# *Assessment of Biofuel Resource Elasticity in APEC Economies*

**APEC Energy Working Group**

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## Preface

This report of the Assessment of Biofuel Resource Elasticity in APEC Economies took place from July 2008 until December 2009. An extensive literature review was conducted based on peer-reviewed journals and publications by international organizations such as the Food and Agriculture Organization of the United Nations (FAO) and the Organization for Economic Cooperation and Development (OECD). Data on crop area, production, and yields for APEC economies was collected from multiple sources including FAO, OECD, U.S. Department of Agriculture and ten-year projections were obtained from the Food and Agricultural Policy Research Institute (FAPRI).

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## Glossary

**Agricultural area** refers to:

(a) arable land - land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for arable land are not meant to indicate the amount of land that is potentially cultivable;

(b) permanent crops - land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee and rubber; this category includes land under flowering shrubs, fruit trees, nut trees and vines, but excludes land under trees grown for wood or timber; and

(c) permanent pastures - land used permanently (five years or more) for herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

*Source: FAOSTAT*

## Abbreviations and Acronyms

APEC – Asia-Pacific Economic Cooperation
Bt – Bacillus thuringiensis
CGE – Computable General Equilibrium
EPACT03 – Energy Policy Act of 2003
EU – European Union
FAO – Food and Agriculture Organization of the United Nations
FAPRI – Food and Agricultural Policy Research Institute, Iowa State University
GDP – Gross Domestic Product
GM – Genetically Modified
GTAP – Global Trade Analysis Project
OECD – Organization of Economic Cooperation and Development
R&D – Research and Development
RFS – Renewable Fuels Standard
RR – Roundup Ready
USDA – United States Department of Agriculture

## Units of Measure

g – gram
ha – hectare
kg – kilogram
MT – metric ton

## Executive Summary


Given the recent emergence of biofuels as an alternative source of fuel for transportation, there is interest in the potential of APEC economies to expand their biofuel sectors through increased production of feedstocks. This expansion could occur through land extensification and/or intensification. The potential for increasing biofuel feedstock production through yield growth is of particular interest.

It is essential to gain a better understanding of the biofuel resource elasticity in APEC economies to help each economy determine the impact of biofuel expansion on their agricultural sectors. Therefore, the aim of this report is to review the literature on factors affecting growth rate of crop yields, particularly for the feedstocks used in the production of biofuels, and to investigate the elasticity of crop yields with respect to various factors. Of particular importance is the impact of crop prices on yields.

The review of the literature and the data reveal that there are a number of key factors affecting crop yields including climatic, environmental, technological, economic, and policy conditions. In summary, the report shows the following:

- A review of the literature on the impact of crop prices on yields indicates that the coefficient estimates of crop prices are statistically significant in a number of studies, i.e., they are significantly different from zero. However, there are some studies in which these coefficient estimates are statistically insignificant.
- Keeney and Hertel (2008) reviewed a number of studies that found a significant impact of crop prices on yields. In these studies, the elasticity of corn yield with respect to the price ratio of corn to fertilizer ranged from 0.22 to 0.76. This implies that a 1% increase in the price of corn results in a 0.22% to 0.76% increase in corn yields.
- The impact of fertilizer and other inputs on crop yields is positive and statistically significant, so the increased use of such inputs could increase the amounts of available biofuel feedstock.
- For many APEC economies, there is room for yield growth through increased input use, technological change, better farm management, etc.
- For APEC economies with high yields, there is potential for continued yield growth through agricultural R&D (biotechnology).
- Studies that examined the impact of biofuel expansion on world agriculture have found that:
  - The crude oil price is a key determinant of biofuel expansion since it provides added incentive to use alternative fuels;
  - Long-term expansion of biofuels may have to rely on the economic viability of ethanol production from cellulosic feedstocks;
  - Biofuel expansion will imply increased land use for feedstock production in the medium term, but growth in feedstock yields will tend to mitigate the impact on crop prices and land use over the longer term.

- Historical trends of crop yields in APEC economies are summarized in the tables below.

