What are the Effects of Biofuels and Bioproducts on the Environment, Crop and Food Prices and World Hunger?

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Key Messages and Facts

1. Biofuels and bioproducts are very positive for the environment in reducing greenhouse gas emissions and reducing fossil energy usage.
2. Biofuels have had marginal effects on Canadian and international food price increases since 2007. These small increases have been offset by the depressive effect of fuel ethanol supply/supplementation on gasoline prices.
3. Recent price spikes will stimulate future agricultural development in developing countries and depress future world grain prices.
4. Bioproducts represent an excellent opportunity to use excessive Canadian agricultural productivity while addressing other societal goals.

Development of Biofuels and Bioproducts

- Biofuels are the most developed in North America, Brazil and the European Union but are also produced in many other countries. The reasons include environmental quality, less dependence on imported petroleum products and rural economic development.
- Canada produces about 1.8 billion litres of fuel ethanol and 110 million litres of biodiesel per year. Ethanol comes from corn and wheat; biodiesel is mostly made from used cooking oil and animal fats though some comes from soy and canola oil. These numbers must grow to about 2 billion and 600 million, respectively, to meet new mandates for Canadian biofuel usage.
- About 5.7% of global grain production (3.7% after netting out byproducts) and 10% of global vegetable oil production is now used to make 85 billion and 15 billion litres of ethanol and biodiesel, respectively. The respective US numbers are 54 and 1.5 billion.
- The global production of bioproducts is about $1-2 billion per year and the potential for growth is huge. Annual world sales of plastics are more than $1 trillion.

Biofuels and the Environment

- Substituting 10% ethanol into gasoline in Ontario/Canada means a 62% reduction in net greenhouse gas (GHG) emissions, on a per-litre basis, adjusted for differences in the relative caloric energy content of ethanol and gasoline, including corn inputs, transportation and associated soil losses.
- The 62% reduction means an annual reduction of 2.3 million tonnes of GHG emissions, equivalent to the annual emissions from 440,000 cars, about two-thirds of this in Ontario.

- Fuel ethanol produced from corn has 1.6 times more combustible energy than is used for its manufacture, including corn production and transport. This ratio could increase to 2.3 by 2015.
- Average GHG and energy efficiency ratios are higher in Ontario than in the United States because of lower energy costs for corn production and ethanol manufacture in Ontario.
- Biofuel production has caused no notable shifts in crop acreages in Ontario and Canada. Total seeded acreage to principal crops has not increased in the United States.

Decades of Increasing Productivity and Declining Real Grain Prices

- After spikes in 1974 and 1980, real price of major agricultural grains and food decreased for about 30 years.
- Average world grain yields have increased faster than the rate of population growth.
- This has meant lower real grain prices, and a major reduction, until very recently, in government support for agricultural development in less-developed countries. It also meant an increased dependence on imported food ingredients for many, though not all, developing countries.
- Doha Round WTO negotiations were initiated in 2001, in part, to address negative effects of low grain prices on third-world agriculture and food security.

Biofuels and Corn Prices

- US government policies in support of fuel ethanol will mean a longer-term increase of about 15% in US corn prices, equivalent to $0.40 to $0.60 per bushel.
- Ethanol production increased Ontario corn prices, compared to Michigan, by an average $0.29/bushel for seven years beginning in 2000/01, but not for the past four. Higher Ontario corn yields have caused the recent decline.
- 110 million bu/year of corn are used to make ethanol in Ontario; without this, Ontario corn prices might have been as much as $0.50/bu lower in recent years.

World Hunger

- The number of hungry people has remained at around 900 million for 40 years. While declining as a percent of world population, this number is still unacceptably high. While most of the hungry are in Asia, the number is declining there while growing rapidly in Africa. Africa will hold a majority of the world's hungry by 2020. Most are in rural areas.

- The “grain deficiency” for the hungry people in the world’s most hungry countries is equivalent to 1.1% of annual world grain production. The problem is lack of local food production in hungry rural areas, not supply of grain from the developed world.
- The “solution” involves greater local grain production – including converting large acreages of potential arable land into agriculture, and higher yields with the adoption of more advanced agriculture – and not more imports from developed countries.
- There are 1.6 billion overweight and obese people, more than the number hungry.
- Twenty-five to fifty percent of world’s food supply is wasted or spoiled.

Effects of 2007-2008 and 2010-2011 Price Spikes

- The 2007-2008 spike in grain prices was greater for rice and wheat than corn. The former are much more important as direct human food in most developing countries.
- Hoarding, export bans and panic buying by governments, and higher energy costs were mostly responsible. World grain supplies did not decline. Speculation may have played a minor role.
- Biofuels did increase $US corn prices by an estimated 20-40% in mid 2008, though less in other countries because of a declining US dollar.
- Local effects varied markedly among/within developed countries because of isolation, government food price policies, import/export policies, and the low dependence on imported corn for direct food needs.
- A second price peak is occurring in late 2010 and 2011. This is very similar to the double price peak experienced in 1974 and 1980, which was followed by several decades of declining real grain and food prices (i.e., after adjusting for inflation).

Effects on Food and Gasoline Prices

- In North America, the increase in corn price caused by biofuels had less than a 1% effect on food prices. Food purchases represent only 12% of total disposal income.
- Farmers receive only about 19% of the average retail price of food.
- Average Canadians earn enough to pay the farmers’ share of annual food purchases by January 9. Price increases caused by biofuels may have delayed this by a few hours.
- Ethanol blending has reduced gasoline prices – i.e., compared to what would have occurred without ethanol blending - by an average of $0.06 to $0.10 per litre. This more than offsets the small food-price effect of ethanol on family financial well-being.

- Obesity and wastage, not food supply and price, are the main Canadian food problems.
- Analyses show the effect of biofuels - and notably ethanol from corn - on world food prices was very minor. Increased oil prices were far more important.
- The largest effects would have been in grain-deficient Latin/Caribbean countries like Mexico, where corn is the main food. However, government pricing policies often mean different prices for white food corn than for imported yellow feed corn. Mexico has a higher percent obesity than in Canada.

Future Expectations and Implications for Ontario Grain Farmers

- A 1.1% in rate of annual grain production is needed to increase total global production by 70% between 2000 and 2050. This should be achievable with the increased attention now being given to global agricultural development, after decades of neglect – even with climate change. Average world grain yield increased by 1.5% per year from 1987 to 2007.
- As food production increases in developing countries, export-oriented countries like Canada could again face serious problems in agricultural over-supply/production and depressed farm income. Slow growth in food consumption in Canada, the US and Europe will add to the problem.
- Increased production of non-food consumer products such as bioproducts represents an excellent means for addressing this impending problem.

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Executive Summary

This report was written to provide the Grain Farmers of Ontario with information on issues relating to the use of farm crops - specifically corn, soybeans and wheat - for the production of biofuels and other non-food bioproducts.

The report provides an overview of Canadian and global biofuel manufacturing, and reviews publicly available information on the effects of biofuels and bioproducts on environmental quality, crop and food prices, and global food supply and hunger, especially during the grain price spikes of 2007-2008 and 2010-2011. The report also makes some projections on what lies ahead and implications for Ontario grain farmers.

The report does not include any examination of federal or provincial government financial programs for biofuels in Canada or other countries – nor defense or criticism of these policies - other than a consideration of usage mandates and import duties.

Development of Biofuels and Bioproducts

Fuel ethanol made from cane sugar (Brazil) and from corn in the United States and Canada is the dominant global biofuel. Fuel ethanol is also made from wheat in Western Canada and in some other countries including Europe. Biodiesel is also important, especially in Europe where it is made from rapeseed oil, and in the United States and Argentina from soybean oil. Most biodiesel in Canada is made from used cooking oil and animal fat, though greater production from canola and soybeans is expected.

In 2010, the global production of fuel ethanol and biodiesel amounted to about 85 and 15 billion litres, respectively. Corresponding quantities for Canada were about 1.83 billion litres of ethanol and 110 million of litres biodiesel – and for the United States, 54 and 1.5 billion, respectively.

Biofuel development is being driven by mandates, subsidies, and supportive import-export policies in many countries of the world. Canada now has a mandate for an average of 5% ethanol in Canadian gasolines, and an expected mid-2011 mandate for an average of 2% biodiesel content in diesel distillates. Canada will need to increase domestic production of ethanol and biodiesel by 7% and 450%, respectively, if these mandates are to be satisfied using biofuels made in Canada.

About 15 percent of global corn production or about 5.7% of total global grain production is used for ethanol production (about 3.7% when byproduct production is included). About 10% of global vegetable oil production goes to make biodiesel. In Canada, an estimated 3.5 million tonnes of corn and 1.0 million tonnes of wheat per year (equivalent to about 30% and 4% of total Canadian production, respectively) are now required to produce fuel ethanol..

Ethanol production from grains is expected to level off in North America during the decade ahead, though biodiesel production will likely continue to grow more quickly, at least on a percent-per-year basis. The rate of expansion may be greater in other countries, especially South America and Europe. Major growth is projected for cellulosic ethanol though production is still miniscule.

The current global market for bioplastics is estimated at $1-2 billion per year, and dwarfed by the size of the global biofuel market and even more so by the size of the world market for plastics at $1 trillion or more. The global bioplastic market is projected to be worth $6 billion by 2015 and $20 billion by 2020.

Biofuels and the Environment

Ethanol blending of gasoline has been supported globally as a mechanism for environmental improvement. Ethanol has replaced other more hazardous compounds used for octane enhancement in gasoline while also reducing harmful engine emissions, reducing the usage and importation of petroleum and refinery products, and reducing net greenhouse gas emissions.

A wide range of estimates exists concerning the magnitude of benefits of fuel ethanol in reducing net greenhouse gas (GHG) emissions and over-all fossil energy efficiency. All of these include considerations of inputs used to grow corn, transportation costs, soil losses of carbon dioxide and nitrous oxide, and credits for byproducts which are used for feed and other purposes.

Efficiencies are generally higher for analyses of Ontario/Canada production compared to the United States, because of the lower use of synthetic nitrogen fertilizer (more manure), less usage of lime and little irrigation in Ontario corn production, and the fact that all Canadian ethanol plants use natural gas rather than coal as the energy supply. Average energy use for corn drying is higher in Canada than the United States.

Recent studies show that ethanol contains about 1.57 joules of combustible energy for every joule of fossil energy used for its production. This ratio is projected to increase to 2.27 by 2015. The substitution of ethanol into 10% blends with gasoline results in a 62% reduction in net greenhouse gas emissions on a caloric basis adjusted for differences between the caloric energy content of ethanol and gasoline. (Ethanol has 68% of the combustible energy of gasoline.)

The 62% reduction means an annual reduction of 2.3 million tonnes of GHG emissions or equivalent to the annual emissions from 440,000 cars. About two-thirds of this is in Ontario.

While the energy and GHG balances are increasing for fuel ethanol, the reverse is true for many Canadian gasolines because of their increasing dependence on tar-sand petroleum as the refinery feedstock.

The blending of up to 10% ethanol into gasoline generally produces about a 1% improvement in caloric engine efficiency, and allows gasoline marketers to use lower-octane levels in “base” (before-blending) gasoline. This is because of the high blending octane of ethanol.

There have been recent reports that the production of biofuels may mean the conversion of non-agricultural lands into crop production and that the production of carbon dioxide from tree burning and grassland soil organic matter loss may be very large. However, there is no evidence for this in Canada as corn acreage in Ontario and wheat acreage in Western Canada have not increased in recent years. Total cropped acreage has not changed in the United States.

Biodiesel produced from soybeans has much higher energy efficiencies and GHG balances than does ethanol production from corn. The lack of requirement for nitrogen fertilizer and limited need for grain drying with soybeans are predominant reasons. Biodiesel from soybeans has about 88-95% of the caloric energy content of diesel fuel.

The highest energy efficiencies and GHG balances are projected to come in the future from cellulosic ethanol manufacturing.

Grain Price Spikes and the Significant of Biofuels

For the past three decades, rates of increase in global grain production have generally exceeded the rate of population growth and real grain prices have declined. Real food prices declined by 53% between 1975/76 and 2000/01. Major concerns about the ability of the world to feed itself, which had been dominant in earlier years, were largely replaced with international concerns about excessive productivity and the effects of declining agricultural prices on farm and rural economic well-being. Farm subsidy payments increased in many developed countries.

The effects were seen as being especially harmful to third-world farmers and were one reason why many third-world countries which were formerly near self-sufficient in grain/food production became major grain importers. The need to increase agricultural commodity prices and to reduce subsidies was one of the priorities for the Doha Round of international trade negotiations.

The complacency about world food supply changed quite abruptly in late 2007 and into 2008 because of a major spike in grain prices. From January 2004 to May 2008, the world price of wheat in US dollars was up 108%, rice up 224%, corn up 88% and soybeans up 53%. Prices for all subsequently dropped by about 30% between May

2008 and March 2009. The price spikes in 2007-2008 were very similar to those experienced three decades earlier in the 1970s.

Many analyses have been done on causes of the spikes and there is broad agreement on the significance of several factors, including: poor wheat crops in some major grain growing areas of the world, low global stocks for principal grains, increases in oil and fertilizer prices, a decline in the rate of exchange of the US dollar (spikes were not so high in other currencies), new grain export restrictions by several countries, and panic buying and hoarding. There was no global grain shortage at the time. Increased global meat consumption, especially in China, was not a contributing factor. China and India were both net grain exporters during 2007/08. There is no consensus as to whether market speculators contributed substantially to the price spikes.

Increases in grain and other commodity prices were not experienced universally around the world. The magnitude, and even the existence of a grain price spike in 2008 and decline thereafter, differed dramatically by geographic area – and even by location within the same country.

Biofuels have figured prominently in discussions about causes of the price spikes in 2007-2008. There are major differences of opinion about the extent of the influence with estimates ranging from about zero to more than 70%.

A very detailed and sophisticated analysis is one completed in 2010 by the Department of Environment, Food and Rural Affairs, United Kingdom. They concluded:

> “Medium-term economic models agree that biofuel demand has and will put upward pressure on prices for those agricultural commodities used in biofuels production.
>
> “However, available evidence suggests that biofuels had a relatively small contribution to the 2008 spike in agricultural commodity prices where its impact was largely limited to the maize market with some knock-on effects on soybean prices.
>
> “Studies which have found a large biofuel impact across agricultural commodities have often considered too few variables, relied on statistical associations or made unrealistic or inconsistent assumptions.
>
> “A significant feedstock for biofuel use, sugar, did not see a large rise in price during the spike period but increased significantly in 2009 when other commodity prices had fallen back from their peaks.

> “Whilst commodity prices have fallen steeply from their peaks in 2008 biofuel demand has remained steady – indicating that the causal link from biofuel demand to short-term crop prices is still relatively weak.”

A review of all studies suggests that ethanol production might have been responsible for 20-40% of the peak price in US corn prices experienced in 2008. There is a consensus in a number of recent studies that an elimination of US ethanol support programs would mean a corn price decline of about 15% relative to the base (status quo) case. At an average Chicago Mercantile Exchange corn price of $2.70/bushel, 15% equates to about 40 cents/bu. For $4.00 corn, this increases to 60 cents. Of course, if ethanol production ceased overnight, the price impact would be far greater, given the near-term inability of supply to adjust to the reduced demand.

By increasing the provincial usage of corn so that Ontario changed from a net-corn-exporting province to a net importer, ethanol production would have been expected to have increased the corn adjusted price basis in Ontario. However, there is only a marginal pattern for this basis having increased, and only for years 2002 through 2005.

Ontario corn prices relative to those in Michigan increased, on average, by about $0.29/bushel, for seven crop marketing years beginning in 2000/01, but the differential has since reverted to more historic levels because of higher Ontario corn yields and production. Increased ethanol production in Michigan is also a likely factor.

A critical question is: What would the price relationship between Ontario and Michigan corn prices be if Ontario did not now use about 110 million bushels of corn, annually, to produce ethanol? A graphing of the long-term relationship between the Ontario-minus-Michigan price differential and the annual difference between Ontario annual corn production-minus-usage shows that a 110-million-bushel reduction in usage could mean as much as $0.50/bushel in lower price. Even if the effect is only half of $0.50/bushel, it amounts to a large amount of farm income, when multiplied by a provincial corn crop of nearly 300 million bushels.

Biodiesel has had no effect on oilseed prices in Ontario/Canada to the present.

As this is being written, another price peak is occurring for grains and other commodities. Current futures prices for corn, wheat and soybeans are close to those seen in 2008.

Price patterns for grains, oilseeds, oil, fertilizer and other commodities in recent years have an uncanny resemblance to what happened in years around 1974 and again around 1980.

As in 2007-2008, recent price changes for specific food commodities have varied dramatically among countries of the developed world – for example, corn price up by almost 100% in Moldavia in Eastern Europe and down by 50% in Uganda.

The 2010-2011 grain price spike seems to have been largely caused by poor wheat crops in several countries, tight global stocks, and unusually large wheat purchases by several countries, especially those experiencing civil unrest in North Africa and the Middle East. Biofuels continue to be identified in the media and by some organizations as one factor contributing to the price increases.

Biofuels, Food and Gasoline Prices, and World Hunger

Primary prices paid for agricultural commodities represent only about 19% of prices paid for food by consumers in developed countries. Average food prices did increase in Canada and the United States, by as much as 7% in year-over-year comparisons, in part because of agricultural and energy price spikes in 2008. Food company profits grew during this period. The food price increases in 2007-2008 also need to be put into perspective of the much longer trend for declining real food prices. Canadian consumers spend only about 12% of disposable income on food.

Average Canadians earn enough money by January 9 to pay for the farmers' share of all food purchases for the year. Biofuels may have caused this date/time to have been delayed by a few hours.

A report by the US Congressional Budget Office (2009) states that "From April 2007 to April 2008, the increasing demand for corn to produce ethanol contributed, in CBO's estimation, between 0.5 and 0.8 percentage points to the 5.1 percent increase in the price of food."

Ethanol blending has reduced gasoline prices (i.e., relative to what they would have been without ethanol supply) by an average of $0.06 - 0.10 per litre in US studies. A similar price benefit can be calculated based on the low elasticity (-0.5) of gasoline consumption versus price, and the fact that ethanol now represents 5% of the world's gasoline supply on a caloric energy basis. The resulting economic benefit for Canadian families is estimated at $100-180 per year – or about three times larger than the estimated additional $35-60 spent for food in 2008 because of biofuel-related grain price increases.

While food does represent a significant expenditure for most Canadian families, price issues need to be put in perspective against the much larger issue of being over-weight or obese. Globally, 1.6 billion people are over-weight or obese.

In addition, about 40% of food is wasted in Canada. The food problem in Canada tends to be one of over-supply, over-consumption and wastage, not inadequate supply or high prices.

About 850 million people around the world were estimated by the FAO to be hungry in 2006 and 925 million in 2010. There were about 880 million hungry people in 1970. While the proportion of humans who are hungry has declined significantly over 40 years, 925 million hungry is still a major tragedy.

One of the critical causes is a substantial reduction in government support for agricultural development in most developed countries over several decades.

Although the largest share of the world's hungry are in Asia, this number is in decline because of substantial improvements in agricultural productivity. The biggest problem is Sub-Saharan Africa where agricultural productivity is very low and scarcely improving; half of the world's hungry will be there by 2020. Fortunately, the opportunity to improve agricultural production – both through increases in cropped acreages and in per-acre yields - is very large. Hunger also exists to an unacceptable level in several Latin American and Caribbean countries.

Rice and wheat are the main food crops in most under-nourished countries, with the exception of Latin America and some East and Southern African countries where white corn is very important. Government pricing policies for white food corn have insulated consumers in some of these countries (example, Mexico) from the effects of increasing prices for imported yellow feed corn.

Recognition is needed of the 25-50% of food which is wasted or spoiled. Poor transportation infrastructure, corruption and high energy costs also contribute to hunger in developing countries.

The USDA has calculated that the amount of grain and equivalent (eg., starchy root crops) needed to eliminate caloric food deficiency for 70 studied countries in 2010 was about 24 million tonnes. This represents about 1.1% of current world grain production (about half of average Canadian output). It's only about 4% of current grain production in the 70 countries themselves.

The FAO's Food Price Index (FPI), after remaining around 100 for nearly two decades, reached a peak of about 215 in mid 2008, then declined to about 140 in early 2009 before moving upward to reach 236 in February 2011. In inflation-adjusted dollars, the FPI is approaching levels not seen since the 1970s. However, the local equivalent of the FPI is strongly influenced by exchange rates and changes in the FPI often bear no resemblance to what happens at the local level in developing countries.

Add to this the fact that the principal food crops in most countries are rice and wheat, rather than corn and soybeans which are mainly used for livestock feed, processed foods and biofuels. It seems reasonable to conclude that effect of the biofuel component of grain commodity price spikes of 2008 on third-world hunger was very small. The same interpretation seems valid for 2011. Oil price increases have had a much larger effect.

Although bioproducts have been largely ignored in the biofuel-versus-food discussion, bioproduct production cannot avoid the debate. We are already seeing examples of discrimination against bioproducts produced from grain and oilseed crops.

What to Expect in the Future

Some forecasters suggest that current high farm crop and food prices are the new norm, and that prices will be both higher and more volatile for years to come.

A common projection is that the world's food supplying capacity will have to increase by 70% between 2000 and 2050, or about 1.1% per year. By comparison, average world grain yield increased by 1.5% per year between 1987 and 2007.

Some forecasters, such as the OECD-FAO Outlook on Agriculture, expect prices to decline from current peak values, but still to persist at above-historic levels at least for the next decade.

A comparison with the era of commodity/food price spikes of the 1970s and 1980 provides valuable insight. During this earlier period, many public statements were made that commodity and food prices had climbed permanently to a new plateau. But in inflation-adjusted dollars, crop and food prices moved to new lows after 1980 as world food supply grew at a rate which exceeded population growth.

No one knows what lies ahead so we can only speculate. Much depends on future petroleum prices and on future rates of inflation.

The writers of this report suggest that history does repeat itself. With the increased attention now being devoted to food production by many countries, especially in developing countries, the rate of growth in global production of grains, oilseeds and other basic food commodities is likely to increase in the coming decade(s). A 1.1% or higher average annual rate of growth is fully achievable if modern agricultural science is allowed to prevail.

Africa has been identified as a primary target for $20 billion in new agricultural developmental assistance agreed to by the G8 Group at its 2009 meeting in L'Aquila, Italy. Major leadership is being provided by some industry and non-government organizations. This does not ensure success in increasing food self-sufficiency in Sub-

Saharan Africa, but the odds for success are much higher now than perhaps ever before in history.

Climate change has been identified as a factor which will dominate future agricultural productivity. However, the International Panel on Climate Change presents a far-less certain view.

A likely response by many developing countries will be efforts to increase food self-sufficiency, thereby reducing dependence on imported food ingredients. The director-general of FAO said recently, “We need to produce where the poor and hungry live.”

If this scenario plays out as projected above, the result could be static or even reduced demand for grain and oilseed exports to developing countries in years ahead. This will occur even as crop yields continue to grow in countries like Canada.

Implications for Ontario Grain Farmers

A critical question is, then, “What will Canada and other countries do with this surplus capacity?” Also, will this mean a return to an era of very depressed crop prices and farm/rural incomes in the decade(s) ahead? A declining rate of population growth and an aging population in Canada and many other developed countries will add to the likelihood of over-supply.

One policy option in the coming years is to return to massive farm subsidies as a means of maintaining farm incomes in developed countries.

A second option is to restrict future agricultural productivity in Canada and other developing countries by restraints on the use of agricultural inputs such as fertilizer, pesticides and advanced genetics. However, this invites crop and food imports from other countries without these restrictions.

A better option is to find other ways of using this excessive domestic productivity while also addressing other societal goals. Biofuels have been one avenue for doing this. Bioproducts represent a major opportunity to use the impending surplus agricultural capacity if supporters can counter reactions to the use of so-called food crops to produce non-food items.

Bioproduct development is an especially appealing market opportunity for Ontario grain and oilseed farmers, given the experience which they already have in growing crops for non-food markets and in growing higher-value, identity-preserved crops for specialty markets.

1. Purpose and Structure of Review

The Grain Farmers of Ontario (GFO) through its predecessor organizations began efforts to develop alternative non-food markets for grain and oilseed commodities as early as 1984. This was driven by a desire, starting with corn and later spreading to soybeans, to develop new and uniquely different markets to match the steady growth in the provincial production of these two crops.

By 1984, Ontario corn production had grown to exceed provincial usage, as represented by both livestock and poultry feeding, and crop processing to make starch, sugar, oil, beverage alcohols, other food products and high-protein materials. The excessive production and the consequent need for exports either to the United States - the world's largest producer of corn and soybeans - or to overseas markets using the relatively costly St. Lawrence Seaway system, meant Ontario prices were among the lowest in North America. This was a primary reason for the depressed income of Ontario grain farmers during that era.

Fuel-grade ethanol made from corn was the first of these non-food markets to be developed on a major scale in Ontario, with Ontario ethanol manufacturing production reaching an annual usage rate of about 110 million bushels (2.8 million tonnes) of corn in late 2010.

Biofuels have been promoted as a promising new market for Ontario soybeans though, to date, unlike the United States and European Union, almost all of the biodiesel produced in Canada is made from used cooking oil and byproducts of livestock processing.

Efforts to increase biofuel production and consumption have been widely applauded for environmental reasons. In addition to environmental benefits and a need to reduce dependence on fossil hydrocarbons (often imported after being shipped for thousands of kilometers), the development of renewable fuels - and other bioproducts in more recent years - was also seen as a way of increasing farm commodity prices. Increased farm commodity prices would mean reduced financial stress for farmers and rural communities in both the developed world and developing countries.

The prospect of higher prices was also seen as a means of reducing farm subsidies - especially in North America and the European Union - which had reached a global level of nearly $1 billion per day in the 1990s and were still over $310 billion per year in the early 21st century (OECD 2002). This represented a major financial drain to government treasuries. Farm subsidies in developed countries were also recognized as depressing grain commodity prices - a major impediment to the advancement of third-world agriculture.

There is also major interest in Ontario in promoting the development and marketing of other non-food bioproducts - for example, bioplastics, biofibres, and biocomposites (combination of plastic resins and fibres), and lubricants, adhesives, coatings, and related materials made from agricultural crops or byproducts associated with their production. Byproducts include corn cobs, soybeans hulls, crop residues and byproducts from corn, soybean and wheat processing.

The report is divided into six main sections – (1) an overview of Canadian and global biofuel production, (2) a consideration of environmental aspects, (3) effects of biofuels on crop prices including an examination of grain price spikes in 2007-2008 and 2010-2011, (4) a review of relationships between biofuels, food prices and world hunger, (5) future expectations, and (6) implications for the Grain Farmers of Ontario.

The report does not include any specific examination of federal or provincial government financial programs for biofuels in Canada or other countries – or defense or criticism thereof - other than a consideration of usage mandates and import duties.

The report consists primarily of a review of published information, of which there is an abundant supply on the world-wide web, coupled with some analysis by KD Communications.

2. Development of Biofuels and Bioproducts

2.1. Biofuels

Henry Ford envisioned that grain-based ethanol would power his Model T cars when first built in 1908. But his vision would not be realized until late in the 20th and the 21st century when the usage of transportation fuels made from biological feedstocks would finally come into its own.

Brazil began to emphasize the use of ethanol made from sugar cane as a substitute for gasoline in the 1970s and the production and usage of fuel ethanol in Brazil has increased steadily since (FAO, 2008). By law, Brazilian gasoline must contain a minimum of 20-25% ethanol and fuels containing nearly 100% ethanol are common, with about half of the Brazilian cane sugar production now being used for fuel ethanol production. Brazil was the world's largest producer of this commodity until being surpassed by the United States very recently.

Table 1. Canadian ethanol production capacity.

Ethanol: Canadian Production List as at November 4, 2010

	Plant	City	Province	Feedstock	Capacity	Status
23	Alberta Ethanol and Biodiesel GP Ltd.	Innisfail	Alberta	Wheat	150 MMly	Proposed Plant
24	Amaizeingly Green Products L.P.	Collingwood	Ontario	Corn	58 MMly	Operational
25	Atlantec Bioenergy	Milford	Nova Scotia	Energy Beets	n/a	Demonstration Facilit
26	Enerkem Alberta Biofuels – Edmonton Waste-to-Biofuels Facility	Edmonton	Alberta	Municipal Solid Waste (landfill waste)	36 MMly	Under Construction
27	Enerkem Inc. – Sherbrooke Pilot Plant	Sherbrooke	Quebec	Various Feedstocks	475,000 litres per year	Demonstration Facilit
28	Enerkem Inc. – Westbury Commercial-Demonstration Facility	Westbury	Quebec	Wood Waste	5 MMly	Demonstration Facilit
29	GreenField Ethanol Inc. Chatham	Chatham	Ontario	Corn	195 MMly*	Demonstration Facilit
30	GreenField Ethanol Inc. Johnstown	Johnstown	Ontario	Corn	230 MMly	Operational
31	GreenField Ethanol Inc. Tiverton	Tiverton	Ontario	Corn	27 MMly*	Operational
32	GreenField Ethanol Inc. Varennes	Varennes	Quebec	Corn	155 MMly	Operational
33	Growing Power Hairy Hill	Hairy Hill	Alberta	Wheat	40 MMly	Proposed Plant
34	Husky Energy Inc. Lloydminster	Lloyminster	Saskatchewan	Wheat	130 MMly	Operational
35	Husky Energy Inc. Minnedosa	Minnedosa	Manitoba	Wheat & Corn	130 MMly	Operational
36	IGPC Ethanol Inc.	Aylmer	Ontario	Corn	162 MMly	Operational
37	Iogen Corporation	Ottawa	Ontario	Wheat & Barley Straw	2 MMly	Demonstration Facilit
38	Kawartha Ethanol Inc.	Havelock	Ontario	Corn	80 MMly	Operational
39	NorAmera BioEnergy Corporation	Weyburn	Saskatchewan	Wheat	25 MMly	Operational
40	North West Terminal Ltd.	Unity	Saskatchewan	Wheat	25MMly	Operational
41	Permolex International, L.P.	Red Deer	Alberta	Wheat, Wheat Starch, Corn, Barley, Rye & Triticale	42 MMly	Operational
42	Pound-Maker Agventures Ltd.	Lanigan	Saskatchewan	Wheat	12 MMly	Operational
43	Suncor St. Clair Ethanol Plant	Sarnia	Ontario	Corn	400 MMly	Operational
44	Terra Grain Fuels Inc.	Belle Plaine	Saskatchewan	Wheat	150 MMly	Operational

* Volumes include industrial alcohol production

Source: Canadian Renewable Fuels Association, www.greenfuels.org/en.aspx .

Fuel ethanol production from corn began in earnest in North America, particularly in the United States, soon after the oil price spike of 1979. This development was initially driven by the desire to reduce dependence on imported oil, but later evolved to include (1) the need to replace lead and other hazardous compounds as octane enhancers for gasoline, (2) concerns about air quality problems and especially carbon monoxide in urban air in winter, (3) concerns about greenhouse gas emissions and (4) a desire to increase grain prices for farmers and reduce government subsidies to support farm income.

Mohawk Oil had begun producing fuel-grade ethanol at Minnedosa, Manitoba and blending it into gasoline in 1981. The Canadian Renewable Fuels Association was created in 1984.

Unlike the United States, Canada is a net exporter of petroleum, though several provinces, including Ontario, are major importers of petroleum and petroleum products - including from foreign sources. Unpublished data from the Ontario Ministry of Energy show that Ontario's net imports of crude petroleum, gasoline, diesel fuel and natural gas

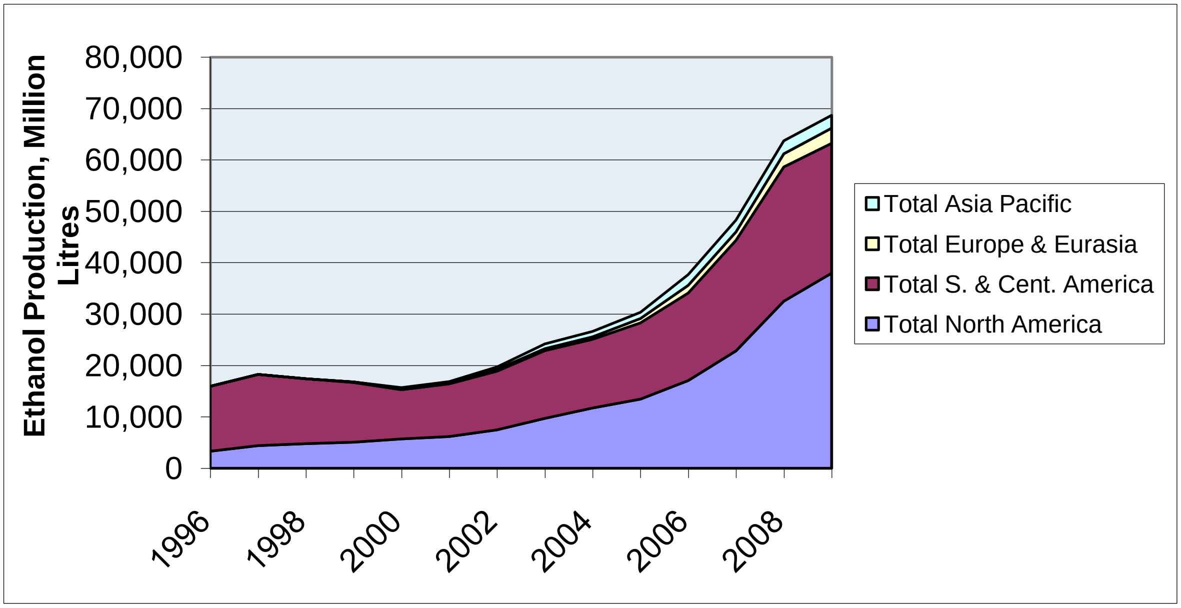
Table 2. Canadian biodiesel production capacity.

