THE CURT BERGFORS FOOD PLANET PRIZE

SPECIAL REPORT BY **AFTON HALLORAN**
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# Managing the Food System's Main Asset: Land

*The relationship between land use and agriculture is a tale of how human beings have pushed natural resources to their limits. This background feature is designed to provide an overview of the issues facing land management worldwide. It also explores some ideas about how we can improve the state of agricultural land use.*

IVAN BANDURA, UNSPLASH

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PHOTO: RUNE PEDERSEN

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# Land-use change—how humans have shaped the Earth

*Within a very short span of our history, humans have dramatically transformed landscapes around the world. Between 1700 and 1990, cropland areas quintupled, while grazing land area grew six-fold—all at the expense of forests and natural grasslands.*

Land-use change refers to human activities that transform the natural landscape. No activity does that more than agriculture.

PHOTO SOURCE: GETTY IMAGES

*Today, one-third of the Earth's land surface is dedicated to crop and livestock production—more than the total area of Europe, North America, and South America combined*[1]

Since they first began domesticating wild plants over 12,000 years ago, humans have depended for their survival on agriculture, making it the dominant form of land management around the world. And although the industrial and technological revolutions of the last few centuries have meant that large swathes of the Earth's population no longer work the land themselves, rapid population and economic growth have increased food requirements and with them, the amount of land given over to food production. Today, one-third of the Earth's land surface is dedicated to crop and livestock production—more than the total area of Europe, North America, and South America combined.[2] Of this land, nearly a quarter is devoted to crops, while the other three-quarters is used for grazing animals.[3]

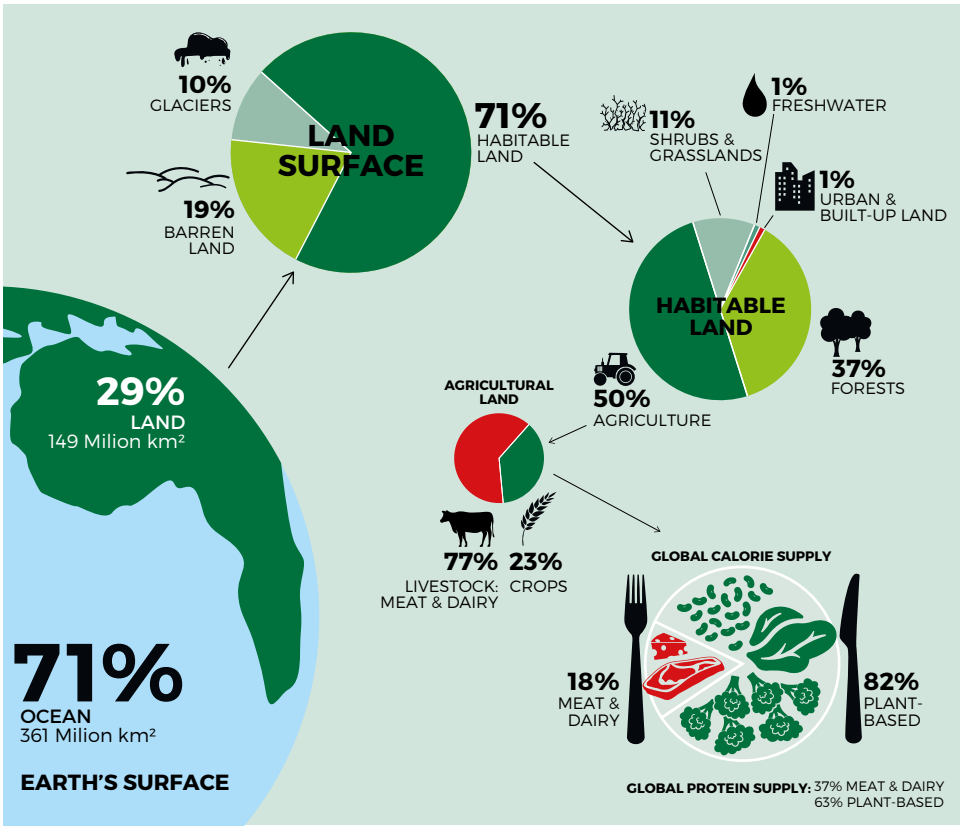
In a very short period of human history, in other words, landscapes around the world have undergone remarkable transformation. Between 1700 and 1990, cropland areas quintupled, from 3–4 million to 15–18 million km$^2$, mostly at

the expense of forests. In the same period, grazing land area expanded six-fold, from 5 million to 31 million km,[2] mainly at the expense of natural grasslands.[4]

*Human-induced changes to the land increase greenhouse gas emissions, result in the loss of natural ecosystems like forests and grasslands, and diminish biodiversity and ocean health*

Growth has accelerated even more in recent decades. In the last 40 years alone, the amount of land dedicated to agriculture has increased by almost 10% — an area that, if accumulated in one place, would equal a landmass larger than South Africa.[5] That expansion is having dire effects on the planet. Human-induced changes to the land increase greenhouse gas emissions, result in the loss of natural ecosystems like forests and grasslands, and diminish biodiversity and ocean health.

**Like fossil fuels, land and soil are finite, non-renewable resources.** They are also vulnerable to depletion and degradation. The conversion of land from one purpose to another — which is known as land-use change and refers, for example, to when grasslands are turned into cropland, or to when urban development encroaches on fertile farmland — is a leading cause of degradation. So too is land-use intensification — the process in which the productivity or profitability of a unit of land is augmented by, say, applying fertilizers or increasing heads of livestock.




**PLANET TO PLATE: A breakdown of how we use the Earth's surface to feed ourselves.**

DATA SOURCE: UN FOOD AND AGRICULTURE ORGANIZATION (FAO), LICENSED UNDER CC-BY BY THE AUTHORS HANNAH RITCHIE AND MAX ROSER IN 2019. ILLUSTRATION: AZOTE

*"The Green Revolution offered the prospect that post-war hunger could be averted, people could move out of poverty and that rural societies — just like new wheat varieties — could grow strong and thrive on giant fields of high-yielding crops."*

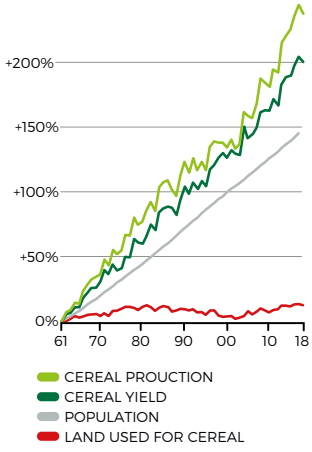
JOHN VIDAL

While expanding oil palm cultivation has lifted many people out of poverty, it has taken a heavy toll on the environment.

PHOTO SOURCE: GETTY IMAGES.

