING LANDS AND LIVELIHOODS IN THE SAHARA AND THE SAHEL

Starting in the 1970s, vast swathes of fertile land in the Sahel, a region that spans the southern edge of the Sahara, started to become severely degraded.[88] Decades of unsustainable land use, compounded by climate change and population pressures, made the area dry and barren, contributing to food insecurity, poverty and displacement across the broader Sahara and Sahel regions.

In response, the African Union launched the Great Green Wall (GGW) initiative in 2007 – a pan-African effort across 22 countries to restore 100 million hectares of degraded land, sequester 250 million tonnes of carbon and create 10 million green jobs by 2030. Around USD 19 billion has been pledged to date by partners including the African Development Bank, the World Bank, the European Union and the Green Climate Fund.[89]

Implementation varies by country, but is typically delivered through structured programmes that combine technical interventions with policy support, financing mechanisms, and monitoring systems. Coordination is led by the Pan-African Agency of the Great Green Wall, with technical backing from the United Nations Convention to Combat Desertification. To accelerate progress, the Great Green Wall Accelerator was launched in 2021 to enhance donor coordination, mobilize funding, and align international support with national restoration strategies.[90]

Action Against Desertification – a land restoration initiative within the GGW framework implemented in northern Nigeria from 2016 to 2020 – operated in areas where forest cover had experienced a 50 percent decline between 2007 and 2015, with most of the land converted to cropland.[91] Focused on Bauchi, Jigawa and Sokoto states, the programme applied a livelihood-centred approach linking restoration with improved agricultural productivity, commercialization of non-timber forest products (NTFPs) and the provision of ecosystem services. A socioeconomic evaluation found that restoration activities did not adversely affect food security among participating households. On the contrary, moderate food insecurity declined, with households reporting fewer skipped meals and food shortages. These gains were associated with shifts in livelihood strategies – including reduced reliance on crop sales and increased engagement in the sale of livestock by-products and high-value NTFPs – highlighting the potential of integrated restoration efforts to deliver both environmental and socioeconomic benefits.

» the most complex and resource-intensive interventions. Regulatory mandates may compel rehabilitation, while incentive-based programmes support major land-use changes such as afforestation and rewetting. Cross-compliance policies often involve coordinated legal, financial and technical tools within a project spanning multiple years and different stakeholders. Monitoring can be site-specific and long-term, but earth observation techniques are increasingly supporting governments in monitoring and enforcing LUCC regulations, particularly in areas where large-scale changes are expected. For example, in Inner Mongolia, remote sensing supported the monitoring of grazing reduction policies where payment schemes led to measurable improvements in grassland quality.[86, 87]

Restoration can require substantial public financing, often through donors or private sector cofinancing. The need for landscape-level restoration may even go beyond national jurisdictions; this is the case of the Green Wall for the Sahara Initiative – a pan-African effort across 22 countries, also known as the Great Green Wall – which aims to restore 100 Mha of land by combining national policy alignment with donor coordination and community engagement (Box 22). The effectiveness of these interventions depends on their integration with national strategies, long-term financing mechanisms, and the ability to sustain outcomes beyond the project cycle.

Integrated land use planning (ILUP) can help align these different types of interventions with both land condition and farm structure. By combining spatial data, stakeholder consultations and cross-sector coordination, ILUP supports the identification of appropriate policy tools and their adaptation to local realities. Box 23 illustrates how countries like Ecuador and Morocco are using participatory, data-driven planning tools to guide sustainable land management decisions. These experiences highlight the importance of embedding technical analysis within inclusive planning processes to ensure that land restoration efforts are both targeted and equitable. ■

BOX 23 IMPLEMENTING SUSTAINABLE LAND MANAGEMENT: LESSONS FROM MOROCCO AND ECUADOR

Integrated land use planning through participatory and data-driven solutions is increasingly becoming integral to country policymaking within the framework of land degradation neutrality and the broader Sustainable Development Goals.

In Ecuador, a tool was developed to support the country's Land Degradation Neutrality goals.[92] Built on a user-friendly digital platform, the tool integrates biophysical and socioeconomic data including survey and geospatial data, as well as documented sustainable land management (SLM) practices. Developed with input from national and international experts, public officials and stakeholders, the tool helps decision-makers to prioritize interventions. This inclusive approach strengthens cross-sector collaboration and will support Ecuador's reporting progress to the United Nations Convention to Combat Desertification. The tool is open source and can be adapted for use in other countries and regions.

A similar approach was applied in Morocco: in 2015, a detailed land degradation assessment in the Souss-Massa region found that approximately 19 percent of land was degraded. The assessment helped map degradation hotspots and existing SLM areas, and was supported by a participatory planning process involving local communities and institutions.[93] This process led to a territorial planning pact and a three-year action plan to integrate SLM into local development priorities. The initiative showed how combining technical analysis with community engagement can lead to more effective, inclusive land use planning.

