Agrochemicals

World food production has approximately doubled since 1960, largely as a result of the introduction of new crop varieties and the intensification of agriculture – supported by increased applications of fertilizers and pesticides. But some scientists suggest that population and economic growth worldwide have raised the demand for food beyond levels that can be supported by extensive and environmentally benign farming[1].

At the end of the 20th century an average of 91 kilos of fertilizer were used on each hectare of the world's cropland, an increase of more than a third since the mid-1970s. This masks huge variations, from just 1 kilo in Rwanda or Mongolia, to more than 700 in Switzerland. Since the mid-1980s, use per hectare in the developed world has declined from 121 kilos to around 81 kilos – a time during which its agricultural production remained almost static.

In the developing world between the mid-1980s and mid-1990s, agricultural production and fertilizer use both increased by almost 42 percent, the latter from an average of 63 kilos per hectare of cropland. Consumption of fertilizers and its growth were highest in Asia, while in Africa usage has actually fallen since the 1980s – from 19 kilos per hectare to 18. The Food and Agriculture Organization of the United Nations predicts further rises in the developing world, probably of around 2.8 percent per year[3] from current levels of almost 99 kilos of fertilizer per hectare of cropland.

The benefits are increased supplies of food, but problems arise when significant amounts of fertilizer escape into the wider environment – for example through the leaching and runoff of fertilizers into ground and surface waters. Elevated nitrate levels in drinking water, recognized as a threat to human health, have been found in 6 percent of wells surveyed by the Environmental Protection Agency in the United States; in the United Kingdom, where over a million people's supply was found to have levels in excess of European legal limits; and in the drinking waters of Sao Paulo, Brazil and Buenos Aires, Argentina. As nitrates take many years to penetrate groundwater, these problems could increase as a result of the heavy applications of fertilizers in the recent past.

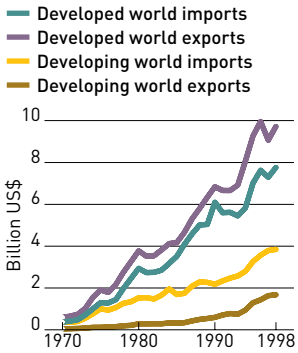
High nitrate and phosphorus levels in rivers, lakes and coastal waters disrupt the balance of aquatic habitats through the process of eutrophication. In freshwaters, high phosphorus levels encourage excessive algal growth and create murky green waters which shade out bottom-rooting plants, impacting invertebrates and fish that depend on such plants for food and shelter. Similarly in coastal and estuarine waters, excessive nitrate inputs boost algae and turbidity, and promote filter-feeding worms and bivalves – effects that may be particularly damaging for coral reefs.

Massive agglomerations of algae known as blooms cause deaths of aquatic life on a huge scale. In 1996 a bloom smothered invertebrates over several hundred square kilometers off Scotland's west coast[4], and in 1998 a bloom off California poisoned more than 400 sea lions[5]. Filter-feeding shellfish such as mussels and oysters can become toxic as they absorb algae from the water. In most developed countries shellfisheries are now monitored to guard against related outbreaks of poisoning, which are becoming increasingly frequent.

Natural pesticides

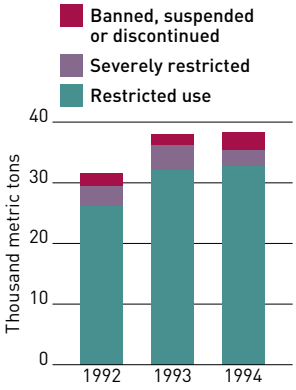
In India, seeds of the neem tree are used as a natural insecticide, protecting crops and stored grain from up to 200 species of pest including locusts, maize borers and rice weevils. But the neem does not harm birds, mammals or beneficial insects such as bees.

THE WORLD TRADE IN PESTICIDES



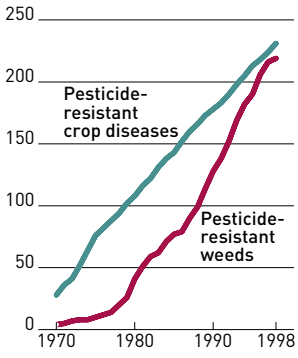
Source: FAO.

