

Climate change

Historically, farmers, pastoralists, forest dwellers and fishers have learned to cope with climate variability and have often adapted crops and farming practices to suit new conditions. But the severity and pace of climate change is presenting new, unprecedented challenges.

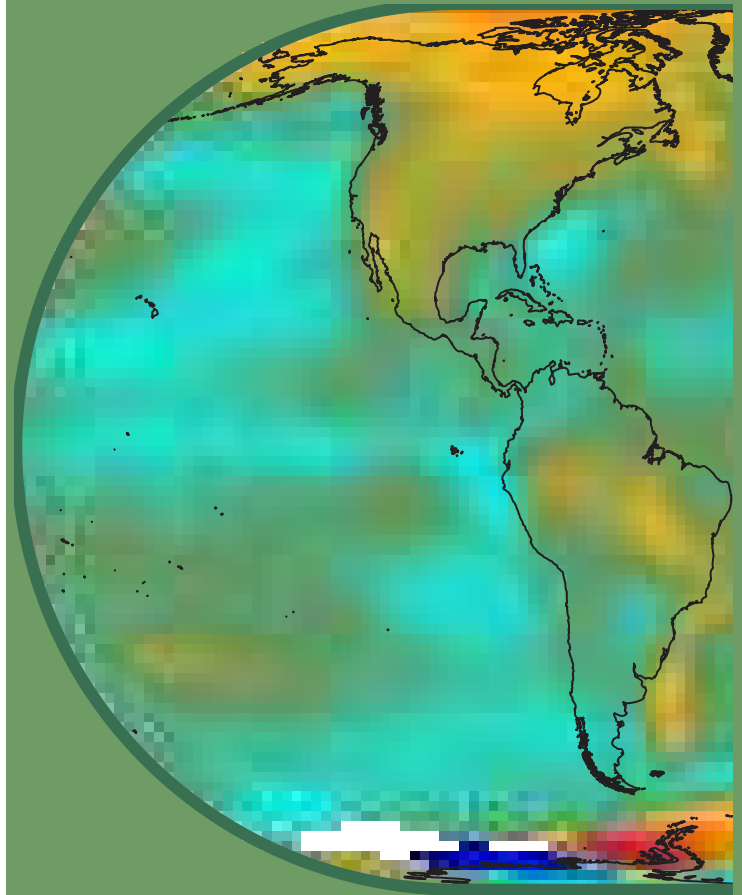
The poorest and most food-insecure regions around the globe are the most vulnerable to effects of climate change. In Africa, low levels of food security and economic development conspire with high levels of climate risk, while large populations and heavily exploited natural resources and climate risk threaten South Asia's poor.

Climate change will significantly impact agriculture by increasing water demand, limiting crop productivity and reducing water availability in areas where irrigation is most needed or has comparative advantage. Global atmospheric **temperature** is predicted to rise by approximately 4 °C by 2080, consistent with a doubling of atmospheric CO₂ concentration. Mean temperatures are expected to rise at a faster rate in the upper latitudes, with slower rates in equatorial regions. Mean temperature rise at altitude is expected to be higher than at sea level, resulting in intensification of convective precipitation and acceleration of snowmelt and glacier retreat.

In response to global warming, the hydrological cycle is expected to accelerate as rising temperatures increase the rate of evaporation from land and sea. Thus rainfall is predicted to rise in the tropics and in higher latitudes, but decrease in the already dry semi-arid to arid mid-latitudes and in the interior of large continents. Water-scarce areas of the world will generally become drier and hotter. Both rainfall and temperatures are predicted to become more variable, with a consequent higher incidence of droughts and floods, sometimes in the same place.

The future availability of water to match crop water requirements is compounded in areas with lower rainfall, i.e. in those that are presently arid or semi-arid, in addition to the southern, drier parts of Europe and North America. Runoff (the water flow from soil when infiltrated to full capacity) and groundwater recharge are both likely to decline dramatically in these areas.