**CHANGE IN CEREAL PRODUCTION, YIELD AND LAND USE, WORLD, 1961–2018**

**Squeezing more out of each piece of land. In the past half-century, sustained population growth has gone hand in hand with increased agricultural intensity.**




Population and cereal production, yield and land use figures are indexed to the year 1961 (i.e. 1961=0)

DATA SOURCE: OWID BASED ON WORLD BANK AND UN FAO. ILLUSTRATION: AZOTE

Improved efficiency has made it possible to feed a greater number of people with the same piece of land; since 1961, the amount of arable land area needed to produce the same quantity of crops has declined by 70%.[6] But that efficiency comes at a cost. Land-use intensification can lead to chemical contamination and pollution, salination, soil erosion, nutrient depletion, and overgrazing, while land-use change frequently results in deforestation and desertification.

The most dramatic changes occurred in the 20th century, which witnessed a substantial increase in the intensity of both crop cultivation and animal farming. At the same time, farm size increased in many regions, and agricultural specialisation set in. Rural landscapes that were once home to a number of diverse crops became monocultures, with vast tracks of land devoted to the cultivation of a single crop. In fact, the conversion of natural ecosystems for crop production or pasture is the principal cause of habitat loss, which, in turn, reduces biodiversity.[54]

The century was also characterised by significant scientific breakthroughs that, from the post-war period onward, had a tremendous impact on farming. This so-called Green Revolution introduced modern plant breeding methods and is often attributed to American plant scientist Norman Borlaug. Borlaug's work, writes John Vidal, "was widely regarded by governments — rich and poor alike — as admirable, progressive, beneficial and even revolutionary. The Green Revolution offered the prospect that post-war hunger could be averted, people could move out of poverty and that rural societies — just like new wheat varieties — could grow strong and thrive on giant fields of high-yielding crops."

The Green Revolution's plant breeding techniques — coupled with new and more potent fertilisers and pesticides, improved irrigation techniques, and increased farm mechanisation — allowed farmers to coax higher yields from the same piece of land. All told, cereal production went up by 280%, while food crop production in general increased by a jaw-dropping 300%.[7,8] As a direct result of these breakthroughs, the world population skyrocketed from 1.6 billion in 1900 to 6 billion in 2000.

The Green Revolution made it possible to feed a lot more people, in other words. But by spurring the shift from traditional to industrialised farming it also altered the face of the planet, and in fact, became a defining feature of the Anthropocene, the geological epoch characterized by significant human impact on Earth's geology and ecosystems. For as much as it raised yields per hectare, generated more calories per person and diminished the overall amount of land required per person to feed the population, the Green Revolution also ushered in transformations that came at great cost. Today, it is not an exaggeration to say that the intensification and expansion of agriculture is quite literally destroying the ground beneath our feet.

Agriculture changes the landscape dramatically. Farms and crops at the foot of hills of rock Zumbahua in the province of Cotopaxi, Ecuador.

PHOTO SOURCE: GETTY IMAGES

# Land abuse all over the world —a dead end

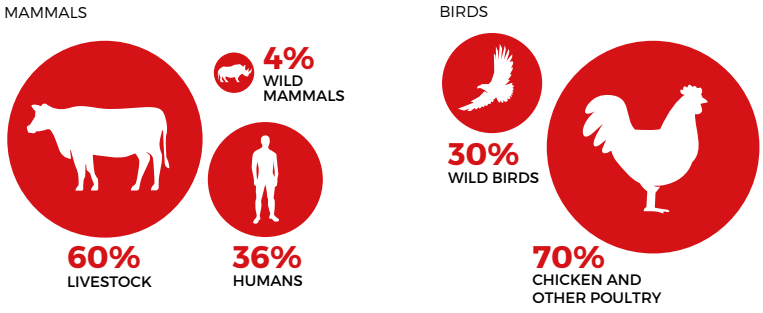
*As competition for land to grow edible crops, feed livestock, and produce biomaterials and biofuel increases on most continents, land use is pressured beyond its limits.*

Three main phenomena drive the expansion of pastures and cropland. First, a growing global population coupled with the increased consumption of animal products in developing countries puts pressure on land resources. As more and more households enter the middle class, a greater portion of their income is available to spend on comparatively expensive foodstuffs like meat. Second, the demand for biofuels and biomaterials, which are produced from plants and fungi, is growing, especially in developed countries. And finally, as agricultural land degrades and becomes less fertile — or is converted to different purposes like urban development — new, ever-larger areas for planting must be found.

*There are now three times as many chickens on Earth as all other wild birds combined. Chicken bones may well become the fossilised markers of the Anthropocene*

Over the past 50 years, both per capita meat consumption and meat production have grown significantly; the latter, in fact, has more than quadrupled.[9] In fact, an astonishing 341 million tonnes of meat was produced in 2018 and an estimated 69 billion chickens; 1.5 billion pigs; 656 million turkeys; 574 million sheep; 479 million goats; and 302 million cattle were killed. While beef and pork are obviously important elements of this shift to more protein-rich diets, especially in middle-income countries and transitional economies, they pale in comparison to poultry. With an estimated population of 23 billion at any given time, chickens are now the most numerous vertebrate species on land; those raised for their meat outnumber all wild birds put together by three to one. A team of scientists from the University of Leicester has predicted that chicken bones will become the fossilised markers of the Anthropocene, the epoch when humans dominate the planet.[10]

**Of all the mammals on Earth, 96% are livestock and humans, only 4% are wild mammals**




Wild mammals and wild birds are in decline. With an estimated population of 23 billion at any given time, chickens are now the most numerous vertebrate species on land. ILLUSTRATION: AZOTE. DATA SOURCE: PNAS 2018

As livestock populations grow and meat production increases, so too does the amount of land needed to grow feed for them. Between grazing and feed production, a full 77% of total global agricultural land is currently used for meat and dairy production. Grazing land area has nearly doubled over the past 100 years. Although 86% of animal feed is inedible by humans, a competition of sorts results, between land devoted to directly edible crops and land devoted to crops used to feed livestock — and that comes on top of competition over other uses, like forestry, housing, or conservation.