EXPORTS OF BANNED OR RESTRICTED PESTICIDES FROM US PORTS



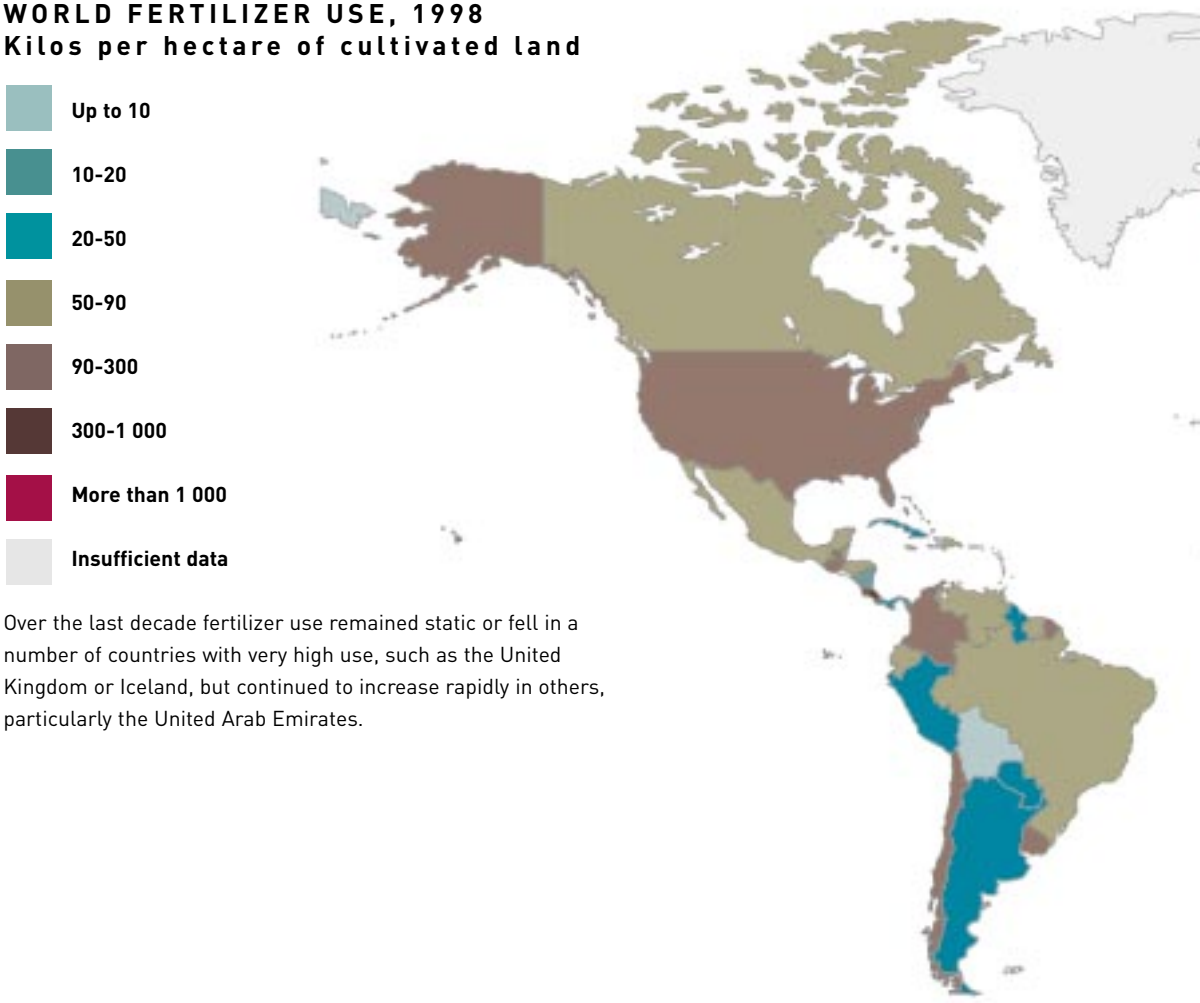
Source: FASE.