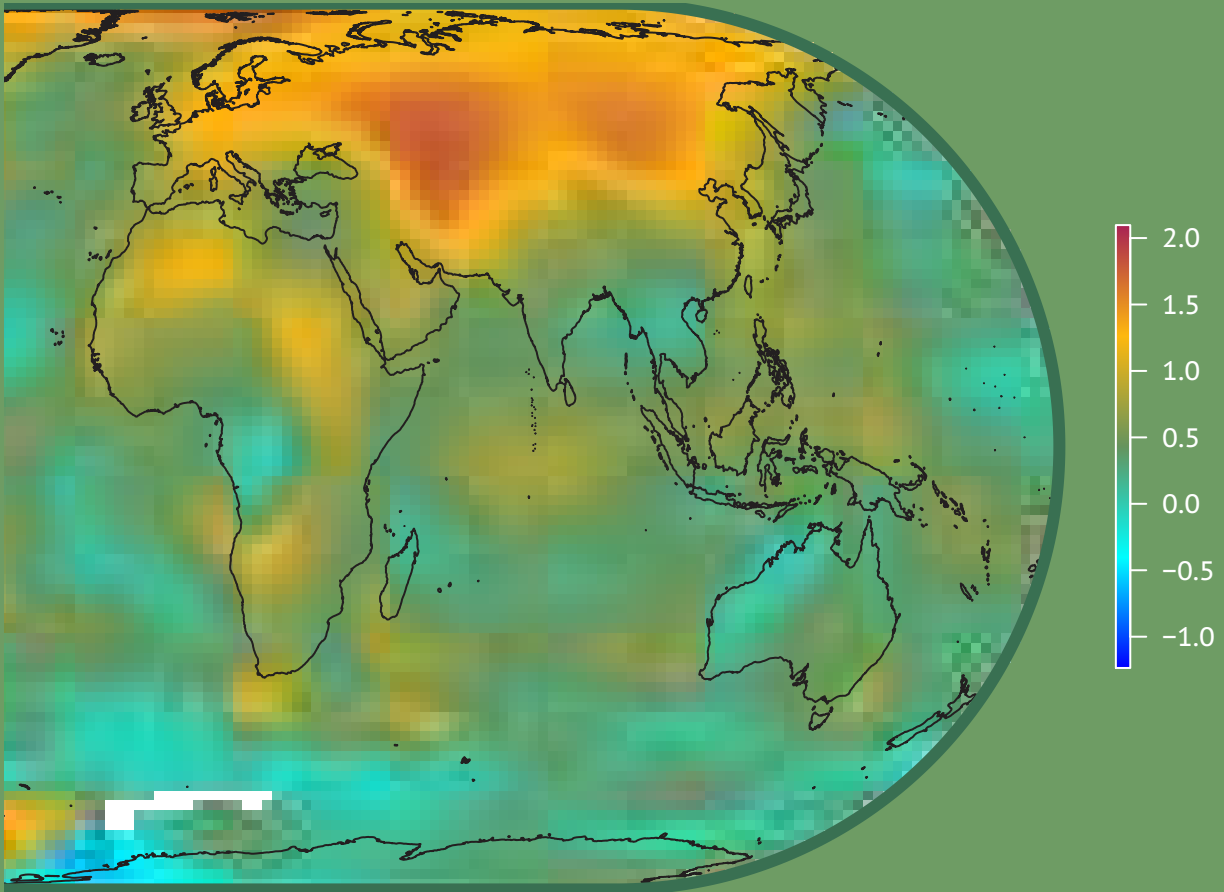
Map 62:



Source: IPCC

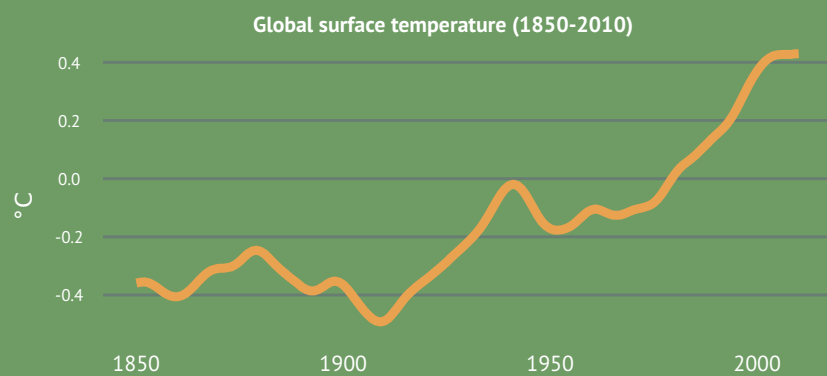
Metalink: [P4.ENV.IPCC.CC.GSTG, p. 349](#) 

- Global warming will have significant impacts on agriculture
- Most notably, these include rising surface temperatures, increasing carbon dioxide concentration and changing rainfall patterns
- The extent of these changes will determine the carrying capacity of bio systems to produce enough food



Global surface temperature (°C, Temperature difference of 2000–08 versus 1940–80)

Chart 109: Rising surface temperature is symptomatic of climatic change



Source: IPCC
 Metalink: P4.ENV.IPCC.CC.GST, p. 349

Runoff is also expected to decline dramatically in areas where annual potential evapotranspiration exceeds rainfall, such as in south eastern Australia where a 40 percent decrease is anticipated. Relatively small reductions in rainfall will translate into much larger reductions in runoff, for example, a 5 percent precipitation decrease in Morocco will result in a 25 percent reduction in runoff.

Although mean annual runoff may be less affected in glacier-fed river systems, the timing of flows will change, which could have critical consequences for agriculture. Where **rainfall** volume increases and becomes more intense (Indian monsoon, humid tropics), a greater proportion of runoff will occur as flood flow that should be captured in dams or groundwater to be useable.

About 40 percent of the world's irrigation is supported by flows originating in the Himalayas and other large mountain systems (e.g. Rocky Mountains in the western United States of America and Tien Shan in Central Asia). The loss of glaciers worldwide has been one of the strongest indicators of global warming. The impacts on some river systems (such as the Indus) are likely to be significant and will change the availability of surface water for storage and diversion as well as the amount of groundwater recharge.