Biodiesel: Canadian Production List as at November 4, 2010

	Plant	City	Province	Feedstock	Capacity	Status
1	Bifrost Bio-Blends Ltd.	Arborg	Manitoba	Canola	3 MMly	Operational
2	Biocardel Quebec Inc.	Richmond	Quebec	Multi-feedstock	40 MMly	Proposed Plant
3	Bio-Lub Canada.com	St-Alexis-des-Monts	Quebec	Yellow Grease	10 MMly	Operational
4	BioStreet Canada	Vegreville	Alberta	Oilseed	22 MMly	Proposed Plant
5	Bioversel Sarnia	Sarnia	Ontario	Multi-feedstock	170 MMly	Proposed Plant
6	BIOX Corporation	Hamilton	Ontario	Multi-feedstock	66 MMly	Operational
7	BIOX Corporation	Hamilton Plant 2	Ontario	Multi-feedstock	67 MMly	Proposed Plant
8	Canadian Bioenergy Corporation – Northern Biodiesel Limited Partnership	Lloyminster	Alberta	Canola	265 MMly	Proposed Plant
9	City-Farm Biofuel Ltd.	Delta	British Columbia	Recycled Oil/Tallow	10 MMly	Operational
10	Consolidated Biofuels Ltd	Delta	British Columbia	Yellow Grease	10.9 MMly	Operational
11	Eastman Bio-Fuels Ltd.	Beausejour	Manitoba	Canola	5 MMly	Operational
12	FAME Biorefinery	Airdire	Alberta	Canola, Camelina & Mustard	1 MMly	Demonstration Fac
13	Kyoto Fuels Corporation	Lethbridge	Alberta	Multi-feedstock	66 MMly	Under Constructio
14	Methes Energies Canada	Mississauga	Ontario	Yellow Grease	5 MMly	Operational
15	Methes Energies Canada	Sombra	Ontario	Multi-feedstock	50 MMly	Under Constructio
16	Milligan Bio-Tech Inc.	Foam Lake	Saskatchewan	Canola	1 MMly	Operational
17	Noroxel Energy Ltd.	Springfield	Ontario	Yellow Grease	5 MMly	Operational
18	QFI Biodiesel Inc.	St-Jean-d'Iberville	Quebec	Multi-feedstock	5 MMly	Operational
19	Rothsay Biodiesel, A member of Maple Leaf Foods Inc.	Sainte-Catherine	Quebec	Multi-feedstock	45 MMly	Operational
20	Speedway International Inc.	Winnipeg	Manitoba	Canola	20 MMly	Operational
21	TRT-ETGO	Bécancour	Quebec	Vegetable Oil	100 MMly	Proposed Plant
22	Western Biodiesel Inc.	Calgary	Alberta	Multi-feedstock	19 MMly	Operational

Source: Canadian Renewable Fuels Association, www.greenfuels.org/en.aspx

Figure 1. World ethanol production.



Source, (S&T)[2] Consultants Inc., data provided by European Bioethanol Fuel Association, F.O. Lichts, Renewable Fuels Association, US Department of Agriculture. US Energy Information Administration.

have had an average total annual value of about $20 billion (about 50% crude, 25% natural gas and 25% gasoline plus diesel fuel).

Environmental issues, including a need to reduce greenhouse gas emissions, have also been a driver for biofuel development in Canada.

The production of biofuels from grains and oilseeds has increased substantially since 2000 in several countries but notably Canada, the United States and the European Union.

A listing of all biofuel manufacturing facilities in Canada, produced by the Canadian Renewable Fuels Association (www.greenfuels.org) is shown in Table 1 and Table 2. Statistics on the production/consumption of ethanol and biodiesel in various countries and on government policies supporting this development are provided in Figure 1 to Figure 6, and Table 3 to Table 10.

Table 3. Global biofuel production.

Bioethanol production in 2008 (million litres)		Biodiesel production in 2008 (million litres)	
United States	36,300	Germany	3,180
Brazil	24,497	United States	2,650
China	2,448	Netherlands	1,372
Canada	870	France	991
Germany	730	Spain	926
France	578	United Kingdom	347
Spain	578	Australia	260
Australia	164	Austria	252
United Kingdom	153	Portugal	227
		Sweden	127
		Brazil	110
		Belgium	108
		Denmark	103
		Canada	100

Source: Bacovsky et al., 2009

Source: DEFRA, 2010.

About 15 percent of global corn production (Table 6) or about 5.7% of total global grain production is used for ethanol production. (The 5.7% becomes 3.7 % when byproduct production is included.) About 10% of global vegetable oil production goes to make biodiesel (Figure 3).

Canadian ethanol is made mainly from corn, but also from wheat in Western Canada. To the present, Canadian biodiesel is made mainly from used cooking oil and animal fats.

An estimated 3.5 million tonnes of corn and 1.0 million tonnes of wheat per year (equivalent to about 30% and 4% of total Canadian production, respectively) are now required to produce 1.83 billion litres of fuel ethanol, the Canadian output in late 2010 (Table 1, CRFA, 2010). About 110 million litres of biodiesel were produced in Canada in 2010, though the productive capacity is 185 million litres (Table 2). These numbers are up from about 215 million litres of fuel ethanol and zero biodiesel in 2001 (AAFC, 2001).

On December 15, 2010, the Government of Canada mandated that Canadian gasolines must contain a minimum average of 5% ethanol. The mandate will likely be extended in

Table 4. Estimates of world fuel ethanol production, by continent.

World Ethanol Fuel Production in Million Litres

	2006	**2007**	**2008**	**2009**	**2010**	**2011**
Europe	1,627	1,882	2,814	3,683	4,615	5,467
Africa	0	49	72	108	165	170
Americas	35,625	45,467	60,393	66,368	77,800	79,005
Asia/Pacific	1,940	2,142	2,743	2,888	3,183	4,077
World	39,192	49,540	66,022	73,047	85,763	88,719

Source: F.O. Licht, 2011, courtesy of Global Renewable Fuels Alliance, http://www.globalrfa.org/pr_021111.php

mid 2011 to include an average of 2% biodiesel content in Canadian diesel fuel and heating fuels. About 40 billion litres of gasoline and 30 billion litres of diesel distillates are used annually in Canada and the mandates (existing and proposed) equate to annual requirements for about 2.0 billion litres of ethanol and 600 million litres of biodiesel. These values are about 9% and 450% above current Canadian production levels for fuel ethanol and biodiesel, respectively.

Ontario and Canadian ethanol manufacturing has also been supported by a number of programs to support both plant construction and operations. As of early 2011, the maximum support in Ontario equates to about 20 cents/litre (Governments of Canada and Ontario) though the Ontario support formula depends on commodity prices. Details on Canadian support programs can be found in *A Report Card on the Canadian Renewable Fuels Industry* (CRFA, 2010, www.greenfuels.org).

Canadian production is dwarfed by that in the United States where 2010 production was 54 billion litres of ethanol and 1.5 billion litres of biodiesel (13 billion and 390 million US gallons, respectively; a US gallon equals 3.89 l). This, in turn, required the processing of about 125 million tonnes of corn (5.0 billion bushels, about 40% of the 2010 US corn crop) and the oil from nearly 4 million tonnes (150 million bu, 5% of 2010 crop) of soybeans, respectively. The ethanol plants also produce 40 million tonnes of high protein distiller's grains and the crushing of the soybeans produces 3.2 million tonnes of soybean meal. About 40-50% of US biodiesel is made from waste grease and animal fat ($(S\&T)^2$ Consultants Inc., personal communication).

Table 5. World feedstock use for bioethanol and biodiesel in 2008 (thousands of tonnes).

2008	Total Grains	Sugar beet	Sugarcane	Total Vegetable oils
EU-27	3,925	6,756	0	6,630
Brazil	0	0	302,500	830
Canada	2,250	0	0	44
US	87,420	0	0	1,852
China	4,309	0	0	0
World	98,133	6,756	305,936	11,525

Source: F.O Licht

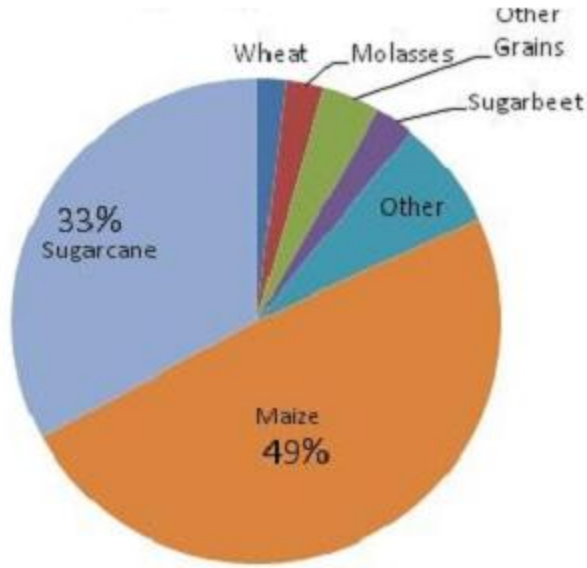
Source: DEFRA, 2010.

US production of fuel ethanol and biodiesel was only 7 billion and 130 million litres, respectively (1.8 billion and 34 million gallons), in 2001. Growth in US fuel ethanol production is shown in Figure 4. The 2010 US production of biodiesel was down by 20% from 2009 and down 50% from 2008 because of the temporary withdrawal of a $1/gallon biodiesel blender's tax credit. However, this tax credit has been recently restored for 2011 (and retroactively for 2010) and much larger production is expected for 2011, at least sufficient to fill an 800 million gallon mandate by the US Environmental Protection Agency.

The US mandate under the Renewable Fuel Standard introduced in the US Energy and Security Act of 2007, and modified in late 2010 by the US Environmental Protection Agency, is for a total minimum usage of 13.95 billion gallons of "renewable fuels" in 2011 of which up to 12.6 billion can be (and almost certainly will be) corn-based ethanol. This increases to a total of 36 billion gallons by 2022, with the corn ethanol component of the mandate reaching 15 billion gallons in 2015 and plateauing at this level for years thereafter (Figure 4). The difference between 36 and 15 billion gallons is to be supplied by biodiesel and so-called "advanced biofuels" which largely means ethanol produced from cellulosic materials and sugar cane. Although not mandated, corn-based ethanol can be used in amounts above 15 billion gallons, depending on demand. US gasoline marketers receive an ethanol blenders' tax credit of 45 cents/gallon, at least until the end of 2011.

Ethanol is normally blended at up to 10% of the gasoline mixture in Canada and the United States though very small amounts of 85% ethanol are sold for use in Flex-fuel vehicles in both countries. The US Environmental Protection Agency has recently granted approval for the use of 15% ethanol blends for automobiles no older than the 2001 model year (though, as of late February, 2011, this could be blocked by an action

Figure 2. Share of world ethanol production by feedstock in 2008.



Source: DEFRA, 2010.

by the US House of Representatives). This change was seen as essential to meet conditions of the Renewable Fuel Standard in future years. Even with the EPA action there remain other issues related to state and federal standards and regulations to be resolved before the fuel becomes widely available.

Despite a huge amount of industry effort and government money being expended internationally, US and global production of cellulosic ethanol is progressing much more slowly than envisioned a few years ago. The US mandated requirement for cellulosic ethanol in 2011 was recently scaled back from 250 million gallons to only 6.6 million to reflect this reality. There is uncertainty as to whether even this modest goal can be met, though there are positive indications of much more extensive cellulosic ethanol production in years to follow.

A Canadian company, Iogen, built a pilot cellulosic ethanol plant in Ottawa in 2004 but has yet to build a commercial-scale facility. Greenfield Ethanol is aggressively pursuing cellulosic ethanol advancement at its Chatham Ontario research facility. Enerkem of Ottawa is building small ethanol-from-waste plants for both Alberta and Quebec.

The Canadian duty on fuel ethanol is $0.0492/litre for importation from non-NAFTA countries while the US imposes a duty of 54 cents/gallon ($0.139/litre) plus an ad valorem duty of 2.5%. Only imports from Canada, Mexico and a few Caribbean countries are exempt from US duties, and imports from these three represent only about 5% of total usage.

In the future, Brazil could become a significant supplier of ethanol to Canada, though this is less likely for the United States unless a very large gap develops between US and international ethanol prices, sufficient to overcome the large import duties. At present, Brazil is not aggressively pursuing added export sales of ethanol - present near-record-high world sugar prices mean a preference for sugar exports from processed sugar cane – but this could readily change when sugar prices again decline.

The Canadian import duty on biodiesel varies by country of origin, but is zero for countries most likely to be exporters to Canada, including the United States and Argentina.

Argentina has a 35% export tax on soybeans but a smaller tax for exports of products of soybean processing (32% on soybean oil, 20% on biodiesel). This has encouraged major production and exportation of biodiesel, especially to Europe. Until very recently, most Argentinean-made biodiesel was exported, though new expanded Argentinean mandates for domestic biodiesel usage will change that. Argentina has replaced the United States as the world's largest biodiesel exporter. Interestingly, Canada exported 160 million litres of biodiesel to the EU in 2009 though European sources claim that this was US-produced biodiesel circumventing recently imposed countervailing and antidumping duties on direct imports of that product from the US.

Biofuels, especially biodiesel, are also being produced and used in major quantities in the European Union (EU) (Table 10). The EU produces about two-thirds of the world's biodiesel and biodiesel represents about 75% of European biofuels. With current

Table 6. Proportion of world wheat and maize used for industrial use and ethanol.

	Wheat		Maize	
	Industrial use as % of total use[1]	Ethanol use as % of total use[2]	Industrial use as % of total use[1]	Ethanol use as % of total use[2]
2001/02	1.8%		13%	4%
2002/03	1.9%	0.0%	14%	5%
2003/04	2.0%	0.1%	15%	6%
2004/05	2.0%	0.2%	16%	6%
2005/06	2.2%	0.4%	17%	7%
2006/07	2.4%	0.4%	19%	9%
2007/08	3.0%	0.6%	22%	12%
2008/09 (est)	2.5%	0.8%	24%	14%

[1] includes all industrial use, of which some is ethanol for fuel and non-fuel use

[2] includes fuel and non-fuel use

Source: IGC website

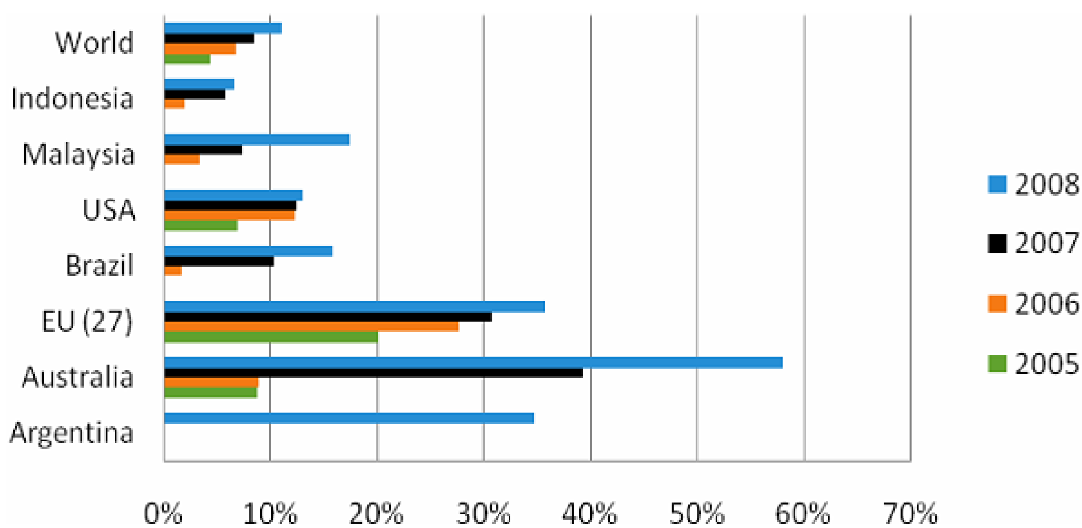
Source: DEFRA, 2010.

mandates for expanded biofuel usage (Table 8 and Table 9), continued growth is projected. Despite this projection, production of biodiesel has declined in very recent years in Germany, Italy and the United Kingdom, though it continues to grow in some other countries including France. Europe's 245 biodiesel plants were only operating at about 40% of capacity, on average, in 2009 (European Biodiesel Board, 2010).

One source (http://marketpublishers.com/lists/7037/news.html) projects world biodiesel production to increase from 15.8 billion litres in 2009 to 45.3 billion litres in 2020. And a joint 2011 report from the OECD (Organization for Economic Co-operation and Development) and FAO (www.agri-outlook.org/document/39/0,3746,en_367747 15_36775671_45438247_1_1_1_1,00.html) sees the relative rate of growth for biodiesel exceeding that for ethanol during the next decade (Figure 5 and Figure 6).

Biofuels are also being produced in a number of countries other than North America, Europe and Brazil but the quantities are relatively small. China produced about 2.4 billion litres of ethanol in 2008. India and several other countries have aggressive programs to produce biodiesel from jatropha, a drought-tolerant oilseed crop (Timilsina and Shrestha, 2010; World Bank, 2010). Oil palms are used to produce biodiesel in Malaysia and other south-eastern Asian countries.

Figure 3. Share of vegetable oil consumption used for biodiesel production in selected countries.



Source: FAO and OECD Secretariats (2009a)

Source: DEFRA, 2010.

Table 7. Land usage for biofuels.

	2000-01	*2002-03*	*2004-05*	*2006-07*	*2008-09*
Biofuels as a share of global grain and oilseed area (percent)					
EU oilseeds	0.00	0.06	0.15	0.24	0.34
US maize	0.13	0.27	0.37	0.76	1.11
Land used for US ethanol from maize as a share of (percent)					
US Maize area	3.63	7.32	9.45	18.03	27.54
US Grain area	0.99	2.00	2.79	5.68	8.44
World grain area	0.16	0.32	0.43	0.85	1.26

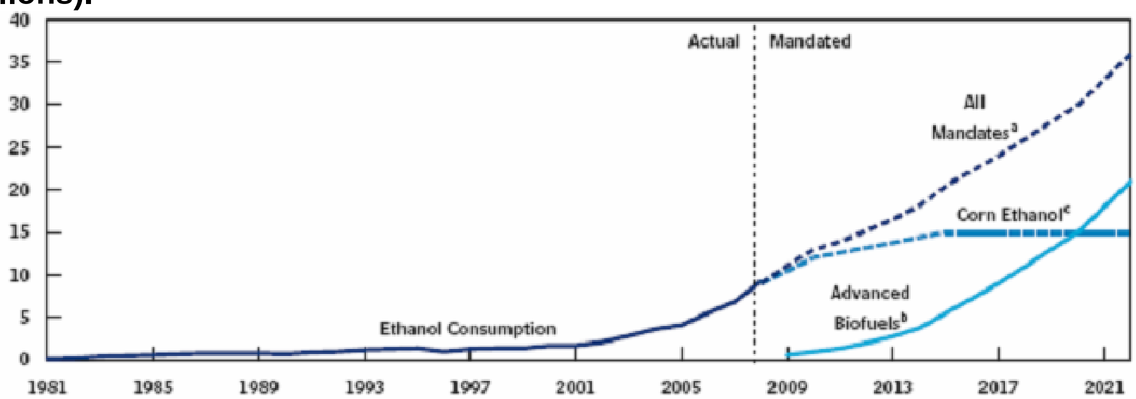
Notes: The shares have been calculated based on average world yields.

Source: Baffes and Haniotis, World Bank, 2010.

F.O. Licht in their February 2011 *World Ethanol and Biofuels Report*, stated that at least $31 billion was invested in biofuel development (mainly plant construction and enlargement) in 2010 – almost all for ethanol from grain/starch/sugar crops and cellulosic feedstocks. By contrast, there was little global investment in biodiesel manufacturing, which F.O. Licht attributes to "global overcapacity" at the present time. However, a billion litres/year plant is nearing construction in Singapore, primarily for export sales to the European Union.

An excellent summary of biodiesel developments around the world can be found at

Figure 4. Effect of US mandates on the consumption of biofuels (billions of gallons).



Source: Congressional Budget Office based on data from the Energy Information Administration.

a. The mandates enacted in the Energy Independence and Security Act of 2007, or EISA (Public Law 110-140), require that by 2022, a total of 36 billion gallons of renewable biofuels (fuels made from biological raw materials) be consumed annually. The law also requires that corn ethanol make up no more than 15 billion gallons of that total.

b. Advanced biofuels are renewable fuels not made from cornstarch that reduce greenhouse-gas emissions over the "life cycle" of the fuel (its production, distribution, and use) by at least 50 percent relative to emissions from gasoline.

c. The Energy Information Administration estimates that annual corn ethanol usage will be 15 billion gallons between 2015 and 2022.

Source: DEFRA, 2010.

www.biodieselmagazine.com/articles/4361/global-biodiesel-production-and-market-report/ .

Table 8. Targets for renewable energy and fuels in 2010 for selected countries.

Countries	% of RES in total primary energy	% fuels from RES[6]
EU-27	12%	5.75%
Austria		Mandatory target of 5.75%
Belgium		5.75%
Cyprus 2, 3	9%	5.75%
Czech Republic	5-6%	5.55%
Denmark	20% in 2011	5.75%
Estonia	13%	5.75%
Finland		Mandatory target of 5.75%
France	10% in 2010	7% (2010), 10% (2015)
Germany	4%	Mandatory target of 5.75%
Greece		5.75%
Hungary		5.75%
Italy		2.50%
Ireland		NA
Latvia	6%	5.75%
Lithuania	12%	5.75%
Luxembourg		5.75%
Malta		NA
Netherlands	10% by 2020	Mandatory target of 5.75%
Poland	7.5% by 2010 14% by 2020	5.75%
Portugal		5.75%
Slovak Republic		5.75%
Slovenia		Mandatory target of 5%
Spain	12.10%	Mandatory target of 5.83% in 2010
Sweden		5.75%
United Kingdom		Mandatory target of 5% of transport fuel sales by 2013/14
Other OECD Countries		
Australia		350 million litres
Canada		5% renewable content in gasoline by 2010
Japan		50 million litres of biofuels by 2011(domestic production)
Norway		No
New Zealand	90% of total electricity	Mandatory target of 3.4% of total transport fuel sales by 2012
United States		36 billion US gallons by 2022

Source: OECD (2008b)

Source: DEFRA, 2010. (RES stands for renewable energy supply.)

Table 9. Mandates for ethanol and biodiesel usage.

Country	*Ethanol*	*Biodiesel*	*Comments*
Argentina	E5	B5	Both effective in 2010
Brazil	E20–E25[a]	B2, B3 effective July 2008	Ethanol blending first mandated in 1938
Canada	E5 starting in 2010	B2 starting in 2012	Nation-wide biodiesel mandate upon successful demonstration of fuel performance under Canada's climatic conditions. Provincial ethanol and biodiesel blending mandates in effect or will come into force in the future.
China	E10 in 10 provinces		Fuel ethanol production began in 2004. Six provinces use E10 throughout the entire provinces.
Colombia	E10 in large cities beginning in 2007	B5 beginning in 2008, increasing to B10 in 2009	Fuel ethanol production began in late 2005 and palm oil diesel production in Nov. 2007.
European Union	10% minimum for the share of biofuels in automotive gasoline and diesel by 2020		Only certified sustainable biofuels for the 2020 target. EU members have country-specific blending mandates.
India	E5 in 20 states and 4 union territories in Nov 2007		Ethanol blending began in Jan. 2003
India[b]	E20 by 2017	B20 by 2017	National Biofuel Policy approved in Sep. 2008
Indonesia	E3 or E7 depending on user starting between 2010 and 2015	B2.5 or B3 (transport), B5 (industry), and B1 (power) between 2010 and 2015	Mandate first in effect in 2009 at lower blending levels.
Peru	E2	B2	Mandate in effect in 2009
Philippines	E5	B2 using coconut-based biodiesel	B1 mandated in 2007, E5 and B2 mandated in 2009, and E10 in 2011.
Thailand		B2 in 2008	B5 planned for 2011
United States	9 billion gallons (34 billion liters) of renewable transportation fuel in 2008, rising to 36 billion gallons (136 billion liters) by 2022		There are requirements on shares of cellulosic ethanol and advanced biofuel nationally, and a number of states have state-specific blending requirements.

Sources: Kojima 2009, European Parliament and the Council of the European Union 2009, CRS 2007.
a. The government varies the blending target between 20 and 25 percent, depending on fuel prices and availability.
b. Targets.

Source: World Bank, March 2010.

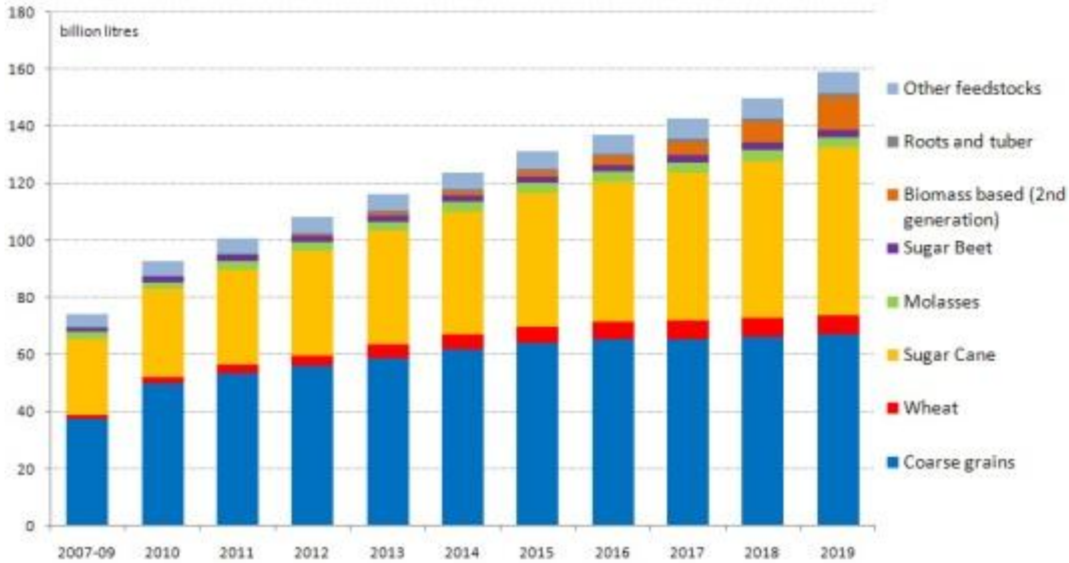
Table 10. Biodiesel production in the European Union (thousands of tonnes).

COUNTRY	2009 Production	2008 Production
Austria	310	213
Belgium	416	277
Bulgaria	25	11
Cyprus	9	9
Czech Republic	164	104
Denmark/Sweden	233	231
Estonia	24	0
Finland*	220	85
France	1 959	1.815
Germany	2 539	2.819
Greece	77	107
Hungary	133	105
Ireland*	17	24
Italy	737	595
Latvia	44	30
Lithuania	98	66
Luxemburg	0	0
Malta	1	1
Netherlands	323	101
Poland	332	275
Portugal	250	268
Romania	29	65
Slovakia	101	146
Slovenia	9	9
Spain	859	207
UK	137	192
TOTAL	9.046	7.755

Figure I: EU 2008 and 2009 biodiesel production estimates

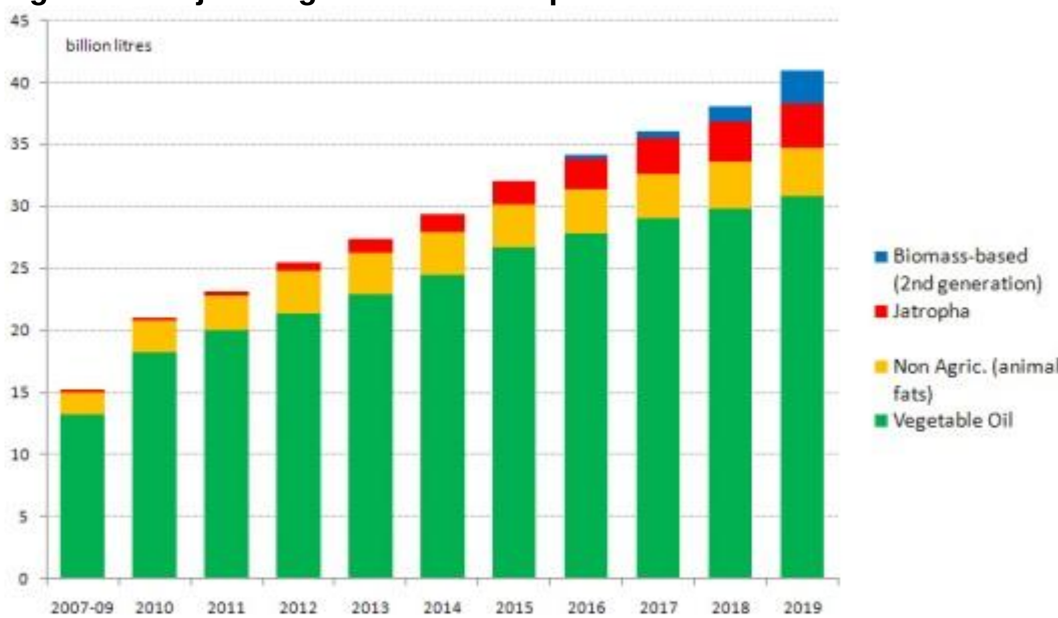
Source: European Biodiesel Board, July 2010.

Figure 5. Projected fuel ethanol production.



Source: OECD and FAO, 2010.

Figure 6. Projected global biodiesel production.



Source: OECD and FAO, 2010.Web page source: www.agrioutlook.org/document/9/0,3746,en_36774715_36775671_45438665_1_1_1_1,00.html .

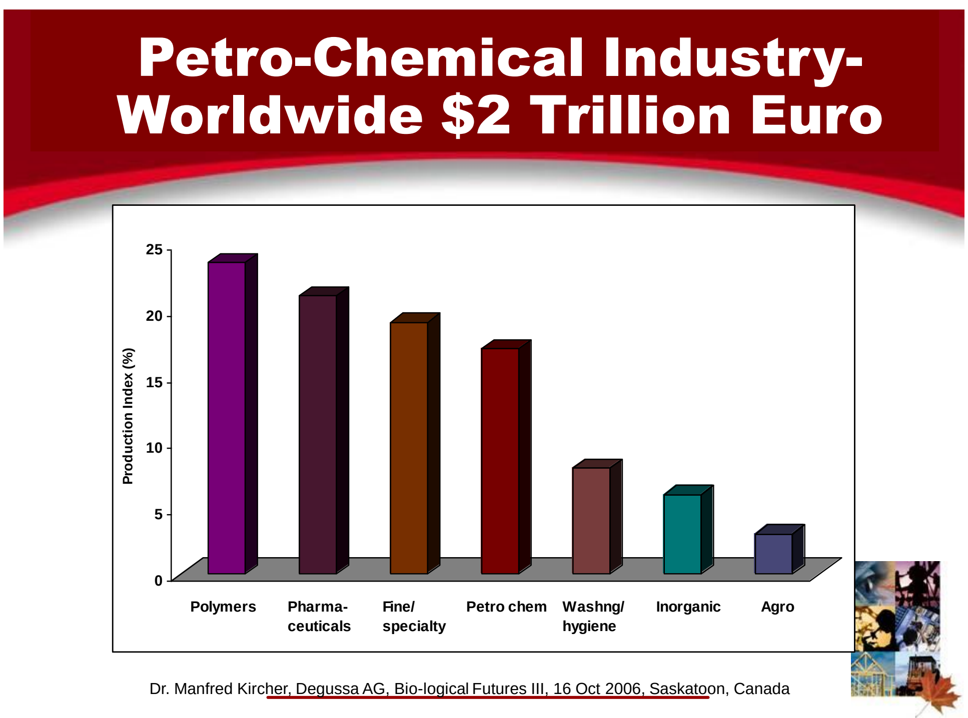
2.2. Bioproducts

Many countries and companies have turned their attention to bioproducts - including bioplastics, biofibres, biocomposites (containing both fibres and plastic resins), bio-based adhesives, coatings, lubricants and other such materials - to replace equivalent products traditionally produced from petroleum and natural gas. The reasons are a combination of environmental improvement (reduced net emissions of GHG compared to hydrocarbon feedstocks), less dependence on imported fossil energy, and cost savings - the latter being stimulated by the huge increases in costs to manufacturers for fossil hydrocarbon-based feedstocks in 2007 and 2008.

Bioproduct development has been seen of particular importance by several countries in Europe (notably Germany and France) and in Japan and China, and also by many leading manufacturers including DuPont, Toyota, Ford, Cargill, BASF and others.

Canada, and especially Ontario, has also shown major interest in bioproduct development. The Ontario BioAuto Council, funded by the Province of Ontario, is one prime example of this interest; support has come in many other ways, including

Figure 7. World petrochemical industry.



Source: Dr. Mohini Sain, University of Toronto.

industry/government funding for Ontario Agri-Food Technologies, the Sustainable Chemical Alliance headquartered at Sarnia, and the Premier's Chair in Biomaterials and Transportation funded by Ontario and located at the Bioproduct Discovery and Development Centre at the University of Guelph. Biomaterial development is a major priority for research programs funded by the Ontario Ministry of Agriculture, Food and Rural Affairs. The National Research Council has also defined bioproduct development as a research priority.

There is major interest in both bioproducts which break down quickly during composting (example, compostable plastic bags) and those which don't. Some bio-based materials are chemically identical to those made from fossil hydrocarbons - an example being polyethylene made from cane sugar now being produced in Brazil by Braskem.

The current global market for bioplastics while significant (perhaps about $1-2 billion per year) is dwarfed by that for plastics alone (estimated at about $1 trillion, based on a market size of 500 million tonnes; personal communication, Dr. Amar Mohanty, University of Guelph). (See also, Figure 7 for estimates of the size of the global market for all petrochemical products.) The potential for growth is enormous with a large amount of effort and money being invested around the world in new bioproduct creation and market development. The global bioplastic market is projected to be worth $6 billion by 2015 and $20 billion by 2020 (Helmut Kaiser Consultancy, 2009, information provided by Dr. Amar Mohanty, University of Guelph).

3. Biofuels and the Environment

One of the early drivers for biofuels, and especially fuel ethanol development, was air and water quality improvement.

Base gasoline generally has an octane level in the vicinity of 82-84 which compares to a minimal octane requirement of 87 in retail gasoline for automobiles. (It's higher for premium gasolines.) The octane enhancers used before ethanol - tetra-ethyl lead, other heavy-metal compounds, methyl tertiary butyl ether (MTBE), and "aromatic" compounds like benzene - all have notable environmental and/or health problems. Ethanol has a high blending octane rating of about 115 which makes it well suited as an octane-enhancing additive. (Octane is what prevents engines from 'knocking," caused by premature ignition; the higher the engine compression ratio, the higher the octane requirement.) The elimination of MTBE from US gasolines in 2006 created a major need for replacement octane which was largely supplied by ethanol.

