What price more food?

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Debora MacKenzie

WHAT do a student in New York, a farmer near Mexico City, a family in London and a nurse in Bangkok have in common? Increasing trouble paying their grocery bill. Since 2000, the average price of food around the world has nearly doubled. In the UK, food prices are rising at three times the rate of inflation. In the US, the price of eggs has risen by 40 per cent in the past year alone, while rice in Thailand and tortillas in Mexico have shot up in price, in some places trebling. This year the soaring cost of food has triggered street demonstrations in 30 countries, some of which tipped over into riots.

For those of us who spend only a fraction of our income on food, the high prices are troublesome. For the one-third of humanity living on $2 or less per day they are tragic. The World Bank estimates that the recent increases could push 100 million people who escaped poverty in the past decade back into it, and push the poor deeper in as the cost of bare survival consumes money that might otherwise have bought extra protein, schooling, farm improvement or medicine.

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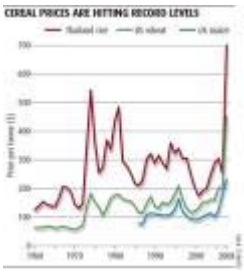
The immediate forces behind the price hikes are clear. Demand for grain, the foundation of the human food chain, is rising rapidly. It is driven not only by a growing population, but also by rising meat consumption among increasingly prosperous people in developing countries. Demand for biofuels is adding to the pressure (see "Why now?"). Production is simply failing to keep up.



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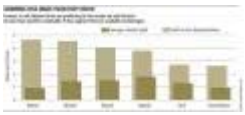
The crisis hasn't come out of the blue. Agricultural experts have been for warning for years that the rich governments, who fund most of the world's agricultural research and development, have not been investing enough. Now we are suffering the consequences. And the problems show no sign of going away. *New Scientist* can reveal that the world's biggest computer model of agriculture and climate, at the International Food Policy Research Institute (IFPRI) in Washington DC, predicts that market forces stemming from the growing gap between demand and supply will keep food prices high for several years. Worse, when crop stresses due to predicted changes in climate are factored in, prices stay up for longer, and even increase.



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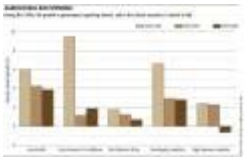
The situation is serious, but it is not hopeless. Rising food prices are finally focusing political attention and public interest on food production. Governments will be able to mitigate the crisis, but only if they invest in the science that can increase yields and the infrastructure to get the resulting technologies to the farmers who need them.

We need to act fast. Science takes 15 to 20 years to filter through to farms and after two decades of neglect there is little in the pipeline.

Investing in science has saved us before. Two centuries ago, the English clergyman Thomas Malthus famously warned that the growth of the human population might outstrip its ability to produce food. But as the population soared, Malthus's famine was averted as the application of science and fossil-fuel energy to agriculture allowed food production in industrialised

countries to keep pace. After the second world war, fear of famine and its political impact led rich countries to fund similar R&D for the rest of the world in the Green Revolution, while continuing to boost their own yields. Again, it worked: increases in yield helped to double food production between 1960 and 1980, faster than the population grew. Food prices fell, and food stocks soared. By the 1980s, famine had ended in much of the world - with the glaring exception of Africa - and the rich had grain mountains.



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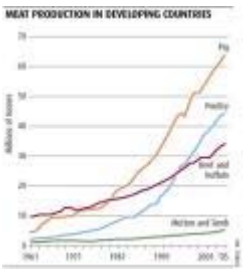
Times of plenty

Then the rich got complacent. Development aid to poor countries was diverted away from helping them to grow more food and towards developing other kinds of industries whose profits could be used to buy the surpluses being grown on the rich world's farms. Investment in agricultural R&D was slashed: it grew at 2 per cent per year through the 1980s, but since 1990 has shrunk by 0.6 per cent per year. Research also shifted away from increasing yields. "They stopped work on productivity and focused on environment or nutrition," says Phil Pardey, director of the International Science and Technology Practice and Policy Center (INSTEPP) at the University of Minnesota, St Paul.



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Another change was that research was increasingly privatised. Companies prioritised research that would boost profits, whether or not it improved yields. For example, they developed hybrid maize, but not wheat, because the flowering mechanism of maize makes it easier for companies to exert patent control over its seeds.

These changes meant that the rate of increase in food production started to slow down. Although the quantity of grain produced on each hectare of farmland is still rising, the rate of increase has slowed to the point where it is being outpaced by the increase in demand. Calculations for *New Scientist* by INSTEPP economics researcher Jason Beddow reveal that yields of wheat and rice are rising at less than 1 per cent per year, and maize is doing little better. According to this analysis, for the past decade yields of the top three grains have been growing more slowly than most agricultural researchers had assumed (see "Yields are falling behind"). They are no longer keeping pace with rising demand from the rising human population, never mind the added demands of livestock and biofuel (see "Demand for grain is growing").

