Climate change and commodity price trends

New cover concepts in agricultural insurance

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Introduction

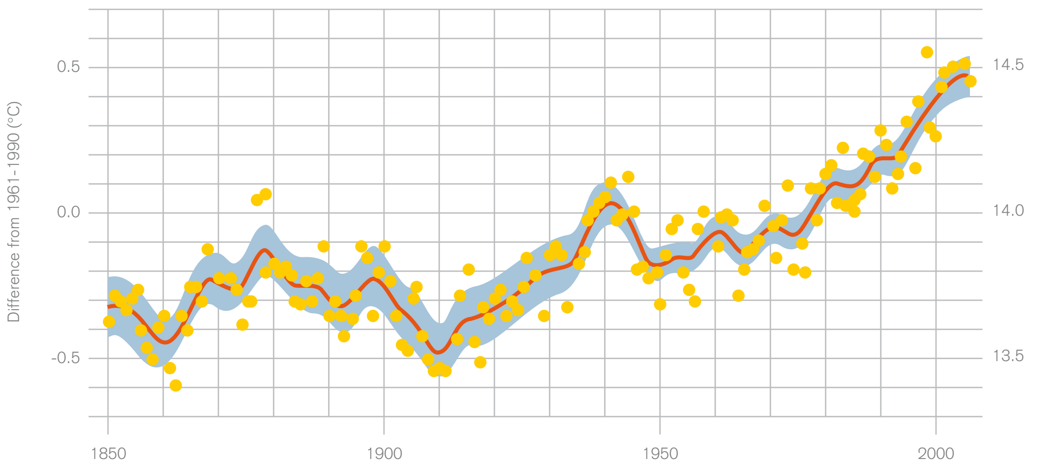
Climate change, biofuels, insurance premium subsidies, commodity price inflation and new farming methods are just some of the many factors now influencing agricultural production. Given the immense importance of sustainability within this sector, this report examines the associated risk data, trends, growth opportunities and impact on insurance risk analysis and cover concepts.

Climate change, according to the Intergovernmental Panel on Climate Change's (IPCC) 2007 report

According to the Intergovernmental Panel on Climate Change's (IPCC) 2007 report (4th Assessment Report on Climate Change) both the causes and effects of observed climate change are now alarming. The report's key findings can be summarized as follows:

- Climate change is now unequivocal.
- Global anthropogenic greenhouse gas (GHG) emissions increased by 70% (carbon dioxide (CO_2) emissions by 80%) between 1970 and 2004; annual rates of increase have accelerated further over the last decade.
- The long-term downward trend in the CO_2 emissions intensity of global energy supply has reversed since 2000.
- Global GHG concentrations have increased markedly since 1750 and now far exceed pre-industrial values.
- The global average net effect of human activities since 1750 has been one of warming. Most of the observed increase in global average temperatures since the mid-20th century can be linked to the observed increase in anthropogenic GHG concentrations. Observational evidence from all major continents shows that the latter changes are attributable to human activity.
- The consequences of climate change can now be proven and are far reaching; in many cases they can be linked to human activity.

Figure 1
Global average temperature
Observed changes in global average surface temperature from 1850 to 2007 showing an overall trend of increasing temperature. All differences are relative to the corresponding average for the period 1961-1990. The smoothed curve (red) represents the decadal average value. The circles (yellow) show the yearly values. The shaded area (blue) is the uncertainty interval estimated from a comprehensive analysis of known uncertainties. Source: IPCC Fourth Assessment Report: Climate Change 2007. Working Group 1 Report "The Physical Science Basis", Summary for Policymakers, page 6, Cambridge University Press, 2007. Layout modified by PartnerRe.



The global average surface temperature increased in absolute terms from 13.5°C in 1850 to 14.5°C in 2007 (**figure 1**). Ten of the last twelve years in fact rank among the warmest since 1850. As has been confirmed by climate model simulations, solar activity and volcanic eruptions have only a short-term impact on global average temperature. The observed rise in global average temperature has therefore now been unequivocally linked to anthropogenic GHG causes.

As the atmospheric temperature has warmed, glaciers and areas of permafrost have melted at increasingly higher rates and sea level has risen, on average by 1.8mm a year since 1961 (**figure 2**). Even this relatively modest rise can salinize fresh water reserves and alter coastal ecosystems. Expenditure for coastal protection must always be weighed against the lower productivity of the affected land.

Over the last 20 years, northern hemisphere snow cover has decreased from approximately 38 to 36 million square kilometers. The effect of this on life is particularly serious in regions where water supplies depend on melting snow. In the European Alps, melting permafrost has had another detrimental effect in terms of increased landslide frequency.

Figure 2
Global average sea level
Observed changes in global average sea level from high tide guage and satellite data showing a trend of rising sea-level. All differences are relative to the corresponding average for the period 1961-1990. The smoothed curve (black) represents the decadal average value. The circles (yellow) show the yearly values. The shaded area (blue) is the uncertainty interval estimated from a comprehensive analysis of known uncertainties.
Source: IPCC Fourth Assessment Report: Climate Change 2007. Working Group 1 Report "The Physical Science Basis", Summary for Policymakers, page 6, Cambridge University Press, 2007. Layout modified by PartnerRe.