Carbon monoxide (CO), associated with emissions from cold engines burning gasoline, was a major environmental concern in several American and Canadian cities during the 1980s and early 1990s and "oxygenated" gasolines - generally containing ethanol - reduced these CO emissions. Indeed, their use was mandated in various jurisdictions (notably Rocky Mountain cities like Denver) during winter months when atmospheric levels of CO became dangerously high (http://clasfaculty.ucdenver.edu/landerso/97rp13905.htm). Changes in automobile fuel injection and emission controls since the early 1990s have largely eliminated the CO problem, but the environmental attractiveness of oxygenated gasolines remains because they burn more completely during combustion.

In recent years, the environmental focus of biofuels has featured reductions in net greenhouse gas emissions and the amount of fossil fuel energy needed for transportation.

There are many published reports on the net greenhouse gas (GHG) emissions associated with biofuel production and usage, and associated energy ratios (joules of energy in the resulting biofuel compared to joules of fossil energy used for its production). These studies include consideration of the fossil energy used for, and GHG emissions associated with, (1) the production of feedstock crops and crop production inputs, (2) grain transportation to processing plants, (3) the direct manufacture of ethanol and biodiesel, and (4) credits for byproducts of biofuel production.

These studies often have very conflicting conclusions. Principal reasons for the disagreement involve different assumptions about inputs used in grain or oilseed production, in accounting for byproducts produced along with ethanol or biodiesel, and in the efficiencies of biofuel manufacture.

With ethanol manufacture from corn, the major byproducts include high-protein livestock feed ingredients (about 30 kg produced per 100 kg of corn consumed) and carbon dioxide (CO_2). The latter may be just vented into the air, but is commonly sold to the soft drink industry and other CO_2 users.

The studies normally include emissions of greenhouse gases from soils used for crop production - including nitrous oxide resulting from nitrogen fertilizer and manure application to crop land, and the CO_2 release caused by soil-tillage-induced soil organic matter oxidation. Differences in assumptions made about these losses vary significantly among the studies. While no-till cropping techniques may actually result in soil carbon dioxide sequestration, this "offset" has not been included in most studies.

Canadian results differ from those in the United States

In the United States, analyses from the Argonne National Laboratory (ANL) have been widely accepted by federal agencies (Congressional Budget Office, 2009). Wang et al. (2007) of ANL have calculated that the production and use of ethanol at the range of coal- and natural gas-fired plants found in the United States results in a 20% reduction in net GHG life-cycle emissions compared to the same quantity of gasoline, adjusted for differences in caloric energy content. (Ethanol has 68% of the combustible energy content of gasoline.) For natural gas-supplied ethanol plants alone, this increases to 30%.

Liska et al. (2008), using a life-cycle analysis to examine GHG and net energy balances for several newer ethanol plants across the US Midwest, calculated that the net GHG emissions were reduced by 48 to 59% where natural gas was used as the operating fuel. The energy ratio (joules in ethanol compared to fossil energy usage for its production) ranged from 1.5 to 1.8. The ratios tended to be higher in northern states than in the southern United States, mainly because of lower nitrogen fertilizer requirements relative to corn yields in the north. Liska et al. estimated that these figures could be raised to 67% and 2.23 if byproduct "distiller's grain" was fed directly to cattle without drying, and if the resulting cattle manure was digested anaerobically to produce biogas to operate the ethanol plant.

Negative CO_2 emission and fossil energy balances have been calculated by some authors (eg., Pimentel and Patzek, 2005). However, as the report of the US Congressional Budget Office (2009) states, "observers argue that such contentions are based on outdated data, on overestimates of how much fossil fuel is used in farming and in ethanol production, and on underestimates of the extent to which the use of by-products from ethanol production reduces the amount of fossil fuels used for producing other goods."

A number of Canadian analyses have been completed too, and the results do not exactly mimic the US results. This is primarily because of differences in the inputs for corn production. On average, Ontario farmers depend more on farmyard manure and less on synthetic fertilizers than do US corn growers. Also, Ontario farmers use less lime per acre (lime manufacture requires large amounts of energy), and are less dependent on irrigation which also requires a substantial energy input. At the same time, Ontario farmers require more energy for grain corn drying than is the norm in the United States, and average per-acre corn yields are usually somewhat lower in Ontario.

The first major Canadian study, completed for Agriculture and Agri-Food Canada by Levelton Engineering and $(S\&T)^2$ Consultants Inc. in 1999, was an analysis of net GHG emissions for corn grown in Southwestern Ontario and processed into ethanol at the Commercial Alcohol Inc. (now Greenfield Ethanol) plant at Chatham. The authors calculated that the blending of 10% ethanol into gasoline resulted in a 3.9% reduction in net GHG emissions, and projected that this would increase to 4.6% by 2010 because of expected improvements in both the efficiency of corn production and in ethanol manufacturing. These values equate to 39% and 46% reductions on a 100% ethanol basis.

Ethanol blending results in a 62% reduction in net GHG emissions

The same study estimated that the ratio of the combustible energy content of ethanol was 1.50 times the amount of fossil energy required for its manufacture, including all inputs used for corn production and transport. This ratio increased to 1.82 if the calculation included an octane credit for ethanol blending; ethanol blending permits gasoline marketers to use lower octane base gasolines which generally require less energy for their production in petroleum refining. The study also recognized that 10% ethanol-blended gasoline has about 1% greater combustion efficiency than gasoline. (Combustion efficiency means mechanical energy produced per joule of combustible energy in the fuel.)

Cheminfo (2009) has recently completed an analysis of Canadian ethanol producers, using a computer simulation model called GHGenius developed by $(S\&T)^2$ Consultants Inc. for Natural Resources Canada (NRCan). Cheminfo calculated that E10 gasoline represents a 4.2% reduction in net GHG emissions compared to unblended gasoline. When they expanded this to a 100% ethanol equivalent, adjusted for differences in caloric energy content plus the 1% better combustion efficiency with blended fuel, and expressed results as grams of CO_2 equivalent per MJ (mega-joule) of combustible energy, they calculated that ethanol blending resulted in a 62% reduction in net GHG emissions (Table 11).

The 62% reduction means an annual reduction of 2.3 million tonnes of GHG emissions or equivalent to the annual emissions from 440,000 cars. About two-thirds of this benefit is in Ontario.

Table 11. Relative fuel-cycle greenhouse gas reduction from ethanol (based on ethanol used in an E10 fuel blend at equivalent vehicle performance distance).

	Calc.	Reformulated Gasoline (RFG)*	Difference E10 Basis**		Difference E100 Basis***	
Volume Basis:		(g_{CO2e}/L_{RFG})	(g_{CO2e}/L_{E10})	(% of RFG)	(g_{CO2e}/L_{E100})	(% of RFG)
Fuelcycle GHG Intensity (g/L)	A	2,967	-125	-4.2%	-1,253	n/a
Energy Content (MJ/L)	B	34.69			23.58	68%
Energy Basis:		(g_{CO2e}/MJ_{RFG})			(g_{CO2e}/MJ_{E100})	(% of RFG)
Fuelcycle GHG Intensity (g/MJ)	A/B	85.5			-53.1	-62%

* RFG is Reformulated Gasoline (at 30 ppm sulphur), the reference gasoline fuel in GHGenius

** E10 is an ethanol fuel blend with 90% gasoline and 10% ethanol

*** E100 is 100% ethanol blendstock produced from either corn or wheat feedstocks

Source: Cheminfo, 2009.

Unlike the analysis in 1999, no octane benefit was assumed in the Cheminfo study. Don O'Connor, president of (S&T)[2] Consultants Inc., who assisted with the Cheminfo analyses, explains that the octane benefit varies from one oil refinery to another; and because the specifics are confidential and cannot be estimated accurately by an outsider in a credible manner (as was done in the 1999 analyses), he chose not to include it in more recent analyses - even though it is recognized as being very real for many gasoline refiners/marketers.

In 2009, (S&T)[2] Consultants Inc. completed an extensive life cycle analysis of ethanol production from grain for the International Energy Agency Bioenergy Task Force, including effects of ethanol blending on both fossil energy usage efficiency and net GHG reductions. The analysis was for global and not just Ontario/Canadian ethanol production. Key results from this study, some of which are shown in Table 12 and Table 13, can be summarized as:

- Energy use and net GHG emissions for corn production, expressed on a per-tonne-of-corn basis, have all declined steadily in recent decades.
- Energy use in ethanol processing has declined at an even greater rate, from about 30 MJ per litre of ethanol in 1983 to about 8 using natural gas in 2005.
- About 0.3 tonnes of DDG (distillers dried grains, the high protein byproduct from ethanol manufacture) is produced per tonne of corn used, and this replaces 0.20 tonnes of corn and 0.18 tonnes of soybean meal in livestock feeding (for the maximum rates of DDG which can be used in livestock diets).
- The energy efficiency of ethanol production increased from 1.31J per J of fossil energy used in 1995, to 1.57 in 2005, and is projected to increase to 2.12 in 2015.

Table 12. Fossil energy balance comparison – gasoline and ethanol.

Fuel	Gasoline		Ethanol		
Feedstock	Crude Oil		Corn		
	1995	2015	1995	2005	2015
	Joules consumed/joule delivered				
Fuel dispensing	0.0005	0.0006	0.0009	0.0010	0.0009
Fuel distribution, storage	0.0049	0.0052	0.0140	0.0143	0.0148
Fuel production	0.1414	0.1612	0.5638	0.4732	0.2895
Feedstock transmission	0.0101	0.0096	0.0125	0.0128	0.0133
Feedstock recovery	0.0795	0.1184	0.1046	0.0938	0.0672
Ag. Chemical manufacture	0.0000	0.0000	0.1221	0.1083	0.0981
Co-product credits	-0.0007	-0.0014	-0.0531	-0.0493	-0.0424
Total	**0.2358**	**0.2935**	**0.7648**	**0.6541**	**0.4413**
Net Energy Ratio (J delivered/J consumed)	**4.2410**	**3.4072**	**1.3076**	**1.5287**	**2.2661**

Source: $(S\&T)^2$ Consultants Inc. , 2009.

- The percent reduction in net GHG emissions for ethanol versus gasoline, expressed on a caloric energy content increased from 26% in 1995 to 39% in 2005 and is projected to increase to 55% in 2015.

$(S\&T)^2$ Consultants Inc. (2009) has explored other ways in which the GHG balance of ethanol production from corn could be improved. For example, if corn stover were used to provide power for ethanol plants (i.e., akin to the combustion of sugar cane bagasse to operate ethanol plants in Brazil) and if the CO_2 released in ethanol production could be sequestered, the result could be a 98% reduction in GHG emissions with corn ethanol compared to gasoline. (There was been no assumption of a 1% increase in combustion efficiency with E10 gasoline in this study, unlike the Cheminfo study.)

$(S\&T)^2$ Consultants Inc. notes that, in contrast to the improvements in energy efficiency and GHG balance which have occurred with fuel ethanol production over the years, the reverse has occurred with gasoline. This is mainly because of a reduction in the maximum sulfur tolerance permitted in gasolines and our increasing dependence on tar-sand petroleum (more energy required for extraction and processing than with traditional crude).

The GHG and fossil energy benefits are even higher with biodiesel. Cheminfo (2009) estimates a GHG reduction of 99% when used-cooking-oil-based biodiesel replaces diesel in a blended fuel. When biodiesel is produced from soybeans, canola and other vegetable oil sources, the GHG and fossil energy benefits are reduced because of fossil

Table 13. Comparison of GHG emissions - gasoline and ethanol.

Fuel	Gasoline		Ethanol		
Feedstock	Crude Oil		Corn		
Year	1995	2015	1995	2005	2015
	g CO_2 eq/GJ (HHV)				
Fuel dispensing	118	90	185	181	142
Fuel distribution and storage	656	507	1,107	1,109	1,124
Fuel production	11,181	12,162	35,012	29,521	17,550
Feedstock transmission	1,084	903	1,004	1,009	1,031
Feedstock recovery	7,257	8,724	12,012	10,550	7,348
Land-use changes, cultivation	8	15	21,827	20,459	19,652
Fertilizer manufacture	0	0	8,261	7,033	6,215
Gas leaks and flares	3,486	1,688	0	0	0
CO_2, H_2S removed from NG	0	0	0	0	0
Emissions displaced	-65	-137	-18,490	-17,828	-17,075
Sub-Total	23,725	23,951	60,919	52,035	35,987
Combustion emissions	62,917	64,813	3,058	2,237	1,973
Grand Total	86,642	88,764	63,977	54,272	37,960
% Reduction			-26.2	-38.2	-57.2

Source: $(S\&T)^2$ Consultants Inc., 2009.

fuel energy required to grow the crops and associated soil losses. However, the ratios are significantly higher than with fuel ethanol. For example, Hill et al. (2006) calculated that while ethanol yields 25% more energy than is required for its production, the equivalent percentage for biodiesel from soybeans is 93%. They also concluded that while ethanol reduced GHGs by 12% compared to gasoline, biodiesel resulted in a 41% reduction compared to diesel. While the absolute percentages for GHG reduction in this study seem low compared to the results of other studies, they do demonstrate the superiority of biodiesel in reducing GHG emissions.

Natural Resources Canada, in its extensive web site on alternative fuels (http://oee.nrcan.gc.ca/transportation/alternative-fuels/) concludes that “over the life cycle – from growing oilseeds or collecting and rendering animal waste through fuel production and use – pure biodiesel is estimated to reduce greenhouse gas emissions by over 80 percent compared with petroleum diesel, depending on what oil or fat is used to make it. A 20 percent blend of biodiesel with petroleum diesel (B-20) can produce over 16 percent fewer emissions, and a 2 percent blend (B-2) can produce nearly 2 percent fewer emissions.” Biodiesel has 88 to 95% of the combustible energy content of diesel fuel (Timilsina and Shrestha, World Bank, 2010), while ethanol has about 68% of the energy content of gasoline ($(S\&T)^2$ Consultants Inc., 2009).

An issue which has arisen recently is the effect biofuels may have in increasing global grain production, thereby forcing new lands to be converted into agriculture. This is projected to cause the release of huge quantities of carbon dioxide, by the destruction of forests and the loss of soil organic matter when grasslands are converted to arable crop production. This is termed the “indirect land use change,” or ILUC. Two papers which were published simultaneously in the journal, *Science,* in 2008 (Searchinger et al., 2008; Fargione et at., 2008) stated that this effect was so large as to mean the net GHG balance from increased biofuel production in the world and notably the United States was strongly negative - that it could take in the order of 170 years (or more) before the ILUC effect could be offset by positive annual GHG balances with biofuels.

These scientific papers appeared at the time when the 2007-2008 food grain prices were reaching their peak, and they added to a huge outcry at that time by many public agencies, non-governmental organizations (NGOs) and the international media which were already concerned about effects of biofuels on food prices and world hunger. Food price and hunger issues are addressed in a subsequent section of this report. The proclaimed ILUC effects represented a direct challenge to the then common consensus that biofuels reduced GHG emissions compared to unblended gasoline and diesel fuel.

Ethanol production has not increased the Ontario corn acreage

Further analyses by others have substantially reduced, though not fully eliminated the concern raised by the two papers in *Science*. For example, Tyner et al. (2010) at Purdue University calculated that while major expansion in fuel ethanol production did mean some increase in global cropping area, the net effect on ILUC was only about 14% of the values projected by Swearinger et al.

Dumortier et al. (2009) of the Center for Agricultural and Rural Development termed the projections for forest conversion to agriculture made by Searchinger et al. to be “unrealistic” noting that, although US forested area had decreased by 4.1% between 1990 and 2005, it has been stable in years since. (Interestingly, some coauthors of the Dumportier et al. paper are the same as those in the Searchinger et al. report.) This was even though years after 2005 corresponded with the time of the most dramatic increases in US ethanol production and the corn used to make ethanol.

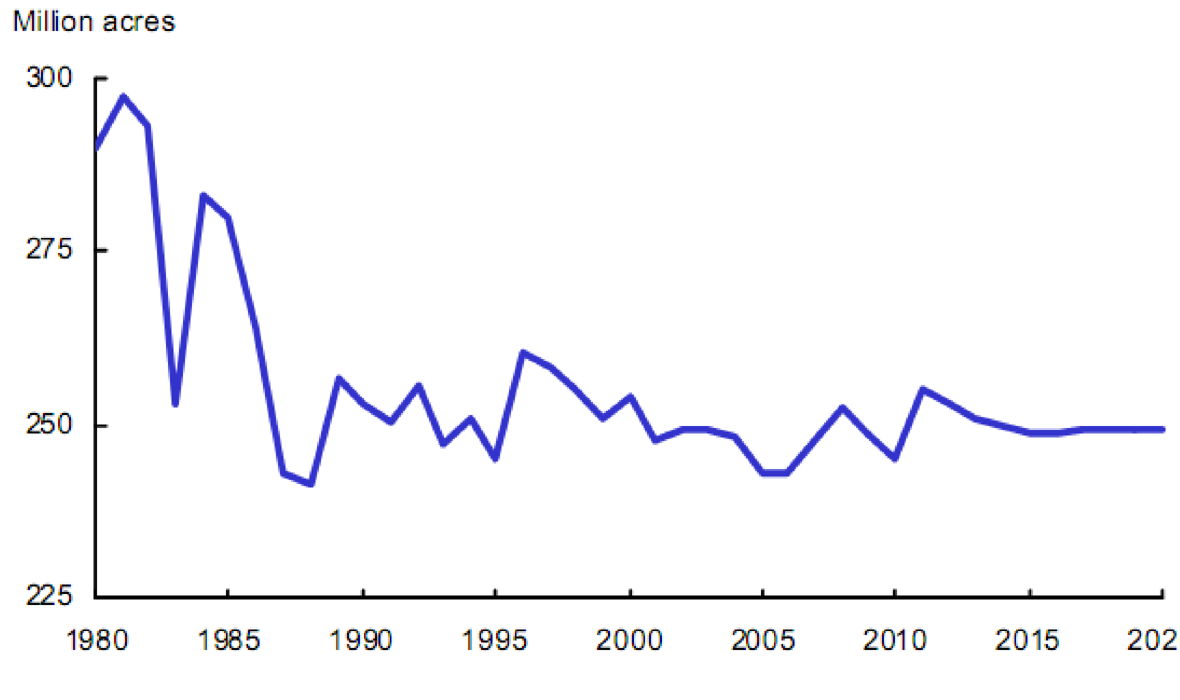
Using a different modeling approach and recognizing that new land for corn production is most likely to come from pasture land and not forests, Dumortier et al. (2009) calculated that if new land was converted to corn for ethanol production, the CO_2 and associated GHG released from soil would be offset by gains associated with ethanol usage for fuel within about 15 years, well within the lifespan of the associated ethanol production plants.

Biodiesel has largely escaped these criticisms in North America, partly because overall production is only about 3 to 10% as large as for ethanol, and partly because biodiesel has inherently larger GHG and fossil-energy efficiencies than ethanol from corn.

In Ontario and Canada, there is no evidence that ethanol production has resulted in increased acreages of corn or wheat. Both Ontario corn and Canadian wheat acreages are well below their peaks of a few years earlier, while soybean and canola acreages have increased even though they are not used to any great extent yet for Canadian biodiesel production. As a result, there seems to be no need to include ILUC estimates when calculating net GHG and energy ratios for fuel ethanol production in Canada.

The situation might be different in the United States where corn acreage has increased (88.2 million planted acres in 2010 versus typical values of about 79 million acres a decade earlier). Soybean acreage has also increased. However, the total acreage of "principal crops" in the United States, at about 305 million acres, has not changed consistently for the last 18 years (www.nass.usda.gov/QuickStats), implying that the increased corn and soybean acreage has come from land which was already in agricultural crop production. Also, a USDA report in February 2011 showed that US acreage seeded to eight major crops (grain crops, soybeans, and cotton) was about 250 million acres in recent years versus close to 300 million in the early 1980s (Figure 8). At

Figure 8. U.S. planted area: eight major crops.



1/ The eight major crops are corn, sorghum, barley, oats, wheat, rice, upland cotton, and soybeans.

Source: USDA-ERS, 2011.

least to the present, the true ILUC effect with biofuel production in the United States may be very small.

The US Environmental Protection Agency (EPA), because of its mandate to oversee the Renewable Fuels Standard (RFS) requirements in the United States, has figured prominently in US discussions about GHG emissions. The RFS requires corn-based ethanol to produce a 20% reduction in net GHG emissions compared to gasoline and biodiesel, a 50% reduction compared to diesel. In a 2009 initial proposal, the EPA suggested that ILUC (especially in other countries) caused directly by US biofuel production would be so huge as to eliminate any GHG benefits with most biofuels.

However, the EPA reconsidered this, and in 2010 announced that corn-ethanol and biodiesel from soy oil would meet the RFS requirements (www.epa.gov/oms/fuels/renewablefuels/regulations.htm). Interestingly the EPA concluded that corn ethanol, without ILUC included, would result in a 52% reduction in GHG emissions – similar to the Cheminfo conclusion (http://green.autoblog.com/2010/02/04/epa-finalizes-biofuel-rules-says-corn-ethanol-beats-gasoline-in/).

While the specifics are beyond the scope of this report, the EPA position on the magnitude of ILUC effects continues to be the subject of intense discussion in both the United States and globally. The US Department of Energy and the US Department of Agriculture have recently released discussion papers (Oladosu and Kline, USDOE, 2010; USDA-ERS, 2011). The US EPA assumes that much of the ILUC associated with US-produced corn ethanol will come from the destruction of forests in other countries – notably Amazon forests in Brazil. It’s of note that Brazilian analyses show Amazon forest cutting has slowed dramatically in recent years (http://news.mongabay.com/2010/1201-brazil_deforestation_2010.html).

In a related research paper, Kauffman and Hayes (2011) calculated that while ethanol made from switchgrass can result in greater GHG reductions per gallon of ethanol produced (110% versus 21% for corn ethanol, based on EPA), when GHG emissions reductions are expressed on a per-acre basis, the difference between the two is much smaller or even reversed. This is especially so if corn stover is also used as a source of bioenergy. The reason involves the much greater per-acre productivity of corn compared to switchgrass.

In summary, ethanol produced in modern manufacturing plants from grains and oilseeds, especially in North America, provides sizable benefits in both greenhouse gas emission reductions and fossil fuel usage - though the size of the calculated benefits is highly dependent on assumptions made about land conversion into agriculture.

There are virtually no published analyses of the effects of bioproducts on GHG emissions on energy balances. However, Carus et al. (2009) of the Nova Institute in

Germany noted that the amount of land currently used for bioplastic manufacture in the world is less than 5% of that devoted to biofuel production.

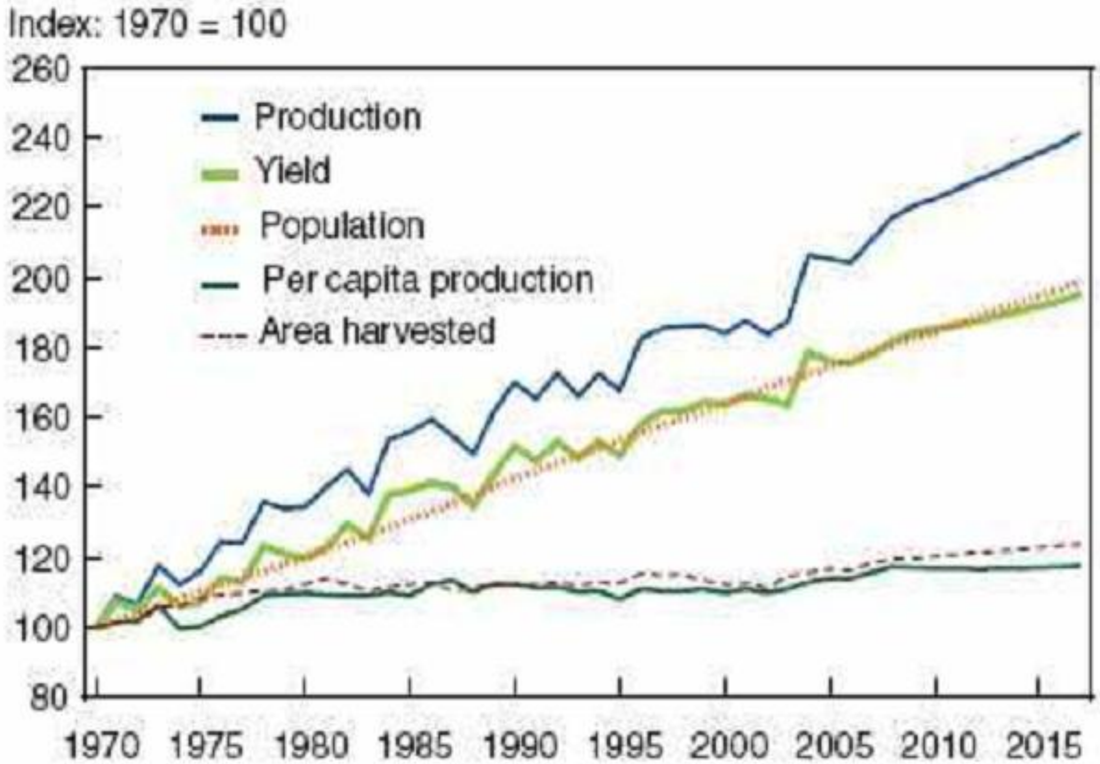
4. Grain Price Spikes and the Significance of Biofuels

This part of the report examines trends in agricultural production and crop prices, grain price spikes in 2007-2008, the extent to which biofuels may have contributed to spikes, and the effects of biofuel production on local Ontario corn prices.

4.1. Decades of Increasing Productivity, Declining Real Grain Prices

Following a major period of higher prices for grains and other commodities from about 1973 through 1980, the world began a near-three-decade era when grain production generally exceeded the rate of population growth (Figure 9 and Figure 10) and real grain prices declined (Figure 11). A report by the World Bank (Baffes and Haniotis,

Figure 9. Increases in world grain and oilseed production and world population.



[1]Total oilseeds = soybeans + rapeseed + sunflowers.

Source: USDA Agricultural Projections to 2017.

Source: Banse et al., 2008, from USDA agricultural projections.

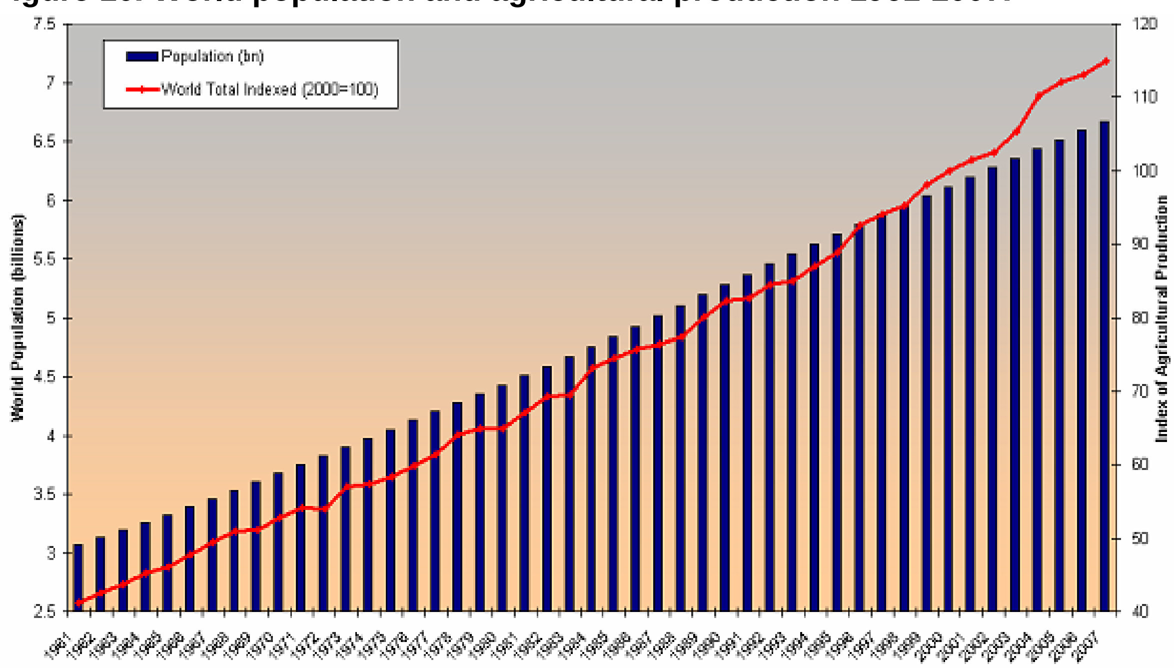
2010) notes that average real food prices declined by 53% between 1975/76 and 2000/01.This was caused, in large part, by the “Green Revolution” which improved grain productivity in many countries, especially South and South-east Asia. As a result, India, China, Vietnam and several other countries became largely self-sufficient in food production.

It was also caused by a rapid rate of technological improvement in developed countries, including Canada. And in addition, Brazil, Thailand and several former members of the Soviet Union emerged as major agricultural exporters.

Major concerns about the ability of the world to feed itself, which had been dominant years earlier, were largely replaced with international concerns about excessive productivity and the effects of declining agricultural prices on farm and rural economic well-being. Several countries introduced programs to remove arable farm land from crop production. Farm subsidy payments increased in many developed countries, reaching a global level of nearly $1 billion per day in the 1990s, and were still over $310 billion per year in the early 21st century (OECD 2002).

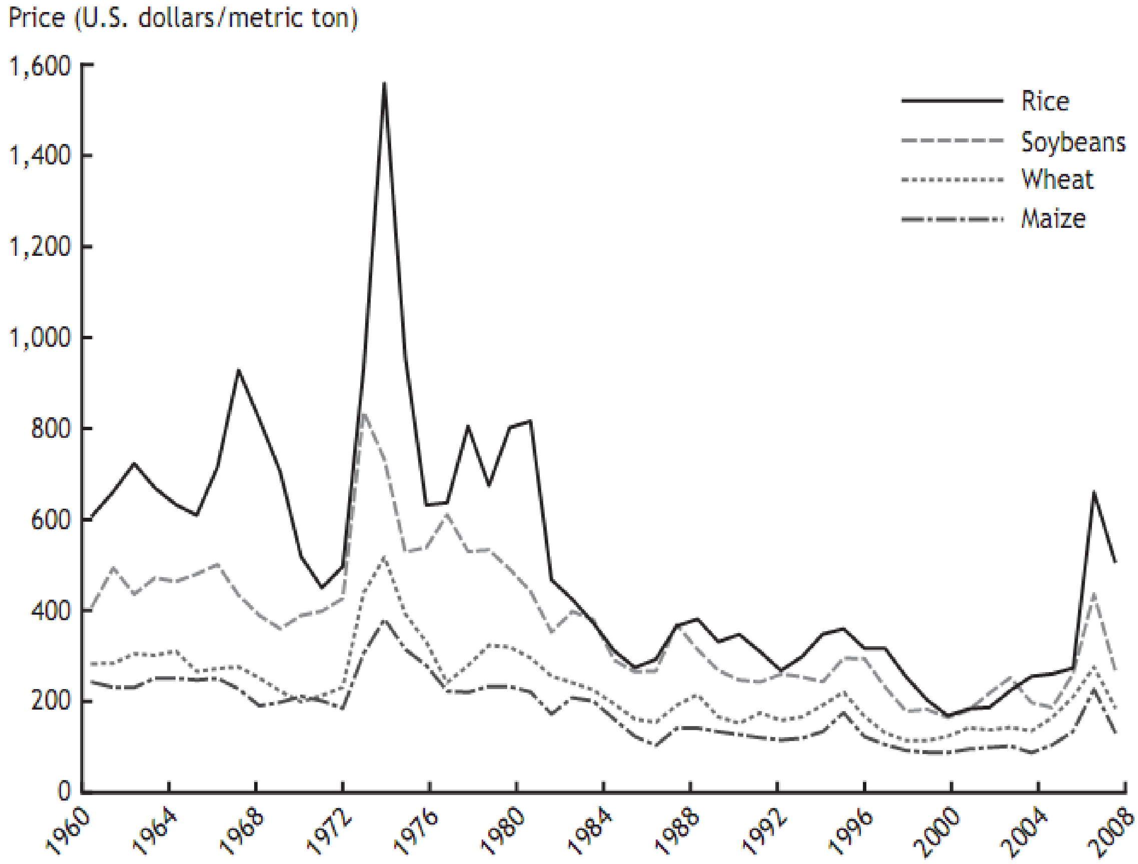
The effects were seen as being especially harmful to third-world farmers who experienced the low prices, but not the offsetting government support. Low international grain prices were one reason why many third-world countries, which were formerly near self-sufficient in grain/food production (i.e., Mexico), became major grain importers during this era (Figure 12).

Figure 10. World population and agricultural production 1961-2007.



Source: DEFRA, 2010, using data provided by FAO.

Figure 11. Trends in real international prices of key cereals, 1960 to mid-2008.



Source: IMF (2009a).

