Water

A very small proportion of the planet's water is available for human use. Around 2.5 percent of the world's water is freshwater. Of this 2.5 percent, more than two-thirds is locked away in glaciers, ice caps and permafrost. About 30 percent is groundwater, with the remaining 1.3 percent of the world's total freshwater being surface water in rivers and other forms such as ice and snow, and lakes and swamps.

Global demand for water has risen sharply within the last century. At the beginning of the twentieth-century, each person withdrew 360 m^3 of water on average per year. By the year 2005 this had risen to 607 m^3, while total annual water withdrawal by agriculture, industry and municipalities together rose from 580 km^3 to 3941 km^3 over the same period.

Precipitation provides some of the water needed by crops to satisfy their transpiration requirements. The soil, acting as a buffer, stores part of the precipitation water as soil moisture and returns it to the crops in times of deficit. In humid climates, this mechanism is usually sufficient to ensure satisfactory growth in rain-fed agriculture. In arid climates or during the dry season, irrigation is required to compensate for the deficit resulting from insufficient or erratic precipitation.

Today, agriculture accounts for about 70 percent of the **freshwater withdrawals** in the world, mostly through irrigation. This has been crucial for gains in food production. Irrigation reduces drought risk and encourages crop diversification, thus enhancing rural incomes.

Consumptive use of **irrigation water** can be computed as the volume of water needed to compensate for the deficit between potential evapotranspiration of plants and effective precipitation over the crop's growing period. The pressure of irrigation on water resources can be defined as the share of water withdrawal in total renewable water resources.

While the pressure on water resources from irrigation was estimated at 6.5 percent for the world as a whole in 2005, there was wide variation across countries and regions. In the Near East/North Africa region and Central Asia, for instance, pressure on water resources from irrigation is estimated at 58 percent, while it holds at 52 percent in South Asia. On the other hand, in sub-Saharan Africa it is less than 3 percent. Variations are even wider at the country level. This indicates that some countries are already beyond the critical level, and their condition may even worsen with time.

Increasing **water productivity** is therefore critical in these countries. And, more generally, it is necessary to reduce over-extraction of groundwater, increase the infiltration of rainwater into soils and reduce the deterioration of water quality owing to waterlogging and salinization. Some of these phenomena are fuelled by agricultural intensification, which affects water availability through increased contamination of groundwater and surface water from fertilizers, pesticides and animal wastes.

Map 57:

No Data < 300

Source: FAO, Land and Water Division (AQUASTAT)

Metalink: P4.ENV.FAO.NRL.WAT.TWWpc, p. 348

- In 2005, 3941 km^3 of water was withdrawn for agricultural, industrial and municipal purposes, representing on average 607 m^3 per person
- 70 percent of global water withdrawals accounted for by agriculture
- Increasing water scarcity increases the competition for water by different sectors