As temperatures rise, the efficiency of photosynthesis increases to a maximum and then falls, while the rate of respiration continues to increase more or less up to the point that a plant dies. All else being equal, the productivity of vegetation thus declines once temperature exceeds an optimum. In general, plants are more sensitive to heat stress at specific earlier growth stages (sometimes over relatively short periods), than to seasonal average temperatures.

Increased atmospheric temperature will extend the length of the growing season in the northern temperate zones, but will reduce it almost everywhere else. Coupled with increased rates of evapotranspiration, water productivity and potential crop yields will fall. However, low yields and water productivity in many parts of the developing world do not necessarily mean that they will decline in the long term. Rather, farmers will have to make agronomic improvements to increase productivity from current levels.

Map 63:



Source: FAO, Land and Water Division (AQUASTAT)

Metalink: [P4.ENV.FAO.ACQ.CLIM.APD](#), p. 344 

- Average precipitation is the long-term average in depth (over space and time) of annual rainfall in a country
- Harvest outcomes in many countries are dependent on sufficient rainfall
- Over 90 percent of agriculture in sub-Saharan Africa, for example, is managed under rainfed systems

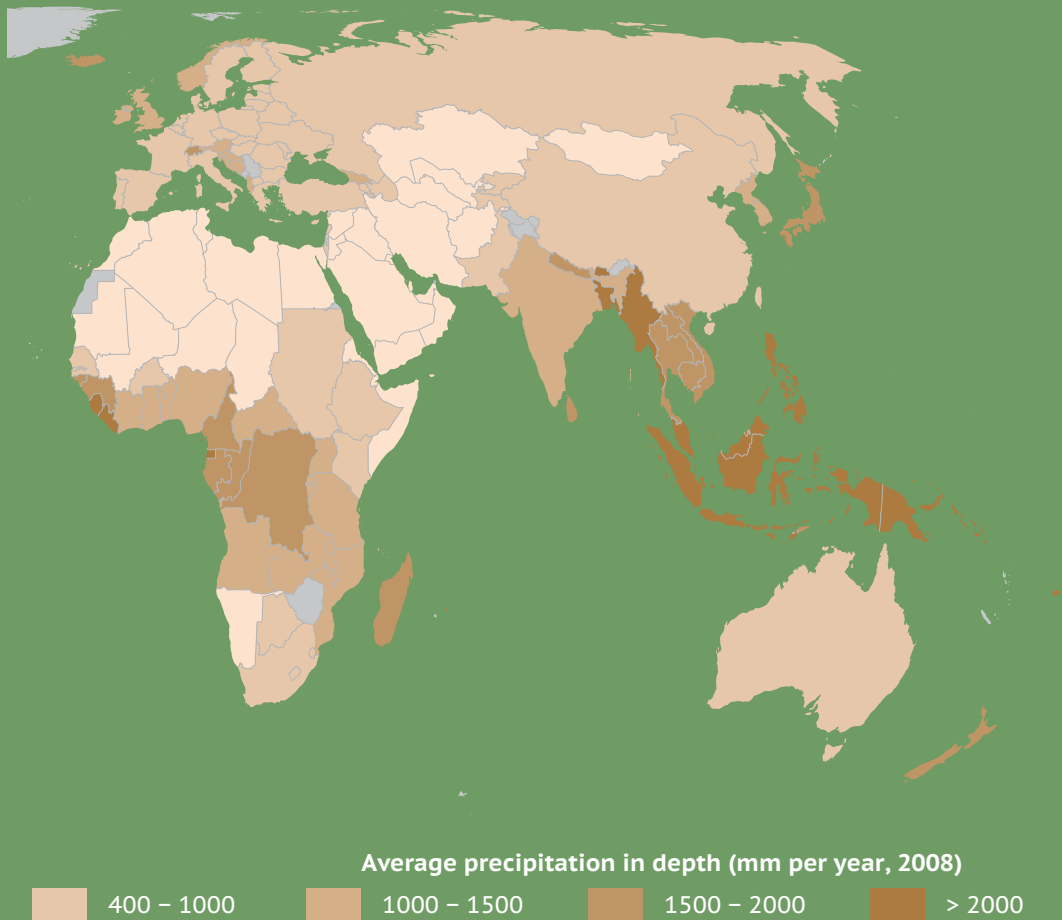
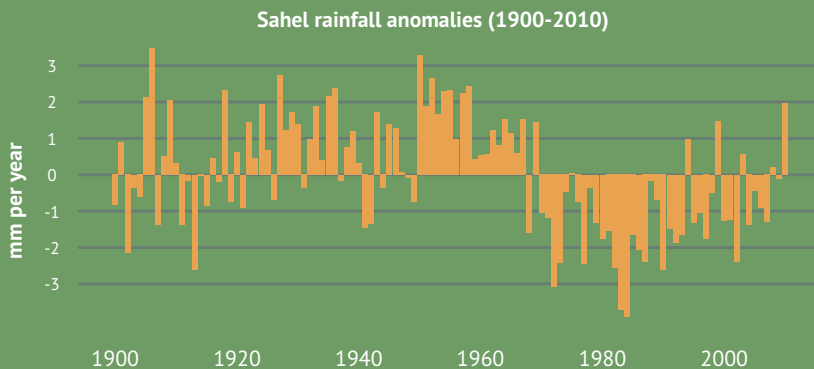