Table ES-1. Trends in APEC Biofuel Feedstock Yields by Commodity, 1998-2008

| Commodity | Average Yield (tons/hectare) All APEC | Range of Yields (tons/hectare) Across APEC | Average Annual Yield Change (%) | Range of Annual Yield Change (%) |
|---|---|---|---|---|
| Sugarcane | 76.2 | 52.3 to 113.0 | 0.3 | -1.8 to 3.1 |
| Corn | 6.3 | 2.1 to 10.5 | 3.2 | 0.7 to 13.7 |
| Rapeseed | 1.5 | 1.0 to 2.4 | 3.2 | -0.04 to 12.1 |
| Palm Oil | 3.6 | 2.5 to 4.0 | 2.2 | -0.1 to 4.3 |
| Soybeans | 1.9 | 1.3 to 2.7 | 1.6 | -0.15 to 8.0 |
| Wheat | 3.8 | 1.3 to 7.0 | 2.7 | 0.4 to 10.2 |
| Sorghum | 2.8 | 1.0 to 4.0 | 1.8 | 0.5 to 4.7 |
| Sugar beet | 41.9 | 21.2 to 59.0 | 3.3 | 1.7 to 5.4 |

Note: Averages are computed over APEC economies and over the 1998-2008 time period. Ranges are calculated as the average for each APEC economy between 1998 and 2008.

As the above table shows, both yield levels and growth rates vary widely within each commodity. For the key biofuel crops, compounding the average rates of yield growth over the coming decades implies that yield improvements will continue to increase feedstock supply thus mitigating land expansion and its potential adverse impacts.

- The range of historical yield growth by crop is presented in the following table. The crop yield growth rate varies significantly among economies and among crops. Corn ranks among the crops with the largest yield improvement in a significant number of the APEC economies.

Table ES-2. Historical Average Growth in Crop Yields by Economy, 1960-2008

| Economy | Average Annual Growth in Crop Yield (%) | |
|---|---|---|
| | Lowest Growth Rate | Highest Growth Rate |
| Australia | 0.4 (sugarcane) | 8.2 (soybeans) |
| Canada | 1.7 (rapeseed) | 3.3 (wheat) |
| Chile | 3.0 (rice) | 6.8 (rye) |
| China | 0.8 (sugarcane) | 4.9 (sugar beet) |
| Indonesia | -1.3 (sugarcane) | 1.8 (corn) |
| Japan | -1.0 (corn) | 2.7 (wheat) |
| Malaysia | 1.1 (rice) | 2.3 (corn) |
| Mexico | -0.1 (soybeans) | 3.5 (barley) |
| New Zealand | 2.4 (wheat) | 2.9 (corn) |
| Peru | 0.1 (sugarcane) | 3.3 (soybeans) |
| Philippines | 0.4 (sugarcane) | 3.3 (corn) |
| Russia | 0.3 (sunflower) | 9.9 (corn) |
| Korea | 1.6 (rice) | 9.2 (wheat) |
| Chinese Taipei | -0.3 (wheat) | 10.1 (sorghum) |
| Thailand | 0.7 (peanut) | 3.3 (corn) |
| United States | -0.1 (sugarcane) | 3.3 (corn) |
| Viet Nam | 1.7 (peanuts) | 3.4 (corn) |

- The yield of key biofuel crops among APEC members is summarized as follows:
  - Sugarcane yields have been fairly stable with the exception of significant growth in China, Philippines and Thailand;
  - Corn yields have shown stronger growth compared to other crops because of increased fertilizer use and biotechnology;
  - One of the highest soybean yields is seen in the United States, which is a major producer. Yields in China and Indonesia are lower relative to the United States, but show much lower variability over time;
  - In the past decade, palm oil yields have increased dramatically in Indonesia.

- Projections of yield growth in APEC economies show a wide range of growth rates among economies and among crops (see table below).

Table ES-3. Projected Improvements in Crop Yields by Economy

| **Economy** | **Ten-Year Growth (%) in Crop Yield 2008/09–2018/19** | |
|---|---|---|
| | **Lowest Growth** | **Highest Growth** |
| Australia | 2.4 (rice) | 29.2 (wheat) |
| Canada | 3.7 (barley) | 10.2 (corn) |
| China | 1.6 (wheat) | 14.1 (rapeseed) |
| Indonesia | 3.9 (rice) | 11.6 (palm) |
| Japan | 0.3 (wheat) | 11.9 (sugarcane) |
| Malaysia | 3.0 (sugarcane) | 11.4 (palm) |
| Mexico | 2.7 (corn) | 13.1 (barley) |
| Peru | Not Available | 17.3 (sugarcane) |
| Philippines | 9.3 (corn) | 13.5 (rice) |
| Russia | -13.1 (barley) | -3.7 (wheat) |
| Korea | 0.9 (wheat) | 10.9 (corn) |
| Chinese Taipei | 1.4 (rice) | 7.2 (corn) |
| Thailand | 5.9 (sugarcane) | 13.0 (corn) |
| United States | -0.5 (peanuts) | 16.3 (soybeans) |
| Viet Nam | 6.1 (corn) | 9.9 (rice) |

