

# SOIL ATLAS

Facts and figures about earth, land and fields

2015



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# IMPRINT

The **SOIL ATLAS 2015** is jointly published by the Heinrich Böll Foundation, Berlin, Germany, and the Institute for Advanced Sustainability Studies, Potsdam, Germany

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With thanks to ISRIC World Soil Information in Wageningen (NL) for the map on page 13



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This publication is written in International English. First Edition, January 2015

Production manager: Elke Paul, Heinrich Böll Foundation

Printed by AZ Druck und Datentechnik GmbH, Berlin, Germany  
Climate-neutral printing on 100 percent recycled paper.

ClimatePartner<sup>®</sup>  
klimaneutral

Druck | ID: 11102-1412-1001

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# INTRODUCTION

**T**he soil seems to be inexhaustible. It is just there, beneath our feet. Under the fields, grass and trees. We live on and from the soil, but we pay it scant attention. A few wine lovers say that each soil has its own bouquet, but how many of us can actually taste it? When we sit down to dine, who thinks of the soil where most of our food grows?

It is important to do exactly that. Soils are the basis of our food production. They supply plants with nutrients and water. Those nutrients are an ingredient in every potato, every loaf of bread, every grain of rice and every plate of cornmeal we eat – and in every pork chop and roast chicken too. Without healthy soils, it is not possible to produce healthy food.

But soils do not just produce food: they do many other things too. They filter rainwater and turn it into clean drinking water. They regulate the climate, for after the oceans, the soil is the world's largest carbon sink: it stores more carbon than all the world's forests put together. And soils are teeming with life! A handful of earth contains more organisms than the planet's entire human population. Two-thirds of all species live hidden below the surface.

The international community has set itself three important goals: to stop the loss of biodiversity, keep global warming to 2° Celsius, and ensure everyone has the right to adequate food. Without fertile soil, none of these objectives will be achieved. For the soil can do its job only if the life it contains is intact, the humus layer is healthy, and land rights are protected. Despite the vital functions it performs, we fail to protect the soil. Through misuse, we lose something like 24 billion tonnes of fertile soil every year.

There are various reasons for this loss. Cities and roads are spreading. Asphalt and concrete seal the surface and damage fertile soil irreparably. A falling population does not stop the damage: in Germany, 77 hectares of soil lose some or all of their functions every day. That is the size of 100 football pitches that are no longer available to grow food. Farming, which is so dependent on the quality of the soil, bears its share of the blame.

**“** We are using the world's soils as if they were inexhaustible, continually withdrawing from an account, but never paying in. **”**

Heavy tractors compact the ground; pesticides and fertilizers decimate soil organisms; wind and water carry away fertile earth.

We are using the world's soils as if they were inexhaustible, continually withdrawing from an account, but never paying in. For it takes several thousand years to build a thin layer of fertile topsoil, but only an hour of heavy rain to lose it. From a human time perspective, soils are a non-renewable resource.

That is not all. Around the world, access to land is very unevenly distributed. Landless rural people and those who farm tiny plots find it hard to feed themselves. The average European needs 1.3 hectares – two football pitches – to produce all of the food and other products he or she consumes each year. That is about six times more than is available to each Bangladeshi. Almost 60 percent of the area consumed by Europeans lies outside the European Union.

Global demand for food, fodder and biofuels is on the rise. So too are land prices. In many regions, the struggle for secure land rights is a struggle for survival for individuals and communities. The global

**” 2015 is the International Year of Soils. This Soil Atlas shows what can succeed and why the soil should concern us all.**

significance of soils demands global responses – responses that take the human rights of land users seriously. Yet opposition from Germany sank a proposal for a common European policy for protecting the soil. Timid reforms to the Common Agricultural Policy show how difficult it is to change existing structures and to promote sustainable, equitable production methods.

2015 is the International Year of Soils. In this year, the United Nations wants to further the goal of soil protection. This Soil Atlas shows what can succeed and why the soil should concern us all. We need to fight for a just and sustainable soil and land policy. And when we are doing our weekly shopping, perhaps we need to think a little about what we can do to conserve the soil on which we depend.

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Sustainability Studies

## LESSONS TO LEARN

# ABOUT SOIL AND THE WORLD

**1** Land and soil have a multitude of **SOCIAL, ECOLOGICAL, CULTURAL, SPIRITUAL AND ECONOMIC** functions worldwide.

**2** Fertile soil is vital. It forms just a thin layer on the Earth's surface. **IT TAKES 2,000 YEARS TO CREATE 10 CENTIMETRES OF TOPSOIL.**

**3** Millions of hectares of land are lost every year through inappropriate farming techniques, for the construction of cities and roads, and through deforestation. **CITIES EAT INTO FIELDS**, and fields expand at the expense of forest and pastureland.

**4** **WITHOUT PROTECTING THE SOIL, IT WILL BE IMPOSSIBLE TO FEED A GROWING WORLD POPULATION**, keep global warming below 2 degrees Celsius, or halt the loss of biodiversity.

Land ownership is distributed inequitably – even more so than income. **ACCESS TO LAND IS FUNDAMENTAL IN THE FIGHT AGAINST HUNGER AND POVERTY.** In many countries, women are disadvantaged compared to men.

**6** **LAND PRICES ARE RISING ALMOST EVERYWHERE.** If individual or communal rights are not assured, local people are forced off the land.



## COMPETITION FOR LAND IS GROWING.

The causes include the spread of fodder crops, and the growing use of crops to produce “green” biofuels.

Global trade has turned arable land into a mobile resource. **DEVELOPED AND EMERGING ECONOMIES ARE EXPORTING THEIR HUNGER FOR LAND TO THE DEVELOPING WORLD.** They import land in the form of products grown abroad.

7

8

9

Despite the fact that chemical fertilizer is being used, yields are not increasing as rapidly as expected. **ORGANIC FARMING STIMULATES SOIL ORGANISMS** and improves soil fertility in the long term – something that mineral fertilizers fail to do.

10

### MODERN CITY PLANNING MUST INCLUDE SOIL CONSERVATION.

Infrastructure and housing must use less fertile land, especially in countries with declining populations.

11

### AN INTERNATIONAL REGULATORY FRAMEWORK

**BASED ON HUMAN RIGHTS** must ensure that the distribution of land is equitable and that fertile soils are not monopolized by the rich.

12

Protecting the soil is a global task. **BUT INDIVIDUALS CAN MAKE A SIGNIFICANT CONTRIBUTION** by purchasing local products and eating less meat.

# ON UNSTEADY GROUND

**A look at history reveals deep-rooted changes in our views about the earth beneath our feet – and helps us understand who we are.**

**S**oil, land, agriculture – the words we use to describe the material basis of food production are deeply embedded in our culture. They have ancient Indo-European roots, yet different, sometimes contrasting meanings. The word “soil” comes from the Latin *solum*, meaning “soil” or “ground”, perhaps with the Old French words *soeul* (threshold, area, place) and *soille* (a miry place) mixed in. “Land”, on the other hand, has a more expansive origins; it connotes “expansion, new areas”.

Wherever the landscape and climate permitted people to settle, the first step was to start working the land. Control and ownership followed. This rewarded the laborious clearing of forests and improvement of the soil, perhaps for private use or for the community, but mostly as bonded labour for a landowner. “Agriculture” – the cultivation of the *ager*, or fields – began to dominate. Its etymology also betrays a transition. The related Old English word *æcer* had the meaning “open land”, where cattle were driven. After people started using it to grow crops, the name stayed. It morphed into “acre”, the amount of land a yoke of oxen could plough in a day.

In many parts of the world, climatic conditions did not permit permanent cultivation. In the drylands, mobile livestock herding was the chief type of land use, and individual ownership rights did not emerge. People relied on oral rather than written records. Wherever animals had to survive on scant vegetation, the joint management of land required careful agreements, customs and trust. Such arrangements were valid across large areas and over long periods, often spanning linguistic and cultural boundaries.

Land ownership led to specific forms of worldly power. In ancient times, the possession of land led to the concept of property, or immobile goods. The Greeks used it as security for loans: the origin of mortgages. Discharged Roman soldiers received a pension in the form of land, and their presence buttressed the empire’s hold on the coasts of the Mediterranean. The barbarian invasions reorganized the settlement and land use patterns in Europe. The Islamic expansion transformed a desolate Spain into a thriving culture. In the Middle Ages, “land” acquired new meanings: land as opposed to water, and the countryside as opposed to the city. In the description of a certain demarcated area, it came to mean a state or territory, as in “England” or “Scotland”.

Land stimulates both curiosity and greed. Early long-distance travellers often brought home little more than reports of distant regions. In the 14th-century, the Venetian Marco Polo told of the wonders of China, while the Moroccan explorer Ibn Battuta travelled to such far-flung places as Central and East Asia, Zanzibar and Timbuktu. The marvels of Asia – pepper, silk and porcelain – tempted, but Islamic and Venetian rulers and traders pushed up prices so high that they became luxuries in Europe.

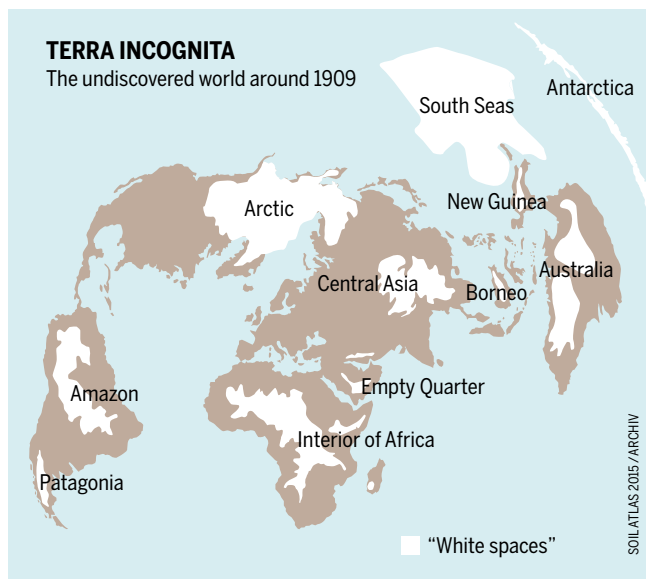
In the 15th century, the Chinese admiral Zheng He led huge trading fleets in the Pacific and Indian Oceans, reaching as far as Mogadishu in today’s Somalia. His travels and Columbus’s discovery of the Americas, were just the beginning. Seafaring began to supplant overland travel; after Vasco da Gama circumnavigated Africa in 1498 and opened the way to India, the Spice Islands and China, the old caravan routes lost their significance. Spain and Portugal quickly divided the world between themselves. Magellan’s circumnavigation of the globe in 1519–22 finally proved that the Earth is round – and that land is limited.

From a European point of view, the competition to conquer the world’s land masses had begun. This took several centuries, and was marked by monstrous brutality – something we still tend to forget, preferring to think instead of the fascination of the foreign, the acquisition of wealth and the “superior” culture of the conquerors.

“Be fruitful, and multiply, and replenish the earth, and subdue it” became a popular Bible quotation. In the 1600s, the Dutch philosopher Hugo Grotius proposed the concept of the “freedom of the seas”, in contrast to the Roman/Venetian tradition of a *mare nostrum*. This idea of open access still applies to most of the oceans and to Antarctica; they have so far avoided being carved up into national territories.

Myths gave rise to lands that did not exist, such as the legendary continent of Atlantis. And they predicted land that actually did exist. In the 17th century, European sailors dis-

*White spaces attracted white men: adventurers, miners and colonialists carved the world up among themselves*





## BENEATH THE GROUND

# THE INVISIBLE ECOSYSTEM

**Soil fertility depends on several factors: the soil age, its parent material, its organic matter content, the climate – and people.**

It takes centuries – more likely thousands or even millions of years – to create soil. That is how long it takes for the surface rock to be weathered down to a depth of several metres. Only half of what we call soil consists of mineral particles such as sand and clay. Roughly 20 percent is water, and another 20 percent is air. The remaining five to ten percent are plant roots and soil organic matter such as living organisms and humus.

Soil organic matter gives the surface soil a dark, brownish black colour. This topsoil teems with life: in addition to earthworms, lice, spiders, mites, springtails and others, a handful of soil contains more microorganisms – bacteria, fungi and archaea – than there are humans on earth. These organisms decompose plant residues, turn them into humus, and distribute this fertility-giving substance throughout the soil.

Humus stores nutrients and water, and gives the soil a stable structure with many pores. It also contains carbon that plants originally absorbed from the air in the form of carbon dioxide, a greenhouse gas. This makes soil one of the most important active carbon pools. The soil organic matter stores 1,500 billion tonnes of carbon, globally – this is almost three times more carbon than in all above ground biomass including trees, shrubs and grasses.

Soil is like cheese; the holes are just as important as the mass. The pores, or the voids between the solid mineral and organic particles, ensure that the soil is aerated, allowing roots and soil organisms to respire. Besides air, the pores may contain water, held there by adhesion and capillary forces. A cubic metre of soil may contain up to 200 litres of water, supplying the precious liquid to plants even though it may not have rained for a long time. The volume of pores in

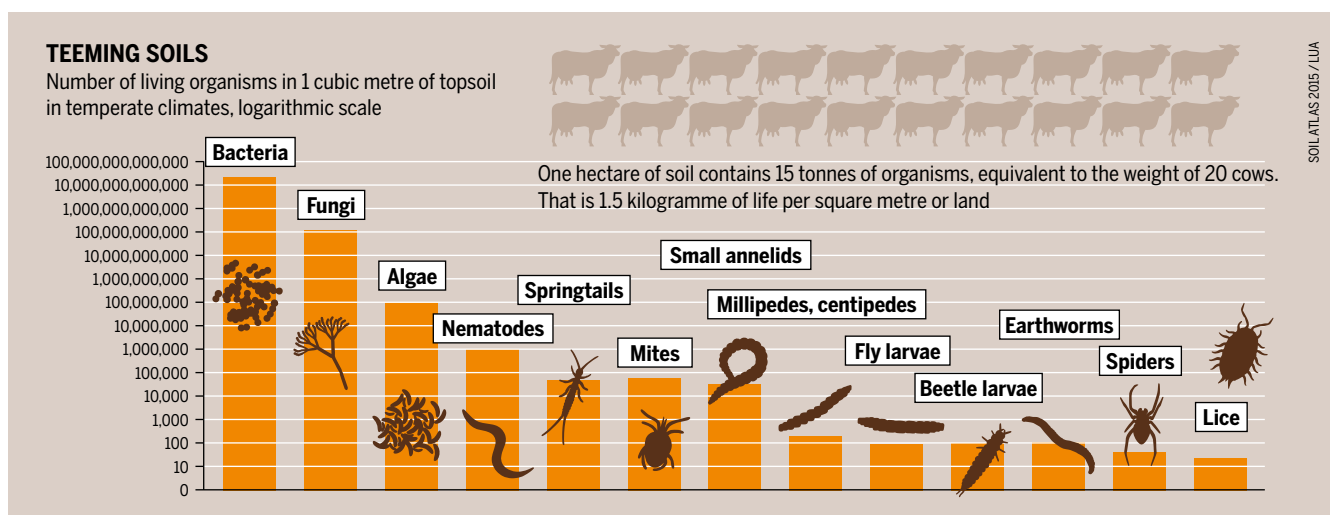
a soil depends on the size of the soil particles, the soil organic matter content, the presence of roots and the activity of soil organisms.

Earthworms are especially important; some of them burrow vertically down into the soil, allowing water to drain into the subsoil quickly during heavy rain. The subsoil contains less humus and fewer living organisms than the topsoil. It is lighter in colour, often yellow-ochre or reddish because of various iron compounds. A deep subsoil, that allows roots to penetrate and extract water even when the topsoil has run dry, is important for soil fertility.

Location often determines how much time was available for soil to form. In Central Europe during the Ice Ages, advancing and retreating glaciers wiped the slate clean by scraping off and churning up existing soils and depositing new sediments. The brown soils typical of the region are only about 10,000 years old – very young and little-weathered compared to most other soils. They often contain minerals that slowly release nutrients such as phosphorus and potassium into the soil. The red soils typical of the tropics, on the other hand, have undergone millions of years of weathering; many of their original minerals have been dissolved, transformed or washed out. Much of the phosphorus that has been mobilized is now firmly sorbed by iron and aluminum oxides and is thus unavailable to plants.

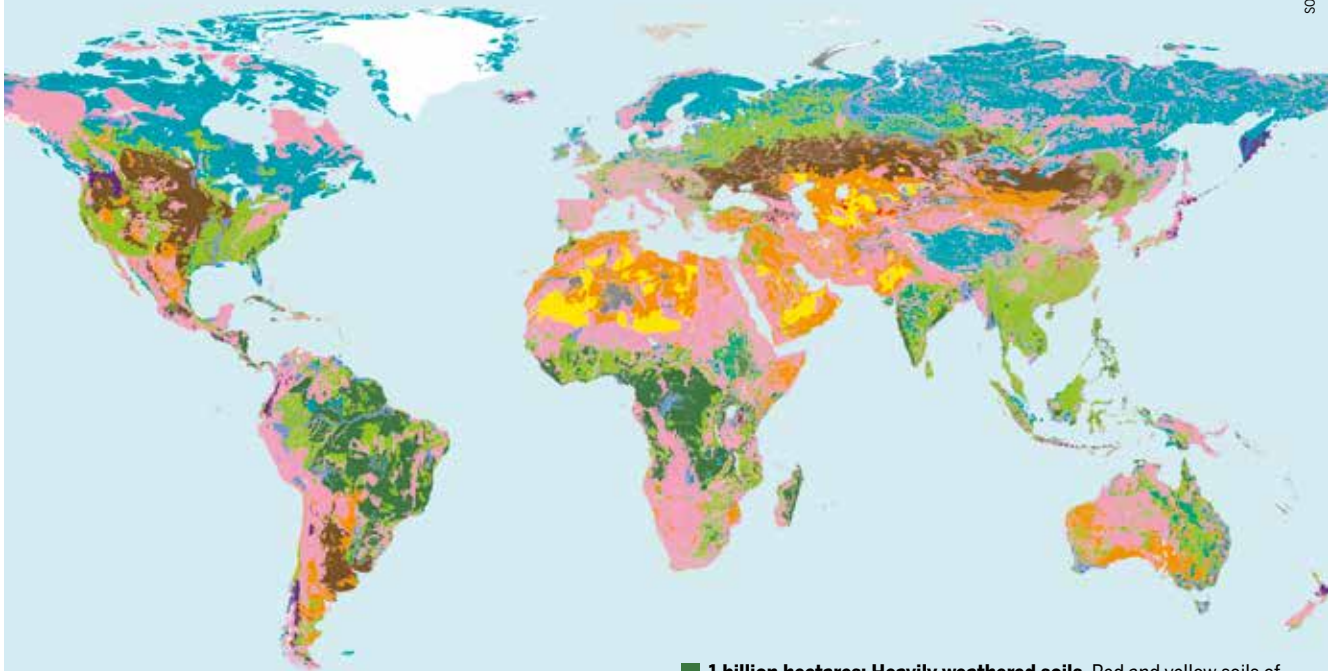
Soil properties depend in large part on its parent material. A rock that is rich in quartz will result in a light, coarse-grained and sandy soil that is well-aerated but stores relatively little water and nutrients. If the parent rock is rich in feldspar, the resulting fine particles will finally form a heavy soil, rich in clay. Such soils can store more nutrients and water, but are poorly aerated. They partially hold onto water so

*Humus harbours many secrets. Only a fraction of the many species that live in it have been identified*



## SOIL GROUPS AROUND THE WORLD

Simplified presentation based on the World Reference Base for Soil Resources (WRB), excluding Antarctica



**> 5 billion hectares: Little to moderately developed soils.**

Young soils; periodically flooded sediments in river beds, deltas and coastal areas; sandy or rocky soils with restricted root zone. Some extensively grazed. Cultivation of easily harvested roots and tubers. Some good farmland (if moderately weathered).

**> 2.5 billion hectares: Soils concentrated in boreal and polar regions.**

Permafrost or forest in cold regions. Also organic soils, especially peats and bogs. In temperate zones often converted to arable land.

**2.4 billion hectares: Soils with clay-enriched subsoils.**

Result of strong weathering and leaching. Dependent on soil chemistry, nutrient availability may be poor (often in forested taiga, soils with livestock raising or careful cultivation) or good (arable land with deep ploughing).

**1.1 billion hectares: Soils with oxygen deficiency.**

Influence of groundwater or temporary waterlogging. Mostly swamp forest or permanent pasture. Arable use requires drainage (then often wet rice cultivation).

**1 billion hectares: Heavily weathered soils.** Red and yellow soils of the humid tropics humid tropics; deep, well-drained and mostly easy to work, but low water and nutrient storage capacity. With year-round rainfall, either low fertility (with continuous or shifting cultivation or extensive grazing) or good, deep rooting (often with plantations).

**1 billion hectares: Soils with pronounced accumulation of organic matter in the mineral topsoil.** Heavy chestnut-brown to black "steppe" soils. Grasslands, sometimes irrigated, partly used for intensive cropping and animal husbandry.

**500 million hectares: Arid-zone soils other than steppe climate.** Accumulation of calcareous, saline or alkaline materials; often extensively grazed or unused.

**>300 million hectares: High clay content soils of the alternating wet-dry tropics.** Swelling clays cause wide cracks under dry conditions. Often unused, or with extensive grazing or cotton cultivation. Cropping is only possible under strict water control.

**>100 million hectares: Soils from volcanic ash.** Mostly black soils, often with tuff or pumice. Generally fertile, with favourable properties for cultivation, plant roots, and water storage.

**Soils with strong human influence**

**Rock and rubble**

**Glaciers and permanent snow cover**

**Sand and dunes**

tightly that plant roots cannot absorb much of it. The best soils are neither sandy and light, nor heavy and rich in clay. Instead, they mostly contain medium sized particles called silt. Silt combines the advantages of both sand and clay: good aeration, along with the ability to store lots of water and nutrients.

Soils that are especially fertile are good for growing crops, while less-fertile soils are more suited for meadows, pastures and forest. For ecological reasons, even less fertile soils can be valuable. Peat soils are too wet for intensive farming, but store huge amounts of carbon. If the soil is used too intensively or in an inappropriate way, its functions de-

*Scientists classify soils according to their properties, such as the degree of weathering or the impact of water*

cline and it starts to degrade. An estimated 20 to 25 percent of soils worldwide are already affected, and another 5 to 10 million hectares – about the size of Austria (8.4 million hectares) degrade each year. Arable land is particularly affected. But cultivation does not necessarily damage the soil: the floodplains of the Tigris and Euphrates in Iraq, and the highlands of New Guinea, have soils that are still fertile despite being farmed for 7,000 years. ●

## ABOVE THE GROUND

# LIVING ON A POSTAGE STAMP, EATING FROM A THIMBLE

**The world is a big place – but we are rapidly running out of room to grow our food, and we are using it in the wrong way.**

**F**or thousands of years, humans have shaped the earth on which we live. Land is where we grow food and graze animals. It is where we build our cities and roads, dig up minerals or chop down trees. It reflects our spiritual values; it is where we go to relax.

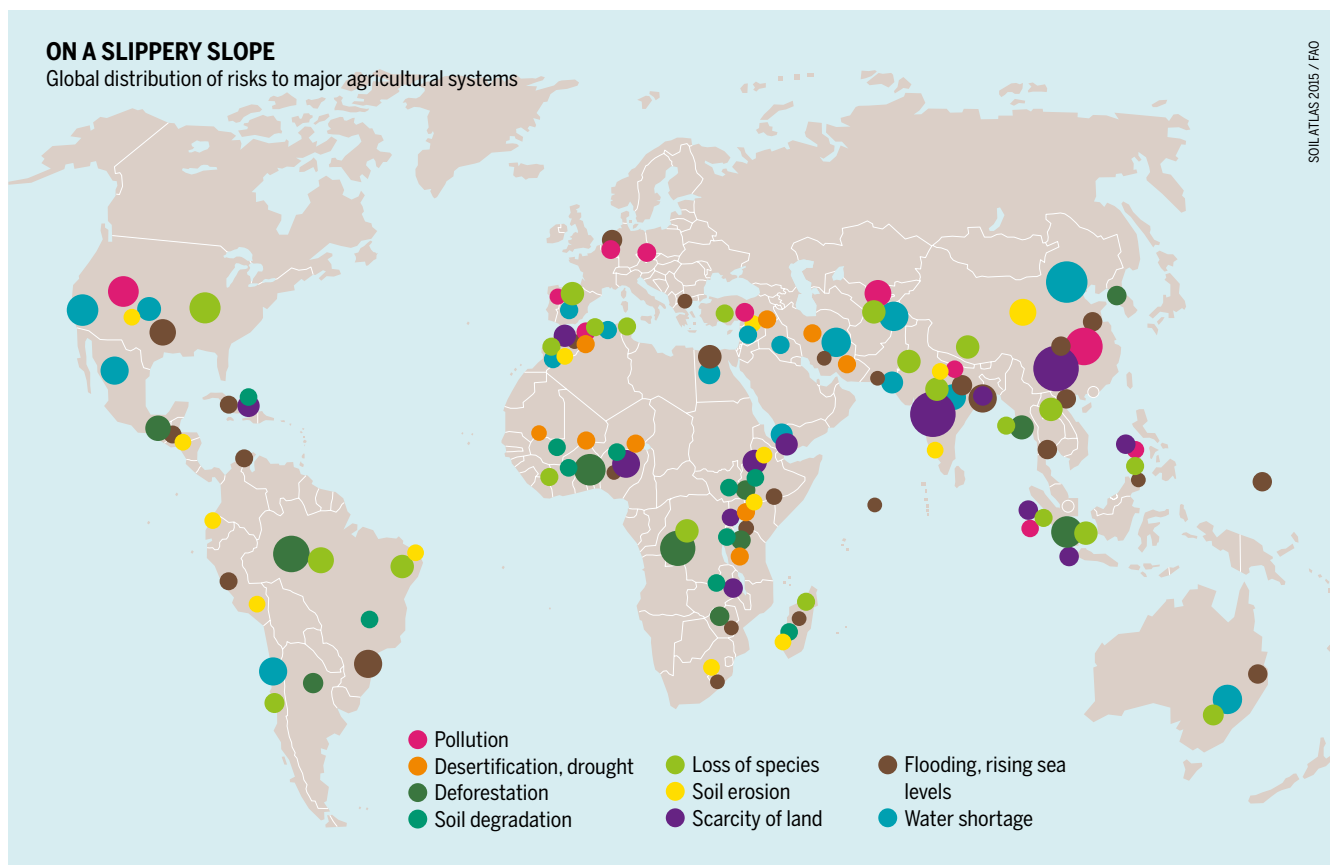
Land and how we use it has moulded history, politics and culture. In many Western countries, individual land ownership is associated with traditional values and social status. Lands were passed down by families from generation to generation. In socialist regimes, the nationalization of land was an expression of political power that reached a gruesome climax in the Soviet Union under Stalin, when millions were dispossessed and expelled from their farms. The structures that resulted from forced collectivization still shape the agricultural systems of much of Central and Eastern Europe.

The world has only so much land. Well into the 20th century, countries expanded their boundaries through war and colonial suppression. However, increasing liberalization

and globalization of agricultural trade since the 1980s, have blurred the importance of a limited national territory. The era of the agricultural multinational firm has arrived. With branches around the globe and logistics that can handle millions of tonnes, the Big Four – Bunge, Cargill, Louis Dreyfus and ADM – shift bulk commodities from where they are grown to where they are processed and consumed. Land shortages can now be outsourced: land, the ultimate immobile resource, is now just another flexible factor of production.

The Green Revolution launched in the 1960s, ushered in the more intensive use of land in the tropics; high-yielding varieties, fertilizers, pesticides and irrigation pushed up crop yields. Fossil fuels compensated for a shortage of land. However, the limits reached by this type of non-sustainable agriculture were ignored. They came to light by the turn of the millennium, when the global ecological damage caused by industrial agriculture became evident.

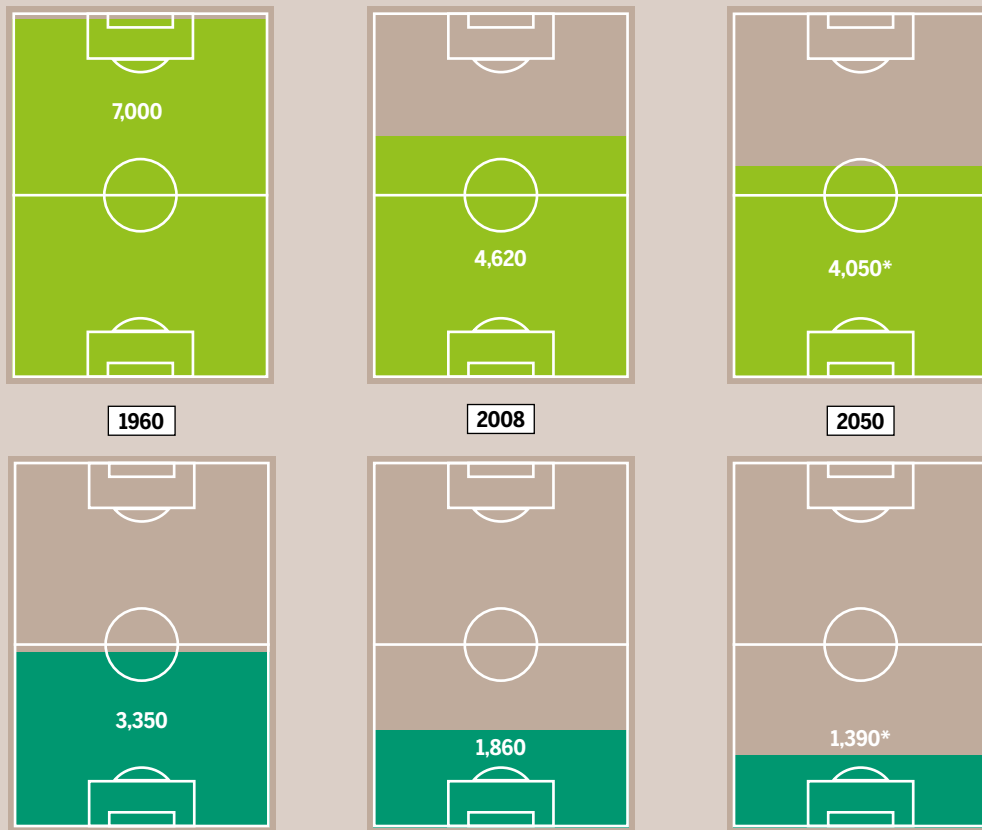
*A selection of man-made problems:  
land scarcity and environmental damage  
endanger our food production*



## A SHRINKING FIELD

Agricultural area per person, in square metres  
Compared with 1 football field = 7,140 square metres

■ Developed countries ■ Developing countries



\* Estimate

Now the limitation of land reveals itself again – this time from a global perspective. Demand is growing everywhere – for food, fodder and biofuels. Consumers are competing with each other. Cities and towns currently occupy only 1–2 percent of the world’s land. By 2050, they will cover 4–5 percent – an increase from 250 to 420 million hectares. Crop-land has to give way; forests are being felled and grasslands ploughed up to compensate. Between 1961 and 2007, the arable surface of the world expanded by around 11 percent, or 150 million hectares. If demand for agricultural products continues to grow at the current rate, by 2050, we will need approximately an extra 320 to 850 million hectares. The lower figure corresponds to the size of India; the higher one, to the size of Brazil.

Growing demand for land heightens tensions among different groups of users. Land is an attractive investment: an increasingly scarce commodity that yields good returns. Worldwide it is the source of livelihood for more than 500 million smallholders, pastoralists and indigenous peoples. People identify with the land; for them it embodies cultural and even spiritual values. Especially in countries without social security systems, access to land is fundamental to survival. But individual and communal rights to land are increasingly under threat.

Rising demand also harms the ecosystem. A humane form of use – one that maintains the quality, diversity and fertility of a landscape – is all too rare. The more intensive

*Football pitches reflect the gap between rich and poor. In a just and sustainable world, each of us would have to make do with 2,000 square metres*

the farming, the more damage it does to the environment. This is the main reason for the decline in biological diversity, above and below the ground. Every year, around 13 million hectares of forest are cleared; of the world’s primary forests, around 40 million hectares have disappeared since 2000. Fertile soils are ruined, deserts expand, and carbon that has been stored in the soil for millennia is released into the atmosphere as greenhouse gases.

Despite all these developments, the governments of developed countries still call for “green growth” – meaning replacing fossil fuels with biofuels. That is the inverse of the Green Revolution; now, intensive farming is supposed to replace petroleum. Such an intensive path towards growth disregards the goals of social justice, biodiversity and climate.

According to the United Nations Development Programme, if land use continues to increase, the world will already have reached the limits of ecologically sustainable land use by 2020. Global land use, mainly to benefit the European Union and the United States, cannot increase much more. With only 1.4 billion hectares of arable land at our disposal, each person will have to make do with just 2,000 square metres – less than one-third the size of a football pitch. ●

## MEMORY

# THE ARCHIVE OF THE ANTHROPOCENE

**Soils preserve the history of the landscape and the people who live there. They will reveal to future generations how good our current stewardship of the planet has been.**

In wine there is truth – and there is terroir too: the special character created by the unique combination of the microclimate and soil at a particular location. The flavours created by the sun and the nutrients stored in the soil unfold in wine; they are the taste of the soil. Viticulture is one of the oldest forms of farming, and the carefully managed soils in vineyards are a detailed archive of human history. The soil bears witness to the history of the landscape and its people.

Soil is a window to the past. Pollen grains and plant remains, or the degree of decomposition in minerals that make up the soil, reflect the climatic conditions of former times. We can reconstruct the evolution of landscapes by examining sediments, especially those resulting from human-induced erosion. Such traces shed light on the dramatic twists and turns in the history of civilization.