Chart 110: Despite a large increase in average rainfall in 2010, Sahel precipitation rates have been persistently below the long-term mean in recent decades



Source: JISAO
 Metalink: P4.ENV.JISAO.CLIM.SAHEL, p. 350

Increased atmospheric **concentrations of CO₂** enhance photosynthetic efficiency and reduce rates of respiration, offsetting the loss of production potential due to temperature rise. However, scientific evidence demonstrates that all factors of production need to be optimal to realize the benefits of CO₂ fertilisation.

Early hopes for substantial CO₂ mitigation of production losses from global warming have not materialized. Also, by the time CO₂ levels have doubled, temperatures will also have risen by 4 °C, negating any benefit.

Agriculture will also be impacted by more active storm systems, especially in the tropics, where cyclone activity is likely to intensify in conjunction with increasing ocean temperatures. The evidence of this is starting to emerge.

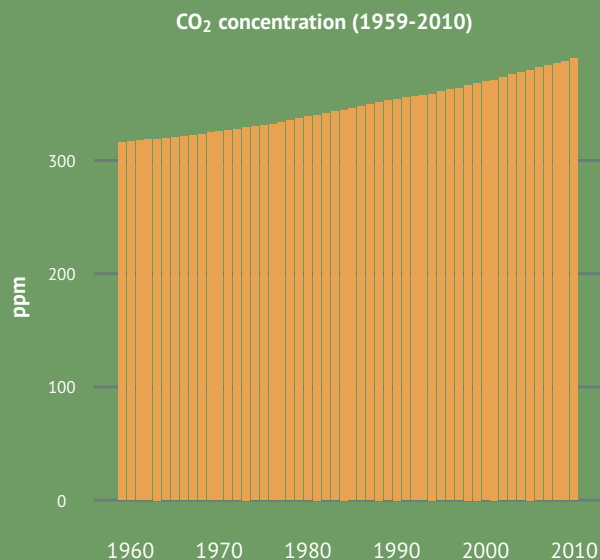
Sea level rise will affect drainage and water levels in coastal areas, particularly in low-lying deltas, and will result in saline intrusion into coastal aquifers and river estuaries.

In order to stabilize output and income, production systems must become more resilient, i.e. more capable of performing well in the face of disruptive events. More productive and resilient agriculture requires transformations in the management of natural resources (e.g. land, water, soil nutrients, and genetic resources) and higher efficiency in the use of these resources and inputs for production. Transitioning to such systems could also generate significant mitigation benefits by increasing carbon sinks, as well as reducing emissions per unit of agricultural product.

Further reading

- [FAO Climate Change \(www.fao.org/climatechange/\)](http://www.fao.org/climatechange/)
- [FAO Climate change, water and food security - FAO \(www.fao.org/docrep/014/i2096e/i2096e00.htm\)](http://www.fao.org/docrep/014/i2096e/i2096e00.htm)
- [FAO Energy-smart food for people and climate \(www.fao.org/docrep/014/i2454e/i2454e00.pdf\)](http://www.fao.org/docrep/014/i2454e/i2454e00.pdf)
- [Intergovernmental Panel on Climate Change \(IPCC\) \(www.ipcc.ch/\)](http://www.ipcc.ch/)

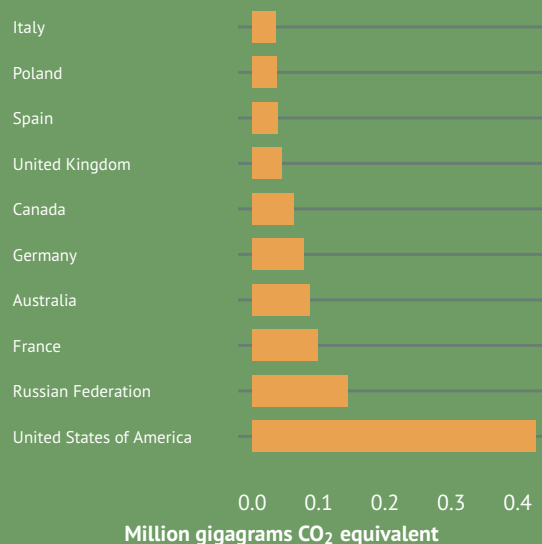
Chart 111: In the past two decades CO₂ concentration has risen by 10 percent. Land use and biomass burning account for over 9 percent of global CO₂ emissions



Source: IPCC
Metalink: P4.ENV.IPCC.CC.CO2, p. 349

Chart 112: Agriculture in the United States emits far more GHGs than any other country, and almost three times more than the next largest emitting country

Total Greenhouse Gas (GHG) emissions from agriculture (2008)



Source: World Bank
Metalink: P4.ENV.FAO.BIO.GHG.AG, p. 344

Biodiversity and conservation

Biodiversity concerns the degree of variation of life forms within a given ecosystem and is ultimately a measure of the health of ecosystems. Biodiversity for food and agriculture includes the components of biological diversity that are essential for feeding human populations and improving the quality of life. It includes the variety and variability of ecosystems, animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain human life as well as the key functions of ecosystems. Such diversity is the result of thousands of years of farmers' and breeders' activities, land and forest utilization, and fisheries and aquaculture activities combined with millions of years of natural selection. Much of the human population lives in areas where food production and nature co-exist together.