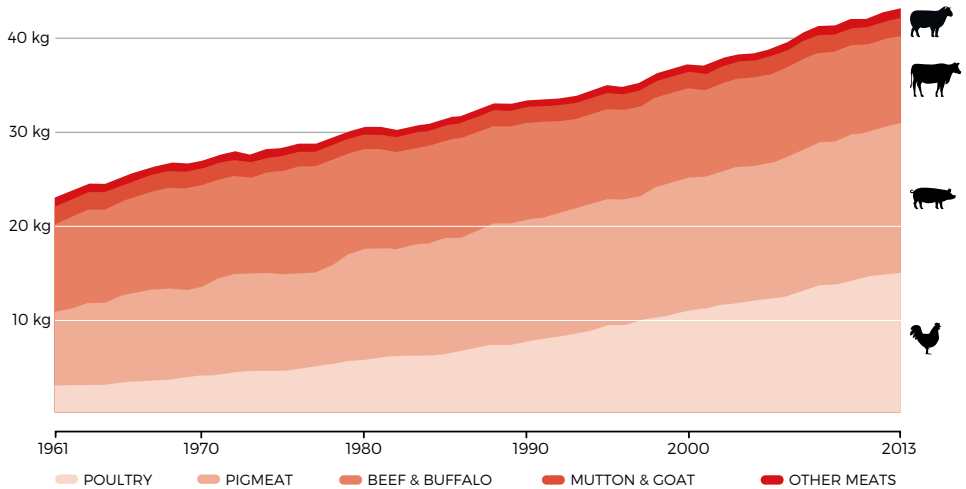
The amount of land required for crops and livestock varies greatly. Meat products sit at the upper end of the spectrum, with the land required for beef or mutton up to 100 times greater than cereals, for example. However, not all meat products are created equally. Poultry and pork have a land footprint 8–10 times lower than that of beef.[11] If the entire global population removed beef, mutton and dairy from their diets, the total amount of land needed for agriculture would be reduced by 75% — an area the size of North America and Brazil combined.[55]

*The quest to replace petroleum-based plastic with more sustainable biomaterials made from corn or algae has increased the need for more agricultural land*

The other major source of pressure on agricultural land comes from biofuels and biomaterials. As they attempt to reduce their reliance on fossil fuels, more and more countries are looking to crops like corn and sugarcane as sources of renewable energy, and biofuels like ethanol and biodiesel currently represent the largest source of it. The share of biofuels in the transport sector in 2017 was small — only about 3%. However, the World Resources Institute estimates that if bioenergy were to meet 20% of the world's total energy demand by 2050 it would require at least a doubling of the world's annual harvest of plant material in all its forms. These two factors — the shift to biofuel and biomaterial and the world's growing appetite for meat — are expected to accelerate in the future, and will only put increasingly heavy burdens on existing agricultural land and spark more competition.

**Per capita meat consumption by type, world, 1961–2013**

White and pink meat (poultry and pork) increase their share of average meat consumption.




Average per capita meat consumption broken down by specific meat types, measured in kilograms per person per year.
Data is based on per capita food supply at the consumer level, but does not account for food waste at the consumer level.

# Different continents, the same challenge: land degradation

*When seeds can no longer sprout, when winds blow away precious topsoil, and when the last patch of grass has been grazed, it's the people who are most closely tied to the land who suffer the harshest blows.*

Land is one of the very few productive assets possessed by the rural poor, and most poor rural households engage in some form of agriculture. Yet poverty forces people to put pressure on fragile resources because, for example, they must let their livestock overgraze, or because they lack sufficient land to practice proper crop rotation. This pressure generates a vicious cycle of resource mismanagement and lost livelihood opportunities. In other words, poverty both drives and is driven by land degradation.

Nowhere is this cycle more obvious than in South Asia and Sub-Saharan Africa, which together account for 85% (629 million) of the world's poor, and where the number of rural poor subsisting on degrading agricultural land increased by 13% percent in the first decade of this century.[13,14]

*The constellation of water scarcity, low land availability, and food insecurity leads households to overexploit natural resources by intensifying and expanding agriculture beyond the capacity of the land*

In terms of the number of lives affected, the whole of Asia — with approximately 60% of the global population — is the region that suffers most from land degradation, desertification, and drought. Over 70% of the continent's people live in rural areas where their livelihoods depend directly on land and land-based ecosystems services.[15] The constellation of water scarcity, low land availability, and food insecurity leads households to overexploit natural resources by intensifying and expanding agriculture beyond the capacity of the land. If crops are cultivated on infertile land or animals are grazed on poor quality pasture, that land will eventually yield less. Those lower yields translate into reduced household incomes and can lead to hunger and malnutrition.

In Africa, where an estimated 97% of the food produced comes from land-based agriculture (rather than hunting or fishing) the picture is even more grim. Up to two-thirds of the productive land is under threat, with desertification alone — due to overgrazing and poor agricultural practices — already affecting half of that area (and 55% of it at high or very high risk of further degradation).[16] And on a continent where much of the rural population relies on biomass for household energy, wood and charcoal production cause widespread deforestation.[17] The loss of trees and other vegetation can result in soil erosion, flooding and desertification.

Clearing of shrublands for agriculture increases soil erosion and accelerates land degradation in many areas. Here, Baobab trees have fallen into an eroded seasonal river bed next to a maize field in Mwembe, North-Eastern Tanzania.

PHOTO SOURCE: JERKER LOKRANTZ/AZOTE

*Poverty both drives and is driven by land degradation*

But these grim impacts are not confined to Asia and Africa. In Central and South America, massive swaths of tropical and subtropical forests are being converted to pasture for livestock grazing both for subsistence and commercial use. The process begins when roads are cut through previously virgin forest to open it for logging and mining. Farming then starts up in cleared sites along the road. But forest soils don't contain the type and quantity of nutrients necessary to sustain agriculture. "After two or three years," reports the UN's Food and Agriculture Organization, "the soil is depleted. Crop yields fall. The farmers let the grass grow and move on. And the ranchers move in."[18] In Brazil, for example, 70–80% of deforestation is estimated to come from the development of livestock systems.[19]

The trap created by land degradation, poverty and inequality poses great challenges to the development of low-income households. Each one of these dimensions are intrinsically interconnected and influences the other. This means that land degradation cannot be solved without addressing the root causes of poverty and inequality in society.

# The threat to soil, the backbone of the food system

*The very things we are doing to increase food production are threatening the soil and land health that are the cornerstones of food security — and ultimately our existence as a species.*

*Soil is life. It produces 95% of our food and holds nearly a quarter of our planet's species, hosting a complex web of diverse life forms and biological activity. A single gram of healthy soil can contain millions of organisms*

The term 'soil health' refers to soil's capacity to function as an essential living ecosystem that sustains plants, animals, and humans. That health has declined significantly over the past century. Many soils degraded through land-use change are less fertile, contain fewer macrofauna, and are less able to perform critical functions like water filtration, the natural cleansing of water by the soil as it makes its way into the groundwater. According to the UN's Global Land Outlook, we are losing fertile soil at a rate of 24 billion tonnes a year.

If we continue this business-as-usual scenario, the global amount of arable and productive land per person in 2050 will fall to a quarter of its 1960 levels. Unhealthy soils mean we will no longer be able to grow enough food to feed the world.