Given all this, it doesn't take a crop scientist to work out that what the world needs is more food. The question is where, and how? While there is still a little spare land that could be turned over to crops, urban sprawl is fast eating it up. So the bulk of the increases will have to come from increasing yields: growing more grain on every hectare that is farmed.

New Scientist has asked the world's leading agricultural experts what it will take to boost yields. They are unanimous: we need research, and support for farmers so that they can make the most of its results.

Specifically, what is needed is research into higher-yielding crop varieties - by conventional breeding or genetic modification - and better ways to grow them. Yet this is exactly the kind of research that went out of fashion amid the grain mountains. "In the mid-1990s you couldn't even mention increased yield in a research proposal and expect to get it funded," says Hans-Joachim Braun, head of wheat at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico - one of the labs that makes up the Consultative Group for International Agricultural Research (CGIAR).

It was the same story with other crops. "In 1992 we told an external review panel that we were starting to see slower growth in rice yield," says Bob Zeigler, head of CGIAR's International Rice Research Institute (IRRI) in the Philippines. "We said 10 years and $50 million would fix it, that it was critically important." They didn't get the money. Maize researchers had similar problems. "Donors say they want drought tolerance, but not more yield potential," says Marianne Banziger, head of maize at CIMMYT.

In the short term, the most effective way to boost world food production would be to increase yields in Africa and parts of south Asia. Agricultural development there has been neglected, so big improvements are within reach even without new R&D. Getting existing high-yielding varieties to farmers, and giving them access to the fertiliser, water and pesticides they need, would make a huge difference. "Off-the-shelf technology exists to triple yields in that region," says agronomist Kenneth Cassman of the University of Nebraska at Lincoln. (See "Growing less maize than they could").

There is also huge potential in Africa for conservation agriculture, where farmers plough the land

perhaps only once every five years and leave crop residues behind to build soil nutrients and retain water. Research at CIMMYT has shown that if a farmer can persevere with such a system for five years as the weed seeds that accumulate in ploughed soils grow out, yields can jump to 30 per cent higher than in a similar ploughed field. Such a scheme would require some financial and technical support for farmers within the first few years, but should ultimately stand alone. The strategy has already proved successful in parts of South America.

Yielding results

In the longer term, though, these regions, like rich countries today, will need the fruits of new R&D to keep yields rising ahead of demand. There is no shortage of proposals. The IRRI gene bank, for example, holds the world's biggest collection of rice varieties. "I would love to hire a scientist just to grow them out and screen them for useful characteristics," says Zeigler. Traits such as resistance to brown leafhopper would be a boon in south-east Asia, where it has become a resurgent pest. Further down the road, IRRI scientists dream of investing rice plants with the more efficient method of photosynthesis, called C_4, found in plants such as maize. This could double rice yields and slash the plants' need for nitrogen and water.

CIMMYT is working with agricultural multinationals Monsanto and BASF on drought-tolerant maize, including one GM variety that is nearing release. CIMMYT researchers are also dissecting the mechanisms wheat uses to survive dry spells. They have found that high levels of stem carbohydrates and deeper roots are important. Finding genetic markers for these characteristics could help efforts to breed drought tolerant varieties.

Making crops more resistant to disease would also help. The world's wheat breeders are frantically trying to produce varieties that can fend off Ug99, a new strain of black stem rust fungus to which virtually no existing commercial breeds are resistant.

New varieties and growing techniques are one thing, but according to Papa Seck, head of the CGIAR's Africa Rice Center (WARDA) in Benin, the most pressing need in Africa is for infrastructure to get new and existing technologies to the farmers. "We need research, but to make an impact we must make that technology available," he says. Seck's lab has developed a new kind of hybrid rice, called Nerica, with double the yield of the Asian varieties currently grown in Africa. Africa imports 40 per cent of its rice, and has been hit hard by the huge increase in prices this year. Yet though dozens of Nerica varieties are available, Seck says they account for only a small part of the crop because local companies cannot produce enough seed and farmers are not being trained in how to use it.

IRRI has run up against similar logistical problems. It has developed cheap sealed bags and a moisture meter for use when drying grain that together could cut the massive losses poor rice farmers suffer after harvest. Yet it has had trouble getting them to the people who need them. During the debt crisis of the 1990s, poor countries had to dismantle government "extension" agencies that distributed such technology, and they still can't afford to rebuild them.

Farmers, especially in Africa, also need infrastructure to sell any surplus crops. Without it, they remain caught in a vicious circle: with no surpluses markets have not developed, and without markets farmers can't profit from surpluses. If they invest in producing extra maize, for example, but can't get it to where there is demand, local prices plummet and the surplus won't earn enough to pay for the fertiliser that produced it.