Agriculture's main impacts on biodiversity are diverse. For instance, the expansion of agriculture can lead to losses of natural wildlife habitat and reduction in the area of natural forests, wetlands and so on, with an attendant loss of species. It also causes a general decline in species richness in forests, pastures and field margins, and the reduction of wild genetic resources related to domesticated crops and livestock. Moreover, the observed reduction of micro-organisms that help sustain food and agricultural production is another way that agriculture's life support system has been damaged. The intensification of agricultural production is equally putting biodiversity at risk.

The conservation and sustainable use of biodiversity for food and agriculture plays a critical role in the fight against hunger, by ensuring environmental sustainability while increasing food and agriculture production. It is imperative to do so in a sustainable way: harvesting resources without compromising the natural capital, including biodiversity and ecosystem services, and capitalizing on biological processes.

To achieve sustainable increases in productivity and provide a sounder ecological basis for agriculture, a large reservoir of genetic and species diversity will need to be maintained and sustainably used. The use of multi-species and multi-breed herds and flocks is one strategy that many traditional livestock farmers use to maintain high diversity. Species combinations also enhance productivity in aquatic systems. Crop rotations, intercropping, alley farming and growing different varieties of a single crop have all been shown to have beneficial effects on crop performance, nutrient availability, pest and disease control and water management. Ensuring diversity will help maintain and rehabilitate productive ecosystems to supply future generations with abundant food and agriculture.

Further reading

- [FAO Biodiversity \(www.fao.org/biodiversity\)](http://www.fao.org/biodiversity)
- [UN International Year of Biodiversity 2010 \(www.fao.org/biodiversity/2010-international-year-of-biodiversity\)](http://www.fao.org/biodiversity/2010-international-year-of-biodiversity)

Map 64:



Source: World Bank

Metalink: [P4.ENV.WBK.WDI.CON.PROT](https://data.worldbank.org/indicator/P4.ENV.WBK.WDI.CON.PROT), p. 350 

- 12.5 million hectares of the world's land terrain is currently protected by law - but this represents a fraction of the world's land area
- What is more, protected areas are particularly scarce in countries that apply the most intensive production systems in agriculture

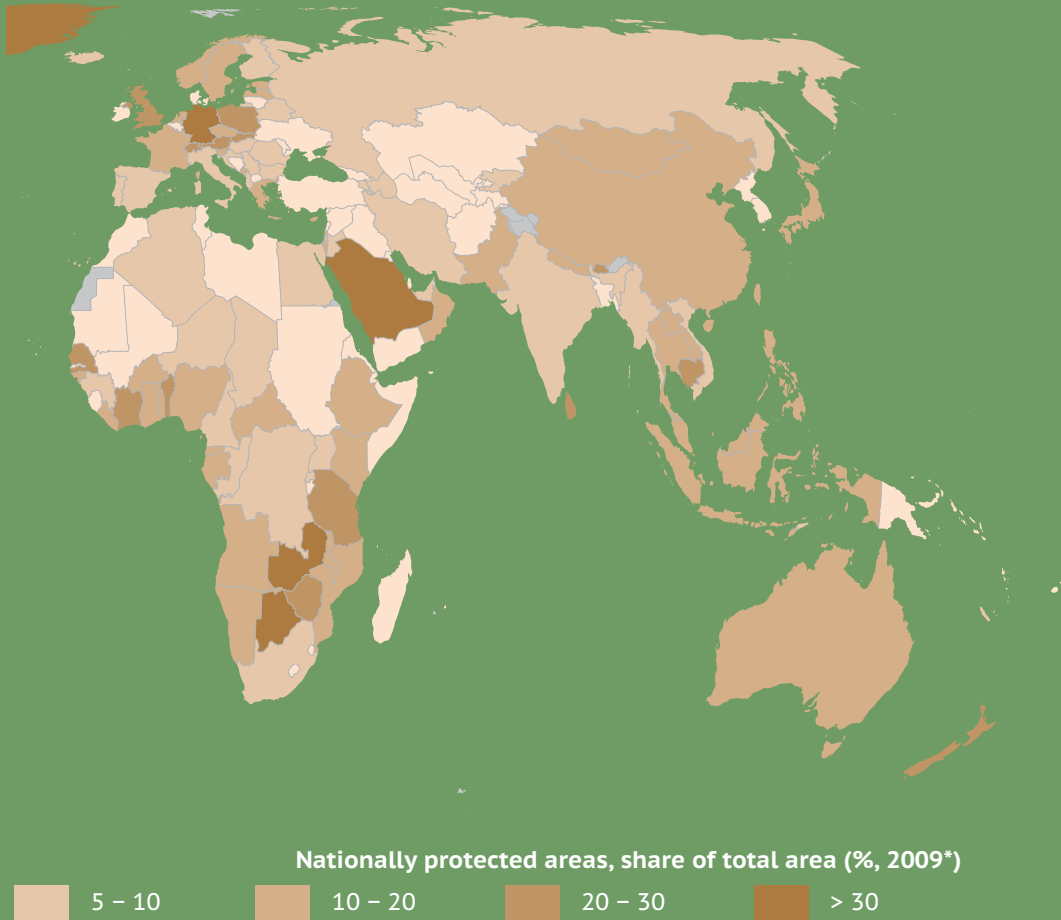
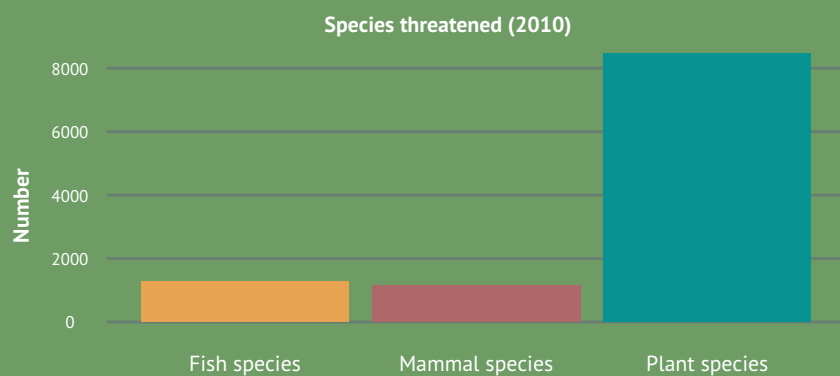