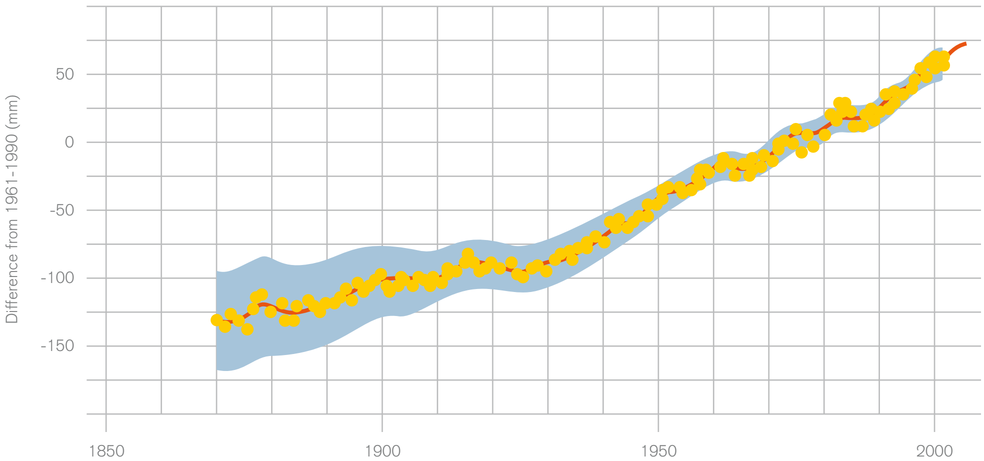


Figure 3
A tractor drives across a flooded dam in Fünen, Denmark.

Effects of climate change on agricultural production

Changes in local climatic factors (temperature, daylight hours, precipitation distribution, accumulated temperatures and evapotranspiration[1] rates) can be responded to naturally by organisms via evolution, which happens over long time periods.

Given the relatively short time period associated with the current changes in climate, and that the observed changes in global average temperature and sea level have not happened uniformly across seasons and locations, the consequences for agriculture are neither consistent nor easily predictable. By way of illustration, we will look now at the possible effects of warmer temperatures on agricultural crop production.

Positive effects:

- Thermophilic plants may push into more northerly producing regions.
- Higher temperatures will allow farmers to grow crop varieties with a longer vegetation phase leading to higher yields.
- A longer pasture growth phase extends the grazing period.
- Higher atmospheric CO_2 concentrations favor photosynthesis
- Global warming will lead to increased precipitation in some areas, enhancing yields.

1 The combination of evaporation and plant transpiration.

Negative effects:

- Temperatures exceeding 35°C for extended periods in the subtropics will expose grain to heat stress during flowering; grain yields in these areas could fall by up to 70%.
- Higher temperatures in northerly latitudes will increase evapotranspiration, significantly disrupting the water balance in the soil and plants.
- Higher evaporation rates in the tropics and subtropics will dry out the soil causing salinization and a reduction in the amount of arable land.
- Higher temperatures speed up the flowering process of fruit trees, putting the blossom at greater risk of damage from late spring frosts.
- Infestation patterns change and may increase in terms of organism density and geographical range. For example, in recent years, mild winters have caused the mountain pine beetle population in British Columbia to explode. The infestation has now devastated around 13 million hectares of pine forest. Temperatures of -35°C are the only thing that will bring the population back down to manageable levels.
- Increasing precipitation intensity will increase runoff and reduce yields.
- Decreased precipitation in some areas will reduce yields.

Precipitation

As mentioned in the last two points above, warmer atmospheric temperatures also impact precipitation. Many locations have reported negative yield effects due to a change in precipitation pattern principally relating to more frequent, heavy rainfall and a more irregular distribution of the total rainfall over the vegetation period. In rain-fed agriculture (more common than irrigated agriculture), at least 50 - 75mm of precipitation needs to be stored in the top soil before sowing, followed by a further, evenly distributed 250 - 300mm during the vegetation period to achieve even modest grain yields. Specifically:

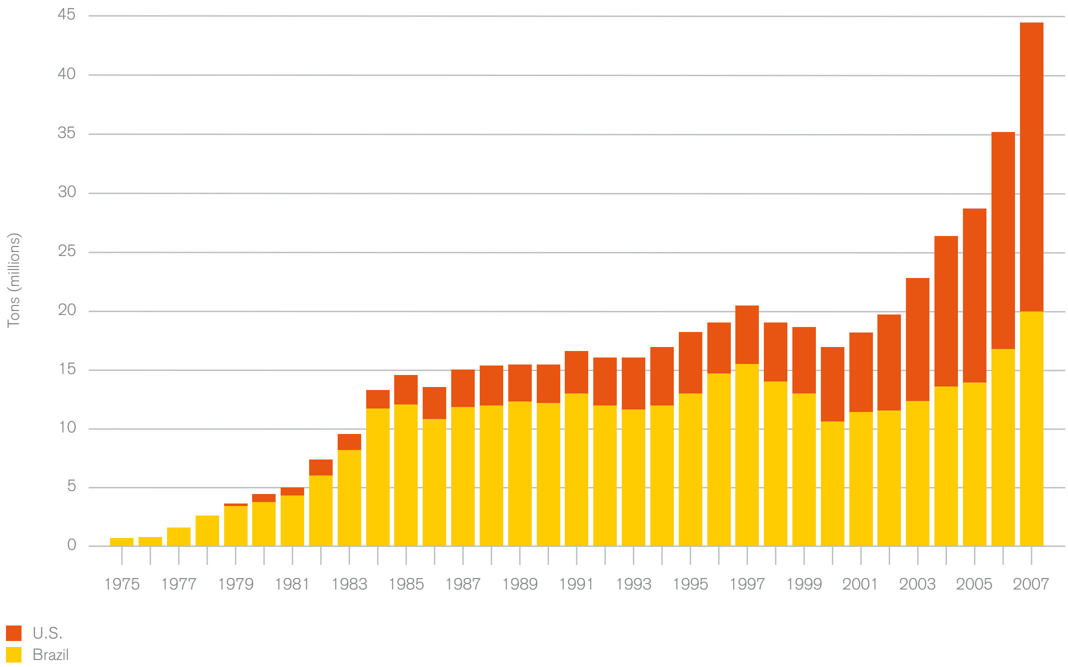
- In many grain-producing regions, melting snow supplies a large proportion of the soil moisture urgently needed by crops in the spring. Warmer temperatures increase the amount of precipitation that falls as rain rather than snow. Rain drains faster, meaning that moisture in the upper soil layers is exhausted more quickly. For example, in North America, warmer winters have resulted in reduced snow cover, which means farmers and foresters in the U.S. and Canada are likely to see more dry years and a significantly higher risk of forest fires.
- Water stress during spring flowering impairs pollination and can cause complete crop failure.
- If the result is diminished rainfall, agriculture will have to shift. In Australia, for example, observational evidence suggests that ocean warming is increasing the frequency of El Niño events, which, in turn, are responsible for diminished rainfall in grain-producing regions of southeastern Australia. In the long term, agriculture in the southeast of the continent may therefore shift to the northwest. Indeed a new pioneering phase in the northwest has already begun.
- Even if it were possible to predict shifts in precipitation distribution, this would not help farmers, as sowing cannot be delayed or brought forward at will. Their window of opportunity for sowing is restricted by other key factors, such as optimum temperatures and daylight hours.