Soil profiles and debris deposits reveal how overuse and deforestation led to devastating floods in Central Europe in 1342. Around 13 billion tonnes of soil was eroded, according to the geographer Hans-Rudolf Bork of the University of Kiel. The resulting harvest losses caused famine, which was followed by the deaths of one-third of Europe's population through the plague. The Black Death resulted in the return of the forests.

The type and composition of soils allow us to draw conclusions about how the land was used and managed in the past. "Amelioration" leads to better yields; "degradation" to worse. Such changes can be dramatic. At the time of the Roman Empire, wide swathes of Europe were deforested: in

the Apennines in Italy, the Peloponnese in Greece, plus parts of Spain. The demand for wood for burning and building caused erosion so extreme that the landscape, climate and soils in these regions are still disfigured.

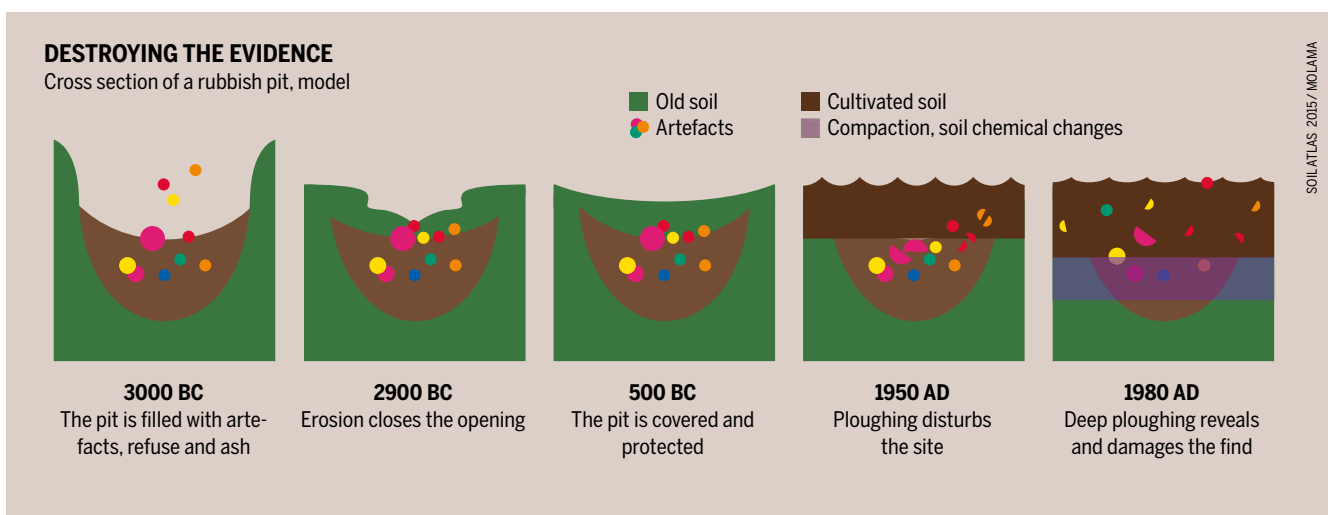
Around the world, the impact of cultivation is so severe that the original characteristics of the soil are difficult to discern. They are known in the jargon as "anthrosols". In infertile, sandy parts of the Netherlands, northern Germany and Denmark, generations of farmers cut away a layer of topsoil and vegetation, carried it to their stables and used it as livestock bedding. After it had been enriched by the animals' dung and urine, the farmers spread it as fertilizer on surrounding fields. This practice began in the Middle Ages and lasted until the advent of mineral fertilizer in the 1930s. Its traces can still be seen in the soils and vegetation of the affected areas.

Another mediaeval practice was to plough strips of land using a single-sided plough, pulled by a team of oxen. The plough turned the soil over to the right. Over time, repeated ploughing created a wavelike ridge-and-furrow pattern that can still be seen on land that has not been ploughed since.

War also leaves its scars on the soil. Landmines prevent farmers from working their fields: the population leaves and the land is left fallow for years on end. Military training grounds, often heavily contaminated, are left to themselves; they develop a rich biodiversity that is the subject of a special field of research.

Soil reflects human history. Charcoal remains allow archaeologists to estimate the number of inhabitants of an

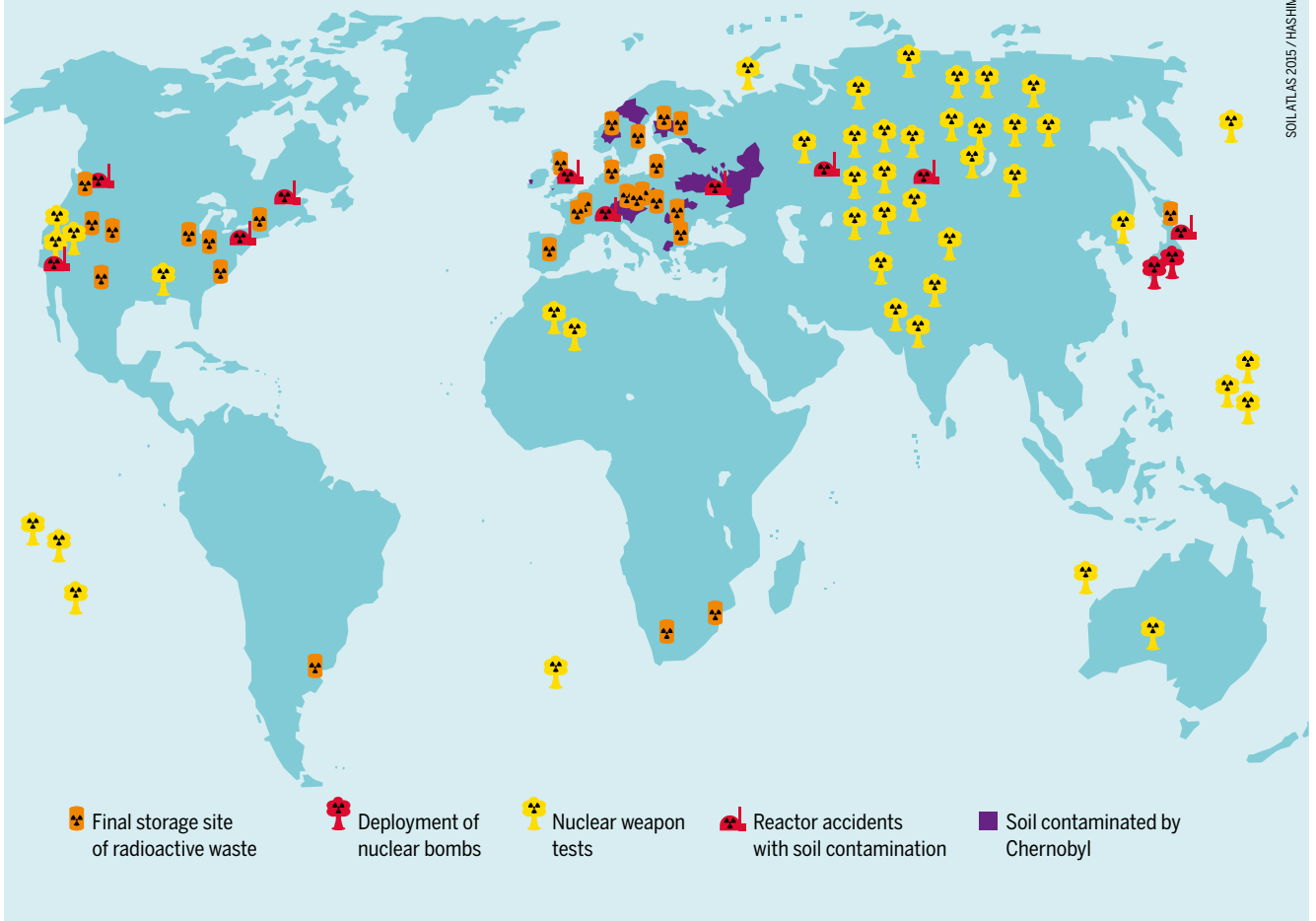
*Over the ages, civilization has left its mark on the soil. Archaeologists race against time to unearth secrets before they are destroyed*





## RADIANT FUTURE

Atmospheric and underground radioactive contamination of soil, selected, 1945–2013



SOIL ATLAS 2015 / HASHIMOTO, WIKIPEDIA

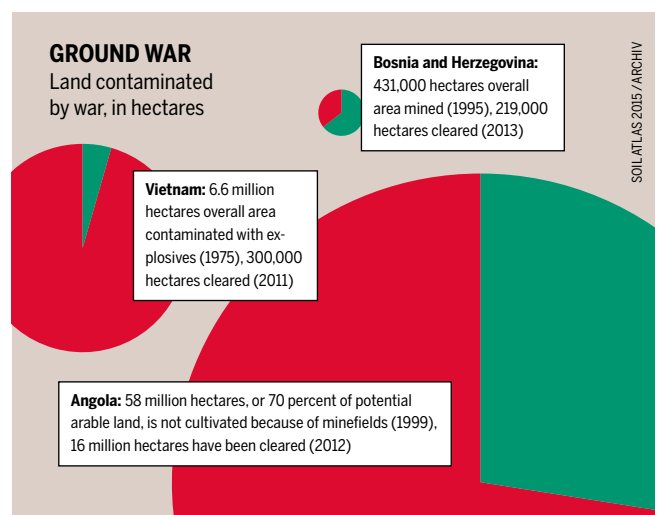
area. Fragments of everyday objects reflect daily life and trade patterns. Grave goods reveal cultic practices. Shell middens along the coast attest to the eating habits and lifestyles of the people, and show the rise and fall of the sea level and the location of the coastline.

In 2000, the Nobel chemistry laureate Paul Crutzen used the word “Anthropocene” at a scientific conference, he only wanted to remind his colleagues that humans have long been a significant factor in geology. However the term stuck. No one doubts that humans have left their traces everywhere, and that our conscious or unconscious transformation of entire ecosystems is likely to be irreversible.

Future generations will see this especially in urban soils. The change in the biological and chemical composition, as well as the physical structure of these urban soils is more pronounced here than anywhere else. They are true “anthrosols”. “Technosols”, on the other hand, are soils that consist mainly of artificial materials such as concrete, glass and bricks, as well as construction debris, rubbish and industrial waste of various types. The anthrosols and technosols, the soils of the Anthropocene, reflect the geological impact of humanity. Experts are still arguing about whether, and how, the Anthropocene will be visible in future rock strata. In the case of shale-gas fracking, the injection of carbon dioxide and subterranean nuclear tests, the question has already been answered. ●

*An unacceptable legacy: radioactive waste from nuclear power will still be here tens of thousands of years from now*

*Nature returns to minefields. But farmers risk their lives and their livestock because they have nowhere else to grow crops and pasture animals*



## HOT SPOTS

# BAD STEWARDSHIP

### TOWN ON THE MOVE

The northern Swedish town of Kiruna has been built around the world's biggest underground iron mine. Below ground, the mine is eating its way towards the town centre. So the town has to get out of the way: it is being moved lock, stock and barrel several kilometres to the east. The clock tower, several historic buildings and the century-old church will be moved; the other buildings will be torn down and built anew. In many other countries, the residents would simply be evicted, but Sweden is different: the state-owned mining company is paying for the move, which is expected to cost more than 600 million euros.

Kiruna

### PHOSPHATE FROM A GREY ZONE

Phosphate is the most important natural resource of the Moroccan-occupied Western Sahara. The open-pit mine at Bou Craa is one of the biggest in the world. A conveyor belt over 100 kilometres long brings the ore to the coast. The economic significance of the mine is increasing as world reserves of phosphate decline and prices rise. From the point of view of international law, the removal of natural resources from an illegally occupied region constitutes theft by the Moroccan state. Several states, including India, recognize the independent Sahrawi Arab Democratic Republic, but imports the phosphate anyway.

Western Sahara

Nigeria

### BENZENE IN THE WATER

The densely populated Niger Delta is one of the most polluted areas of the planet. More than 5,000 oil wells and 7,000 kilometres of pipelines obstruct farming, aquaculture and fisheries. Water sources contain too much benzene – a carcinogen – to be used for drinking. After the Ogoni and Ijaw, two Delta tribes, failed to benefit from government programmes, they launched a resistance movement in the early 1990s. This has led to bloody repression by the government, especially against the Ogoni. Political conflict has led to ethnic strife, with the Ijaw declaring the Delta to be theirs, and the Itsekiri people registering their claims to oil-rich land faster than the Ijaw. The United Nations Environment Programme estimates the cost of cleaning up the pollution at 1 billion dollars.

### SPRAYING ON A GRAND SCALE

Nearly all of the soybeans grown in Argentina are genetically modified to resist Glyphosate, a herbicide. Farmers use tractors or planes to spray their crop. According to the Argentinian health ministry, twice as many people die from cancer in areas with large-scale use of agrochemicals than the national average. In 2012, a pilot and two soy producers were found guilty of spraying Glyphosate and the insecticide Endosulfan near a residential area. In the last year alone, Argentinian farmers are thought to have sprayed 200 million litres of pesticides on soybean crops.

Argentina



### A SALTY, BARREN HERITAGE

Government subsidies for electricity, fertilizer and high-yielding crops have given rise to a tribe of “tubewell nomads” in the Thar Desert in Rajasthan. These are farmers who pump groundwater to grow mustard and wheat, pushing out the pastoralists who graze their animals there. That lowers the water table, forcing the farmers to deepen the wells. After a few years, the groundwater level sinks below the reach of the pumps. The farmers move on to the next spot, leaving behind barren, salty ground in place of the previous drought-resistant plants. Camels are the only livestock that can eat the salty vegetation.

### NITROGEN, ARSENIC AND MERCURY

In much of China, far more nitrogen fertilizer is applied than is necessary. Only 30 percent of the applications are effective; the rest is carried away by runoff or percolates down into the groundwater. Antibiotics that contain arsenic and mercury are a special problem: animals excrete them in their dung. The use of antibiotics in livestock-raising is subject to only weak controls in China. The government has declined to publish details of research about the extent of heavy metal contamination from industry.

### CRUMBLING TERRACES

The spectacular rice terraces of Banaue are some of the oldest constructions in the Philippines, and are a Unesco World Heritage Site. Up to 2,000 years old, many have been reinforced with stones for at least 600 years. They climb hillslopes at angles of up to 70 degrees – but they are starting to erode. For they need regular maintenance, which they no longer get. Local people prefer to move into the towns or work in the new tourist industry, rather than doing the back-breaking work needed to care for the area’s stepped landscape.

Rajasthan, India

China

Bhopal

Banaue

### TRAGEDY WITH NO END

In 1984, a poisonous cloud of gas escaped from a pesticide plant belonging to Union Carbide (now part of Dow Chemical) in Bhopal, blanketing nearby shanty towns. Up to 25,000 people to date have died as a direct result of this industrial accident, and hundreds of thousands were injured. The site has still not been cleared of its toxic chemicals. Local residents are still exposed to pollution from the plant, and polluted groundwater still threatens their health.

Borneo

### MISGUIDED IRRIGATION

Once almost completely covered with dense forest, the island of Kalimantan (Borneo) has lost much of its tree cover since the arrival of two invader species – the chainsaw and the caterpillar tractor. In the 1990s, an attempt to grow one million hectares of rice failed because the irrigation channels dug drained the land instead of watering it. The dry peat burns easily, releasing huge amounts of carbon dioxide into the atmosphere and causing an annual “haze” that blankets much of Southeast Asia in choking smog. Logging – much of it illegal – oilpalm plantations and open-cast coal mines are major current causes of soil loss.

## INTENSIVE CROPPING

# A TROUBLED FUTURE FOR INDUSTRIAL FARMING

**Less humus means lower fertility – something that no amount of fertilizer can solve. And new cultivation methods bring new problems.**

**C**ompared to other parts of the world, Europe has remarkably resilient soils. The mild climate puts few stresses on arable land. Farming is subject to numerous regulations that aim to protect the environment. Nevertheless, 35 percent of the agricultural land in the European Union shows signs of compaction, and 17 percent is degraded – with soils significantly damaged or even completely destroyed. Nearly 150 million hectares are subject to wind or water erosion: 42 million acres by wind, and 105 million by water.

Because of farming, 45 percent of Europe's soils have lost significant amounts of organic matter, including humus and soil organisms. The natural fertility of the fields has declined. In temperate climates their bad state can often be masked by mineral fertilizers and liming. But while crop yields are stable today, they may fail in the future.

What causes these problems? Decades of using “modern” techniques such as high-yielding seeds, fertilizers, pes-

ticides, monoculture and irrigation have led to sharp rises in yields. This is the case in North and South America, Australia and northern China. Worldwide, farm production almost tripled in the last 50 years, while the area of agricultural land expanded by only 12 percent.

At the same time, precisely the same set of techniques, along with shorter rotations and fewer fallow periods, has caused the amount of humus – the organic matter – in the soil to decline. That removes the habitat of organisms that keep the soil loose and friable. The structure breaks down, and the soil becomes compacted. The range of soil functions is disrupted:

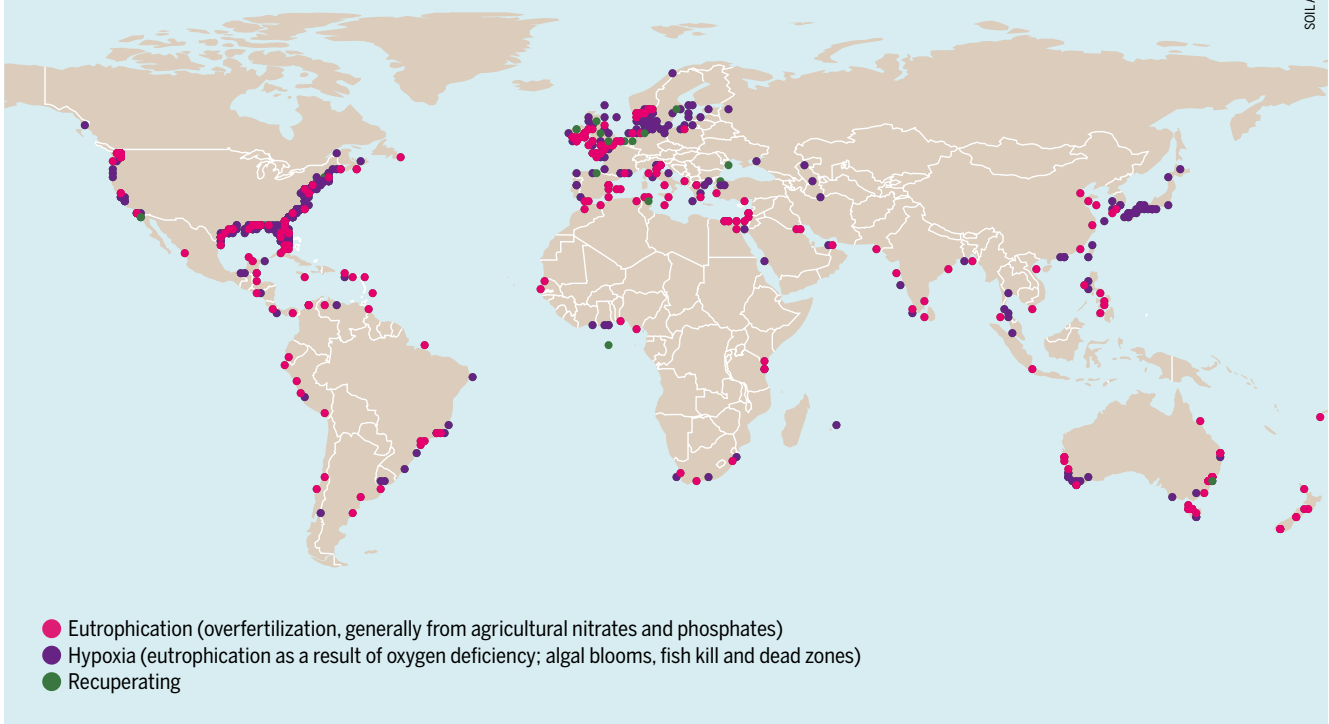
- Habitat (biodiversity, beneficial organisms)
- Regulation (water absorption, storage and purification; the breakdown of pesticides and other pollutants)
- Production (nutrient exchange and natural fertility).

In the last two decades, no-till farming has been suggested as a means to combat soil erosion. This involves sowing seed

*Excess fertilizer washes into rivers and is carried into the sea, where it causes algal blooms and destroys the ecological balance*

### COASTAL CRISIS

Regions polluted by an oversupply of nutrients and oxygen deficiency, 2010



directly into the soil after the previous harvest, without first ploughing the land. Specialists call these methods “conservation agriculture” or “zero tillage”. These methods are now widespread: in 2011, 125 million hectares were under “no-till”, with 55 million in Latin America, 40 million in the United States and Canada, and 17 million in Australia.

But merely throwing away the plough does not help overcome the problems of compaction and loss of humus. In general, direct seeding is not combined with rotating crops, which would loosen the soil by stimulating soil life and allowing roots to penetrate deeper. And many no-till farmers do not apply organic matter, which would build up the humus layer.

If the soil is not turned over by ploughing, weeds, pests and fungi can multiply quickly. So no-till farming often requires lots of herbicides and pesticides – an attractive market for the agrochemical industry and the producers of genetically modified seed. The chemicals kill all plants and animals that are not resistant to them. In Latin America, especially, vast no-till fields sown with soybeans are sprayed from planes. The surface and groundwater in these areas are contaminated with glyphosate, the world’s best-selling herbicide.

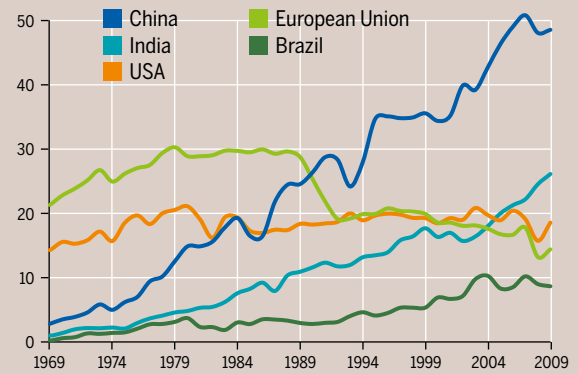
Phosphorus will also cause problems in the near future. This element is vital for plant growth, and is applied as a commercial fertilizer, just like nitrogen. But global phosphate supplies are being used up. Based on the current levels of demand, the world’s known reserves will be exhausted in the next 50–100 years. Peak phosphorus output may be reached as early as 2030. Many experts believe that future consumption will have to come not from mines, but from recycling.

We currently waste phosphate. We must use it more efficiently and more sustainably. Phosphate prices are likely to rise, making new technologies more economic. But it will still be difficult to close the phosphate cycle. The main focus is on sewage sludge, which contains large amounts of phosphorus, as an adult human excretes 1.7 grams of this substance each day, 60 percent in the urine. But sewage sludge contains too many contaminants for direct use in farming. Furthermore, the large-scale extraction of phosphorus is expensive.

Mycorrhizal fungi offer another potential solution. These are symbiotic organisms that occur naturally in all soils. They colonize the roots of plants and provide them with considerably more water, nitrogen and phosphorus than the plants require. Little research has been done on the mechanisms that several thousand species of fungi use to extract phosphorus from the environment, or how these processes work in degraded soils and in various crop types. It is conceivable that these fungi could be used to convert sewage, human and agricultural waste into valuable fertilizer. ●

### THE INPUT BOOM CONTINUES

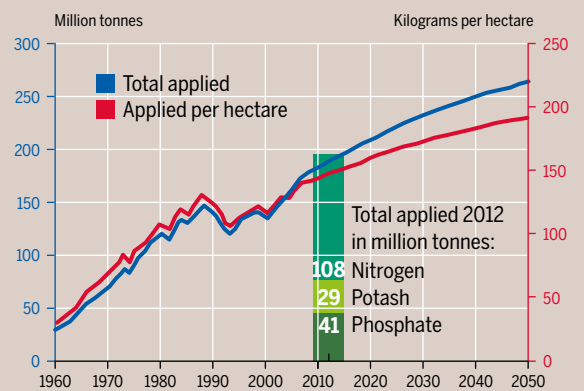
Use of mineral fertilizer, million tonnes



SOIL ATLAS 2015 / KOTSCHI

### STILL RISING

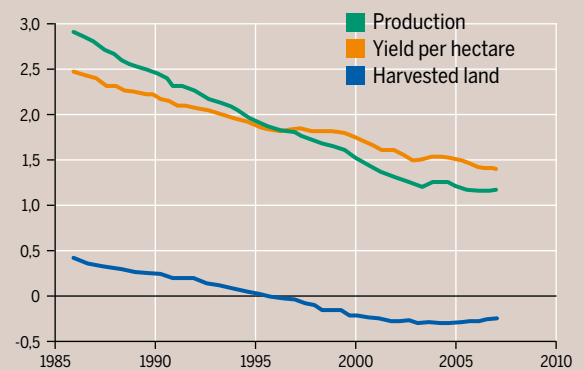
Quantity of fertilizer applied



SOIL ATLAS 2015 / ALEXANDRATOS ET AL., VARA

### THE LIMITS TO GROWTH

Annual global decline in growth, in percent



SOIL ATLAS 2015 / ALEXANDRATOS ET AL.

*The ever-increasing use of synthetic fertilizers, especially in Asia, brings little: global yields are still rising, but at a slower pace*

## MINERAL FERTILIZERS

# AN EMPTY PROMISE TO END GLOBAL HUNGER

Fertilizers are often seen as a vital means to increasing food production and crop yields worldwide. But the long-term damage they cause to the soil is often forgotten.

Never before in the short history of mineral fertilizers have they been used as often as today. Consumption has risen more than fivefold in the last 50 years, but it is unevenly distributed around the globe. China, the biggest consumer, uses an average of 344 kg of mineral fertilizer per hectare per year; it is followed by Brazil and Japan. In contrast, consumption is very low in most of Africa: just 2.7 kg per hectare in Rwanda, and 7.5 kg in Ghana. In Europe and the United States, consumption has declined in recent years. Soils in the developed world are generally oversupplied with the nutrients nitrogen, phosphorus and potassium. This is not just because of mineral fertilizers; the nutrients also come from animal dung, and especially liquid manure.

Of course, plants need sufficient nutrients to grow. But are mineral fertilizers necessary? That depends on what

nutrients, and in what form, they are needed to maintain the soil fertility, produce optimal yields and conserve the climate and environment. Worldwide, nitrogen accounts for 74 percent of mineral fertilizer use; in some countries it is as high as 90 percent. This has enormous negative effects on the environment: the most common nitrogen fertilizers, especially urea, are based on ammonia, a chemical that acidifies the soil. That in turn reduces the availability of phosphorus, another vital nutrient. Nitrogen also speeds the decomposition of humus, depriving soil organisms of their food.

Nitrogen is the only plant nutrient that is biologically renewable; it could therefore be produced in an environmentally friendly way. Growing legumes, which have symbiotic bacteria in their roots that fix nitrogen from the air, could make sufficient quantities of this nutrient available for other

*Future crops will rely even more on artificial nutrients to produce bigger yields*



*In Africa, governments spend a big share of their agricultural budgets on nutrient subsidies*

crops. That would not only secure food production but the fossil fuels needed to synthesize nitrogen fertilizer would no longer be required. Approximately one tonne of natural gas is needed to make one tonne of ammonia. The energy requirements are substantial. Replacing artificial nitrogen with legumes could reduce global energy consumption by 1.5 percent.

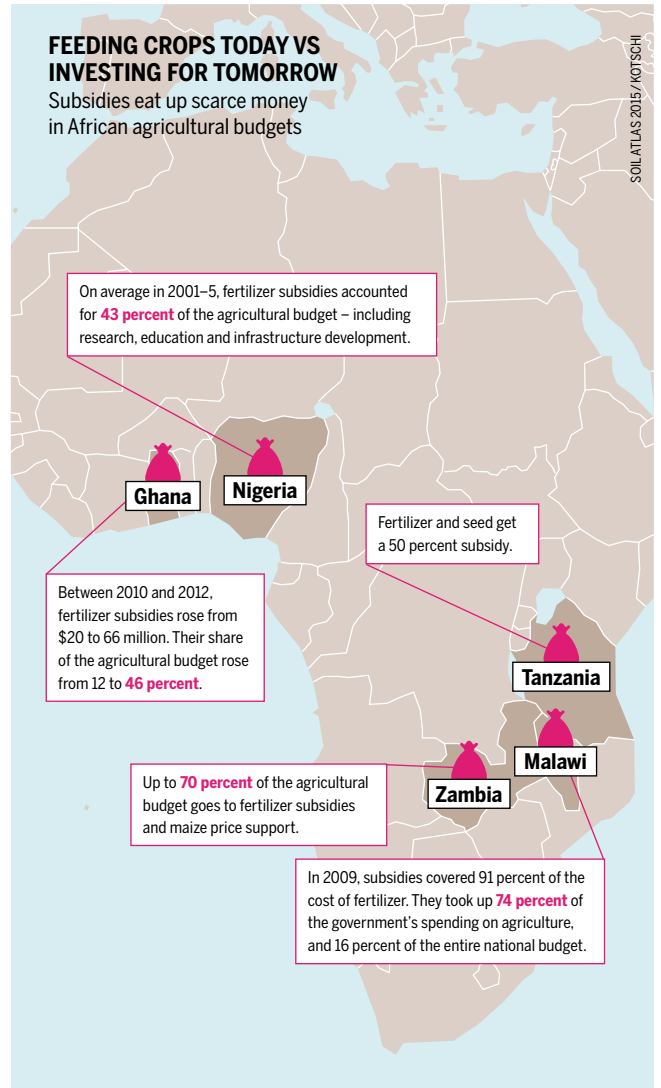
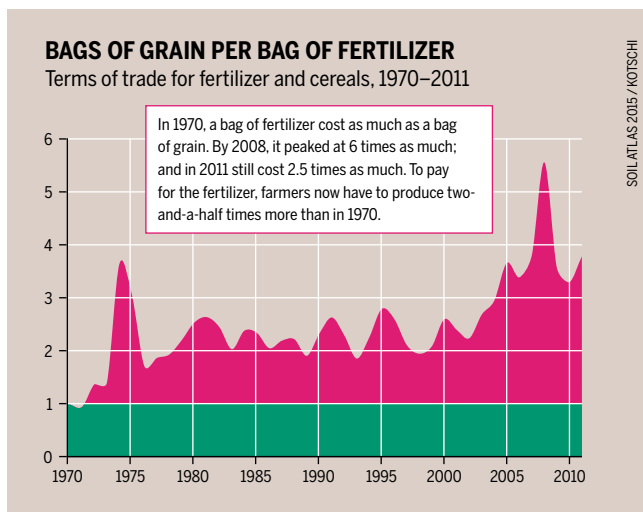
Even so, in developing countries synthetic nitrogen is increasingly subsidized to make it possible for small-scale farmers, who feed around 2.6 billion people, to increase their yield. But at best, such subsidies succeed only in the short term, and their effect is not permanent. At worst, fertilizers will eventually destroy the soil.

In addition, small-scale farmers tend to stop buying the fertilizers when they are no longer subsidized. The comparatively small extra yield does not make it profitable for these farmers if their costs go up – say, for energy or ever-scarcer resources such as phosphorus. So a strategy for agricultural intensification and food security based on mineral fertilizers is doomed to fail.

This has serious consequences for the economies of developing countries and food-deficit regions. Subsidizing mineral fertilizers is a poor investment. It yields low or negative interest rates, it is unsustainable, and it overburdens national budgets. In some African countries, subsidies account for 45 percent or more of government funding for agriculture. That money would be better invested in extension, education and infrastructure.

We cannot avoid using mineral fertilizers completely, but we have to use them in a different way. Here are four recommendations:

- Mineral fertilizer should complement organic manure. Improving soil fertility must aim first at building up the humus layer and enhancing the cycling of nutrients and energy. That can be done in various ways: applying animal manure or compost, using green manure or intensive fallows, or through agroforestry, including shrubs and trees in fields.



- Phosphorus is critically deficient in some places, and phosphate reserves are dwindling. New technologies have potential: for example the recycling of phosphate from sewage and less-wasteful mining of local deposits.
- We need an about-turn in how we use nitrogen. A complete switch from synthetic production to biological fixation is feasible – not overnight, but the change should begin as soon as possible.
- Strongly acidic soils need systematic liming. We should stop using fertilizers that cause acidification.

A shift towards sustainable intensification has to be a long-term process. Appropriate technologies must be developed and disseminated, and funded. Resistance can be expected. After all, these changes go against the economic interests of those who profit from the current system of using public money to fund mineral fertilizers – especially the few large, powerful fertilizer producers and distributors. But to make a meaningful contribution to food security, the production, trade and use of fertilizer must be completely re-oriented. ●

*The exchange relationship between artificial nutrients and food has continuously worsened over the years*

## THE FERTILIZER INDUSTRY

# PLANT FOOD IN A BAG, FIRMS WITH A COMMON CAUSE

**Producing and marketing nitrogen, phosphorus and potassium take a lot of investment, so the industry is dominated by big business.**

**A** 2009 report by the Food and Agriculture Organization of the United Nations predicted that the world would need 70% more food by 2050 to keep up with growing demand. That was powerful ammunition for those who want to raise output by intensifying agricultural production and using more genetically modified organisms, pesticides and mineral fertilizers.

In Africa, fertilizer use is very low – only 8 kg per hectare in 2006. A proposal to start a continent-wide fund to finance fertilizer production, distribution, procurement and use targeted an increase of an average 50 kg per hectare by 2015. The fund has not started operating yet, but individual countries have started their own support programmes. Today, some African countries spend more than half their agricultural budgets on fertilizer subsidies – although there are more efficient and sustainable ways of increasing food production and fighting hunger.