Chart 115: A large number of animal and plant species threatened from human activity including the intensification of agriculture



Source: World Bank

Metalink: P4.ENV.WBK.WDI.BIOD.PST, p. 350

Organic farming

Organic agriculture is a production management system that aims to promote and enhance ecosystem health, including biological cycles and soil biological activity. It is based on minimizing the use of external inputs, and represents a deliberate attempt to make the best use of local natural resources. Methods are used to minimize pollution of air, soil and water. Organic agriculture comprises a range of land, crop and animal management procedures, circumscribed by a set of rules and limits usually enforced by inspection and certification mechanisms. Synthetic pesticides, mineral fertilizers, synthetic preservatives, pharmaceuticals, Genetically Modified Organisms (GMOs), sewage sludge and irradiation are prohibited in all organic standards.

Growth rates of land under organic management in Western Europe, Latin America and the Caribbean, and the United States of America have been impressive despite low-base beginnings and the reclassification of land. Between 1995 and 2010, the combined area of organic cultivation tripled to 38 million hectares. A number of industrial countries have action plans for developing organic agriculture. Targets are set for the sector's growth and resources are allocated to compensate farmers during, and sometimes after, the conversion period, and also to support research and extension in organic agriculture.

Organic practices that encourage soil biological activity and nutrient cycling include: manipulating crop rotations and strip cropping; green manuring and organic fertilization (animal manure, compost, crop residues), minimum tillage or zero tillage and avoidance of pesticide and herbicide use. Research indicates that organic agriculture significantly increases the density of beneficial invertebrates, earthworms, root symbionts and other micro-organisms (fungi, bacteria). Properly managed organic agriculture reduces or eliminates water pollution and helps conserve water and soil on the farm.

At the international level, the general principles and requirements for organic agriculture are defined in the Codex Alimentarius guidelines adopted in 1999 and regularly updated between 2001 and 2010. The growing interest in organic crop, livestock and fish products is mainly driven by health and food quality concerns. However, organic agriculture does not make a product claim that its food is healthier or safer, but rather a process claim intending to make food production and processing methods respectful of the environment.

Map 65:



Source: FAO-FiBL-IFOAM

Metalink: [P4.ENV.FAO.BIO.ORGAN.HA](https://doi.org/10.1017/P4.ENV.FAO.BIO.ORGAN.HA), p. 345 

- 38 million hectares of land were organically farmed in 2009
- Oceania has more area under organic farming than any other region