To scale such efforts globally, FAO promotes integrated land use planning, a systematic approach to evaluating and selecting the most appropriate land uses to balance environmental, economic and social goals.[94] FAO is currently updating the 1993 Guidelines on Land Use Planning to emphasize recent trends, including the optimization of resources, stakeholder consultation and multidisciplinary technical support.[95]

EFFECTIVENESS OF AGRI-ENVIRONMENTAL POLICIES

Globally, evidence for the effectiveness of agri-environmental policies has to date been based primarily on national or subnational analyses, which vary in scope and methodology. To address this gap, a background paper by Wuepper *et al.* (2025)[42] evaluated the impact of over 4 500 policies on cropland, grassland and forest conditions, while maintaining agricultural production across diverse economic and institutional contexts. The policies analysed include mandatory crop rotations, pesticide regulations and subsidies for sustainable land management on croplands; grazing limits and payments for ecosystem services on grasslands; and logging limits, protected areas and carbon credits on forest lands. Given the differences across land cover types in the outcome indicators that need to be measured to assess effectiveness, specific indicators are used (Box 24). These indicators can support the design of cost-effective monitoring frameworks for similar policies as they are publicly available data sources.

Figure 26 summarizes the results of this global analysis. Land-use regulations consistently emerge as effective instruments for improving land conditions. On average, each additional land-use regulation improved cropland soil conditions by about 2 percent, increased the species richness of threatened birds by about 6 percent, and reduced forest loss by about 10 percent.[42] These findings align with broader evidence showing that regulations often improve land conditions by promoting sustainable land management practices, including forest conservation,[35, 108] reduced grassland use intensity,[97, 109] and the adoption of conservation agriculture techniques such as low or no tillage, crop rotation and soil cover.[103, 110, 111] The trade-offs, however, need to be carefully managed. For example, while land-use regulations may be very effective in conserving biodiversity in grassland ecosystems, they may decrease potential protein production,[97, 109] underlining the need to carefully balance conservation and production needs.

Agri-environmental payments also show positive impacts, though with greater variability. They are particularly effective in forest conservation[35, 97, 108] and contribute to improved cropland conditions at the global level.[96] However, they have on average proven ineffective for grassland biodiversity.[97] Globally, payment schemes are estimated to be as effective as regulations for forest conservation, and about half as effective for croplands. In some contexts, combining payments with regulations yields better outcomes. For example, in Switzerland, payments linked to management extensification have improved biodiversity

BOX 24 SYNTHESIS OVERVIEW OF POLICIES THAT IMPROVED LAND CONDITIONS

The background paper for this report, authored by Wuepper *et al.*,[42] presents a unique global analysis of agri-environmental policies that have improved land conditions, drawing on empirical evidence combining remote sensing and other geospatial panel data. The findings synthesize research on how policies affect land conditions in cropland,[96] grassland[97] and forest land,[98] while maintaining agricultural production.

Because of inherent differences across land cover types, the analyses adopt unique, albeit related, approaches. First, the land cover is identified spatially, then its condition is analysed through proxies including soil quality for cropland, bird biodiversity and protein production for grassland, and deforestation for forest land (see the table for details on how these were measured).

Policies were analysed using difference-in-difference (DiD) and difference-in-discontinuity (DiDC) methods. The DiD approach estimates changes in land condition trends by comparing countries before and after the introduction of a policy. The DiDC approach is similar, drawing on remote sensing data near international borders to estimate how policy affects border discontinuities in land condition trends over time.[99, 100]

Contextual factors are also assessed to understand how diverse economic and institutional landscapes hinder or enable policy impact. This includes examining country income, institutional capacity, property rights, enforcement stringency and median farm size to determine how they modify policy effects across contexts.

While filling a gap in the literature, especially for cropland and grassland, this synthesis has certain limitations. Remote sensing data are prone to measurement errors and lack information on many types of biodiversity and pollution. The policy data used in this analysis focus on specific types of policies and outcome indicators, excluding other types of policies (e.g. livestock support or trade policies) that also have an impact on land conditions. Additionally, causal effects from border-level DiD estimates may not be representative of the whole country, and therefore comparisons with other methods have been implemented in the background paper to corroborate findings and ensure robustness.

TABLE SUMMARY OF DATA

	Cropland	Grassland	Forest land
Land cover class identification	Annual land cover maps[101]	MODIS Land Cover Type Yearly Global 500 m dataset, resampled at 1 km resolution and classified into natural and managed grassland using grassland management type and intensity data[97, 101–103]	MODIS-based global land cover map,[101] classified into natural and managed forests, including planted forests, tree crop plantations and intensively managed natural forests
Proxy outcome indicators for land conditions	Soil quality: annual maximum enhanced vegetation index, adjusted for weather, topography, and agricultural technology[104]	Bird diversity: bird species richness based on eBird;[105] potential protein production (from livestock) estimated on grassland by multiplying net primary productivity, which measures biomass production, by protein feed efficiency[106]	Deforestation: Intact Forest Landscapes Data[107] and MODIS map to classify forest patches as intact or non-intact, track annual land cover changes, and calculate forest loss at the country-year level