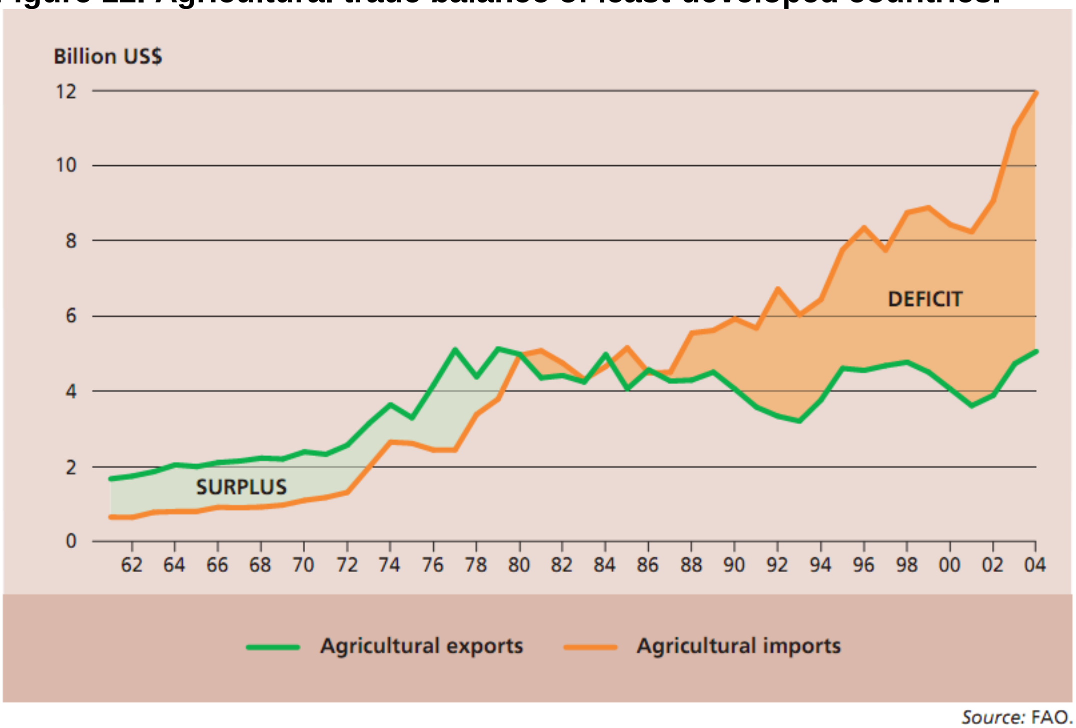
Notes: Data are deflated using the U.S. Bureau of Economic Analysis gross domestic product deflator. The 2008 data are for July.

The need to increase agricultural commodity prices and to reduce subsidies was stated as one of the priorities for the Doha Round of international trade negotiations - the so-called “Doha Developmental Round” (Baffes and Haniotis, World Bank, 2010). The need to reduce the effect of subsidy-distorting, price-depressing effects of developed world policies on third-world agricultural development was endorsed by many prestigious international bodies, as well as non-governmental organizations.

Swinnen (2010) and Timilsina and Shrestha (2010) have provided an excellent summary of statements made by FAO, the International Food Policy Research Institute (IFPRI), World Bank, OECD, International Monetary Fund, Oxfam and other agencies in years immediately before the 2007-2008 food price crisis, all emphasizing the threat caused by low grain prices to third-world agriculture and world food security.

The complacency about world food supply changed quite abruptly in late 2007 and into 2008 because of a major spike in grain prices – as is discussed in Chapter 4.

Figure 12. Agricultural trade balance of least-developed countries.



Source: FAO, 2008.

4.2. Causes of the Grain Price Spike in 2007-2008

Beginning in about 2006, world crop commodity prices began to move upwards with the rate of increase becoming more substantial in 2007 and into 2008 - reaching peak values in mid 2008. From January 2004 to May 2008, the world price of wheat in US dollars was up 108%, rice up 224%, corn up 88% and soybeans up 53% according to calculations by Heady and Fan (IFPRI, 2010). Prices for all subsequently dropped by about 30% between May 2008 and March 2009. (See Table 14, from Heady and Fam, IFPRI 2010.)

The price spikes were not unique to agricultural commodities, with both metals and energy prices reaching peaks much higher than those for farm commodities (Figure 13 and Figure 14). The price of fertilizer quadrupled during this period (Baffes and Haniotis, 2010), a greater increase than for any grain commodity.

The price spikes in 2007-2008 were very similar to those during the 1970s

In percentage terms, the price spikes in 2006-2008 were very similar to those experienced three decades earlier in the 1970s. The spikes were also higher for energy and fertilizer during the 1970s. (See, also, ICTSD, 2009.)

The media in Canada, the United States and Europe at that time were full of features on agriculture and food prices. *The Economist*, *Time* and many major newspapers positioned "the food price crisis" as their front-cover/lead stories as did the *Canadian Broadcasting Corporation*, *BBC*, *CNN* and other national/international television outlets. *The Economist* called it "The Silent Tsunami" on the cover page of its April 17, 2008 edition (www.economist.com/node/11050146).

In response to this huge public and governmental attention to hunger and food prices, a large number of reports were issued quickly by academics, global organizations, the media and private organizations in 2008. Heady and Fan (2010) referred to some of these studies as "'quick and dirty' in response to the pressing needs of policymakers." Among the higher-profile international reports were ones done by the FAO (2008), the OECD-FAO (2008), International Food Policy Research Institute (Von Braun, 2008), and the World Bank (Mitchell, 2008).

Swinnen (2010) provides an analysis of the politics and psychology of the reporting done at or near the height of the 2008 crisis, and of the need for international organizations to be seen as reacting quickly.

Weersink et al. (2008) completed a major analysis with specific attention to the implications for Ontario agriculture.

Since then, more reports on the same topic have been issued – generally far more

Table 14. Percent changes in world prices of agricultural and other commodities.

Commodity	1970-74	1974-78	January 2004-May 2008	May 2008-March 2009
Food				
Staples	136.6	-41.2	124.8	-34.7
Wheat	182.0	-53.8	107.9	-27.6
Maize	80.4	-42.2	88.5	-30.4
Soybeans	88.0	-27.6	52.9	-29.6
Rice	225.3	-48.1	223.6	-36.2
Nonstaples	159.3	-40.4	62.4	-30.9
Meat	24.5	10.1	50.7	-21.8
Beef (Brazil)	n.a.	n.a.	40.2	21.7
Seafood	42.8	7.2	41.7	-15.7
Fertilizers	299.4	-44.6	369.8	-36.5
DAP	280.8	-58.3	676.1	-55.9
Potash	475.3	-75.8	381.8	-70.7
Metals	82.1	-5.9	121.1	-32.6
Energy				
All energy	327.8	-3.0	136.4	-50.7
Petroleum	410.2	-15.7	181.4	65.6
Coal	360.1	-16.2	139.8	-41.9
Natural gas	n.a.	n.a.	162.7	-56.7
General prices				
U.S. Inflation	26.0	31.7	15.5	-2.9
Pound	1.9	15.4	-1.7	39.3
Yen	-15.9	-35.3	0.0	-5.7
Euro	n.a.	n.a.	-12.4	19.3

Source: Heady and Fan, 2010

analytical than their predecessors, and also having the benefit of hind-sight including the knowledge of the price declines which occurred later in 2008. These latter reports include Westhoff (Food and Agricultural Policy Research Institute, 2010), Baffes and Haniotis (World Bank, 2010), DEFRA (Department of Environment, Food and Rural Affairs, Government of the United Kingdom, 2010), Headey and Fan (International Food Policy Research Institute, 2010), US Department of Agriculture - Economic Research Service (2010), FAO (2010), Montpellier Panel, (2010), International Centre for Trade and Sustainable Development (2009), and Foresight (2011).

Almost all reports recognize that the spikes were caused by a combination of factors, and there is broad agreement on the significance of several, including:

- Poor wheat crops in some major grain growing areas of the world, including Australia, Western Europe and the Ukraine.

- Low global stocks for principal grains and the expectations that poor crops again in crop year 2008/09 could lead to wide-spread shortages contributed to the price increases.

- The relatively small amount of rice which is traded internationally compared to global production and also compared to the much larger volumes traded for wheat and corn – and the consequently exaggerated effect which relatively small changes in tradable supply can have on global prices for rice (Heady and Fam, 2010).

Table 15. Energy-related costs for major field crops in the US in 2009.

	Energy-related costs 2009 (forecasts)					
US major field crops	fertiliser ($/acre)	fuel, lube and electricity ($/acre)	total operating costs ($/acre)	total production costs ($/acre)	Energy related costs as a proportion of total operating costs	Energy related costs as a proportion of total production costs
Maize	135.86	28.66	292.27	535.77	56%	31%
Soybeans	24.57	13.82	134.42	398.15	29%	10%
Wheat	51.54	17.94	115.23	273.55	60%	25%
Rice	110.71	95.83	454.17	828.35	45%	25%
Barley	51.29	19.44	129.86	341.99	54%	21%

Source: USDA ERS (2009) available at http://www.ers.usda.gov/Data/CostsAndReturns/data/Forecast/cop_forecast.xls

Source: Pfuderer et al., DEFRA, 2010.

- Increases in world energy prices which triggered increases in the cost of grain production (fuel and fertilizer manufacture) and in transportation. Heady and Fan (2010) estimated that higher energy costs meant an increase of 30-40% in costs of grain production in the United States in 2007. Energy represents about 60% of total operating costs for corn and wheat production (Table 15, DEFRA, 2010, citing USDA-ERS data). Increases in ocean shipping rates for grains, up to $50/tonne and caused principally by higher oil prices, are shown in Figure 15.

- Heady and Fan also noted that oil import costs are 2.5 times larger than food imports for low-income countries, and cited a conclusion by the International Monetary Fund that the oil price shock had a much greater effect than food prices in low-income countries in 2008 (Table 16).

- A decline in the value of the US dollar relative to many other currencies which meant that changes in grain and oilseed prices were greater when reported in US dollars than in most other currencies. The US dollar declined by 30% between 2002 and 2008 compared to an average of the euro, yen and pound sterling, meaning that price spikes were lower when measured in other currencies (Heady

Table 16. Countries severely affected by food and oil price increases, 2007–08.

Type of shock[a]	Number of low-income countries severely affected	Number of middle-income countries severely affected
Severe negative shocks		
Oil price shock	48	33
Food price shock	13	3
Combined shocks	42	30
Positive shocks		
Oil price shock	11	23
Food price shock	30	28
Combined shocks	23	23
Less-than-adequate reserves		
Before the combined shocks	30	18
After the oil price increase	37	26
After the food price increase	27	19
After the combined shocks	37	25
Total countries	74	71

Source: IMF (2008a).
[a]Severe negative shocks are defined as those that induce drops in reserves of more than 0.5 months of imports. Positive shocks are those that result in increased reserves.

Source, Heady and Fan, 2010.

and Fan, 2010).

- Changes in import and export policies by individual countries also had a major bearing on the increases. Many countries, perhaps even most, have a range of subsidy programs or price controls which affect or dominate food prices and agricultural production practices. Examples are controls by the Government of Mexico on white corn flour used for tortilla production and Egyptian price controls for wheat, but there are also subsidy programs for fertilizers, irrigation, transportation, storage and other farm inputs. Bangladesh and Indonesia use variable import duties to stabilize domestic prices (FAO, 2008). Changes in these

Table 17. World supply/demand indicators for corn (million tonnes).

	03-04	04-05	05-06	06-07	07-08	08-09
Supply						
Beg Stocks	126.21	104.58	132.14	124.49	105.46	109.69
Production	627.25	714.76	696.86	706.70	779.83	777.56
Imports	76.39	76.67	79.47	90.65	94.32	90.70
Use						
Feed	445.09	473.41	476.31	476.09	496.52	482.47
Non-feed	648.88	687.98	703.89	725.76	775.60	788.21
Exports	77.28	77.64	80.93	93.06	99.13	92.31
Ending Stocks	104.58	131.36	125.11	105.46	109.69	99.03
Stock/Use	16.1%	19.1%	17.8%	14.5%	14.1%	12.6%

Source: USDA Supply & Demand Review, May 2008

Source: Weersink et al., 2008.

Table 18. World supply/demand indicators for wheat (million tonnes).

	03-04	04-05	05-06	06-07	07-08	08-09
Supply						
Beg Stocks	166.35	132.39	150.76	147.50	124.05	110.02
Production	554.42	626.83	621.30	592.00	606.40	656.01
Imports	100.79	109.45	110.15	112.33	107.31	114.59
Use						
Feed	96.16	105.43	111.40	105.76	98.04	113.11
Non-feed	588.37	608.60	624.37	615.45	620.43	642.04
Exports	108.43	110.70	116.16	110.69	109.56	117.46
Ending Stocks	132.39	150.76	147.50	124.05	110.02	123.99
Stock/Use	22.5%	24.7%	23.7%	20.2%	17.7%	19.3%

Source: USDA Supply & Demand Review, May 2008

Source: Weersink et al., 2008.

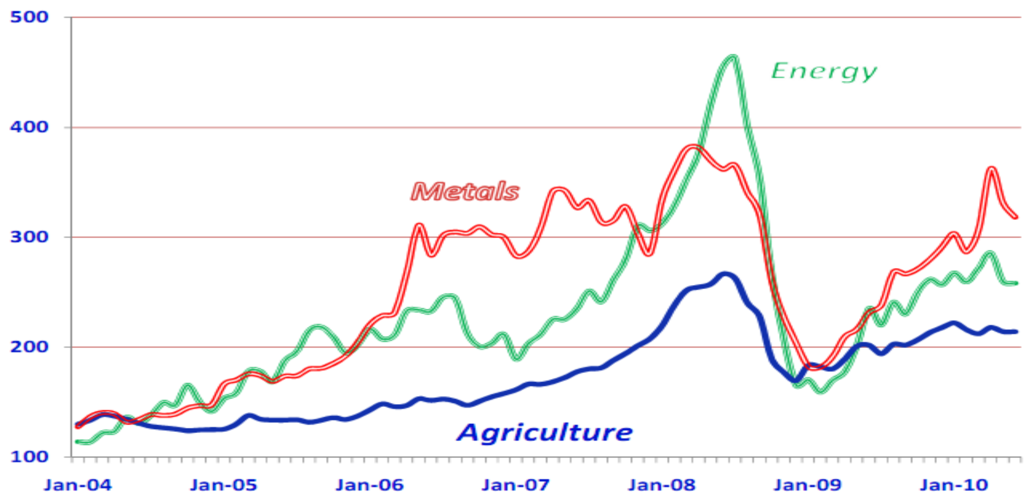
Table 19. World supply/demand indicators for rice (million tonnes).

	05-06	06-07	07-08	08-09
World Balance (milled basis)				
Production	424.3	428.7	429.3	
Trade	29.2	29.9	30.5	
Total Use	418.3	425.9	429.2	
Ending Stocks	105.5	106.8	107.6	
Stock/Use	24.8%	24.9%	24.8%	

Source: FAO, Rice Market Monitor, May 2008

Source: Weersink et al., 2008.

Figure 13. Commodity price indices (nominal, 2000=100).



Source: Baffes and Haniotis, World Bank, 2010.

programs triggered some of the food price stress experienced in 2008 (Paarlberg, 2010).

Many analysts agree that there was no real global shortage of food ingredients during this time interval. While weather-induced crop yield reductions occurred in some countries, above-average yields occurred elsewhere. World corn production was record high in 2007 and the global production of both wheat and rice were above levels of the previous year.

One notable exception was soybeans for which global production was down, mainly because of a significant reduction in number of planted acres in the United States in 2007.

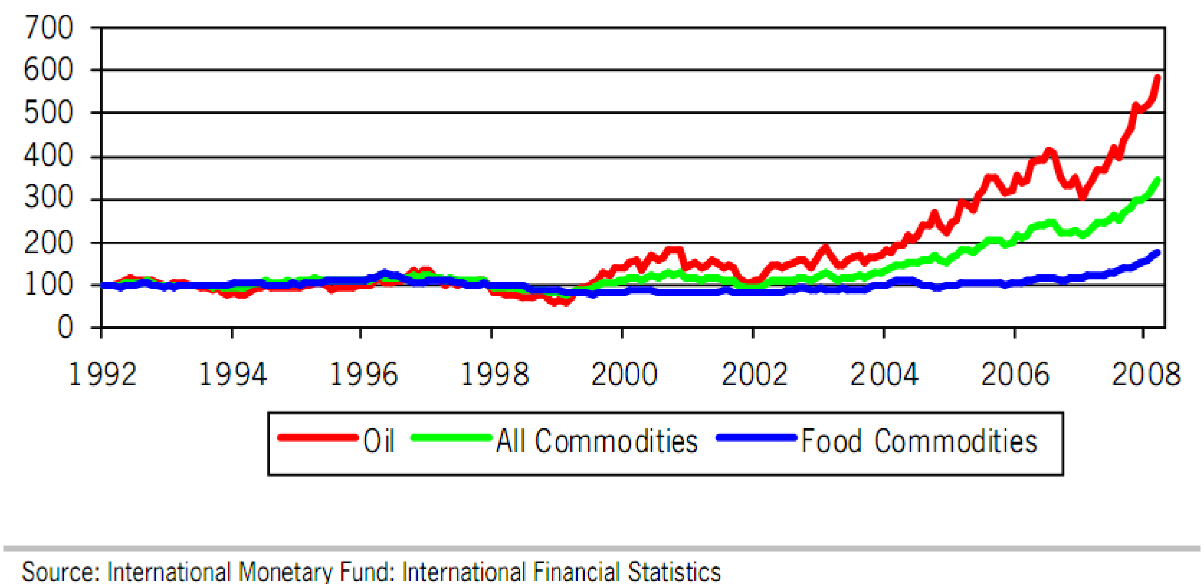
Global stocks of grain decreased in 2007-2008 compared to previous years though analysts differ in the importance of this decline in explaining the price peaks.

For the North American grain industry, the stocks-to-use ratio has a major effect in setting grain futures prices - with the market price usually changing quite significantly whenever the projected end-of-year stocks-to-usage ratio changes notably between successive monthly reportings. Stock measurements and predictions are usually quite accurate for grain production/usage in Canada, the United States and other developed countries.

Weesink et al. (2008) emphasized the importance of low stock levels and projections of even lower stocks for 2008/09 in their analysis of the grain price spike. Their numbers, based on USDA May 2008 analyses, are presented in Table 17, Table 18, and Table 19 for world corn, wheat and rice. Price increases in 2007-2008 are consistent with stock reductions for corn and wheat, though not for rice even though rice experienced the largest price spike of all grains.

Other analysts are quite ambivalent about the relative importance of world stock estimates in explaining the price spikes in 2008. They note there is no measurement of available stocks at all in many developing countries; stock estimates are based on notoriously inaccurate estimates of annual domestic production and consumption adjusted for imports minus exports.

Figure 14. Index of oil, food and all commodities, 1999-2008, 1992=100.



Source: Baffes and Haniotis, World Bank, 2010.

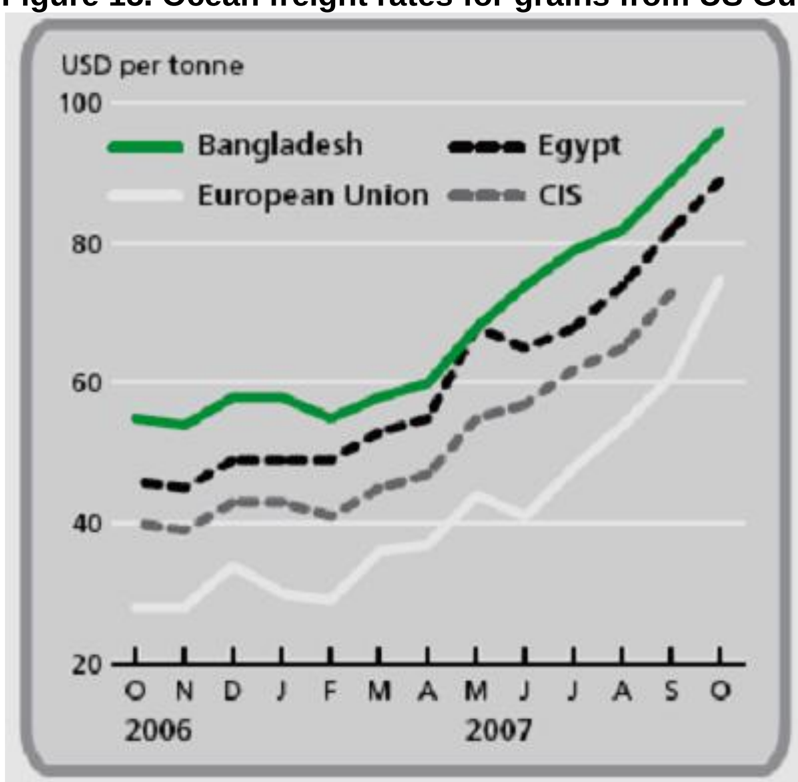
In addition, nearly all of the world grain stock reduction experienced during the last decade can be attributed to a decision by China to substantially reduce stocks (Figure 16, Heady and Fan, 2010). The Chinese do not report these data themselves, so analysts can only guess, sometimes very inaccurately.

Nevertheless, there is no doubt that published stock-to-use statistics had a notable effect on agricultural crop commodity future prices during 2007-2008. And when it later became apparent in mid year that the size of the 2009 world grain crop would be adequate to meet needs, futures prices dropped quickly.

While global supply of principal grains (corn, wheat and rice) was not a major restraint in 2007/08, government trade restrictions, hoarding and panic buying did result in critical local shortages.

Among the trade actions taken: Argentina put quantitative limits on wheat exports and raised export taxes on wheat, corn, soybeans, and soybean products. The Ukraine, Serbia and India banned wheat exports. Russia and Kazakhstan raised export taxes on wheat. Kazakhstan banned exports of oilseeds and vegetable oils. Malaysia imposed export taxes on palm oil. India, traditionally an important rice exporter, placed an

Figure 15. Ocean freight rates for grains from US Gulf ports.



Source: DEFRA, 2010, using data from FAO.

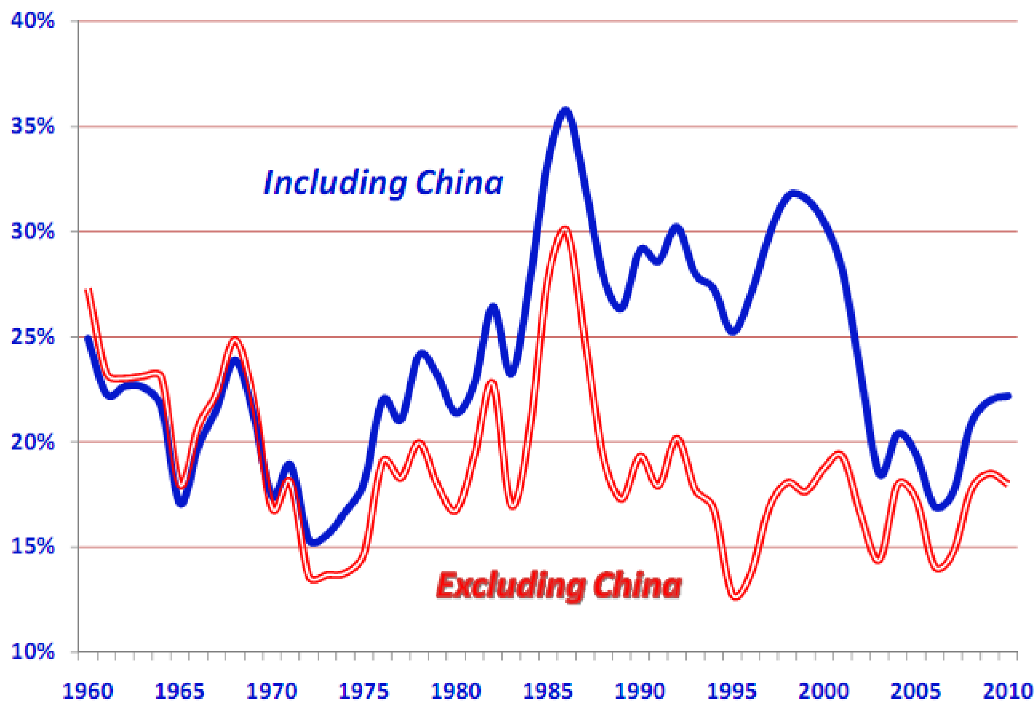
absolute restriction on all exports of non-basmati rice. (India subsequently allowed rice exports to Bangladesh to prevent a crisis there.) Egypt, Cambodia, Vietnam and Indonesia banned rice exports. China restricted corn exports. On the positive side, a number of countries reduced import duties on key food ingredients (Banse et al., 2008; Heady and Fan, 2010).

Other countries panicked and bought rice and wheat at peak prices, not because their cupboards were bare but as precautions. The Philippines bought more rice during the first four months of 2008 than during the previous year. Imports also surged for Bangladesh – up by more than 500% in 2007/08 and 2008/09 relative to 2006/07 (Heady and Fan, 2010).

A detailed listing of policies, including export restraints and changes in import polices taken by many developing countries can be found at the 2008 FAO web site, www.fao.org/docrep/010/ai470e/ai470e05.htm .

This hoarding was not restricted to the developing world. In April 2008, the Sam's Club Warehouses division of Wal-Mart in the United States announced restrictions on sales of rice (maximum of four 20-pound bags per customer per visit) because of abnormally large purchases triggered by media reports of rice shortages. This was despite assurance by the California Rice Commission that "there is no rice shortage in the

Figure 16. Global grain stocks-to-use ratios.



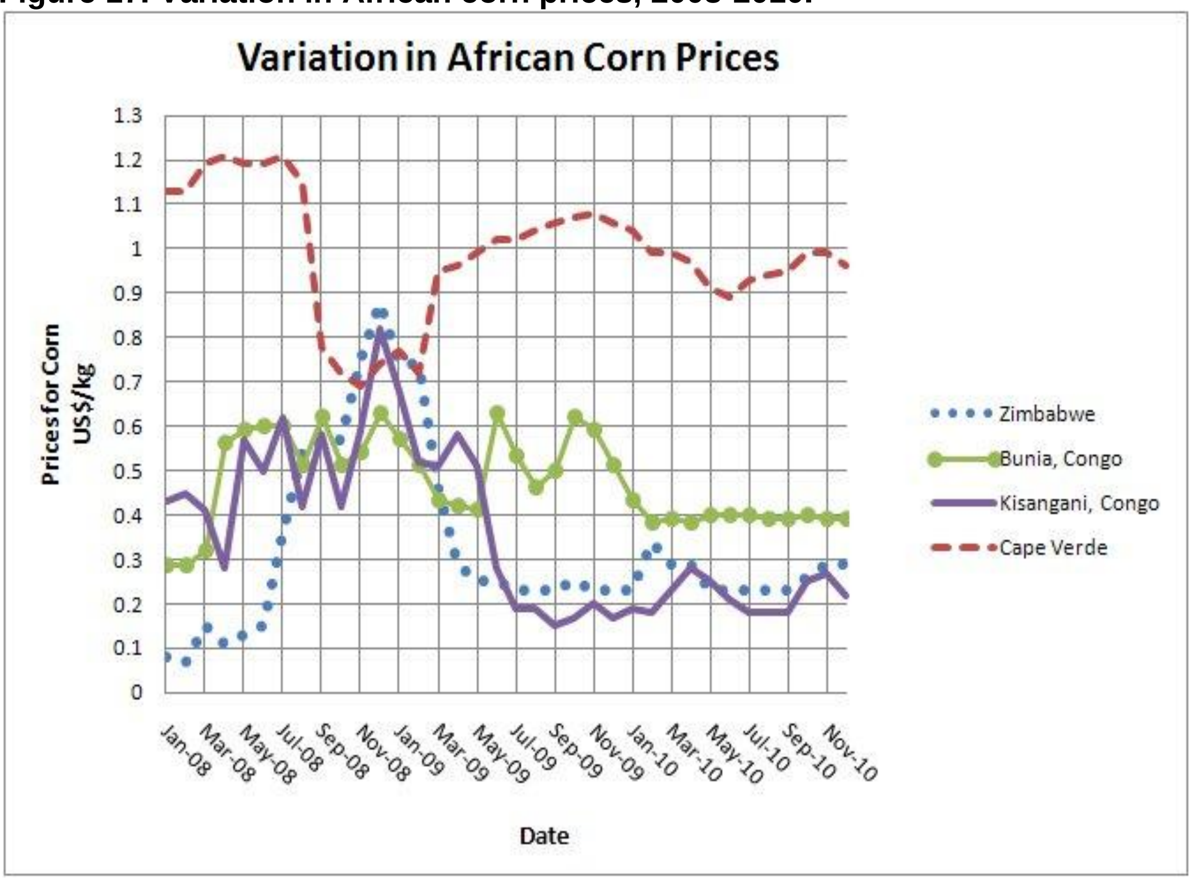
Source: Baffes and Haniotis, 2010, using data supplied by USDA.

United States” (www.reuters.com/article/2008/04/23/walmart-samsclub-idUSN2323679120080423).

Some reports have suggested that increased global meat consumption, especially in China where per capita meat consumption doubled between 1990 and 2003, was a major contributor but the data are not supportive. In 2007-2008, China was a net exporter of grains (DEFRA, 2010). (So too was India.)

Commodity market speculators/investors have been accused of causing the grain price spike in 2008 and there is a huge amount of literature on this subject - some largely finger pointing – but some very analytical. The conclusions from these studies are quite contradictory (Banse et al., 2008; Baffes and Haniotis, 2010; Heady and Fan, 2010; DEFRA, 2010). However, it seems reasonable to conclude from them all, collectively, that, while market speculators and longer-term commodity fund investors may have influenced short-term volatility and/or the absolute height of the price spikes, they were not responsible for the over-all rise or decline in prices during the wild ride of 2008. This subject is reviewed in depth by Hailu and Weersink (2010).

Figure 17. Variation in African corn prices, 2008-2010.



Source of data: www.fao.org/giews/pricetool/ .

Increases in grain and other commodity prices were not experienced universally around the world. Figure 17 created from data provided by the FAO's Price Tool web site (www.fao.org/giews/pricetool/) demonstrates that the magnitude, and even the existence, of a grain price spike in 2008 and decline thereafter, differed dramatically by geographic area – and even by location within the same country. (See also, Table 20, from Heady and Fan (2010).)

Biofuel production has also been identified as a cause of grain and food prices in 2007-2008 and this is discussed in the following section.

Table 20. Changes in price of basic food ingredients in 2008.

			Change in prices (percent)		
Country	Commodity	Market	Average increase M-07 to M-08[a]	January-June 2008	July-December 2008
East Asia					
China	Rice (*Indica*)	Wholesale	6.3	8.1	0.3
Philippines	Regular milled rice	Wholesale	20.5	38.6	-9.4
Thailand	Rice	Wholesale	75.3	44.5	-6.8
Vietnam	Rice	Retail	25.7	44.0	-17.2
South Asia					
Afghanistan	Wheat	Retail	71.4	24.2	n.a.
Bangladesh	Rice (coarse)	Wholesale	31.1	2.4	-24.1
India	Rice	Wholesale	15.7	2.2	4.6
Pakistan	Wheat	Retail	36.4	-0.3	4.1
Sri Lanka	Rice	Retail	39.2	-8.8	n.a.
Eastern Africa					
Djibouti	Rice (*belem*)	Retail	63.7	9.5	n.a.
Egypt	Rice	Retail	25.9	11.8	n.a.
Ethiopia	Maize	Wholesale	114.7	119.2	-45.0
Kenya[b]	Maize	Wholesale	60.1	41.7	0.6
Uganda[b]	Maize	Wholesale	108.6	27.6	-1.2
Sudan	Millet	Wholesale	59.7	68.5	n.a.
Southern Africa					
Burundi	Maize	Retail	21.8	154.8	-28.0
Democratic Republic of Congo[b,c]	Cassava	Retail	56.7	59.3	n.a.
Madagascar	Rice (local)	Retail	-8.1	-6.2	-0.6
Malawi	Maize	Retail	116.3	52.9	3.3
Mozambique	Maize (white)	Retail	42.3	5.7	10.4
Namibia	Millet	Retail	10.9	31.2	1.7
Rwanda[b]	Beans	Wholesale	18.1	-9.1	-31.9
South Africa	Maize (white)	Wholesale	-4.8	5.5	-3.1
Tanzania[b]	Maize	Wholesale	73.1	-26.9	32.6
Zambia	Maize (white)	Retail	25.6	-9.9	40.7
West Africa					
Burkina Faso	Millet (local)	Wholesale	14.2	25.9	-12.8
Cameroon	Maize	Retail	8.4	5.5	23.6
Ghana	Maize (white)	Retail	39.1	84.6	0.0
Mali	Millet (local)	Wholesale	8.4	14.3	-17.4
Mauritania	Wheat (flour)	Retail	12.8	-0.4	-4.6
Niger	Sorghum	Wholesale	26.4	16.0	3.3
Nigeria	Millet	Wholesale	113.9	11.0	-21.3[d]
Senegal	Millet	Retail	7.0	8.3	-5.1
Senegal	Rice (imported)	Retail	51.5	58.9	-3.3
Togo	Maize	Retail	38.9	62.3	-14.6

Source: Calculations by the authors using data from GIEWS (2009).
Notes: n.a., data not available.
[a]Average percentage difference between the change in price from a given month in 2007 to the corresponding month in 2008. In this way seasonal fluctuations can be accounted for.
[b]Data for these countries are available in U.S. dollars only. They should be regarded with caution, as they may not be appropriately deflated.

4.3. Role of Biofuels in 2007-2008 Price Spike

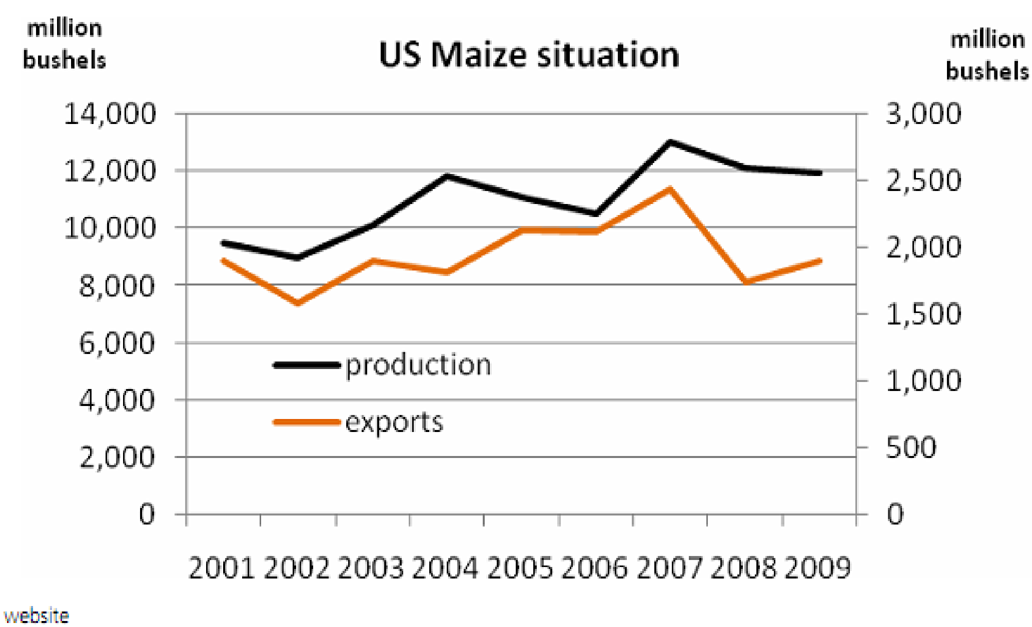
Biofuels have figured prominently in discussions about causes of the price spikes in 2007-2008.