As José Graziano da Silva, former director of the United Nations Food and Agriculture Organization notes, "We have taken soils for granted for a long time. Nevertheless, soils are the foundation of food production and food security, supplying plants with nutrients, water, and support for their roots. Soils function as Earth's largest water filter and storage tank; they contain more carbon than all above-ground vegetation, hence regulating emissions of carbon dioxide and other greenhouse gases; and they host a tremendous diversity of organisms of key importance to ecosystem processes."[20]

A single handful of soil contains considerably more life than the human population of planet Earth.
PHOTO SOURCE: GETTY IMAGES

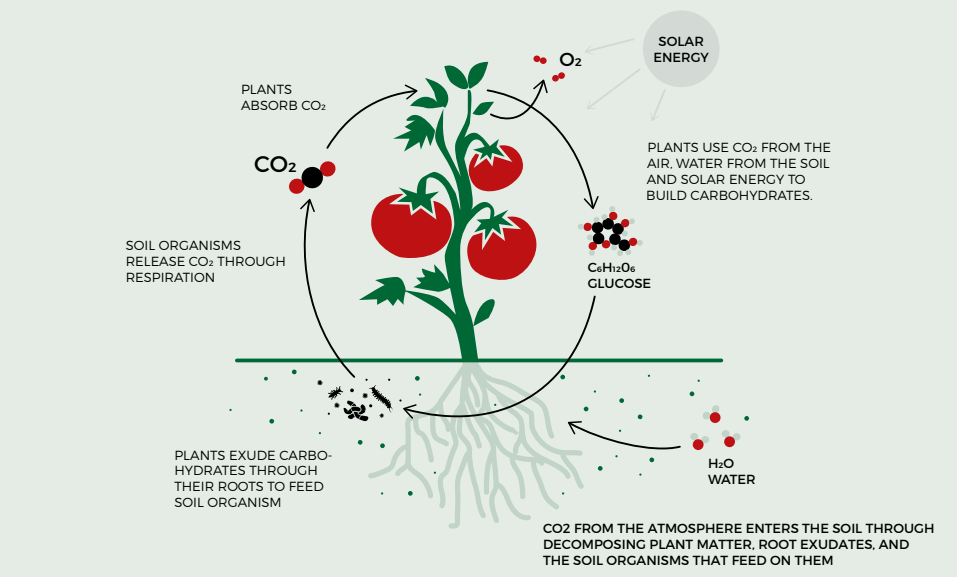
**Soil is not only the backbone of the food system; it also plays a crucial role in absorbing carbon** from the atmosphere. Soil is the planet's greatest carbon sink. Healthy soils contain over twice the amount of carbon found in trees and other kinds of biomass.[21] Less healthy soils lose their ability to store carbon effectively, which creates yet another vicious cycle: reduced storage capacity makes the world hotter, and hotter temperatures degrade soils further.

*Soil is the planet's greatest carbon sink. Healthy soils contain over twice the amount of carbon found in trees and other kinds of biomass*

Forests act as the Earth's lungs, absorbing significant amounts of carbon dioxide from the air and storing it in their biomass. Between 2007 and 2016, those forests removed a net six gigatonnes of $CO_2$ per year,[22] which is the equivalent to the annual greenhouse gas emissions of the United States.

But if trees are removed, those forests, and the soils that support them, can no longer perform that function efficiently. In fact, the ability of forests around the world to store CO2 is weakening. New research shows that between 2001 and 2019 the Brazilian Amazon acted as a net carbon source.[56] Fully half of all agricultural expansion in tropical and subtropical countries comes at the expense of forests, chipping away still further at the planet's carbon sink. The food system accounts for somewhere between 21 and 37% of total greenhouse gas emissions. The IPCC estimates that 5–14% of that derives from land use and land-use change, including deforestation and peatland degradation.[23]

According to a 2019 International Panel on Climate Change report, afforestation (planting trees on barren land) and reforestation (replanting areas with trees) can significantly improve the soil's carbon capture potential.[24] Enhancing soil carbon by increasing organic carbon inputs and/or reducing losses is another strategy. This can be done by maintaining crop stubble (the unharvested part of the crop) or by returning manure or compost the soil.




The carbon merry-go-round. How carbon cycles in and out of the soil along with oxygen and hydrogen.

DATA SOURCE: JOCELYN LAVALLEE. CC BY-ND[25]. ILLUSTRATION: AZOTE.

# When the rain doesn't fall

*Heat and drought are projected to increase worldwide as global warming continues. In turn, this will amplify land degradation, food security, famine-induced migration, and political turmoil.*

Drought, land-use, and soil health are interconnected. Healthy soil retains water, which in turn supports the plants and other organisms that grow there. But a lack of rainfall will quickly disrupt this system. While the effects of droughts may not be immediately apparent, they can be devastating and deadly. New research suggests that by the late 21st century, the global land area and population facing extreme droughts could more than double.[57] And as drought occurs more frequently, it can make it increasingly difficult for the soil's water reserves to recover in between dry spells.

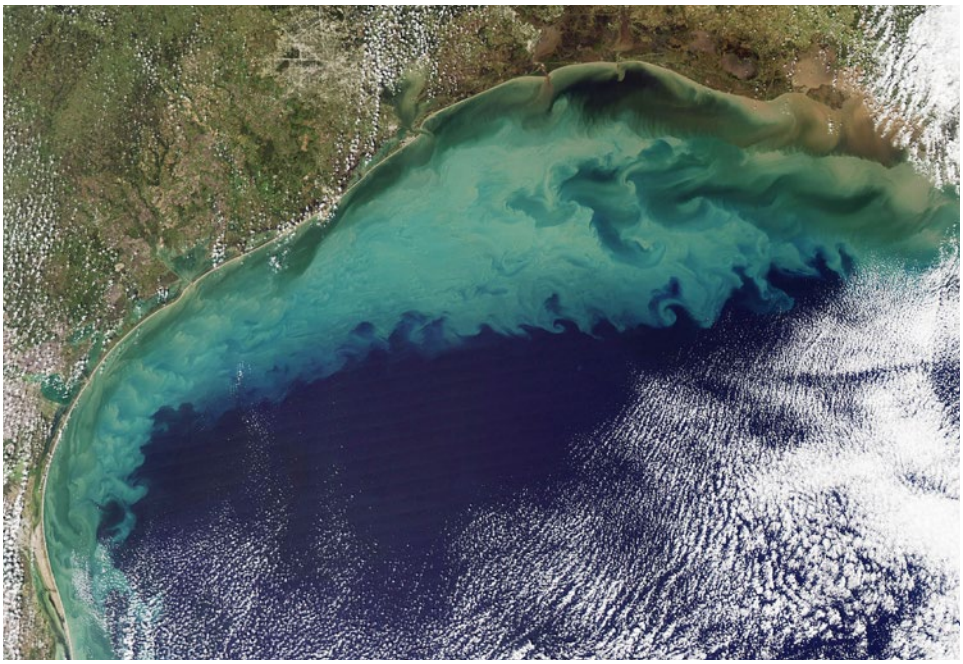
Recent NASA data gathered from tree rings confirms that human activity has increased the worldwide risk of drought since the beginning of the 20th century.[26] And while we frequently think of droughts as occurring primarily in low-income countries, their effects are being felt to an unprecedented level all over the world. By combining hydrological modelling and tree-ring reconstructions of summer soil moisture, a research team of American scientists found that the period from 2000 to 2018 was the driest 19-year span in the southwestern United States, for example, since the late 1500s, and the second driest since 800 CE.[27]

Drought hits the rural poor hardest.