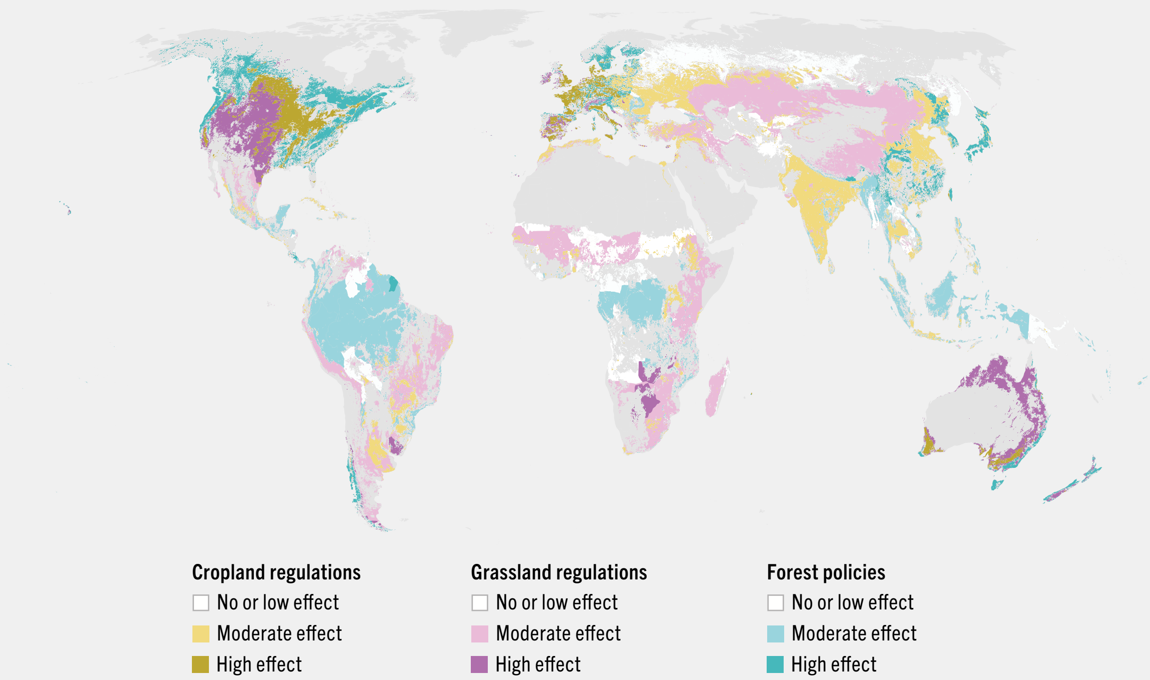
NOTE: MODIS = Moderate Resolution Imaging Spectroradiometer.

SOURCES: Authors' own elaboration based on Wuepper, D., Homma, K., Dureti, G., Schioppa, A. & Clemence, S. 2025. *Policies that improved land conditions – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-15. Rome, FAO. Findings for cropland draw on Dureti, G., Hadi, H. & Wuepper, D. (forthcoming). *Public policies have globally improved cropland condition*; findings for grassland draw on Homma, K., Jinfeng, C., Hadi, C.P. & Wuepper, D. (forthcoming). *Public land-use policies have improved biodiversity on the world's grasslands*. University of Bonn; findings for forest land draw on Homma, K., Hadi, C.P., Jäger, N., Driscoll, A., Mueller, N., Koch, N. & Wuepper, D. (forthcoming). *Does public policy mitigate land conversion and therefore reduce carbon emissions globally?* University of Bonn.

in grasslands.[41, 68] In China, reductions in sheep numbers under payment schemes have improved grassland quality, particularly on large farms in Inner Mongolia.[86, 87] A key challenge, however, is that payments are often voluntary and, if monitoring frameworks are weak, they may be disbursed even without substantial management change.

Policies targeting use of inputs (e.g. fertilizers, pesticides) and broad regulations on habitat or biodiversity showed the least impact on soil quality measured by the enhanced vegetation index in the global analysis.[42] However, this finding should be interpreted with caution, as an important goal of such regulations is to address environmental pollution externalities beyond croplands, and these were not assessed

FIGURE 26 POTENTIAL EFFECTS OF ADDITIONAL POLICYMAKING ACROSS COUNTRIES AND LAND COVER TYPES



NOTES: Refer to the disclaimer on the copyright page for the names and boundaries used in this map. The figure categorizes the performance of grassland, cropland and forest policies in various countries into "no or low effect", "moderate effect" and "high effect". These effects represent the expected impact of additional policies, considering interactions with five contextual factors: income, institutions, policy stringency and enforcement, property rights security, and median farm size. For forests, impacts relate to conservation; for grassland, to bird species richness; and for cropland, to land-use regulation.

SOURCE: Figure 16 in Wuepper, D., Homma, K., Dureti, G., Schioppa, A. & Clemence, S. 2025. *Policies that improved land conditions – Background paper for The State of Food and Agriculture 2025*. FAO Agricultural Development Economics Working Paper 25-15. Rome, FAO.

in this study. Agricultural inputs are also often less relevant for other land cover types.[96] For instance, an action plan in northeast China reduced fertilizer use intensity by nearly 12 percent and improved soil conditions.[112] The limited effectiveness of habitat and biodiversity regulations may reflect their broad scope and lack of targeting.