These subsidies are good news for a small group of fertilizer manufacturers that enjoy enormous bargaining power. The industry is highly concentrated. MarketLine, a consultancy, estimates that global fertilizer sales totalled 192 billion dollars in 2013; the world's 10 largest companies accounted for 35 percent of these sales. In all major fertilizer producing countries, except China, the top four firms control more than half the production capacity. In some countries, there is only one production company.

Large deposits of exploitable minerals are rare, and they are located in a handful of countries where businesses rely

on political patronage. Establishing a fertilizer plant requires sizable investments. Furthermore, enterprises often handle several steps in the chain: mining the raw materials, processing, manufacturing the finished products, trading and distribution.

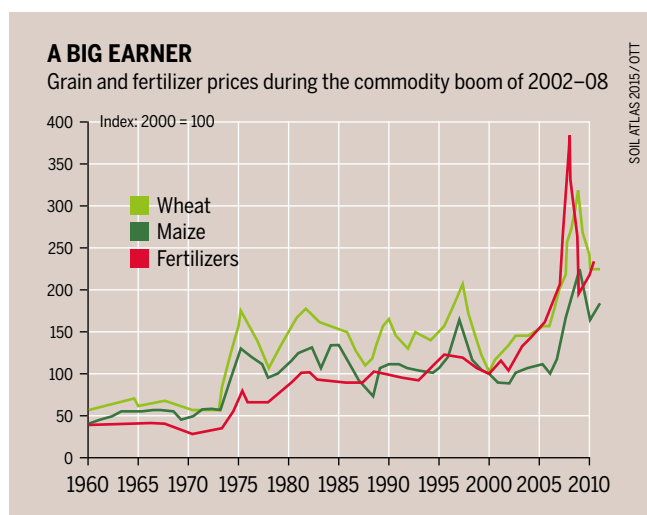
Such integration creates obstacles for market entry and competition. Firms exploit their market power; collusion is said to be common. The International Food Policy Research Institute found that during the food price crisis in 2007–8, prices for fertilizers spiked higher than oil or agricultural products. The leading fertilizer producers earned record profits in these years.

The industry has strong ties to related sectors. Mining is integral to potash and phosphate production, while energy firms supply the natural gas and electricity needed to produce nitrogen fertilizers. Whereas most of the major players in the mined fertilizer sector began as state-owned enterprises – as is true of other extractive industries such as petroleum and gas – today, full government ownership is rare. An exception is Belaruskali, which is fully owned by the government of Belarus, a major potash producer.

Consolidation is now the trend, despite the fact that individual companies are constantly buying or selling off regional assets, investing in other companies, launching joint ventures or refining (legal) cartel arrangements – a feature that has been common to the fertilizer industry for over a century. Canpotex is a distribution company jointly owned by the Saskatchewan-based industry. Its shareholders include Agrium, the world's largest fertilizer company, Mosaic (#3), and PotashCorp (#4). PotashCorp also owns between 14 and 32 percent of four other major fertilizer players, including Sinofert (#6) and ICL (#7). In 2014, ICL sold its phosphate mining and manufacturing business to Mosaic (#3) for 1.4 billion dollars.

Intrigue sometimes emerges from the sector's shadows, for example when a “potash war” broke out between Russia's Uralkali (#8) and Belaruskali, partners in a pricing cartel known as the Belarusian Potash Company. When Uralkali pulled out of the cartel in late July 2013, it accused Belaruskali of cutting side deals. A month later, Uralkali's CEO was arrested in Belarus, extradited to Moscow and put under house arrest. The break-up of this cartel resulted in potash prices plummeting by 30 percent.

Demand is now on the rise again, especially from large developing countries, and analysts are cautiously optimistic that prices will regain their former levels. The shock of the cartel's collapse was displaced by bigger news when

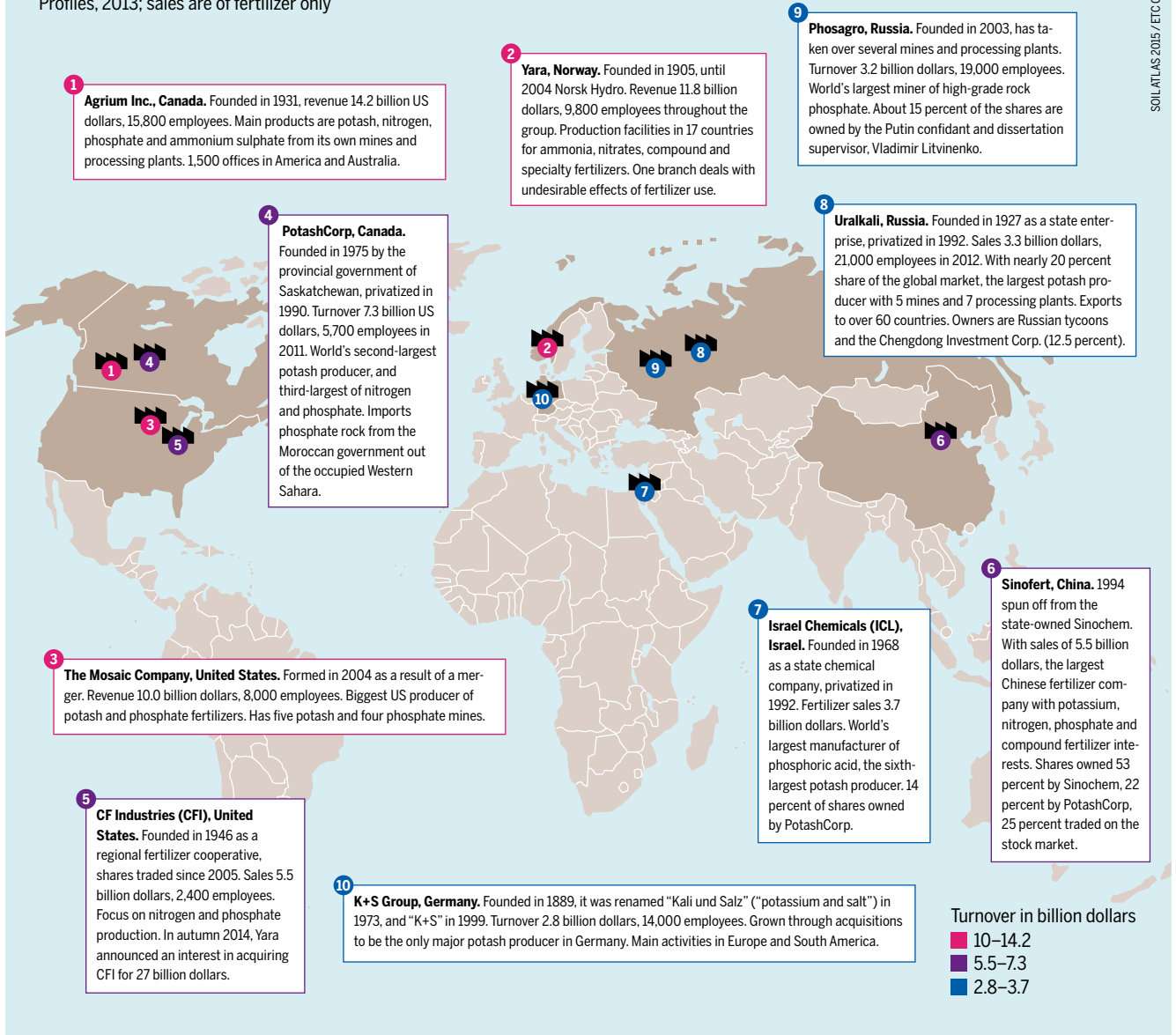


*Many observers think the explosion in fertilizer prices in 2008 was caused by speculation and collusion among producers*



## WORLD'S TOP 10 FERTILIZER COMPANIES

Profiles, 2013; sales are of fertilizer only



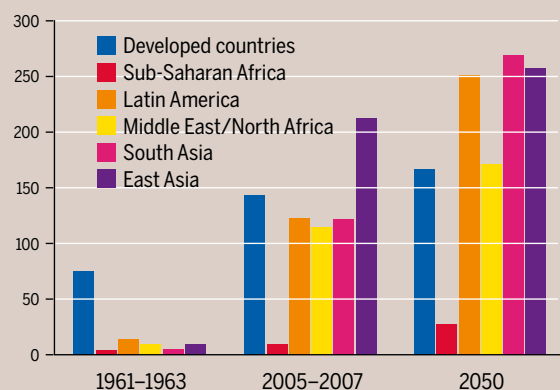
*Four of the top five fertilizer companies are North American. Mutual shareholdings and close government links are a feature of the industry*

Norway-based Yara International (#2) announced a possible "merger of equals" with US-based CF Industries (# 5) in September 2014. Access to cheap natural gas in the USA, especially thanks to hydraulic fracturing (i.e., fracking), translated into a 43 percent operating profit margin last year for CFI, more than five times greater than Yara's. But negotiations to form the world's largest nitrogen producer collapsed in October. Global fertilizer sales are expected to increase to nearly 230 billion dollars by the end of 2017. However, the number of firms that profit from these trends will not change. ●

*Producers want sales – and they like subsidies. African governments are paying for a problematic product*

## AFRICA: UNTAPPED OPPORTUNITIES FOR CORPORATIONS

Fertilizer use by region, kilogrammes per hectare



## FODDER CROPS

# FEEDING FACTORY FARMS

**Is industrial livestock production really an efficient way to produce meat and milk? The fodder needed to feed confined animals must be imported – and the manure has to go somewhere.**

**W**e are often told that by cramming huge numbers of animals into crowded sheds, industrial livestock production saves land. This ignores the huge areas of land needed to grow the cereals and soy that are used to feed industrially produced animals. About 33% of global croplands are used to produce feed for livestock: in the European Union the figure is even higher, with 60% of EU cereals being used to feed animals.

Feeding cereals to animals is inefficient. For every 100 calories that we feed to animals in the form of human-edible crops, we receive on average just 17–30 calories in the form of meat. Using arable land to produce feed crops for animals is wasteful; more people can be fed from a given area of arable land if it is used to grow crops for direct human consumption.

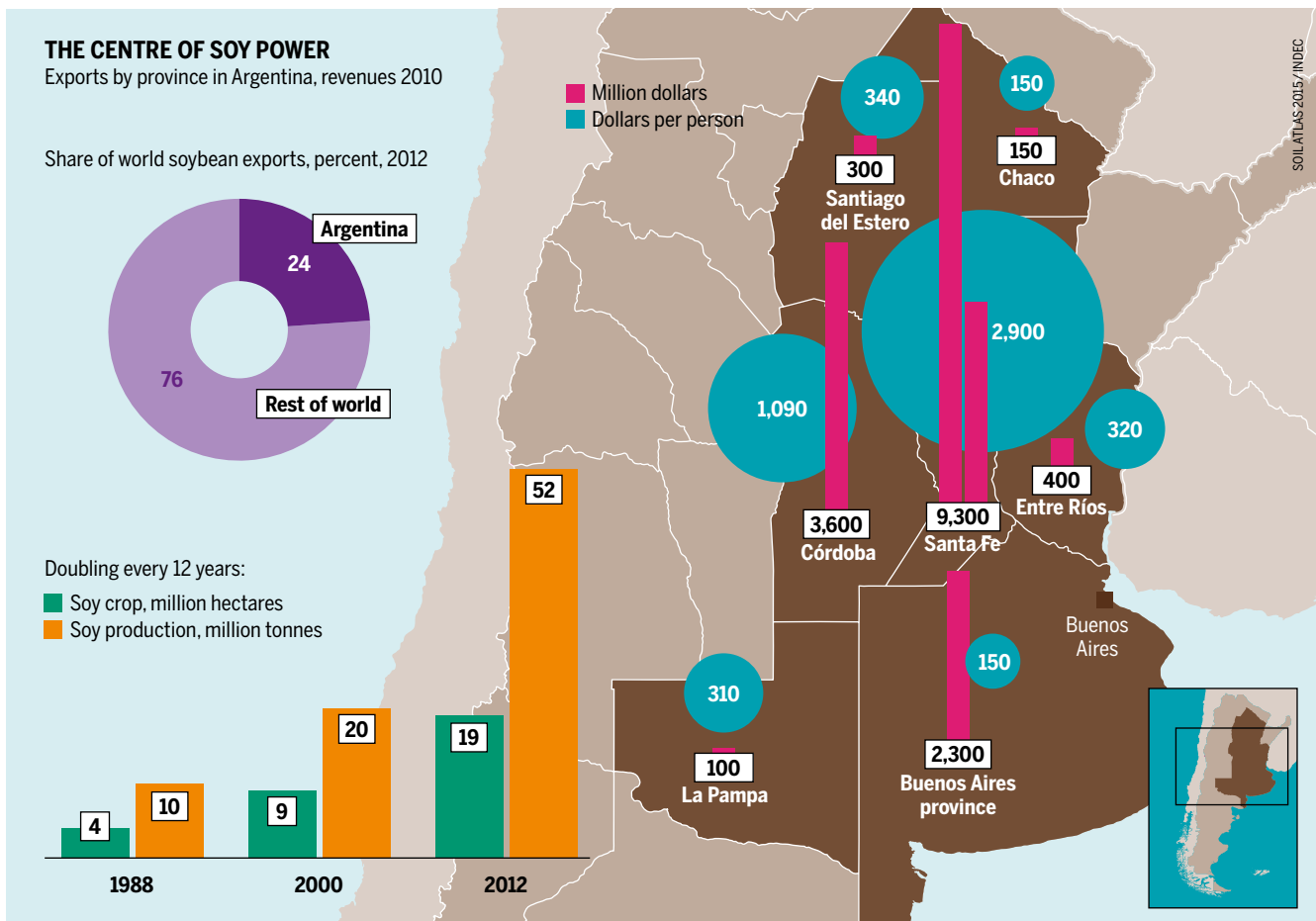
In contrast to this, animals make efficient use of land when they are raised:

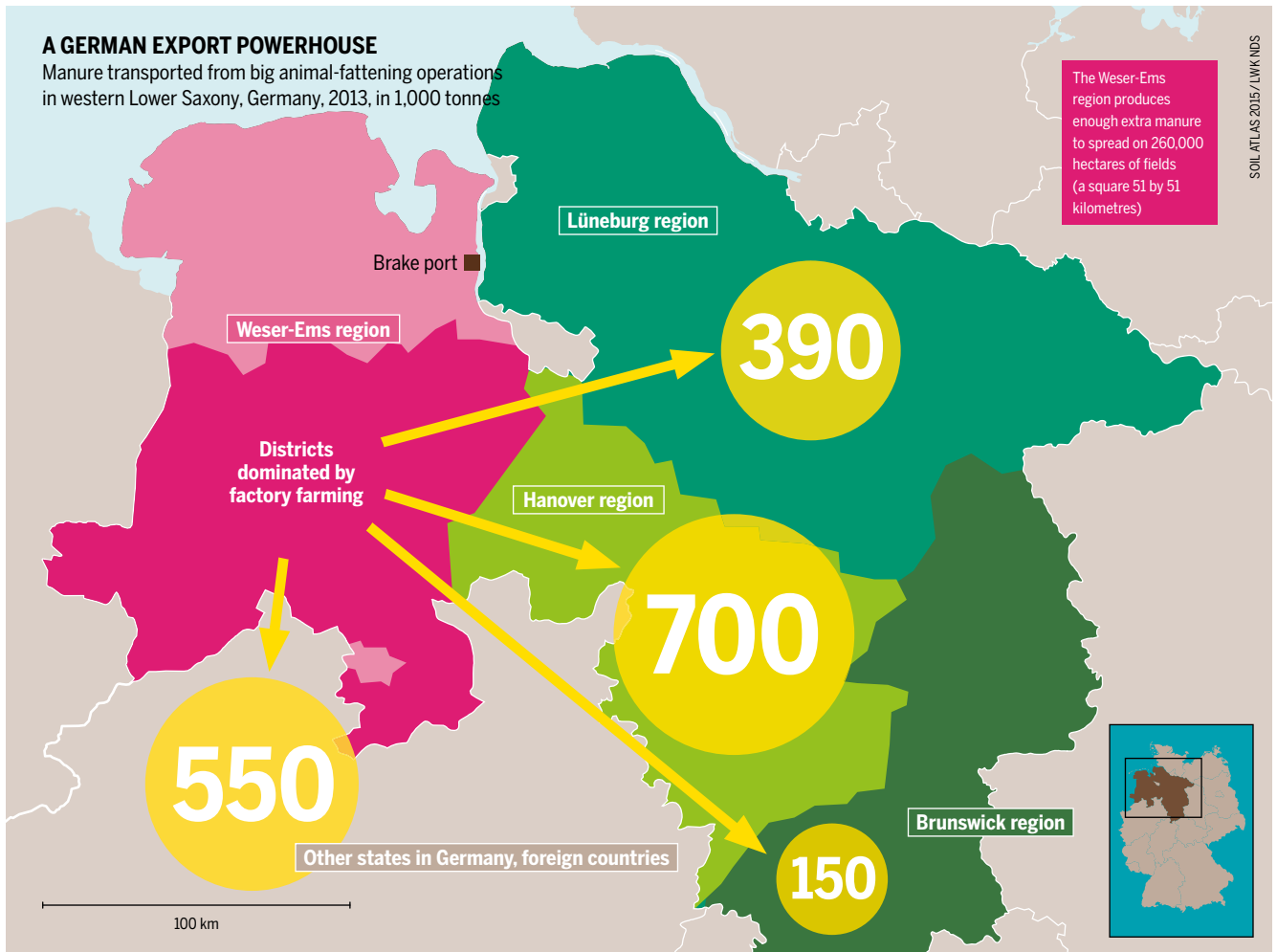
- On pastures, where they convert grass into food that we can eat and use land that is generally not suitable for other forms of food production.
- In integrated crop/livestock systems, where they are fed on crop residues – i.e., the part of the crop that people cannot eat.

The need to produce huge quantities of fodder has led to intensification of crop production. If demand for fodder crops were reduced, arable land could be farmed less intensively, with fewer monocultures, chemical fertilizers and pesticides. This would allow soil quality to be restored through use of rotations, legumes (plants that can take nitrogen from the air and add it to the soil), fallow periods and manure. This is a pressing challenge: 45% of European soils face problems of soil quality, as shown by low levels of organic matter.

Globally, if demand for crops to feed industrially farmed animals continues to rise, cropland will either have to expand, or it will be farmed more intensively, or both. Expan-

*In Argentina, fodder crops are replacing grazing land and forests – and pushing out pastoralists, livestock farmers and indigenous people*





sion of cropland is likely to be at the expense of grasslands and forests. Among the detrimental effects would be:

- Release of stored carbon into the atmosphere as land is cleared for cropland
- Loss of biodiversity
- Desertification as pastoralists are pushed into more marginal lands
- Erosion of indigenous livelihoods that accompanies deforestation.

In some parts of the world, in particular in sub-Saharan Africa, crop yields could be improved. In many areas, however, further intensification would probably be damaging as it could undermine biodiversity and increase pesticide use. Heavy machinery would compact the soil, impeding plant growth. Intensification could also mean more irrigation, which in the medium term leads to salinization and reduces soil fertility. Expansion and intensification of crop production can best be avoided by reducing the use of human-edible crops as animal feed, and instead feeding animals on pasture and crop residues.

Enormous quantities of soy are used in industrial livestock production. Over 90% of the world's soymeal is destined for industrial livestock. Soy cultivation has been a major driver of deforestation in South America. In Argentina the spraying of the soy plantations with pesticides and herbicides is associated with increased rates of respiratory problems, birth defects and miscarriages. Argentina used to be famed for its cattle roaming over vast plains. These plains

*The port of Brake on the River Weser was built to handle soy imports. Factory farmers in Lower Saxony get their fodder there*

are increasingly being ploughed up for soy production, and the cattle are crammed into barren feedlots where they are fattened on cereal-based diets.

Huge volumes of water are used in industrial livestock production, not as drinking water but to grow fodder crops. Industrially produced meat, milk and eggs generally require, and pollute, more water than the same products from grazing or mixed systems.

Although nutrient inputs are needed to grow crops, nutrient loss is a major source of pollution. Excess reactive nitrogen in the environment damages the soil, water and air. The largest use of reactive nitrogen in Europe is to make fertilizers used to grow fodder crops for animals. When the fertilizers are applied to a field, much of the nitrogen is not actually taken up by the crop roots. And when the fodder is fed to livestock, the animals do not assimilate all of the nitrogen it contains; they excrete it in their urine and dung. Spreading the manure on fields adds yet more nitrogen to the soil.

The unabsorbed nitrogen pollutes the environment; it is washed into rivers and leaches from the soil into groundwater, contaminating sources of drinking water. Across the world, in China, the Gulf of Mexico, Brittany and Chesapeake Bay, industrial pig and poultry farming is damaging aquatic and marine ecosystems. ●

## CLIMATE

# THE GIVE AND TAKE OF AIR AND EARTH

**Climate and soil influence each other in many ways: the climate helps form the soil, and the soil in turn affects the composition of the atmosphere – in particular the amount of carbon dioxide and other greenhouse gases.**

**C**limate, an active factor of soil formation, is intricately linked with soil and its attributes. At any point in time, soils are in a dynamic equilibrium with the climate.

Take a spade and dig a pit in the ground, about 50 cm deep. Smooth the pit walls and you will see a series of layers: probably black at the top, but then fading into brown or grey, perhaps with bands of black or red.

The layers are called “horizons” and they are characteristic for particular climates. The coniferous forests that stretch across northern latitudes have a typical grey band that looks like ash; they are called “podzols”. Many humid tropical soils are red or yellow because of the iron and aluminium they contain; they are called “ferralsols”.

The layers are caused by the climate. Rain dissolves certain minerals and salts, and leaches them downwards. Evaporation and capillary action bring them upwards again, depositing them in distinctive layers, or even on the surface. Fine particles may accumulate at a particular depth, forming a hardpan. Water and acid gnaw at the rock below, breaking it up and forming new soil. The interplay of climate, this parent material and the topography, as well as human activities such as ploughing and irrigation, produce soils that are sandy, silty or clay-like, acid or alkaline, water-logged or well-drained, fertile or infertile.

The climate also influences the soil through the vegetation that grows on it and the animals and microorganisms that live in it. Plant roots and fungal mycelia bind the soil and extract water and nutrients; earthworms, moles and insects dig and burrow. When they die, plants decompose into humus – the black layer near the surface of many soils. This organic matter is vital for soil fertility; it binds soil particles together and traps water and nutrients where roots can find them.

A lack of vegetation – after ploughing, for example, or in drier areas – leaves the soil exposed to the elements. Raindrops break up clods and wash particles away. Heavy rain pounding the surface can form crusts, which prevent water from sinking in quickly. The runoff carries precious topsoil with it, turns rivers brown and silts up reservoirs. During dry periods, the wind can whip up dust and sand, blowing it hundreds of kilometres.

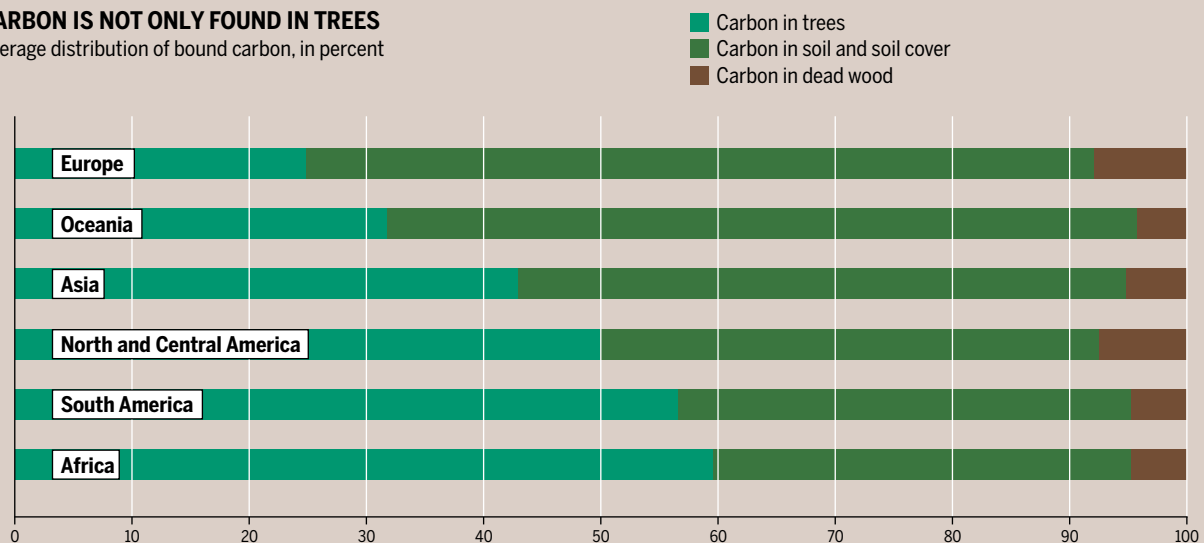
So the climate affects the soil – but the soil also influences the climate. Carbon dioxide and other greenhouse gases are especially important. The soil is a huge carbon sink; it contains more carbon than the atmosphere and all terrestrial vegetation combined. Relatively small changes in the amount of organic matter in the soil can have a major effect on the atmosphere – and on global warming.

Croplands, which cover about 1,500 million hectares worldwide, tend to have less organic matter than

*In Europe more carbon is stored in the soil than in the vegetation – the opposite is true in Africa*

### CARBON IS NOT ONLY FOUND IN TREES

Average distribution of bound carbon, in percent

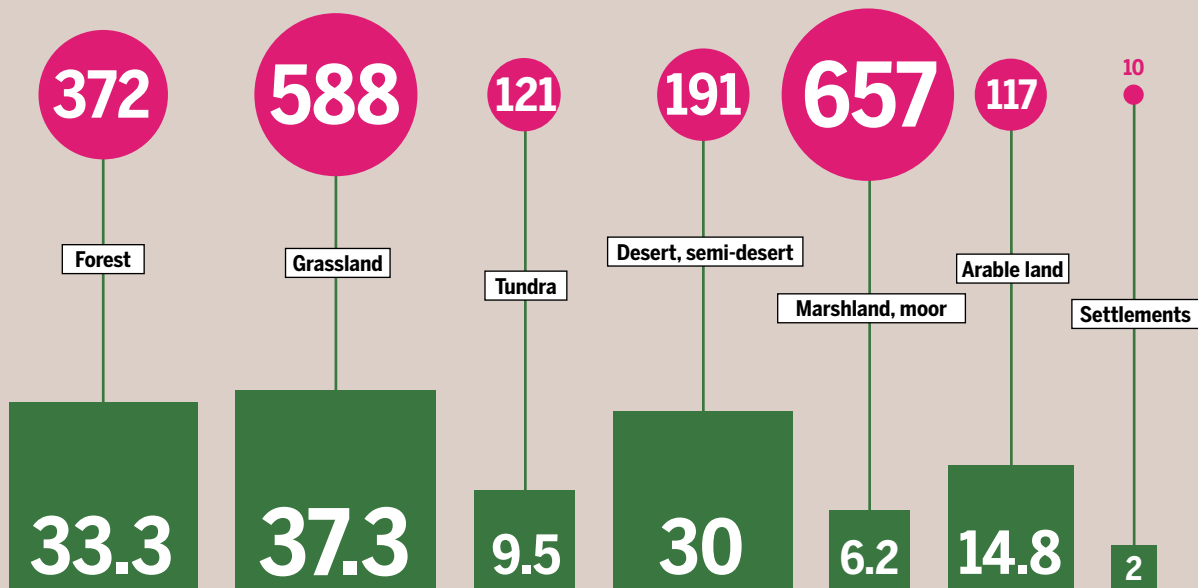


SOIL ATLAS 2015 / FAO

## MOORS ARE THE MOST IMPORTANT

Stored carbon by ecosystem, in million km<sup>2</sup> and billion tonnes

● Amount ■ Area



SOIL ATLAS 2015/EC

neighbouring soils under natural vegetation. Ploughing arable land and harvesting crops accelerate the release of carbon dioxide back into the atmosphere. Growing paddy rice releases methane, a greenhouse gas that is 25 times more potent than carbon dioxide. Applying nitrogen fertilizer results in emissions of nitrous oxide, 310 times more potent. Improved management can put carbon back into the soil; techniques include reduced ploughing, preventing erosion, planting cover crops, and applying compost and manure.

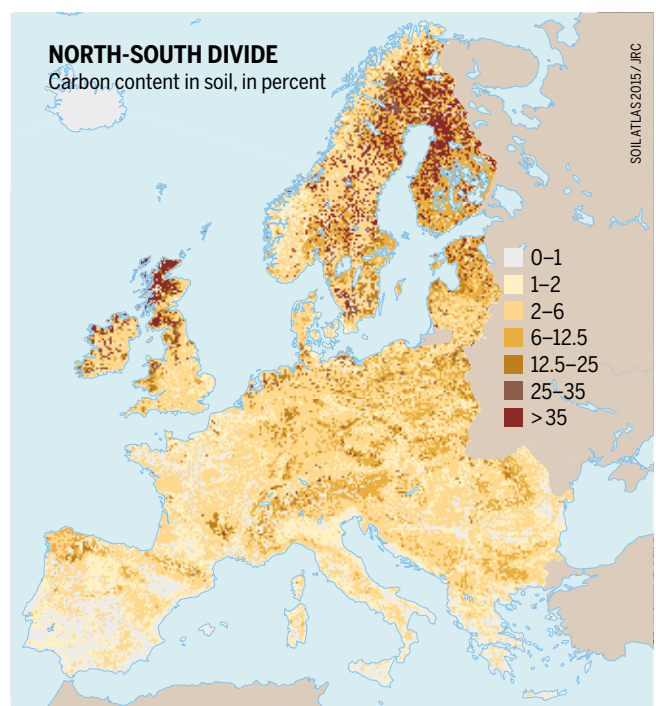
Grazing lands cover about 3,500 million hectares around the world. Cattle and other ruminants are a major source of greenhouse gases: burping, flatulence and manure emit both methane and nitrous oxide. Grazing lands in dry areas can absorb relatively little carbon per hectare. But they cover vast areas and so collectively can absorb large quantities of carbon if they are managed well – for example by controlled grazing, preventing fires, planting trees, conserving soil and water, restoring eroded and saline land, and rehabilitating wetlands.

Forests cover about 4 billion hectares globally. The soils that support tropical rainforests are surprisingly infertile; rain quickly washes soil nutrients away. Most of the plant nutrients and carbon in rainforests are contained in the vegetation itself. When organisms die, they decompose rapidly in the hot, wet climate, and the nutrients are recycled into new plants. Cutting or burning the trees releases large amounts of carbon into the atmosphere. The soils beneath the vast boreal forests of North America, Scandinavia and northern

*Conserving and restoring moors and marshland is especially worthwhile. But no ecosystem should be neglected*

Russia, on the other hand, contain large amounts of carbon, especially in peat bogs.

With the right management, soil has the potential to absorb large amounts of carbon, and so combat global warming. Restoring the soil's ability to lock away carbon is an important way to reduce the impact of climate change. ●



SOIL ATLAS 2015/JRC

*Europe emits more greenhouse gases than it stores. The quality of its soils is declining. The less the soil lives, the less carbon it can store*

## ENERGY

# DIGGING FOR FUELS

**Can alternative fuels save the planet? Some, such as tar sands, are obviously dirty. But growing biofuels takes lots of land, and they may not be as climate-neutral as once hoped.**

**S**oils, and the rocks beneath them, harbour much energy. Biomass grows above; fossil fuels and geothermal reserves lie below; solar and wind farms are built on the surface. Worldwide, the rising demand for energy means that larger areas of land are needed to generate it. In the last 20 years, classical fossil fuels such as coal, oil and gas have been joined by tar sands, shale gas and biofuels.

In Canada, tar sands cover 15 million hectares, an area larger than England's 13 million hectares. In 2012, they produced 1.9 million barrels of oil per day – a significant proportion of the world's daily consumption of 90 million barrels. But extracting the oil requires a lot of land, energy and water, and results in widespread environmental destruction. The sands lie an average of 30 metres below the surface; to reach them, forests must be cleared and topsoil removed. Separating the oil from the sand produces four times more greenhouse gases than the refinement of conventional petroleum. Producing a barrel (159 litres) of oil creates 636 litres of toxic wastewater. The mined area ends up looking like a lunar landscape; its ecosystem utterly destroyed.