All that could change with better roads, transport, storage facilities and, most of all, information. One major reason farmers do not sell outside their local area is the risk that they might pay to haul a crop to a buyer, only to find the buyer has cut the price or disappeared. Ethiopia is trying to fix that. In April, it opened Africa's first commodities exchange, which sends buyers' offers electronically to 20 major market towns, and stores deliveries. "When farmers can sell their crops on the open market and get a fair price, they will have much more incentive to be productive," says Eleni Zaude Gabre-Mahdin, who designed and now heads the exchange.

There are other fixes in the works. Dennis Garrity, head of the CGIAR's World Agroforestry Centre in Kenya, says that nitrogen-fixing "fertiliser trees" can be grown amid rows of maize to improve degraded soils and provide nutrients, cutting the need for industrially produced, oil-hungry fertilisers.

Small-scale techniques such as soil depressions that accumulate moisture and mulches that keep it from escaping could also make an impact in drought-prone areas, according to Johan Rockström, director of the Stockholm Environment Institute in Sweden. The bulk of the precipitation available in these areas normally quickly evaporates from leaves and soil, never making it into the streams or irrigation ditches. So traditional efforts which focus on managing water in streams and ditches may be missing the point, says Rockström. Experiments in Malawi with techniques that cut evaporation losses have led to bumper harvests in years when other farms succumbed to dry spells.

While raising yields in Africa and parts of Asia may be the fastest and most obvious road to more food, there will be pressure everywhere to grow more. And to do that in richer nations where most of the low hanging fruit has been picked will take a massive research effort to boost yields. That might include breeding new crops, but a major focus, Cassman says, should be on reducing the "yield gap" between what a crop variety and management system can produce in tests, and what farmers actually get. This will mean micro-management of fields, so each patch gets exactly the water, fertiliser and other treatments it needs. This will be increasingly important as spiralling oil prices push up the price of nitrogen fertiliser and deposits of phosphate are exhausted. Farmers can no longer simply apply an excess of fertiliser to ensure plants get enough.

The new Green Revolution will need to deliver increased yields in a world in which energy and fertiliser are more expensive and water and soil resources have been degraded. On top of that there's climate change, which is already replacing familiar weather patterns with unpredictable droughts and deluges.

In short, feeding everyone will require much more investment in research. Regrettably, that's a message that has yet to be heard in some of the places it matters most. The US, for example, is threatening to cancel funding for the CGIAR next year, putting in jeopardy vital work that helps the world's poorest countries. Both the research and getting its results into farmers' fields will take a huge effort by all governments, rich and poor - starting with the recognition that a few decades of plenty were not enough to defeat the ancient scourge of famine. It is perhaps the most urgent message of our time.

Why now?

For the past eight years, global demand for grain has been increasing faster than supply.

While grain yields are increasing at 1.1 per cent per year, the world's population is growing slightly faster at 1.2 per cent per year - but that's just the start. Growing prosperity and increasing urbanisation, especially in India and China, are driving up demand for animal-based food, putting further pressure on grain supplies. It takes 2 to 6 kilograms of grain fed to a cow, pig or chicken to make 1 kilogram of meat, milk or eggs. Together with increasing population, increasing prosperity is pushing the annual growth in demand to 1.6 per cent.

Biofuels are playing a part too. Since 2000, some government subsidies have encouraged farmers to divert food grain into biofuel production. According to the International Food Policy Research Institute in Washington DC this accounts for 30 per cent of current increases in the price of grain. IFPRI calculates that removing these subsidies could slash prices by 20 per cent overnight. If demand for biofuel continues on its current course, however, demand for grain will increase by 2.5 per cent per year between now and 2020.

Other factors have compounded the problem. Australia, a major wheat exporter, has had six years of drought. Oil prices are hitting all-time highs, making it more expensive to run tractors, transport food and make nitrogen-based fertilisers. To add to it all, sources of phosphate fertiliser are running out, leading to a trebling of prices in the past year.

Meanwhile, speculators are moving in. Some are small-time traders who are hoarding rice, for example, in the expectation that prices will continue to rise. Vast amounts of speculative money is also coming from investors fleeing the US real-estate market, who have poured billions of dollars into commodities futures. This has led to price rises that are not necessarily linked to real consumer demand, says Joachim von Braun, head of the IFPRI. The price of rice rose from $200 to $300 per tonne on supply and demand issues, he says, but because of speculators has hit peaks of $1000 in recent months.

Finally, some governments, notably India and China, have responded to the looming shortages by restricting grain exports to make sure their own people get fed. With less grain on international markets, the world price is more prone to sudden fluctuations. This has particularly hurt net food importers such as Bangladesh, Indonesia and most African countries. The US and European Union have deliberately run down the grain stockpiles they built up in past decades, so there is no easy way to release surplus stocks to temporarily push down grain prices.