Overall, approaches that combine regulatory and incentive-based instruments offer strong potential to improve land conditions. Their effectiveness depends on careful tailoring to land cover types and local contexts. In croplands, for example, regulations can be complemented by payments supporting biodiversity in non-productive landscape features such as hedgerows or stone walls. In forests, combining legal protections with recognition of Indigenous Peoples' land rights and enforcement mechanisms has proven effective.[35, 108] Ultimately, a context-specific approach that combines policy instruments – tailored to local economic and institutional realities – is essential for improving land conditions. ■

THE WAY FORWARD

Addressing land degradation across landholding scales is not only a technical challenge but a societal imperative. The evidence presented in this report underscores the urgency of reversing land degradation to safeguard food security, sustain livelihoods and preserve the ecological functions that underpin agrifood systems. Yet, the path forward must be as diverse and dynamic as the landscapes and land users it seeks to support.

First, land degradation must be understood within the broader context of land-use decisions – shaped by local choices and global drivers such as trade, climate change and demographic transitions. Farmers, as private actors, make decisions primarily based on productivity and profitability. This means that efforts to promote sustainable land management must take account of the economic realities they face – including the time, labour and financial costs of implementation – and ensure that these do not outweigh the expected benefits.

Second, the diversity of farm sizes and structures must be embraced as a central axis of policy design. Smallholder farmers, who often operate under resource constraints and on marginal lands, need targeted support to sustainably intensify production. Closing yield gaps without further degrading land calls for access to appropriate technologies and extension services, secure tenure, and inclusive financing mechanisms. In places where accumulated land degradation is not the primary constraint, strengthening enabling environments will be key to breaking path dependencies that have led to unsustainable intensification. At the other end of the spectrum, large-scale commercial farms – though fewer in number – manage most of the world's agricultural land and have a disproportionate impact on land systems. These farms must play a leading role in achieving land degradation neutrality by complying with environmental regulations, adopting sustainable land management practices, and participating in incentive schemes that reward ecosystem stewardship.

Third, the restoration of degraded land must be differentiated. Severely degraded areas may require transformative approaches, including land-use change or long-term fallowing, while land in agricultural production can benefit from improved management practices that enhance productivity and resilience. This calls for a nuanced policy mix that combines regulatory frameworks with incentive-based mechanisms, underpinned by robust monitoring systems and adaptive governance. Tailoring interventions to the specific needs, capacities and responsibilities of different land users is essential for equitable and effective progress.

Fourth, land governance must be strengthened. Well-defined tenure rights – both individual and collective – are non-negotiable for sustainable land use and livelihoods. Inclusive governance structures are also essential to manage trade-offs, which are often unavoidable in land systems. Win–win scenarios are rare; thus, enabling environments must support transparent decision-making and equitable outcomes.

Encouragingly, sustainable land management and land restoration efforts are already underway in many parts of the world, demonstrating that solutions exist and can be scaled. These efforts show that reversing degradation is possible when the right enabling conditions are in place. However, land degradation must still be addressed within the broader context of global sustainability goals. While land is foundational to national food security and development strategies, it is also central to the global challenges of climate change and biodiversity loss. Governments and international bodies are increasingly aligning efforts under the three United Nations Rio Conventions (UNCCD, UNFCCC, CBD), but progress is hindered by weak implementation, limited coordination and insecure tenure. Strengthening institutional coherence and political will is essential to translate global commitments into local action.

The way forward is clear: to avoid and reduce land degradation, and to reverse it where it has already occurred, we must invest in people, policies and practices that recognize the value of land, not only as a productive asset but as a foundation for human and planetary well-being. The time to act is now – before the costs of inaction become irreversible. ■

ANNEX 1

TABLE A1 NUMBER AND SIZE OF AGRICULTURAL LAND HOLDINGS

Country/territory	Year	Number of holdings	Number of holdings (smoothed 2025 projection)	Mean holding size (ha)	Median holding size (ha)	Census/Survey, Institute
Albania	2012	324 013	320 163	1.2	0.7	Agriculture Census,* Institute of Statistics (INSTAT)
American Samoa	2018	6 329	6 329	1.3	0.7	Census of Agriculture, United States Census Bureau
Argentina	2018	227 323	218 050	681.0	81.9	Agricultural Census,* National Institute of Statistics and Censuses (INDEC)
Armenia**	2014	360 611	328 178	1.5	1.0	Agricultural Census, National Statistical Services (ARMSTAT)
Australia	2021	87 402	129 212	4 430.8	327.8	Agricultural Census, Australian Bureau of Statistics
Austria**	2020	110 250	173 001	23.6	14.8	Agricultural Census, Eurostat
Azerbaijan	2015	1 352 121	1 336 677	1.7	0.5	Agricultural Census, State Statistical Committee
Bangladesh	2019	16 881 756	19 041 859	0.5	0.4	Agricultural Census, Bangladesh Bureau of Statistics
Belarus	2019	2 262 616	1 655 269	4.2	0.1	Population Census – Agricultural module, National Statistical Committee (BELSTAT)
Belgium**	2020	35 299	36 767	38.8	25.2	Agricultural Census, Eurostat
Benin**	2022	1 093 851	1 035 360	3.6	2.0	Harmonized Survey on Household Living Conditions,* National Institute of Statistics and Economic Analysis (INSAE)
Bhutan	2019	66 587	66 587	1.5	1.1	Renewable Natural Resources Census, Ministry of Agriculture and Forests (MoAF)
Bolivia (Plurinational State of)**	2015	614 303	680 753	48.7	4.0	Household Survey,* National Institute of Statistics (INE)
Brazil**	2017	5 072 152	3 302 087	70.3	9.4	Census of Agriculture, Brazilian Institute of Geography and Statistics (IBGE)
Bulgaria**	2020	127 280	123 232	35.9	2.4	Agricultural Census, Eurostat
Burkina Faso**	2019	2 141 330	2 342 842	3.5	2.5	Harmonized Survey on Household Living Conditions, National Institute of Statistics and Demography (INSD)
Cambodia**	2023	1 863 830	2 009 324	1.6	1.1	Agriculture Survey, National Institute of Statistics (NIS)
Cameroon**	2014	2 439 935	2 418 099	2.1	1	Fourth Cameroon Household Survey, National Institute of Statistics (INS)
Cabo Verde	2015	34 033	34 033	1.1	0.8	Census of Agriculture, National Institute of Statistics (INE)
Canada	2021	189 874	224 746	327.6	85.6	Census of Agriculture, Statistics Canada