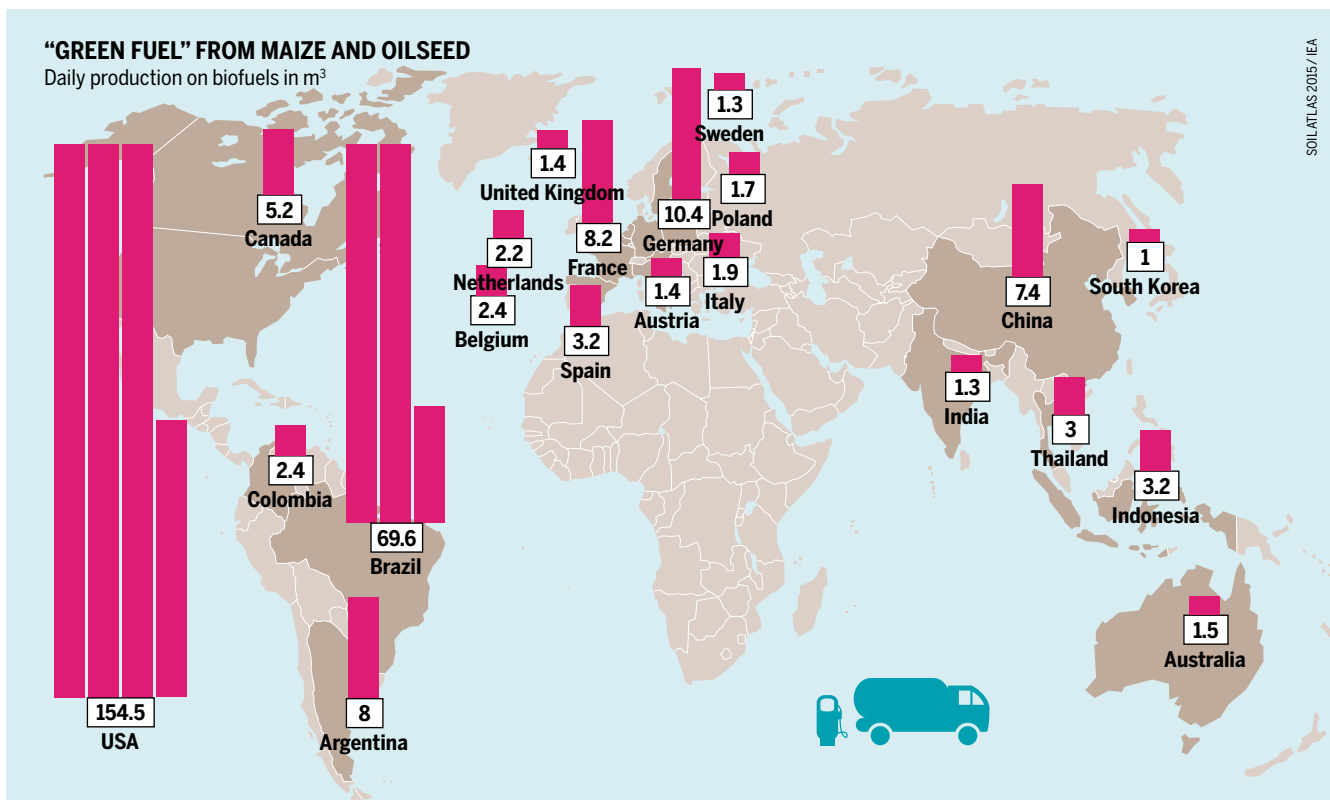
By 2010, oil shale accounted for 20 percent of the gas production in the United States. By 2035, it is forecast to reach

46 percent. One-tenth of the surface area of the United States may be suited for fracking. The land is scarred by production facilities, petrochemical infrastructure and pollution; the ground is left contaminated because the chemicals injected into the rocks do not degrade.

Conventional sources of energy also harm the soil; 40 percent of Germany's open-cast lignite mines are flooded and are only of interest to water sports enthusiasts. Efforts to reclaim the mined-over land usually fail because of the costs; the original ecosystem and soil quality cannot usually be restored.

Renewable sources of energy such as biofuels, receive a lot of political support. They supposedly mitigate climate change and reduce dependency on non-renewable resources. A European Union directive requires that by 2020, at least 10 percent of transport fuels must come from renewable sources. A renewable energy law in Germany supports the use of biomass and biogas to produce heat and electricity. The necessary biomass comes from energy-rich crops such as maize and rape. But in terms of the land used, these biofuel crops are an inefficient way of saving the climate. Compared to wind farms or solar panels, they harvest only one-tenth of the energy per square metre.

*Field crops produce almost 300 million cubic metres of biofuels a day. At the same time, almost 800 million people go hungry*



## GROUND GOBBLERS AND JUICE PRODUCERS

Alternative energy sources and renewable fuels compared

■ Square metres needed to light a 20 W lightbulb for a year

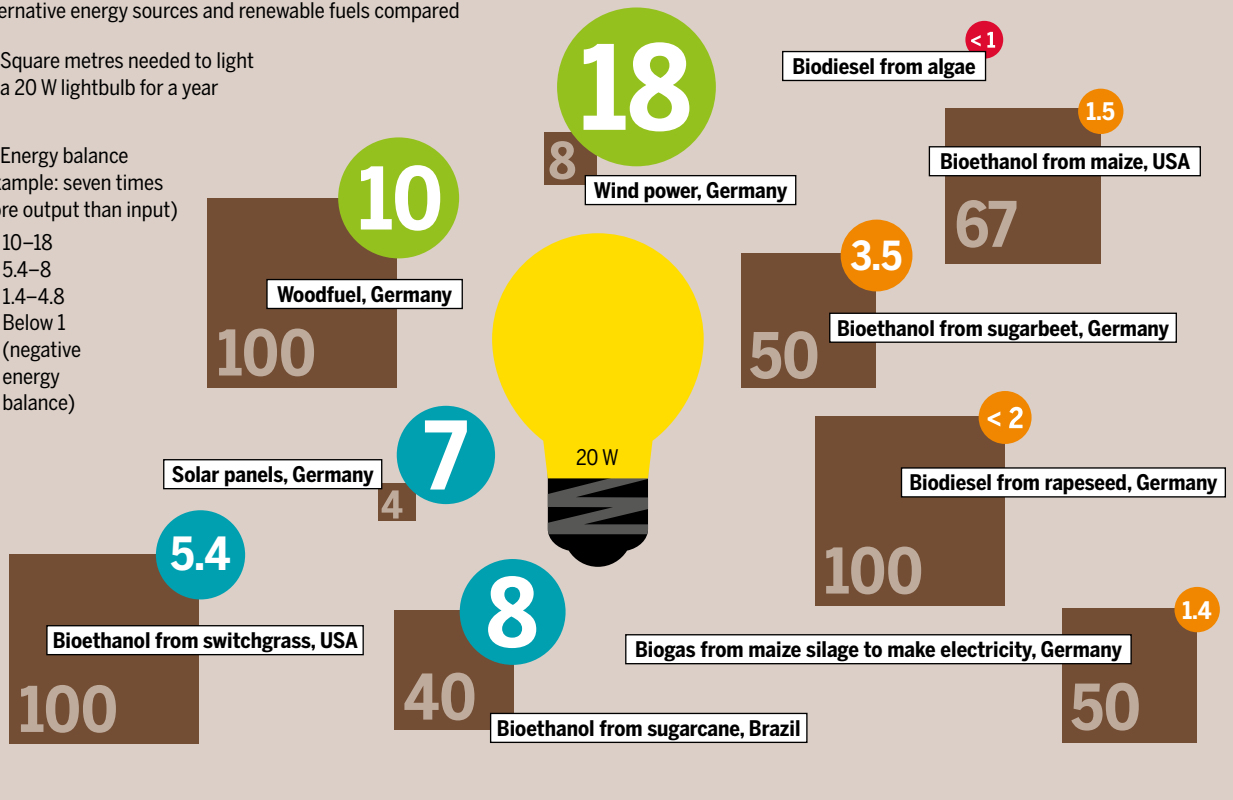
⑦ Energy balance (Example: seven times more output than input)

● 10–18

● 5.4–8

● 1.4–4.8

● Below 1 (negative energy balance)



SOIL ATLAS 2015 / LEOPOLDINA

At first sight, using biomass for energy appears climate-neutral; the crops pull carbon dioxide from the atmosphere by photosynthesis, and the same amount of greenhouse gas is released when the biomass is converted to energy. But this ignores three issues:

- Additional energy is needed to produce the biomass – for growth, harvesting, processing and transport. Applying manure as a fertilizer releases lots of methane, a greenhouse gas 25 times more potent than carbon dioxide. Using synthetic nitrogen fertilizer releases nitrous oxide, with 300 times the potency. These emissions must be counted against the biomass when comparing the energy budgets of different sources.
- Biofuel production generally replaces some other type of land use. Converting land can generate new emissions, for example when woodland is cleared or pastureland is ploughed. It is not yet clear how much extra greenhouse gas this produces.
- Biofuels also affect biodiversity, water resources and soil quality. These areas have not yet been adequately researched. Throughout the world, monocultures are spreading and new, environmentally damaging trade flows are arising – for wood pellets, biodiesel and ethanol. Where the crops are grown, biodiversity suffers while the use of water and agrochemicals rises. Land used to grow biofuels cannot be used to grow food. This poses an ethical dilemma while 800 million people continue to go hungry.

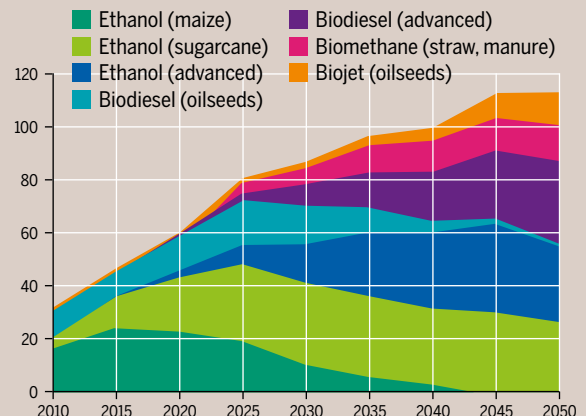
*In 30 years, the area needed to grow biofuels will more than double. Novel sources will become more important than maize and sugarcane – today's biggest burners*

*Regardless of the criteria used, bioenergy is an inefficient way to produce power*

It is possible to use biomass in a way that makes sense in terms of energy – if crop residues and waste are used. Because of the number of people who still go hungry, the Food and Agriculture Organization of the United Nations (FAO) and the World Bank recommend that government support for biofuel crops be stopped. Support for the production of biomass as a source of energy entails perverse incentives. It should therefore be radically changed to avoid further social and ecological harm. ●

## FUTURE DEMAND

Land for biofuels, in million hectares



SOIL ATLAS 2015 / EIA

## MINING

# ADDING UP THE COSTS OF A HOLE IN THE GROUND

Less than one percent of the world's land is used for mineral extraction – a tiny amount compared to agriculture. But mining has a disproportionate effect on the environment.

With a rising demand for metals, minerals and fossil fuels the mining sector is booming. This involves big changes for the landscape and for nature. In the last 10 years, the output of iron ore has gone up by 180 percent, cobalt by 165 percent, and coal by 44 percent. China's mining sector grew by one third between 2005 and 2010 alone.

In the United States, one person consumes 17 tonnes of metal, minerals and fossil fuels per year – that makes 1,343 tonnes in a lifetime. For every tonne of ore, 3 tonnes of soil

and rock have to be removed. Refining the ore produces toxic waste. Current high commodity prices make it profitable to operate, or to reactivate, mines with low ore content. The global commodity boom has effects that cannot be ignored.

Opening a new mine involves clearing large areas of land: for the mine itself, spoil-heaps and tailings, infrastructure such as road and rail connections, processing facilities and workers' accommodation. Extraction is increasingly taking place in ecologically sensitive or virgin areas such as the Arctic and the rainforests of Latin America and Central Africa. In countries with insecure land titles, mining may result in the eviction of local inhabitants. According to John Ruggie, the United Nations Special Representative for Business and Human Rights, more complaints are made about the mining and oil sector than any other branch of the economy.

Open-cast mining is of particular concern because it claims vast expanses of land. Some 300 hectares of forest are destroyed every year at the Rio Trombetas bauxite mine in Brazil. In Canada, tar-sand extraction has wrecked 15 million hectares; this area cannot be put to any other use for decades to come. In Colombia, Cerejon is the largest coal mine in the world: it covers an area of 690 square kilometres, bigger than Chicago in the United States or Merseyside in the UK, and almost the size of Hamburg in Germany.

Mining can irreversibly change the landscape. The most extreme form is known as "mountaintop removal". In the Appalachians, in the eastern USA, the "overburden" is blasted away to expose the underlying seams. The loose rock is removed by huge excavators and dumped in nearby valleys. Between 1970 and 2008, more than 500 summits lost up to 350 metres in height in this way. Over 5,700 square kilometres of land have so far been transformed.

Shifting rock around on a large scale ruins cultivable land. At a large open-cast coal mine in Jharkhand, India, the topsoil was removed so it could be replaced later when the site was restored. But a study found that it had lost its fertility after 6 years in storage. The work of microorganisms had been disrupted; wind erosion and leaching dominated. Restoring soil fertility when a mine closes is one of the largest problems open-cast mining faces worldwide.

A fall in the water table that usually accompanies mining has negative consequences for the surrounding soils and farms. In the Lausitz, a lignite-producing area in eastern Germany, the water table has sunk by 50–100 metres. The farmland and nature reserves around the open pits have to be watered from deep boreholes. In the Ruhr, a densely pop-



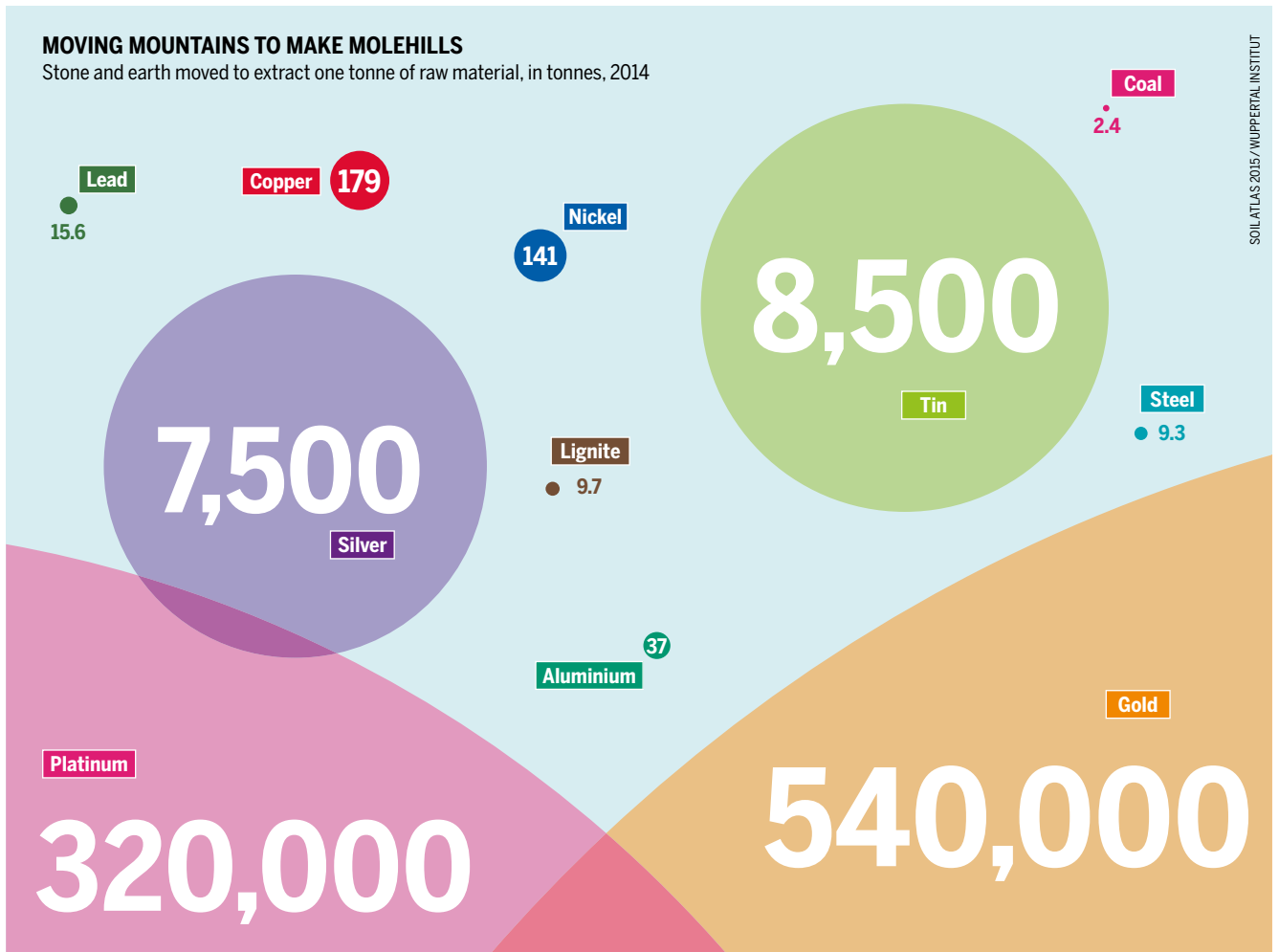
*Miners often come into conflict with local people, who see their lives disrupted and their livelihoods disappear*



## MOVING MOUNTAINS TO MAKE MOLEHILLS

Stone and earth moved to extract one tonne of raw material, in tonnes, 2014

SOIL ATLAS 2015 / WUPPERTAL INSTITUT



*Getting at raw materials means moving lots of rock – especially for the metals needed to make electronic devices*

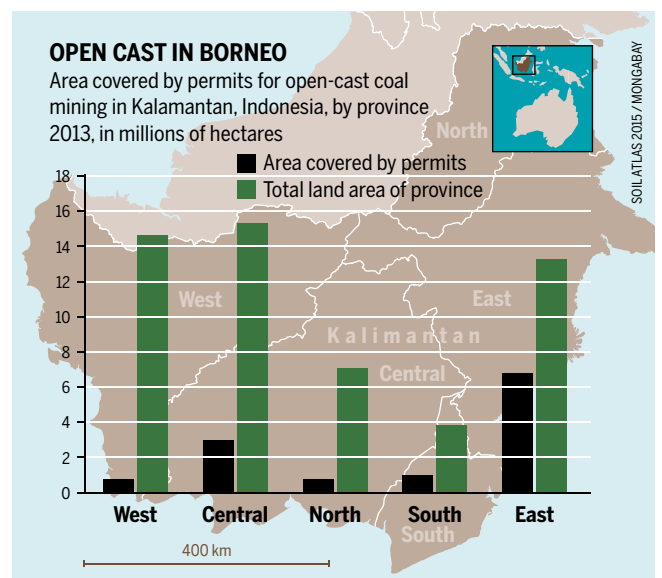
ulated former coal-mining area in western Germany, the water table has to be kept artificially low to prevent the area from being transformed into a network of lakes. Such pumping is a long-term cost that must be borne long after the end of mining.

To extract the raw material from its parent rock, the ore is treated with chemicals: sulphuric acid to extract copper, cyanide for gold, and sodium hydroxide for aluminium. The resulting toxic waste usually ends up in storage reservoirs which can be huge. The Kidd Creek mine, in Ontario, Canada, is one of the world's largest metal mines; silver, copper, cadmium, indium and zinc have been mined there since 1966. When it closes in 2023, some 130 million tonnes of mostly toxic tailings will remain. Legally, the mining companies are responsible for dealing with the waste. But they often close or go bankrupt when extraction ends, leaving the cleanup to governments and taxpayers.

A leak in a tailings reservoir may result in the contamination of the surrounding soil and water. In the worst case, the

*Digging up coal is a booming business in Indonesia. Mining concessions cover huge areas of land*

reservoir overflows or a dyke breaks. That happened in 2000, after several days of heavy rain near Baia Mare in Romania. Some 100,000 cubic metres of water and sludge containing cyanide and heavy metals flowed into the River Tisza. From there it poured into the Danube, killing fish and polluting floodplains and farmland downstream. The long-term costs of this environmental disaster had to be borne by nature and by the people affected. ●



## URBANIZATION

# FLOCKING TOGETHER: LIVING IN A CROWD

**Humans are a gregarious species. As more and more of us move into cities, we are paving over big chunks of the planet.**

In 2007, for the first time ever, more people lived in cities than in the countryside. By 2014, 54 percent of the world's population was urban; by 2050, two-thirds of us will be. Ancient cities were fairly small in modern terms; even Rome, the biggest city of antiquity, had only about 1 million people in 1 AD – about the size of present-day Birmingham in the UK or Cologne in Germany. Most people lived in the countryside and produced their own food.

Improvements in farming and the industrial revolution in northwestern Europe in the late 18th century led to the first great wave of urbanization. By 1825, London, with 1,335,000 inhabitants, had overtaken Beijing as the world's largest city. Just 75 years later, in 1900, London had nearly quintupled in size, with 6,500,000 residents.

The developed world is heavily urban: 90 percent of the population of Japan live in cities. In Australia and New Zealand 88 percent of the population is urban; in Canada and the United States the figure is 80 percent; and in Europe, 73 percent. The population growth rate in these regions is fairly stable, i.e., slow or declining, and their cities continue to grow at a relatively slow rate.

The pace of urbanization is much faster in the developing world, where the rapid growth of cities began in the 1950s. Sizable numbers of people are now flocking into the cities; this second wave of urbanization is the largest movement of people in history. With 79 percent of the population in the cities, Latin America and the Caribbean are already heavily urbanized, while Africa (38 percent) and Asia (45 percent) are more rural. Several countries in East and West

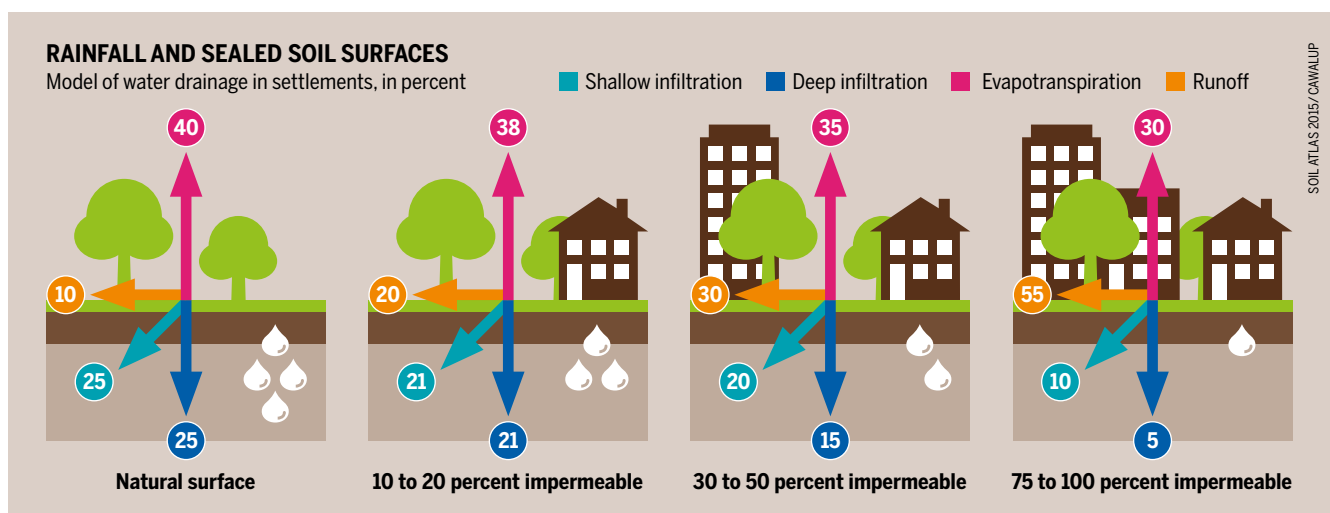
Africa, including Burundi, Uganda, Ethiopia, Niger and South Sudan are less than 20 percent urban. More than four out of five people in Papua New Guinea, Nepal and Sri Lanka live in rural areas.

The world's urban population is not evenly distributed. Just a few countries, including China and India, are home to more than half of the world's city dwellers. However, most urban residents do not live in the so-called megacities of over 10 million people, but dwell in smaller centres. If the entire global population lived in one city as densely populated as Paris, the built-up area would be only the size of England.

Urbanization poses many social and economic challenges: poverty, slums, overcrowding, pollution, clogged transport, unemployment, crime and violence, to name a few. It is also an environmental issue. Growing cities expand into prime agricultural land – after all, many cities were founded in places where fertile soils enabled farms to produce a surplus. This threatens future food security. The spreading city covers the ground with concrete and asphalt, stopping rainwater from sinking in and causing floods. It wrecks biodiversity, and stops the soil from absorbing carbon. It takes thousands of years for soil to form, but only minutes to destroy. Globally, urbanization causes the loss of 2 hectares of soil per minute.

In Europe, the amount of land “sealed” by concrete and asphalt depends largely on economic growth. Between 1990 and 2006, the sealed area increased by 8.8%, and in 2006, 2.3% of Europe's land surface was covered by artificial surfaces of one type or another. In Germany, the figure is 5 per-

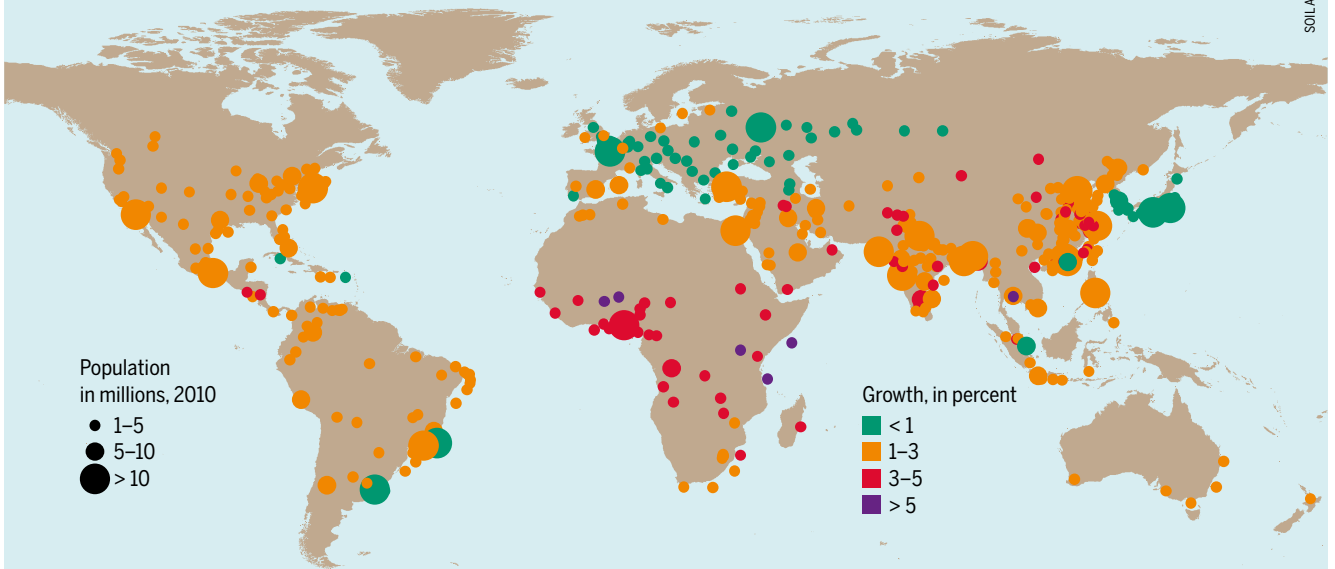
*Climate change increases the risk of floods. Preventing them is a major challenge for urban planners*



## SMALLER CITIES ARE GROWING TOO

Predicted demographic trends

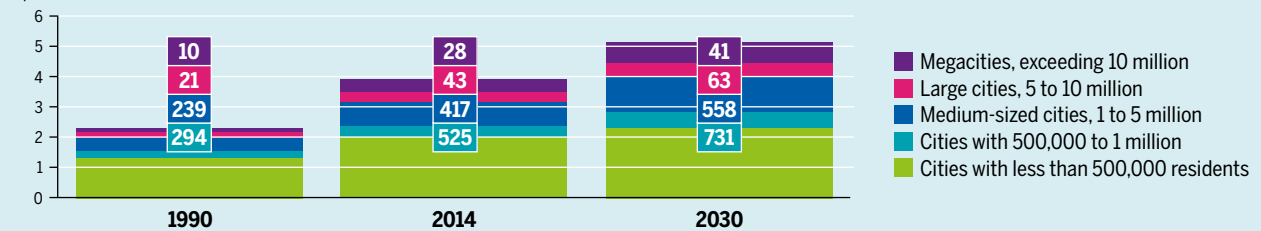
City size and average annual population growth, in percent, 2010–2025



SOIL ATLAS 2015 / BSD, UN

Number of cities in each size category and their total population, 1990–2030

Population, in billion



cent, and the country is still converting another 77 hectares a day – larger than 100 football pitches – for transportation purposes and residential use. European governments are trying to reduce the amount of concrete used, but Germany is unlikely to reduce its land conversion rate to the targeted 30 hectares per day by 2020.

It should be possible to reduce the amount of soil lost when cities are designed. Greener cities would be denser and more compact; commercial areas would be scattered throughout the city, rather than spread out on the edges. This would avoid paving over large areas, shorten transport distances, make way for open landscapes and gardens, and result in a smaller ecological footprint.

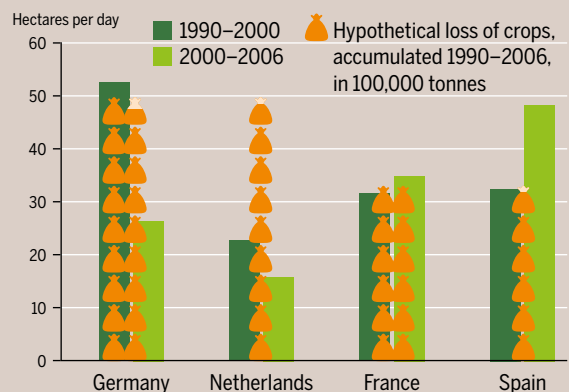
The uses of land in natural, agricultural and urban areas differ greatly. However, their soils share many features in terms of biodiversity and ecosystem services. The decision-making trade-offs may be surprisingly similar. In urban areas it may be possible to apply the same sustainable management measures, such as a rational spatial arrangement, that are designed for agricultural landscapes. ●

*Hectare by hectare – urban growth eats up the fields that used to provide the cities with food*

*Urban populations are growing fast – especially in Africa and Asia – and city areas are expanding even faster*

## LAND LOSS IN THE EU

Reduction of arable area and crop production in selected countries



SOIL ATLAS 2015 / EC

## HOT SPOTS

# STRUGGLE AND STRIFE

### THE IMPACT OF EBOLA

The ebola epidemic has cut agricultural production in West Africa dramatically. In Guinea, coffee output has fallen by 54 percent, cacao by 35 percent, and palm oil by 75 percent because the plantation workers have fled. Border closures and quarantine measures hinder trade and interrupt supply chains. In 2014 half a million people were suffering from food shortages. The decline in food production has been fairly limited on a national scale, but is high in those areas hit by the disease.

### PEACE LEADS TO MORE CONFLICT

In Colombia, the war between the government, paramilitaries, guerrillas and drug gangs has led to many people being evicted forcibly from their land – especially indigenous people, Afro-Colombians and peasant communities. A law passed in 2012 envisaged that some of the millions of hectares that changed hands illegally will be returned. It was designed to be part of a peace process; in practice the usurpers who had established mines and plantations or built houses on the land just chased the rightful owners away again. Murder, rape and torture have also been reported.

Colombia

Brazil

### ACTIVISTS MURDERED

In Brazil it is dangerous to want to stay in your home. The Guarani-Kaiowá people have long been at the top of a list maintained by the Indian Missionary Council of the number of people murdered in the Amazon. In 2000 to 2013, one person from this group was murdered every 12 days, including 16 of its leaders. While the violence grows, around 50,000 Guarani-Kaiowá in the state of Mato Grosso do Sul wait in temporary camps for their land rights to be recognized.

Guinea

Ghana

### DISAPPOINTING FUEL CROP

In the first decade of the millennium, the rising demand for biofuels led to the establishment of many oilseed plantations in Africa. In Ghana, 132,000 hectares were turned over to jatropha cultivation. But the plants need more water than anticipated, and to cut their irrigation costs, farmers started growing it on better land where they used to grow food crops. Add social conflict to the mix: in Ghana, land rights do not belong to the individual farmers but to the clan chief. In several instances, the chief has sold the land to an investor without the farmers' knowledge. They defend their land how they can – with road blocks or weapons. Falling petroleum prices make jatropha cultivation unprofitable, and the jatropha has to be uprooted and replaced by other crops.

### LAND RIGHTS ABUSED

Cambodia is an attractive destination for foreign land investors. Since 2000, at least 2.1 million hectares have been transferred for large-scale commercial agricultural development, affecting between 400,000 and 700,000 people. Forced evictions, politically motivated prosecutions and a biased judiciary foster a culture of violence and impunity. The vast majority of ordinary Cambodians benefit little from the injection of foreign capital: the United Nations Special Rapporteur has questioned the impact of concessions on the country's long-term stability.

### THE DEVIL'S TREE

Well-meaning foresters have inadvertently created a thorny problem in East Africa's drylands. Introduced in the 1980s from its native South America as a way to produce fuelwood, *Prosopis juliflora* quickly became an invasive weed that herders call "the devil's tree". It grows quickly, outcompeting native species, and forms impenetrable thorny thickets that take over huge areas of rangeland and clog waterways. Livestock find the leaves unpalatable but eat the pods. The seeds are passed out with dung, helping spread the tree to new areas.

### A WAR CAUSED BY MINING

At 12,500 hectares, the copper, gold and silver Panguna mine on Bougainville, part of Papua New Guinea, was one of the largest open-cast mines in the world. The mine, which was operated against the wishes of the local population, caused enormous environmental damage, especially by discharging untreated waste water into the rivers and the sea. In 1989, a rebel movement sabotaged the mine, leading to its closure. The rebels turned into an effective armed independence movement in the 1990s. Lawsuits sought billions of dollars in damages from the mine operators, but failed. A referendum on independence for the island is supposed to be held before 2020.

Cambodia

South Sudan

Northern Kenya, Ethiopia

Tanzania

### HUNTERS VS HERDERS

Maasai pastoralists are fighting a move by the Tanzanian government to establish a 1,500 square kilometre wildlife corridor bordering the Serengeti national park, one of the country's main tourist attractions. The government wants to evict the 30,000 herders who live in the area, and displace tens of thousands of others who graze their cattle there in the dry season. It has leased the corridor to the Ortello Business Corporation, an Emirati company that flies in wealthy clients to hunt wildlife.

Bougainville,  
Papua New Guinea

### FLEEING THEIR FARMS

Escalating conflict between the government and rebels in South Sudan since 2013 has forced more than a million people to flee. They cannot cultivate their fields, and are now reliant on outside help. Flooding exacerbates the situation. Politicians of the Dinka and Nuer ethnic groups are fighting over power in this newly independent, oil-rich but politically weak state.