RESISTANCE TO PESTICIDES



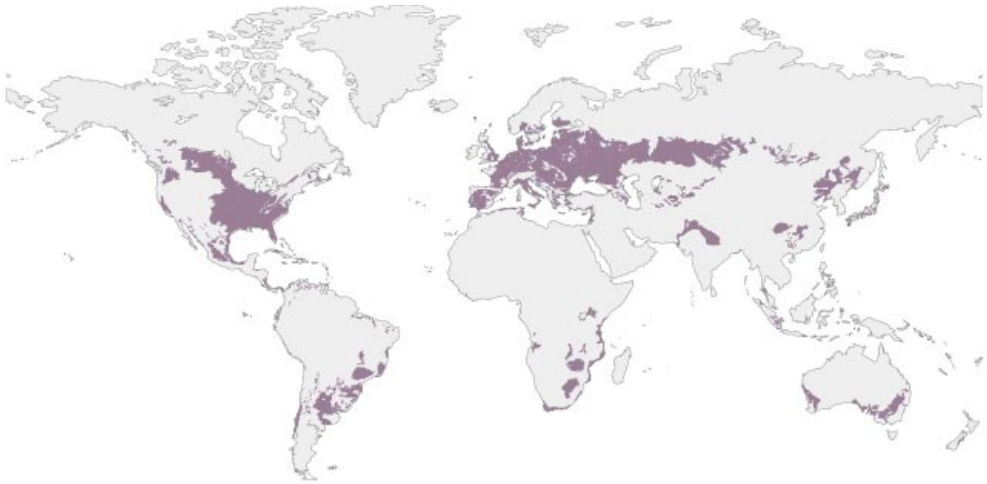
Source: Worldwatch Institute.