Let them eat grain

On average, people around the world get 1055 calories per day from eating grain directly - that's 45 per cent of their total intake. A lot of the rest comes from meat, milk and eggs from animals that

themselves were fed grain. No other food source can make up for a shortage of grain. Here are just a few of the ways we could increase yields in the three main crops.

RICE Calories per person per day: 456

Problems: Two billion people depend on rice, which is more than any other single crop. That number is growing with the global population and as more people in Africa eat rice. Yet rice yields are growing more slowly than those of any other crop, averaging 0.84 per cent per year since 1996.

Solutions:

- Wider adoption of higher-yielding hybrid varieties
- Improve drought tolerance and resistance to common pests
- Reduce spoilage by protecting rice stores

WHEAT Calories per person per day: 440

Problems: The world's main wheat-growing areas, Europe and North America, produced substantial surpluses, which led to low prices in the 1980s and 1990s. This put a brake on R&D to boost wheat productivity, and yields have grown only 0.93 per cent per year since 1996. The scaling back of research also slowed the response to a virulent new fungal disease called Ug99.

Solutions:

- Breed Ug99-resistant varieties into high-yielding ones
- Breed drought-resistant plants
- Cross wheat with wild relatives to boost its genetic repertoire and its ability to resist diseases

MAIZE Calories per person per day: 159

Problems: Africans depend on maize more than any other grain. However, most maize is fed to livestock and there is a growing demand for meat, milk and eggs in developing countries. It is also the chief source of biofuel. That means people, livestock and cars are competing for the same crop.

Solutions:

- Develop drought-tolerant varieties to increase yields in Africa
- Roll out newly developed varieties that resist grain weevils to reduce post-harvest losses
- Introduce no-till farming to improve soil, drought resistance and yields, and cut CO_2 emissions

(Data from the UN's Food and Agriculture Organization)

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3 September 1994
Famines before the floods?
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31 March 1990

Weblinks

International Food Policy Research Institute
http://www.ifpri.org/

International Rice Research Institute
http://www.irri.org/

International Maize and Wheat Improvement Center

http://www.cimmyt.org/

UN Food and Agriculture Organization
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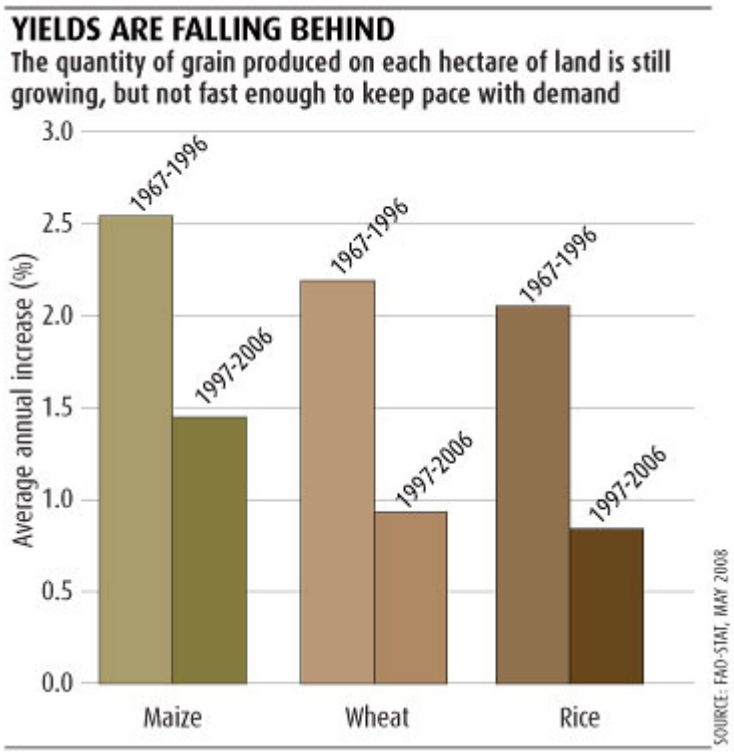
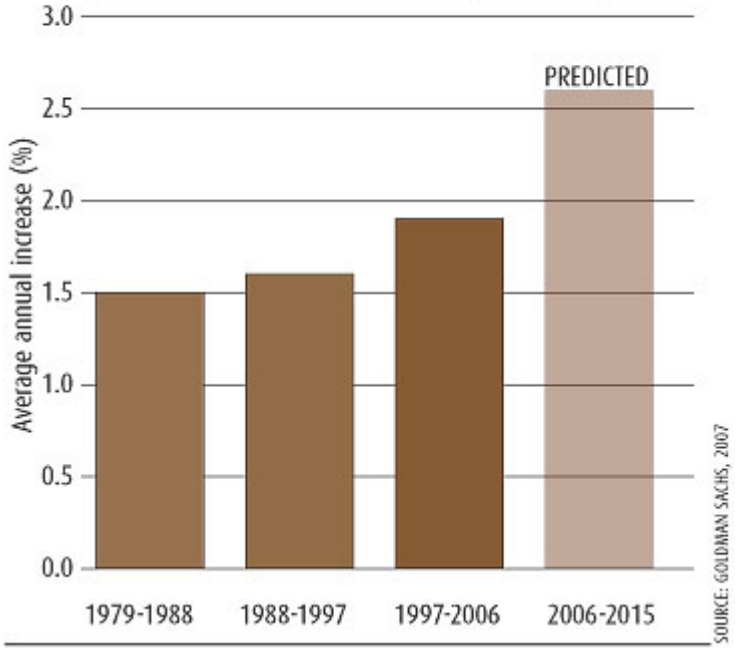