Source: FAPRI Preliminary Projections (2008)

- A given percentage increase in crop yields would be accompanied by the same percentage increase in available crop residue. According to the Survey of Biofuel Resource Assessments and Assessment Capabilities in APEC Economies (Milbrandt and Overend, 2008), ethanol from currently available crop residues could potentially displace about 33% of gasoline (petrol) consumption in the APEC region, assuming that cost-competitive technologies for production of ethanol from second-generation lignocellulosic feedstocks can be deployed. Thus, for example, a 10% increase in average APEC crop yields over a 10-year period (slightly less than a 1% increase per annum) could potentially displace an additional 3.3% of gasoline (since 0.33 x 0.10 = 0.033). The table below gives the gasoline replacement share from crop residue for a select number of APEC economies.

Table ES-4. Gasoline Replacement Share by Crop Residues

| Economy | Potential Gasoline Replacement by Farm and Forest Residue | Farm Residue Share in Total Farm and Forest Residue | Ten-Year Yield Growth Projection (Average) (2008/09-2018/19) | Final Gasoline Replacement by Crop Residue[1] (Columns 1X2X3) |
|---|---|---|---|---|
| Australia | 36.0% | 81.7% | 29.2% for wheat | 8.6% |
| United States | 49.0% | 34.9% | 12.7% for corn | 2.2% |
| Thailand | 130.0% | 45.2% | 5.9% for sugarcane | 3.5% |

Note: Average yield growth projections are computed for each crop for the 2008/09-2018/19 time period.

- An examination of the elasticities of yield with respect to time for various APEC economies reveals that:
  - In most economies, corn has the highest responsiveness of yield over time;
  - Across economies, China shows consistently higher elasticities for most crops;
  - Across crops, sorghum has the highest elasticity in China, corn in the Philippines, sugar beet in Canada, wheat in New Zealand, rice in Indonesia, and sugarcane in Malaysia.

- The report concludes that:
  - In terms of first-generation biofuels, yield growth is imperative for the long-term potential for biofuel expansion in APEC economies;
  - Based on the literature and the data analysis, APEC economies have the capability and the capacity to increase feedstock yields for biofuel production;
  - This requires targeting yield-enhancing activities including investments in agricultural R&D, better farm practices, and increased input use.
  - Some of the practices that have resulted in yield improvements, such as extension services and fertilizer subsidies, could be transferred to other APEC economies. APEC economies may also provide incentives, such as tax reductions or government payments, which have proven to be successful in inducing farmers to invest in yield-improving technologies.

[1] These computations are based on the strong assumption that each economy will use crop residues from the current predominant biofuel feedstock, and that the yield of the crop residue grows by the same percent as that of the crop.

## Introduction

There has been continuous debate on the impact of biofuels expansion on the agricultural sector, food production, and the environment. Some argue that with agricultural feedstocks being used for the production of fuel for transportation, namely ethanol and biodiesel, biofuels are bidding land away from food production for energy production. In this view, the prices of the feedstocks such as corn and soybeans are rising because of increased demand, while the prices of other crops are also increasing as land is “lost” to biofuels production, resulting in an increase in all major agricultural commodity prices. The land extensification brought about by biofuel expansion is also said to have environmental implications.[2]

The counterargument is that while increased demand for agricultural feedstocks for biofuel production has led to some increase in crop prices, the dramatic increase in prices in 2007 and 2008 was the result of many factors, including increases in crude oil prices and increased demand from countries with rising incomes. The impact of biofuels expansion on commodity prices can be mitigated by improvements in yield such that both land expansion and land reallocation is limited. The increase in crop prices is a catalyst for higher investments in agricultural productivity such that land intensification, rather than land extensification, occurs. The result of this increased productivity and yield improvements is that there is reduced competition for land between different uses so that there is enough land to produce both fuel and food without significant increases in crop prices. Moreover, as technologies develop for the commercial production of biofuels from non-food feedstocks such as farm and forest residues, biofuels can expand without competing for crops used in food production. Biofuels may also contribute to reducing the transportation cost component of total food costs.

The objective of this report is to assess the biofuel resource elasticity in APEC economies so as to determine the impact of biofuel expansion on the agricultural sector. Since the potential for developing biofuel industries in APEC economies depends on a constant supply of feedstocks and since land is a major component, a biofuel resource assessment is imperative. The report is organized as follows:

- First, an overview of the literature is provided with discussions of the major factors impacting crop yield (such as commodity prices and fertilizer use), the impact of biotechnology on crop production, and the economic models that were used to examine the impact of biofuel expansion on agricultural markets.