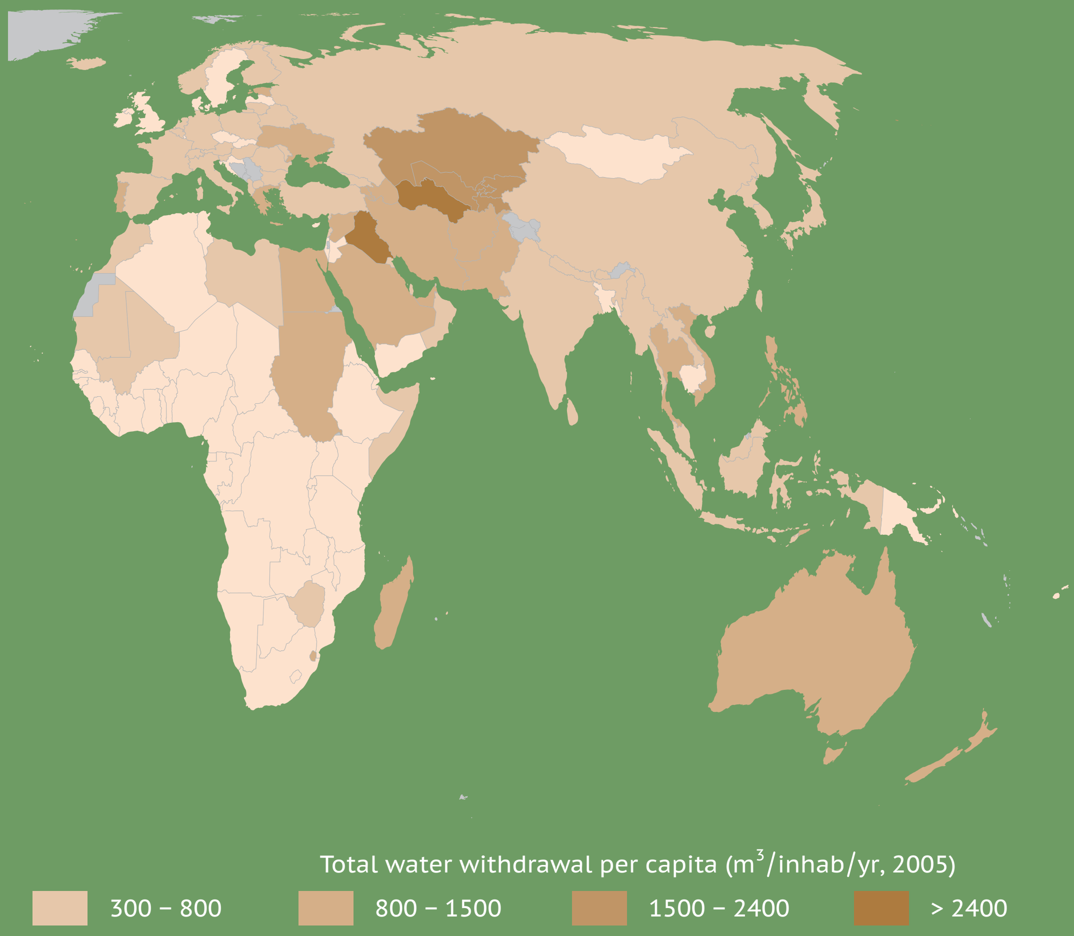
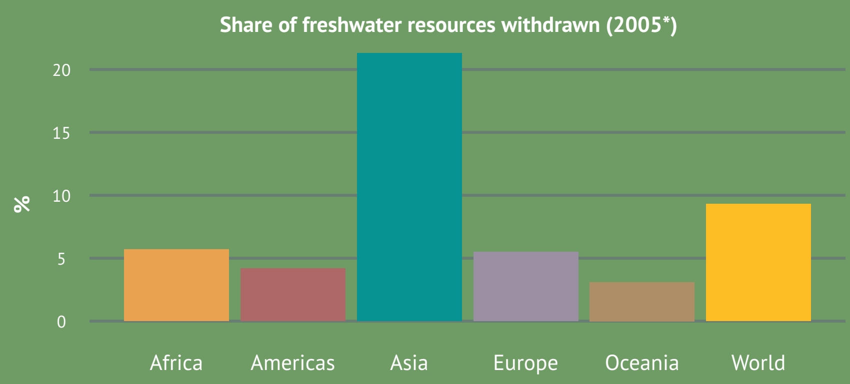


Chart 104: Share of freshwater resources withdrawn highest in Asia, owing to large annual withdrawals by countries in the west of the region



Source: FAO, Land and Water Division (AQUASTAT)

Metalink: P4.ENV.FAO.NRL.WAT.WWfr, p. 348

Widespread and largely unregulated groundwater withdrawals by agriculture have resulted in depletion and degradation of some of the world's most accessible and high-quality aquifers. Examples exist in the Central Valley in California, the Ogallala aquifer in the US Great Plaines, the Punjab in Pakistan, the North China Plain, the Souss basin in Morocco and parts of India. In some coastal areas, over-extraction causes saltwater to permeate into freshwater aquifers, making them unfit for irrigation or drinking water without costly treatment.

Irrigation mismanagement can also contribute to waterlogging and **salinization**. Waterlogged soil results from over-irrigation and inadequate drainage. It restricts plant growth and in many cases precedes salinization. Generally, salinization results from the build-up of dissolved solids in soils, and can also occur in rain-fed areas with inherently susceptible soils.

The United Nations Environmental Programme (UNEP) considers salinization to be the second largest cause of land loss. In some semi-arid countries, 10 to 50 percent of the irrigated area is affected to a greater or lesser degree with average yield decreases of 10 to 25 percent for many crops. Worldwide, FAO estimates that 34 million hectares (11 percent of the irrigated area) are affected by some level of salinization; Pakistan, China, United States of America and India represent more than 60 percent of the total (21 million ha). An additional 60-80 million hectares are affected to some extent by waterlogging and related salinity.