YIELDS ARE FALLING BEHIND
The quantity of grain produced on each hectare of land is still growing, but not fast enough to keep pace with demand
Average annual increase (%)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1967-1996
1997-2006
1967-1996
1997-2006
1967-1996
1997-2006
Maize
Wheat
Rice
SOURCE: FAO-STAT, MAY 2008

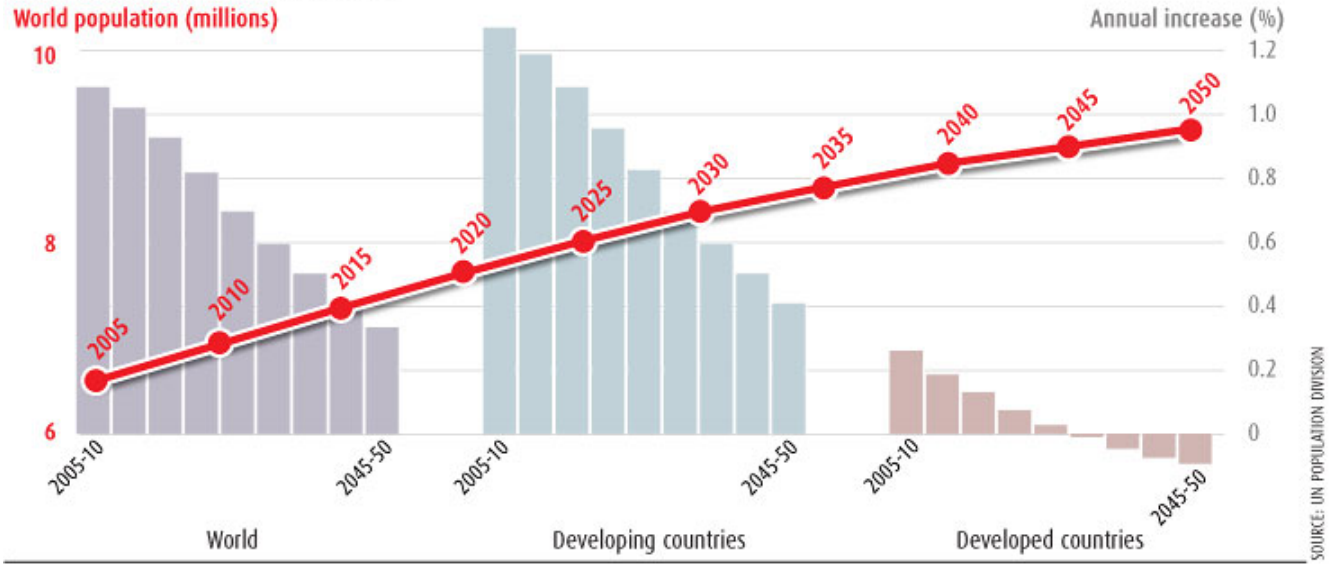
DEMAND FOR GRAIN IS GROWING

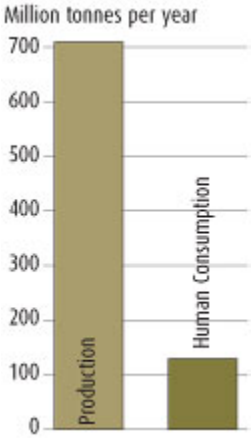
The requirements of a growing population, increasing meat consumption and biofuels mean demand for grain is likely to rocket

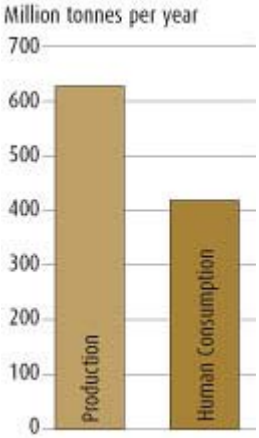


MORE MOUTHS TO FEED

The global population is expected to increase for the foreseeable future, though the rate of growth will decline and the number of people in the developed world will fall after 2030