- Next, historical data on agricultural land resources, crop yields and yield elasticities over time are presented for APEC economies. An assessment of each individual APEC economy’s projected potential in terms of supply of crops through area and yield is provided in an Appendix.

- Finally, a discussion of the findings and conclusions is presented.

[2] For more details on the impact of biofuel expansion on greenhouse gas emissions through indirect land use changes, see Searchinger *et al*. (2008) and Fargione *et al*. (2008).

## Review of Literature on Crop Yields, Prices and Technology

### Factors Affecting Crop Yield

A number of studies have examined the factors affecting crop yields. Most of the studies explain yield as a function of a variety of explanatory variables including rural labor input, fertilizer use, capital use, technological change, among others. Table 1 shows the key variables that have been listed in the literature as impacting crop yield either positively or negatively. As Table 1 and the literature below suggests, there is not one key factor affecting crop yields. Yields are determined by a myriad of factors ranging from climatic, environmental, technological, economic, and policy conditions. The literature review shows that the impact of these factors cannot be analyzed separately.

Table 1. Factors Impacting Crop Yield

| ***Positive Impacts*** |
|---|
| Technological change through public and private R&D (development of varieties such as commercial hybrids, genetically modified crops) |
| Technological diffusion |
| Input use such as fertilizer |
| Climate conditions |
| Resource conditions (water, infrastructure, etc.) |
| Land improvements (drainage and soil conservation) |
| Adoption of conservation tillage techniques |
| Denser planting (narrower rows) |
| Earlier planting |
| Irrigation |
| Pest control |
| Weed control |
| Farm programs |
| ***Negative Impacts*** |
| Land degradation (soil loss, compaction, loss of fertility) |
| Adverse climate conditions |
| Limited resource conditions (water, infrastructure, etc.) |
| Rain-fed (NOT IRRIGATED) |

#### *Relative Impacts of Physical and Socioeconomic Factors on Crop Yield*

According to Menz and Pardey (1983), yield is a function of the environment, technology, skill of farmers, water, temperature, disease, insects, and weed.

Kaufmann and Snell (1997) also integrated both climatic (physical) and socioeconomic determinants of corn yield in the United States based on crop physiology and economic behavior (such as management decisions, the use of purchased inputs, size of farms, level of technology, and quality of land). They found that corn yield is determined by both the physical and socioeconomic environment, with the socioeconomic variables accounting for the larger impact.

Chang (2002) evaluated the impact of climate variations on the yield of various cereal, pulses, roots, vegetables, fruits and special agricultural commodities in Chinese Taipei. Results suggest that variations in temperature and precipitation have a significant impact on yield of many crops. Temperature variations are relatively favorable to crop yield, whereas precipitation variations generally adversely affect yield growth. A welfare analysis of various temperature and precipitation scenarios was conducted, and the author found that the impacts of temperature rise on farmers in Chinese Taipei could be beneficial when adaptation is taken into account. In contrast, increase in rainfall intensity could be harmful to farmers' welfare.

A study by Rosen *et al.* (2008) found that the low and inconsistent crop yield in Africa is due to multiple causes including lack of water. Rain-fed agricultural land often suffers from lower yield and greater yield variability than irrigated land and higher yield requires fertilizer use, pesticides, and herbicides.

In a study on Zimbabwe, Myers and Jayne (1997) found empirical evidence of the impact of introduction of hybrid seed varieties on trend yield growth of maize. However, in order for technology diffusion to succeed, the proper performance of input and output markets, extension system, and infrastructure is required. In particular, diffusion of improved seed varieties required increased use of inputs such as fertilizers, chemicals, and water control.

Hafner (2003) evaluated the global trends in the yield of corn, rice and wheat between 1961 and 2001. A total of 188 nations in the database of the United Nations Food and Agriculture Organization (FAO) were evaluated. Each data set was classified into one of the five categories (substantial growth, moderate growth, slowing growth, declining, or no trend) based on a statistical test. Results suggested that most of the evaluated countries have shown a trend of linear growth in yields during the study period, with almost 20% showing significant growth in the yield of corn, rice and wheat. (where significant growth is defined as an increase in output of greater than 33.1 kilograms per hectare per year, that being the rate at which cereal yields must reach to maintain the current per-capita production by 2050, given an estimate of 9 billion people in 2050 by United Nations). This study also found the differences of yield growth among those five categories are primarily related to economic and biophysical factors, such as per-capita GDP, fertilizer usage, and latitude, instead of the general physiological limits.