Renewable commodities as energy sources

The rise in the price of crude oil has created a strong demand for renewable agricultural and forestry commodities. Interest focuses in particular on plants that are rich in carbohydrates (starch or sugar) such as sugar beet, sugar cane, corn and other cereals. Through fermentation, these crops can be processed into ethanol which is then blended with gasoline.

The amount of grain used globally for ethanol production rose from 72 million tons in 2006 to 108 million tons in 2007; approximately 90% of this was produced in Brazil and the U.S. (**figure 4**).

Figure 4
Ethanol production in Brazil and the U.S
Observed growth in the amount of grain allocated to ethanol production between 1975 and 2007. Brazil and the U.S. now account for approximately 90% of this market.
Source: F.O. Licht Commodity Analysis, Impact of Biofuels on Commodity Markets, 2007.

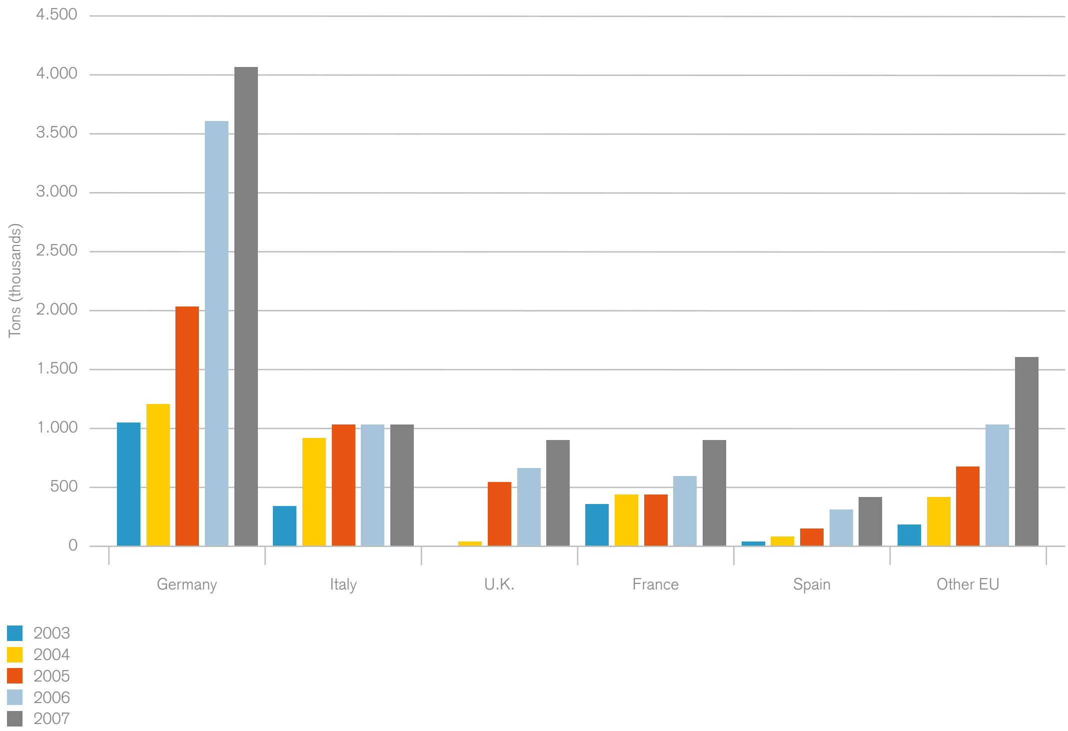


In contrast to ethanol production, replacing conventional diesel with biodiesel requires oleiferous plants such as rapeseed, soya beans, oil palms, or jatropha. Biodiesel production in the European Union (EU) is dominated by Germany (**figure 5**).

Questions remain however about the efficiency of fuel production from renewables

Today, Brazil produces around 40% of its gasoline from alcohol distilled from sugar cane and has the resources to increase this proportion to 70%.
In virtually all other countries the situation is much less favorable. Sugar cane and oil palms are high-yielding, multi-year monocultures, however they can only be grown in moist tropical regions. In more moderate latitudes, rapeseed and sugar beet can only be grown in the same field once every four years using crop rotation. Yields are also far lower (**figure 6**). To satisfy 17% of fuel consumption (excluding aviation fuel) in Germany, for example, 30% of the country's agricultural land would have to be set aside for rapeseed (biodiesel) and grain (ethanol). In recent years the price of such agricultural commodities has also become unreasonably high for biofuel producers. Crude oil would have to cost around US$ 150 a barrel for rapeseed oil to be competitive in Germany. In Brazil, ethanol can be manufactured so cheaply that it would even be competitive if crude oil were selling at US$ 40 a barrel. Given these market conditions, the prospects for German energy farmers being able to operate competitively are bleak. Politicians intend to incrementally remove subsidies for this sector in order to shield businesses from bankruptcy.