Million tonnes per year
700
600
500
400
300
200
100
0
Production
Human Consumption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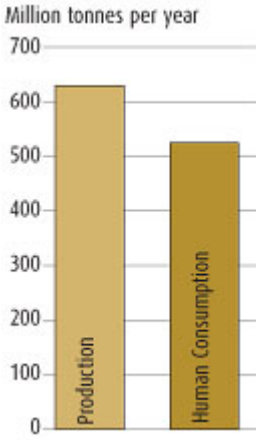
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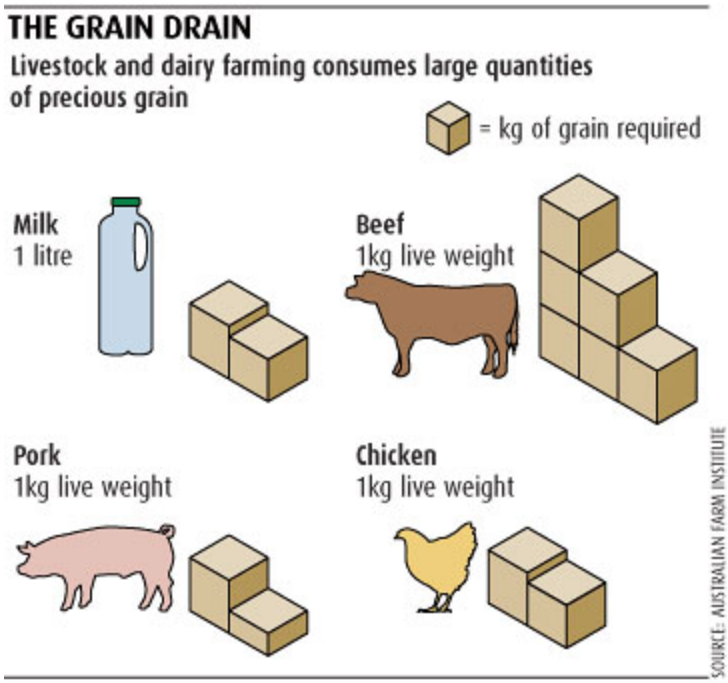
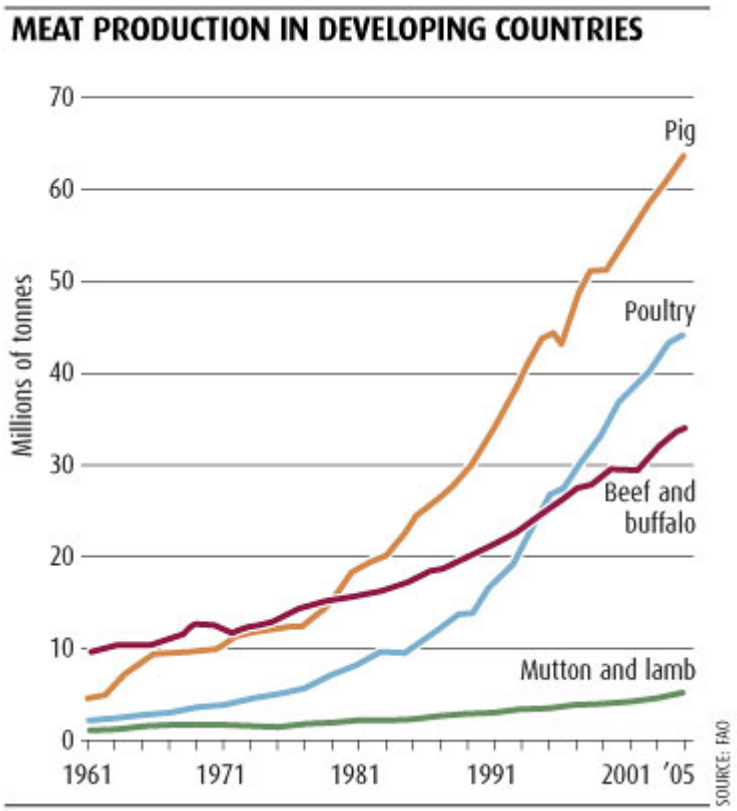
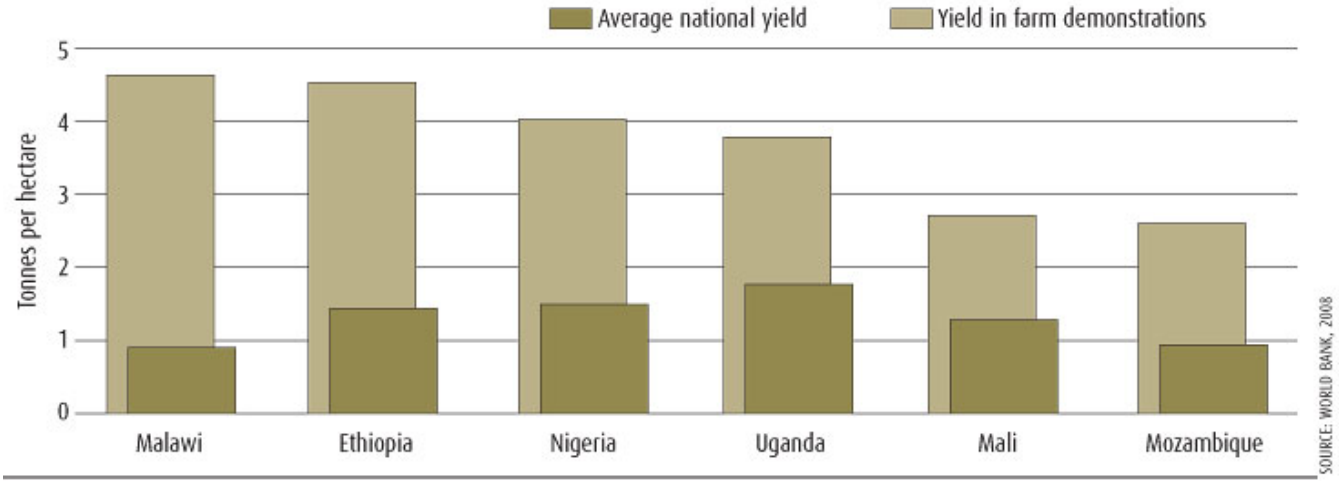