Appropriate measures need be implemented to limit over-extraction, waterlogging and salinization that can lead to considerable losses of irrigated land and result in unsustainably high operating costs.

Climate change prospects make such measures even more urgent. Given the likely increase of associated risks, such as aridity and further increases in soil moisture deficits, improving water management becomes even more crucial. Sustainable land and water management can not only increase resilience of farming in the face of climate change, but it can also have a positive impact on the drivers of climate change, offering cost-effective mitigation options. Many management techniques that strengthen productions systems also tend to sequester carbon either above or below the ground, as well as reducing direct greenhouse gas emissions.

Further reading

- FAO The State of the World's Land and Water Resources for Food and Agriculture (SOLAW): managing systems at risk 2011 (www.fao.org/nr/solaw/solaw-home/en/)
- FAO Water (www.fao.org/nr/water/)
- FAO AQUASTAT (www.fao.org/nr/aquastat/)

Map 58:

Source: FAO, Land and Water Division (AQUASTAT)

Metalink: P4.ENV.FAO.NRL.WAT.WWfrag, p. 348

- Measured against the sum of all renewable water resources, withdrawal by agriculture accounts for a significant share in some regions
- In water scarce regions, such as the Near East and North Africa, agricultural withdrawal can exceed 100 percent of freshwater resources
- In these instances, water is extracted from non-renewable aquifers (fossil water), desalination plants or from recycling

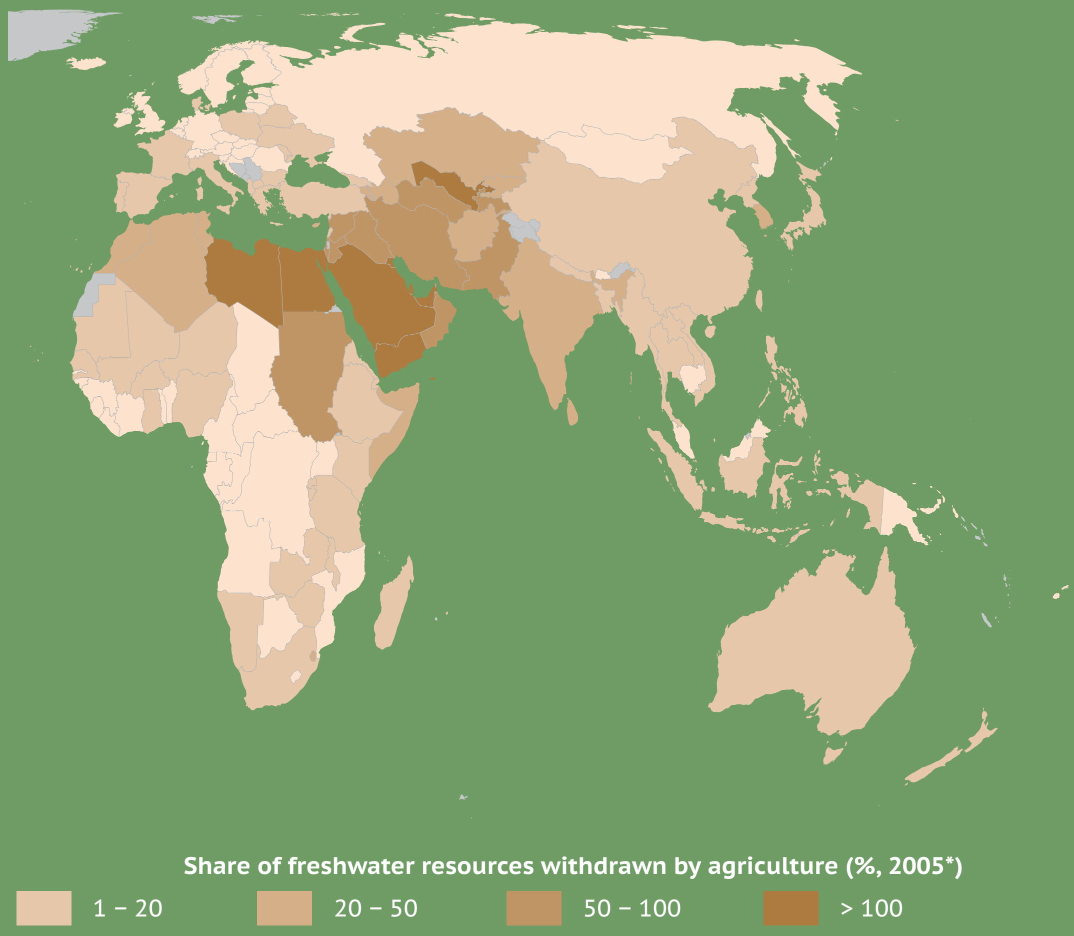
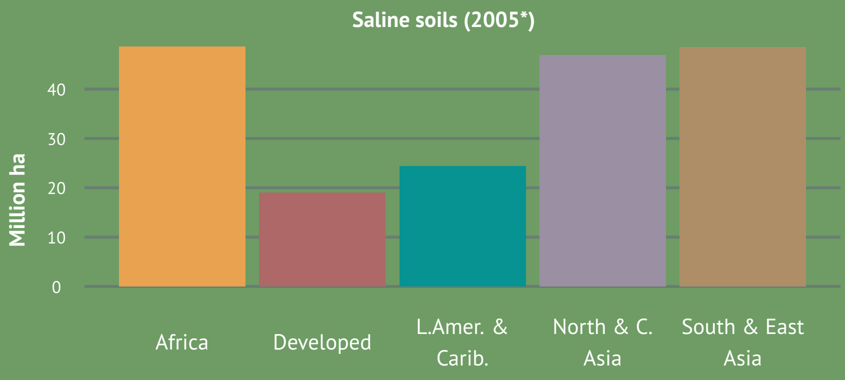