TABLE A1 (Continued)

Country/territory	Year	Number of holdings	Number of holdings (smoothed 2025 projection)	Mean holding size (ha)	Median holding size (ha)	Census/Survey, Institute
Chile**	2021	138 628	194 396	330.0	7.6	VIII National Agricultural and Forestry Census,* National Institute of Statistics (INE)
China	2016	209 500 000	149 486 858	0.6	0.4	Third National Agricultural Census, Steering Group Office of the Third National Agricultural Census of the State Council
Colombia**	2019	2 370 099	1 722 549	54.4	3.0	Agricultural Census, National Administrative Department of Statistics (DANE)
Congo	2015	267 419	306 261	1.3	0.2	General Agricultural Census (GAC), Ministry of Agriculture, Livestock and Fishing (MALF)
Costa Rica**	2014	93 017	78 221	26.7	4.8	IV National Agricultural Census,* National Institute of Statistics and Censuses (INEC)
Côte d'Ivoire**	2019	2 408 709	1 992 821	4.2	2.5	Harmonized Survey on Household Living Conditions,* National Institute of Statistics (INS)
Croatia**	2020	140 940	148 543	8.7	2.5	Agricultural Census, Eurostat
Cyprus**	2020	33 680	32 768	4.0	1.0	Agricultural Census, Eurostat
Czechia**	2020	28 909	32 618	122.8	15.9	Agricultural Census, Eurostat
Denmark**	2020	36 091	49 853	72.9	19.3	Agricultural Census, Eurostat
Ecuador**	2014	805 916	918 177	5.1	1.0	Living Conditions Survey,* National Institute of Statistics and Censuses (INEC)
Egypt	2010	5 404 395	7 376 309	0.9	0.4	Agricultural Census, Ministry of Agriculture and Land Reclamation (MALR)
El Salvador	2008	397 433	332 055	2.4	0.8	Census of Agriculture, General Directorate of Statistics and Censuses (DIGESTYC)
Estonia**	2020	11 130	13 439	87.6	16.4	Agricultural Census, Eurostat
Ethiopia**	2019	11 452 116	15 744 622	0.9	0.6	Ethiopia Socioeconomic Survey, Central Statistical Agency
Fiji	2020	68 424	68 424	2.8	0.5	Agriculture Census, Ministry of Agriculture (MoA)
Finland**	2020	45 390	58 585	50.3	22.7	Agricultural Census, Eurostat
France**	2020	388 530	495 376	70.4	42.6	Agricultural Census, Eurostat
French Guiana	2010	5 983	5 983	4.2	1.9	Agricultural Census, Service for Statistics and Prospective (SSP)
Georgia**	2022	573 543	532 047	1.2	0.7	Survey of Agricultural Holdings, National Statistics Office of Georgia (GEOSTAT)
Germany**	2020	262 000	385 057	64.1	25.2	Agricultural Census, Eurostat

TABLE A1 (Continued)