WORLD FERTILIZER USE, 1998
Kilos per hectare of cultivated land

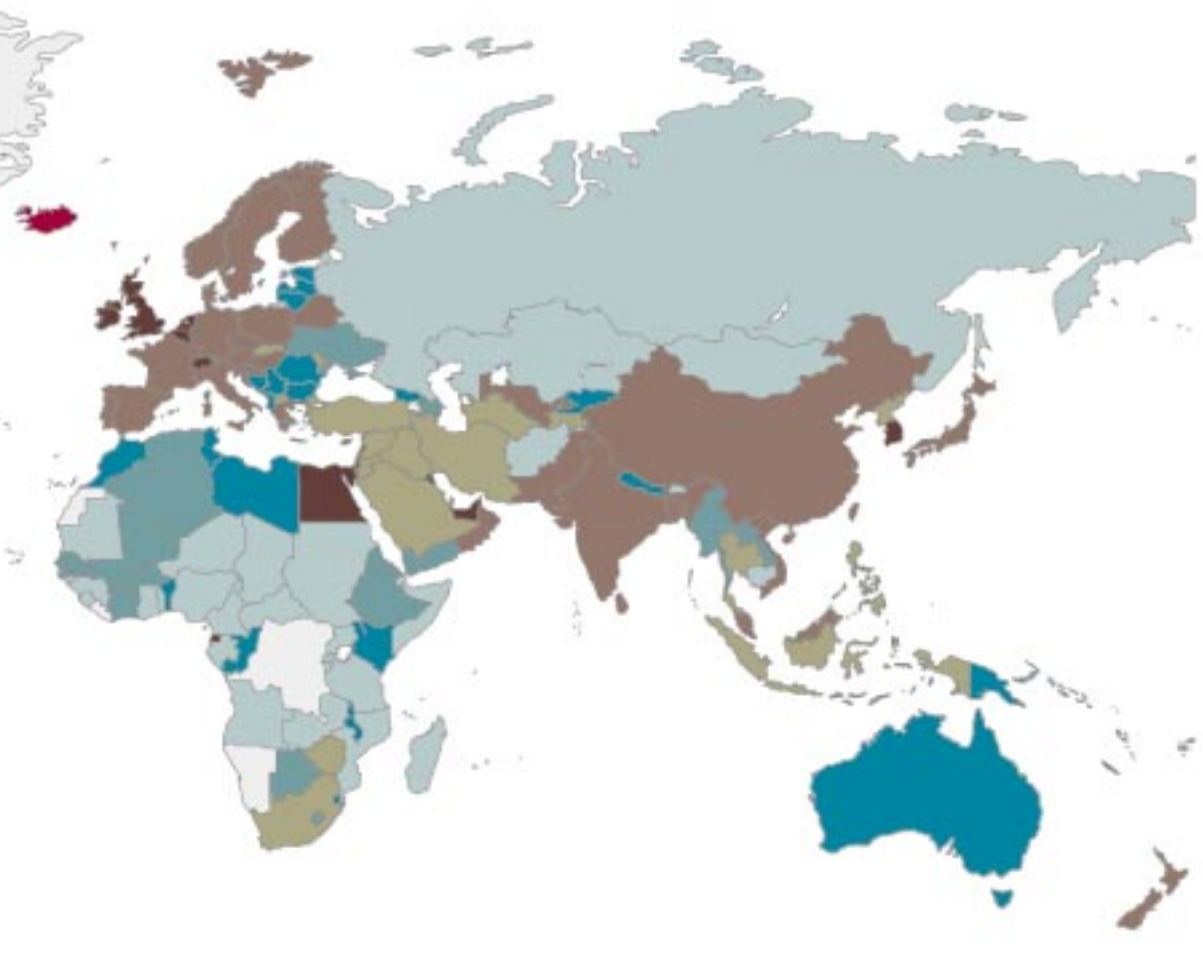


Over the last decade fertilizer use remained static or fell in a number of countries with very high use, such as the United Kingdom or Iceland, but continued to increase rapidly in others, particularly the United Arab Emirates.

AREAS OF HIGH PESTICIDE USE

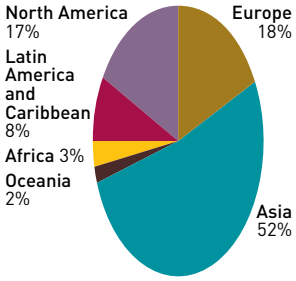


Source: ESRI.



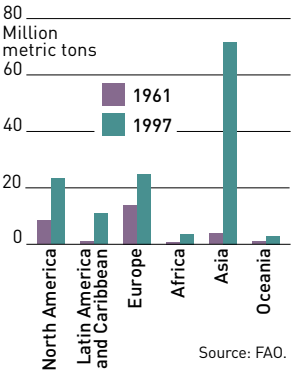
Source: FAO.

FERTILIZER USE
Regional share, 1997



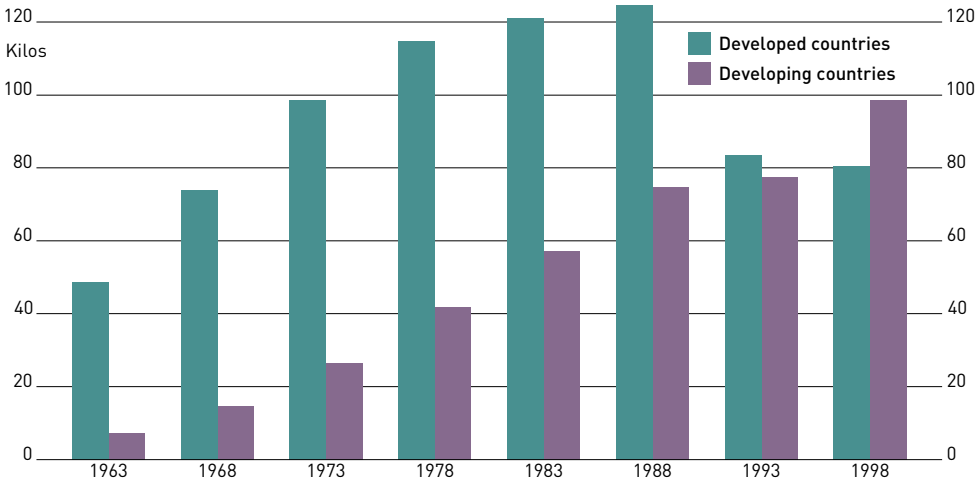
Total fertilizer use:
137.25 million metric tons

Regional growth



Source: FAO.

THE GROWTH OF FERTILIZER USE
Kilos per hectare of arable and cropland



Source: FAO.

FERTILIZER USE AND CEREAL YIELDS
Selected countries

	Fertilizer use Kilos per hectare 1968	1998	% increase in yield 1968-98
Papua New Guinea	2	22	108
Kenya	8	28	21
India	11	99	114
China	26	259	153
Italy	76	158	101
USA	77	110	77
Israel	113	277	23
Egypt	115	337	87
Denmark	204	170	51
Korea, Rep.	206	458	91
UK	243	330	93
Ireland	258	520	58
Switzerland	348	749	76
Japan	365	290	11
Netherlands	622	494	78
World	**43**	**91**	**77**

Source: FAO.