Chart 105: Around 168 million hectares of developing country land affected by salinity



Source: FAO, Statistics Division

Metalink: P4.ENV.FAO.POL.SAL, p. 349

Pollution from agriculture

Public attention tends to focus on the more perceptible signs of agriculture's impact on the environment, but the non-visible or less obvious effects of pollution have the greatest economic costs.

Agriculture affects air quality and the atmosphere in four main ways: 1) particulate matter and Greenhouse Gases (GHGs) from land clearance by fire (mainly rangeland and forest) and the burning of rice residues; 2) methane from rice and livestock production; 3) nitrous oxide from fertilizers and manure; and 4) ammonia from manure and urine.

Pollution from agriculture is not confined to atmospheric contaminants; the same pollutant sources – especially runoff from fertilizers, pesticides and animal wastes – can affect both groundwater and as well as surface water.

Pollution problems caused by agriculture are by no means insurmountable. Industry has shown that the environmental impact of agricultural pollution can be moderated through better management and regulation.

Soot, dust and trace gases are released by biomass burning during forest, bush or rangeland clearance for agriculture. Burning is traditionally practised in "slash and burn" tropical farming, in firing of savannah regions by pastoralists to stimulate forage growth and in clearing of fallow land and disposing of crop residues, particularly rice. Burning has had major global impacts, causing air pollution in tropical regions far from the source of the fires.

Agriculture now contributes about 30 percent of total global anthropogenic (human induced) **emissions of GHGs**. There is increasing concern not just with carbon dioxide but also with the growth of agricultural emissions of other greenhouse producing gases such as methane, nitrous oxide and ammonia arising from crop and livestock production. In some countries these can account for more than 80 percent of GHG emissions from agriculture. The conversion of tropical forests to agricultural land, the expansion of rice and livestock production and the increased use of nitrogen fertilizers have all been significant contributors to GHG emissions.

Map 59:

Source: World Bank

Metalink: P4.ENV.WBK.WDI.POL.MTHEA, p. 351

- Methane is a principal greenhouse gas driving climate change
- It has a warming potential 20 times more powerful than carbon dioxide
- Global methane emissions currently amount to about 540 million tonnes per annum with agriculture contributing around 40 percent