Country/territory	Year	Number of holdings	Number of holdings (smoothed 2025 projection)	Mean holding size (ha)	Median holding size (ha)	Census/Survey, Institute
Ghana**	2017	2 158 697	2 720 623	2.4	1.6	Ghana Living Standards Survey, Ghana Statistical Services
Greece**	2020	525 300	516 789	5.4	2.1	Agricultural Census, Eurostat
Guadeloupe	2010	7 852	7 852	4.0	2.4	Agricultural Census, Service for Statistics and Prospective (SSP)
Guam	2018	234	234	1.3	0.7	Census of Agriculture, National Agricultural Statistics Service (NASS)
Guatemala**	2014	1 054 647	1 261 608	0.8	0.5	National Survey of Living Conditions,* National Institute of Statistics (INE)
Guinea-Bissau**	2019	120 174	150 013	12.5	1.0	Harmonized Survey on Household Living Conditions,* National Institute of Statistics (INE)
Haiti	2009	1 018 951	947 074	0.9	0.8	General Agricultural Census, Haitian Institute of Statistics and Informatics (IHSI)
Hungary**	2020	215 720	351 469	22.8	2.7	Agricultural Census, Eurostat
Iceland**	2020	2 100	2 100	620.9	365.3	Agricultural Census, Eurostat
India**	2016	146 000 000	167 713 632	1.1	0.5	Agriculture Census, Ministry of Agriculture and Farmers Welfare
Indonesia	2023	29 359 594	23 340 052	0.9	0.7	Census of Agriculture, Statistics Indonesia (BPS)
Iran (Islamic Republic of)	2014	3 359 409	3 410 316	4.9	1.5	Census of Agriculture, Statistical Center of Iran (SCI)
Iraq**	2012	397 289	954 676	4.2	2.0	Household Socio-economic Survey, Central Organization of Statistics and Information Technology (COSIT)
Ireland**	2020	130 190	97 503	34.6	24.2	Agricultural Census, Eurostat
Italy**	2020	1 118 030	1 720 979	10.8	2.8	Agricultural Census, Eurostat
Jamaica	2007	228 683	192 056	1.6	0.4	Census of Agriculture, Statistical Institute of Jamaica (STATIN)
Japan	2020	1 058 754	1 176 829	3.1	1.0	Census of Agriculture and Forestry, Ministry of Agriculture, Forestry and Fisheries (MAFF)
Jordan	2017	107 707	89 661	2.6	0.3	Agricultural Census, Department of Statistics (DoS)
Kazakhstan	2007	200 676	214 681	394.3	18.7	Agricultural Census, Bureau of National Statistics
Kenya**	2019	6 354 211	7 375 046	0.7	0.4	Kenya Population and Housing Census, Kenya National Bureau of Statistics (KNBS)
Lao People's Democratic Republic	2020	851 000	921 712	2.4	1.7	Census of Agriculture, Lao Statistics Bureau

TABLE A1 (Continued)

Country/territory	Year	Number of holdings	Number of holdings (smoothed 2025 projection)	Mean holding size (ha)	Median holding size (ha)	Census/Survey, Institute
Latvia**	2020	67 260	70 851	29.3	5.7	Agricultural Census, Eurostat
Lebanon	2010	169 512	166 333	1.4	0.5	Agricultural Census, Central Administration of Statistics (CAS)
Liberia**	2016	328 936	381 749	1.7	1.3	Household Income and Expenditure Survey, Liberia Institute of Statistics and Geo-Information Services (LISGIS)
Lithuania**	2020	130 400	137 033	22.4	5.1	Agricultural Census, Eurostat
Luxembourg**	2020	1 881	1 881	70.2	55.6	Agricultural Census, Eurostat
Malawi**	2020	3 195 852	4 104 862	0.6	0.5	Fifth Integrated Household Survey, National Statistical Office (NSO)
Mali**	2019	1 571 417	1 638 311	4.8	3.5	Harmonized Survey on Household Living Conditions,* National Institute of Statistics (INSTAT)
Malta**	2020	7 360	7 360	1.3	0.8	Agricultural Census, Eurostat
Martinique	2010	3 307	3 307	7.6	2.8	Agricultural Census, Service for Statistics and Prospective (SSP)
Mauritius	2014	23 456	24 423	2.8	0.6	Census of Agriculture, Statistics Mauritius
Mexico**	2022	4 629 134	2 789 387	14.9	2.6	Agricultural Census, National Institute of Statistics and Geography (INEGI)
Micronesia (Federated States of)	2017	15 545	15 545	2.7	0.6	Integrated Agriculture Census, Department of Resources and Development (FSM RD)
Mongolia**	2019	236 312	276 359	0.8	0.1	Household Socio-economic Survey, National Statistics Office (NSO)
Montenegro**	2010	48 824	48 824	4.6	0.9	Agricultural Census, Eurostat
Mozambique	2010	3 827 797	5 013 411	1.5	1.1	Census of Agriculture, National Institute of Statistics (INE)
Myanmar	2010	5 426 083	4 739 441	2.6	1.6	Census of Agriculture, National Agricultural Statistics System (NASS)
Namibia	2014	209 413	175 676	4.1	2.3	Census of Agriculture, Namibia Statistics Agency (NSA)
Nepal**	2022	3 999 285	4 713 844	0.6	0.4	National Sample Census of Agriculture, National Statistics Office (NSO)
Netherlands (Kingdom of the)**	2020	51 281	38 952	35.4	22.5	Agricultural Census, Eurostat
New Zealand	2017	52 293	52 013	265.8	62.5	Agricultural Production Census, Statistics NZ (Stata NZ)
Nicaragua**	2011	268 527	281 984	23.1	4.4	IV National Agricultural Census,* National Institute of Development Information (INIDE)

TABLE A1 (Continued)