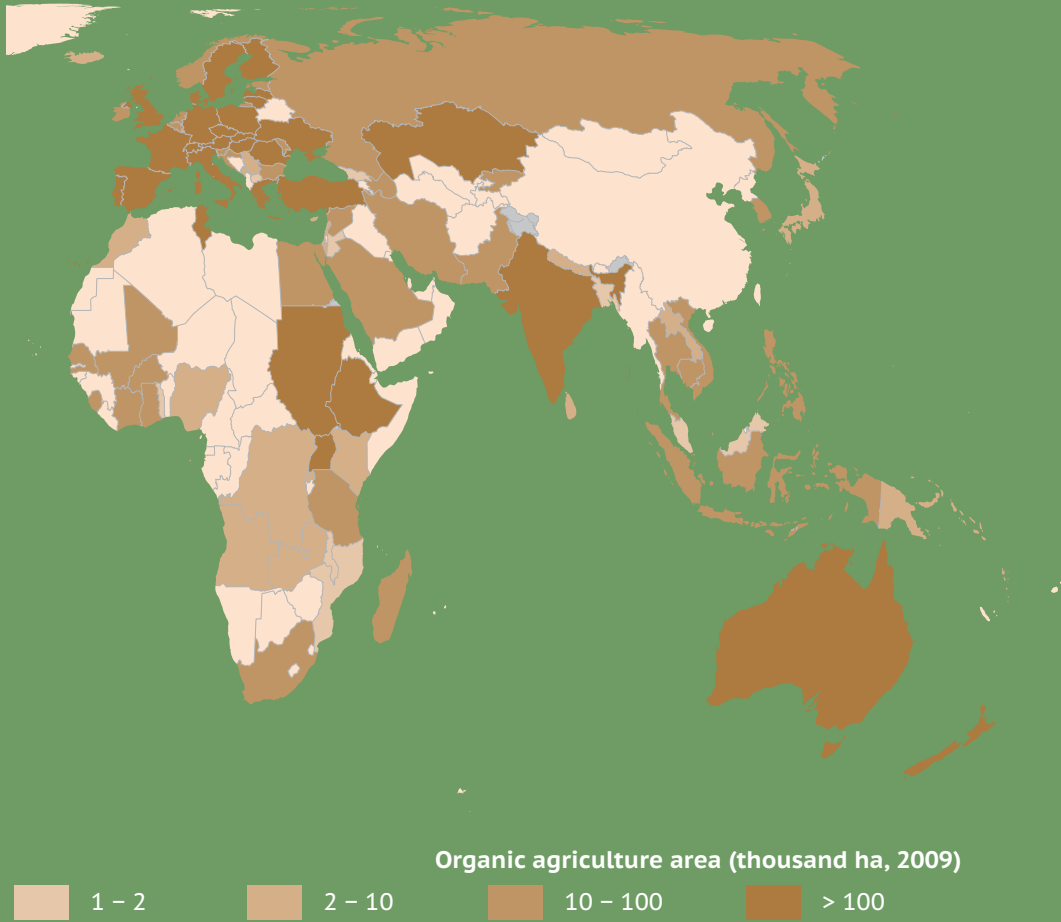
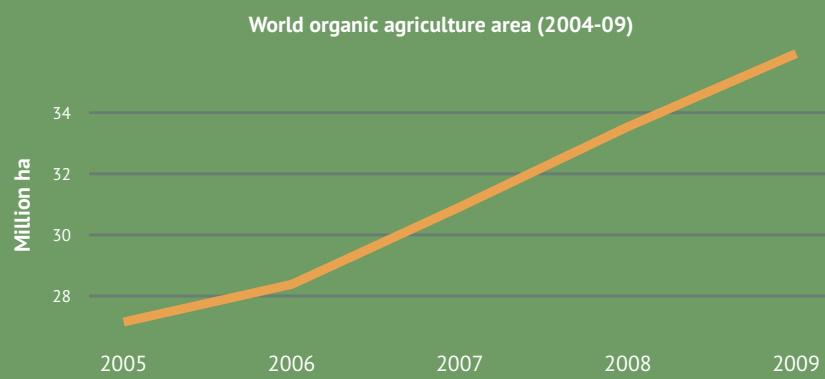


Chart 116: Organic area rose by almost 30 percent in the second half of the last decade



Source: FAO-FiBL-IFOAM

Metalink: [P4.ENV.FAO.BIO.ORGAN.HA](https://doi.org/10.1017/S1522203109990000), p. 345

Organic agriculture is not limited to certified organic farms and products. Non-certified products can be included as long as they fully meet the requirements of organic agriculture. This is the case for many non-certified organic agricultural systems in both developing and industrial countries where produce is consumed locally or sold directly on the farm or without labels.

Organic production systems can make important contributions to food supply stability and farmer livelihoods by establishing soil fertility and providing diversity and thus resilience to food production systems in light of the many uncertainties of climate change. In particular, they contribute positively to food stability in terms of fertile and well-structured soils, improved water retention, protection of biodiversity with beneficial side effects on phytomedical (plant health) stability and nutrients and efficient water use.

Thus far, organic agriculture has proven to be a relatively cheap and practical option to address climate instability. This option is based on scientific evidence for certain regions and extensive, though not scientifically documented, effective field application. Reports consistently show that organic systems have enhanced ability to withstand droughts and floods and maintain high resilience in the face of unpredictable impacts of climate change.

The deficits of organic agriculture are mainly related to lower productivity. However, the deficits should not be exaggerated. Significantly lower yields, those in the range of more than 20 to 30 percent compared to conventional agriculture, occur mostly in cash-crop-focused production systems and under most favourable climate and soil conditions.