### *Impact of Fertilizer on Crop Yield*

Malone *et al*. (2007) looked at crop yield as a function of temperature, rainfall, fertilizer amounts, fertilizer timing, and fertilizer source (for northeastern Iowa). They found that corn yield increased with increasing rain and nitrate application, with below-average July and August temperatures, and with above-average July and August rainfall.

Vera-Diaz *et al.* (2008) found that climatic and edaphic conditions, economic factors, such as government credits, and fertilizer use have a positive and statistically significant impact on soybean yield in the Brazilian Amazon, while transportation costs had a negative yield impact in the region. According to their analysis, a 1 kg increase in fertilizer use would increase soybean yields by nearly 215 g per hectare.

Baker *et al.* (2004) tried to determine the profit-maximizing Nitrogen fertilization levels of Hard Red Spring Wheat for various wheat prices through controlling factors like Nitrogen application rate, seeding rate, variety that affect the yield and the protein levels. Their study was conducted in the United States using data from the southeastern portion of the state of Washington. They also found that the impact of applied fertilizer on marginal wheat yield declines as the overall levels of nitrogen fertilizer use rise. The empirical analysis showed that the coefficient estimate for applied Nitrogen level (in kilogram per hectare) was 0.02741 with a t-statistic of 15.11, with wheat yield (in metric tons per hectare) as the dependent variable. So an extra kg per hectare of fertilizer would yield about 27.4 kg per hectare of wheat, plus or minus 3.6 kg, with 95% likelihood.

Egli (2008a) compared historical yield trends of corn and soybeans in high yield Midwestern states and low yield Southern states in the United States and found that corn yield increased significantly due to adoption of high input systems including commercial hybrids, manufactured Nitrogen fertilizer, herbicides, and higher plant populations. Soybean yield also increased steadily from the beginning, although corn yield increased faster than soybean yield in the early decades of the high-input era. For the rest of the period, both crop yields grew at the same rate. The study concluded that "the efforts to improve the plant and production environment had essentially the same affect on these two very dissimilar crops" (page 79).

Smith, McKenzie, and Grant (2003) examined the impact of various factors on the CWRS wheat yield for six agro ecological areas in the Canadian prairies for the period 1997-2000. They estimated that the elasticity of wheat yield was 0.156 with respect to available Nitrogen, 0.625 with respect to total moisture, and -1.119 with respect to growing degree days (where degree days are the number of days in the growing season times the average number of degrees by which temperature exceeds 5 degrees Celsius during the day in the course of the season).

***Impact of Commodity Prices on Crop Yield***

A number of studies have examined the price impact on crop yield. A prominent study is Houck and Gallagher (1976), which analyzed the price responsiveness of U.S. corn yield when both input and output prices are considered. Their empirical analysis results showed evidence of the price responsiveness of corn yield. They showed that yield increases with higher corn to fertilizer price ratio. Yield elasticities with respect to the ratio of corn to fertilizer prices ranged from 0.24 (with a t-statistic of 3.11) to 0.76 (with a t-statistic of 6.33). At the lower end, this means that a doubling of the price ratio would result in a 24% increase in corn yields, plus or minus 14% (i.e., between 11% and 38%), with 95% confidence.[3] Similarly, at the higher end, a doubling of the price ratio would lead to a 76% rise in corn yields, plus or minus 24% (or between 52% and 99%), with 95% confidence. The specification of the equation also impacted the estimates of the yield elasticities. In the cases where a linear trend variable was used as an additional explanatory variable, the yield elasticities with respect to the ratio of corn to fertilizer prices were in the range of 0.24 to 0.28. In the cases where the natural log of trend variable was used as an additional explanatory variable, the yield elasticities with respect to the ratio of corn to fertilizer prices were in the range of 0.68 to 0.76.

Choi and Helmberger (1993) tried to replicate Houck and Gallagher study for the United States using times series data from 1954 through 1988 for corn, wheat and soybeans. They found that the yield response of crops to output price changes is modest for wheat and soybeans and on the low end of the range that Houck and Gallagher reported for corn. The estimated elasticities of crop yield with respect to crop price were 0.27 for corn, 0.13 for soybeans, and 0.03 for wheat.[4]

Additionally, Menz and Pardey (1983) replicated Houck and Gallagher's estimate of yield response in the U.S. for the period 1951-1971, but failed to identify a significant yield price relationship beyond 1971. The impact on corn yield of a price ratio (lagged average price of fertilizer divided by the price of corn) was statistically significant for the1951-1971 period, with a coefficient estimate of -0.45 and t-value of 5.17. This implies that a doubling of the ratio of fertilizer price to corn price meant a 45% decline in corn yield, plus or minus 18% (a decline between 27% and 63%), with 95% confidence. But for the period from 1972-1981, the coefficient was just -0.33 with a t-value of 1.34, which does not afford a high degree of confidence that the impact differs from zero.