PHOTO SOURCE: GETTY IMAGES

In addition to the environmental damage they cause, severe drought episodes also have drastic socio-economic effects. Their primary impact — up to 80% — is on agriculture, where they lower yields and endanger food security and rural livelihoods.[28] Enduring or frequent droughts can provoke mass famine and migration, as well as impeding economic performance.

Heat and drought are projected to increase worldwide as global warming continues.[29] In turn, this will amplify land degradation. But we still have a choice: drought can either be mitigated or exacerbated by changes in land use and cover. It's what we do with the land that will soften the blow.



Portions of the Gulf of Mexico have become a "dead zone" due to nutrient runoff from agriculture.

PHOTO SOURCE: GETTY IMAGES

*Agriculture as it is practiced today, based on irrigation, accounts for 90% of global freshwater consumption.*

**Troubled waters reflect intensive farming.** The relationship between land and water is intertwined. If land and soil are well managed, they have the ability to act as important filters, absorbing and storing excess water in times of flooding, and slowly releasing stored water during times of drought. But agriculture as it is practiced today has a way of upending that balance; irrigation currently accounts for 90% of global freshwater consumption.

At the same time, nutrient and sediment runoff from agriculture — responsible for more than 50% of the nitrogen and phosphorus delivered from land to ocean — threatens aquatic life. "Dead zones" — large zones of low-oxygen water that affect hundreds of thousands of square kilometres of marine ecosystems — are one result. So too is contaminated groundwater, since whatever is applied to the soil, including nitrates from fertilizer, will eventually find its way into aquifers.

In the midwestern United States, for example, annual rains wash the synthetic nutrients used in fertilizer into the Mississippi river, which then carries sediment into the Gulf of Mexico. Because fresh water is less dense than ocean water, it sits on top of the ocean, preventing oxygen from mixing through the rest of the water column. The lack of sufficient oxygen suffocates and eventually kills the animal life within that patch of water. The affected areas can be huge; some scientists have estimated that the dead zone within the Gulf of Mexico will eventually spread to 20,700 square kilometres, roughly the size of Israel.[30]

Since the 1960s, dead zones have doubled in size and number. As they've grown, they've damaged marine species, including those that are important sources of food, like shrimp in the Gulf of Mexico.[32] Mistreatment of the land, in other words, can have huge repercussions on marine ecosystems and threaten food security.

In addition to the environmental damage they cause, severe drought episodes also have drastic socio-economic effects. Enduring droughts can provoke mass famine and migration.

# Biodiversity in peril

*As the global population grows in size and affluence, land-use change is also reducing the planet's biodiversity. In fact, the insatiable demand for agricultural products has made land-use change the most important factor in biodiversity loss.*

**Land use change threatens habitats and biodiversity, Sarawak, Borneo, Malaysia.**
PHOTO SOURCE: AFTON HALLORAN

Approximately one out of every eight plant and animal species on this planet is now threatened with extinction. These numbers do not apply to wild animals alone: 9% of all domesticated breeds of mammals used for food and agriculture had become extinct by 2016, with at least 1,000 more breeds still threatened.[32]

Just a handful of foods can do a lot of damage. Beef, for example, is the single more important driver of biodiversity loss. When cattle grazing encroaches on new territory, forest cover often suffers, as trees are removed and with them the habitats for insects, birds, fish and other critters, who live amid their branches, trunks, and roots.

*The growing global appetite for cooking oil is driving agricultural expansion into the habitats of critically endangered species like orangutans, one of human being's closest relatives*

Oilseed, an important component in livestock feed, is another food with an outsized impact on land-use conversion. In addition to eating more meat, newly prosperous populations are consuming more vegetable oil. Clearing land for the soy, palm, coconut, and cottonseed from which that oil is made has meant the destruction of tropical forests, and with them the vast biodiversity those forests support. On the island of Borneo, for example, oil palm plantations have replaced nearly 40% of the native forest cover since 2000.[33,34,35] The expansion threatens further the habitats of species that are already critically endangered, like orangutans, one of human beings' closest relatives.[36]

Through its contribution to climate change, the food system becomes an indirect driver of biodiversity loss. Climate change alters the suitability of habitats, causing sensitive species to die out or move elsewhere. In some cases, other species move in to occupy the territory left behind. These alterations compromise the overall resilience of the ecosystem in question.[58]

For more information about biodiversity in farming and nature, please read the Food Planet Prize special report by Dan Saladino.

Through its contribution to climate change, the food system becomes an indirect driver of biodiversity loss.

# The world can't afford more soil degradation or land mismanagement

*Human development is so tightly interwoven with the land, that reaching the United Nations Sustainable Development Goals depends on ameliorating soil degradation and land mismanagement.*

The economic implications of land degradation are immense. According to estimates, the total annual costs of global land degradation due to land-use and land-cover change (including external losses in carbon sequestration, biodiversity, genetic information and cultural services) are about US $231 billion per year. For sub-Saharan Africa, which bears 26% of the total global cost of land degradation due to land-use and land-cover change, the total losses amount to US$60 billion, or three times the GDP of the United States.[37]

Land degradation drives migration. Over 1.3 billion people, or approximately 17% of the world's population, live on agricultural lands whose already precarious condition is further impaired by climate change and poor management strategies.[38] When those lands can no longer adequately sustain the communities that depend upon them, their inhabitants will be forced to seek other means — and places — for survival. Because the factors that compel migration

Deforestation significantly alters landscapes, local climate and environment for a long period of time. The Amazon, Brazil.

PHOTO SOURCE: GETTY IMAGES

are multiple and often complex, it's hard to put numbers on the role that land degradation alone plays in the decision. However, this trend is expected to extend well into the future. In 30 years from now, an estimated 4 billion people will live in drylands. Land degradation, together with the closely related problems of climate change, is estimated to force 50-700 million people to migrate, according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

*Preventing human-induced soil erosion in Africa alone would lead to an additional million tonnes of cereal crops produced every year*

Soil degradation also threatens future food supply, especially in countries where undernourishment is commonplace. The Economics of Land Degradation Initiative Africa reports that failure to act will reduce crop productivity and yields — a loss that could amount to 12% of the GDP of African nations. Decreasing land productivity also makes societies more vulnerable to social instability. This is particularly true in dryland areas, where years with extremely low rainfall have been associated with an increase of up to 45% in violent conflict. In Africa alone, preventing human-induced soil erosion would result in an additional million tonnes of cereal crops produced every year.[39] And everywhere, improved conditions will increase food security, national incomes and productivity while simultaneously reducing poverty and dependence on food imports — a win-win situation for all. Human development is so tightly interwoven with the land, that reaching the United Nations Sustainable Development Goals depends on ameliorating soil degradation and land mismanagement.