## LAND INVESTMENTS

# A NEW TYPE OF TERRITORIAL EXPANSION

As foreigners snap up farmland around the world, it is hard to know who is investing in what, and what the effects on local people might be. An international database is throwing light on the murk.

Climate change, growing populations, changing consumption patterns, and rising demand for energy from renewable sources affect the demand for land. The scarcity of farmland is a problem in countries with fast-growing populations, such as Ethiopia. Rising land prices make it impossible for would-be farmers in France, Germany and the United States to rent or buy. With interest rates low and demand for agricultural products rising, the value of land is likely to continue to rise.

Major investors now see land as an attractive asset. Over the last decade, they have bought or leased large areas, especially in developing countries, for farming, mining, tourism and other uses. Governments welcome the influx of cash in the hope that it will stimulate the economy. But these land acquisitions are controversial; opponents speak of “land grabbing”.

It is common in some circles to fiercely criticize China for its multi-billion-dollar investments in Africa. But Saudi Arabia, South Africa, South Korea and the United States are also active players in Africa, as are domestic companies that invest in land in their own countries. Big deals are not confined to Africa; Eastern Europe, South America, and South and Southeast Asia are targeted for investment. Romania has seen the value of its land rise by 40 percent a year over the last 10 years, or 1,817 percent in a decade.

Major acquisitions of land in countries with many small-scale farmers make them prone to disputes between the

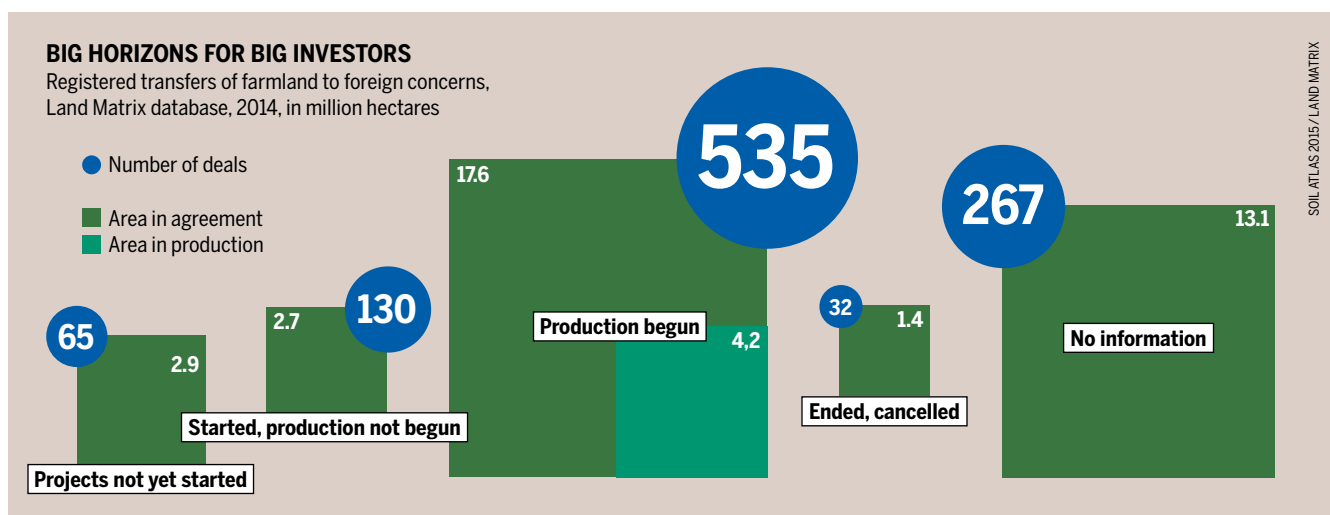
smallholders and commercial interests. Land rights are often poorly defined, and ownership may be communal rather than individual. Investors and the government may regard the land as “idle”, while in most cases, the people actually live and grow crops there, or use it to graze their animals.

Land deals tend to be opaque, making it hard for the people affected to get information and express their opinions. Even if they have clear rights to the land, rural producers often lack the power to enforce them. Women are in an especially vulnerable position. They have little say in their communities, and officials choose to ignore the fact that they collect water, firewood, wild food and medicinal plants in the area.

The amount of land being traded is also unclear. In response, the Land Matrix Global Observatory has attempted to shine a light on this question. It has tracked land acquisitions in low- and middle-income countries since 2000. Its database contains information on just under 1,400 deals involving foreign investors. Of these, over 1,000 deals covering 39 million hectares have been concluded – more than the total area of Germany. Another 200 deals covering 16 million hectares are intended. Other organizations such as GRAIN or Oxfam report a much larger volume of deals.

The Land Matrix has more detailed data on 877 of the 1000+ concluded and transnational deals. Of these, 570 (65 percent) are actually in operation, while another 144 are in the start-up phase. However, implementation in terms of the actual size in operation is rather slow: only 23 percent of the size under contract is currently used for production.

*A signed deal does not mean that production starts immediately. It may take years before a country sees the promised investment*

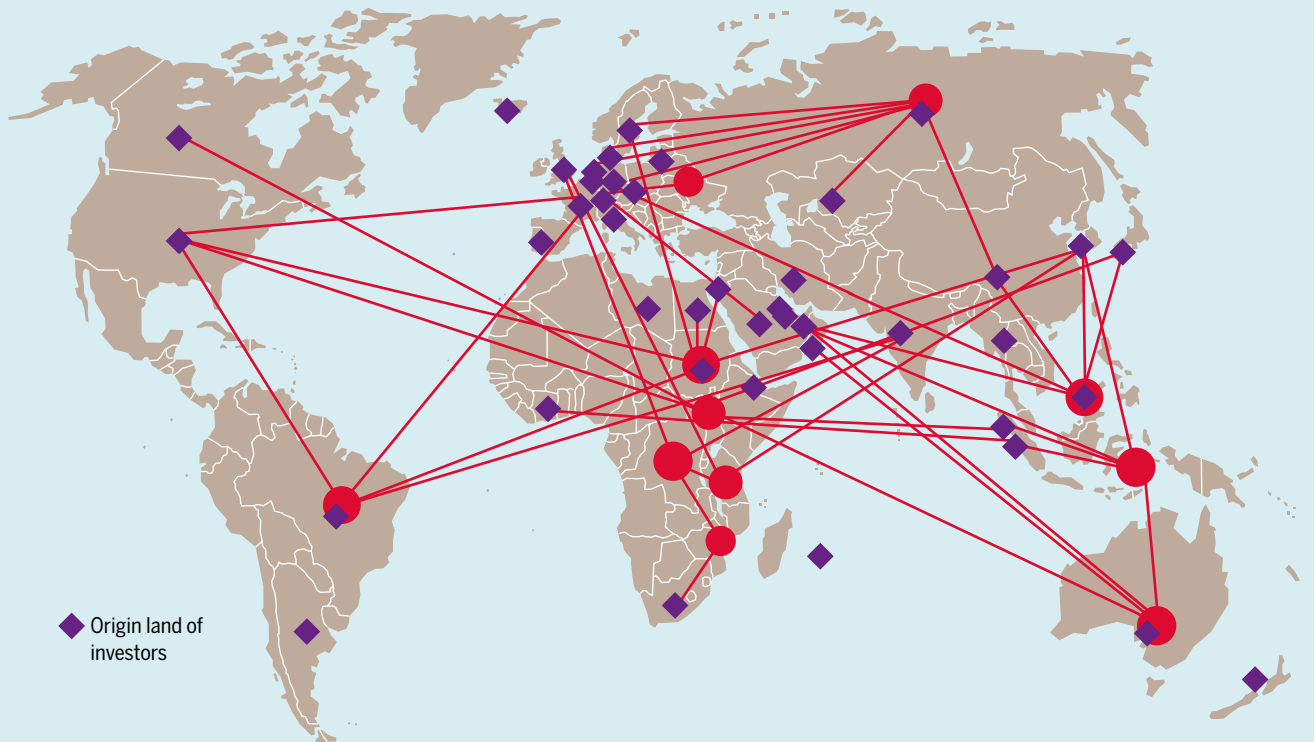


SOIL ATLAS 2015 / LAND MATRIX

## WHO BUYS WHERE?

Land transfers in the 11 most important target countries, with origin of the investors, 2012, in hectares

● 1 to 2 million    ● 2 to 3 million    ● 3 to 8 million



Only deals registered by the Land Matrix and Genetic Resources Action International (GRAIN)

SOIL ATLAS 2015 / RULLI ET AL.

The land under contract is much larger than the land that seems to be under production. There may be various reasons for this:

- Large-scale land acquisitions are notoriously opaque. Data is difficult to get and keep current. This is particularly true for the status of implementation.
- Aside from the expense of buying or leasing the land, investors face significant costs when implementing agricultural projects, such as land preparation and infrastructure development. Investments often take place in high-risk environments, and the number of failed and abandoned deals indicate the difficulties faced. Overconfident investors may underestimate the risks. As a result, in many cases only a fraction of the contracted area is used.
- Low implementation rates may also be the result of speculation rather than an intention to start production. However, most projects have begun production, so while land speculation may exist, it does not seem to play a major role. The Land Matrix data shows that the “rush for land” is real, with demand in low- and middle-income countries, where populations and the demand for food are growing fast, especially in Africa. Soaring food prices led to social unrest in

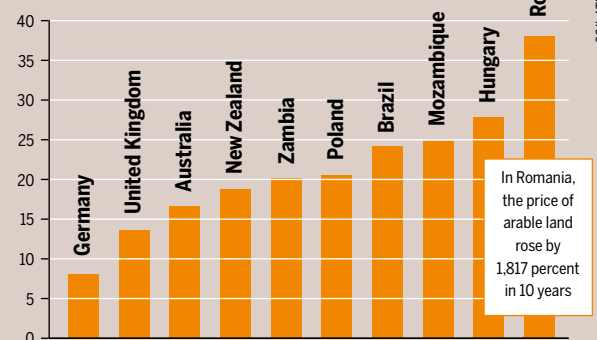
*The land rush has pushed up prices, especially in countries where acres were cheap. Good for landowners who want to sell, but bad for those with insecure property rights*

*A web of greed: huge areas are changing hands. The biggest investors are from developed and oil-producing countries*

various countries in 2008–9. The same may happen if communities are left stranded by large-scale, intensive production. Fertile soil is a limited resource, and competition for it may foster social unrest, especially in countries with weak regulations and power imbalances. ●

## HOT PROPERTY

Percent annual increase in prices in US dollars per hectare, 2002–2012



In Romania, the price of arable land rose by 18.17 percent in 10 years

SOIL ATLAS 2015 / SAVILLS

## EUROPEAN LAND IMPORTS

# CONSUMING MORE THAN OUR FAIR SHARE

When we consume products, we are using land – and that land may well be in another country. Our consumption patterns have big effects on the economy, society and ecology of the producing areas.

Everything we consume or use takes land to produce. We can calculate the area required to produce each item. Add up the total, and it is possible to calculate our “land footprint” – the amount of land needed to support our lifestyle. We can go one step further, and calculate how much of this “virtual land” is traded between regions and countries when food and other goods are shipped from one place to another.

Europe is the continent that is most dependent on land located outside its borders. The European Union’s land footprint is an estimated 640 million hectares a year, an area 1.5 times the size of its 28 member countries. This land is located in other parts of the world, including China, Mongolia, Russia, Brazil and other countries, some of which cannot provide basic food needs and resources for their own citizens.

The land footprint figures currently available do not include many key imported materials such as cotton, minerals and metals. If they were included, the EU’s land footprint would probably be even higher. Six of the top 10 land-importing countries are located in Europe: Germany, the United Kingdom, Italy, France, the Netherlands and Spain, with

Germany and the UK each importing almost 80 million hectares a year.

Each citizen of the EU consumes on average 1.3 hectares of land per year, six times more than the average Bangladeshi. Inequalities like these cannot be reduced without addressing the fact that a small proportion of the global population, mostly located in developed countries, consumes more than its fair share. If everybody in the world were to consume as much meat as the average European, we would need 80 percent of the current worldwide arable land just to produce meat. On the other hand, halving the EU’s consumption of all types of animal products would cut its footprint by 35 million hectares of arable land and 9 million hectares of grassland.

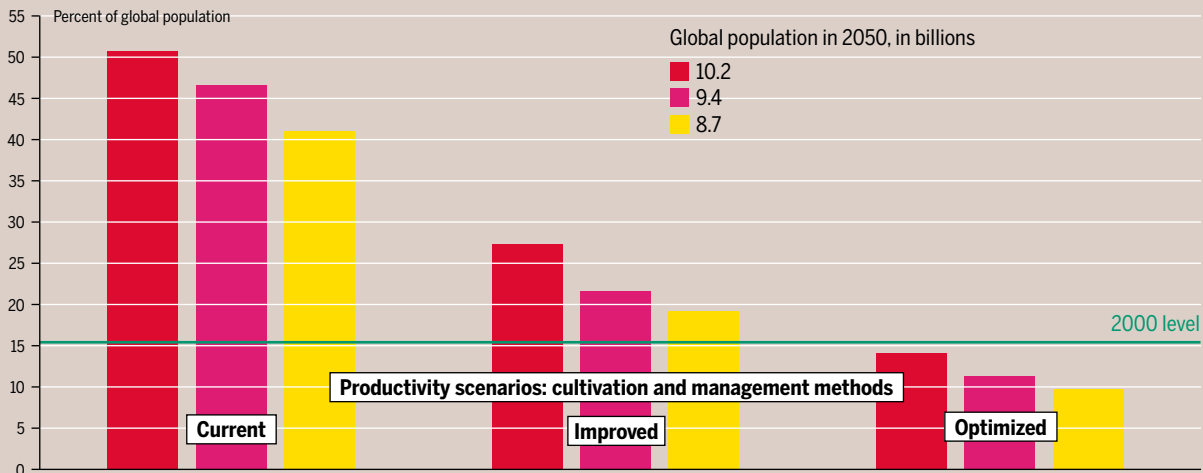
Europe’s enormous demand for land has negative environmental, social and economic effects elsewhere. In the developing world, it is a major cause of ecosystem degradation, large-scale land acquisitions – “land grabbing”- the displacement of communities, and poor working conditions.

Instead of tackling this situation, the EU is consuming even more land, increasing its dependence on land imports, and multiplying its negative environmental and social effects. For example, the switch to biofuels ignores the effects on Europe’s land footprint. Recent research has shown that

*Better farming methods and less cultivation for export would reduce the global “land footprint”*

### DEPENDENCE ON LAND IMPORTS FROM ABROAD

Global population in need of land imports in 2050, in percent, for different population and productivity scenarios

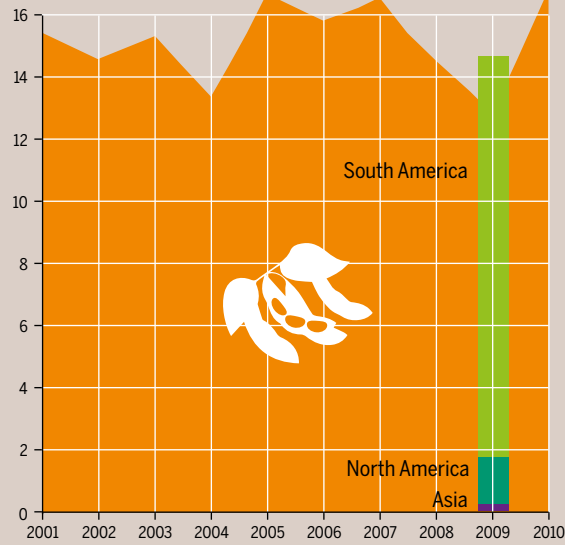


SOIL ATLAS 2015 / FADER U.A.



### FODDER FOR EUROPE'S LIVESTOCK

Land used for soy imports to the EU, millions of hectares and main source regions, 2008–2010



SOIL ATLAS 2015 / WWF

*In Latin America, an area the size of England is devoted to growing fodder for animals eaten in the EU*

Palm oil, used as a food ingredient, is another example. The virtual area imported has more than doubled since 2000, from 1 to 2 million hectares – though the virtual area for oilseed rape, another vegetable oil, has tripled to nearly 3 million hectares during the same period. Production has particularly damaging environmental and social effects in Indonesia and Malaysia, the biggest palm oil producers. These countries are biodiversity hotspots and have insecure land rights. Establishing new plantations often means clearing forests and displacing small-scale farmers and indigenous people.

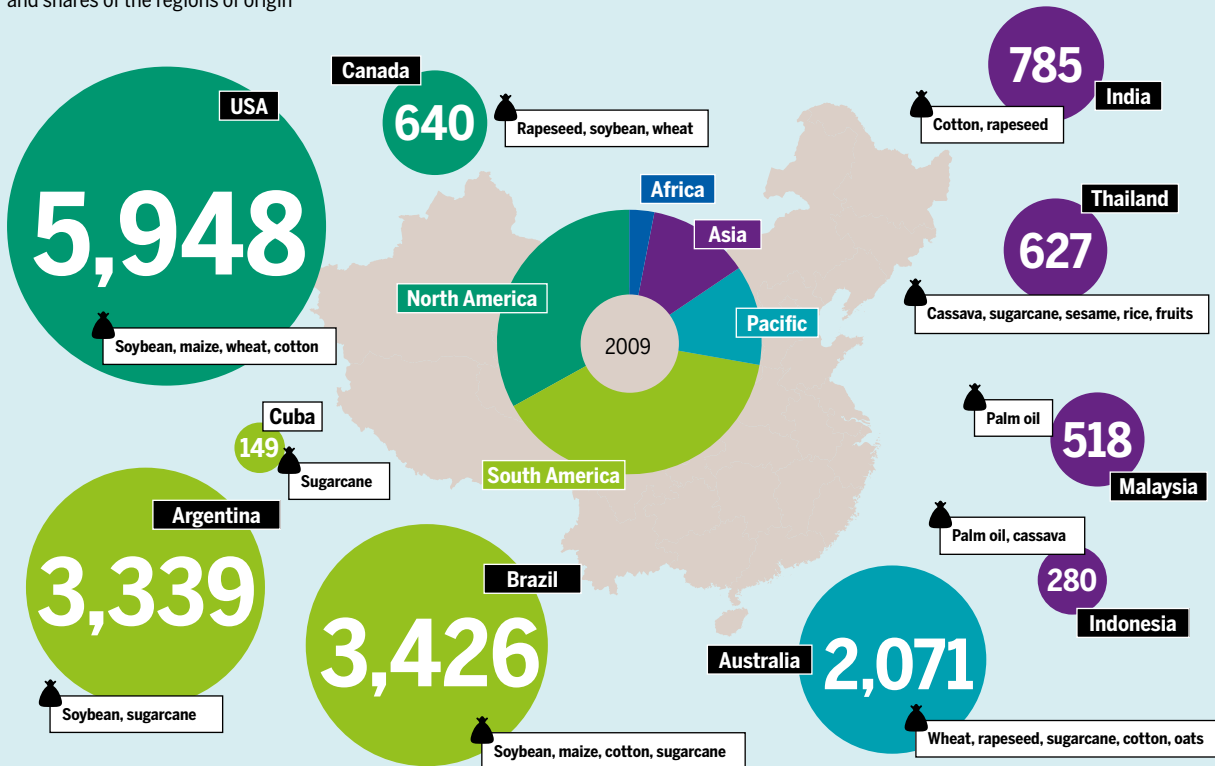
Europeans consume more than their fair share of the Earth's land. The International Resources Panel, a group of experts convened by the United Nations Environment Programme, has calculated how much cropland we would need if we shared it equally. The answer is 0.2 hectares per person per year – less than one-third the size of a football pitch, and less than one-sixth of the area each European currently consumes. ●

to meet the bioenergy requirements of its 2030 Framework for Climate and Energy, the EU will need an extra 70 million hectares of land, an area larger than France. The emerging markets for bio-based materials such as bio-plastics and bio-based chemicals will only accentuate this problem.

*The EU is especially dependent on land imports, but China is growing fast – and it buys mainly from the United States*

### CHINA'S LAND IMPORTS

Imports of field crops by cultivation area, 1,000 hectares, average values 1999–2009, and shares of the regions of origin



SOIL ATLAS 2015 / QIANG ET AL.

# FIGHTING BACK AGAINST FOREIGN ACQUISITIONS

Large investors are buying up land in developing countries. The locals often suffer as a result. They lose their land and access to food.

Since the commodity boom and the financial and economic crisis that followed in 2007–8, fertile farmland has become a focus for investment. Foreign states and companies, as well as national investors are buying or leasing land in developing countries – often to the detriment of the local population. It is hard to tell how much land is affected because reliable information is scarce and report-

ing opaque. The “Land Matrix”, an independent land-monitoring initiative, currently lists deals that affect more than 39 million hectares of land worldwide; an area larger than Germany, or about the size of Zimbabwe. Oxfam even speaks of 200 million hectares; the size of France, Germany, Spain, Poland, Italy and the United Kingdom combined. The World Bank economist, Klaus Deininger, says that “land grabbing” affects between 10 and 30 percent of the arable land worldwide.

The reasons for this trend lie in both the developed and developing worlds. Expanding cities, mines, infrastructure projects and higher prices for agricultural commodities make land a profitable investment. Factors such as lack of water, as in Saudi Arabia, changes in diets, as in China, or biofuel policy, as in the European Union, reinforce the hunger for land among states and companies. The governments of developing countries encourage investment in agriculture to boost yields and improve nutrition. Authoritarian governments use land sales to fill treasury coffers; corrupt officials use these deals to line their own pockets.

Land deals take place all over the world. Particularly in Africa, large areas that are bought or inherited are designated as “degraded” or “unused”, and do not appear in statistics that cover only fertile land.

According to the Food and Agriculture Organization of the United Nations, the rural poor collect up to 80 percent of their food from wild plants during hunger periods – despite the fact that they lack the formal right to do so. A 2009 World Bank report on Tanzania says that most of the building materials, energy and traditional medicines used by the rural population comes from “unused” forests. Designating the land in this way is unrealistic but highly political.

Land grabs often lead to evictions of people who live and farm there – especially of people who lack formal rights or the means to fight back. Indigenous people, smallholders, women and pastoralists are particularly hard-hit. Moving into the city may be their only option, further accelerating already-rapid urbanization. Access to land gives people access to food. This is especially important where people have no social safety net and few other income opportunities.

The impact of ownership transfers varies from place to place. In Ethiopia, the Anuak people were expelled from fertile parts of the Gambella region and had to resettle on barren land. Their food situation has deteriorated markedly as a result. In Madagascar, the government tried to sell 1.3 million hectares of arable land to Daewoo, a South Korean conglomerate. The resulting unrest led to a coup in 2009.

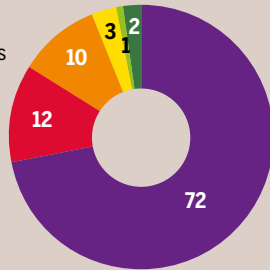
*Most farms are tiny – but governments seldom support the needs of smallholders*

## MOST ARE SMALL

Comparing farms, 2013 estimates\*

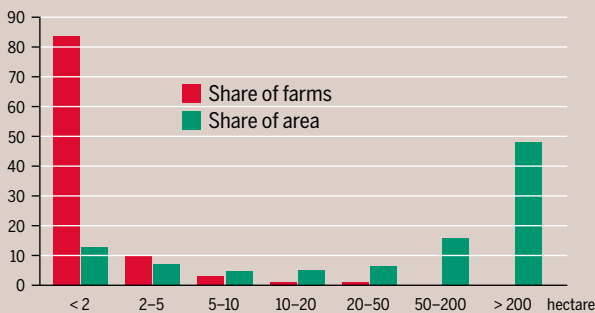
Farm sizes, percentage of 460 million farms in 111 countries

- < 1 hectare
- 1–2 hectares
- 2–5
- 5–10
- 10–20
- > 20

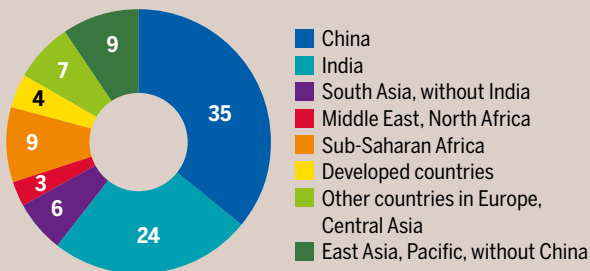


SOILATLAS 2015 / LOWDER ET AL.

Distribution of agricultural land by farm size, 106 countries, in percent



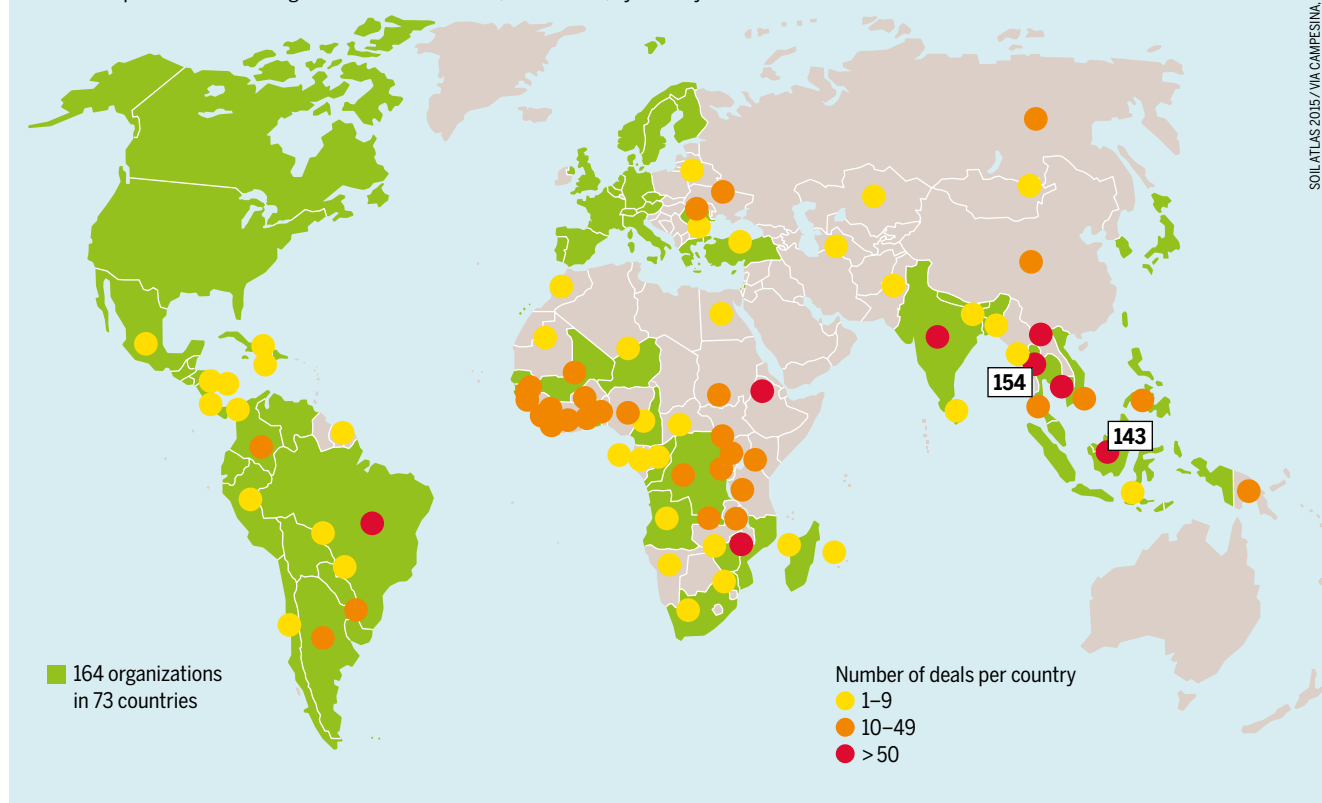
Distribution of 570 million farms by region, 161 countries, in percent



\*According to census data collected at irregular intervals until 2005; more recent data are not available.

## FARMER SOLIDARITY AND INVESTOR ACTIVITIES

Members of the smallholder network "Via Campesina" 2013 and land purchases exceeding 200 hectares and more, 2000–2011, by country



*Farmers worldwide are affected by land grabbing – and they are organizing themselves to defend their rights*

After elections at the end of 2007 in Kenya, disputes over land between the members of different tribes contributed to bloody clashes. Developed countries are not immune to these problems; small-scale farmers often complain about outside investors buying up land and pushing up prices.

Social movements involved in agriculture and nutrition are increasingly concerned by investors' greed for land as well as access to seed and clean water. As varied as they are, these movements are united by the same goal – to secure access to land and food sovereignty for small farmers and marginalized groups.

In India, the landless movement, Ekta Parishad, has staged protest marches to push the issue of land reform onto the political agenda. The international network of Via Campesina ("Farmers' Way") represents the interests of the landless and small farmers; it documents land grabbing and evictions worldwide, and links together the various movements with their multitude of interests and motivations.

This is also the goal of a grassroots movement that emerged in February 2007. In Sélingué, in Mali, 500 representatives of small farmers, fisherfolk, indigenous people, ranchers, consumers, environmental and women's groups as well as social movements from the cities adopted the "Nyéléni Declaration for Food Sovereignty".

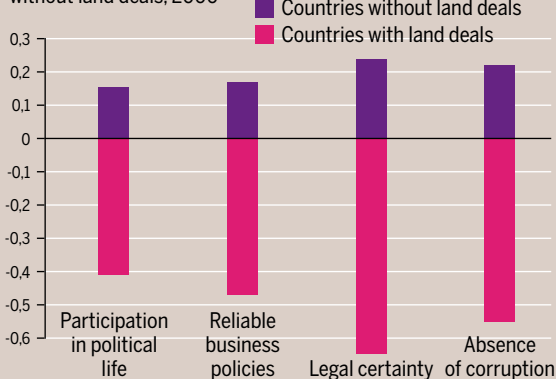
The term "food sovereignty" was coined by Via Campesina, which sees it as a way to democratize food production.

Countries should develop their own independent agricultural and food policies. The means of production, such as land, water and seeds, should be in the hands of small farmers; they must not be monopolized by major agro-industrial concerns. This implies that governments represent the interests of small producers and are able to prevail against the interests of investors. ●

*Countries with weak or corrupt governments are attractive for speculators*

### WHERE SPECULATORS FEEL MOST AT HOME

World Bank Good Governance scores, for countries with and without land deals, 2000



## LANDOWNING

# BUY AN ESTATE AND HARVEST THE SUBSIDIES

Europe’s small-scale family farmers are subject to many of the same pressures as those in the rest of the world. In addition, the cards are stacked against them by government policies.

The structure of farming in the European Union is changing fast. While an increasing number of small farmers are leaving the fields, a few sizable farms are expanding. Between 2000 and 2010, the number of farms in the EU has fallen by 28 percent, and the trend continues. The changes are not only being driven by market forces. They are also being pushed by two sets of government policies: Europe’s agricultural subsidies, and land policy in the former Eastern Bloc countries.

Every year, the EU spends 55 billion euros, or 45 percent of its budget on agricultural subsidies. A large part of this amount depends on the area that is farmed; the subsidies pay around 300 euros per hectare. For KTG Agrar, a big company that operates 30,000 hectares in eastern Germany, that is about 9 million euros a year in bonus payments. Smaller subsidies per hectare apply to the newer EU members, but the rates are expected to converge in the coming years. The tie-in with land area means that the largest one percent of farms in the EU reap more than 30 percent of all farm subsidies; the top 20 percent harvest a whopping 85 percent.

That is not going to change in a hurry. The most recent reforms will take effect in 2015, and will cap the amount a single farm can receive. However, Germany, for one, has chosen not to implement this provision. Other regulations

mean that, in the future, farms exceeding 1,000 hectares will receive 1 to 2 percent less support than in 2014. But large farms employ fewer people per hectare, and can amass 150,000 euros in subsidies per worker per year. In contrast, an average small farm receives less than 8,000 euros per worker.

Various attempts to end the disproportionate distributions have failed: one in 2002 by Franz Fischler, the EU agriculture commissioner, and another by his successor, Mariann Fischer Boel. Both say that their efforts foundered because of resistance from fewer than 1,500 large enterprises in eastern Germany. These enterprises used their influence with the German Farmers Association, the local state governments, and the German federal government to block reform in Brussels. Lobbying has also been successful because the European Commission sees the industrialized agricultural production that is common in eastern Germany as a desirable model for the future of farming throughout Europe.