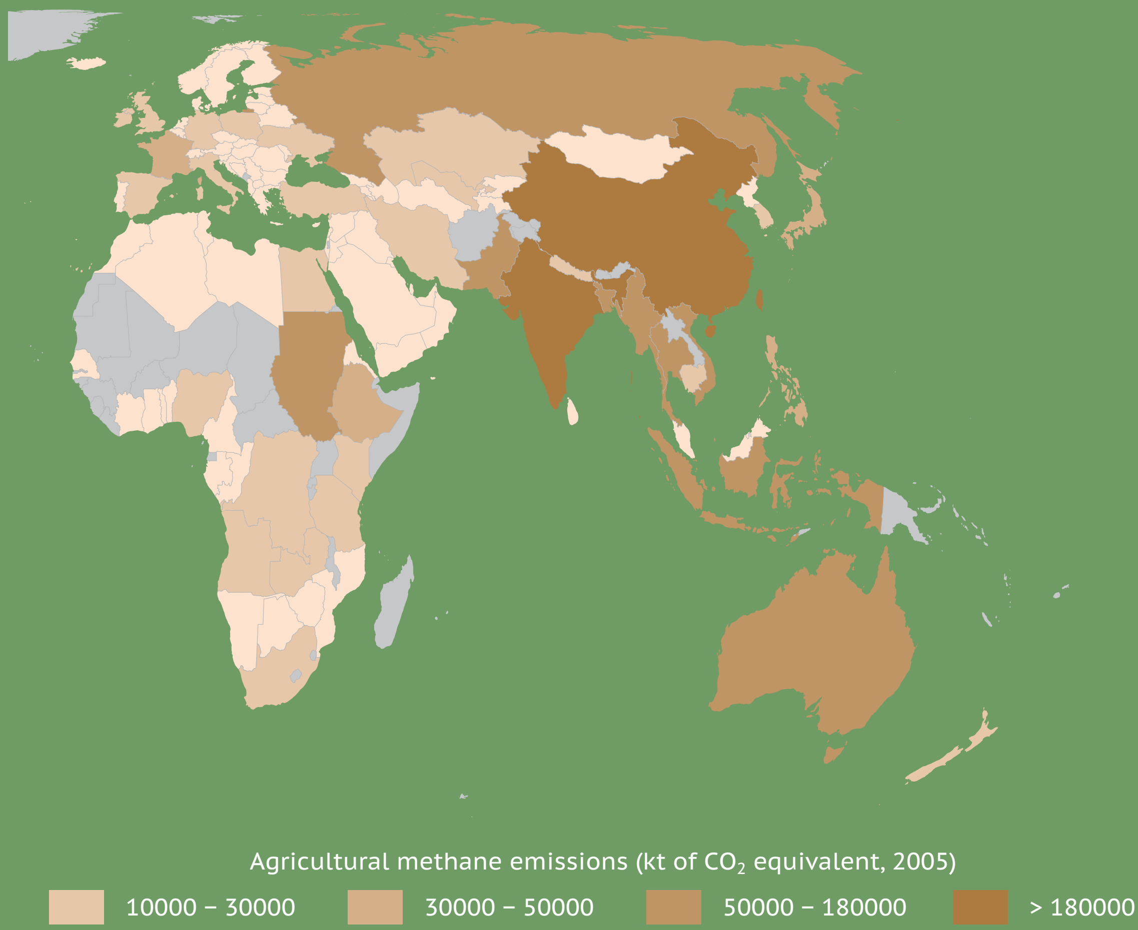
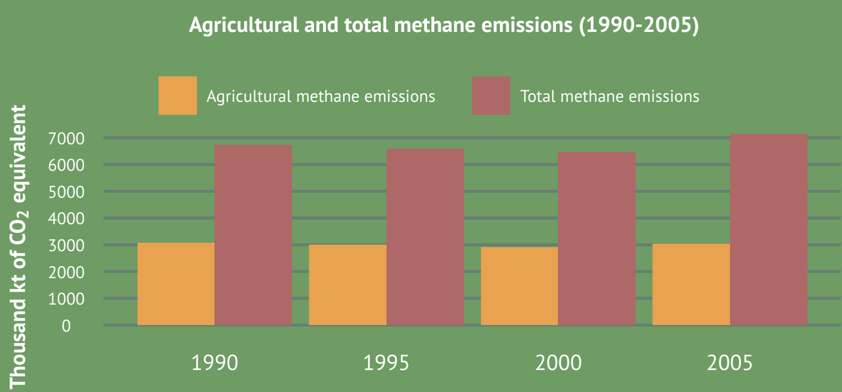


Chart 106: Despite a reduction in recent years, agriculture still accounts for more than 40 percent of total methane emissions



Source: World Bank

Metalink: P4.ENV.WBK.WDI.POL.MTHEA, p. 351

Methane is a principal GHG driving climate change. Its warming potential is about 20 times more powerful than carbon dioxide. Global methane emissions amount at present to about 540 million tonnes per annum, increasing at an annual rate of 20-30 million tonnes. Rice production currently contributes about 11 percent of global methane emissions (up to 90 percent of the methane from rice fields is emitted through the rice plant). Depending on the extent and level of intensification, around 15 percent comes from livestock (from enteric fermentation by cattle, sheep and goats and from animal excreta). The storage of manure in a liquid or waterlogged state is another principal source of methane emissions from agriculture – these are conditions typical of the lagoons, pits and storage tanks used by intensive stall-feeding systems.