The study also showed a measurable and statistically significant contribution of nitrogen and non-nitrogen technologies to corn yield increases. The authors used a time trend as an explanatory variable as a proxy for non-nitrogen technology. The empirical analysis showed that the averaged annual corn yield increase (bushel/acre/year) resulting from nitrogen technology was 1.98 bushels per acre per year for the period from 1954 to 1960, 1.73 bushels per acre per year for the period 1961-1970, and 0.33 bushels per acre per year for the period 1971-1980. The averaged annual corn yield increase resulting from non-nitrogen technology was 0.95 bushels/acre/year for 1954-1980.

Lyons and Thompson (1981) showed that a significant part of the observed corn yield differences among major corn producers can be explained by the differences in the corn-nitrogen price ratio in these countries. They used pooled time series data for 14 countries (United States, Canada, Mexico, Brazil, France, Spain, Italy, Hungary, Yugoslavia, Egypt, South Africa, Pakistan, Thailand, and the Philippines) for the time period 1961-1973. They claimed that the results of this study provide evidence that policies which distort corn and fertilizer prices have a significant effect on corn yields.

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[3] The standard deviation used in determining the confidence intervals was calculated using the coefficient estimate and the t-statistic provided in the paper.

[4] Because they do not separate out the effects of technological change, Choi and Helmberger admit that their yield-price elasticity for corn is upwardly biased and thus likely to be less than 0.27.

The elasticity of cross-country yield with respect to price of corn over the price of nitrogen ratio was computed as 0.22, with a t-statistic of 3.13. This means a doubling in the ratio of corn price to fertilizer price increased corn yields by about 22%, plus or minus 14% (by between 8% and 36%), with 95% confidence.

Keeney and Hertel (2008) reviewed a number of studies, including those mentioned above, to examine the importance of the yield-price relationship. They used the average yield price elasticity for corn from these studies (0.4) in their analysis. Table 2 presents a summary of Keeney and Hertel's review of the different studies examining the yield price response for corn. As the table shows, the elasticities range from 0.22 to 0.76, which implies that a 1% increase in the price of corn results in a 0.22% to 0.76% increase in corn yields.

Table 2. Yield Price Response for Corn

| **Authors** | **Period** | **Data** | **Elasticity** | **Economy** |
|---|---|---|---|---|
| Houck and Gallagher | 1951-1971 | Time series with log trends | 0.76 | United States |
| Houck and Gallagher | 1951-1971 | Time series with log trends and acreage control | 0.69 | United States |
| Houck and Gallagher | 1951-1971 | Time series with linear trends | 0.28 | United States |
| Houck and Gallagher | 1951-1971 | Time series with linear trends and acreage control | 0.24 | United States |
| Menz and Pardey | 1951-1971 | Time series with log trends and acreage control | 0.61 | United States |
| Choi and Helmberger | 1964-1988 | Time series without trend | 0.27 | United States |
| Lyons and Thompson | 1961-1973 | Pooled time series | 0.22 | 14 economies |

Source: Keeney and Hertel, 2008

Hertel, Stiegert and Vroomen (1996) noted that if yield response occurs primarily through growth in farm size by best managers, then the gap between realized and potential yields may well have narrowed, leaving less room for price to impact output. If prices spark technological innovations, then the potential yields may themselves increase as a result of the biofuels boom, thereby widening the gap.

***Yield Plateaus***

Furthermore, in the discussion on factors impacting yield growth, there has also been some debate on whether a yield plateau has been reached.

Studies that have concluded that a yield plateau has been reached include Brown (1994), Oram and Hojjati (1995), Pingali *et al.* (1997), Calderini and Slafer (1998), and Cassman *et al.* (2003). Particularly for rice and wheat, some literature suggests that yields may have reached plateaus in some countries (Pingali, Hossain, and Gerpacio (1997), Calderini and Slafer (1998), Cassman *et al.* (2003)).