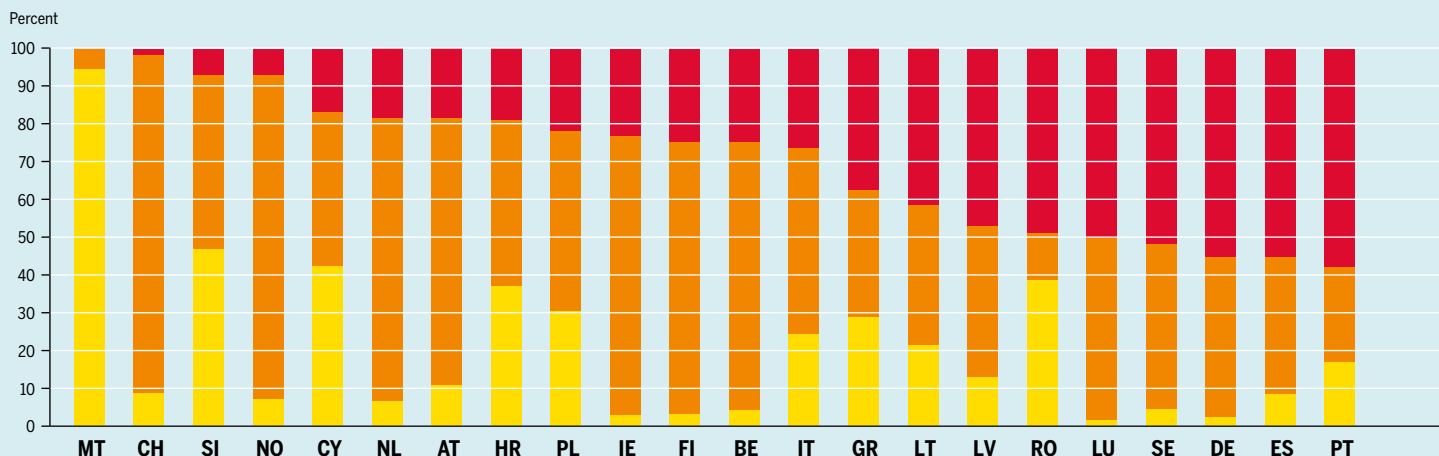
In the former Eastern Bloc countries, the Soviet legacy continues to influence land policies. Rural institutions were broken up under Lenin, farms were nationalized, and big enterprises were established. Small-scale farmers were marginalized – except in Poland, where the farmers successfully resisted collectivization. The socialist cadres have not lost their influence since the revolutions of 1989; the enterprises

*In some European countries medium-sized family farms prevail. But in the Czech Republic, Slovakia and Romania they are virtually non-existent*

### WHERE THE BIG GUYS CALL THE TUNE

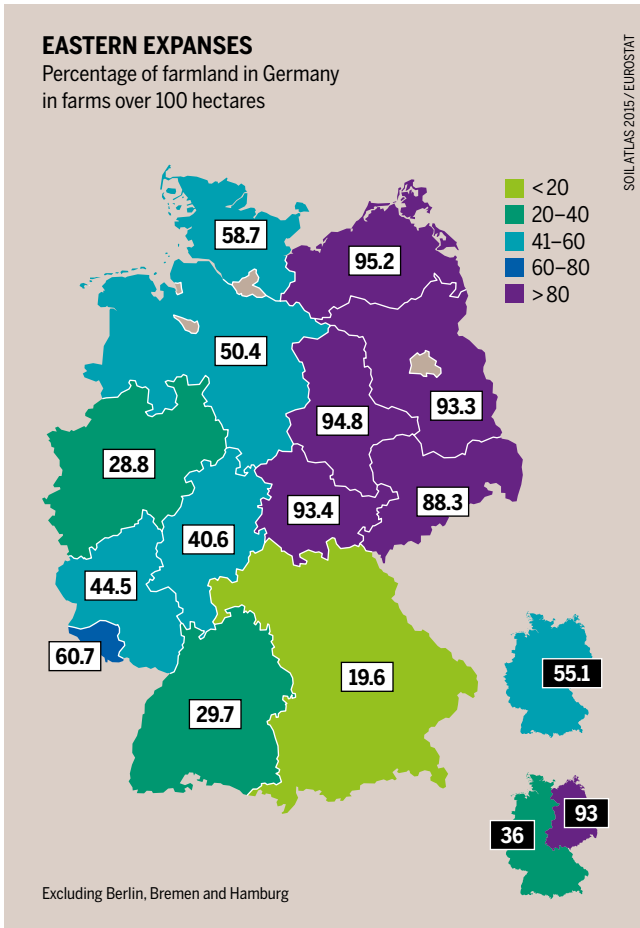
Distribution of farmland by size of farm enterprise, 2010

■ Less than 10 hectares ■ 10 to 100 hectares ■ Over 100 hectares



### EASTERN EXPANSES

Percentage of farmland in Germany in farms over 100 hectares



*The boundary between the former West and East Germany is still razor-sharp – in terms of the sizes of their farms*

exclusively in former East Germany. In contrast, the state of Lower Saxony in western Germany has only 10 enterprises covering more than 1,000 hectares; neighbouring North Rhine-Westphalia has just four.

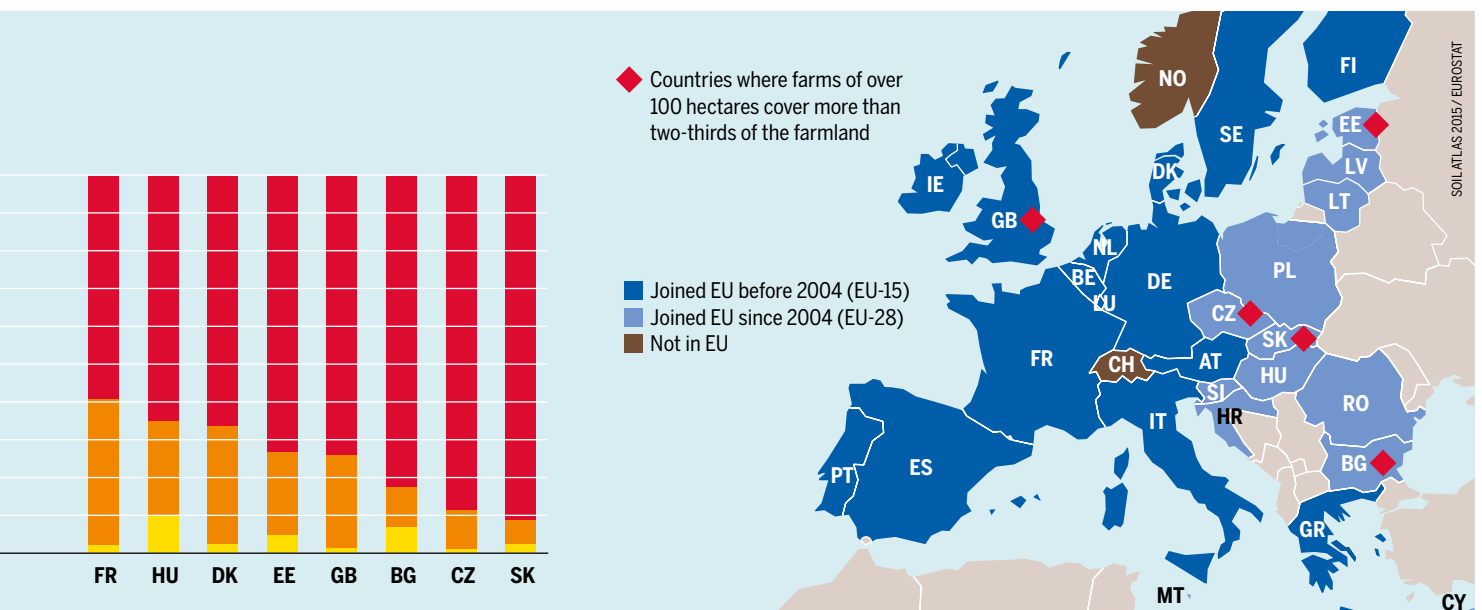
Statisticians use the 20 percent threshold to measure the concentration of farmland ownership. In Bulgaria, the top 0.04 percent of enterprises manage 20 percent of the farmland; each has an average of 3,128 hectares. In Hungary, the figures are 0.44 percent of enterprises with 3,164 hectares each. In Slovakia it is 0.14 percent and 3,934 hectares. In other eastern European countries except Poland the numbers are similar. However, the farms in these countries are generally small because of the large number of farms and subsistence units under 10 hectares in size. These farms remain tiny because they did not have access to nationalized land after 1990 when privatization began.

In contrast, many small farms still exist, and ownership is more diverse in many parts of western and central Europe. Britain is an exception; it has a substantial number of large farms, as well as a broad rural middle class. About half the agricultural area is managed by enterprises that have between 20 and 200 hectares. Eastern Europe has very few medium-sized farms.

In countries with large estates, a new phenomenon is emerging: the sale of farmland to outside investors. Since the financial crisis of 2007–8, farmland has been regarded as an attractive investment. Most sales have consisted of large, contiguous areas and farm facilities. The trend has not yet much affected western Europe with its broad range of ownership. That contrasts sharply with the situation further east. In Romania, sales to outside investors have been so extensive that in 2014 the government in Bucharest passed several laws to support medium-sized family farms between 30 and 100 hectares. However, the EU system of subsidies has been meanwhile extended to 2020 with only minor changes. ●

that succeeded the collectives still control the land. In 1990 in East Germany around 40 percent of the farmland was under state control. The government agencies entrusted with managing this land assigned it almost exclusively to large companies dominated by the old East German elite. Most has now been sold.

In Germany, a mere 0.66 percent of all farm enterprises manage 20 percent of the farmland. These enterprises operate on an average area of 1,391 hectares, and they are almost



## LAND REFORM

# THE POWER OF PROPERTY: A PRIVILEGE FOR A FEW

**The feudal lord, the local squire, the village chief, the hacienda owner, the rancher and the plantation baron. They owned, or own, expansive acres, and they pull the strings of power.**

In recent years, attention has focused again on the uneven distribution of income. According to Oxfam, the world's 85 richest people are as wealthy as the poorest half of humanity.

However, one resource is even more unevenly distributed than income: land. In only one country, the Côte d'Ivoire, is land distributed similarly for all, though still not equitably. In the other 49 countries for which data are available, land ownership is skewed towards the rich. Access to land is one of the main determinants of hunger; half of the households that go hungry are smallholder families, another 20 percent are landless. Research on chronic poverty shows that access to land is often crucial in determining whether households are doomed to poverty or have a chance to better their lives. Even a little more land can lead to markedly increased income. This effect is reflected in the national economy; between 1960 and 2000, countries with an equal distribution of land experienced significantly higher economic growth.

Land reform is a key demand of smallhold farmer movements worldwide. It covers a range of measures that aim to distribute land more equitably, settle people on state-owned land, or recognize and protect customary rights. In rural areas, access to land often means access to political power. But

attempts at reform often fail in the face of the existing power structures. Together with the desire to combat hunger and poverty, the quest for rural democracy is another argument in favour of land reform and fair access to land.

While more equitable land distribution does not automatically lead to broader political participation, access to land is often central to the democratization of rural societies. In the 1980s, national governments began decentralizing an increasing number of services by turning over the responsibility for natural resources and similar issues to the local level. Users of these resources have to negotiate the rules on-site. This often highlights the close links between access to land and decision-making power in the community. In one project in Kenya, the wealthiest households – those with the most land – profited most from the introduction of community-based natural resource management. Studies in Nepal and Tanzania call attention to the disadvantages suffered by the poorest users of a resource; the users are either strongly under-represented or are ignored altogether.

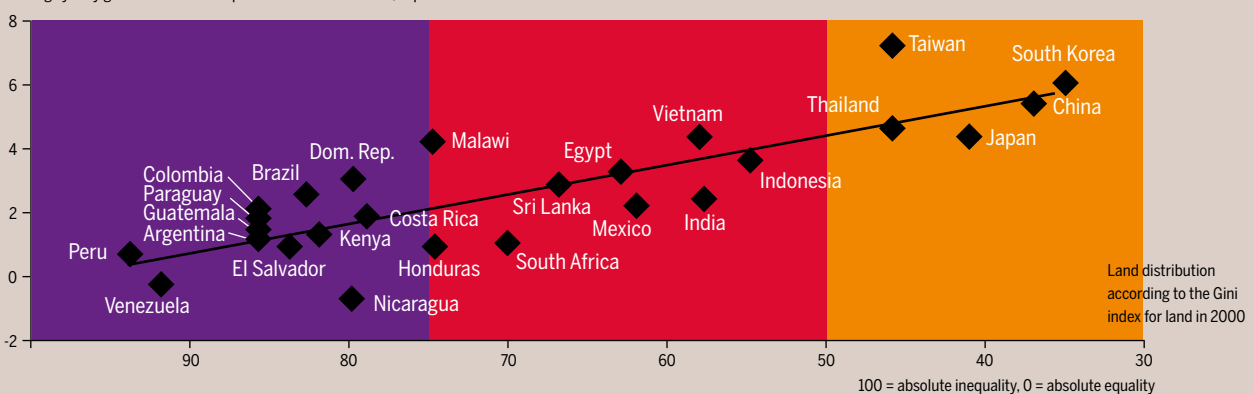
Two states in India have undergone ambitious land reforms. In Kerala, 99 percent of the households cultivate 74 percent of the arable land; in West Bengal the figure is 85 percent. In West Bengal, 51 percent of voters have a high degree of trust in their local government. In the neighbouring

*If many people have access to a reasonable amount of land, national economic growth tends to be higher*

### HAVE LAND, WILL DEVELOP

Connection between land distribution and economic growth

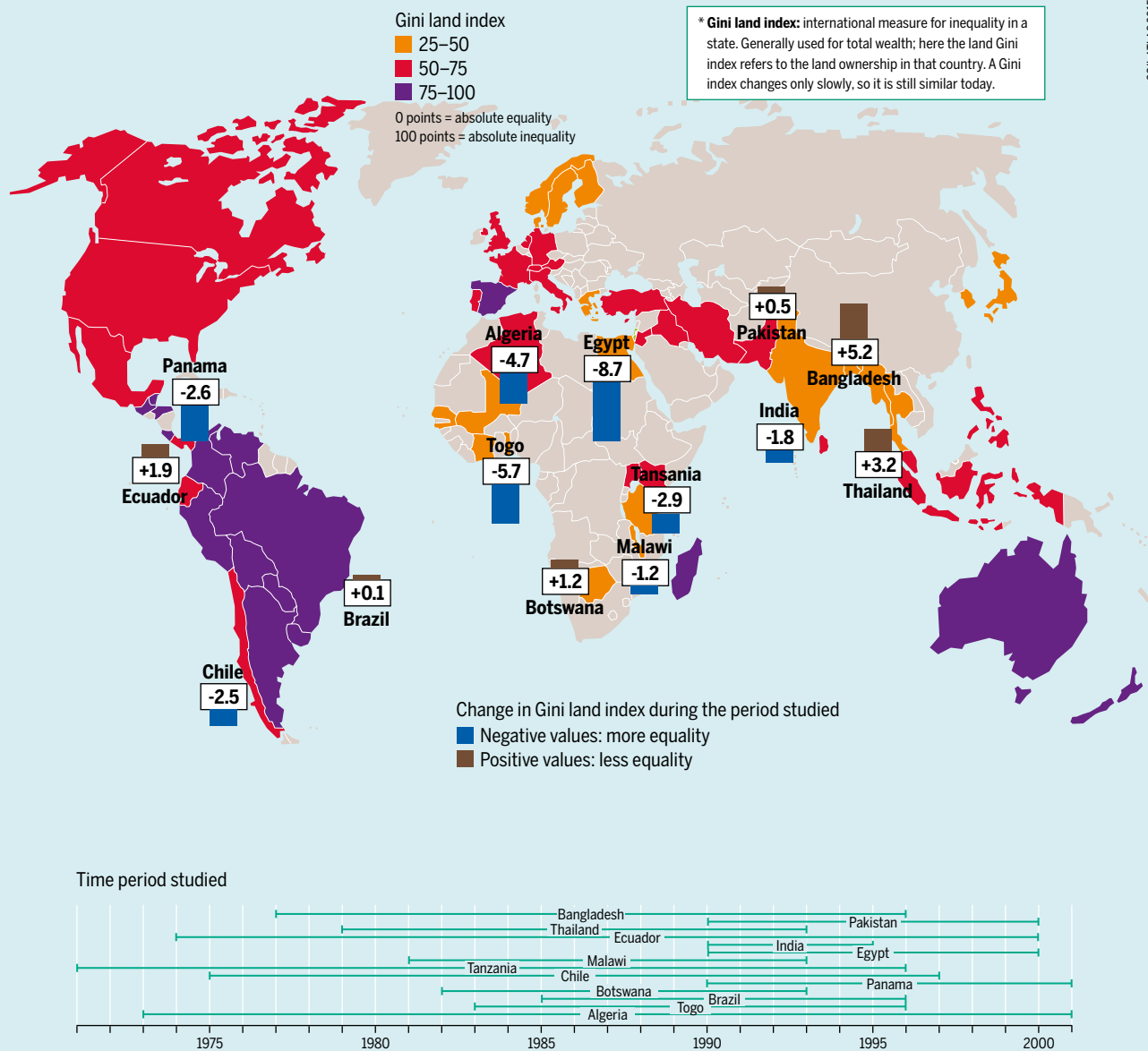
Average yearly growth of economic performance 1960–2000, in percent



SOILATLAS 2015 / DENINGER

## UNEQUAL LAND OWNERSHIP

Equality of distribution according to the land Gini index\*, 1990, or at the end of the period indicated



Bihar, where land reforms have been much weaker, only 30 percent do.

Jump to Brazil. The former military dictatorship launched a large-scale settlement programme in the Amazon basin aimed at introducing extensive grazing. By the end of the military rule, 18 percent of the households in the state of Pará cultivated 82 percent of the farmland, even though government resettlement programmes now also supported smallholders. The establishment of new communities often fell to timber companies and ranches that had benefited from the military regime. Many communities in the Amazon are controlled by illegal loggers or ranchers and are accused of further large-scale illicit logging. The judicial system is also tainted. From 1972 to 2005, 772 murders related to land conflicts were recorded in Pará. The bosses who ordered the killings were sentenced in only three cases.

*In Latin America millions of smallholder households suffer from the power of the large landowners. Occupying the land is one of the few options they are left with*

Since the world food crisis in 2008, investments in land have increased. They are often accompanied by human rights abuses. In response, the Food and Agricultural Organization of the United Nations has drawn up a set of “Voluntary Guidelines on the Responsible Governance of Tenure of Land, Forest and Fisheries in the Context of National Food Security”. This is the first internationally negotiated agreement to lay out the principles of good governance in rural land based on human rights. It represents a move towards more equitable distribution of land and more rural democracy. It is just one step in the right direction – but an important one. ●

# ACCELERATING OFF A CLIFF

**Soils are scarcely mentioned in international agreements. The neglect has not been benign.**

Three trends dominate how we use land today. First, we are crossing several global ecological limits simultaneously, and at increasing speed. The consequences are in part non-reversible and for humans they are incalculable – especially in terms of biodiversity loss and climate change. Second, despite economic growth, billions of people are left without a fair share of land resources. Third, we know all this, yet we lack policies to correct the situation.

As with other environmental problems, this has many causes. But unlike protecting the climate or biodiversity, soil conservation has not been an explicit goal of international agreements. The world community has set itself three major goals that cannot be reached without soil conservation: to stop the loss of biodiversity by 2020, to limit global warming to 2 degrees Celsius, and to ensure everyone access to enough food.

We can achieve none of these goals without appropriate policies to conserve the soil and use land in a more sustainable way. But all of the more than 200 international treaties, agreements and protocols neglect soil conservation and fail to define specific targets.

Instead, soil conservation is seen as a vehicle for achieving climate goals; it is of interest only insofar as the amount of carbon dioxide the soil can store. In 2013, the United Nations Environment Programme presented no-till farming as a way of limiting greenhouse gas emissions. The risks involved, such as the harmful effects of pesticides on biodiversity, or water pollution, are neglected.

The only international agreement that refers explicitly to soils is the UN Convention to Combat Desertification (UNCCD). But this is limited to dry areas. Efforts to extend

its scope to wetter climates have foundered on resistance by various governments. In any case, such an extension, or even a separate UN convention to protect the soil, could be effective only if it were supported by determination, a clear political will, and an independent monitoring mechanism. The decades-long climate negotiations demonstrate how difficult these multilateral discussions can be.

Nevertheless, in a conference before the Earth Summit in Rio in 2012, the UNCCD set a goal of halting net soil degradation worldwide by 2030. The “net” means that degradation in one place can be offset by restoration somewhere else. This goal made it into the final document of the Rio summit, and is even part of the development agenda that in 2015, will replace the Millennium Development Goals that were set in 2000. But compared to the other demands in the summit document, the call to halt soil erosion is weakly formulated.

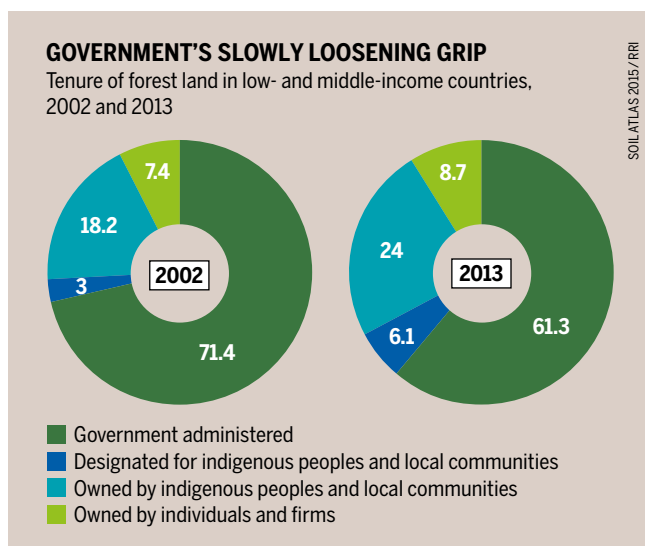
International agreements on land rights present a somewhat brighter picture. In 2012, the member states of the Food and Agriculture Organization of the United Nations agreed to a set of “voluntary guidelines” to manage land rights in a responsible way. These are a response to large-scale land acquisitions by foreign investors, along with evictions, inadequate compensation and expropriation. The document is remarkable in the context of international politics:

- It is the first intergovernmental agreement to address responsible government in rural areas that is based on human rights. Despite its voluntary nature, the agreement carries weight because it rests solidly on international law.
- Representatives of civil society were involved in the negotiations from day one. They represented the various interests of different groups who use the land in diverse ways.

The formal title of this document is “Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security”. That is quite a mouthful, but to activists worldwide it is an important contribution to the protection of land rights, and they campaign for it to be implemented locally. The guidelines consider soil conservation only with reference to sustainable land use, although the secure access to land should go hand in hand with the maintenance of soil quality.

In the past, the link between soil conservation and other policy aspects has been very weak. This has meant that the central function of the soil in the ecosystem and in society has been undervalued, and soils and land have received far too little protection. On the other hand, the overlaps with other areas are enormous: agriculture, food, energy, climate, biodiversity and the right to food. Soil and land must be seen as cross-cutting themes in policymaking; only then will they receive adequate protection. ●

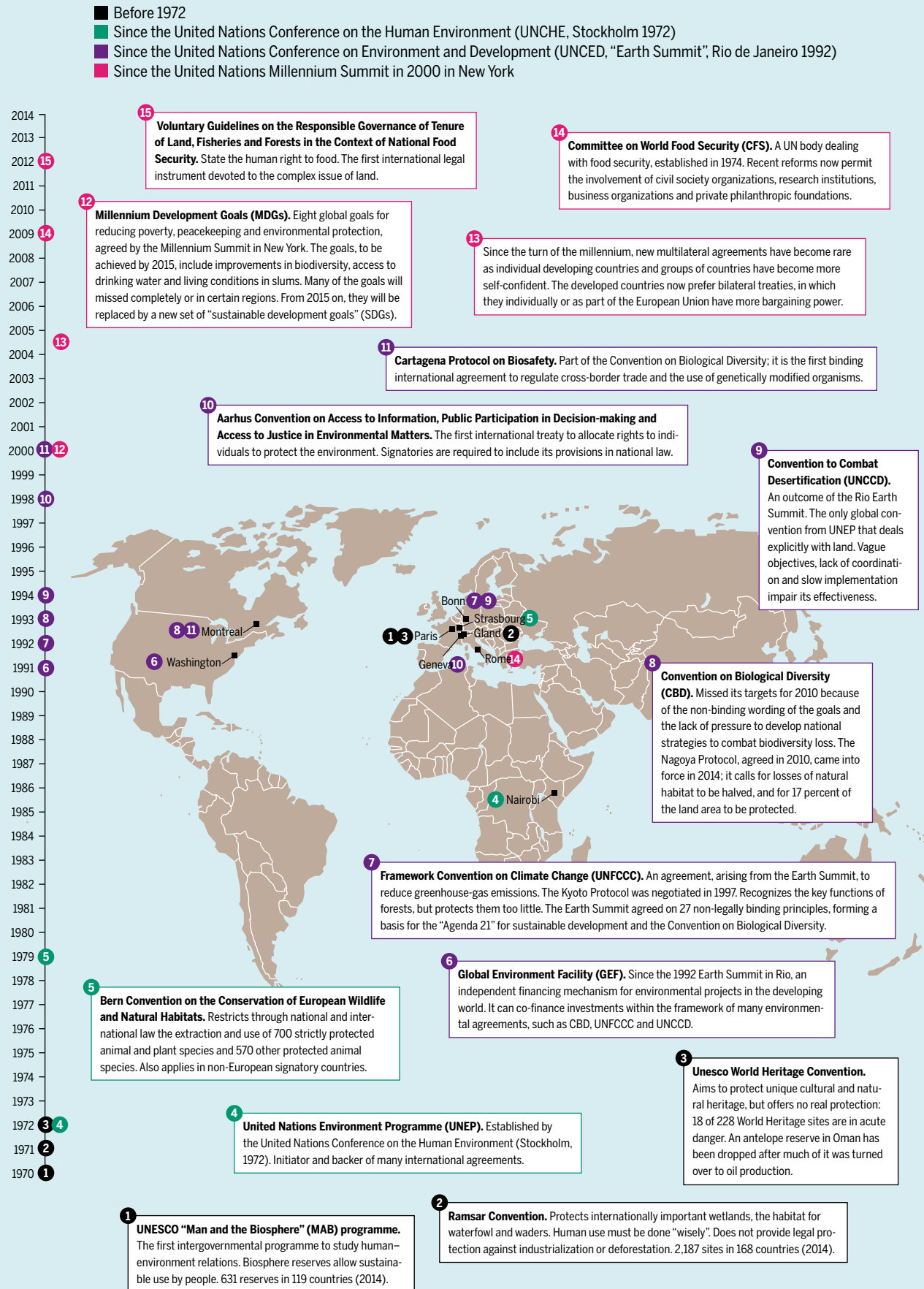
*Forests are attractive resources for outsiders. Despite agreements, politicians are only slowly accepting the rights of indigenous peoples to their land*





## ENVIRONMENT, CLIMATE, DEVELOPMENT... BUT HOW ABOUT SOILS?

Selected global treaties and institutions influencing land and soil policies; year of foundation and locations if available



## HOT SPOTS

# BRIGHTENING UP

### RESTORING THE FLOW COUNTRY

The far north of Scotland is home to Europe's largest contiguous area of blanket bog – the "Flow Country". Thick peat in this 4,000 square kilometre area stores huge amounts of carbon. Encouraged by tax concessions, in the 1980s foresters drained part of the moor to plant trees. But that dried out the peat and destroyed the habitat of birds and other wildlife. In 1987, the government scrapped the tax relief, and tree planting stopped. The Royal Society for the Protection of Birds has bought a large area back from the developers and is trying to restore the peat bog. One of the UK's last remaining wildernesses, the Flow Country is being considered for listing as a Unesco World Heritage Site.

Scotland

Berlin

France

### PREVENTING SPECULATION

Since 2003, the French organization "Terre de Liens" has been buying up farms and farmland in order to keep it away from speculators and to make it available to farmers to cultivate using organic methods. Several thousand regular supporters have so far raised around 34 million euros to purchase land. It currently owns 118 farms and 2,300 hectares, providing employment to more than 300 people.

Burkina Faso

### CUTTING DOWN ON CHOPPING DOWN

In 1995 alone, nearly 30,000 km<sup>2</sup> of forest – the size of Belgium – was cleared for farming and ranching. In 2013, only 5,800 km<sup>2</sup> – as big as Norfolk in England or twice the size of Saarland in Germany – was cleared. Still too much, but a big improvement. The change had many causes. They include a strong government commitment to stop deforestation, improvements in cattle raising methods, and consumer boycotts of soybeans and cattle raised on newly cleared land.

Brazil

### SECURE RIGHTS FOR A LOST PEOPLE

After a long struggle, the Quilombolas won their fight for their land. They are descendants of African slaves who fled into Brazil's jungles, where they established between 1,000 and 10,000 self-governing, fortified communities. They were rediscovered only in the 1970s when loggers reached their area. Since 1988 their land rights have been recognized in the Brazilian constitution.



### URBAN AGRICULTURE

Part of the former Tempelhof airport in Berlin has been given over to allotments where more than 500 gardeners grow vegetables, fruit and flowers. The rules prohibit allotment owners from planting in the ground, as the area may be turned over to other uses in the future. So they bring in sacks of soil and compost and make temporary raised beds out of used shipping pallets. Result: a green oasis in the heart of the city. Many immigrant families who have settled in Berlin have embraced the opportunity to grow their own food.

### REGREENING THE SAHEL

Over the past 30 years, hundreds of thousands of farmers have transformed large swathes of the Sahel into productive farmland. In Burkina Faso, farmers sow crops in planting pits and pile stones along the contour to prevent erosion. In Niger, they encourage tree stumps to regrow by careful selection and pruning. As a result, food security has improved for about 3 million people, and once-denuded landscapes are now home to abundant trees, crops, and livestock.

### SAVING HOLY GROUND

After years of legal wrangling with aboriginal groups, in 2014 the Australian government gave up its plans to set up a final disposal site for radioactive waste at Muckaty Station in the Northern Territory. In 2007, the Ngapa clan agreed to store low- and medium-level waste on their land. Thereupon four other clans laid claim to the land and declared that the site was close to their holy ground.

### DIGGING HOLES TO FIGHT EROSION

Scarred by gullies, mountainous Lesotho is one of the most eroded places on the planet. Every year, millions of tonnes of topsoil disappear down the Orange River towards the Atlantic. Between 1995 and 2010, grain production fell by half as a result. An answer is a pure form of conservation agriculture, without genetically modified seed or heavy use of herbicides. Instead of ploughing, farmers leave the crop residue on the surface to protect the soil. They dig small basins with a hoe, drop in some compost or inorganic fertilizer and some seeds, and cover them with soil. They weed by hand, and rotate crops to prevent the build-up of pests. This system, called likoti (holes) in Sesotho, can be used for maize, beans, sunflower, sorghum, potato and tomato. It can double or even treble yields, doubles incomes, and cuts erosion significantly.

Lesotho

Muckaty Station

## GENDER

# A PIECE OF LAND TO CALL HER OWN

Land is important for women not just because it enables them to grow food. It is also a form of wealth, somewhere to live, a source of independence and bargaining power, and a means to obtain credit and government services.

Nearly half the world's farmers are women. According to the UN Food and Agriculture Organization (FAO), in 2010 women accounted for 43 percent of the agricultural labour force worldwide, with wide regional variations. For example, in Latin America and the Caribbean women make up 21 percent of the population economically active in agriculture, but 43 percent in Asia (outside of Japan) and 49 percent in sub-Saharan Africa. In a total of 30 countries, the majority of farmers are women. In Mozambique, the figure is 67.3 percent; in Lesotho, 65.2 percent. Libya ranks highest, with women representing 69.9 percent of the agricultural labour force.

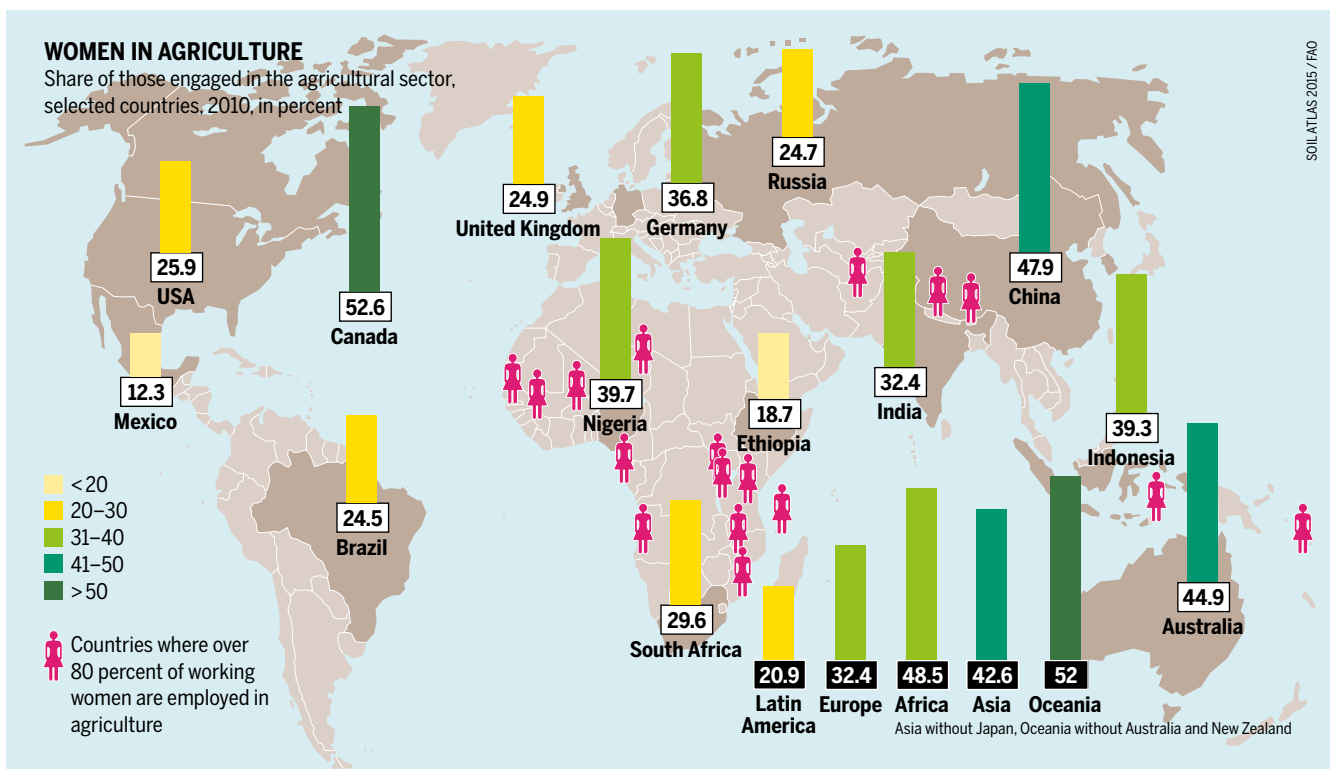
For women in many countries, farming is by far the most important source of livelihood. In Burundi, Rwanda, Niger and Nepal, more than 95 percent of all economically active women work in agriculture. In Germany, by contrast, the figure is 1.3 percent; in the United Kingdom, it is less than 1 percent.