**Digging ourselves of out of a deep hole.** How do we reverse land and soil degradation, and with them, the nefarious effects on poverty levels, climate change, and biodiversity? According to the Food and Land Use Coalition (FOLU), there is a remarkable opportunity to transform food and land use systems, but we need to act urgently as the challenges continue to grow.

We'll look into some of these actions in the following sections.

# Shifting dietary behaviour

*Consumption is a key entry point to addressing land use change and degradation. By changing our diets, we can support an agriculture that, quite simply, requires less land.*

*According to the World Resources Institute, reducing food loss and waste by 25% globally would reduce the land-use gap by 27%*

Between the projected amount of land needed to meet global food demand in 2050 and the amount of land in agricultural use now lies something called the land gap — a difference of 593 million hectares or twice the area of India. One strategy to close this gap would be to clear more land for agriculture. As we have seen, however, this strategy would result in deforestation and the destruction of ecosystems; it would also release large quantities of stored carbon into the atmosphere.

A healthier strategy would be to change dietary behaviour. Limiting ruminant meat consumption to 52 calories per person per day in all regions of the world would close the land gap almost singlehandedly. "Eating foods that are less resource-intensive and don't take up as much space to produce makes it possible to add another 2 billion or so people to the planet in coming decades without knocking down any more forest," says Richard Waite, Senior Research Associate of the World Resources Institute's Food Program, "While also reducing emissions from food production."[40]


The EAT-Lancet report is the first full scientific review of what constitutes a healthy diet from a sustainable food system, and which actions can support and speed up food system transformation.

A recent study found that if every person on planet Earth were to eat according to the United States Department of Agriculture's dietary guidelines, we would need to cultivate an additional gigahectare of land — an area roughly the size of Canada.[41] It's a vivid reminder that the Westernised diet, which relies heavily on meat and dairy products, as well as processed grains, requires unsustainably vast natural resources to produce.

"Some dietary choices require more land and water and cause more emissions of heat-trapping gases than others," explains Debra Roberts, a scientist collaborating with the ipcc. "Balanced diets featuring plant-based foods, such as coarse grains, legumes, fruits and vegetables, and animal-sourced food produced sustainably in low greenhouse gas emission systems, present major opportunities for adaptation to and limiting climate change." In other words, by changing our diets, we can support a food system that, quite simply, requires less land.

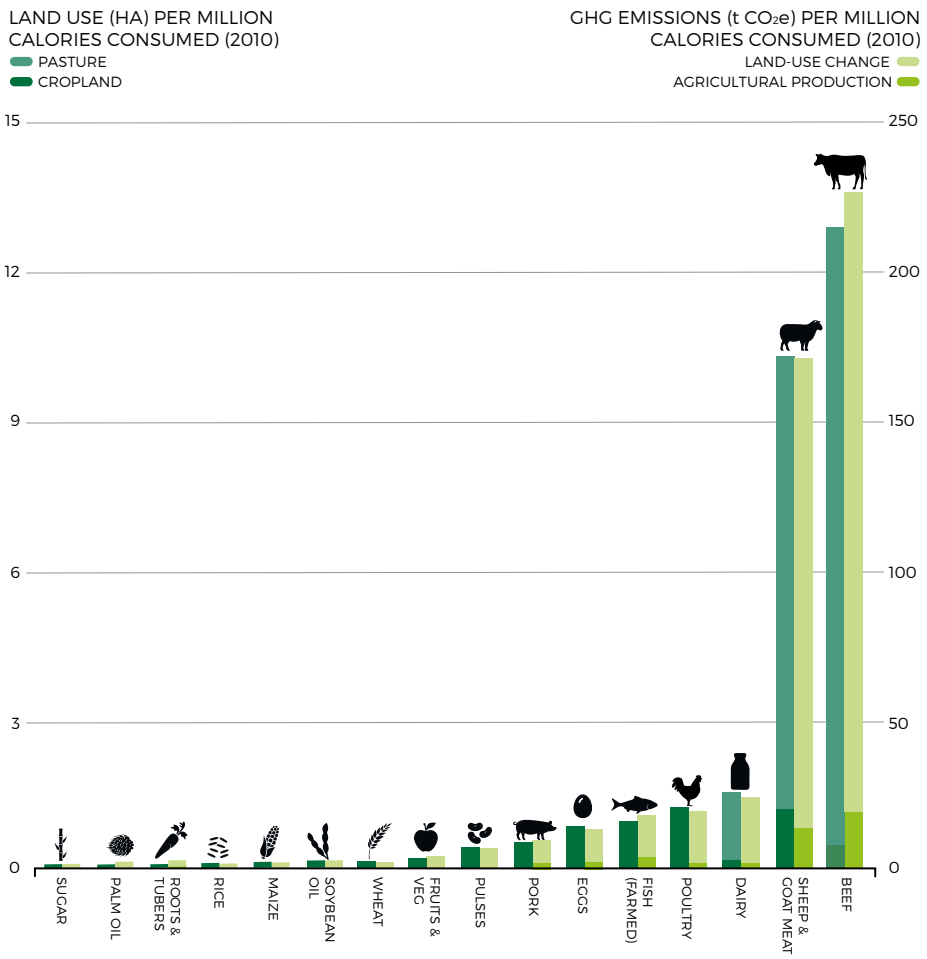
Part of that transformation will entail changing what we **don't** eat. Roughly one third of all food produced is lost or wasted between the farm and the plate.[42] According to the World Resources Institute, cutting food loss and waste by 25% globally would reduce the land use gap by 27%.[43]

# Regenerative techniques, spare or share —or go vertical?

*How can we produce more food on the same amount of land, while staying within the operating boundaries that secure planetary and biosphere health?*

Experts agree that avoiding land degradation is always preferable to restoring land after it has already been harmed, both because of the costs, and because of the slow pace of recovery.[45] Soils that lose organic matter — the components that consists of plant or animal tissue in various stages of breakdown — hold less water. They are also less responsive to fertilizers, which means more must be applied in order to achieve the same yields — at greater cost. Preventative measures should always take priority over treatment.

*Organic farming does not necessarily imply small-scale. Although there are specific core principles for this agricultural practice, farms can range from polycultures to monocultures*




**Animal-based foods are more resource-intensive than plant-based foods. Pork is a relatively modest resource user in comparison with beef, sheep, poultry and even farmed fish.**

DATA SOURCE: GLOBAGRI-WRR MODEL.[44] ILLUSTRATION: AZOTE.