Alternatively, Reilly and Fuglie (1998) disputed the existence of a yield plateau in the United States. They suggested that the major factors that contribute to yield growth are fertilizer use, denser planting, and development of varieties. According to Reilly and Fuglie, genetic changes are significant in yield growth. Genetic improvements lead to commercial yield growth depending on climatic, commercial, and resource conditions. Other factors are land degradation (soil loss, compaction, loss of fertility) and land improvements (drainage, soil conservation), irrigation, pest control, farm management, and public and private R&D. It should be noted that Reilly and Fuglie’s arguments regarding yield plateaus do not necessarily conflict with indications in other studies (like Menz and Pardey) that yields have plateaued with respect to fertilizer application.

Egli (2008b) also argued that there is no convincing evidence that U.S. yields are reaching plateaus in the case of soybeans. His study focused on soybean yield trends from 1972 to 2003 in Midwestern United States utilizing county level data in six production systems. He found that soybean yield increases are usually attributed to cultivar improvement and better management practices (narrower rows, weed control, earlier planting, adoption of conservation tillage techniques). Menz and Pardey (1983) also claimed that no yield plateau has yet been reached for corn.

## The Impact of Biotechnology on Crop Production

The agricultural sector in many economies has experienced great gains in productivity, particularly since the mid-twentieth century. Also, in many economies, productivity growth is the main source of agricultural output growth. There is extensive literature that has focused on understanding the determinants of this productivity growth. This literature suggests that public and private research and development (R&D) investments played a crucial role in realizing productivity growth. Biotechnology is the most recent result of these R&D investments and it has contributed to gains in productivity and reduced costs of production in the agricultural sector. Biotechnology has introduced Genetically Modified (GM) crops, which have transformed the agricultural sector immensely.

The GM crops mostly have the characteristic of being herbicide resistant or insect resistant, and therefore have a strong positive impact on the farmers’ profitability. These innovations result from the efforts of private national or multinational companies and research institutions, and are available to farmers through purchase of seeds (Roundup Ready (RR), Bacillus thuringiensis (Bt) corn, etc.), leading to diffusion of technology.

There has been wide adoption of GM crops in some economies and resistance in others. In 2007, more than 114 million hectares in the world have been planted with GM crop varieties, up from 102 million hectares in 2006 and 90 million hectares in 2005. Table 3 shows the crop area planted with GM crops for selected countries over the years (Moschini 2008).

Table 3. Crop Area Planted with Genetically Modified Crops (million acres)

| Economy | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| United States | 42.8 | 47.6 | 49.8 | 54.6 | 57.7 |
| Argentina | 13.9 | 16.2 | 17.1 | 18.0 | 19.1 |
| Brazil | 3.0 | 5.0 | 9.4 | 11.5 | 15.0 |
| Canada | 4.4 | 5.4 | 5.8 | 6.1 | 7.0 |
| India | NA | 0.5 | 1.3 | 3.8 | 6.2 |
| China | 2.8 | 3.7 | 3.3 | 3.5 | 3.8 |

Source: Moschini (2008)

The United States is a leading economy in this regard. In 2007, 57.7 million hectares in the United States were planted with GM crop varieties, up from 54.6 million hectares in 2006 and 49.8 million hectares in 2005. In 2007, 21% of U.S. corn planted acreage was insect-resistant corn, 24% was herbicide resistant corn, and 28% was stacked gene varieties. A total of 73% of corn planted acreage was of biotechnology varieties. In the same year, 91% of soybeans planted acreage in the United States was herbicide-resistant soybeans (NASS 2008).

Since agricultural biotechnology has been adopted widely in the United States and other economies, studies have attempted to identify agricultural biotechnology's direct impact on farmers through yield and profit margins. RR soybeans and Bt corn were the first highly successful GM crops. Moschini, Lapan and Sobolevsky (2000) described the RR soybeans market which was developed by Monsanto. RR soybeans are tolerant to a particular herbicide and allow farmers to decrease their costs of production. Farmers pay a price premium for this soybean variety compared to the traditional ones. RR soybeans allow over-the-top applications of Roundup, which is an effective weed control product. Thus, through lower herbicide expenses, farmers' costs of production are cut.

The impact of RR on the soybean yields is discussed in the literature, with contradictory reports. Extension (1998) and Oplinger *et al.* (1998) found that RR soybeans were less productive than traditional soybean varieties. Van Meijl and van Tongeren (2004) also stated that the yield of GM soybeans is lower than that of traditional soybeans. In contrast, Monsanto (2008) claimed that RR varieties outperformed standard varieties in the United States in 1997 and 1998. It should also be noted that better weed control by RR may improve the average yield.