Basic economics say that any increase in crop usage for any purpose, including biofuel production from corn or biodiesel from vegetable oils, has to have had some upward effect on crop prices.

But there are major differences of opinion about the extent of the increases, and the degree to which the stimulation spread to other crops.

The range of estimates is quite extreme. Lipski of the International Monetary Fund said in 2008 that biofuel production caused 70% of the increase in corn price and 40% of that for soybeans (www.imf.org/external/np/speeches/2008/050808.htm). Mitchell (2008) of the World Bank, while not being specific, stated that biofuel production was the most important factor contributing to a 105% increase export food prices not attributable to increased energy costs or changed currency exchange rates, between January 2002 and February 2008. (See Pfuderer et al., DEFRA, 2010, for interpretation of Mitchell's analysis.) (The World Bank released a subsequent report by Baffes and Haniotis in 2010 stating that, with respect to the 2008 price spike, "Biofuels played some

Figure 18. US corn exports



Source: Pfuderer et al., DEFRA, 2010, using USDA data.
Note that the x-axis is for crop years: for example, "2007" means "2007/08."

role too, but much less than originally thought," but did not attempt to be more quantitative.)

At about the same time, the US Secretary of Agriculture stated that biofuels were responsible for no more than 3% of the increase in world food prices (http://gas2.org/2008/05/22/usda-says-ethanol-accounts-for-only-3-of-increased-cost-of-food/). And Banse et al. at the University of Wageningen (Netherlands) issued a statement in June 2008 subtitled, "Neither biofuels nor speculation to blame for high food prices" (www.ppo-eu.org/3000/high_foodprices_20080619.pdf.

And there have been many reports making estimates in between.

Baier et al. (2009) of the US Federal Reserve concluded that, globally, biofuels increased the prices of corn, soybeans and sugar by 27%, 21% and 12%, respectively,

Figure 19. Nearby Chicago Board of Trade futures price and volume traded for corn.

Source: TFC Commodity Charts http://futures.tradingcharts.com/chart/CN/M

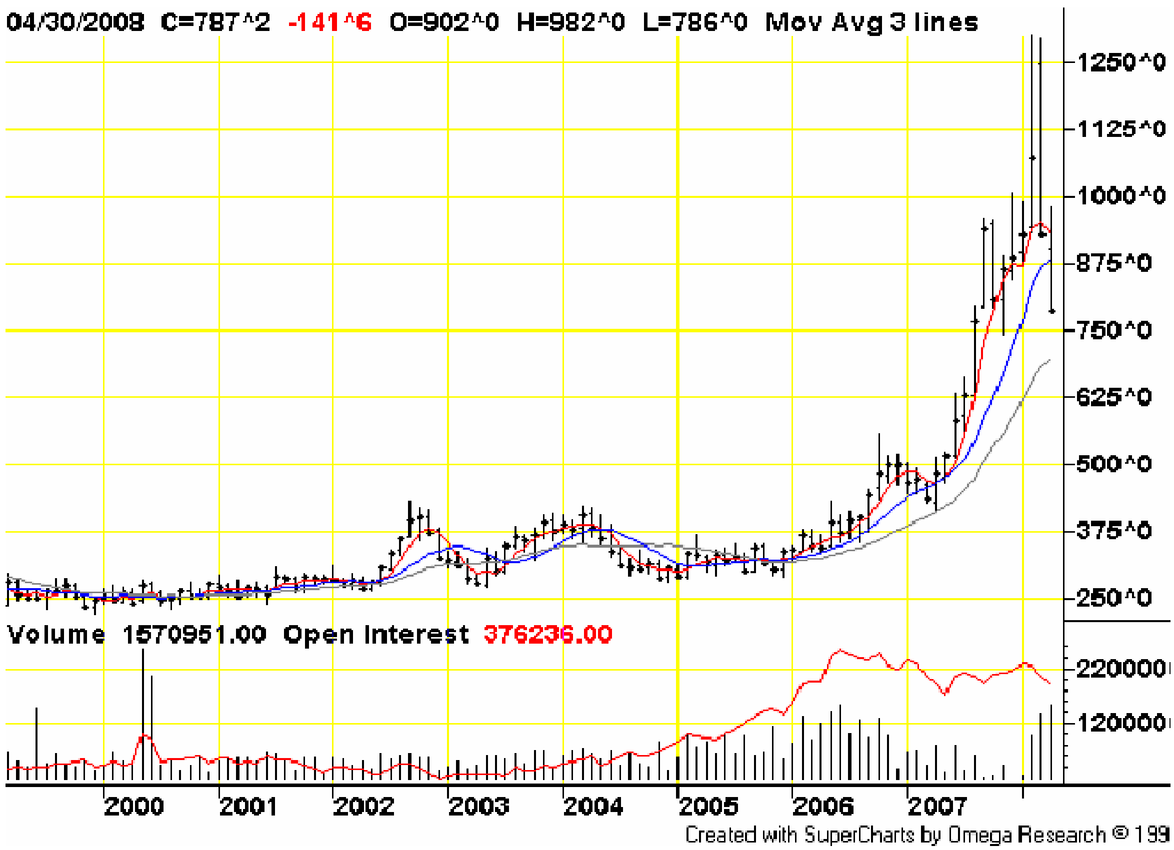
Source: Weersink et al., 2008.

in a two-year period ending in June, 2008. However, they also concluded that biofuels were responsible for only a 12% in the FAO's food price index during this period, and that 88% of the food price increase was attributable to other factors.

Banse et al. (2008) cite an IFPRI study estimating that 39%, 21% and 22% of the price spike for corn, rice and wheat, respectively, was caused by increased biofuel demand. Other estimates (summarized in Timilsina and Shrestha, World Bank, 2010) ranged from 20% to 70%. Pfuderer et al., (DEFRA, 2010) provide a good summary and analysis of the conclusions of others.

Without drawing any firm conclusions himself, Westhoff (2010) provides an excellent overview of the cases presented by others in arguing that biofuels (especially ethanol) had a dominant effect on world food commodity prices in 2008, and of those who argue the reverse.

Figure 20. Nearby Chicago Board of Trade futures price and volume traded for wheat.



Source: TFC Commodity Charts http://tfc-charts.w2d.com/chart/CW/M

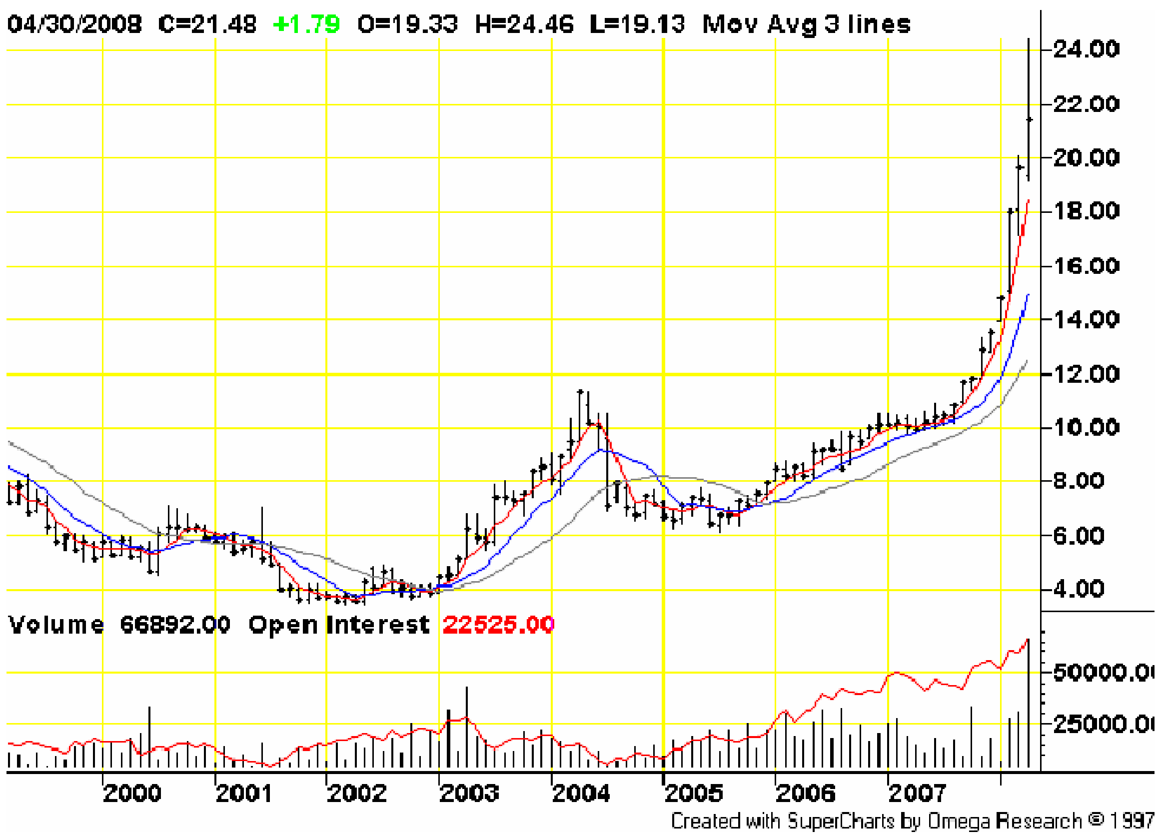
Source: Weersink et al., 2008.

Those who argue for the affirmative note that corn usage for ethanol represented half of the increase in total global cereal usage between 2005/06 and 2007/08 – indeed, all of the increase in per-capita consumption.

Those opposed note that ethanol usage represented only 4% of total cereal usage (3% if feed credits from byproducts are included) and that the usage was nearly all corn, as distinct from wheat and rice which are the world's major food grains. US ethanol production for crop marketing year 2008/09 remained stable even as grain prices fell. US corn exports increased in 2007/08 (though decreased in 2008/09; see Figure 18). In addition, total global corn consumption in 2007/08 (as distinct from that of all grains) increased much more than did its usage to make ethanol.

Ethanol plants did close or operated at well below capacity for several months in late 2008 and 2009 because of the combined effects of high corn prices (notably for plants which had "booked corn" for fall delivery before the price reversal occurred in mid 2008)

Figure 21. Nearby Chicago Board of Trade futures price and volume traded for rice.



Source: TFC Commodity Charts http://tfc-charts.w2d.com/chart/RI/M

Source: Weersink et al., 2008.

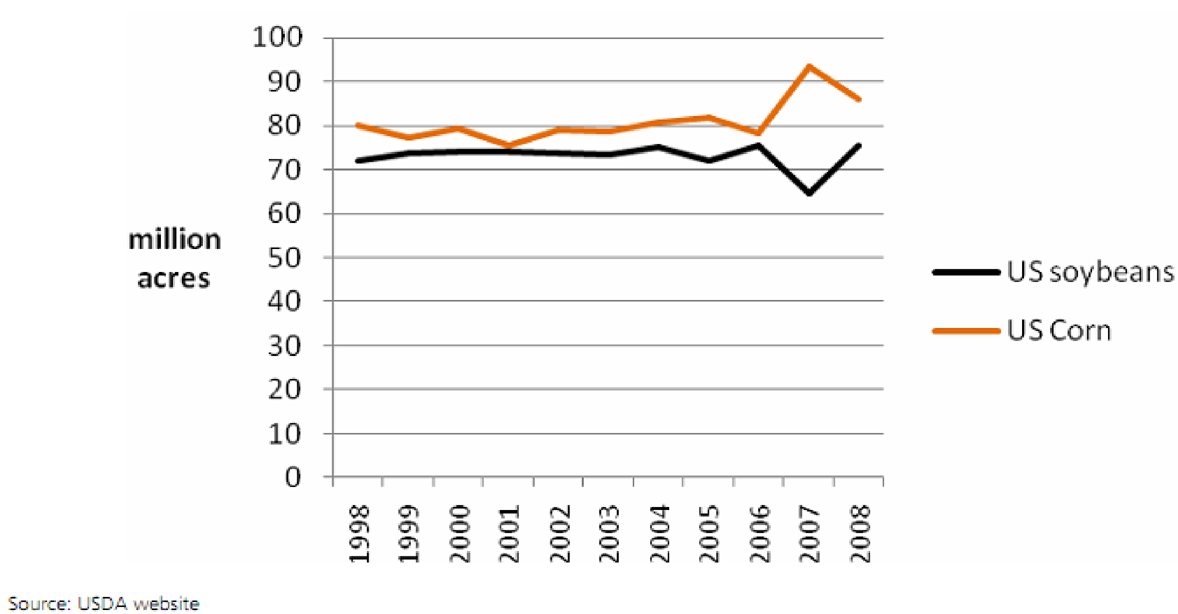
and low gasoline prices later in 2008 and 2009. However, total US ethanol production did not decline in 2008 and the rate of growth resumed during 2009.

Probably the most detailed and sophisticated analysis is one completed by Pfuderer et al. (2010) as a annex to a much larger study by DEFRA (Department of Environment, Food and Rural Affairs, Government of the United Kingdom) entitled, *The 2007/08 Agricultural Price Spikes: Causes and Policy Implications*. The authors developed their own economic model of supply-demand-price relationships for ethanol and corn, and used this, the findings of others, and some pragmatic considerations of the differential timing of price spikes and declines for various grains, to reach their conclusions.

Pfuderer et al. concluded:

> "Medium-term economic models agree that biofuel demand has and will put upward pressure on prices for those agricultural commodities used in biofuels production.
>
> "However, available evidence suggests that biofuels had a relatively small contribution to the 2008 spike in agricultural commodity prices where its impact was largely limited to the maize market with some knock-on effects on soybean prices. By way of contrast, the price of wheat increased before maize and to a higher peak, moving the ratio of wheat to maize prices higher than the recent

Figure 22. US plantings of maize and soybeans from 1998 to 2008.



Source: Pfuderer et al., 2010 using USDA data.

past and suggesting that incentives for any demand-side substitution were actually away from wheat.

“Studies which have found a large biofuel impact across agricultural commodities have often considered too few variables, relied on statistical associations or made unrealistic or inconsistent assumptions.

“A significant feedstock for biofuel use, sugar, did not see a large rise in price during the spike period but increased significantly in 2009 when other commodity prices had fallen back from their peaks.

“Whilst commodity prices have fallen steeply from their peaks in 2008, biofuel demand has remained steady – indicating that the causal link from biofuel demand to short-term crop prices is still relatively weak.”

Ethanol uses 40% of U.S. corn

There is some disagreement with the conclusion by Pfuderer et al. that corn prices rose after those for wheat and rice. Weersink et al. (2008) and Headey and Fan (2010) concluded the reverse. An examination of Chicago Board of Trade nearby future charts for corn, wheat and rice (Weersink et al., 2008) (Figure 19, Figure 20, and Figure 21) indicates that rice prices did begin to rise first though the comparison is less clear for corn and wheat. It’s a judgment based on what one defines as the beginning of a rise. (The same uncertainty exists in a graph which Headey and Fan present to support their interpretation.)

As for the effect on soybeans, Pfuderer et al. (2010) noted that US soybean acreage dropped significantly in 2007 with this acreage all shifting to corn – presumably at least partly because of the anticipation of higher corn prices caused by demand for ethanol production. (See Figure 22.) However, this was a one-year trend with the corn-soybean acreage ratio returning to more normal levels in 2008 and subsequent years.

Given the wide range of estimates and interpretations, it is very difficult to draw firm conclusions. Ethanol production now uses about 40% of US corn and this obviously has a substantial market effect. However, ethanol production and the associated price enhancement have also stimulated US corn production; without ethanol, annual US corn production would be significantly lower.

Table 21. Estimates of effect of biofuels on crop and food prices.

Study	Coverage and assumptions	Estimated effects
Banse et al. (2008)	Effects of EU biofuel mandates, 2001-2010	7% effect on cereal price, 10% effect on oilseed price.
Baier et al., US Fed Reserve (2009)	24 months ending June 2008	Global biofuel production growth caused 27%, and 21% of increased price of corn and soybeans, respectively but 12% of increase in Food Price Index.
Lazear, US Council of Econ. Advisors (2008)	12 months ending March 2008	US ethanol growth caused 20% of corn price increase; global ethanol caused 35%.
IMF (2008)	Estimates based on price elasticity	25-45% of corn price increase caused by ethanol growth.
Glauber, USDA (2008)	12 months ending April 2008	US ethanol growth caused about 25% of corn price increase.
Lipsky, IMF (2008)	2005 to 2007	Global biofuel growth caused 70% of price increases for corn.
Mitchell, World Bank (2008)	2002 to mid 2008, very simple calculation	Global biofuel growth caused 70-75% of price increases for corn, interpretation by Timiksina and Shrestha, World Bank (2010).
Abbott et al., Purdue U (2008)	2004 to 2008	25% of US corn price increase caused by ethanol subsidy of 51 cents per gallon.
Rosegrant et al., IFPRI (2008)	2000 to 2007	Biofuel growth caused 39%, 21% and 22% of increased price for corn, rice and wheat, respectively.
US Congress. Budget Off. (2009)	12 months ending April 2008	US ethanol growth caused 28-47% of corn price increase.
Pfuderer et al., DEFRA (2010)	Analysis of 2008 price peak	Biofuels had small effect on corn and soybean prices, but not wheat and rice. Very minor effect on food price.
Meyers & Meyers, FAPRI (2008)	Effect of US Renewable Fuels Standard and tax credits	Support US corn price by 20%.

Principal sources: Pfuderer et al., 2010; Timilsina and Shrestha, 2010.

Notwithstanding these difficulties, a review of a number studies summarized in Table 21 suggests that ethanol production might have been responsible for 20-40% of the peak price in US corn prices experienced in 2008.

A credible approach is to consider what would happen over a period of a few years in the future if all US support programs for ethanol were to be eliminated. For this, a couple of recent studies have concluded that an elimination of US ethanol support programs would mean a corn price decline of about 15% in the United States (Babcock et al., 2010; Tyner et al., personal communication related to their report published in 2010). The FAO (2008) estimated that the elimination of all global biofuel subsidies would only mean a reduction of 5% in corn prices. This takes into account expected reductions in both corn usage and production.

Current US support programs include a 45 cents/gallon blender tax credit for gasoline producers/blenders, a fixed import duty of 54 cents/bushel plus an ad valorem import duty of 2.5% (applies to all fuel ethanol imports except those from a few Caribbean countries and Canada), and a national mandate (i.e., the Renewable Fuel Standard referenced earlier) requiring the use of 12.6 billion gallons of grain-based ethanol in 2011, rising to a maximum of 15 billion in 2015 and years to follow.

At an average Chicago Mercantile Exchange corn price of, say, $2.70/bu, 15% equates to about 40 cents/bu. For $4.00 corn, this increases to 60 cents.

Of course, if ethanol production ceased overnight, the price impact would be far greater, given the near-term inability of supply to adjust to the reduced demand. For example, Babcock (2010) calculated that an elimination of US policy support for fuel ethanol in late 2010 (i.e., mandate, import duties, blending credit) would have caused the average US price of corn to drop by 26% in 2011.

Pricing/usage models show that if US support policies ended, substantial ethanol production would still continue because lower corn prices would permit some manufacturers to continue to produce and market ethanol profitably at a price attractive to gasoline marketers. Babcock and his colleagues (2010) at the Center for Agricultural and Rural Development (CARD) at Iowa State University estimated in mid 2010 that elimination of US support policies would still permit 13.5 billion gallons of ethanol to be produced in 2014 compared to 14.9 billion with current policy support. Their assumption that limited future ethanol importation would occur from Brazil, even without import duties because of continuing restraints in Brazilian export capacity, seems far from certain – and highly dependent in future world sugar prices.

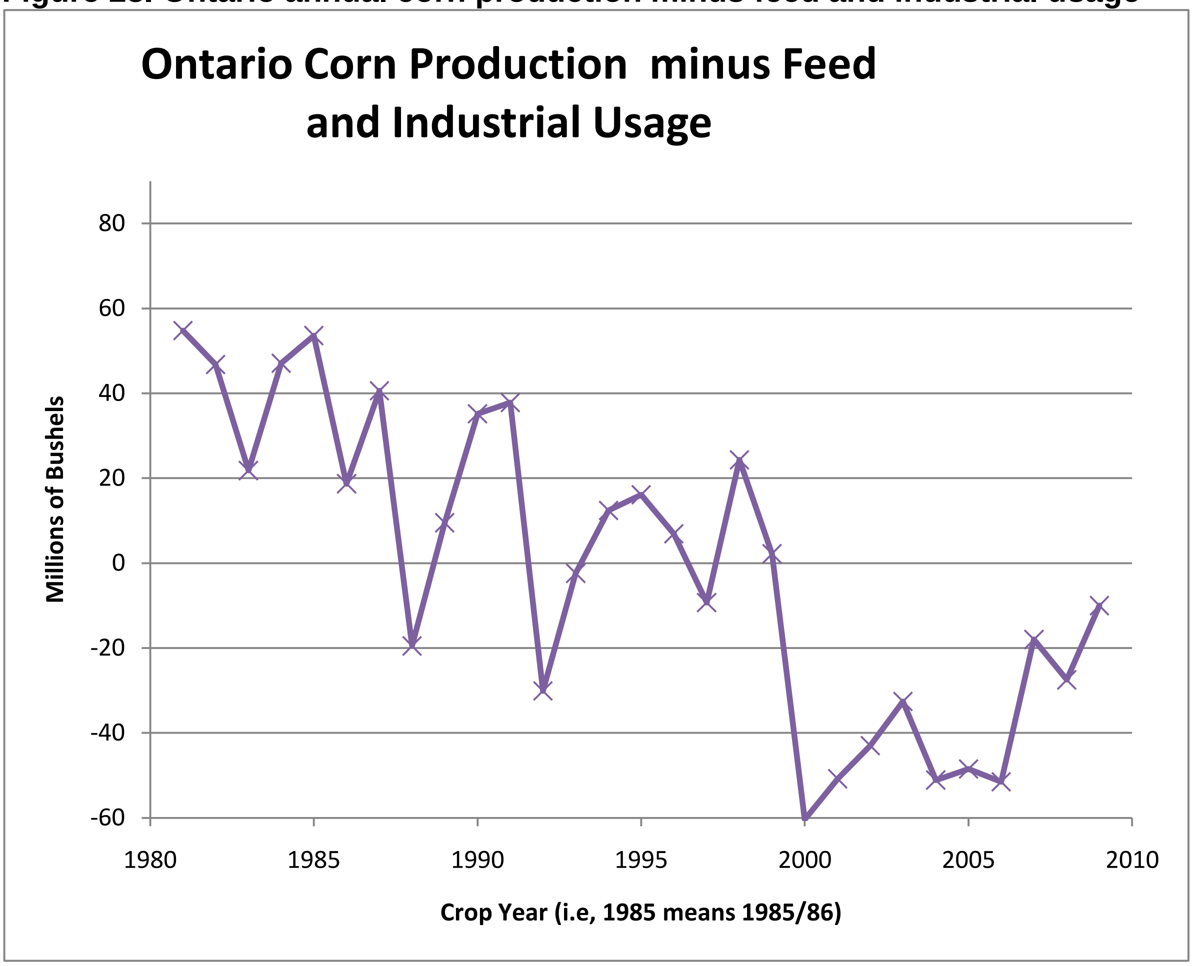
The Babcock conclusion has been countered by an analysis by Urbanchuk (formerly at Purdue University, now a private consultant) claiming that the elimination of support policies would cause US ethanol production to drop by 38% (http://ethanolrfa.3cdn.net/341d9ee2e19a7276d5_5lm6iisrk.pdf).

4.4. Biofuels and Ontario Corn Prices

A primary reason why grain farmers have supported biofuel and bioproduct development in Canada involves the prospect of higher crop prices. Biofuel production is also seen as a means of reducing public expenditures for farm income support programs (because of higher crop prices) and for enhancing rural income through plant construction and operation.

The price effect to Ontario corn growers consists of two components, the first being the extent to which biofuels have increased the US price, which is addressed in the previous section. The second component involves changes in Ontario prices compared

Figure 23. Ontario annual corn production minus feed and industrial usage



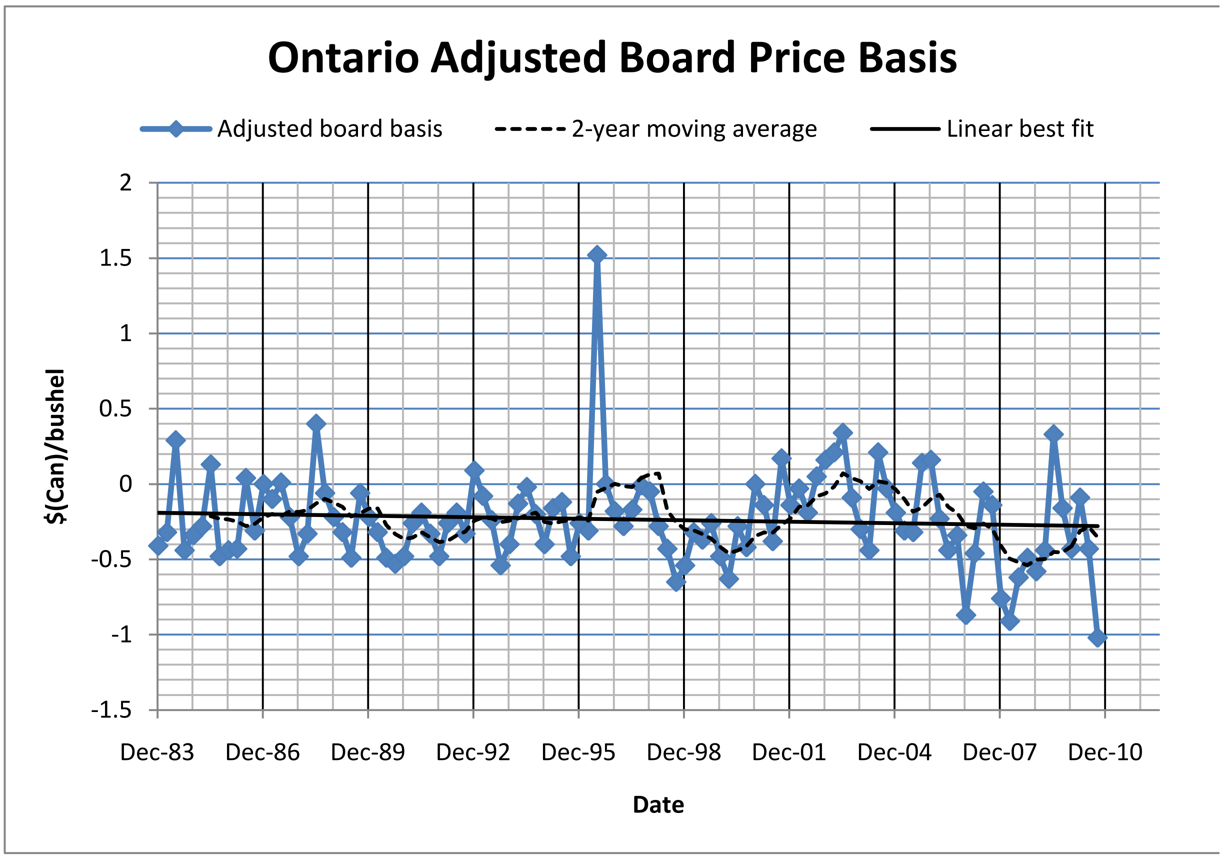
Data provided by Ontario Corn Producers' Association and Grain Farmers of Ontario.

to those in the United States. A common way of doing this is to compare local prices to those for nearby futures on the Chicago Mercantile Exchange (CME, and formerly, the Chicago Board of Trade). This relationship is commonly referred to as the “local price basis.” To remove distortions caused by changes in Canadian-US currency exchange rates, “adjusted basis” values are calculated by converting CME futures prices to Canadian currency before calculating price basis relationships.

By increasing the provincial usage of corn to the extent that Ontario changed from a net-corn-exporting province to a net importer (Figure 23), ethanol production would have been expected to have increased the corn adjusted price basis in Ontario.

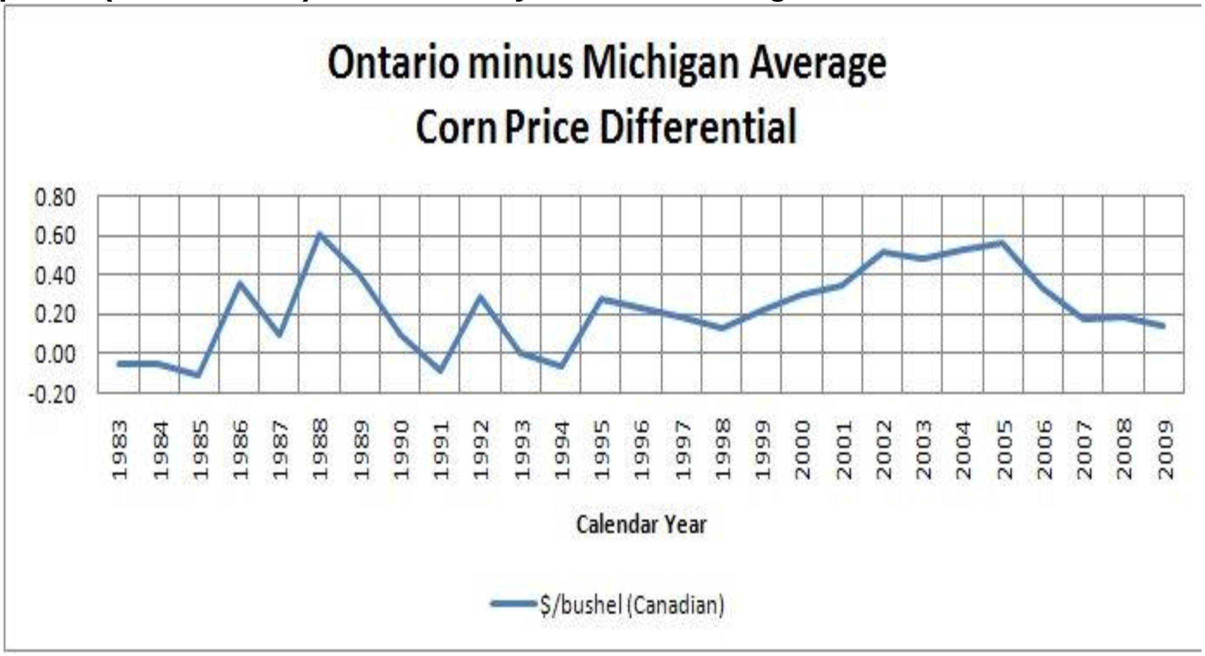
A review of data published over the years by the Ontario Corn Producers’ Association

Figure 24. Ontario adjusted corn price basis ($Can/bushel), 1984 through 2010.



Source: calculations by KD Communications based on data for Chatham provided by Ontario Corn Producers’ Association and Grain Farmers of Ontario.
Data are average adjusted board price bases at Chatham, ON, on last Wednesday of January, April, July and October. Value for July 1996 is a price anomaly which occurred in summer prior to 1997 fall harvest.

Figure 25. Average annual differences between Ontario and Michigan corn prices ($Can/bushel) for calendar years 1983 through 2009.



Source of data: OMAFRA, www.omafra.gov.on.ca/english/stats/crops/price_grcorn.htm, and USDA, www.nass.usda.gov/QuickStats/ .

(more recently, the Grain Farmers of Ontario) shows although year-to-year price volatility masks any trends, the two-year-average trend line was above the long-term trend from 2002 through 2005, but not more recently (Figure 24). The higher basis values in 2002-2005 are in contrast to the abnormally low values for three years prior to 2002. The Ontario adjusted price basis was also significantly above historic levels for most of 1996 through 1998 when Ontario ethanol production was much smaller than at present.

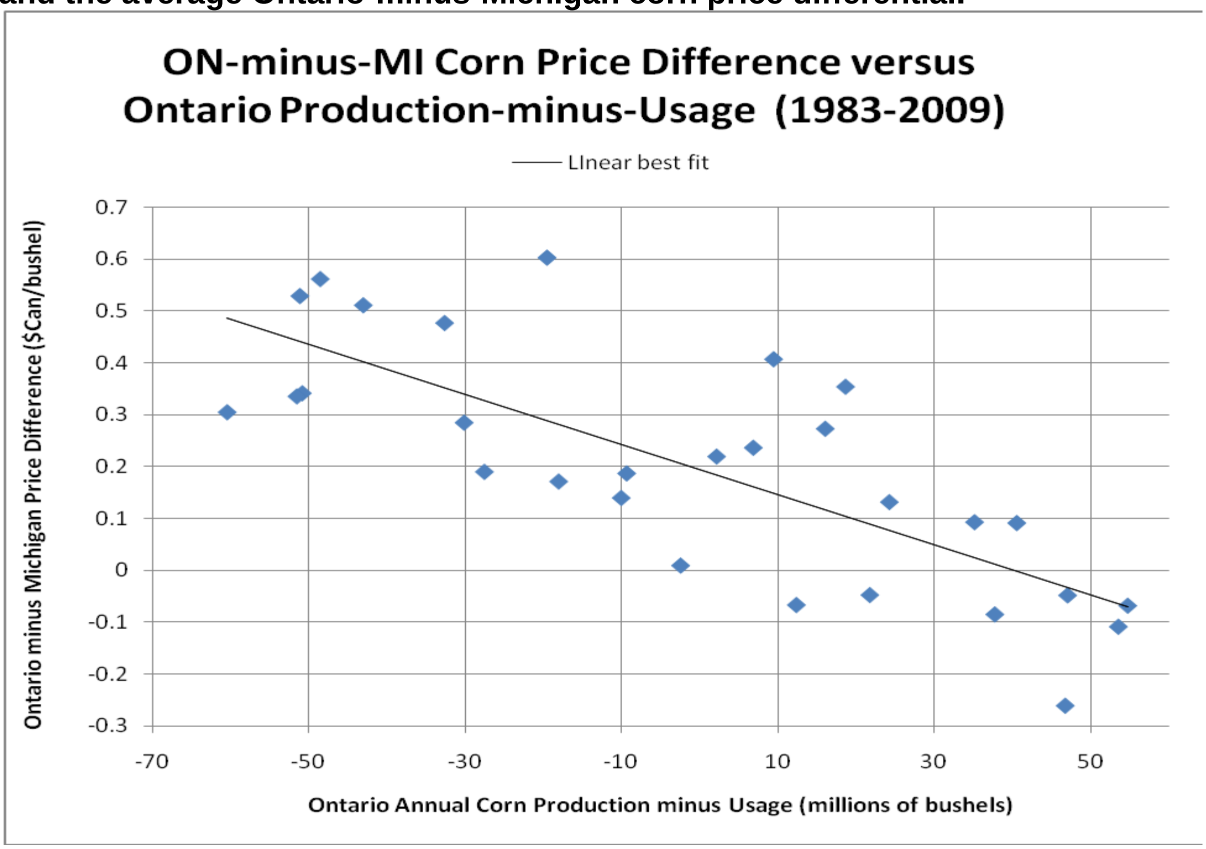
Terry Daynard examined this more thoroughly for a column published in the *Ontario Farmer* in October 2009 and found that a more meaningful comparison involved corn market prices in adjacent parts of the State of Michigan - the location to which a significant portion of Ontario exports went before major ethanol production began in Ontario, and from which corn was imported when Ontario became a net corn importer in more recent years.