Regenerative agriculture may be a path out of the conundrum. A system of farming and grazing practices that can help reverse climate change by rebuilding soil organic matter, regenerative agriculture restores the soil's biodiversity, making it better able to capture and store carbon, protect the water cycle, increase agricultural yields, and mitigate climate change.

Practiced among many traditional small-scale farmers, agroecology can hold solutions for modern land use.

PHOTO SOURCE: GETTY IMAGES

Agroecology, a kind of regenerative farming, takes a highly integrated approach by applying ecological and social principles to the design and management of agricultural systems. Using both traditional wisdom and modern science, it seeks to optimize the interactions among plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system. Techniques include growing multiple crop species in close physical proximity to each other so that they can take advantage of complementarities that improve nutrient use and pest regulation, and combining animal husbandry and crop cultivation to reduce the need for chemical fertilizers. Agroecology is most often practiced on small, traditional farms, but potentially, it can be scaled up.

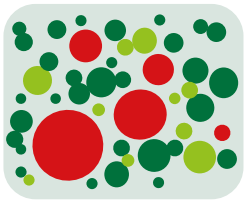
Organic farming is another kind of regenerative farming. Its defining feature is its rejection of chemical products like pesticides; instead of synthetic inputs, it relies on fertilizers of organic origin, such as compost manure, and seeks natural solutions to pest control. Like other forms of regenerative farming, it also tends to emphasize crop rotation and companion planting, but only organic farms can be certified by national and international bodies for adhering to a common set of principles. They range from polycultures — the simultaneous cultivation of several crops — to monocultures.

Land use is an important factor in the debate over organic vs. conventional farming.[46] Compared to conventional farming, organic agriculture requires more land to grow the same amount of produce. Its yields also vary more dramatically than those of conventional farming.[47] But it has clear advantages as well, included reduced chemical inputs and the potential to improve soil health.

There are other solutions beyond regenerative agriculture that are sensitive to their local contexts. Sustainable intensification, for example, aims to produce more food on existing farmland by matching crops, varieties, and management to seasonal conditions. But for all the diversity of approaches, one thing remains clear: the conversion of forests and other natural ecosystems to agricultural land needs to come to an end. According to the Food and Land Use Coalition, 300 million hectares of tropical forest — equivalent to the amount of forest and woodland that exists in the USA — will need to be restored to their natural state by 2030 if we are to reduce annual net greenhouse gas emissions, and halt and reverse biodiversity decline.[48]

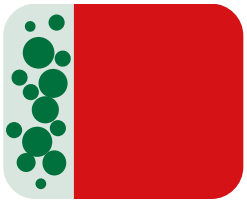
**Land sparing and land sharing are two solutions** at opposite ends of a continuum. Both have been proposed as ways of limiting the negative impacts of agriculture on biodiversity. As a concept and a practice, land sharing means that farm landscapes are made as friendly as possible to wild plant and animal species, often by encouraging the growth of endemic species, or planting crops that attract wild pollinators. These practices may result in lower yields. Land sparing, on the other hand, maximizes yields so that less land is needed for farming and more is set aside for nature.

LAND SHARING



wildlife-friendly farmland everywhere

LAND SPARING



some "Natural" habitat

some High-Yield farmland

Land sharing or land sparing. Two strategies to limit the negative impacts of agriculture on biodiversity.

DATA SOURCE: RSPB CENTRE FOR CONSERVATION SCIENCE.[52]
ILLUSTRATION: AZOTE

Human-wildlife conflicts are particularly rampant in areas where wildlife coexists with crops or livestock. These conflicts arise when some form of economic damage — like an entire vegetable patch eaten by a herd of deer — is incurred by the farmer. As such, true land-sharing can only happen if coexistence is considered an end goal. Some governments promote land sharing by paying to protect ecosystems. In Canada, for example, farmers can receive money in exchange for flooding land that would otherwise be cultivated in order to create habitat for wildfowl. It's hard to imagine the widespread adoption of land sharing without these kinds of incentives.

While land sparing seems like a plausible idea, historical data has shown that it is rarely practiced. Opponents criticize it for emphasising yield over nutrition and food security, and for assuming that 'spared' land will be used to establish protected areas, when that conversion has consistently proven difficult to implement.

Yet continuing to encroach on nature is unsustainable, and not only for the reasons outlined above. Deforestation and other land-use changes constitute a major threat to human health, for they contribute to the emergence of novel viruses like SARS-CoV, which originated in bats, and most recently to SARS-CoV-2, or Covid -19, which many suspect of having the same origins.[49,50] In fact, nearly 50% of the zoonotic diseases that have emerged in humans since 1940 are a product of changes in land use, whether they be alterations in agricultural or other food production practices, or from wildlife hunting.[51]

**More radical approaches to the problem of land use are emerging.** Some entrepreneurs around the world are converting unused spaces like former industrial sites, abandoned mines, and rooftops to food production. New farms that grow produce vertically, in stacked layers in a climate-controlled, indoor setting, as opposed to horizontally outdoors, are popping up throughout the US, Asia and Europe, in an effort to grow vegetables and mushrooms in as small an area as possible. Gas fermentation, a process where single cell proteins are made from the $CO_2$ in industrial waste gas, is another up-and-coming technique for producing protein with a significantly lower amounts of land. Others are promoting farming more marine food species in the sea to free up the land (some are even preparing future farming scenarios in space). Data-driven technologies, such as soil monitors that use sensors to trigger targeted irrigation or fertiliser application, offer other solutions.

*Human-wildlife conflicts are particularly rampant in a context where wildlife coexists with crops or livestock. Major threats to human health ensue when the interface between livestock and wild animals is surpassed, as in Asia's wet markets*

Urban and vertical farming may help reduce land use, the need for transport, and the human-wildlife conflicts.

PHOTO SOURCE: GETTY IMAGES

Policy also has a role to play. In order to avoid competing land-use claims, governments should ensure that their policies are coherent across rival sectors. They should also be ready to get out of the way at times; there is mounting evidence that community-based approaches for managing shared environmental resources can be more effective than top-down ones.