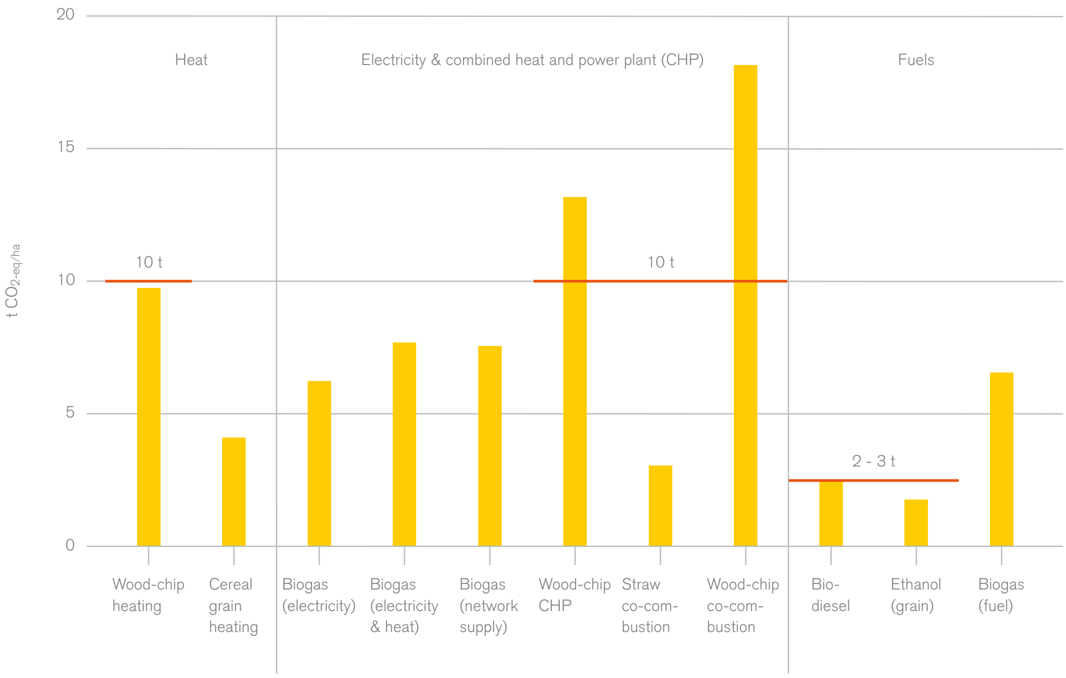
Figure 5
Biodiesel production in the EU
Development of biodiesel production in the EU from 2003 to 2007. Germany remains the principal producer. Source: Union zur Förderung von Oel und Proteinpflanzen e.V. (UFOP).



The industry's efficiency is also suffering from the fact that the transportation of agricultural commodities is very energy intensive.

Realistically, even if one factors out price distortions, the estimated percentage of total fuel which could be supplied by renewables currently lies at around 3 - 5% in most industrialized countries. Politicians previously set their sights much higher and created investment incentives to speed up the change. The EU, for instance, has stipulated that biofuels must make up 10% of the energy mix by 2020. However, if biodiesel is produced from oil palms which can only be grown by clearing tropical rain forest, this will ultimately have a detrimental effect on the CO_2 balance. Thus, according to EU law, palm oil may only be imported if it meets specific sustainability criteria.

Figure 6
Climate yield comparison
"Climate yield" per hectare (net CO_2 equivalent avoided). Biofuels: low yield; biogas: high yield, but expensive. Straw, wood chip (short-rotation plantation, or SRP) perform best.
Source: Scientific Advisory Board on Agricultural Policy, 2007[2].



2 "Use of biomass for energy generation – Recommendations to policy makers"; a summary of expertise to the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV).

Figure 7
In the highlands of Guatemala, the large market at Chichicastenango is an important trading venue for farmers and local buyers. Demand for biofuels has sharply raised crop prices in Mexico, Guatemala and in other countries of Latin America, and every gram on the scales now has far greater value.

Impact of biofuels on commodity price and food affordability

Over the last two years, the cost of staple foods in many parts of the world has increased by around 50 - 70%; many living on the poverty line are now scarcely able to afford basic foodstuffs. The rising demand for agricultural goods used in fuel processing has contributed to this inflation, unleashing a major ethical debate. A good example of this is the "tortilla crisis", where the effects of rising maize prices in the U.S. spilled over into Mexico; attracted by high maize prices, Mexico began exporting more commodities, causing sharp inflation in their own domestic market.

Aid and development organizations have been criticizing the emerging biofuels industry ever more vocally of late. Growing crops that cannot be used as foodstuffs and which also do not compete for the same farmland as foodstuffs may be one compromise. Such crops include oil-rich jatropha, which flourishes in marginal subtropical locations and is already being cultivated in pilot projects in India and Africa. But once the development phase is over, researchers may well conclude that jatropha cultures can only be grown profitably in better locations, in which case they will compete with food production after all.

State support for the agricultural sector

In 2001, the Organization for Economic Co-operation and Development (OECD) put global state support for the agricultural sector at US$ 600 billion, and broke it down as follows:

Direct subsidies

- Total: US$ 350 billion
- OECD countries: US$ 310 billion; rest of world: US$ 40 billion
- Breakdown of the subsidies to OECD countries:
  - US$ 60 billion for tax breaks
  - US$ 25 billion for direct transfer payments linked to surface area, plant product and livestock numbers
  - US$ 145 billion for price protection, e.g. making up the difference between domestic and global market prices (export subsidies)
  - US$ 80 billion for subsidized production costs, reduced (subsidized) cost of borrowing, state research and development as well as subsidized insurance premiums.

Indirect subsidies

- Total: US$ 250 billion; of which US$ 175 billion was for allocating water to agriculture at below-market rates.

Given the low amount allocated to individual farms in India (**table 1**), the Indian Government has vehemently opposed reducing state agricultural subsidies in its negotiations with the World Trade Organization (WTO). Between 1993 and 2003, around 100,000 Indian farmers committed suicide because they were unable to pay back loans to banks and therefore lost their land. In March 2008, in the run-up to elections, the Indian government even considered canceling debts for small-scale farmers with less than two hectares of land. The state would have had to repay banks some US$ 15 billion. Critics of this populist move claim that it would in any case have a limited effect as most farmers had borrowed from private money-lenders. It would also fail to address the underlying causes of debt.