Michigan produces about the same amount of corn or perhaps slightly more than Ontario, but its within-state consumption for livestock production and food and industrial processing is much lower, meaning that Michigan has to “export” about 100 million bushels of corn in a typical year - commonly to livestock and poultry markets in Atlantic states. This makes Michigan corn prices low compared to many other Mid-Western states. An updated version of the data used by Daynard is shown in Figure 25. For about seven crop years beginning in 2000/01, Ontario corn prices were higher than those in Michigan by an average of $0.44/bu, as compared to an average of about $0.15 for 10 years before that. This difference represents a calculated average increase for Ontario corn growers of about $0.29/bu beginning in 2000/01.

However, for the last three crop marketing years, 2007/08 through 2009/2010, the average differential between Ontario and Michigan has dropped to more historic levels. This is presumably the result of a substantial increase in Ontario production beginning in 2007/08. From 2007/08 through 2009/10, Ontario grew more than 6.7 million tonnes (270 million bu) each year, compared to 4.4 to 5.8 million tonnes (177 to 231 million bu) for the seven crop years prior to 2007/08 (ww.gfo.ca/Marketing/CornandSoybeanMarketing.aspx). Increased ethanol production in Michigan is also a likely factor.

A critical question is: What would the price relationship between Ontario and Michigan corn prices be if Ontario did not now use about 110 million bushels of corn annually to

Figure 26. Relationship between yearly production-minus-usage for Ontario and the average Ontario-minus-Michigan corn price differential.



Source of data: Figure 23 and Figure 25.

produce ethanol? In order to provide an answer, in Figure 26 we have graphed the relationship between the Ontario-Michigan average annual corn price differential (data from Figure 25) and annual statistics of Ontario corn production-minus-provincial-usage (from Figure 23). From the slope of the line of best fit, one can calculate that a 110-million-bushel decline in the production-usage balance means about a $0.50/bushel decline in price. This may be an overestimate of the correct number since a decline of $0.50/bushel in corn price would also mean some reduction in corn acreage and production. But even if the effect is only half of $0.50/bushel, it amounts to a large amount of farm income when multiplied by a provincial corn crop of nearly 300 million bushels.

In March, 2011, the elevator board price for corn in southern Ontario averaged about $0.40 to 0.50/bu, in equivalent dollars, below that for similar elevators in parts of eastern Michigan near Sarnia, Ontario. This is a direct result of the record large corn crop harvested in Ontario in 2010 (7.7 million tonnes, 305 million bu).

In summary, ethanol production appears to have increased the average Ontario corn price, at least compared to Michigan, by about 29 cents/bu from about 2000/01 to 2006/07 but not since. Without ethanol production in Ontario, the price would be substantially lower.

The George Morris Centre (GMC) has been a critic of ethanol support programs saying that, because they increase the price of feed grains, they are detrimental to the Canadian livestock industry. In a 2008 report, Mussell et al. make this argument using an adjusted basis chart very similar to that of Figure 24, though ending in 2008. (The GMC graph is for “track price,” the price at which elevators sell corn, as compared to Figure 24 which is the “board price” that elevators pay to farmers.)

Mussell et al. calculated that for the years 2003 through 2007, the Ontario corn price would have had to have averaged no more than $93/tonne for hogs and $18 for cattle feeders in order to permit profitability for these livestock farmers. (The GMC analysis involved subtracting all other costs from gross returns to determine what was left over to pay for corn for feed.)

There are reasons to expect that fuel ethanol production from corn may now be leveling off in both Canada and the United States (Figure 5). Canada now produces almost enough ethanol to meet the newly introduced blending mandate of an average of 5% inclusion in gasoline. The rate of construction of new ethanol plants in the United States has dropped dramatically and little increase in corn ethanol production is projected after the 15 billion gallons/year maximum mandate is reached in 2015.

Biodiesel has had no apparent basis effect on oilseed prices in Ontario/Canada to now because of their sparse usage in Canadian biodiesel production. However, a new Canadian mandate for the inclusion of an average of 2% biodiesel in Canadian diesel fuel will require a supply of about 600 million litres of biodiesel annually. If this is produced primarily from soybeans and canola, it could mean an improvement in the Ontario soybean price basis. However, the relevant analyses have not yet been done.

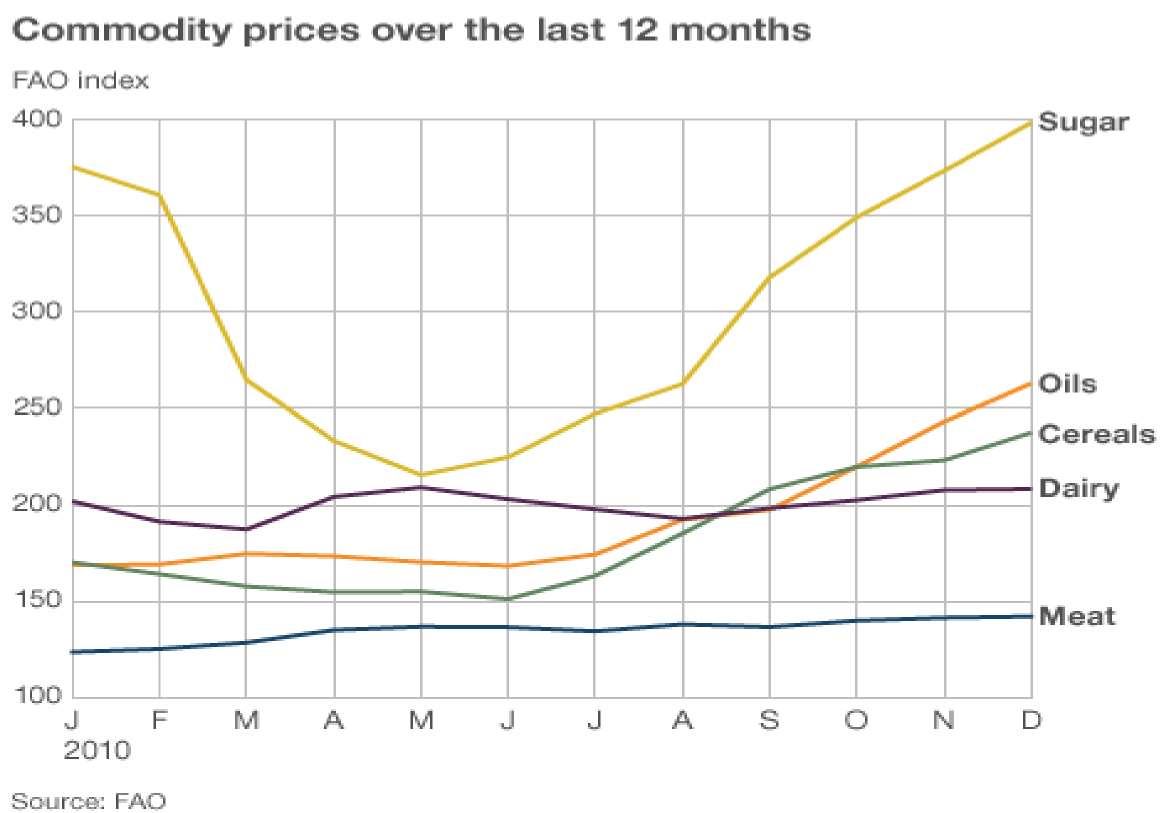
4.5. The 2010-2011 Price Spike

As this is being written (March, 2011), another price peak is occurring for grains and other commodities. It is too soon to know if prices have peaked or will still continue higher. Recent futures prices for corn, wheat and soybeans have been close to those seen in 2008. Expectations for world crops to be harvested in 2011 will have a dominant influence on price directions over the next few months, as estimated world stocks of grains and oilseeds remain very low.

Fertilizer prices, while rising in late 2009, are well below values of 2008. The same applies for world oil prices, though current turmoil in the Middle East could yet send oil prices to new historic highs.

Price patterns for grains, oilseeds, oil, fertilizer and other commodities in recent years have an uncanny resemblance to what happened in years around 1974 and again around 1980. The 1970's "price peak" was really a double peak, and the same is occurring at this time. It may be referred in the future as the double peak of 2008 and

Figure 27. Commodity price changes during 2010.



Source: BBC, www.bbc.co.uk/news/business-11177214, using FAO data.

2011.

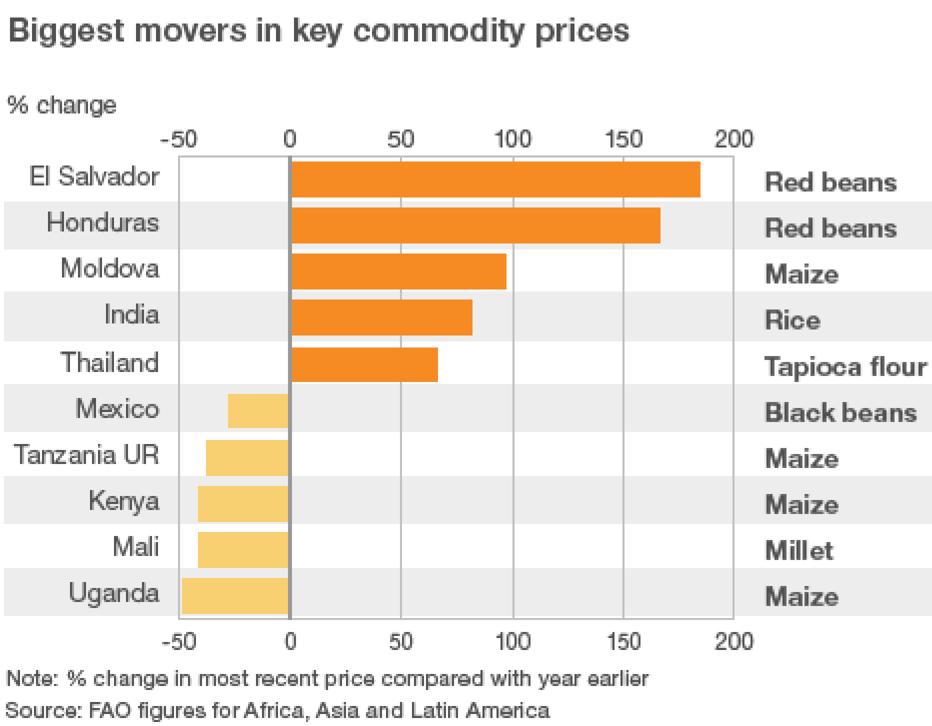
The FAO's food price index reached a value of 236 in February, 2011 – greater than the highest value in 2008 - though the spike this time is as much due to high international prices of some other food materials – fats and oils and sugar– as for grains (Figure 27). The FAO cereal price index in February was still 8% below its peak in April 2008.

As in 2007-2008, recent price changes for specific food commodities have varied dramatically among countries in the developed world – for example, corn price up by almost 100% in Moldavia in Eastern Europe but down by 50% in Uganda (Figure 28).

Unlike the situation in 2007-2008, world rice prices have risen very little in 2011, only about 6.5% in the last 12 months compared to gains of 60 to 90% for wheat and corn. This means that the effect on third-world hunger has been less dramatic this time, given that "rice is the staple food of more than half of the world population," according to the International Rice Research Institute" (www.businessweek.com/news/2011-03-03/world-food-prices-rise-to-record-may-gain-further-un-says.html).

The 2010-2011 grain price spike seems to have been largely caused by poor wheat crops caused by drought in Russia, the Ukraine, other parts of Eastern Europe, and by excessive summer rains in Western Canada. Record amounts of rainfall in early 2011

Figure 28. Changes in prices of food commodities over last year.



Source: BBC, www.bbc.co.uk/news/business-11177214, using data provided by FAO.

in Eastern Australia have affected the quality of wheat available for export. However, global wheat stocks are actually significantly higher now than in 2006/07 and 2007/08 (Table 22).

A drought in Argentina is one reason for the 2011 price increase for soybeans. A below-trend-line average yield for corn in 2010 in the United States has been the primary driver for higher corn prices.

All crop prices are being pressured higher to some extent by investor purchases of commodity fund index funds.

Unusually large wheat purchases by several countries, especially those experiencing civil unrest in North Africa and the Middle East, have also contributed to the wheat/grain price increase.

Biofuels continue to be identified as one factor contributing to the price increases, an example being a joint OECD-FAO Agricultural Outlook 2010-2019 released in mid 2010 (www.agri-outlook.org/pages/0,2987,en_36774715_36775671_1_1_1_1_1,00.html). While the OECD-FAO report was written before the upturn in prices which began later in 2010, it does highlight the significance of biofuels to overall grain usage, stating that "By 2019, about 13% of the global production of coarse grains will be used to produce ethanol compared to 9% over the base. 16% of the global production of vegetable oil will be used to produce biodiesel compared to 9% over the base" (the base being the 2007-2009 average).

It is too early to predict the extent to which food production/supply/hunger will dominate global attention during the "second peak" - and the extent to which this attention will remain after the prices begin to decline. A statement by the president of the World Bank in mid February that another 44 million people have now been pushed into extreme poverty by high food prices received global attention (www.theglobeandmail.com/report-on-business/economy/rising-food-prices-increasing-poverty-world-

Table 22. Global wheat production and consumption (millions of tonnes).

Year	Global Production	Global Consumption	Ending Stocks
2006-07	596	616	131
2007-08	611	617	125
2008-09	684	642	167
2009-10	683	652	197
2010-11	646	665	178

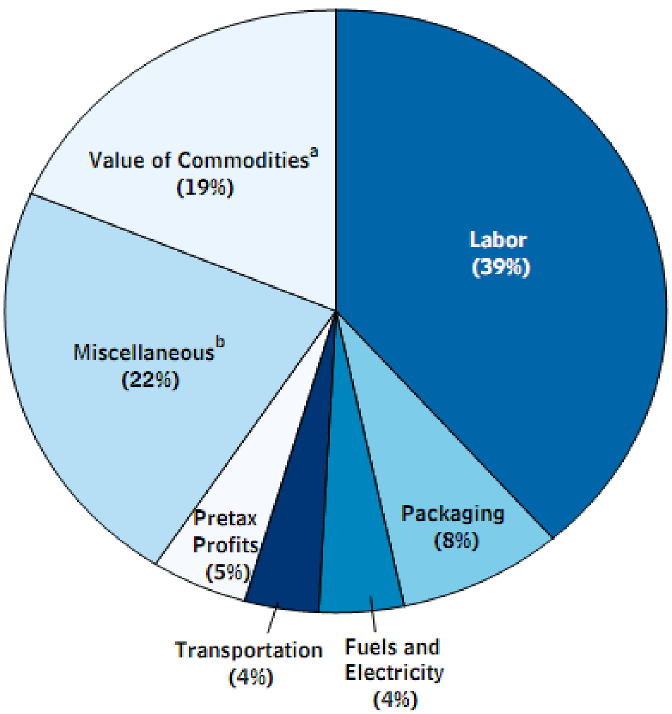
Source: BBC, www.bbc.co.uk/news/business-11177214, using data provided by USDA.

bank/article1907850/?cmpid=rss1). Food prices are a key part of the agenda for the November 2011 meeting of the G20 group of world leaders.

The Economist published a major feature on global grain and food prices in late February, very similar to its feature in April 2008 referenced earlier. Once again, *The Economist* fingered biofuels as one of the causes of the current price run-up.

Continuing global economic turmoil and civil unrest in the Middle East and North Africa are competing for media attention in the initial months of 2011.

Figure 29. Components of consumers' expenditures on farm foods, 2006.



Source: Congressional Budget Office based on data from the Department of Agriculture's Economic Research Service (available at www.ers.usda.gov/Data/FarmToConsumer/Data/componentstable06.xls).

a. Payments to farms for fruits, vegetables, field crops (for example, corn and soybeans), dairy products, and so on.

b. Includes depreciation, rent, advertising and promotion, interest, taxes, licenses, insurance, professional services, local for-hire transportation, food service (in schools, colleges, hospitals, and other institutions), and other items.

Source: Congress of the United States, Congressional Budget Office, 2009.

5. Biofuels, Food Prices and World Hunger

5.1. Biofuels, Food and Gasoline Prices in North America

Primary prices paid for agricultural commodities represent only about 19% of prices paid for food by consumers in developed countries (Figure 29 and Figure 30). Because of this, the volatility in crop prices is not reflected directly in food prices (Figure 31).

Average food prices did increase in Canada and the United States, by as much as 7% in year-over-year comparisons, in part because of agricultural and energy price spikes in 2008. This is an increase greater than what would be expected by grain price increases alone. Food company profits grew during this period (Grier, 2008).

A report by the US Congressional Budget Office (2009) states that “From April 2007 to April 2008, the increasing demand for corn to produce ethanol contributed, in CBO’s estimation, between 0.5 and 0.8 percentage points to the 5.1 percent increase in the price of food.”

Du and Hayes (2008) of the Center for Agricultural and Rural Development at Iowa State University have calculated that ethanol blending reduced the retail gasoline price in the United States by an average of about 25 cents/gallon (6.4 cents/litre), and by 39.5 cents/gallons (10.2 cents/litre) in the US Midwest. Using this calculation, Knudsen (2008) calculated that, for typical households, the resulting saving in gasoline purchases more than offset any food price effect caused by ethanol production from corn. Though analyses have not been done formally in Canada, a similar effect can be expected.

The issue can also be addressed through more basic calculations. Ethanol now provides about 5% of the world’s “gasoline” supply on a caloric energy basis (85 billion litres of fuel ethanol compared to 1.25 trillion litres of total gasoline usage (www.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=62&aid=2&cid=regions&syid=2005&eyid=2009&unit=TBPD; 159 litres per barrel). (The percentage is higher than 5% on average in North America, because of US biofuel mandates.) With a consumption-to-price plasticity of about -0.50 (Brons et al., 2006), this means that a 5% increase in “gasoline” supply should mean a 10% reduction in price. However, this must be modified by the fact that gasoline prices also include taxes and retail margins which may be at fixed (not variable) rates per litre, and consideration of the amount of petroleum energy used to produce ethanol. Du and Hayes estimated the latter at about 1 litre of petroleum energy per 10 litres of ethanol. (Most of the energy used to produce ethanol is natural gas of which there is an abundant supply in North America.) If the 10% price effect is reduced to 5 to 8%, this equates to a reduction of about 6 to 10 cents per litre given recent gasoline retail prices in Canada – the same result as with the Du and Hayes (2008) analysis.

Don O'Connor (president of (S&T)[2] Consultants Inc. has estimated, based on data from Transport Canada, that the average light vehicle in Canada used 1740 litres of gasoline in 2007. Six to 10 cents per litre equates to about $100 to $180 per year per vehicle, and if the average Canadian family has at least one vehicle (there are 19 million operating light vehicles in Canada) the savings in fuel costs per year will be at least as large.

By comparison, the Congressional Budget Office (2009) has estimated that the maximum effect of biofuels on food prices in 2008 was 0.5 to 0.8% - or about $35-60 dollars per year based on an average Canadian family annual expenditure on food and beverages (restaurant meals included) of $7264 in 2009 (www40.statcan.gc.ca/l01/cst01/famil16a-eng.htm).

Any added costs for food caused by biofuel production from grains are more than compensated for (perhaps by three times as much) by downward pressures on gasoline prices. (The issue is not that current gasoline prices are low – which they are not – but rather how much higher they would be without the added supply provided by ethanol blending.)

The food price increases in 2007-2008 also need to be put into perspective of the much longer-term trend for declining real food prices (Figure 32). Canadian consumers spend only about 12% of disposable income on food. It's a similar percentage in most developed countries. The equivalent percentage was 41% a century earlier (Paarlberg, 2008).

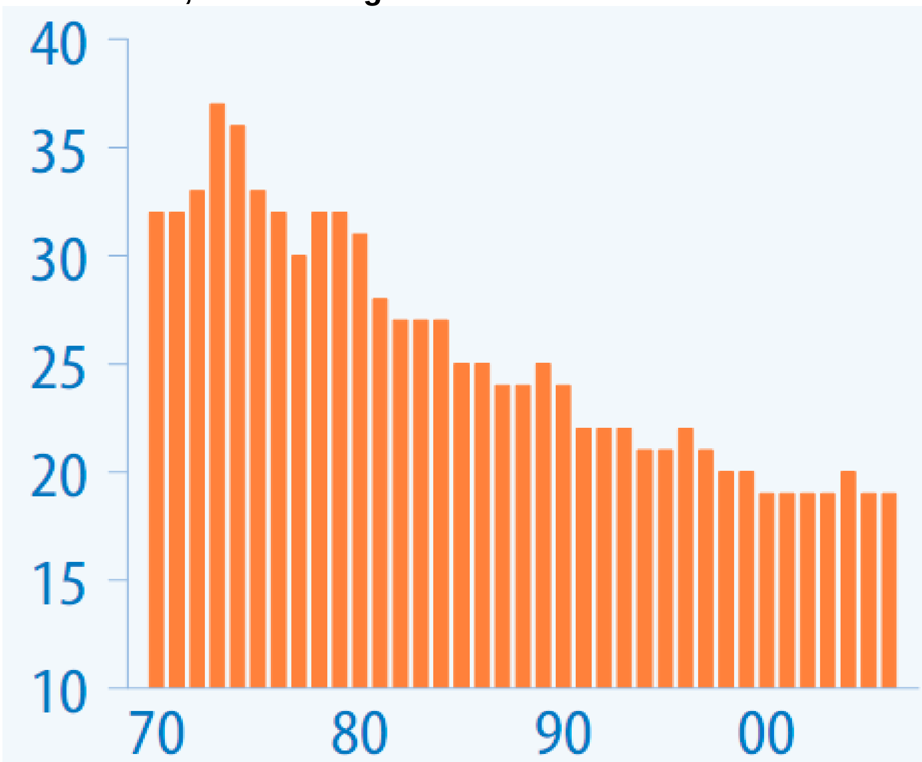
The Canadian Federation of Agriculture defines February 12 as "Food Freedom Day." With farmers receiving about one-fifth of each dollar spent on food the equivalent "Farmer Food Freedom Day" occurs on about January 9. Increased grain and oilseed prices in 2007-2008 may have delayed this "freedom date" by a few hours.

Most of the year-over-year increase in Consumer Price Index (CPI) experienced in 2008 was attributable to energy prices (Figure 33). Statistics Canada calculated the average CPI in 2008 as 113 for "all items," 115 for food and 149 for energy.

A January 27, 2011 posting on www.foodnavigator-usa.com says, "The US Department of Agriculture has said it expects the Consumer Price Index (for food) to rise by 2 to 3 percent in 2011, ending a period of near-stagnant food price inflation over the past two years." This was modified to 3 to 4 percent in a statement by Joseph Glauber, Chief Economist, USDA on February 24, 2011. A similar experience may be expected in Canada.

While food does represent a significant expenditure for most Canadian families, price issues need to be put in perspective against the much larger issue of over-weightiness and obesity. A World Health Organization web site

Figure 30. Farm value share of retail food prices (percent), United States, for the decades, 1970 through 2000.

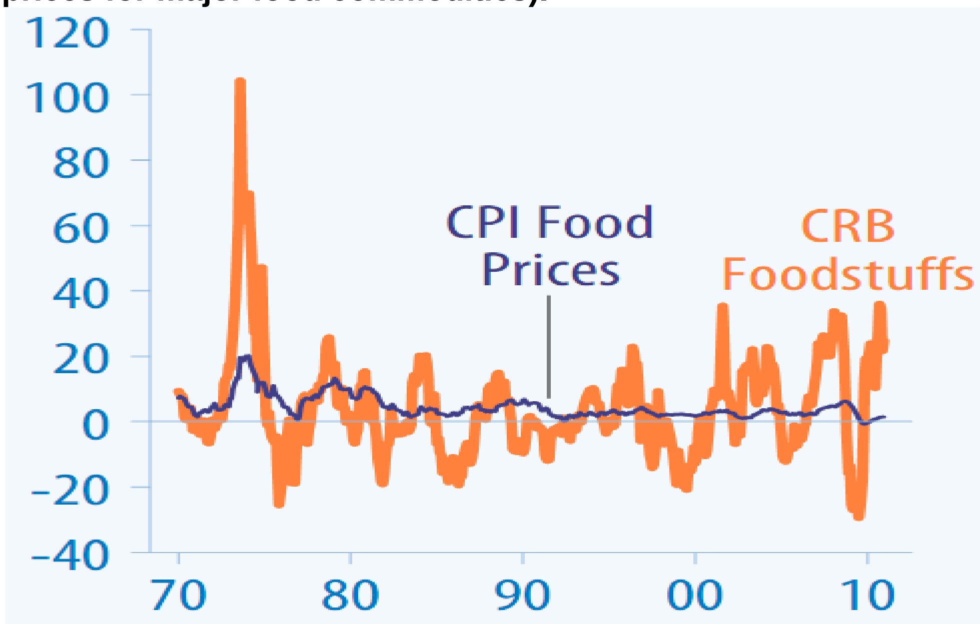


Source: BMO, 2011.

(https://apps.who.int/infobase/Comparisons.aspx) says about 25% of Canadians are obese (Body Mass Index over 30) and it's a similar percentage for most Western World countries (about 45% in the United States).

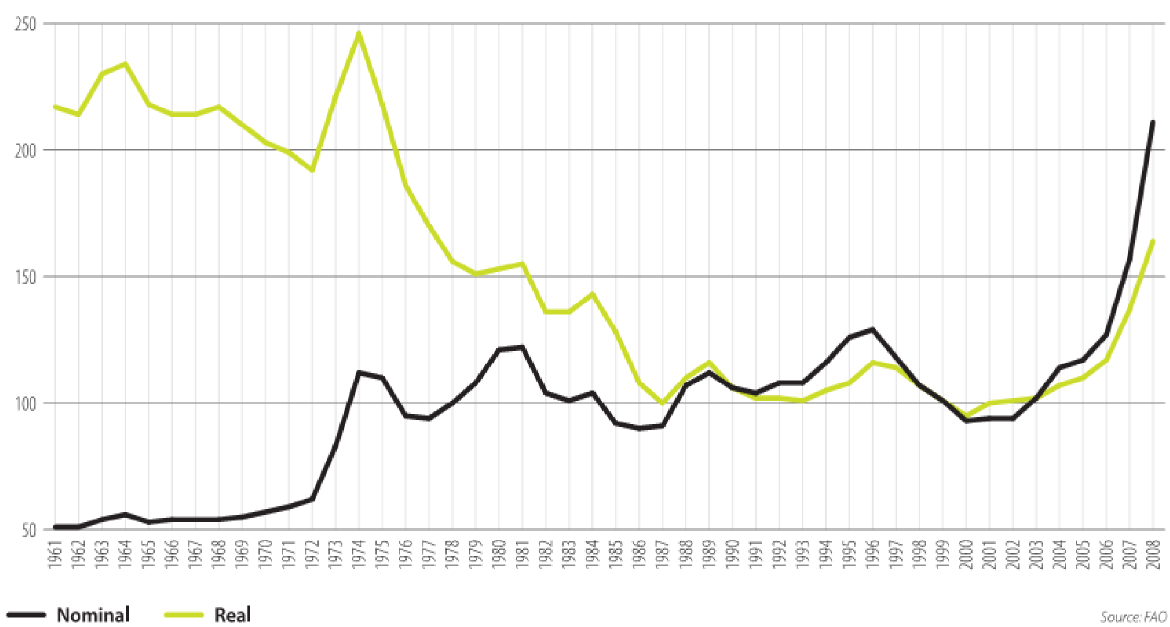
In addition, a recent George Morris Centre (Gooch et al., 2010) analysis estimated that about 40% of food is wasted in Canada. The food problem in Canada tends to be one of over-supply, over-consumption and wastage, not inadequate supply of food or high prices.

Figure 31. Year-to-year changes in the United States in Consumer Price Index for food and Commodity Research Bureau Index for foodstuffs (an index of futures prices for major food commodities).



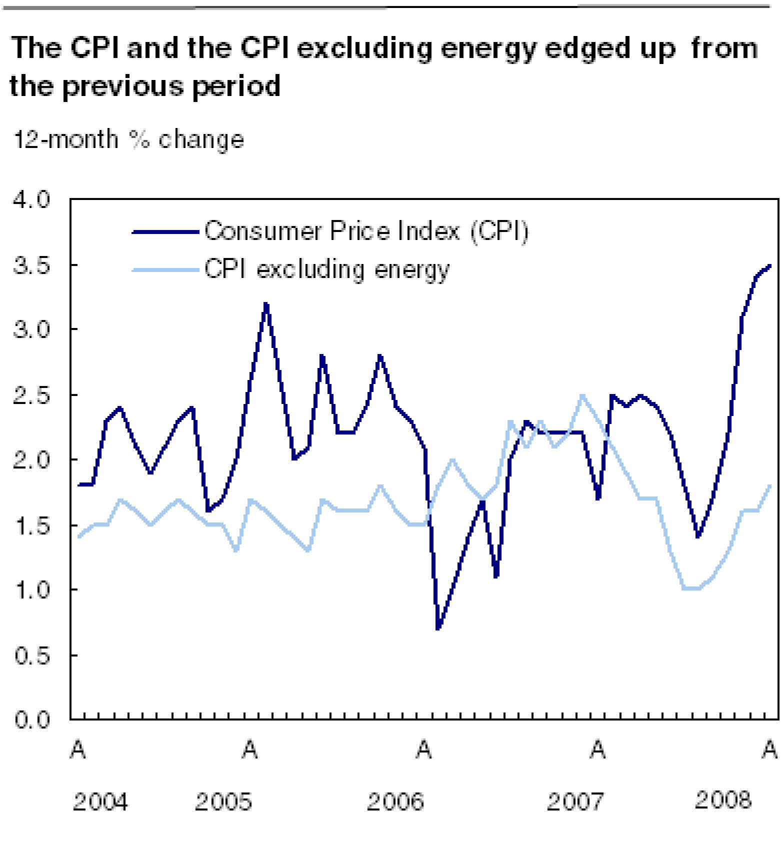
Source: BMO, 2011.

Figure 32. FAO Food Price Index, 1961 to 2008 – nominal and real (inflation corrected) values.



Source, FAO, 2008a.

Figure 33. Consumer Price Index for Canada, with and without energy included.



Source: www.statcan.gc.ca/daily-quotidien/080923/dq080923a-eng.htm.

5.2. Background on World Hunger

The Food and Agriculture Organization of the United Nations (FAO) defines the term "undernourished" as a daily food caloric intake of fewer than 2100 calories. Some organizations and analysts use the alternative terms, "food insecure" and "hungry." We have used the word, "hungry," in this report.

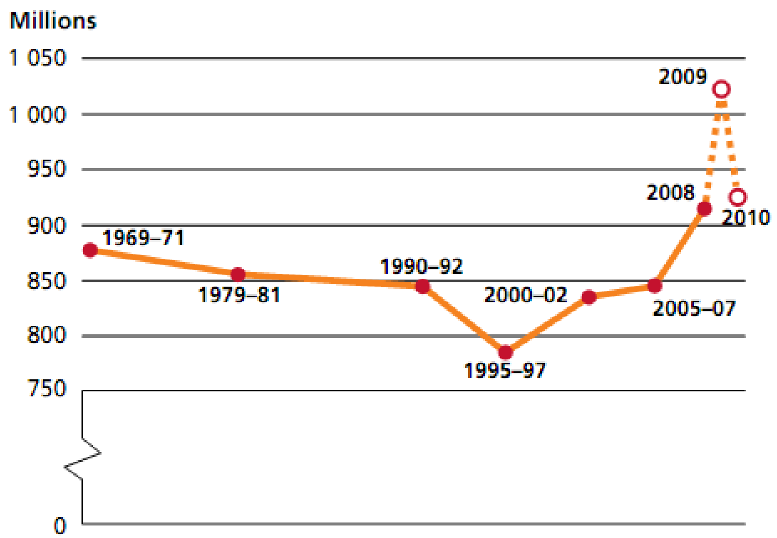
About 850 million people around the world were estimated by the FAO to be hungry in 2006 and 925 million in 2010 (FAO, 2010; Figure 34 and Figure 35). The number was calculated to have exceeded one billion for a period in 2009 because of the 2007-2008 food price spike. The actual number of people who receive inadequate nutrition in some manner – e.g., critical minerals or vitamins - may be twice as large, though there is no quantitative measure (*The Economist*, 2011).

There were about 880 million hungry people in 1970 (FAO, 2010).

Some view this as a major achievement: The number of hungry has not grown much despite an increase of the world's population from 3.7 to 6.9 billion during this period – or a decrease from 32% of the proportion of the developing world hungry in 1970 down to about 15% in 2010.

However, 925 million hungry is still a major tragedy.

Figure 34. Number of hungry people in world.



Note: Figures for 2009 and 2010 are estimated by FAO with input from the United States Department of Agriculture, Economic Research Service. Full details of the methodology are provided in the technical background notes (available at www.fao.org/publication/sofi/en/).

Source: FAO.

Source: FAO, 2010.