But there are solutions. For instance, as ruminant production structures in developing countries evolve towards those found in industrial ones, the lessons of improved feed intake and digestibility can significantly lower emissions per animal. Regarding the storage of manure, when appropriate technologies are introduced to harness methane in local power production, as has been done in some South and East Asian countries, environmental impacts can even become beneficial. Finally, as a greater proportion of rice is being grown under controlled irrigation and better nutrient management, methane emissions are potentially manageable.

Nitrous oxide (N_2O) is the other powerful GHG for which agriculture is the dominant human-induced or anthropogenic source. Mineral fertilizer use and cattle production are the main culprits. N_2O is generated by natural biogenic processes, but is enhanced by agriculture through nitrogen fertilizers, the creation of crop residues, animal urine and faeces, and nitrogen leaching and runoff. N_2O formation is sensitive to climate, soil type, tillage practices and type and placement of fertilizer. It is also linked to the release of nitric oxide and ammonia, which contribute to acid rain and the acidification of soils and drainage systems. Nitrogen fertilizer, a major source of nitrous oxide emissions, is used very inefficiently in many developing countries. In China, for example, the world's largest nitrogen fertilizer consumer, it is not uncommon for half to be lost by volatilization and 5 to 10 percent by leaching.

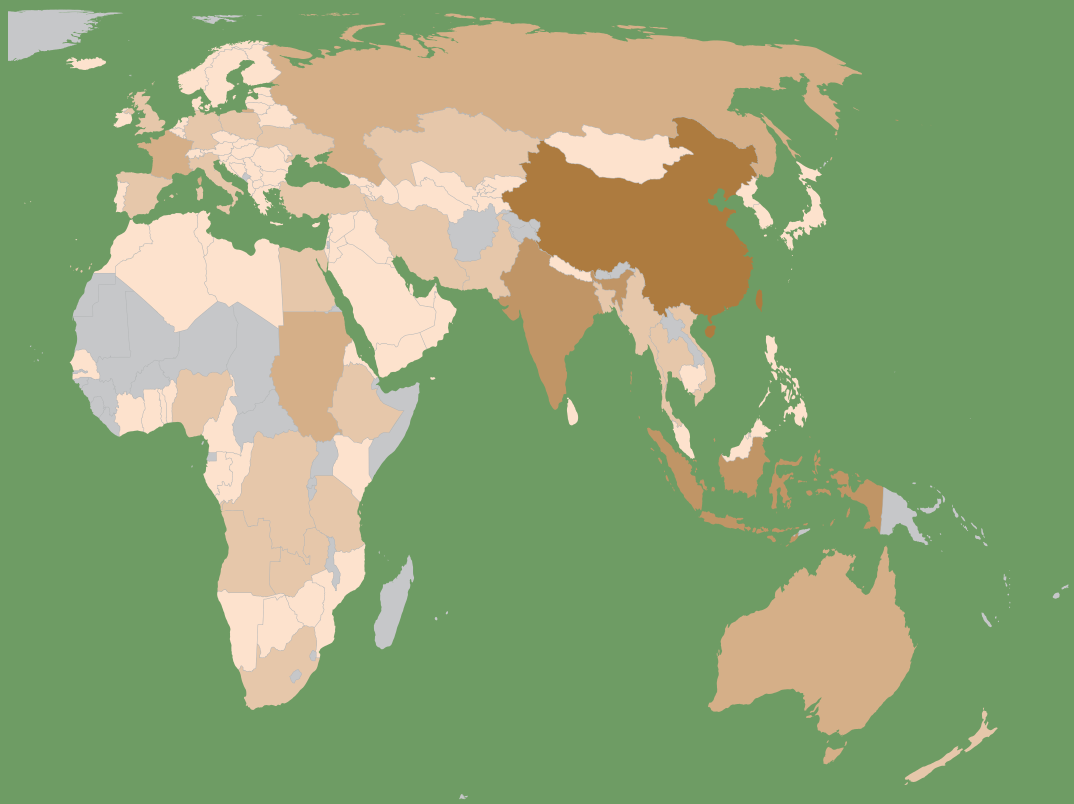
The livestock sector is the other major source of N_2O emissions resulting from the breakdown (nitrification-denitrification) of manure applied as fertilizer primarily to crops but also to pastures. In developed countries, only about 15 percent of the nitrogen applied to crops is thought to be derived from livestock manure. In developing countries, the relative contribution of livestock manure can be high but is not well documented. However, where growth in industrial-scale livestock production is separate from crop production, where labour availability is low and where subsidies are available, the trend is to rely more on mineral fertilizers to maintain or raise crop yields.