Table 1
Direct subsidies in 2005
Direct subsidies in the U.S., India, Europe and Japan (in US$), showing widely contrasting subsidization by region.
Source: http://farmsubsidy.org/ and internal PartnerRe estimates.

	U.S.	India	Europe	Japan
Total subsidies	47 billion	13.7 billion	55 billion	49 billion
Subsidies per farm	22,500	124	7,500	139,200
Subsidies per hectare	126	88	373	11,443

The growth of agriculture

Cultivable land as a factor of production

Between 1965 and 1990 the total area of land cultivated for agricultural production grew by 9%. Since then it has fallen despite the clearing of rainforest to create new agricultural land (a policy that is being restricted due to climate change concerns).

In terms of per capita of world population, cultivable land decreased from 0.45 in 1960 to 0.25 hectares in 2000 (**figure 8**). Land consumption, however, continues to increase relentlessly as a result of urbanization, industrialization, salinization, steppe formation and many other factors. Biofuel production is also now competing with food crops for cultivable land (**figure 9**).

Figure 8
Global cultivable land
Graph showing the reduction in total cultivable land per capita of world population from 1960 to 2007, and the estimated trend to 2020.
Source: Yara International, 2007.

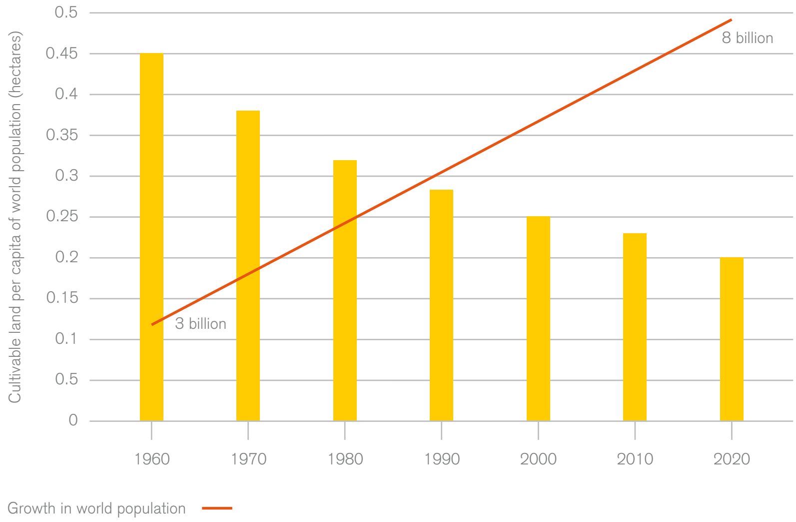
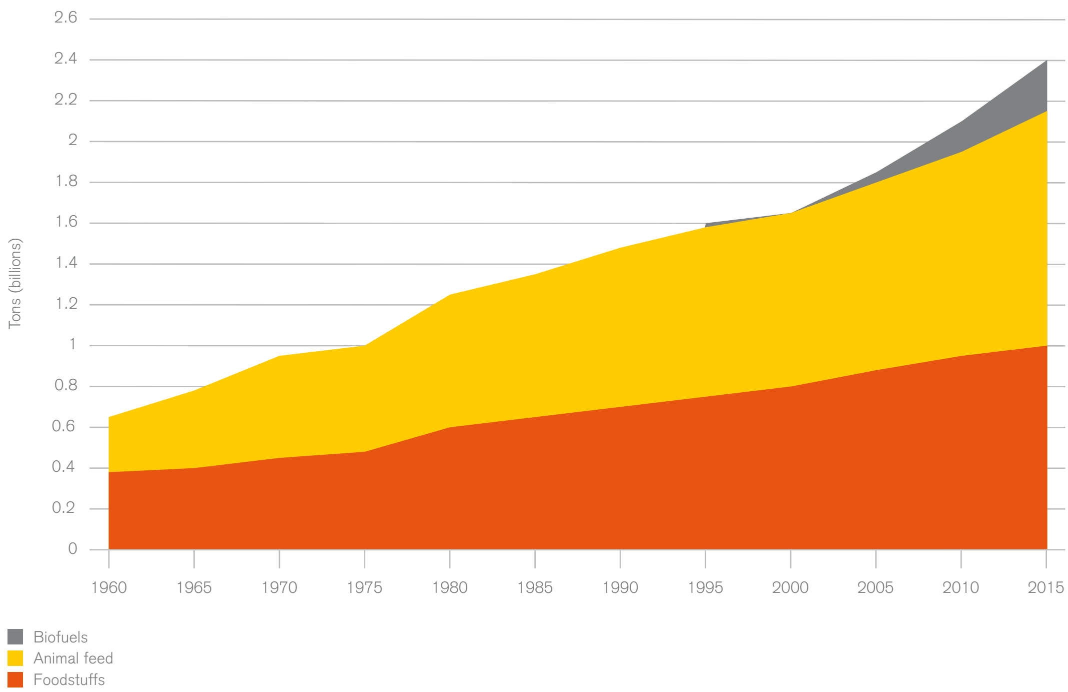


Figure 9
Crop production and usage
Biofuel crops are increasingly competing with animal feed and foodstuffs for cultivable land.
Source: US Department of Agriculture, Goldman Sachs – all rights reserved.



Growth due to technological advances

Technological progress over the last 45 years ("Green Revolution") has allowed food production to keep pace with rapid global population growth (from approximately 3 billion in 1960 to approximately 7 billion in 2007). However, although in percentage terms the proportion of people living below the poverty line has fallen (from 31% in 1960 to 23% in 2006), in absolute terms, the number has risen from 930 million to 1.61 billion.

Annual average per capita meat consumption in China rose from 4.5 kg in 1965 to 50 kg in 2005. Given a feed conversion rate of around 2.5 - 3.0, this increased meat consumption means that Chinese farmers now have to produce 120 instead of 10 million tons per year of grain for livestock rearing.