Country/territory	Year	Number of holdings	Number of holdings (smoothed 2025 projection)	Mean holding size (ha)	Median holding size (ha)	Census/Survey, Institute
Niger**	2022	2 983 130	3 330 748	2.9	2.0	Harmonized Survey on Household Living Conditions,* National Institute of Statistics (INS)
Nigeria**	2022	40 200 000	17 411 551	1.4	0.8	National Agricultural Sample Census, National Bureau of Statistics (NBS)
Niue	2021	481	481	2.4	1.0	Census of Agriculture, Department of Agriculture, Forestry and Fisheries (DAFF)
Northern Mariana Islands	2018	252	252	2.2	1.0	Census of Agriculture, National Agricultural Statistics Service (NASS)
North Macedonia**	2007	192 675	189 762	1.7	0.8	Farm Structure Survey, Eurostat
Norway**	2020	38 710	44 731	26.2	17.8	Agricultural Census, Eurostat
Oman	2013	166 610	61 772	1.0	0.1	Census of Agriculture, Ministry of Agriculture and Fisheries (MAF)
Pakistan**	2010	8 264 531	12 684 315	1.9	1.2	Agricultural Census, Pakistan Bureau of Statistics (PBS)
Palestine	2021	140 568	145 365	0.9	0.3	Agricultural Census, Palestinian Central Bureau of Statistics (PCBS)
Panama	2011	248 560	161 467	10.9	1.0	Agricultural Census, National Institute of Statistics and Censuses (INEC)
Paraguay**	2023	316 608	392 046	8.9	2.6	Permanent Household Survey,* National Institute of Statistics (INE)
Peru**	2019	2 063 394	1 752 087	5.0	1.0	National Agricultural Survey,* National Institute of Statistics and Informatics (INEI)
Philippines	2012	5 563 138	8 001 393	1.3	0.5	Census of Agriculture and Fisheries, Census Steering Committee (CSC)
Poland**	2020	1 297 291	1 821 511	11.4	4.7	Agricultural Census, Eurostat
Portugal**	2020	286 200	303 433	13.9	2.0	Agricultural Census, Eurostat
Puerto Rico	2022	7 602	7 602	25.6	7.1	Census of Agriculture, National Agricultural Statistics Service (NASS)
Republic of Korea	2020	1 026 053	481 502	1.1	0.6	Census of Agriculture, Forestry and Fisheries, Statistics Korea (KOSTAT)
Republic of Moldova	2011	902 463	755 616	2.5	0.6	General Agricultural Census, National Bureau of Statistics (NBS)
Réunion	2010	7 623	7 623	5.6	2.9	Agricultural Census, Service for Statistics and Prospective (SSP)
Romania**	2020	2 887 070	2 745 746	3.6	0.8	Agricultural Census, Eurostat

TABLE A1 (Continued)

Country/territory	Year	Number of holdings	Number of holdings (smoothed 2025 projection)	Mean holding size (ha)	Median holding size (ha)	Census/Survey, Institute
Russian Federation	2016	23 783 658	16 959 143	19.9	0.1	Agricultural Census, Federal Service for State Statistics (Rosstat)
Rwanda**	2013	16 003	1 228 939	0.4	0.2	Seasonal Agricultural Survey, National Institute of Statistics of Rwanda (NISR)
Saint Lucia	2007	9 448	9 448	1.3	0.5	Census of Agriculture, Central Statistical Office of Saint Lucia
Saudi Arabia	2015	285 166	348 940	12.0	0.6	Agricultural Census, General Authority for Statistics (GASTAT)
Senegal**	2022	676 354	839 071	3.1	2.4	Harmonized Survey on Household Living Conditions,* National Agency of Statistics and Demography(ANSD)
Serbia**	2012	631 552	584 505	5.5	2.1	Agricultural Census, Eurostat
Seychelles	2011	17 380	17 380	0.9	0.6	Census of Agriculture, National Bureau of Statistics (NBS)
Slovakia**	2020	17 980	24 569	103.6	8.2	Agricultural Census, Eurostat
Slovenia**	2020	71 631	72 700	6.7	3.8	Agricultural Census, Eurostat
South Africa	2011	2 919 604	920 829	1 232.4	184.7	Population Census 2011 (Agricultural Households), Statistics South Africa (Stats SA)
Spain**	2020	914 871	1 058 524	26.1	4.7	Agricultural Census, Eurostat
Sri Lanka	2014	4 353 121	4 197 578	0.9	0.4	Economic Census, Department of Census and Statistics (DCS)
Suriname**	2016	5 903	5 903	1.5	0.3	Suriname Survey of Living Conditions, Inter-American Development Bank (IDB)
Sweden**	2020	58 290	60 823	51.6	15.3	Agricultural Census, Eurostat
Switzerland**	2020	49 360	98 025	18.2	15.3	Agricultural Census, Eurostat
Tajikistan**	2013	1 087 298	1 201 250	0.2	0.1	Census of Agriculture, State Statistical Agency (TAJSTAT)
Thailand	2023	8 659 470	6 204 298	3.1	2.1	Agricultural Census, National Statistical Office (NSO)
Timor-Leste	2019	141 141	167 009	1.5	0.3	Timor-Leste Census of Agriculture, General Directorate of Statistics (GDS)
Togo**	2014	508 599	576 053	3.1	1.5	Census of Agriculture, Agricultural Statistical Service (DSID)
Uganda**	2016	5 828 858	7 409 788	1.1	0.7	Uganda National Panel Survey, Uganda Bureau of Statistics (UBOS)
United Kingdom of Great Britain and Northern Ireland**	2021	217 000	161 858	80.3	21.7	Agricultural Census, Department for Environment, Food, and Rural Affairs
United Republic of Tanzania**	2015	6 296 569	8 864 085	2.0	1.1	National Panel Survey, National Bureau of Statistics (NBS)