THE GRAIN DRAIN
Livestock and dairy farming consumes large quantities of precious grain
= kg of grain required
Milk
1 litre
Beef
1kg live weight
Pork
1kg live weight
Chicken
1kg live weight
SOURCE: AUSTRALIAN FARM INSTITUTE


MEAT PRODUCTION IN DEVELOPING COUNTRIES
Millions of tonnes
70
60
50
40
30
20
10
0
1961
1971
1981
1991
2001 '05
Pig
Poultry
Beef and buffalo
Mutton and lamb
SOURCE: FAO

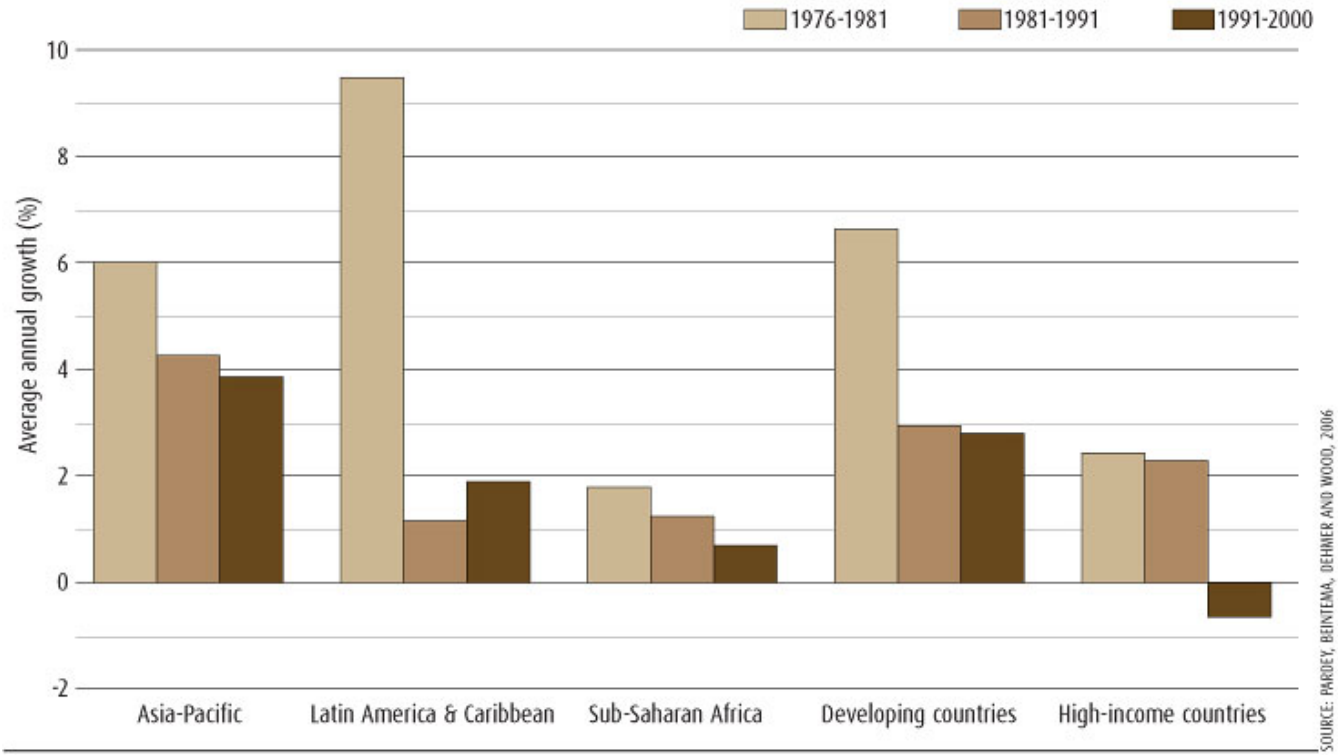
GROWING LESS MAIZE THAN THEY COULD

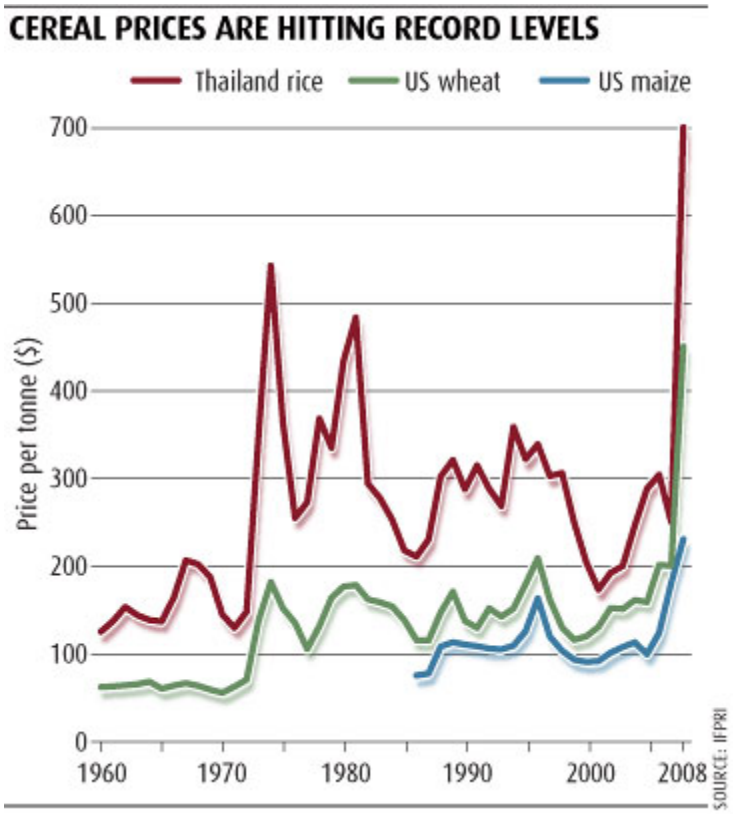
Farmers in sub-Saharan Africa are producing far less maize on each hectare of land than would be attainable if they applied the best available technologies