Attempts to increase yield through genetic engineering will only bring modest improvements. Many grain-producing countries such as Australia, Canada and Argentina harvest an average of 2 tons per hectare from rain-fed agriculture and 6 - 8 tons per hectare from irrigation, so the limiting factor for growth is water. Whether irrigated or non-irrigated, farmland that is currently poorly managed will see the largest productivity improvements in the coming years, assuming farmers refine their techniques.

For example, Africa's largest country, Sudan, has around 20 million hectares of cultivable land, 2 million hectares of this is irrigated. The farmers' yields are depressingly low, but there is significant room for improvement. Seen globally, however, there is little potential for growing crops more efficiently and countries like Sudan are the exception, not the rule.

Growth due to rising commodity prices

Depending on circumstance, increased purchasing power tends to alter eating habits, initially to increase the intake of carbohydrate-rich foodstuffs (cereals and vegetables) and thereafter animal protein. Gross domestic product (GDP) is rising fast in Africa, China and India, and the expectation is that there will be a continued shift toward animal protein based diets. This increasing global demand is putting pressure on prices, worsened further by demand for agricultural commodities to produce biofuels (see **table 2**).

Table 2
Global commodity prices
Crop commodity prices (in US$ per ton) rose sharply from 2006 to 2007.
Source: FAO Food Price Index.

	Bread wheat	**Malting barley**	**Rapeseed**	**Rye**
2006	192	224	352	192
2007	428	429	521	368
Growth in %	123%	91%	48%	92%

Figure 10
Above, salmon broodstock kept in freshwater on a Canadian fish farm.
Below, cod, as one of an experimental aquaculture species.

Positive outlook for aquaculture

Aquaculture is the fastest growing food production sector; between 2000 and 2005 output increased from 35 to 48 million tons (**table 3**). At present, around 4-5% of global aquaculture production is insured; there have traditionally been an insufficient number of insurance companies willing to invest in this sector. To date, the insured portion of the industry has mainly covered game fish, such as salmon, trout, eel, gilt-head bream, tuna and shrimp.

In some regions, authorities have now ceased to issue licenses for aquaculture pending environmental impact studies. In some cases, aquaculture competes for tourism or drinking water sites. Modern aquaculture is investment-intensive and dominated by a small number of players: 95% of the salmon industry, for instance, is in the hands of less than 10 large companies. Of these, Marine Harvest/Oslo alone holds a 60% stake. Major food and shipping firms have entered this growth market and are investing heavily in high-end fish, such as halibut and cod.

The Food and Agriculture Organization of the United Nations (FAO) has reported an increase in the number of aquaculture companies being opened in Asia, Latin America and the tropical belt of Africa (**table 4**) – and not just in the luxury segment. Selected developments are being supported by special FAO training projects (Best Practice, Micro Finance). Despite the fact that they are mostly produced in small-scale farms, fish species like the tilapia and catfish have already conquered international markets. Fish farmers are increasingly involved in political lobbying to ensure that they enjoy the same price protections as their counterparts in agriculture.

This lobbying has already proved successful in many areas, in particular as regards:

- the inclusion of fish diseases in epidemic control regulations
- payments from agricultural catastrophe funds for damage sustained in aquaculture
- the dismantling of protective duties
- the subsidization of insurance premiums.

Table 3
Fish production
Global "capture" and "aquaculture" fish production (in millions of tons) showing aquaculture as one of the fastest growing food production sectors.
Source: FAO aquaculture statistics, 2006.

	2000	**2001**	**2002**	**2003**	**2004**	**2005**
Production						
Inland						
Capture	8.8	8.9	8.8	9.0	9.2	9.6
Aquaculture	21.2	22.5	23.9	25.4	27.2	28.9
Total inland	30.0	31.4	32.7	34.4	36.4	38.5
Marine						
Capture	86.8	84.2	84.5	81.5	85.8	84.2
Aquaculture	14.3	15.4	16.5	17.3	18.3	18.9
Total marine	101.1	99.6	101.0	98.8	104.1	103.1
Total capture	95.6	93.1	93.3	90.5	95.0	93.8
Total aquaculture	35.5	37.9	40.4	42.7	45.5	47.8
Total world fisheries	131.1	131.0	133.7	133.2	140.5	141.6
Utilization						
Human consumption	96.9	99.7	100.2	102.7	105.6	107.2
Non-food uses	34.2	31.3	33.5	30.5	34.8	34.4
Population (billions)	6.1	6.1	6.2	6.3	6.4	6.5
Per capita food fish supply (kg)	16.0	16.2	16.1	16.3	16.6	16.6

Table 4
Aquaculture producers
Global aquaculture production (in tons) by region in 2002 and 2004. The top 10 regional producers, led by China, represent almost 90% of total production.
Source: FAO aquaculture statistics, 2006.

	2002	**2004**
China	27,767,251	30,614,968
India	2,187,189	2,472,335
Viet Nam	703,041	1,198,617
Thailand	954,567	1,172,866
Indonesia	914,071	1,045,051
Bangladesh	786,604	914,752
Japan	826,715	776,421
Chile	545,655	674,979
Norway	550,209	637,993
U.S.	497,346	606,549
Top ten subtotal	35,732,648	40,114,531
Rest of the world	4,650,830	5,353,825
Total	40,383,478	45,468,356

The effects of ocean warming in Europe, as predicted in the IPCC reports, can already be observed in some areas. Among the most dangerous are the proliferation of marine algal blooms (see **figure 12**) and jelly fish, as well as the warming of streams that are diverted for aquaculture; as water warms it contains less dissolved oxygen and can stress fish species and other organisms.

Only 4 - 5% of global production is currently insured. This low figure mainly reflects difficulties associated with market access and the fragmented, small scale nature of aquaculture operations.

Agricultural insurance: status quo in 2007

The world's core areas of agricultural production insure crop and livestock. Penetration of insurance for forestry and aquaculture is however not as high. Where natural catastrophe exposure allowed affordable premiums, hail insurance for crops and disease insurance for livestock evolved 150 years ago – without subsidies. Over the last 50 years, subsidized premiums have increased and extended the scope of agricultural insurance cover (**table 5**). Compared to total government subsidies to agriculture, however, insurance premium subsidies have always remained modest (2-3%).