Map 60:

Source: World Bank

Metalink: P4.ENV.WBK.WDI.POL.NOEA, p. 351

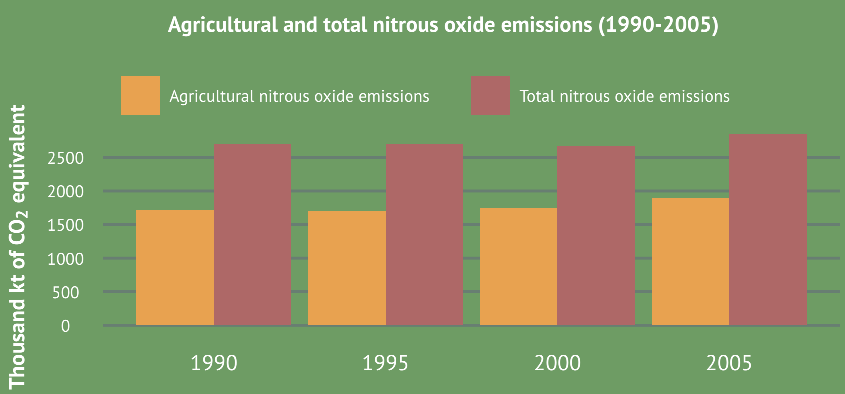
- Nitrous oxide is the other powerful green house gas for which agriculture is the dominant human-induced source
- Around two-thirds of total nitrous oxide emissions are attributed to agriculture
- Major sources of emissions are fertilizer production and livestock rearing



Agricultural nitrous oxide emissions (kt of CO_2 equivalent, 2005)

10000 – 30000 | 30000 – 50000 | 50000 – 180000 | 346981

Chart 107: Agriculture accounts for more than 66 percent of total nitrous oxide emissions, and rising



Source: World Bank

Metalink: P4.ENV.WBK.WDI.POL.NOEA, p. 351

Agriculture is the dominant source of **ammonia** emissions, which are nearly fourfold greater than natural emissions. Livestock production, particularly of cattle, accounts for about 44 percent of ammonia emissions, mineral fertilizers for 17 percent and biomass burning and crop residues for about 11 percent, of the global total. Volatilization rates from mineral fertilizers in developing countries are about four times greater than in developed countries because of higher temperatures and lower quality fertilizers. Ammonia emissions are potentially even more acidifying than emissions of sulphur dioxide and nitrogen oxides.

Concerning **water pollution** by agriculture, extensive leaching of nitrates from soils into surface water and groundwater, which was traditionally an issue in almost all industrial countries, is now becoming a problem in many developing countries. It poses a risk to human health and contributes to eutrophication of rivers, lakes and coastal waters. The bulk comes from diffuse sources arising from mineral fertilizer and manure use on both crops and grasslands. The problem occurs primarily when nitrogen application rates exceed crop nutrient uptake. The risk depends on crop type and yield, soil type and underlying rocks. However, extensive areas in both developed and developing countries already receive large nitrogen fertilizer applications in commensurate with the availability of adequate soil moisture, other nutrients and management practices employed to attain higher yields.

Pesticide use, the cause of serious water pollution in many industrialized countries, is now appearing in developing countries as well, and is exacerbated by the availability of cheap, out-of-patent, locally produced chemicals. Shortages of farm labour, reduced use of flood irrigation for rice and the spread of minimal tillage systems are leading to major increases in the use of herbicides. Water pollution also arises from intensive dairying and landless rearing of pigs and poultry, particularly in East Asia. The problem arises from discharges or runoff of nitrogen and other nutrients into surface waters because of bad waste management.