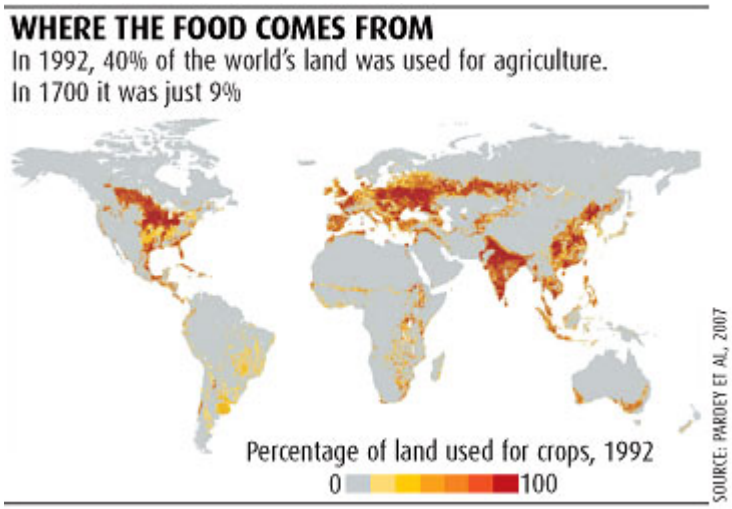


AGRICULTURAL R&D SPENDING

During the 1990s, the growth in government spending slowed, and in the richest countries it started to fall




CEREAL PRICES ARE HITTING RECORD LEVELS
Thailand rice
US wheat
US maize
Price per tonne ($)
700
600
500
400
300
200
100
0
1960
1970
1980
1990
2000
2008
SOURCE: IFPRI


WHERE THE FOOD COMES FROM
In 1992, 40% of the world's land was used for agriculture.
In 1700 it was just 9%
Percentage of land used for crops, 1992
0
100
SOURCE: PARDEY ET AL, 2007