TABLE A1 (Continued)

Country/territory	Year	Number of holdings	Number of holdings (smoothed 2025 projection)	Mean holding size (ha)	Median holding size (ha)	Census/Survey, Institute
United States of America**	2017	2 042 220	1 466 670	187.4	22.3	Census of Agriculture, National Agricultural Statistics Service (NASS)
United States Virgin Islands	2022	3 019	3 019	5.6	1.1	Census of Agriculture, National Agricultural Statistics Service (NASS)
Uruguay**	2011	44 781	33 262	365.3	73.9	General Agricultural Census,* Ministry of Livestock, Agriculture and Fisheries (MGAP)
Venezuela (Bolivarian Republic of)	2008	424 256	413 221	63.8	5.7	Census of Agriculture, Ministry of People's Power for Agriculture and Land
Viet Nam**	2016	8 223 191	11 746 133	1.0	0.5	Rural, Agricultural and Fishery Census, General Statistics Office (GSO)
Zambia**	2015	1 540 390	2 321 559	1.7	1.3	Rural Agricultural Livelihoods Survey, Central Statistical Office (CSO)

NOTES: The number of reported holdings in this table does not match the total presented in Table 1. This is because some countries and territories submitted updated figures for the total number of farms after their last reporting of holdings by farm size category. Additionally, in a small number of cases earlier data were used due to more comprehensive sampling frames. The data in Table A1 were used in the projection to improve the modelling of farm counts in 2025. All data used in **Chapter 3** (including production figures) and Table A1 are available for download at https://doi.org/10.4060/cd7067en-supplementarydata. The mean and median holding sizes are based on data from Cabrera Cevallos *et al.* (forthcoming). * Only available in the original language. ** Countries and territories represented in the crop production dataset (77 in total).

SOURCES: Lowder, S., Arslan, A., Cabrera Cevallos, C.E., O'Neill, M. & de la O Campos, A.P. 2025. *A global update on the number of farms, farm size and farmland distribution – Background paper for The State of Food and Agriculture 2025.* FAO Agricultural Development Economics Working Paper 25-14. Rome, FAO; Cabrera Cevallos, C.E., de la O Campos, A.P., O'Neill, M., di Simone, L. & Fahad, M. (forthcoming). *Divide in the fields: A study of global agricultural land inequality.* FAO Agricultural Development Economics Working Paper. Rome, FAO.

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1974 Population, food supply and agricultural development

1975 The Second United Nations Development Decade: mid-term review and appraisal

1976 Energy and agriculture

1977 The state of natural resources and the human environment for food and agriculture

1978 Problems and strategies in developing regions

1979 Forestry and rural development

1980 Marine fisheries in the new era of national jurisdiction

1981 Rural poverty in developing countries and means of poverty alleviation

1982 Livestock production: a world perspective

1983 Women in developing agriculture

1984 Urbanization, agriculture and food systems

1985 Energy use in agricultural production
Environmental trends in food and agriculture
Agricultural marketing and development

1986 Financing agricultural development

1987–88 Changing priorities for agricultural science and technology in developing countries

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1995	Agricultural trade: entering a new era?
1996	Food security: some macroeconomic dimensions
1997	The agroprocessing industry and economic development
1998	Rural non-farm income in developing countries
2000	World food and agriculture: lessons from the past 50 years
2001	Economic impacts of transboundary plant pests and animal diseases
2002	Agriculture and global public goods ten years after the Earth Summit
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2016	Climate change, agriculture and food security
2017	Leveraging food systems for inclusive rural transformation
2018	Migration, agriculture and rural development
2019	Moving forward on food loss and waste reduction
2020	Overcoming water challenges in agriculture
2021	Making agrifood systems more resilient to shocks and stresses
2022	Leveraging agricultural automation for transforming agrifood systems
2023	Revealing the true cost of food to transform agrifood systems
2024	Value-driven transformation of agrifood systems

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CHAPTER 3

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THE STATE OF THE WORLD

2025 THE STATE OF FOOD AND AGRICULTURE

ADDRESSING LAND DEGRADATION ACROSS LANDHOLDING SCALES

Land is the foundational resource of agrifood systems, playing a crucial role in securing global food supply and achieving the Sustainable Development Goals. Yet, increasing pressures are degrading this finite and essential resource, undermining its capacity to meet growing – and often competing – demands for more efficient, productive and sustainable agriculture.

The 2025 edition of *The State of Food and Agriculture* explores the theme "Addressing land degradation across landholding scales". It examines the implications of human-induced land degradation for agricultural production, producers of all scales and vulnerable populations. The report presents new findings on how cropland degradation contributes to the yield gap worldwide against a backdrop of broader degradation processes on other land cover types and even land abandonment. Drawing on the latest data on global farm distribution, farm sizes and crop production, the report highlights how the scale at which land is managed shapes both the constraints and the opportunities for adopting sustainable land use and management practices. It also underscores the importance of policymaking that encompasses regulatory and incentive-based measures, tailored to the varied conditions and scales of land use, to avoid, reduce and reverse land degradation.

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