Further reading

- FAO Natural Resources Department (www.fao.org/nr/nr-home/en/)
- Bruinsma (2003)

Map 61:

No Data | < 10

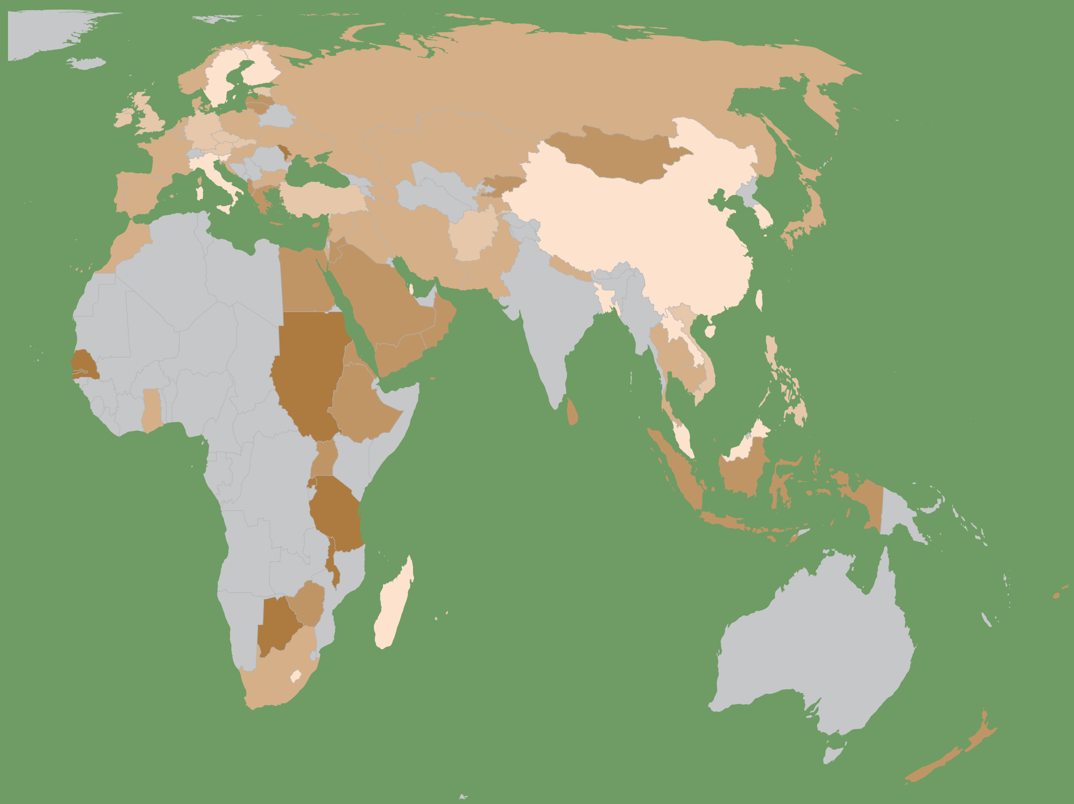
Source: World Bank

Metalink: P4.ENV.WBK.WDI.POL.WATF, p. 351

→ Water pollution is becoming a serious concern in many developing countries

→ In lower income countries, the contribution of the food sector to the production of organic water pollutants amounts to 54 percent, compared to 40 percent in high-income countries

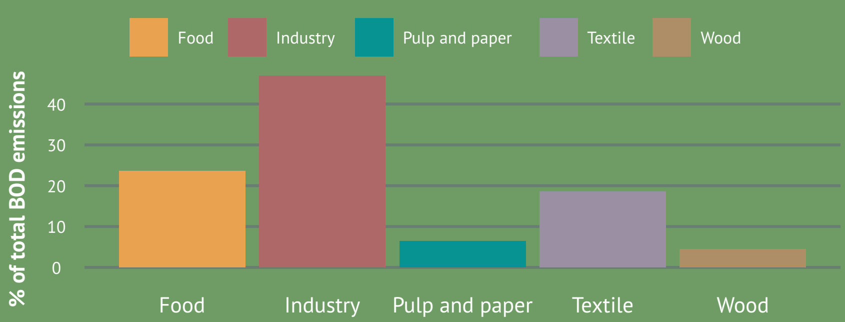
→ Unregulated livestock waste management and fertilizer applications result in the substantial leaching of nitrates from soils into surface water and groundwater



Water pollution, food industry (% of total BOD emissions, 2007*)

Chart 108: The food sector is a significant source of water pollution but industry dominates

Pollution by sector in total BOD emissions (2007*)



Source: World Bank

Metalink: P4.ENV.WBK.WDI.POL.WAT, p. 351