A more holistic approach to policymaking is also needed. According to the Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium, countries need integrated long-term strategies that cover the three pillars of sustainable land-use and food systems. These strategies include efficient and resilient agriculture systems that ensure farmers' livelihoods, conservation and restoration of biodiversity, and food security and healthy diets.[59]

All solutions, including those not listed here, have their trade-offs. But understanding the relationships among the multiple functions of agriculture — food and fibre production, environmental, cultural and socio-economic outputs — is essential to comprehending which bundle of approaches is best suited to each context. Although humans have dramatically shaped the land over history, this generation and the generations to come have an opportunity to leave it in a better state than we received it. But doing so begins with acknowledging the ground beneath our feet.[53]

# Recommended reading

This overview is intended as a primer on land use and agriculture. To learn more, Afton recommends the following publications:

Assessing global land use

Global Land Outlook

Status of the World's Soil Resources

IPCC Special Report on Climate Change and Land

The assessment report on land degradation and restoration

Land Degradation, Poverty and Inequality

Addressing the Land Degradation — Migration Nexus: The Role of the UNCCD

Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050

The Economics of Land Degradation in Africa

The Economics of Land Degradation Neutrality in Asia

Growing Better: Ten Critical Transitions to Transform Food and Land Use

2020 Report of the FABLE Consortium Pathways to Sustainable Land-Use and Food Systems

# References

[1] https://ipbes.net/global-assessment

[2] https://ipbes.net/global-assessment

[3] https://ourworldindata.org/global-land-for-agriculture

[4] https://link.springer.com/article/10.1007/s10708-004-5050-z

[5] https://ourworldindata.org/grapher/peaking-farmland-global-arable-and-permanent-crop-area-and-ausubel-2013-projections-of-peak-farmland?time=1961..2060

[6] https://ourworldindata.org/grapher/arable-land-pin

[7] https://ourworldindata.org/yields-vs-land-use-how-has-the-world-produced-enough-food-for-a-growing-population

[8] https://ipbes.net/global-assessment

[9] https://ourworldindata.org/meat-production

[10] https://theconversation.com/how-chickens-became-the-ultimate-symbol-of-the-anthropocene-108559

[11] https://science.sciencemag.org/content/360/6392/987

[12] https://worldbioenergy.org/uploads/191129%20WBA%20GBS%202019_LQ.pdf

[13] https://blogs.worldbank.org/opendata/half-world-s-poor-live-just-5-countries

[14] https://www.nature.com/articles/s41893-018-0155-4

[15] https://www.eld-initiative.org/fileadmin/pdf/Asia_Report_EN.pdf

[16] https://www.eld-initiative.org/fileadmin/pdf/ELD-unep-report_07_spec_72dpi.pdf

[17] https://ipbes.net/assessment-reports/ldr

[18] http://www.fao.org/3/a-a0262e.pdf

[19] https://ipbes.net/assessment-reports/ldr

[20] http://www.fao.org/documents/card/en/c/c6814873-efc3-41db-b7d3-2081a10ede50/

[21] https://www.nature.com/articles/d41586-018-07587-4

[22] https://www.ipcc.ch/srccl/chapter/technical-summary/

[23] https://www.ipcc.ch/srccl/chapter/chapter-5/

[24] https://www.ipcc.ch/srccl/chapter/technical-summary/

[25] https://theconversation.com/soil-carbon-is-a-valuable-resource-but-all-soil-carbon-is-not-created-equal-129175

[26] https://www.nature.com/articles/s41586-019-1149-8

[27] https://science.sciencemag.org/content/368/6488/314

[28] http://www.fao.org/land-water/water/drought/en/

[29] https://www.agriculture.gov.au/sites/default/files/documents/aust-govt-drought-response-plan_0.pdf

[30] https://www.usgs.gov/news/very-large-dead-zone-forecast-gulf-mexico?qt-news_science_products=4#qt-news_science_products

[31] https://coastalscience.noaa.gov/news/price-of-shrimp-affected-by-gulf-of-mexico-dead-zone/

[32] https://ipbes.net/global-assessment

[33] https://www.nature.com/articles/s41559-019-0824-3

[34] http://www.agri-outlook.org/commodities/Agricultural-Outlook-2018-Oilseeds.pdf

[35] https://www.nature.com/articles/s41559-019-0824-3

[36] https://portals.iucn.org/library/sites/library/files/documents/2018-027-En.pdf

[37] https://link.springer.com/chapter/10.1007/978-3-319-19168-3_6

[38] https://www.unccd.int/sites/default/files/documents/2017-09/GLO_Full_Report_low_res.pdf

[39] https://www.eld-initiative.org/fileadmin/pdf/ELD-unep-report_07_spec_72dpi.pdf

[40] https://www.marketwatch.com/story/how-to-eat-less-meat-without-driving-yourself-nuts-and-3-good-reasons-to-try-it-2020-02-06

[41] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0200781

[42] https://wriorg.s3.amazonaws.com/s3fs-public/reducing-food-loss-waste-global-action-agenda_1.pdf

[43] https://reliefweb.int/sites/reliefweb.int/files/resources/Creating-a-sustainable-food-future.pdf

[44] https://www.wri.org/publication/shifting-diets

[45] http://www.ipbes.dk/wp-content/uploads/2018/09/LandDegradation_SPM_2018.pdf

[46] https://www.nature.com/articles/s41467-017-01410-w.pdf

[47] https://www.nature.com/articles/s41467-018-05956-1

[48] https://www.foodandlandusecoalition.org/wp-content/uploads/2019/09/FOLU-GrowingBetter-GlobalReport.pdf

[49] https://onlinelibrary.wiley.com/doi/abs/10.1111/zph.12489

[50] https://www.sciencedirect.com/science/article/pii/S1477893920300740?via%3Dihub

[51] https://www.nature.com/articles/nature09575

[52] https://community.rspb.org.uk/ourwork/b/biodiversity/posts/sparing-or-sharing

[53] https://ipbes.net/global-assessment

[54] https://www.chathamhouse.org/sites/default/files/2021-02/2021-02-03-food-system-biodiversity-loss-benton-et-al_0.pdf

[55] https://ourworldindata.org/land-use-diets

[56] https://www.nature.com/articles/s41558-020-00976-6

[57] Reference: https://www.nature.com/articles/s41558-020-00972-w

[58] https://science.sciencemag.org/content/355/6332/eaai9214

[59] http://pure.iiasa.ac.at/id/eprint/16896/1/2020%20FABLE%20Report_Full_High_Resolution.pdf

THE
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PRIZE

**The Curt Bergfors Food Planet Prize** aims to identify and reward initiatives and projects that can contribute to reshaping the food system all around the world.

Two prizes of $1 million each will be awarded annually, starting in 2020. One prize will go to an existing solution that can be scaled quickly for a global impact. The second prize will go to a radically innovative project that can sustainably transform parts of the food system. The nomination process is currently open.

**The Curt Bergfors Foundation** was founded in 2019 to support the transition to resilient food systems that protect both people and the environment.

To ensure free and independent research in the field, the foundation is funding a new professorship at the Stockholm Resilience Centre, Stockholm University: *"The Curt Bergfors professorship in sustainability science with a focus on sustainable food systems."* The funding over ten years corresponds to a donation of SEK 20 million.

The foundation is capitalized with half a billion SEK from Curt Bergfors' private assets. It will continuously take new initiatives to contribute to resilient food sourcing and a responsible food culture.

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