Thus, women are important for agriculture and agriculture is important for women – at least in less industrialized countries. However, women are often discriminated against when it comes to land, an important asset, not only for agri-

culture. The legal situation can be very complex. Social scientists distinguish between the rights of access, ownership and control. Gender-specific data collection regarding these intertwined forms of land rights is only available for a handful of countries. In all three points, women may face disadvantages. For example:

- A woman may have the right to access a piece of land; she may be able to plant crops or keep livestock there. But she may not be allowed to decide what crops to grow. These decisions may be made by her husband, her male relatives, the clan or the government. In addition, other people may have the right to harvest fruit or collect firewood there.
- If a woman owns a piece of land, it means that she can use the land, prevent others from using it, and rent it out or sell it. In countries where data are available, women are often far less likely to own land than men; the share of female landowners ranges from 51 percent in Cape Verde, to just 5 percent in Kenya and 1 percent in Saudi Arabia. In Paraguay, women own 27 percent of the total farmland.
- Even if a woman owns the land, she may lack control over it. Women in many countries cannot inherit land, and they may not be able to buy or sell it without their husbands' permission. It is often assumed that women will be cared for by their fathers, husbands and male relatives. But re-

*Wherever farming is a man's job, women are excluded: they are expected to take care of the children and the home*

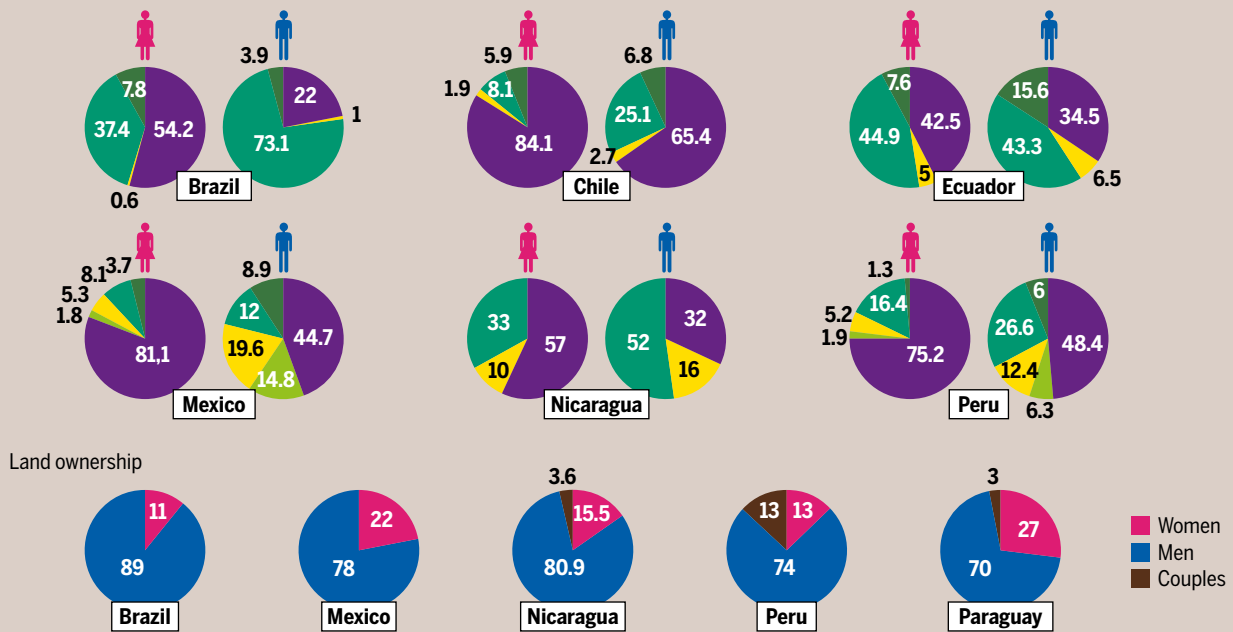


## LAND ACQUIRED BY WOMEN, MEN AND COUPLES

The gender asset gap in Latin America

Land acquisition by type, selected countries, in percent

Through inheritance Through community From the government From the market Other



SOIL ATLAS 2015 / DEERE & LEÓN

ality may well be different. If a woman gets divorced, or if her husband dies, she may lose the house she lives in and the land where she grows food. Only one-third of widows in 16 sub-Saharan African countries inherit the majority of their spouses' estate; more than half get nothing. Likewise, when a woman gets married, she may leave her parents' house to join her husband; it is her brothers who then usually inherit the parents' land.

Property laws for women have been improved in some countries. In Ghana, Malawi, Uganda and Zambia, those who evict widows from their lands can now be prosecuted. In Argentina, Bolivia and Venezuela, widows must be included in wills. In Brazil, Cambodia, Colombia, India and Rwanda, both daughters and sons are legally entitled to a share of their parents' land. These rules are an improvement, but they are not necessarily enforced. Sons may still be favoured through a will or by being awarded more and better quality land. And traditional rules and customs often trump the formal legal system.

How do women become landowners? Inheritance – despite traditional and legal barriers – remains the most common means. Women are much less likely than men to buy land, or to have it allocated by the community or state. Neoliberal, market-centred policies have put large-scale land reforms out of fashion; many countries now instead focus on providing formal land titles, at times specifically to women. Titles may also be granted to a couple jointly; programmes that do this have quadrupled the share of registered women landowners in Ethiopia and Colombia. But well-intentioned

*Women who own land often have more freedom to make decisions than if they rent their plots*

schemes may backfire. In Kenya, Mozambique and the Solomon Islands, new laws ignored traditional user rights and transferred land ownership to men. Women who previously had access to the land lost that access as a result.

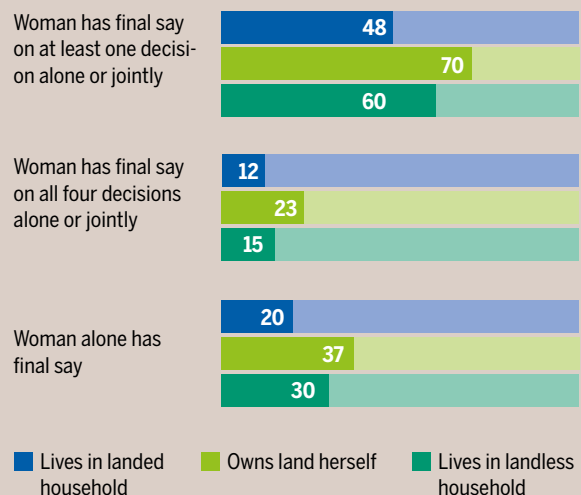
Solutions will depend on the situation. Overall, governments should remove gender discrimination in both formal and traditional law, inform women and men about their rights, train staff and improve land administration systems, and ensure that women's voices are heard. ●

## LAND OWNERSHIP MEANS MORE AUTONOMY

Survey in Nepal, 2001, responses in percent

Married women decide alone or with their husbands about:

- their own health care
- large household purchases
- daily purchases
- visits to family, friends and relatives



SOIL ATLAS 2015 / ALLENDORF

## THE COMMONS

# THIS LAND IS OUR LAND

**Who controls the land: private individuals, the government, or the community? Without private ownership, people have little incentive to invest. But community-managed commons are vital for billions of people.**

In the developed world, most of the land – at least in settled areas – belongs to someone. Private ownership comes with certain rights; the owner can use the land to grow crops and raise animals, sell it, pass it on to his or her heirs, build on it (with permission from the authorities), and put a fence around it to stop others from trespassing.

But most of the world is not parcelled out in this way. Formally, the land may belong to the national government, but it is managed collectively by the people who use it. They graze their animals on it, hunt, collect wood and water, and even build houses and grow crops. Common land is a vital source of livelihood for many of the world’s poor: according to the International Land Coalition research group, up to 2.5 billion people live or rely on the commons.

It is difficult to obtain exact figures, but 8.5 billion hectares, or 65 percent of the earth’s land surface outside Antarctica, can be regarded as common land. Protected areas such as national parks cover about 1.7 billion hectares, leaving 6.8 billion hectares, or 52 percent, for common use. These commons cover extensive areas of dryland and forests, as well as much of the world’s deserts. They are unevenly distributed across the globe; most are in sub-Saharan Africa, Asia and Europe. But the world’s population is also unequally spread, so the biggest common areas per rural inhabitant are in Oceania and the Americas.

An essay by the American ecologist, Garrett Hardin, in 1968 drew attention to the “tragedy of the commons”. He argued that anyone who uses the commons has an interest in extracting as much as is possible. That, he said, leads to increasing overuse and eventually to irreversible degradation.

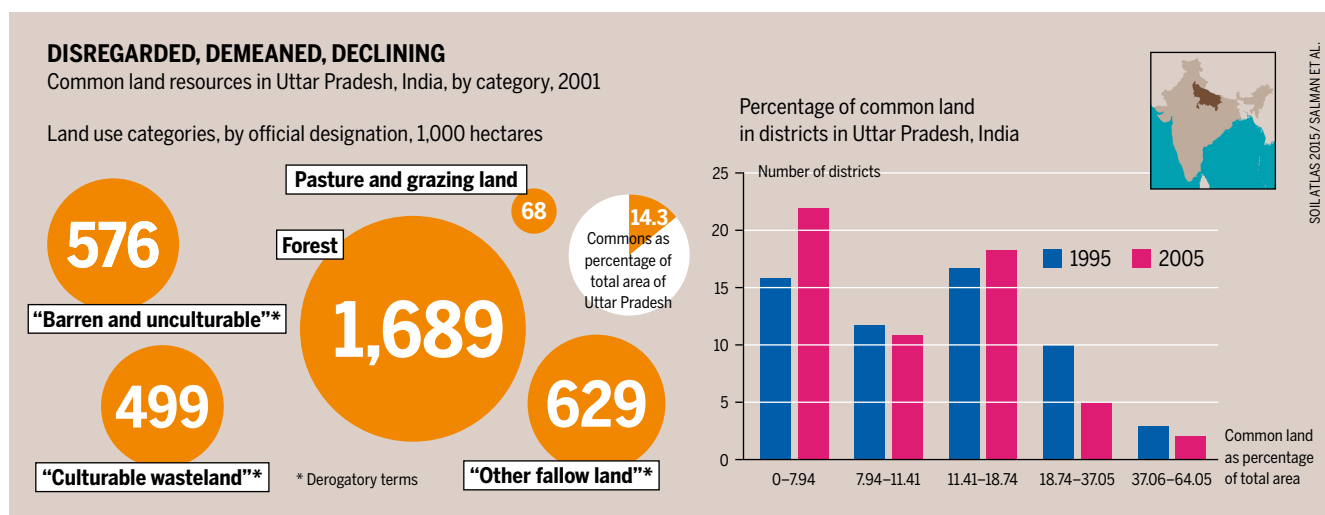
Later, the Nobel Prize-winning economist, Elinor Ostrom, showed that this was not as prevalent as expected. Locals often come up with ways to prevent overuse, and the benefits of collective management may outweigh its disadvantages. Problems often occur when outsiders come in and the traditional management methods are no longer used.

Nevertheless, governments and companies are pushing for the privatization of the world’s remaining untitled lands. Timber companies want to cut down trees; miners want to dig up minerals; investors want to turn apparently “idle” land into ranches and plantations.

The people affected are fighting back. They organize themselves, refuse to vacate the land, and campaign for their rights. By re-claiming the commons, rural social movements are re-claiming control over how their traditional lands are used, managed and shared. They are asserting various alternative property regimes that are not necessarily capitalist, public or private. At the same time, they are strengthening or re-establishing the public acceptance of the commons.

The commons are the focus of public debate, especially in India where they cover 49 million hectares, or nearly 40 percent of the country’s 120 million hectares of arable land. As many as 70 percent of the population rely on them for food, fodder, fuel, grazing and building materials. But India’s rush towards development seems to leave no space for the commons. New factories and roads, burgeoning cities, some 500 new “special economic zones” and expanding biofuel plantations are eating into the common land; approximately 2 percent are being lost every 5 years. Groups that rely almost entirely on the commons for their livelihoods are especially vulnerable; these include historically disad-

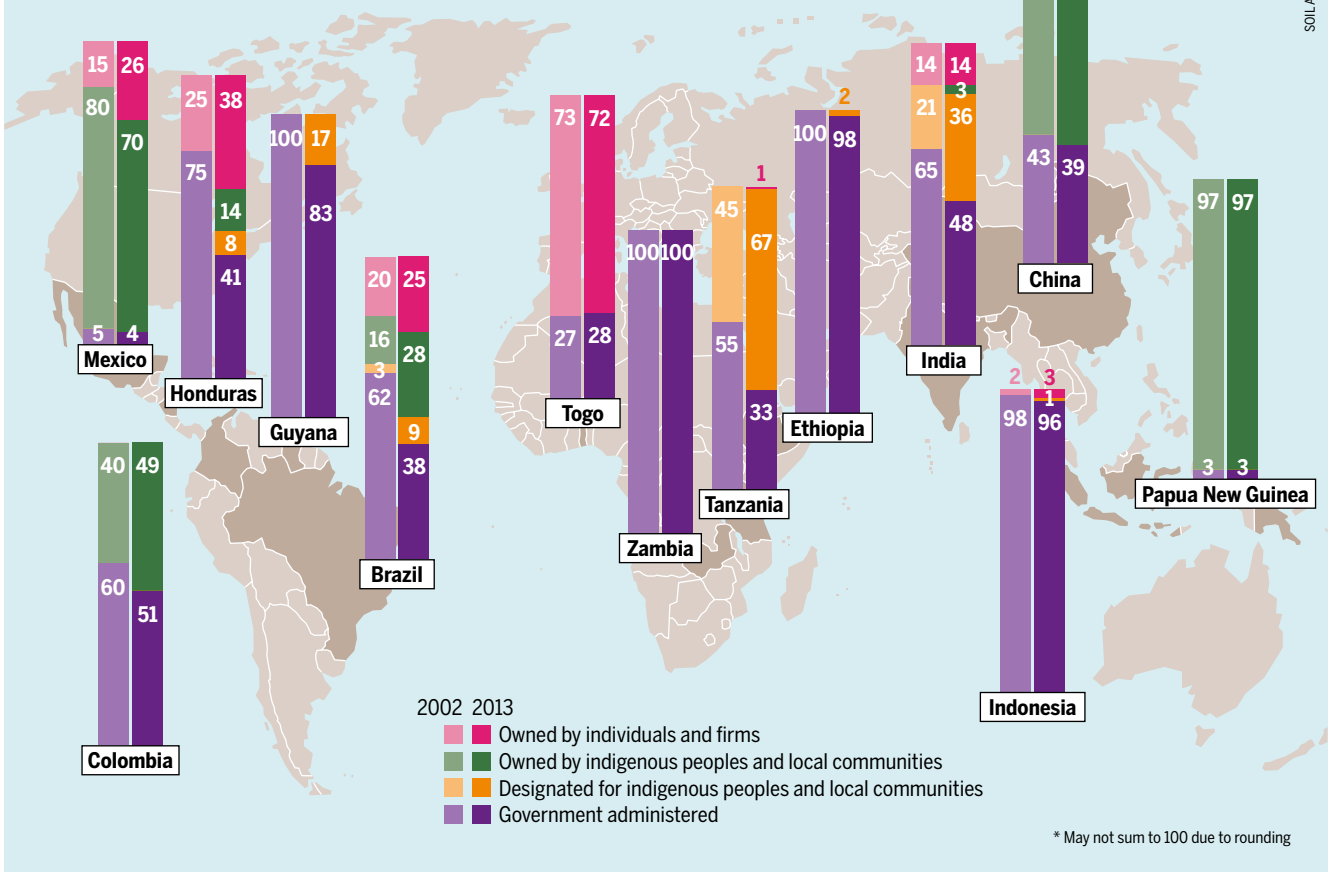
*The size of the United Kingdom, Uttar Pradesh in India has 200 million inhabitants. Its common land covers an area as big as Wales and Northern Ireland combined*



## SLOWLY BREAKING THE LOGJAM

Forests by tenure, 2003 and 2013, percent\*, selection

SOIL ATLAS 2015 / IRI



*Forest ownership varies from country to country. Indigenous inhabitants often have few or no rights; only a few countries grant them a significant degree of control*

vantaged tribes, pastoralists and fisherfolk who make up 24 percent of the population.

The problem has deep roots. Under British colonial rule, the land and forest laws did not recognize traditional rights; they were regarded as “concessions”, “privileges” or “facilities”. Following India’s independence, the government did not revise these laws to meet the needs of the communities but instead increased its own stranglehold. Governance and management of the commons still rests largely with the state. Laws and policies ignore the principles of optimal use and equity; they promote corporate ownership of natural resources. This is one of the key reasons for the conflicts that have affected nearly 200 of the country’s 676 districts.

One of the world’s largest rural movements, Ekta Parishad – Hindi for “unity forum” – is a non-violent umbrella group in the Gandhi tradition consisting of over 10,000 community organizations. It has staged a series of mass rallies to push for change. After a rally in 1999/2000 with 25,000 marchers, some 350,000 land titles were distributed

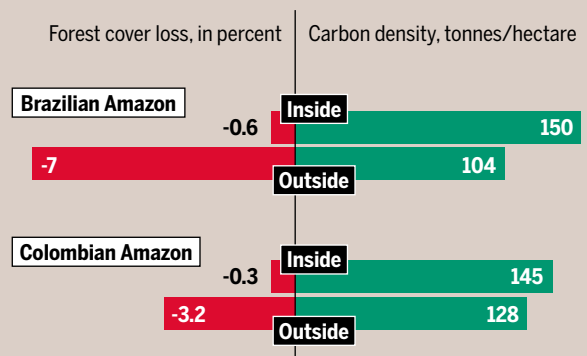
*Indigenous peoples live in and from the forests. They do not cut them down. The carbon stays stored in the trees and the soil*

to landless households, and the Forest Department dropped 558,000 charges against tribal people for violations of forest use. In 2012, 60,000 people participated in a 350 km “march for justice” to Delhi and came to a triumphant halt after just one week, when the government agreed to the marchers’ demands. The most far-reaching of these was to establish a joint task force on land reforms. Politics in India is complex and progress can be slow, but these marches keep up the pressure for meaningful change. ●

## INDIGENOUS CLIMATE PROTECTORS

Forest losses and carbon sequestration inside and outside indigenous lands in the Amazon, 2000–12

SOIL ATLAS 2015 / IRI



## DRYLANDS

# KEEPING LIVESTOCK ON THE MOVE

Until recently, drylands were thought to be fragile and unproductive, and the pastoralists who live there were criticized for harming the environment. But these views are changing.

**D**rylands cover about 41 percent of the Earth’s land surface, and are home to about a third of its population. They encompass hyper-arid, arid, semi-arid and sub-humid ecosystems and vary from savannah woodlands to grassland, deserts and high mountains. Mostly located in developing countries, these areas are often hot, and the sparse vegetation offers scant shelter against the wind. Meagre amounts of rain tend to fall in heavy storms during the short wet seasons.

Most drylands are rangeland covered by grass and shrubs. During the long dry periods, the grass dries out, leaving nutritious standing hay. It does not decay unless it is eaten by livestock or termites. So dryland soils are generally low in organic matter; they cannot absorb much water and dry out quickly. When raindrops hit the exposed soil, they compact the soil surface, forming crusts. Little water sinks in, and most of it evaporates or runs off, taking with it valuable carbon and minerals. To prevent erosion and fertility loss, any agricultural use needs to enhance the soil organic matter, and maintain or improve the vegetation cover.

In arid and semi-arid areas, livestock provide the best way of looking after the land. However, they can be a blessing or a curse, depending on how they are managed. For hundreds of thousands of years, African – and to a lesser

degree also Asian and American – drylands supported vast herds of wildlife, followed by packs of predators. Pastoralists also herd their animals here, moving from place to place in search of grass and water.

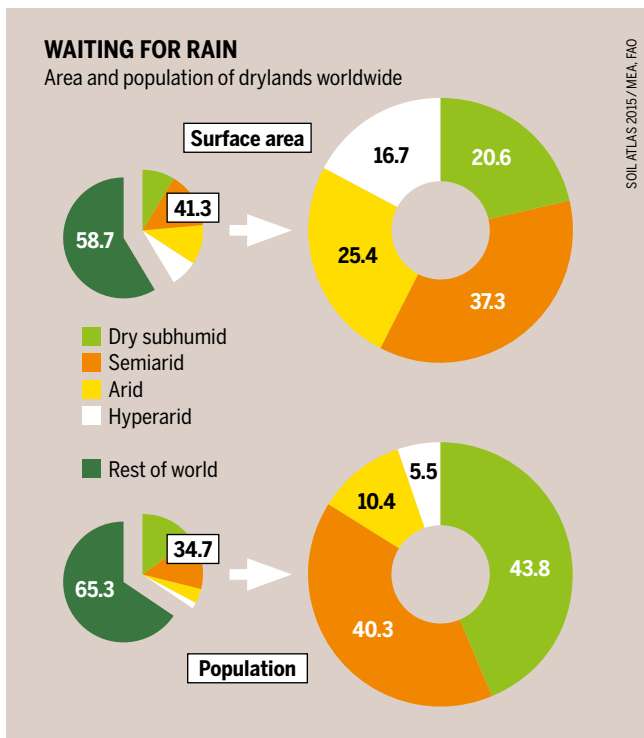
Cattle, sheep, goats, camels and other herbivores have stomach microbes that enable them to digest fibre-rich vegetation. Their dung contains plant residues and is rich in minerals. Therefore, livestock keep the decay process going during long dry seasons, which is critical to the soil and a healthy ecosystem. Their hooves break up the crusts on the soil surface, allowing water to seep in and restoring a healthy growth of grass.

But these advantages can be realized only if the livestock is properly managed. Key to the sustainable use of drylands is herd mobility and communal management, as practised by many pastoral groups. The Borana in Ethiopia and northern Kenya, for example, have a complex network of institutions that regulate access to water and pasture, organize herd movements and coordinate with other pastoral groups. Their herds stay in one place for a short time, giving the vegetation a chance to regrow. Different animal species graze on different plants, maintaining diverse grassland and controlling the growth of bush.

Modern trends disrupt these traditional systems. An increase in human populations, new technologies, education and policies are changing the drylands. Growing settlements and expanded cropping curb animal movements and fuel conflicts between settled farmers and pastoralists. Instead of concentrated herds of wildlife or livestock that move across the terrain without spending too much time in one place or returning to the same place too soon, grazing is now less coordinated. In many areas, smaller numbers of animals wander free-range on what is left of the commons around settlements. This leads to a downward spiral of overgrazing, bare soil, runoff, silted rivers and impoverished land and people.

But there is hope. Governments, researchers and development specialists have started to recognize the importance of drylands as a carbon store, and as one of the last places where food production can be enhanced. They increasingly acknowledge that pastoral livestock production can be more productive per hectare than ranching. In West Africa, for example, governments have started supporting pastoralists and re-establishing migration corridors. Farmers manage reception areas where they grow fodder on harvested fields to sell to migrating pastoralists. In many areas, farmers traditionally allow pastoralists to graze their livestock on their harvested fields, thus fertilizing the soil.

Scientists in Zimbabwe have developed a holistic method called “planned grazing” that mimics wildlife and pasto-



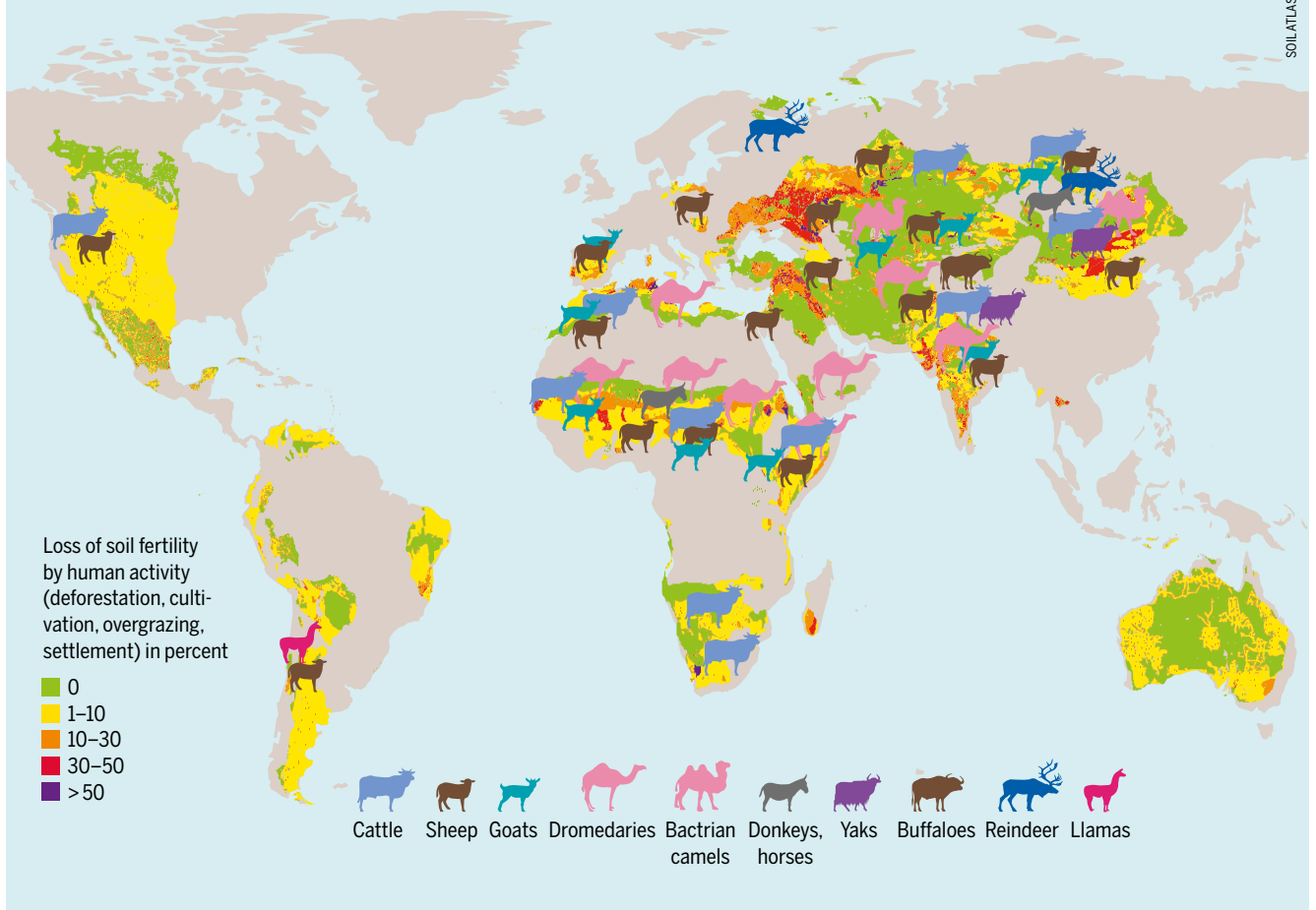
*One-third of the global population lives in the drylands, 16 percent of them on arid or hyperarid land*



### MOBILE HERDS ARE NOT THE PROBLEM

Soil degradation in drylands and mobile animal husbandry, by major species, selected

SOIL ATLAS 2015 / FAO, UNEP



ral herds. Local people combine their animals into one large herd, which grazes one area at a time. This avoids overgrazing, restores soil fertility and stimulates new growth. The approach has spread to neighbouring Namibia, where many communities have started using it. The government and civil society there are working together on a national community-based grazing management policy.

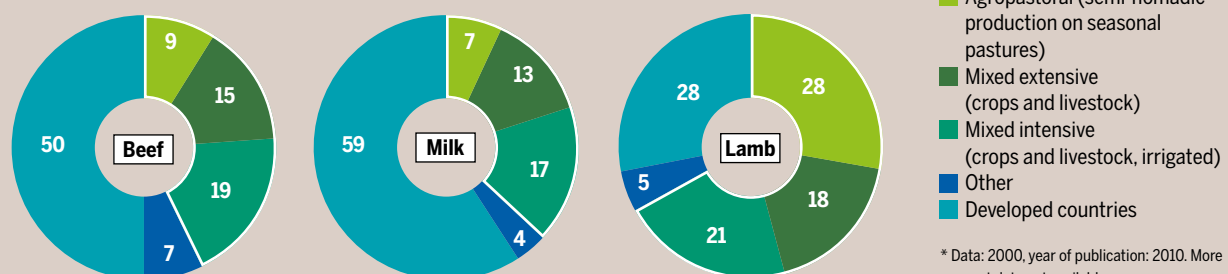
A related method is to use moveable kraals. The animals are penned in these enclosures each night, leaving their dung and urine behind. The kraal is moved each week, allowing a fresh area to be fertilized.

*A lot of damage occurs without seasonal grazing, and many seasonal pastures are not damaged*

These approaches work with nature – not against it. They have huge potential: they can reverse the downward spiral of land degradation and improve livelihoods in the drylands. They rely on mobilizing the local livestock-keeping communities, developing strong local leadership, a clear understanding of how the land is managed, and a commitment to improving it. ●

### MEAT AND MILK FROM SEASONAL PASTURES

World share, percent, 2000/2010\*



SOIL ATLAS 2015 / ILRI

## TRADITIONAL SYSTEMS

# REHABILITATING THE SOIL: WHAT FARMERS CAN DO

**Years of overuse have left soils compacted, eroded and depleted of nutrients. What can small-scale farmers do to restore the soil?**

**F**armers are usually well aware that their soil is degrading. They can see rills and gullies forming in their fields. They count fewer bags of grain at harvest-time each year. But what can they do about it?

Over the centuries, smallholder farmers throughout the world have come up with many ingenious ways to grow crops while conserving the soil on steep slopes, and to restore soil that has been degraded. In Ethiopia, for example, farmers traditionally use a wide repertoire of measures: stone bunds and terraces, vegetation strips, ridges and basins, stone mulch, multiple cropping and planting shade trees. Newer approaches have added to this repertoire, often by adapting the traditional systems. The remedies fall into four broad types: agronomic, vegetative, structural and management.

Agronomic measures involve changing how the crop is grown. Ploughing and planting along the contour instead of up and down the slope can reduce erosion. Intercropping or rotating cereals with legumes restores soil fertility and reduces the need for nitrogen fertilizer. Applying mulch, com-

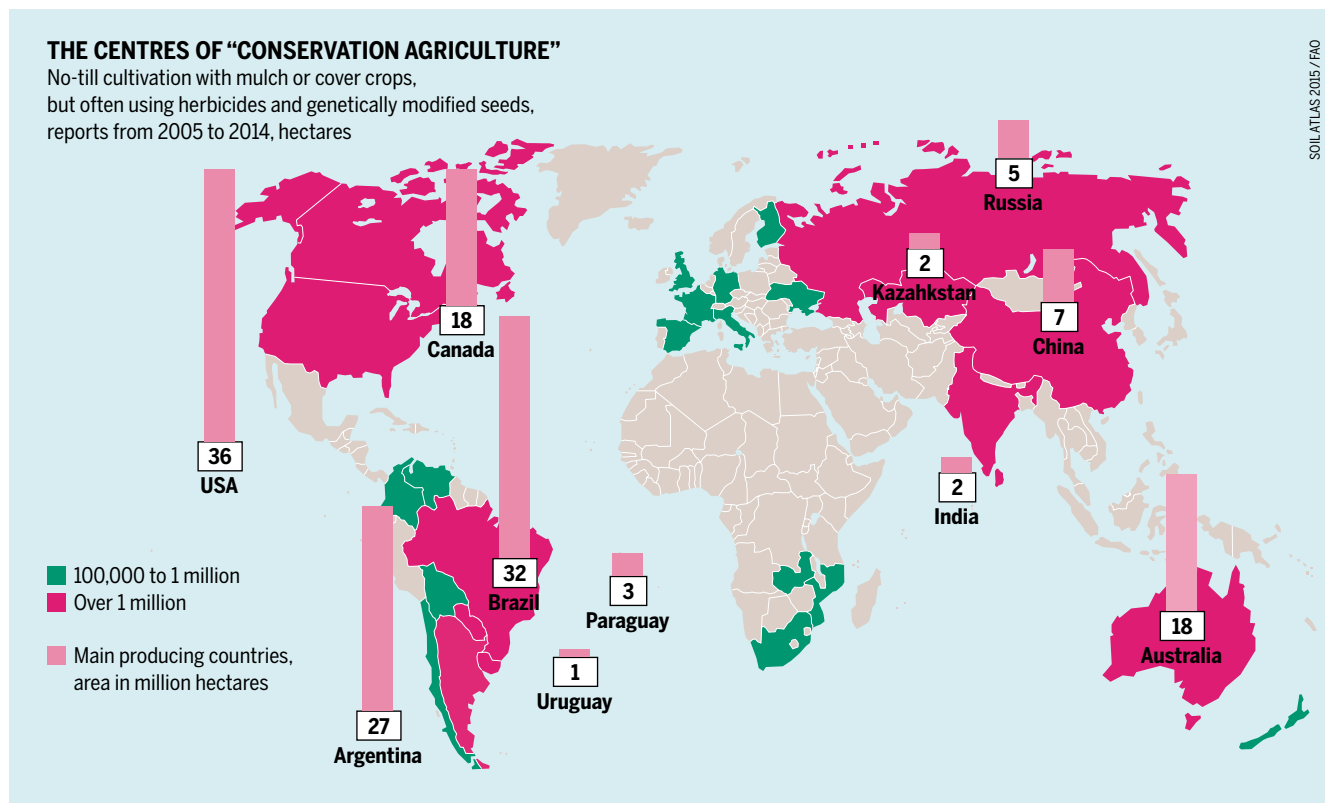
post and manure adds nutrients and organic matter to the soil and stimulates earthworms and other soil life. Adding lime cuts acidity.