Carnivorous algae

Fish farmers suffered major economic losses in the Neuse estuary in North Carolina, United States, when a billion fish were killed by a recently discovered carnivorous species of alga. *Pfiesteria* chemically senses fish and produces lethal toxins which kill in only a few hours, and then feeds off their decaying remains. The toxins can also cause skin ulcers on people exposed to them.

When blooms die back and decay they exhaust supplies of dissolved oxygen, suffocating fish and other aquatic species. Oxygen deficiency has been reported as damaging wildlife in the coastal waters of the Gulf of Mexico, Chesapeake Bay and Long Island Sound in the United States, and the Baltic Sea, while in the United Kingdom some 150 tons of farmed fish were suffocated in 1998 by starch-like chemicals released by algae[6].

Alongside nitrogen oxide emissions from burning fossil fuels, nitrogen fertilizers lead to an increase in nitrogen-containing emissions from plants and soils, adding to the nitrogen load in the atmosphere. Additional deposition of nitrogen compounds over land disturbs upland ecosystems which are naturally constrained by low nitrogen levels. Atmospheric deposition to the world's oceans, which is estimated to exceed the total nitrogen input from rivers, may also trigger algal blooms[7]. Nitrogen fertilizers also contribute to emissions from soil of nitrous oxide – the third most significant greenhouse gas. Similarly, nitrogen in rivers results in emissions of the gas from estuaries, but human impacts on the scale of this natural process are still little understood[8].

Although the use of pesticides increased more than 30 times between 1950 and the end of the 1980s, pests still cost the world billions of dollars annually in lost agricultural production, and more species of weeds, diseases and insects are becoming resistant, up from under 100 in the 1950s to more than 700 today. Use of pesticides in the developed world is now decreasing, in part as a result of the substitution of new more powerful chemicals which are used in much smaller amounts. However, it is still increasing in developing countries, which currently account for more than a quarter of the world's consumption – with a total estimated value of US$25 to US$32 billion annually[9], up from US$16 billion in 1986.

Applications of pesticides inevitably lead to residues in soils which may evaporate to the air or be washed into watercourses, causing contamination of food and the environment, and endangering human health. In the early 1990s, the World Health Organization estimated that 3 million people a year suffered from acute pesticide poisoning with as many as 200 000 of them dying. Most are in the developing world, where village conditions virtually prohibit the safe use of dangerous pesticides. A 1993 study in Indonesia showed that 21 percent of spraying operations resulted in three or more symptoms associated with pesticide poisoning. Eighty-four percent of farmers were also found to be storing chemicals in their homes, in unsafe conditions where children could reach them[10].

Groundwater contamination is particularly serious as it is long-lived and expensive or impossible to remedy. Spray drift into streams and rivers, and contamination from spillages, tank washings or discarded pesticide containers also present a real threat to watercourses. It has been estimated that up to 50 million United States citizens may be drinking pesticide-polluted water, while in England and Wales, reducing pesticides in public drinking water supplies to a precautionary level of 0.1 micrograms per liter is estimated to have cost water companies in excess of US$1.2 billion[11]. Despite the efforts of chemists to design products which bind to soil or crop surfaces, water contamination appears to be unavoidable[12]. Some pesticides are also persistent organic pollutants (POPs), including DDT, hexachlorocyclohexane, toxaphene and dieldrin, and are transported through the atmosphere to be redeposited in cooler regions.

Concern over pesticide residues has prompted the development of integrated pest management (IPM) – the use of a variety of controls including the conservation of existing natural enemies, crop rotation, intercropping, and cultivation of pest-resistant varieties. Pesticides may still be used, but selectively and in greatly reduced quantities. This approach is producing striking results: in Indonesia rice yields have increased by 13 percent alongside a drop in pesticide use of 60 percent, while a study of fruit growers using IPM in New York State and California showed falling costs alongside increased yields.

The revival of organic farming may also prove significant. This already accounts for 10 percent of the food system in Austria and Switzerland, and is growing at 20 percent a year in France, Japan, Singapore and the United States. Whether this represents limited idealism or the presaging of widely accepted agricultural practices that embrace more holistic approaches to the wider environment remains to be seen.