Map 66:



Source: FAO-FiBL-IFOAM

Metalink: P4.ENV.FAO.BIO.ORGAN.SHA, p. 345 

- Despite significant growth in organic farming, as a percentage of overall area cultivated, the sector remains miniscule in comparison
- In Europe the percentage of agricultural area allocated to organic farming rises to single digit levels, but elsewhere a fraction of a percentage point is common

Further reading

- FAO Organic Agriculture (www.fao.org/organicag/en/)
- FAO Organic Agriculture and Environmental Stability of the Food Supply - FAO (<ftp://ftp.fao.org/docrep/fao/meeting/012/ah950e.pdf>)

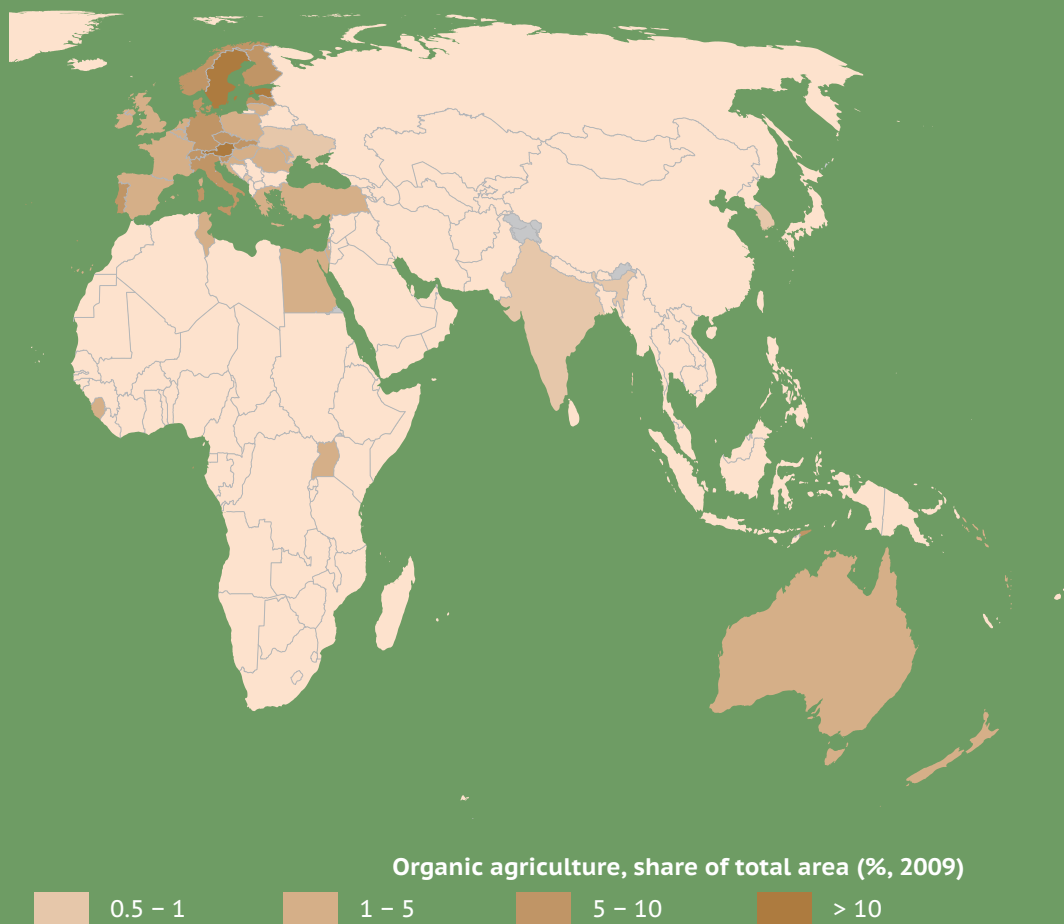
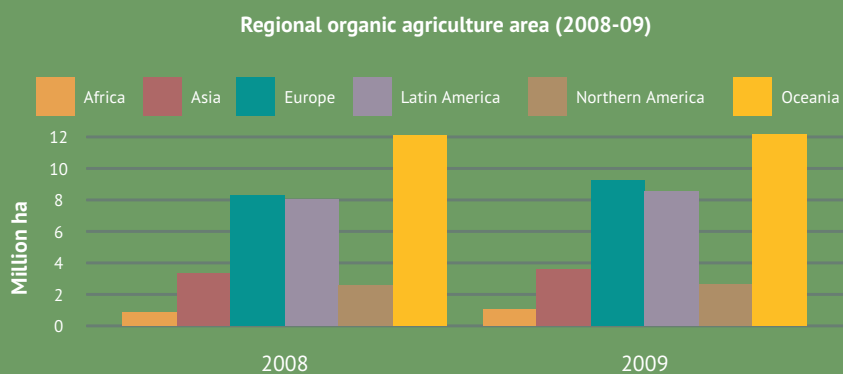


Chart 117: Europe added an extra one million hectares of organically farmed area in 2009



Source: FAO-FiBL-IFOAM

Metalink: P4.ENV.FAO.BIO.ORGAN.HA, p. 345 