Conservation agriculture is a combination of agronomic measures: it eliminates ploughing, protects the soil with mulch or cover crops, and rotates crops to maintain fertility and control pests and weeds. This approach is common in the Americas and Australia, but it often uses herbicides to suppress weeds, along with crop varieties that have been genetically modified to resist the herbicide.

In Africa and Asia, smallholder farmers sow and weed by hand or using special animal-drawn implements that disturb the soil as little as possible. But switching from ploughing to conservation agriculture can be difficult: farmers may need to learn new skills, change the crops they grow, invest in new equipment and put more effort into controlling weeds.

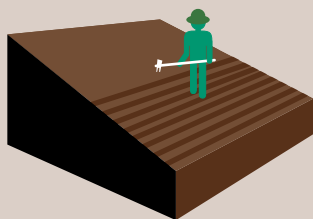
Vegetative measures mean planting grass, bushes or trees to slow down the flow of water, trap soil and cut the wind speed. Hedges and trees planted around fields keep

*Big industrial farms use some conservation agricultural practices, but combine monocultures with genetically modified seed*

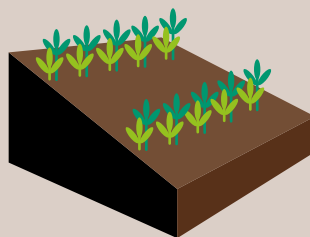


## NEW IDEAS FOR OLD SYSTEMS

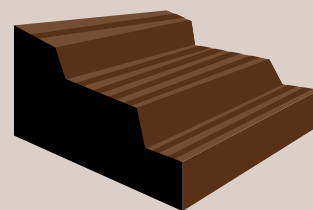
Measures against soil degradation



**Agronomic measures:** Contour cultivation across the slope, without changing the shape of the slope

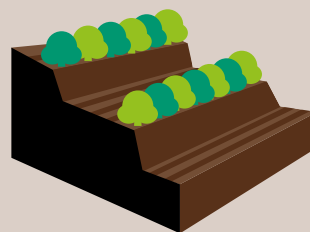
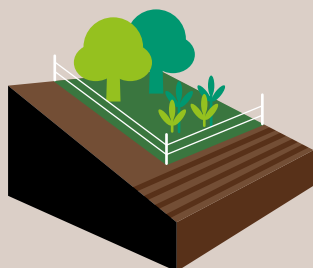


**Vegetative measures:** Grass, hedges and trees planted in strips, long-lasting, suited to small fields



**Structural measures:** Terraces, dams and similar structures, time-consuming investment, long-lasting if maintained

**Management measures:** Changing use by fencing off, rotational grazing, less-intensive cropping



**Combined measures:** For example, growing a mix of crops on small, terraced fields with grasses and leguminous shrubs on the bunds

SOIL ATLAS 2015 / WOCAT

straying animals away from crops and produce fruit and firewood. Grass strips along contours can be a valuable source of fodder; they can trap enough soil to build up a series of terraces. Trees and grass planted along waterways can restore existing gullies and prevent new ones from developing.

Structural measures involve moving earth and stones to build physical barriers. In many parts of the tropics, spectacular terraces make it possible to grow crops on steep slopes. In China, the Himalayas and Southeast Asia, centuries-old earthen terraces are used to grow rice. In the Andes, stone terraces are used for potatoes; in Konso, in Ethiopia, they are planted with cereals, coffee and cotton. Other structural measures include contour bunds, cut-off drains, check-dams in gullies, and reservoirs to harvest water.

The final category, management measures, involves changing the land use. An example is to fence off an area of degraded land to keep grazing animals out, giving the vegetation a chance to recover. Farmers can cut and carry forage to feed to livestock. Rotational grazing, growing fodder crops rather than allowing animals to roam freely also allow grass and trees to regrow on bare land. By moving their herds in search of grass and water, pastoralists avoid denuding a particular area of vegetation.

The most appropriate soil-conservation measures depend on the particular situation. Contour bunds are fine on shallow slopes, but are ineffective on steeper hills. Grass strips do not grow in dry areas, or if livestock are allowed to graze and trample on them.

Individual farmers can apply some measures on their own – such as ploughing and planting along the contour.

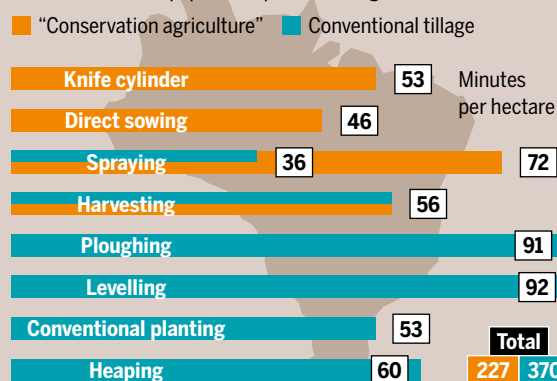
*Conventional cultivation uses ploughing to kill weeds. "Conservation agriculture" often uses herbicides instead. That saves time but risks poisoning the environment*

*A mix of measures is generally the best solution. Even smallholders with few options can significantly improve their yields*

But other measures require all the farmers in a particular area to cooperate. Terraces and other structural measures take a lot of labour to build and have to extend across a hillside in order to be effective. Planning, constructing and repairing them are usually a community effort. Where such a tradition of mutual help does not exist, building such structures may need outside support. Even so, the investment may not be worthwhile given the value of crops that can be grown on the rehabilitated land, and the need to maintain structures once they are built. Often a combination of agronomic, vegetative, structural and management measures is best, for example building terraces to grow a mix of crops, and planting the risers with fodder grasses and trees. ●

### TIME SAVER: SPRAYING PESTICIDES

Time needed for equipment/operations to grow beans in Brazil



SOIL ATLAS 2015 / FIBL

## ORGANIC FARMING

# FEEDING CROPS BY FEEDING THE SOIL

**Conventional farming relies on fertilizer to feed the crops, but in doing so it wrecks the soil. Organic farming sees the soil as the basis of sustainable production.**

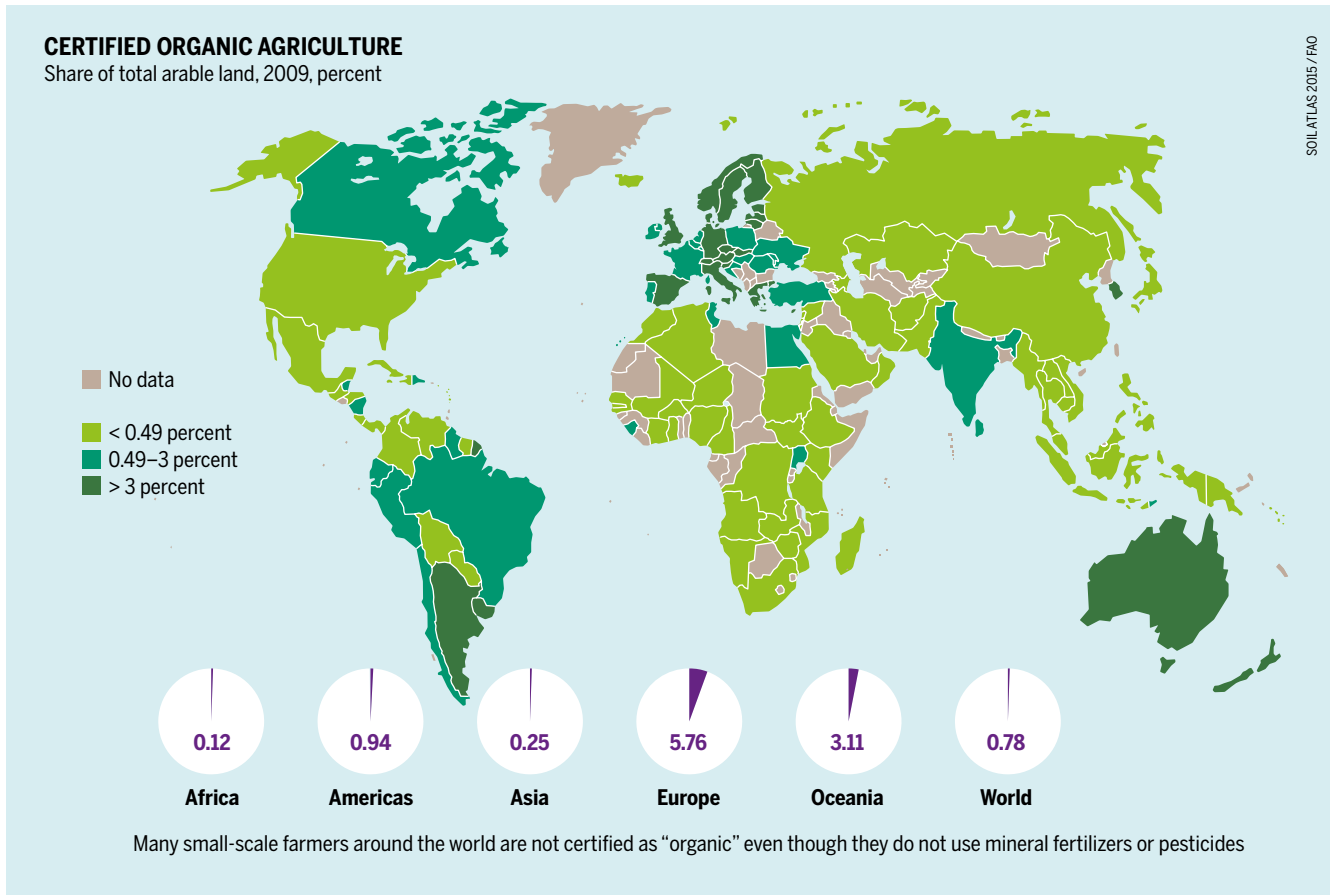
In terms of production and area, organic farming represents a thin slice of the agricultural pie. However, its ideas and methods have a sizeable impact. They are pioneering a wave of innovation. This is especially true of its central idea: maintaining and increasing soil fertility as the key to sustainability and productivity. And that is where soil organisms come into play.

Soil organisms are capable workers; they provide the plants with healthy nutrients by working with nature to ensure good soil structure. These should not be overlooked – but that is exactly what conventional farming does. Spreading mineral fertilizers out of a bag may feed the crop, but it ignores the needs of the living organisms in the soil. Applying fertilizer reduces the amount of organic material that these organisms break down and recycle, and as a result, the organisms starve.

Artificial nitrogen is part of the problem; it speeds up the decomposition of organic substances in the soil. The higher the dosage, the faster the degradation occurs and the bigger the surplus of nitrogen. With the loss of humus many of the positive effects of soil organisms disappear. Crops become more susceptible to pests, and the quality of the soil decreases. Applying phosphate fertilizer can also be counterproductive: it damages the very mycorrhizal fungi that help plant roots absorb this nutrient.

In contrast, a core concept of organic farming is the creation of ideal conditions for soil organisms. Diverse crop rotations and year-round cover crops maintain a rich variety of life above and below the ground, protect the soil surface from erosion, and promote the growth of roots. This in turn feeds more organisms and improves the physical structure of the soil. A healthy soil can store up to four times its own weight in water. That enables it to compensate for periods of

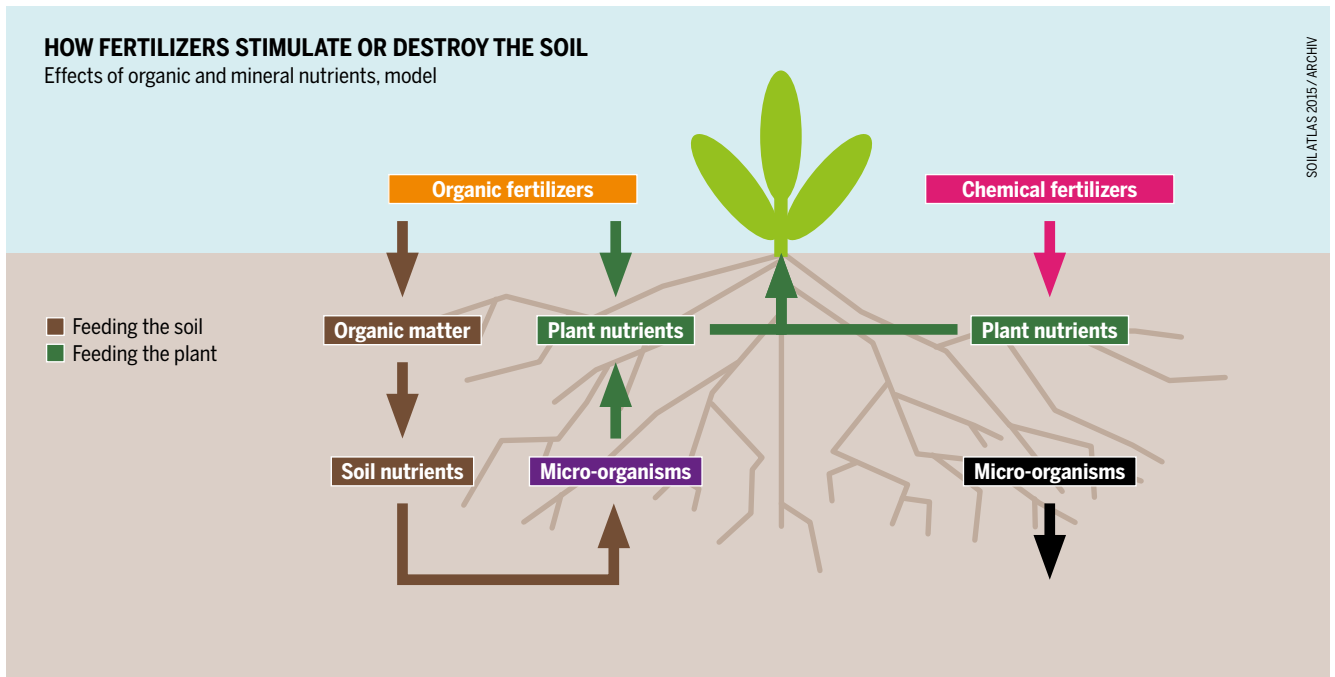
*In many places the demand for organic quality exceeds the supply – a compelling incentive for farmers, if only land prices were not increasing*



## HOW FERTILIZERS STIMULATE OR DESTROY THE SOIL

Effects of organic and mineral nutrients, model

SOIL ATLAS 2015 / ARCHIV



*The shortest path is not always the most effective one. Micro-organisms die when fertilizers feed only the plants*

heavy rainfall or drought, which depleted, compacted soils cannot handle.

In the tropics, organic farming can ensure a rich species mix not only by crop rotations, but also through multiple cropping, i.e., growing several crops in a field at the same time. They may form several storeys: trees above, shrubs in the middle, shorter plants close to the ground. Soil organisms decompose the leaves that fall from the trees; they recycle the nutrients and make them available to other crops. These mixed cultures would also make sense in mid-latitudes – such as in viticulture or fruit-growing. The mix of crops suppresses pests and stimulates reciprocal growth. By decomposing and converting organic matter, these measures help create a high level of biological activity in the soil that nourishes the crops.

Because it avoids mineral fertilizers and improves the soil quality, organic agriculture uses one-third less fossil fuel per hectare than conventional farming, and on average it stores twice as much carbon dioxide in the ground. Organic matter binds nutrients and holds them in the soil. If there is little humus, the nutrients – especially nitrogen – can easily be washed into the groundwater, out of the reach of plants. Leaching rates on organic farms are half those in conventional production. In addition, organically grown crops can mobilize phosphorus from the soil itself, reducing or eliminating the need to apply phosphate fertilizer.

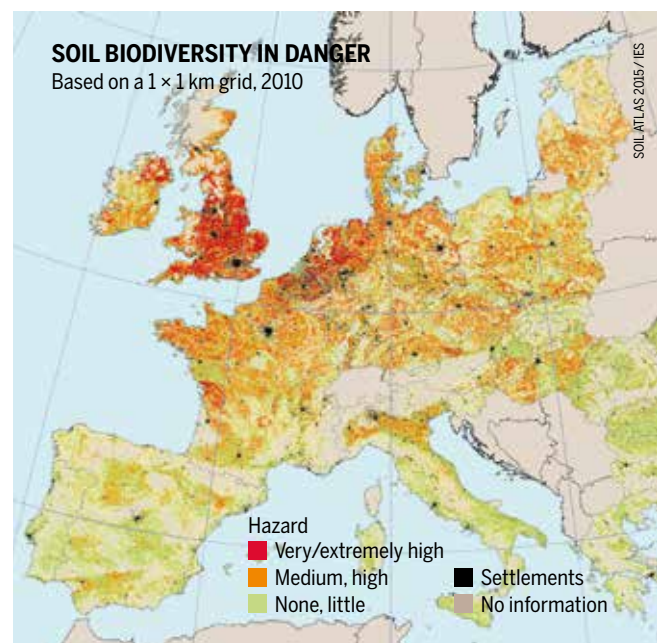
How about yields? An analysis of 160 studies has shown that in developed countries, the yields from organic farming methods were an average of 92 percent of those using con-

ventional methods. In the tropics, an analysis of 133 studies showed organic farming boosted yields by up to 74 percent, without depleting the long-term soil fertility.

Organic farming has a basic approach and techniques for managing soils sustainably over the long term. However, it has to be developed further to combine modern science and practice. In particular, it is necessary to improve organic fertilization through modern composting methods. To dispense with synthetic fertilizer, mechanical, chemical, microbiological and biological techniques are required for small production plants that can convert rock phosphate into more soluble forms, as well as farming systems that produce high yields and fix sufficient biological nitrogen.

The benefits of organic farming are obvious. For the soil, it does not matter whether the production is “certified organic”, but that it follows organic principles. ●

*Soils organisms have a hard time – especially in England and the countries around the North Sea. Scientists are alarmed*



## GREEN CITIES

# FROM URBAN GARDENING TO AQUAPONICS

**By 2050, two-thirds of humanity will live in urban areas. Our quality of life depends on how liveable our cities are. Gardens have multiple functions: they produce a surprising amount of food, help prevent floods, cool the air – and are a pleasant place to relax away from the city bustle.**

**P**ublic parks, gardens and tree-lined streets are not only a welcome splash of green, but are vital lungs for the city and its inhabitants. Healthy urban soils, unsealed and aerated, can quickly absorb large amounts of rainwater, preventing flooding. They also provide open spaces where people can relax.

Green spaces in and around cities are surprisingly important for food production. Up to 80 percent of the poorest residents in some countries are involved with some type of “urban agriculture”; they grow vegetables and fruit, raise chickens and goats. This provides them with fresh, healthy food they otherwise could not afford. However, urban farmers must cope with lack of space, degraded soils, unreliable supplies of water, and urban encroachment.

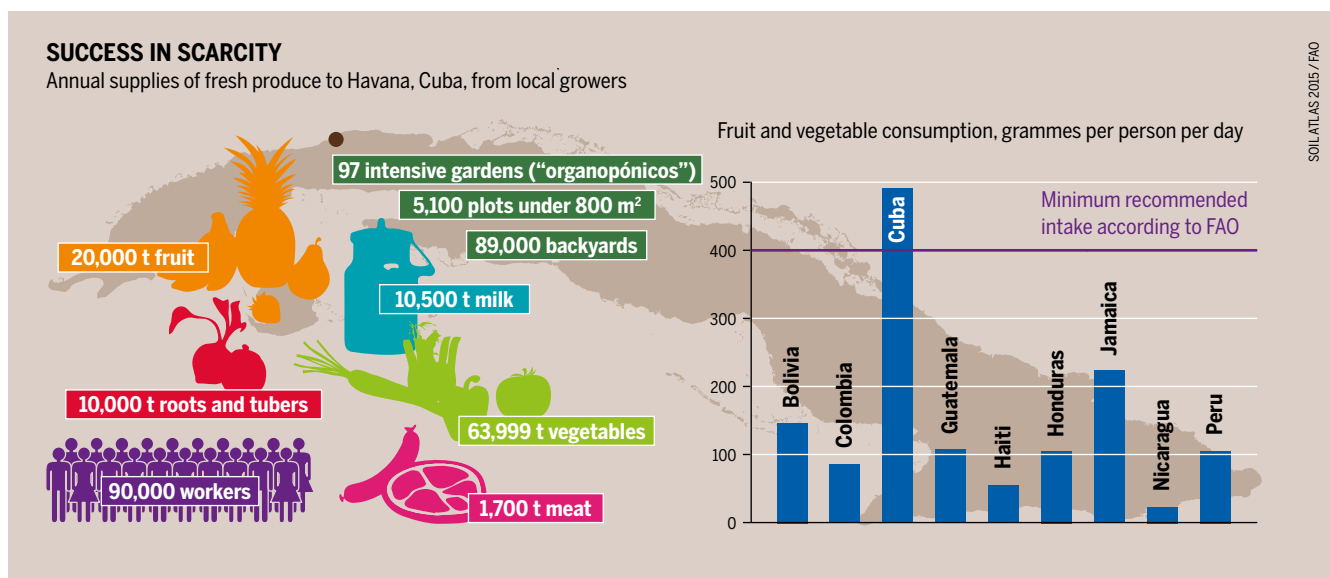
Nevertheless, cities still produce a substantial amount of food. In sub-Saharan Africa, 40 percent of the households have gardens. In Nepal, it is 57 percent; in Nicaragua, 68 percent; and in Vietnam, 69 percent. Gardens do not have to be large; people often grow plants in pots on balconies and rooftops. But rapid urbanization puts pressure on available open space, converting allotments into apartments, gardens into garages. Designating certain areas as agricultural

zones would protect food supplies and preserve flood-control zones. Teaching people the skills of organic farming, helping them get high quality seeds, and supporting markets would increase the amount of food grown.

Urban and peri-urban agriculture is well-established in Latin America where most of the population lives in cities. As a result, farming is often included in national policy, and in research and education programmes – and in some places even in local land-use plans. Farmers’ markets are increasingly common, and their output is impressive: 15,000 tonnes of vegetables per year are grown on 22,800 hectares in Mexico City. On the edges of water-scarce Lima, food for city markets is produced on 5,000 hectares of irrigated land. Poor areas in cities like Detroit, in the United States, are food deserts. Local convenience stores do not sell fresh produce; the grocery stores that do are far away; public transport is almost non-existent. But there is no shortage of brownfields, where community gardening projects can easily be organized. Detroit has 1,200 gardens, including a two-acre site downtown.

Cities are islands of heat; because building and paved surfaces absorb solar radiation, they are between 1 and 4 degrees Celsius hotter than the surrounding areas during the day, and up to 10 to 15 degrees Celsius at night. Vehicles, and air conditioners contribute additional heat. Vegetation cools the air through evapotranspiration and provides shade. Even small areas of urban green can cool their neigh-

*Local production is very important for Havana, the capital of Cuba – and is welcomed by both consumers and nutritionists*

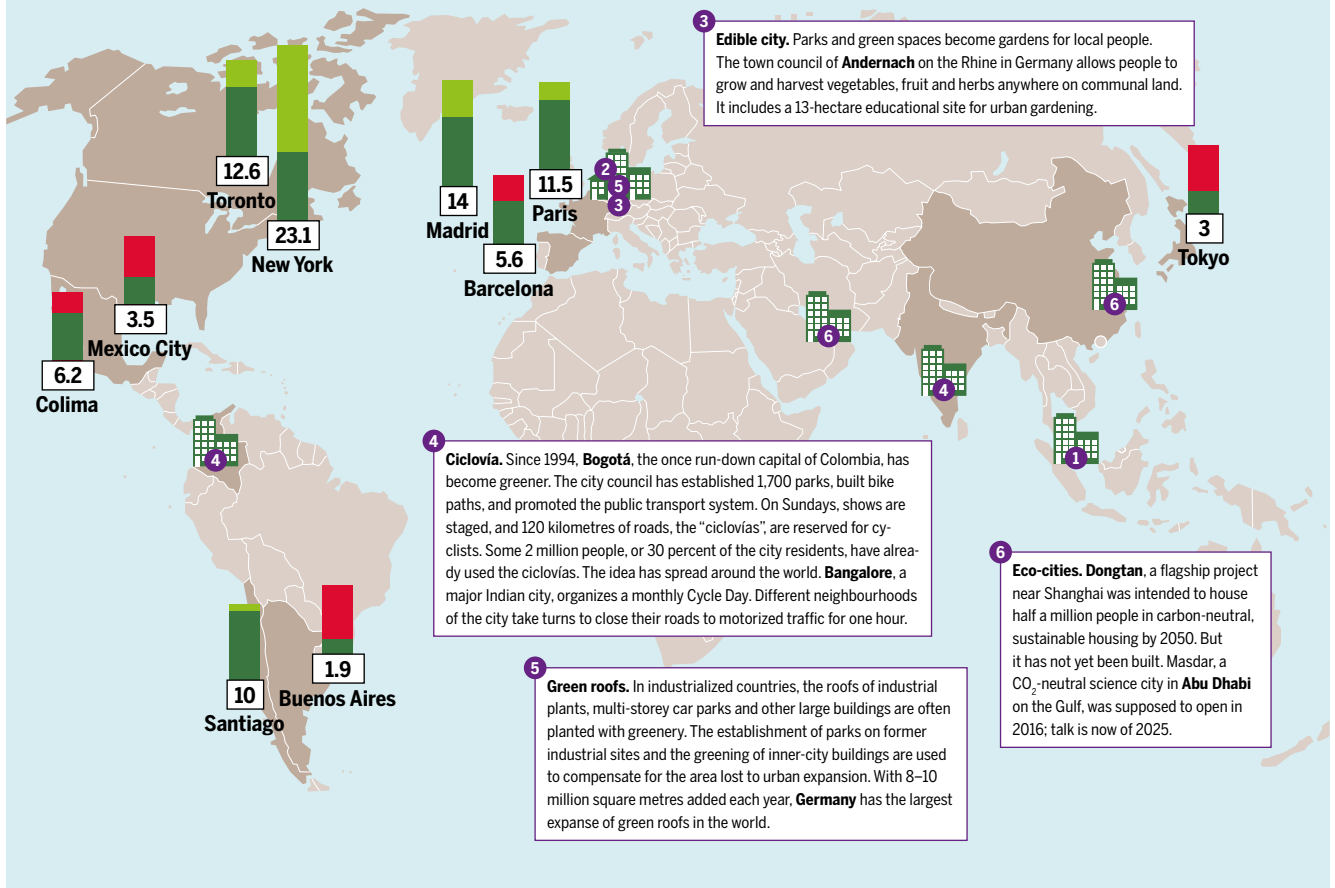


## A LONG WAY TO THE GREEN CITY

Current land use, ideas for the future

Green space per person in selected cities, in m<sup>2</sup>

- 9 m<sup>2</sup> minimum area per person according to World Health Organization
- Area above minimum
- Area below minimum



**1 Vertical farming.** This will save space, allow recycling and produce healthy food in the centre of the city. Vertical farming means growing crops on multiple storeys. It is being tested in many cities, but the costs of construction and operation are huge. Only **Singapore** has commercial facilities, and its towers are only 9 metres high.

**2 Aquaponics.** The city farm "Uit je eigen stad" ("From your own town") opened in 2012 on 2 hectares of former industrial land in the port of **Rotterdam**. It produces vegetables and flowers. Since 2014 it has used aquaponics: fish farming in combination with growing hydroponic crops.

**3 Edible city.** Parks and green spaces become gardens for local people. The town council of **Andernach** on the Rhine in Germany allows people to grow and harvest vegetables, fruit and herbs anywhere on communal land. It includes a 13-hectare educational site for urban gardening.

**4 Ciclovía.** Since 1994, **Bogotá**, the once run-down capital of Colombia, has become greener. The city council has established 1,700 parks, built bike paths, and promoted the public transport system. On Sundays, shows are staged, and 120 kilometres of roads, the "ciclovías", are reserved for cyclists. Some 2 million people, or 30 percent of the city residents, have already used the ciclovías. The idea has spread around the world. **Bangalore**, a major Indian city, organizes a monthly Cycle Day. Different neighbourhoods of the city take turns to close their roads to motorized traffic for one hour.

**5 Green roofs.** In industrialized countries, the roofs of industrial plants, multi-storey car parks and other large buildings are often planted with greenery. The establishment of parks on former industrial sites and the greening of inner-city buildings are used to compensate for the area lost to urban expansion. With 8–10 million square metres added each year, **Germany** has the largest expanse of green roofs in the world.

**6 Eco-cities.** **Dongtan**, a flagship project near Shanghai was intended to house half a million people in carbon-neutral, sustainable housing by 2050. But it has not yet been built. **Masdar**, a CO<sub>2</sub>-neutral science city in **Abu Dhabi** on the Gulf, was supposed to open in 2016; talk is now of 2025.

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bourhoods dramatically. Urban green also improves air quality, cleaning the air by replacing carbon dioxide with oxygen, and by filtering dust. A belt of trees and bushes 50–100 metres wide improves air quality up to 300 metres away.

As a city's population grows, the pressure on green areas increases. These open spaces are either paved, built upon, or regarded as a luxury, even though investments in urban green pay off through savings in health, energy and drainage. In 2008, São Paulo, Brazil, invested about \$180 million in urban green, saving an estimated \$980 million in costs.

Not only are cities hotter; they are also wetter than the surroundings, because smoke and other particles in the air causes more rain to fall. Extreme, unpredictable weather is becoming more common due to climate change. Heavy rain can result in flooding, traffic chaos and sewage overflows. In Berlin, this type of overflow occurs on average 35 times a year. Soils that can absorb the extra water are important to avoid such problems.

Parks and green spaces also provide essential, non-commercial, spiritual, and public health functions. Urban open space is a gathering space and thus a place of democracy.

*Many small projects are often more successful than a few large ones. Some futuristic projects founder from the very start*

Wealthier people have private gardens; public parks and playgrounds are especially important for marginalized groups such as the elderly, children, and the poor.

Urban design is a question of priorities. In the United States, single family homes, massive highway construction projects, and cheap gasoline were in effect subsidized over decades. This has resulted in car-centered urban sprawl and city centres with vast areas dedicated to parking. Houston, Texas, has 30 parking spaces per person. A reorganisation of the transportation system would reduce the need for parking, making possible a change from grey to green.

But not everything that is green is golden. Unmaintained green spaces are often dangerous and considered an eyesore. Lawns guzzle water and fertilizer. Green strips trapped between multi-lane roads cannot offer a haven for relaxation. Urban design providing for accessible green city spaces is a key to livable, pleasant and thus people-oriented cities. ●

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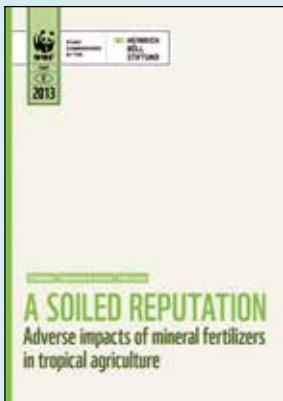
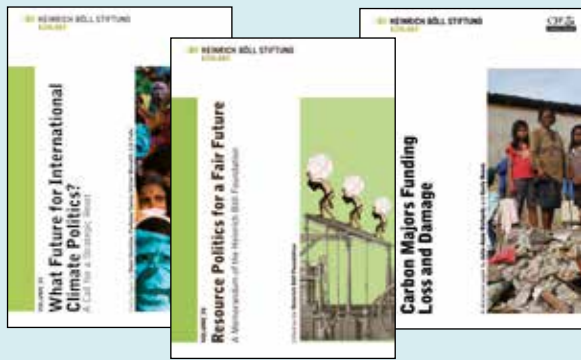
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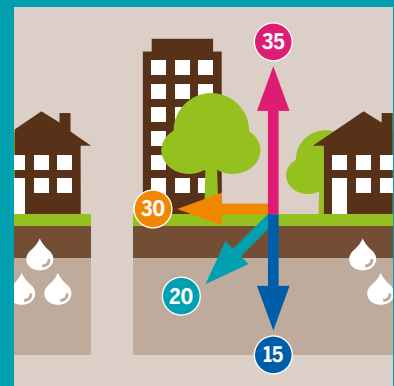
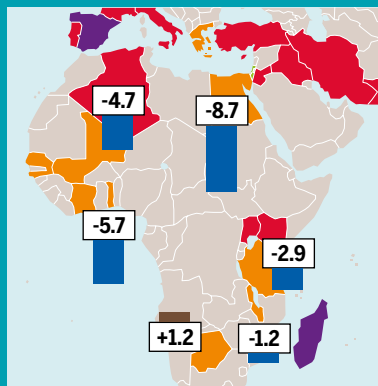
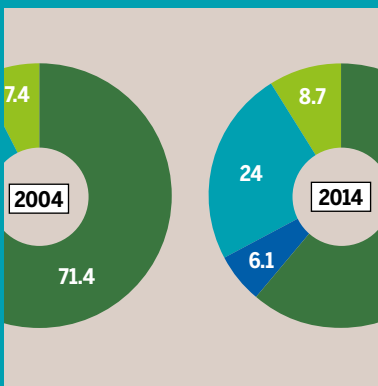
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Women in many countries cannot inherit land, and they may not be able to buy or sell it without their husbands' permission.

from A PIECE OF LAND TO CALL HER OWN, page 52

Since the commodity boom and the financial and economic crisis that followed in 2007–8, fertile farmland has become a focus for investment.

from FIGHTING BACK AGAINST FOREIGN ACQUISITIONS, page 42

Urban farmers must cope with lack of space, degraded soils, unreliable supplies of water, and urban encroachment.

from FROM URBAN GARDENING TO AQUAPONICS, page 62

Land used to grow biofuels cannot be used to grow food. This poses an ethical dilemma while 800 million people continue to go hungry.

from DIGGING FOR FUELS, page 30