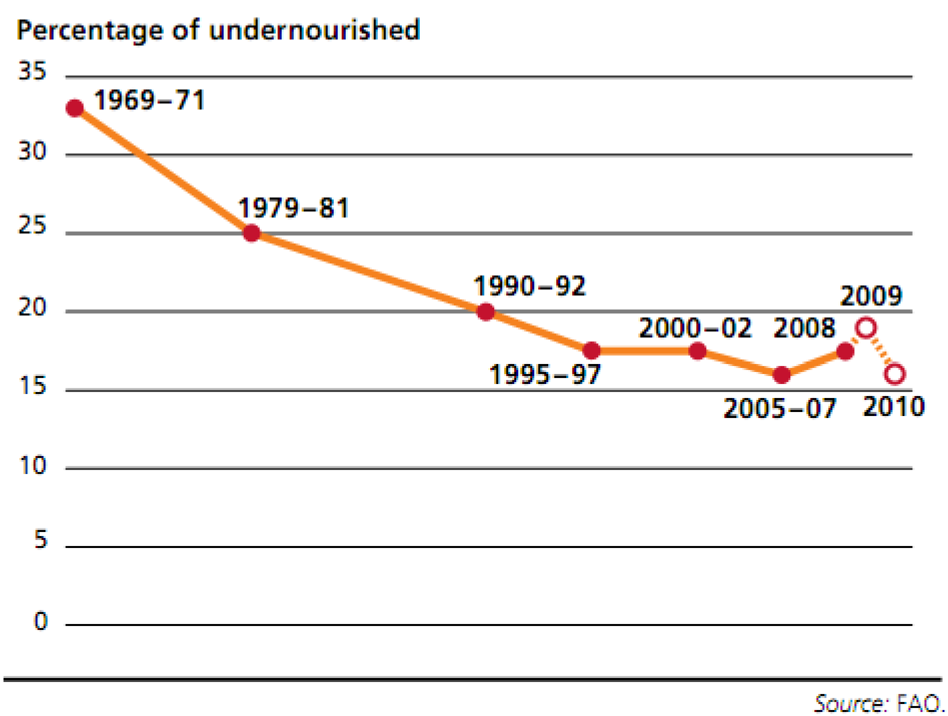
A critical question is: Why are there still so many underfed people when real food prices have declined for many decades and there is clearly no global shortage of basic food commodities in the world? The goal of the World Food Summit held in 1996, to reduce the number of undernourished people by 50% between 1990 and 2015, is far from being realized (FAO, 2010).

Remembered by some is a quote by Henry Kissinger, US Secretary of State at the first World Food Conference in Rome in 1974, as a famine crisis worsened in India and Bangladesh, "Within a decade no child will go to bed hungry, no family will fear for its next day's bread, and no human being's future and capacities will be stunted by malnutrition."

There has been a lot of valuable research and analysis on this issue.

One of the critical reasons is a substantial reduction in government support for international agricultural development in most under-developed countries, over several decades - sometimes dramatically so. The Canadian Council for International Co-operation reports that support for agricultural development dropped from 18 per cent of total international developmental assistance in 1979, to 3.5 per cent in 2004 (CCIC, 2010). Paarlberg (2008) reports that support for international agricultural development

Figure 35. Proportion of undernourished people in developing countries.



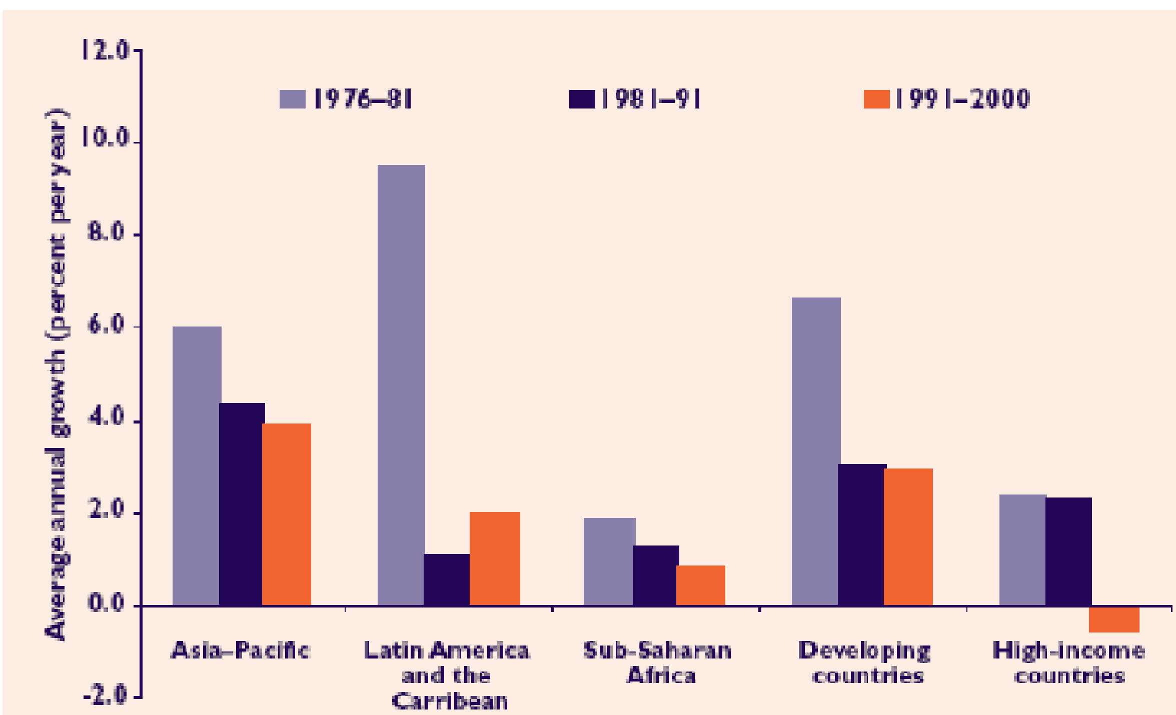
Source: FAO, 2010.

fell from 25% to 1% of US foreign assistance during the 1980s and 1990s.The share of European international developmental funds going to farming dropped by two-thirds over the same period.

While it is not easy to get specific numbers from Government of Canada web sites about historic levels of international agricultural support, it is clear that the same reduction occurred with Canada, as well. And unfortunately, this pattern of neglect for agricultural development has been the norm for many developing countries themselves. See Figure 36, Figure 37 and Figure 38, courtesy of the Montpellier Panel (2010) and Banse et al. (2008).

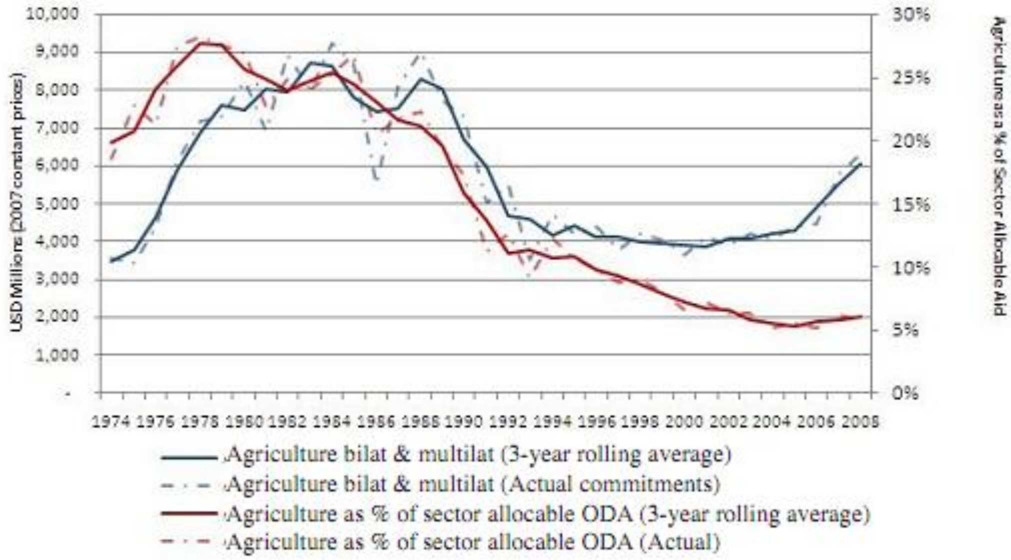
Progress has been made in much of Asia which in 2007 held 550 million of the world's 850 million hungry (FAO, 2010). Eighty-two percent of the Asian hungry are in four countries, India, China, Pakistan and Bangladesh. The Economic Research Service of the US Department of Agriculture (USDA-ERS, 2010), in a major analysis of world hunger, predicts that the number of Asian hungry (not including China) will decline by about 100 million by 2020. Grain crop yields continue to climb steadily in most Asian countries and the level of technological advancement is growing rapidly. About 40% of the land planted to grain crops production is now irrigated, and fertilizer and modern pest-control technologies are used widely.

Figure 36. Decline in public agricultural R and D spending, 1976-2000.



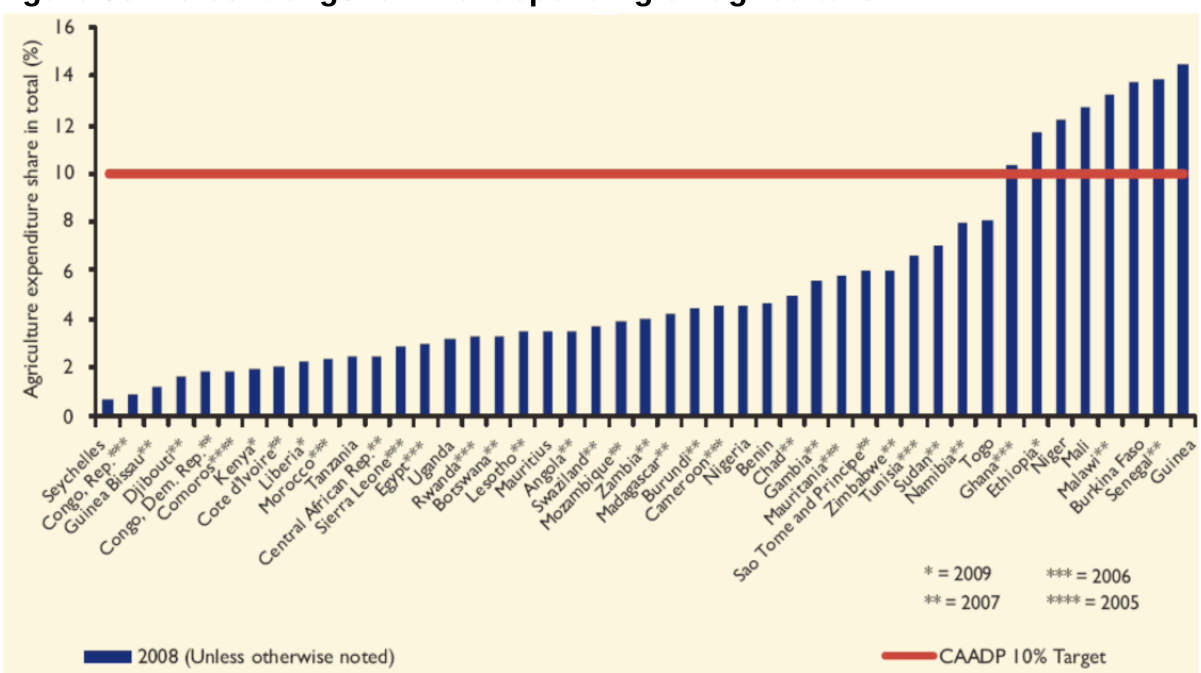
Source: Banse et al., 2008.

Figure 37. Decline in funding for international agricultural development.



Source: Montpellier Panel, 2010.

Figure 38. Percent of government spending on agriculture.



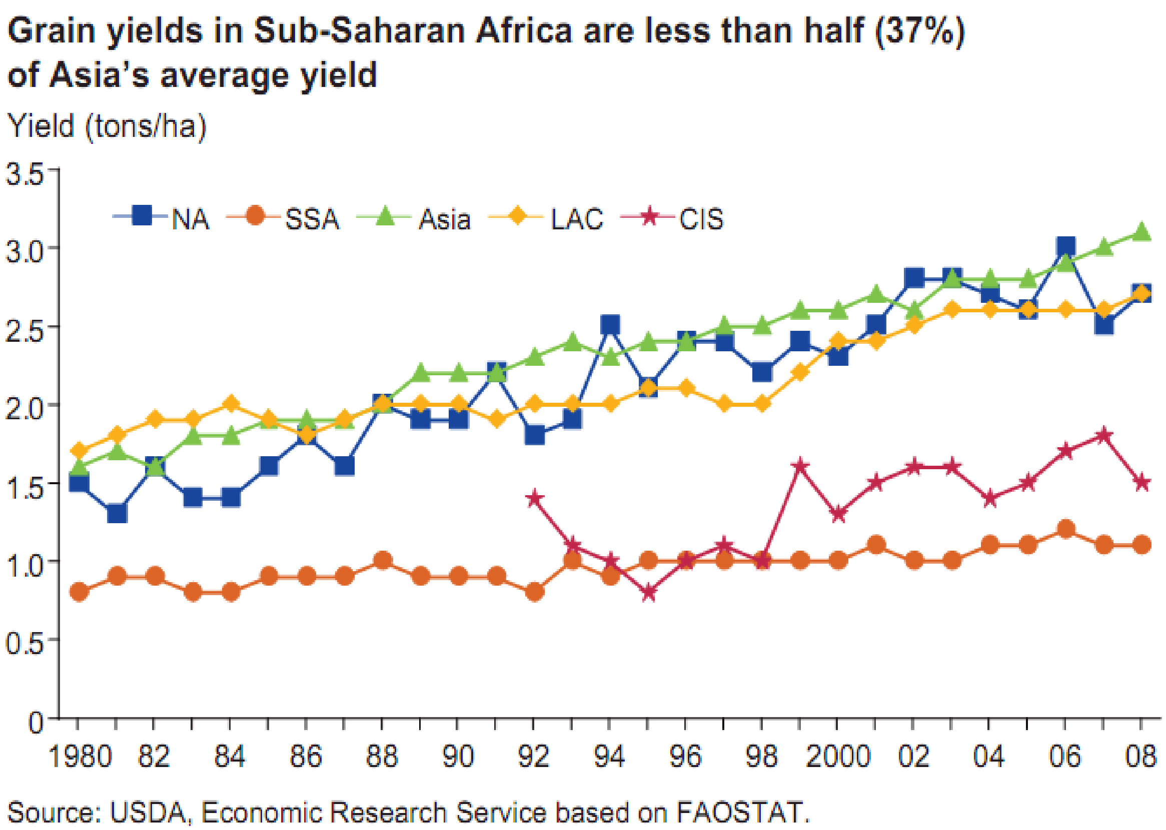
Source: Montpellier Panel, 2010. CAADP means the Comprehensive African Agricultural Development Programme, agreed to by members of the African Union in 2003.

In these countries, the problem is often one of internal domestic distribution. India has been a major world rice exporter in most recent years and Pakistan exports significant quantities of wheat. China was a net exporter of corn, wheat and rice in 2008. Yet these three countries represent almost half of the world's hungry in 2006 (FAO, 2010).

Asian countries with at least 20% of the population classed as hungry in 2007 are India, Pakistan, Bangladesh, North Korea, Mongolia, Cambodia, Laos, Tajikistan, Yemen and Armenia (FAO, 2010). (China was estimated to have 10% hungry people in 2007, down from 18% in 1991.) The need in these countries is mainly for rice and wheat.

Though Asia has the largest number of hungry in 2010, the biggest long-term problem is in sub-Saharan Africa (SSA). About 240 million people were considered by FAO (2010) to be hungry in 2010, or about 30% of the population. USDA-ERS (2010) estimated the number of hungry at 390 million, or about half of the SSA population of about 860 million (Worldwatch Institute, 2011).

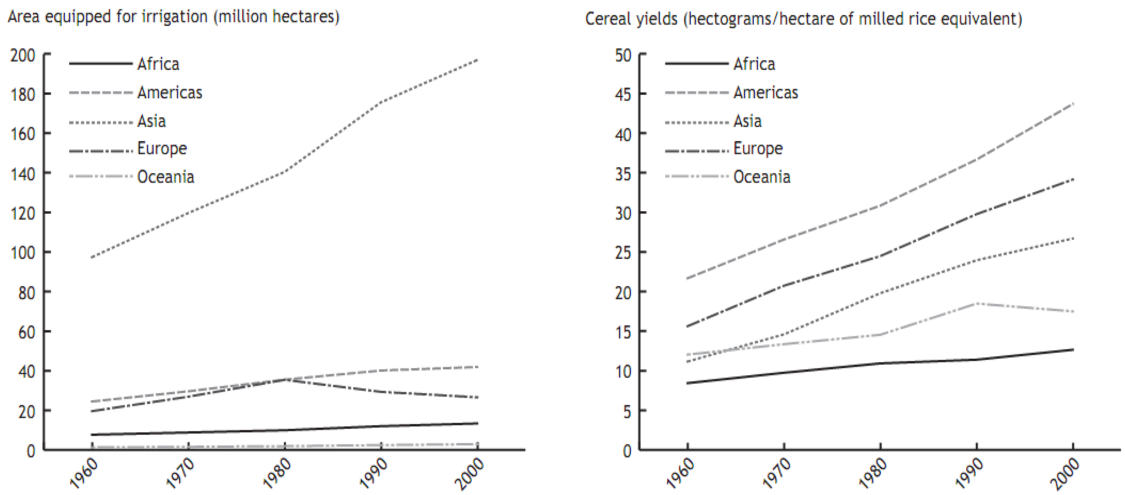
Figure 39. Changes in grain yields in regions of the world.



Source, USDA-ERS, 2010 (NA, North America; SSA, Sub-Saharan Africa; LAC, Latin America and Caribbean; CIS, Commonwealth of Independent States – six countries formerly in Soviet Union).

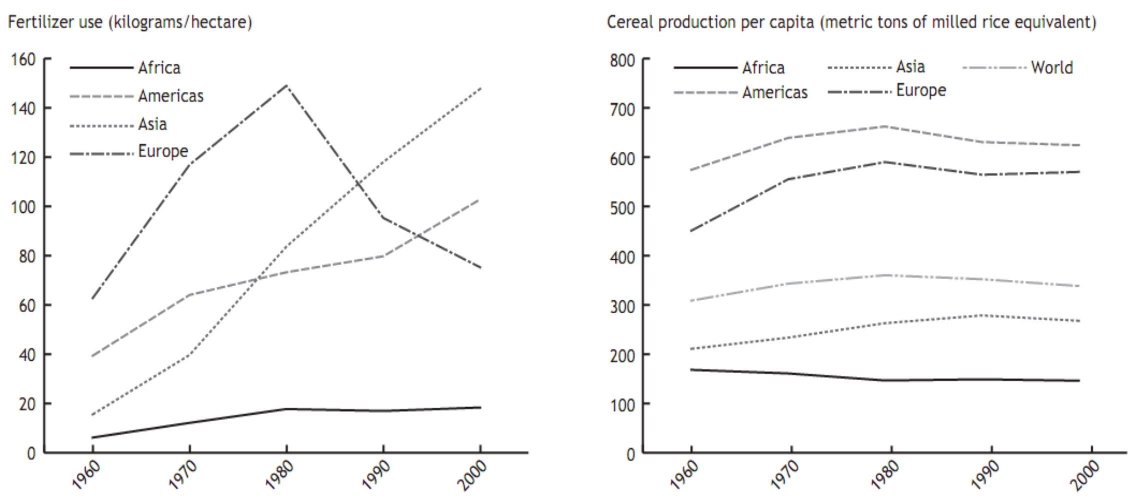
The FAO identifies 23 countries with more than 20% hungry in 2007 with this percentage over 60% for the Congo, Eritrea and Burundi. And these numbers are increasing for many countries; USDA-ERS expects the number of hungry people in SSA

Figure 40. Trends in yields, production, and input use across regions and decades.



Source: Heady and Fan, 2010.

Figure 41. Fertilizer usage and per-capita cereal production by region, 1960-2000.



Source: Calculations by the authors using data from FAO (2009).

Source: Heady and Fan, 2010. The declines in fertilizer usage, and in per-ha and per-capita cereal production in Europe are caused by changes in former Soviet countries.

to reach 500 million by 2020 – more than half of the world's total at that time. Some of the problem is directly attributable to warfare and political unrest or government policies - Sudan, Somalia, Eritrea and Zimbabwe being examples - but hunger reigns supreme in most countries of Africa south of the Sahara.

It's of interest that while much of the global media attention in early 2011 - and also in 2008 - has been on food-price-related riots in North Africa, it's further south where the real hunger resides. Cairo, for example, has a major problem with obesity (Paarlberg (2010).

Unlike Asia, crop yields in Sub-Saharan Africa (SSA) have not increased much in recent decades; the use of irrigation and fertilizer (9 kg/ha average rate) or modern pest-control methods is limited (Figure 39 to Figure 43, Table 23). In addition, much of the potentially arable land remains uncultivated (Figure 44). The FAO estimated in 2000 that as little as 15% of potentially arable land in SSA was used, and even if the production potential of unused land is not as high, the scope to increase food production capacity through more hectares of production and higher yields is great. (There are exceptions: with their large population densities, most of the available land in Ruanda and Burundi is now in food production.)

While some of this land is presently under forest, which causes concern about potential effects on greenhouse gas emissions from land clearing, a large amount of available

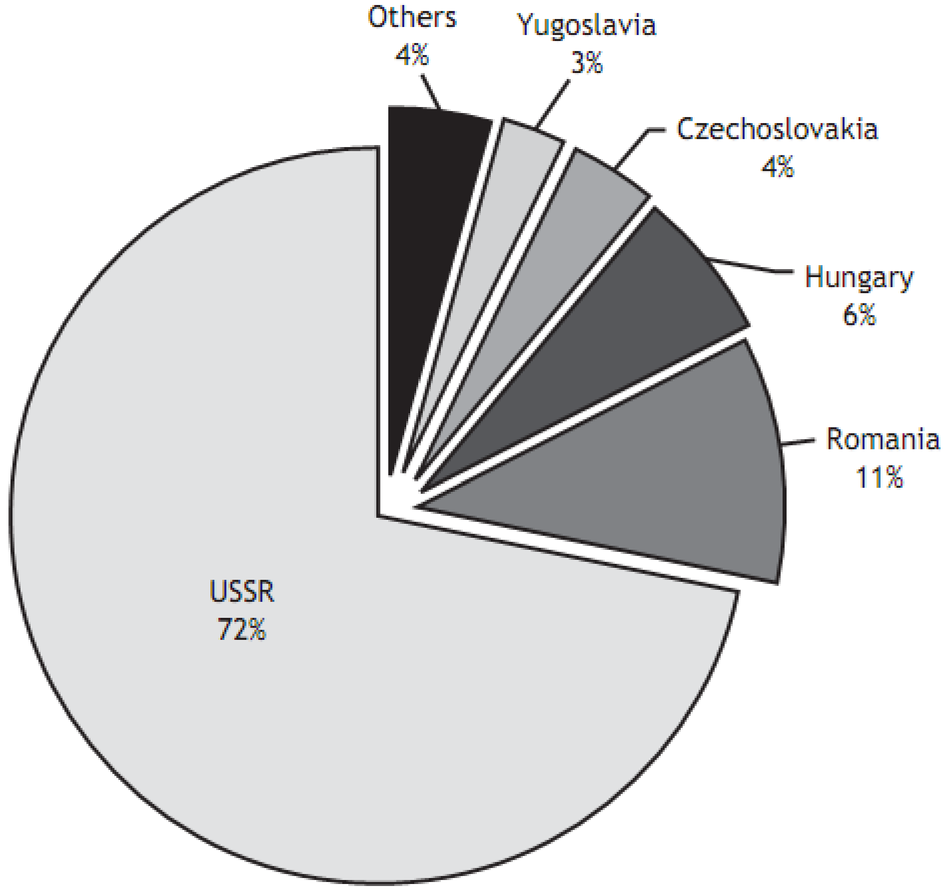
Table 23. Percent changes in growth rates in per-capita cereal production, 1980s–2000s.

Region	Growth rate (percent)	Implication
World (total)	-6.1	
World minus Africa	-4.8	Africa accounts for almost one-quarter of global shortfall
World minus Americas	-5.8	
World minus Asia	-9.6	Asian growth was much stronger than global growth
World minus Europe	-2.8	Eastern Europe accounts for almost half of global shortfall
World minus Oceania/Australia	-6.3	

Source: Calculations by the authors using data from FAO (2009).
Notes: Growth rates are calculated as the percentage difference between average annual cereal production per capita during 2000-06 and average annual production in the 1980s. Cereal production is measured as milled rice equivalent.

Source: Heady and Fan, 2010.

Figure 42. Explaining Europe's declining cereal production, 1985–2006.



Source: Calculations by the authors using data from FAO (2009).

Source: Heady and Fan, 2010.

arable land is not forested. Fisher (2008, cited in FAO, 2008) estimated that between 250 and 800 million hectare of non-forested land is available for food production, mostly in tropical Latin America and Africa.

The Montpellier Panel (a European group affiliated with the Imperial College, London) recently estimated that the SSA has the potential to increase annual agricultural productivity to $800 billion in 2030 compared to a present value of $280 billion (www3.imperial.ac.uk/africanagriculturaldevelopment/themontpellierpanel/panelreport, 2010).

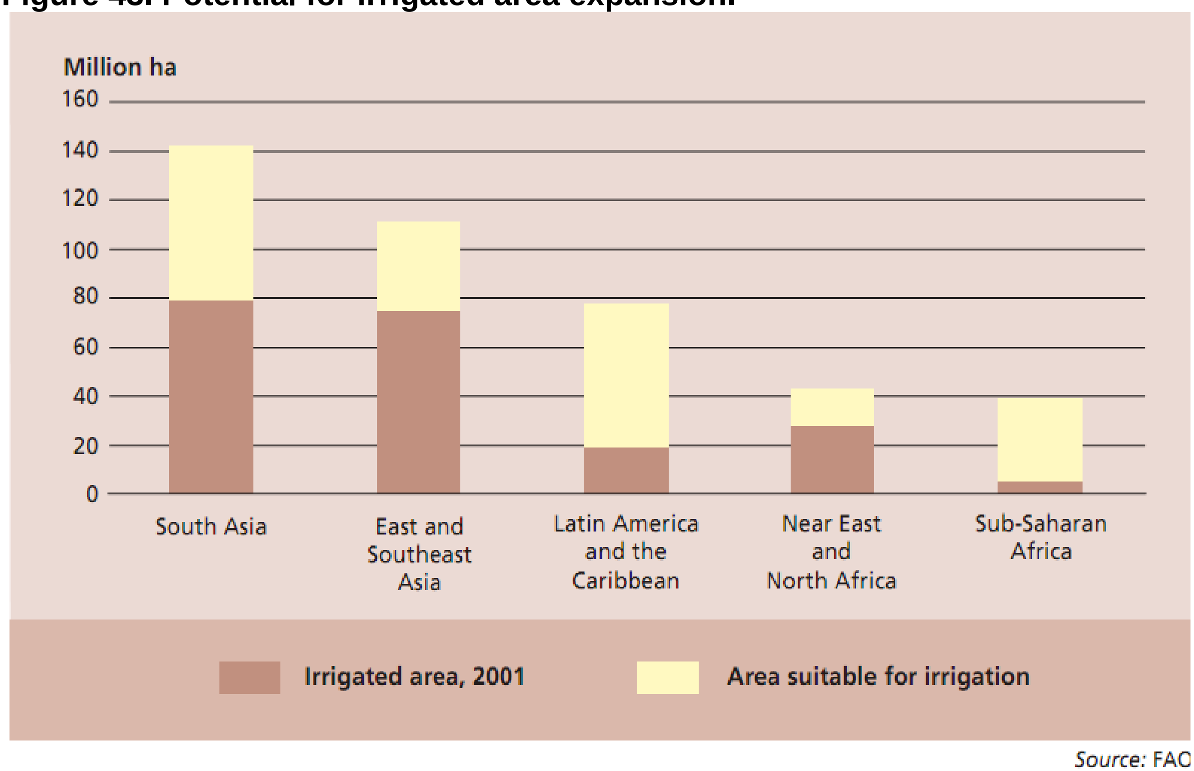
Relative to its land area, the population of SSA is not that large, about 860 million compared to 2.5 billion in China and India alone, and the region clearly does have the potential to feed itself. Regrettably, SSA has been the largest victim of four decades of neglect of agricultural development - notwithstanding the ardent efforts of organizations like the members of the Consultative Group on International Agricultural Research (aka, CGIAR; its members include CIMMYT based in Mexico and the International Rice Research Institute, IRRI, in the Philippines) and other public agencies.

African diets tend to be large in corn, wheat and rice as well as a wide range of other cereals and root crops. At least two-thirds of the hungry are in rural areas as is two-thirds of the SSA population.

This pattern of greater hunger in rural areas is common elsewhere (USDA-ERS, 2010) Most of the world's hungry are also small farmers. Hunger is closely linked to poverty (Paarlberg, 2010) and most of the world's poorest live in rural areas. The World Bank (http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:20040961~menuPK:34480~pagePK:34370~piPK:116742~theSitePK:4607,00.html) says that 1.4 billion, or one-quarter of the world's population, lived on less than $US1.25/day in 2005, though this percentage was down from 52% in 1981 and 42% in 1990 – and is projected to decline to 15% in 2015.

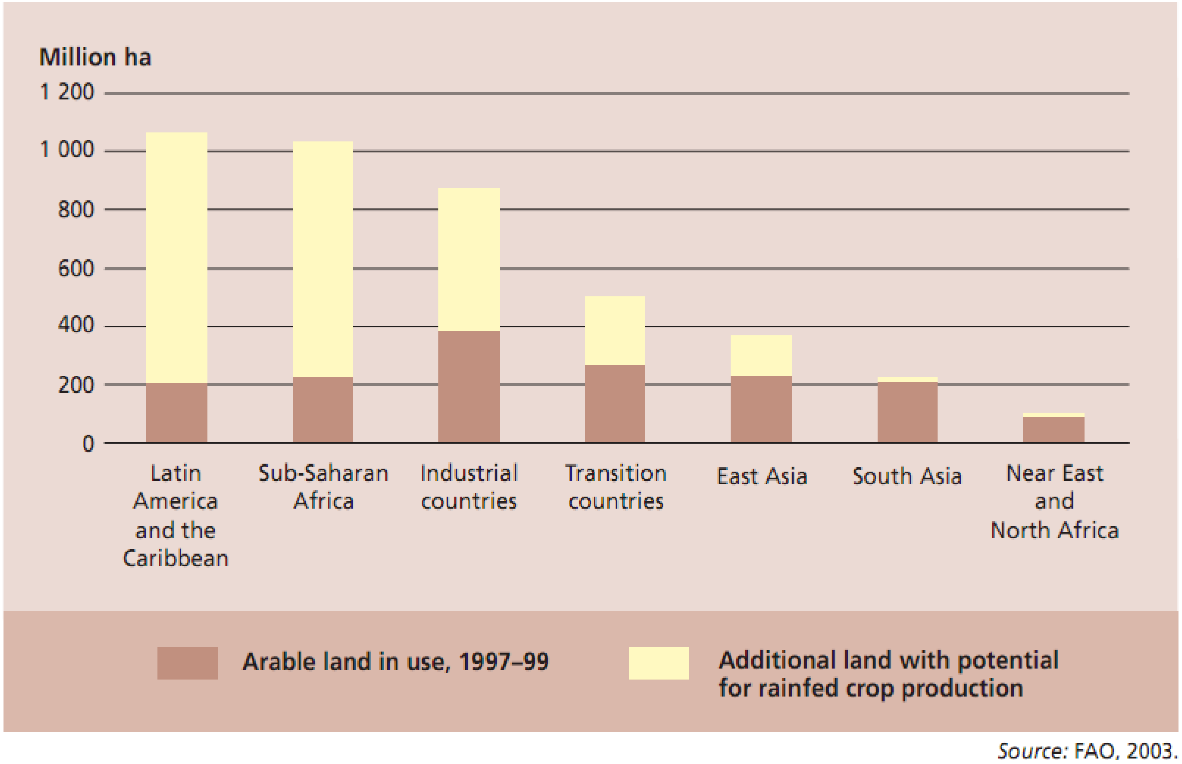
Despite their large need, most SSA countries are small importers of grains lacking both the funds and infrastructure for major imports, especially to remote, interior locations. Oil-rich countries like Nigeria are the exceptions (Akpan, 2009; www.vanguardngr.com/2011/02/for-how-long-will-nigeria-continue-with-this-import-syndrome-madness/).

Figure 43. Potential for irrigated area expansion.



Source: FAO, 2008.

Figure 44. Potential for cropland expansion.



Source: FAO, 2008. "Transition countries" refers to former Soviet countries.

A third notable area of world hunger is in certain countries of the Caribbean, Central and South America. While only about 6% of the world's hungry are in the Americas, the percent hungry in 2007 was at least 15% in Nicaragua, Guatemala, Panama, Ecuador, Peru, the Dominican Republic and Bolivia, and over 50% in Haiti (FAO, 2010). Statistics were not provided by FAO for Mexico and Cuba. The dominant grain used for food in these countries is corn – usually white corn which is generally not used for ethanol production.

Mexico is a special situation. Though not classed by FAO as a "hungry country" (i.e., more than 10% hungry), there are still many undernourished people. Mexico has imported increasingly large amounts of US yellow corn in recent years for livestock feed. About 25% of Mexican total corn consumption of 32 million tonnes per year is imported from the US; this is sufficient to provide about half of the corn needed to feed Mexican livestock (USDA-FAS, 2011). Mexico has increased its total cereal imports in recent years (to about 12 million tonnes/year; from a position of near self-sufficiency in the late 1980s, http://countrystudies.us/mexico/72.htm) by a higher percentage than almost any other country in the world (Heady and Fan, 2010).

Table 24. Daily diet, average for low-income food-deficit countries.