The U.S., a pioneer in premium subsidies for crop insurance, has long been lobbying at the WTO negotiations to encourage other countries to replace subsidies with insurance premium subsidies (green box compliance, etc.). In the U.S., insurance premium subsidies make up around 10.5% of total subsidies.

Were governments to follow the U.S.'s lead, this would open up enormous growth opportunities for the agricultural insurance industry outside of North America. However, farmers' associations have so far been unwilling to forfeit the benefits of direct subsidies and are demanding insurance premium subsidies as additional subsidies. The dramatic rise in commodity prices has now created a new negotiating position:

- grain, milk powder and meat reserves have all declined sharply and the EU alone is saving billions of euros thanks to lower storage costs
- global market prices have increased rapidly, bringing them much closer to typical EU price levels and substantially reducing the need for support subsidies
- EU expansion has resulted in 10 new countries joining the Union, but with a barely increased budget for agricultural subsidies.

However, many farmers from the "old" EU countries are keen to defend the status quo, claiming that it is too early to remove support price subsidies as one cannot be sure that commodity prices will remain at the current high levels.

Table 5
Insurance premium spend
Approximate agricultural insurance premium expenditure (in US$ millions) by region, showing widely differing subsidized premium percentages.
Source: PartnerRe.

	Canada	**U.S.**	**Europe**
Premium spend	1,150	6,560	2,150
% subsidized	65%	58%	32%
Subsidized premium	748	3,805	688

New cover concepts in agricultural insurance

In the following sections, we outline examples of developments in crop, forestry and aquaculture insurance, as well as parametric alternatives for agricultural risk and CO_2 trading. The interplay between cause and effect is always complex and we hope that we do justice to this complexity in our short and sometimes oversimplified summary. The key catalysts for development are climate change, commodity prices, or both.

Crop insurance

Organic growth of crop hail insurance
Sums insured and premium income are growing due to the dramatic increases in agricultural commodity prices. As an indication of this growth, the premium income for hail portfolios containing a large proportion of grain increased by 30-40% between 2007 and 2008. Increases have been less extreme in portfolios with a heavy fruit and vegetable weighting.

Demand for biofuels is partially factored into rising commodity prices. As regards associated new concepts in biofuel crop insurance, PartnerRe has seen requests to cover new varieties of these plants at the experimental stage.

Multi-peril crop insurance with subsidized premiums
Pilot projects have been launched and concluded in several European countries. These are now gradually being scaled up into national programs, such as in Italy (**tables 6 and 7**). France, Poland and Italy are increasing their budgets for crop insurance premium subsidies year-on-year.

Table 6
Crop insurance in Italy
Insurance cover trends in Italy showing the result of a national project to introduce subsidized multi-peril covers.
Source: PartnerRe.

Insured perils	2004	2005	2006	2007
Hail	90%	81%	72%	58%
Multi-peril	6.5%	15%	18%	27%
Greenhouses	3.5%	4%	6%	8%
Livestock diseases			4%	7%
Total	100%	100%	100%	100%

In Turkey, insurance market premium volume increased from around US$ 20 million to US$ 90 million in two years thanks to government insurance premium subsidies. In Brazil, we expect market premium volume to increase from around US$ 70 million in 2007 to US$ 100 million by the end of 2008. As premium subsidies account for such a small proportion of total agricultural subsidies, growth opportunities in agricultural insurance are particularly high.

Price protection in crop insurance

In recent years, rising commodity prices have bolstered demand for insurance solutions coupled with partial price protection, such as "revenue cover" in the U.S. Farmers who sell a portion of their harvest in advance on a futures market need to hedge against commodity price fluctuations; if a natural catastrophe were to destroy the "pre-sold" crop, replacement crop would have to be bought at a time when prices would be inflated due to reduced supply. In times of high inflation, the potential loss to the insured is greater and solutions that mitigate this risk will increase in popularity.

Traditional crop insurance covers can also be restructured to include a double trigger (natural catastrophe loss event plus simultaneous price increase). When calculating the premium it is important to make sure that commodity price fluctuations are priced with an appropriate fluctuation loading.

Table 7
Insurance premium subsidies in Italy
Premium subsidy trends in Italy following a national project to introduce subsidized multi-peril covers.
Source: PartnerRe.

Year	Total Subsidy (euro millions)	Average premium rate (%)	Premium paid by farmer (%)	Subsidized premium (%)	Sum insured (euro millions)	Insured perils
2001	100	7.57	59	41	3.03	Hail
2002	103	8.38	56	44	3.20	Hail
2003	100	8.14	57	43	3.33	Hail
2004	100	7.25	42.5	57.5	3.58	Hail/frost
2005	150	6.97	35	65	3.64	Hail/frost/wind
2006	160	6.60	33.5	66.5	3.52	Multi-peril
2007	190	6.20	32	68	3.86	Multi-peril

Figure 11
Windstorm Kyrill initiated over Newfoundland on January 15, 2007, and then moved eastward across Europe with peak gust speeds including 144 km/h recorded at Germany's Dusseldorf Airport. The storm caused at least 47 fatalities and extensive damage to property and forest. Over one million people were left temporarily without electricity.

Forestry insurance

Windstorm

Experience with hurricanes Lothar, Martin and Kyrill has shown that windstorm is a catastrophe risk for Europe's forests (**figure 11** and **table 8**).

A major storm can be expected to bring down about 4 - 5 years' worth of low-grade timber which floods the market and causes prices to collapse, often for several years. An insurance solution would need to guarantee the price of timber before an event to ensure that forest farmers are indemnified for the entire fall in value caused by the storm.

Forest owners may be broken down into the following categories: small private owners, local authorities, pension funds and banks, large private owners (timber and paper industry) and religious organizations.

Insured interests include:

- market value of destroyed timber
- replanting costs
- clean-up costs and the cost of building harvest access roads
- storage costs (often for multiple years due to collapse of timber prices).

Key information needed for re/insurance:

- geographical distribution/tree variety/age class
- tree variety (coniferous or deciduous)
- value per tree variety and age class
- topography
- tree height
- husbandry (e.g. thinning).

Table 8
European Windstorm
Examples of windstorm damage (lost timber volume and value) by storm and region.
Source: PartnerRe.

Year	Windstorm	Region	Forest damage m³ timber (millions)	euro (millions)
2005	Erwin	Sweden	75	
1999	Lothar and Martin	Europe	193	2,700
		France	140	1,000
		Germany	30	1,000
		Switzerland	12	500
1990	Vivian and Wiebke	Europe	120	

Using forestry inventory data before and after the storms, PartnerRe developed vulneribility functions which calculate loss ratios on the basis of wind speed. Tree variety, tree height, forest husbandry and topography are all factored into our model.

To calculate the full loss potential to a forestry portfolio from any one event requires the combination of the respective wind field data and vulneribility functions; the latter on their own are insufficient. PartnerRe's catastrophe department has developed such wind field data, for use in both property and agricultural lines of business. With vulneribility functions, wind field data and portfolio data, individual storm covers can be priced and portfolio-specific probable maximum losses (PMLs) modeled.

Figure 12
Algal bloom in British Columbia (2006). Such events cause high mortality rates amongst farmed fish because of their inability to swim to lower depths or unaffected water to escape suffocation/intoxication.

Aquaculture insurance

An aquaculture portfolio is primarily exposed to marine natural catastrophes such as tsunami, storm, algal bloom (**figure 12**) and pollution, but with a loss experience that only extends back about 20 years. Reinsurers are now increasingly being asked to break new ground by carrying development risks relating to new markets, unknown fish species and production techniques.

In conjunction with an aquaculture insurer, PartnerRe has consequently devised a PML method that addresses the key issues, including maximum liability per event and estimated return periods for specific events.

Our PML method, which makes a range of assumptions and standardizes various calculation steps, provides an estimate. This estimate allows us to determine maximum capital deployment and capital requirements. Our calculation revealed that the 20-year average claims ratio does not accurately reflect our clients' probable exposure. The fluctuation loading for catastrophe scenarios can in fact be as high as 20%.

At PartnerRe we are working on the assumption that aquaculture insurance will soon spread to the Asian market. This means that insurers will have to revise the "natural perils", "social and technical risks", and "risk management" components of their existing PML calculation to ensure that their estimates correspond to the new risk profiles and locations.

Parametric alternatives

Building an insurance infrastructure according to traditional models can be problematical principally because:

- traditional structures are very personnel-intensive, especially in loss assessment
- conventional distribution channels are often unsuitable for rural settings
- smallholdings farmed in open-field strips already bear high administration costs.

As a result, many countries do not have crop insurance. Parametric covers may be an alternative in regions where traditional crop insurance is not suitable as they reduce the insurer's startup cost. However, parametric covers settle on an index that may not perfectly reflect a given farmer's loss and thus create basis risk for the original insured.

Parametric covers have been successfully employed to manage precipitation, flooding, accumulated temperatures and frost risks in agriculture. In many crop producing regions, water is the single most important factor in determining yield. Drought index products are designed to pay out on a sliding (parametric) scale depending on the rainfall deficit. This deficit is measured at an official weather station that is protected against manipulation. On-site checks are not performed to verify crop loss, thus reducing individual loss assessment costs.

These new, customized solutions require development work and intelligent product architecture. Expectations in terms of price and loss assessment accuracy must also represent an acceptable compromise. While parametric products are new, we observe a growing trend toward developing parametric covers, particularly in emerging markets.

Advantageous to both traditional and alternative parametric solutions, remote sensing can now perform traditional risk acceptance and loss evaluation tasks. Satellite images, for instance, can be used to monitor crop covers that are only supposed to incept once the seed has successfully emerged. This saves on expensive, personnel-intensive, on-site risk inspections.

Remote sensing is now also able to measure damaged surfaces and negative yield effects very accurately, bringing down the cost of on-site claims handling. Naturally, remote sensing services require insurers to digitally map their portfolio; however, doing this is still significantly cheaper than building a traditional crop insurance infrastructure.

Trading in CO_2 certificates

CO_2 trading has now almost evolved into an internationally liquid market. From the agricultural insurer's point of view, all renewable commodities that qualify for CO_2 certificates remain insurable against standard risks. CO_2 accreditation will increase the insured value of a crop (i.e. the sum insured for frost, fire, hail or drought is the CO_2 contract value plus the commodity price). As the price per ton of CO_2 fluctuates considerably, annual fixed commodity prices should be agreed for insurance purposes.

In forestry, the accreditation of CO_2 contracts depends, amongst other things, on best practice management criteria. This is generally positive in terms of improving risk quality.

As the accounting standards for the accreditation of CO_2 contracts have yet to be internationally harmonized, CO_2 securities are exposed to a certain degree of trading or disallowance risk. For insurers who cover plants such as the Australian saltbush (which has no additional commodity value beyond its CO_2 contract value), disallowance of the certificates could increase the risk of moral hazard where plantations are insured against fire, for instance.

Insurance products designed to protect clients against CO_2 contract trading risks really belong to financial guarantee and credit insurance.

Closing remarks

There has been significant momentum at all levels of the agricultural sector (production, markets, politics and regulation) in recent months, and there is broad agreement that agricultural production will continue to attract substantial investment. This investment will be backed by banks and insurance companies provided that risk management is in place and the risk capital stands to generate a reasonable return.

As a professional multi-line reinsurer, PartnerRe provides intelligent risk management products to global insurance companies and the capital markets. Our success is rooted in our ability to understand, evaluate and manage risks, and to meet the needs of our clients at all times. To keep our stakeholders fully informed on all aspects of risk assumption, we attach great importance to transparency, credibility and professionalism, and also regularly publish reports on a variety of insurance themes.

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