Item	Food supply quantity (kg/capita/yr)	Food supply (kcal/capita/day)	Percent
Cereals	151.4	1383	59
Wheat	56.3	474	20
Rice (Milled Equivalent)	66.5	670	29
Corn	14.9	125	5
Millet	6	49	2
Sorghum	6	50	2
Starchy Roots	62.9	153	7
Pulses	7	65	3
Soybeans	1.8	17	1
Vegetable Oils	8.5	204	9
Other plant materials		484	21
Meat	23.4	166	7
Milk	46.6	77	3
Total		2326	100
Plant Products		2095	90
Animal Products		231	10

Source: FAOSTAT, http://faostat.fao.org/default.aspx .

US corn prices have an important effect on Mexican domestic corn prices, even for white food-grade corn. However, Mexican food pricing policies and subsidy programs mean that the changes in the price of tortillas (or flour for tortillas) are commonly isolated from those for imported US corn (USDA-FAS, 2011). Food riots in Mexico may be as much a result of changes in government polices as in changes in global grain prices (http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Tortilla%20Price%20Crisis%E2%80%A6%20To%20Be%20Determined_Mexico_Mexico_12-15-2010.pdf). Mexico is like Egypt in having many hungry people but also a serious problem with obesity. Nearly 30% of Mexicans are classed as obese by the World health Organization (http://apps.who.int/bmi/index.jsp) – an even higher percentage than in Canada.

Mexico and certain other countries in Central American, the Andean region of South American and the Caribbean are relatively unique in their dependence on corn for direct caloric intake. Corn represents 34% of direct human caloric consumption in Mexico (Westhoff, 2010). In most other countries, wheat and rice are far more important as food grains (Table 24). Corn also dominates caloric intake in some African countries such as Lesoto (64% of annual caloric intake) and Malawi (58%) (ICTSD, 2009).

Robert Paarlbeg of Wellesley College and Harvard University has recently published *Food Politics* (2010) which provides an excellent discussion on many issues associated with world food supply and hunger. Paarlberg credits the FAO's Famine Early Warning System and the World Food Programme with improving the global response to genuine food supply crises, but notes that domestic politics has a dominant influence on food supply and pricing, both domestically and internationally. For example, many governments view it as more important to keep food prices low in urban areas (which are politically more important and more volatile) than to look after the well-being of farmers and agriculture in remote parts of the country.

Paarlbeg notes that - though not to diminish the tragedy of about 900 million hungry people - this number is exceeded by an estimated 1.6 billion who are now overweight or obese. The World Health Organization (WHO) projects this number to reach 2.3 billion by 2015. Though obesity is largely viewed as being a developed-world problem, many developing countries have problems with excessive weight too – though not India and sub-Saharan Africa. The Democratic Republic of the Congo had an obesity rate of 0.1% in 2010 (https://apps.who.int/infobase/Comparisons.aspx).

It is a world tragedy that so much hunger is created by such a relatively small deficiency

In the context of global hunger, recognition is needed of the amount of food wastage/spoilage which occurs globally. Halweil and Nierenberg of the World Watch Institute (WWI, 2011) estimate the loss to be 25-50% in developing countries, much of this associated with the spoilage and destruction by pests (rats) of grain in storage. The WWI also notes that poor transportation infrastructure also contributes to hunger in developing countries – the inability to move grains from areas of surplus to deficit production even within individual countries. Indeed, even when efforts are made to supply large quantities of outside grain through food aid programs, the success is limited by both transportation/distribution limitations and corruption.

The USDA-ERS (2010) has calculated that the amount of grain and equivalent (eg., starchy root crops) needed to eliminate caloric food deficiency for 70 studied countries in 2010 (virtually all of the world's hungry nations, though not including China) was about 24 million tonnes – rising to 28 million in 2020. This represents about 1.1% of current world grain production (about half of average Canadian output). It's only about 4% of current grain production in the 70 countries themselves.

It is a world tragedy that so much hunger is created by such a relatively small deficiency.

The *OECD Observer* published a remarkably strong statement about hunger in March 2010 (www.oecdobserver.org/news/fullstory.php/aid/3212/Food_security.html). The statement concludes, “If people are hungry today, it is because they cannot afford to buy food, not because there is not enough available. Obesity is now a problem even in some developing countries, and much of the food produced (half, according to Oxfam) is either thrown away uneaten or spoiled because of poor storage and transport conditions. The immediate answer to hunger is to reinforce the capacity of the World Food Programme and other emergency response initiatives, but a more lasting solution requires placing food security in the wider context of economic development.”

And also, “In reality, the world has never produced so much food, and the EU and the US even had to implement policies to reduce various food “mountains” and “lakes”– butter, beef, milk, wine, and so on. The rate of progress in agricultural productivity over the past few decades has been phenomenal, even for long-established crops.”

This progress in agricultural productivity needs to be extended to all parts of the developing world, especially Africa.

5.3. Price Spikes, Hunger and Biofuels

The grain and other food commodity price spikes of 2008 and again in 2011 must be viewed against a background of major world hunger and poverty. As Banse et al. (2010, Table 25) and others have noted, a given percentage increase in grain price has a far more negative effect on those for whom food purchases (often of primary grains, not processed foods) represent a high percentage of income.

The FAO publishes a Food Price Index (FPI) which it uses to assess annual changes in food prices. The index is a weighted average of price indices in US currency for five food groups – cereals, oils/fats, dairy, meat and sugar. After remaining around 100 for nearly two decades, the FPI quickly reached a peak of about 215 in mid 2008, then declined to about 140 in early 2009 before moving back upward to reach 236 in February 2011 (FAO, 2008a; www.fao.org/worldfoodsituation/FoodPricesIndex/en/).

However, the FPI is calculated in US dollars, and the local equivalent of the FPI is strongly influenced by exchange rates. For example, as shown in Figure 45, the FPI in mid 2008 was only 100 if expressed in "Special Drawing Rights" (i.e., SDR, a World Monetary Fund creation which is a blend of the value of US dollars, euros, pound

Table 25. Impact of higher food commodity prices on consumers' food budgets.

	High income countries	Low income, food deficit countries
Initial Situation		
Income	€ 40,000	€ 1,000
Food Expenditure	€ 4,000	€ 500
Food Costs as % of Income	10%	50%
30% increase in food prices		
new costs for total food expenditure	€ 5,200	€ 650
Food Costs as % of Income	13%	65%

Source: Own compilation.

Source: Banse et al., 2008.

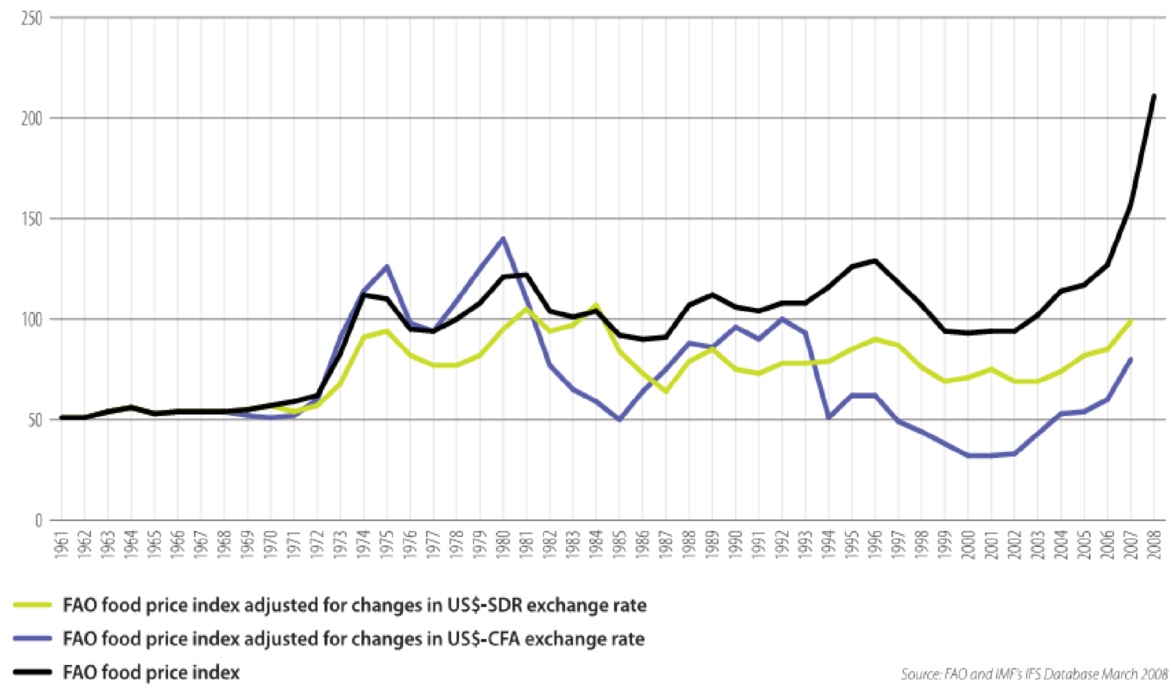
sterling and yen), and was only about 80 if expressed in CFA francs, a currency linked to the euro used in 14 African countries.

In addition, changes in the FPI often bear no resemblance to what happens at the local level in developing countries. The reasons are a combination of government policies (import and export duties and subsidies, internal subsidies and pricing policies) and poor transportation infrastructure which isolates rural communities from both external supplies in times of need, and from market opportunities in times of local surplus production.

Figure 46 shows the wide range in food price indices which existed in several African countries in 2007 and 2008. Figure 28 shows a similar wide range in 2010.

To add to this is the fact that the principal food crops in most countries are rice and wheat, rather than corn and soybeans which are mainly used for livestock feed and industrial processes (products which are widely used in processed foods).This should be coupled with the conclusion from earlier sections that biofuels have had a far greater

Figure 45. Food Price Index shown as normally presented (US currency) and after conversion to SDR and CFA francs.



Source: FAO 2008a. SDR = Special Drawing Rights of the International Monetary Fund, a weighted average of the exchange rates among the $US, yen, euro and pound sterling.
CFA francs are a currency, linked to the euro, used in 14 African countries.
The FPI reached 215 in 2008. However, this was equivalent to a value of 100 in SDR units or about 80 in CFA currency.

effect on corn prices than on wheat and rice. It seems reasonable to conclude that the effect of the biofuel component of grain commodity price spikes of 2008 on third-world hunger was very small.

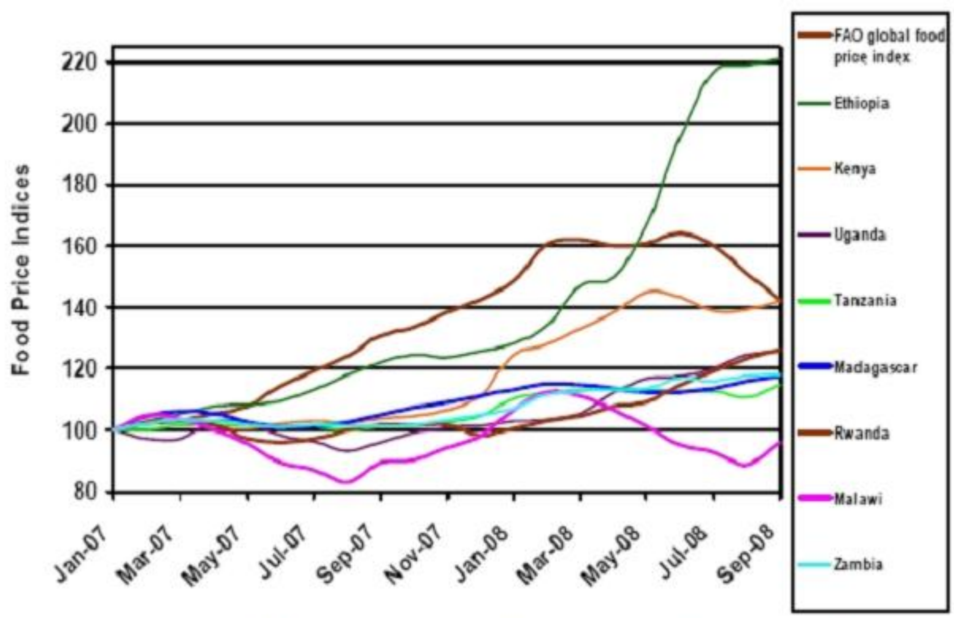
The same interpretation seems valid for 2011.

Also, oil import costs are 2.5 times larger than food imports for low-income countries, and the oil price shock of 2008 had a much greater effect than food prices in low-income countries (Table 16). Energy prices also have a major effect on world food prices (Figure 47).

There is a small, but growing production of biofuels in developing countries where substantial hunger exists. One school of thought says that this is immoral and that arable land in these countries should only be used to grow food. But another notes that high energy costs can be even more challenging for impoverished people in remote regions of the world; lack of good roads means that the costs for imported petroleum products can be very high. The prospect of growing local biofuels has appeal. (See FAO, 2008.)

There has been a lot of international media focus on companies and other countries buying large tracts of land in poor countries to produce crops for biofuel production for export. However, a recent report suggests that, at least to date, only a small portion of

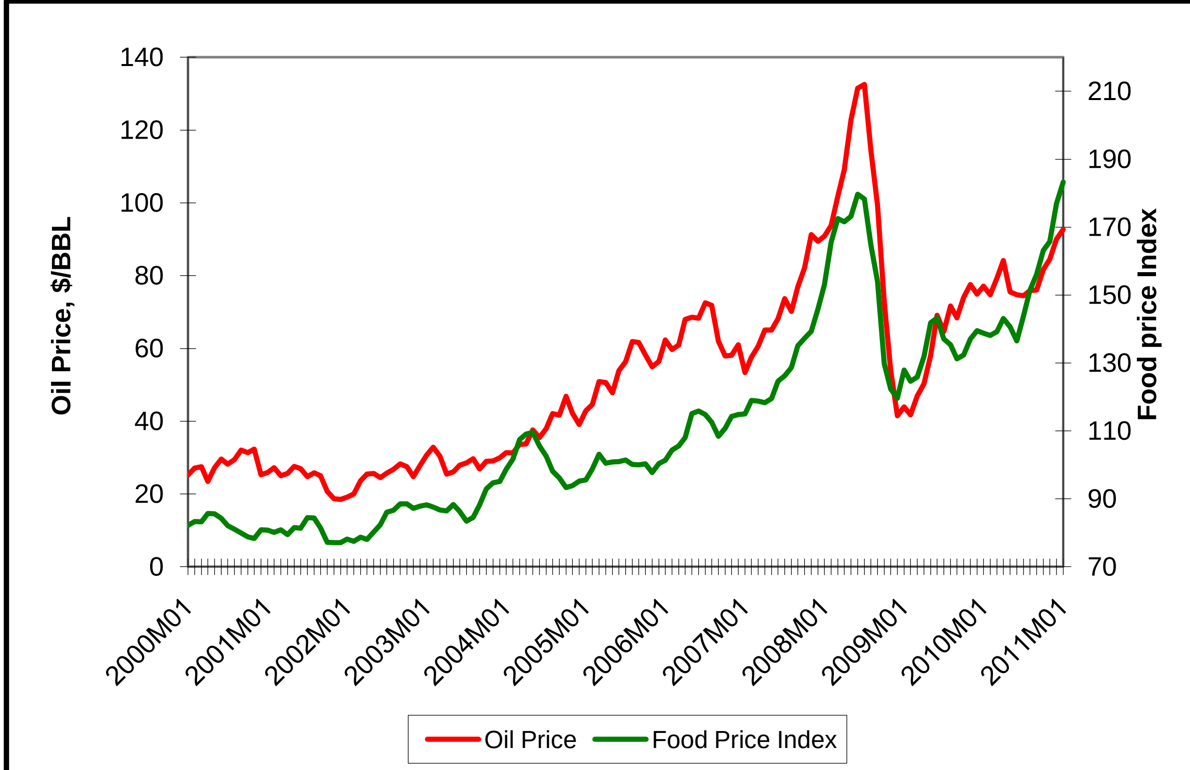
Figure 46. Evolution of global food price index and food price indices of selected African countries.



Source: Reproduced by kind permission of CGIAR. From 'Responding to Food Price Crisis in Eastern and Southern Africa: Policy Options for National and Regional Action' (Karugia, et. al. 2009)

Source: DEFRA, 2010.

Figure 47. Relationship between Food Price Index and oil prices.



Source: (S&T)[2] Consultants Inc. using data from International Monetary Fund.

these ventures have actually proceeded beyond the announcement stage (World Bank, 2010). It's too early to judge whether this is a trend of significant international importance in efforts to reduce world hunger.

5.4. Bioproducts, Food Prices and Hunger

Although bioproducts have been largely ignored in the biofuel-versus-food discussion, as bioproduct production grows, these materials cannot avoid the debate. Michael Carus and colleagues at the Nova Institute in Germany are among the few bioproduct developers who have addressed this issue to date. In a 2009 article in *Bioplastics,* Carus and Piotrowski noted that bioplastics now represent less than 0.1% of global cultivated land, compared to about 2% for biofuels. However, this percentage will grow.

We are already seeing examples of discrimination against bioproducts produced from grain and oilseed crops. For example, European automobile makers have said that they do not want to use bioproducts made from "food" crops, even while they welcome materials made from non-food crops such as hemp and grass species. In Canada bioproduct researchers in the National Research Council (NRC) say that they have been discouraged from working with crops such as corn, soybeans, barley, canola and wheat in favour of other species. The Natural Sciences and Engineering Research, Council, which provides substantial funding for university research in Canada, is reported to have dropped bioproducts from its areas of funded support.

Some of these discriminatory policies do not make much sense. For example, public authorities have discouraged the use of agricultural food crops to produce bioproducts while encouraging the transition of land now growing food crops into non-food crop production for bioproduct development. (An example is switchgrass production on land which formerly grew corn and soybeans.) And often lost in all of this is the recognition that byproducts from crop production (i.e., corn cobs, dry soybean pods and other crop residues) and from crop processing (meal products left after producing corn starch and sugar, wheat flour, soybean and canola oil, etc.) can be used to make high-value and low-cost bioproducts.

In brief, even though the use of agricultural crops for bioproduct manufacturing is still very small – far smaller than for biofuels - the food-versus-biofuel debate has critical implications for the development of bioproducts in Canada and the rest of the world.

6. What to Expect in the Future

Some forecasters are suggesting that current high farm crop and food prices are the new norm, and that prices will be both higher and more volatile for years to come (Foresight, 2011; Worldwatch Institute, 2011; International Monetary Fund, www.ft.com/cms/s/0/4c46da8c-45ca-11e0-acd8-00144feab49a.html#axzz1Fowequqd). This opinion is bolstered by the knowledge that the world's population will continue to grow, albeit at a declining relative rate, to reach a projected peak of about 9 billion by 2050.

And with food diets in many countries continuing to evolve to include more meat, the demand for food ingredients, especially grains and oilseeds will grow at a rate of at least 1 percent per year.

A common projection is that the world's food supplying capacity will have to increase by 70% between 2000 and 2050 (FAO, 2009). This equates to an annual rate increase of 1.1%. By comparison, the average world grain yield increased by 1.5% per year from 1987 to 2007 (DEFRA, 2010) and the rate of growth in global grain production increased at about 1.5%/year (2.0% in developing countries) between 1961 and 2008 though the rate was higher before 1985 than afterwards (Foresight, 2011).

Food supply must increase by 1.1% per year until 2050

Others argue the reduced rate of growth since 1985 was the direct result of low real prices for food and government policies which either ignored agricultural production or actually discouraged high productivity (these policies include acreage set-aside programs, prohibitions on use of new technology, growth in organic foods, and environmental restraints) – and not because of any impending biological-resource-environment limit to the ability of mankind to increase productivity (Paarlberg, 2008 and 2010).

Some forecasters, such as the OECD-FAO Outlook on Agriculture (2010, www.agri-outlook.org/pages/0,2987,en_36774715_36775671_1_1_1_1_1,00.html), expect prices to decline from current peak values, but still to persist at above-historic levels at least for the next decade.

A comparison with the era of commodity/food price spikes of the 1970s and 1980 provides valuable insight. During this earlier period, many public statements were made that commodity and food prices had climbed permanently to a new plateau. To put this into perspective, the relative rate of world population growth was greater at that time than now. And virtually no projections were being made during the 1970s that world population growth would level off during the foreseeable future.

While growth in biofuel production presents a new dimension to global grain supply and demand in the 21st century, a similar upward pressure existed in the 1970s through new and substantial buying by the Soviet Union. There were few expectations in 1980 that two of most populous nationals in the world - China and India - would become almost completely self sufficient in food supply in the years ahead – let alone, significant exporters of some food products. Also, largely unforeseen was the extent to which other developing countries such as Brazil, Thailand, Russia, Kazakhstan and the Ukraine would became major exporters of farm commodities (near-term effects of the 2010 eastern European drought not withstanding).

The alarms voiced about future food supply during the 1970s largely disappeared during the decades to follow as world food supply grew - at a rate which exceeded population growth. Global per-capita caloric food supply grew by 15% over a four-decade interval beginning in 1970 (Foresight, 2011) - though not in some critical areas, such as Sub-Saharan Africa. In fact, complacency came to replace alarm.

Future food prices will be strongly affected by oil prices and inflation

No one knows what lies ahead. We can only speculate.

Much depends on future petroleum prices and on future rates of inflation. The two tend to be closely linked. Energy, much of it petroleum derived, has a huge bearing on the cost of crop production, especially in countries where agriculture is well mechanized. These include all developed countries plus a growing percentage of agricultural production in developing countries, as well.

Agricultural commodity prices did rise to a higher plateau after the 1970s compared to the 1960s. Oil prices were permanently higher after the 1970s.

But very high rates of inflation occurred in the 1970s and if adjustments are made for this, real farm commodity prices were no higher after 1980. Indeed, they continued their historical downward slide.

In contrast to the 1970s, inflationary rates are currently very low in North America and Europe, though that could change. Inflation is already considered to be of serious concern in China, India, Brazil and several other large countries. Permanently higher oil prices in the coming years will have an inflationary effect on prices for food.

The writers of this report are inclined to believe that history does repeat itself. With the increased attention now being devoted to food production by many countries, especially in developing countries, the rate of growth in global production of grains, oilseeds and other basic food commodities is likely to increase in the coming decade(s). The rate can be expected to grow enough to not only meet the needs for food and biofuel production in many countries, but also with increased amounts available for export.

A 1.1% or higher average annual rate of growth is a stiff, though not insurmountable, challenge, especially if modern agricultural science is allowed to prevail. It should be noted that the 1.1% estimate applies globally. In fact, demand for food will grow at a much lower rate in developed countries as rates of population growth continue to shrink (or, indeed, cease for some countries) and citizens age. The rate will need to be much higher in many developing countries but the potential for acreage expansion and yield increases using already available technology is also greatest there.

There are several areas where substantial increases in agricultural output can be expected. One of these areas is Eastern Europe, where an estimated 40 million ha of arable land which went out of production after the breakup of the Soviet Union (see Figure 42) can be expected to be returned to the planting of grains and oilseed crops. (Eastern Europe was once the “breadbasket” which fed the United Kingdom and other western countries in the era before World War I.)

$20 billion committed to third-world agriculture development

South America also has major scope to increase the amount of land devoted to agriculture without damaging tropical rain forests (See Fisher, 2008, cited in FAO, 2008).

Africa is the largest problem for a world seeking to lessen global hunger. As documented earlier, Sub-Saharan Africa (SSA) is projected to have half of the world’s hungry by 2020.

The good news is that the potential for increased agricultural output in SSA is also very large. Africa has been identified as a primary target for the $20 billion in new agricultural developmental assistance agreed to by the G8 Group at its 2009 meeting in L’Aquila, Italy FAO (2010). (The Canadian commitment was $1.18 billion, which is being met - www.acdi-cida.gc.ca/acdi-cida/ACDI-CIDA.nsf/eng/NAD-426114720-LJ5.) Countries in the SSA are also increasing their own investment in agricultural and food development (FAO, 2010; Foresight, 2011).

Major leadership is being provided by some non-government organizations such as the Bill and Melinda Gates Foundation and the Howard G. Buffett Foundation in fostering agricultural development in the SSA. (For example, a joint program by CIMMYT and the International Institute for Tropical Agriculture, with Gates-Buffett funding has produced new drought-tolerant corn varieties with the ability to boost African yields by 20-50 percent (http://dtma.cimmyt.org/index.php/component/content/article/113-news-release/131-researchers-predict-new-varieties-of-drought-tolerant-maize-could-generate-up-to-us15-billion-for-african-farmers-consumers ; see also Paarlberg, 2008).

Finally, some of the phobias about genetically modified crops and other advanced technologies which have seriously impeded African agricultural development strategies, are now weakening somewhat. (See Paalberg, *Starved for Science – How Biotechnology is being kept out of Africa,* 2008, for extensive documentation on how animosities to biotechnology, largely coming from Europe, have hampered efforts to improve third-world agriculture.)

Of course, all of this does not ensure success in increasing food self-sufficiency in SSA, but the odds for success are much higher now than perhaps ever before in history.

“We need to produce where the poor and hungry live,” Dr. Jacques Diouff, director-general of FAO, 2009 World Summit on Food Security

Climate change has been identified as a factor which will affect future agricultural productivity. The near-unanimous opinion in the popular press, as well as in many institutional reports (eg., IFPRI, 2006), about impending food supply needs is that climate change will reduce global productivity – perhaps dramatically so. However, a careful reading of the 2007 report of Working Group I of the International Panel on Climate Change (United Nations Environmental Program) presents a far-less certain view – stating that conditions for crop growth can be expected to improve for some parts of the populated world (including some tropical regions), and worsen in others, by the year 2050 and in the decades to follow. (Working Group I is the group of scientists responsible for presenting a collective global consensus on the science of climate change.) Very few of these analyses contain any recognition of the way in which crop plants are likely to change because of genetic improvement in the decades ahead.

The current spikes in grain and food prices will also have an effect on trade policies. The World Trade Organization is promoting freer international trade in food commodities as a critical step in reducing world hunger. Impediments to trade did create or intensify the stress in many countries in 200-2008 and again in 2010-2011.

However, a more likely response by many developing countries will be efforts to increase food self-sufficiency, thereby reducing dependence on imported food ingredients. Many of these countries will want to mimic the policies of China and India – two countries which have come through recent volatile times relatively unaffected. Governments have seen the internal turmoil which can occur when domestic food prices rise rapidly, and they will do what it takes to avoid this, regardless of the effect on other countries.

Dr. Jacques Diouff, director-general of FAO said in an opening statement to the 2009 World Summit on Food Security, “We need to produce where the poor and hungry live.”

Even well-fed and net-food-exporting countries like Canada have seen greater public pressures to reduce food imports.

If this scenario plays out as projected, the result could be static or even reduced demand for grain and oilseed exports to developing countries in years ahead. This will occur even as crop yields continue to grow in countries like Canada, the United States, Australia, the European Union, Argentina and Brazil.

7. Implications for Ontario Grain Farmers

If the future plays out as portrayed in the previous section, a critical question is, "What will Canada and other countries do with this surplus capacity?" Also, will this mean a return to an era of very depressed crop prices and farm/rural incomes in the decade(s) ahead? A declining rate of population growth and an aging population in Canada and many other developed countries will add to the likelihood of over-supply.

To continue our historic overview, crop prices returned to very low values in North America in years which followed the price peak of 1980. For example, the nearby futures price for corn dropped to near $1.50/bushel in 1986 after having been over $4.00/bu in late1980. ("Chicago" wheat dropped from $5.40/bu to $2.40/bu during the same interval.) This was in large part, the result of agriculture in developed countries gearing up for an expected large increase global export demand - which did not occur.

One policy option in the coming years is to return to massive farm subsidies as a means of supporting income, coupled with the shipment of below-cost of-production food ingredients into third-world countries - this despite efforts of the latter to reduce their dependence on external supplies. This option is effectively a return to what was the norm for 20-25 years or more prior to about 2006. In fact, many farm organizations still bear this legacy, with a large portion of their resources devoted to efforts to maintain public farm income support programs.

A second option is to restrict future agricultural productivity in Canada and other developing countries – for example, by restraints on the use of agricultural inputs such as fertilizer, pesticides and advanced genetics. This could occur by either government edict or consumer (and food retailer) demand for the use of more "sustainable" or "natural" production technologies. Organic agriculture, for example, offers a trade-off between higher food commodity prices and higher production costs and (usually) lower per-acre yields.

A major risk for this "lower-input-higher-crop-price" option is that the same restraints will not occur in other countries such as in South America and Eastern Europe. Imports from these countries could limit the ability of developed-world farmers to benefit through higher farm commodity prices here at home. Even with organic foods, imports from low-labour-cost countries such as China already threaten the competitiveness of organic food producers in Canada.

Another, option – better, at least in the view of drafters of this report - is to find other ways of using this excessive domestic productivity.

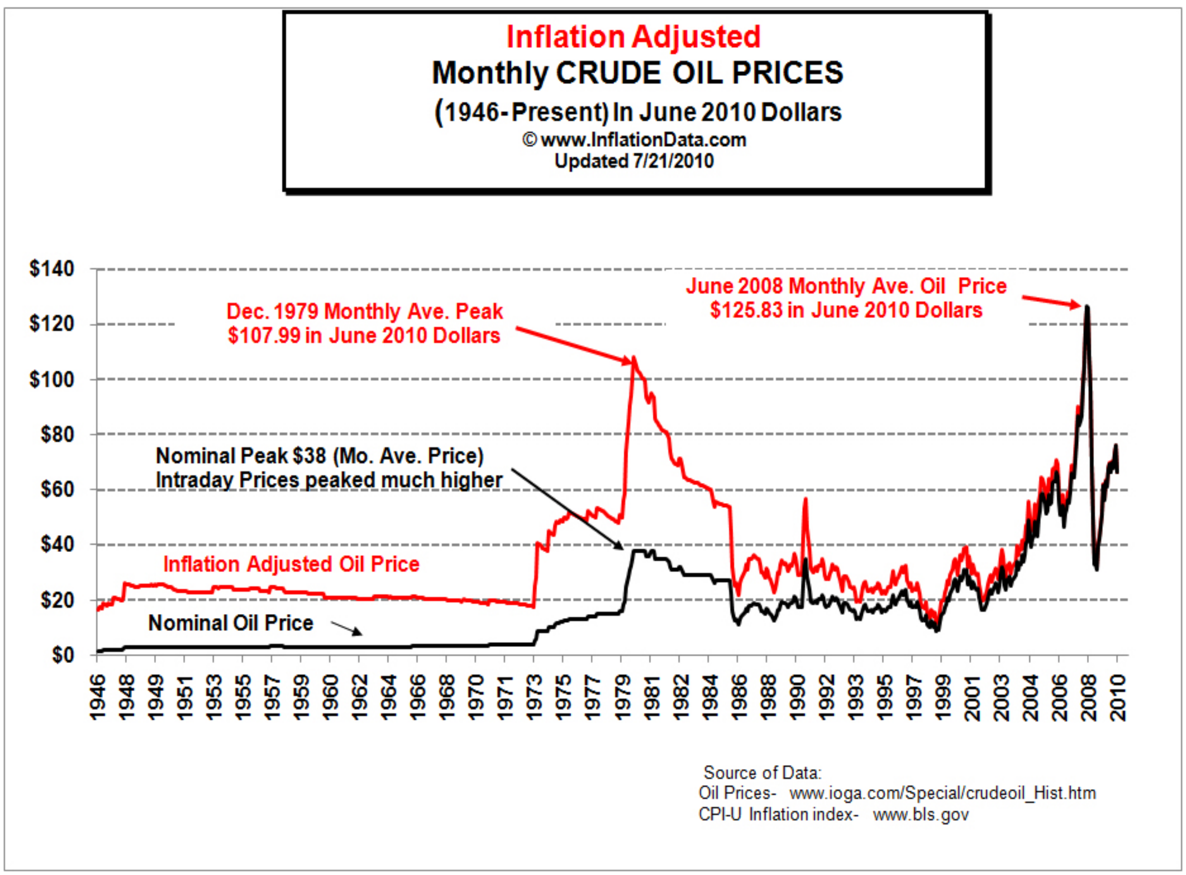
Biofuels have represented one avenue for doing this, while also addressing other societal goals - environmental improvement and reduced dependence on fossil energy. There are expectations that biofuel production, at least from grains, will level off in the coming decade – at least in North America. This may not occur so quickly with biodiesel because the state of development of the North American biodiesel industry is not nearly as advanced as with fuel ethanol.

Biofuels and other bioenergy production from cellulosic crops and crop residues offer large potential, but the extent to which this potential will become reality remains still unknown. If energy prices become permanently higher, the opportunity for much greater biofuel production, using all feedstocks (including grain) and technologies, will become even larger.

Bioproducts made from biological feedstocks represent a major opportunity to use the impending surplus agricultural capacity in many developed countries – especially if advocates can counter reactions to the use of so-called food crops to produce non-food items.

Another possibility is that land now used to produce food crops may be diverted to the production of new plant species not considered as traditional food crops for biofuel and

Figure 48. Changes in crude oil prices since 1946.



Source: www.inflationdata.com .

bioproduct manufacture. However, this may be a more expensive route, given the complications of converting new species into agronomic crops which can be grown at competitive costs of production and with reasonable freedom/protection from plant pests. And further, the end result with this approach will not likely be any different in overall usage of farm land for food versus non-food end markets. Despite these drawbacks, this approach may be seen by some as a way of doing an end-run around public and political angst about the use of food crops for non-food purposes.

Bioproduct development is an especially appealing market opportunity for Ontario grain and oilseed farmers, given the experience which they already have in growing crops for non-food markets (i.e., biofuels) and in growing higher-value, identity-preserved (IP) crops for specialty markets. The IP approach may be needed to meet the requirements of some promising bioproduct markets.

Ontario farm expertise meshes well with the existence of a large manufacturing economy in Ontario and the desire of both manufacturers and the Government of Ontario to reduce their dependence on imported hydrocarbons while also striving to improve environmental quality.

In years ahead, the price of both agricultural crops and petroleum can be expected to oscillate – sometimes dramatically so - over short periods of time. However, the long-term trend in real oil prices is up (Figure 48) while that for agricultural crops is down (Figure 11). And as technology continues to improve the efficiency with which bioproducts can be made from biological feedstocks, the cost competitiveness of bioproducts will continue to rise.

There is plenty of scope for growth of a global bioproduct industry, currently estimated at about $1-2 billion per year, to replace a larger portion of an annual plastics/petrochemicals industry market estimated at $2-3 trillion – and for nations to use this as a means to reduce net greenhouse emissions by substantial percentages during the coming 10 to 40 years.

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