Another important GM crop is Bt corn which is resistant to European corn borer because it produces its own insecticides. In corn, the productivity impact of GM technology is clearly positive as stated in Van Meijl and van Tongeren (2004), European Commission (2000), and Gianessi and Carpenter (1999). For corn, some Bt varieties that are resistant to the corn rootworm are also available.

Other examples of GM crops are cotton, rapeseed, tobacco, and potatoes. Wheat and rice are crops for which GM technology is either lagging or not commercially available (Moschini 2008).

A recent study by Brookes and Barfoot (2008) estimated the economic and environmental impacts of GM crops for the period between 1996 and 2006. They incorporated the impact of GM technology on yield, costs of production, crop quality, and the scope of facilitating a second crop in a season in their analysis. They found that GM technology has increased farm incomes due to productivity and efficiency gains. The crops that they analyzed were GM herbicide-tolerant (HT) soybeans, GM HT corn, GM HT cotton, GM HT canola, GM insect-resistant (IR) corn, GM IR cotton. Table 4 shows the baseline assumptions the study used in terms of the impacts of GM technology on crop yield. The authors gathered the data from previous literature and used conservative estimates of the impact on yield. In Table 4, the results for some APEC economies are reported for soybeans, corn, and canola.

Table 4. Impact of GM Technology on Crop Yield

| Crop | Economy | Yield Change |
|---|---|---|
| GM HT soybeans | US | None |
| | Canada | None |
| | Mexico | +9.1% |
| GM HT corn | US | None |
| | Canada | None |
| | Philippines | +15% |
| GM HT canola | US | All years = +6% |
| | Canada | All years = +10.7% (but applied to a reduced share of GM HT crop in line with adoption of hybrid varieties-applied to 50% of GM HT area in 2004, 37% in 2005, and 29% in 2006) |
| GM IR corn | US | All years = +5% |
| | Canada | All years = +5% |
| | Philippines | All years = +24.5% plus 10% price premium for better quality |
| GM IR (corn rootworm) corn | US | 5% |
| | Canada | 5% |

Source: Brookes and Barfoot (2008)

***Diffusion of Technology***

The adoption rate of a new technology depends on multiple external factors, such as heterogeneity among users, uncertainty, information considerations, and licensing (Moschini, Lapan and Sobolevsky (2000)). Van Meijl and van Tongeren (2004) also discussed several factors that speed or slow technology spillovers. They identify a country's absorption capacity, structural similarity between the innovating and the adopting country, and level of consumer acceptance to GM crops. The respect of intellectual property rights across economies is crucial as well.

Since agricultural biotechnology is seen as an important instrument for poverty reduction, agricultural development, and economic growth in developing economies, many studies have analyzed the impact of agricultural biotechnology on farmers in developing economies and why this process has been rather limited and slow. A study by Spielman, Cohen, and Zambrano (2006) identified the main barriers to dissemination of agricultural biotechnology research and GM crops to resource-poor and small-scale farmers in developing economies. They found that the regulatory environment in these economies is slowing the movement of research and new technologies into the later stages of product development. The efforts that focus on the movement to later stages have not made much use of available information from other economies on efficacy and safety. Furthermore, public research institutions that lead the agricultural biotechnology research in developing economies mostly operate in isolation from the private sector which is the leader in this arena.

The solutions that the authors offer are more investment in the design and implementation of biosafety regulations, construction of clearinghouses for information on agricultural biotechnology, and policy incentives to promote public-private research partnerships. These policy incentives include tax incentives for poverty-reducing research and government programs to commercialize the existing research, competitive research grants and awards, restructuring of incentives for the management and use of intellectual property.

***The Determinants of Technical Change and R&D***

There have been numerous studies that attempted to explain technical change in the agricultural sector. Hayami and Ruttan (1985) developed a theory of induced innovation that tried to incorporate technical change as a process that is endogenous to the economic system. They identified the conditions of factor supply and product demand as the venues for technical change. Griliches (1988) also observed that both the level and the rate of adoption of new agricultural techniques respond to economic incentives. He claimed that variations in adoption could be explained by variables that represent the profitability of such adoptions.

There is also extensive literature on the determinants of public and private R&D investments in both developed and developing economies. In the United States, agricultural R&D activities historically have been dominated by the public sector. However, in recent years, the private sector has become an important factor in R&D activities for the U.S. agricultural sector. There are different factors responsible for this, such as improvements in the biotechnology sector and strengthened patent protection for biological inventions that help private firms find new sources of profit from agricultural R&D and secure better returns from their investments (Agricultural Outlook (1999), Fuglie *et al.* (1996)).

One study that focuses on factors that affect private agricultural R&D investments is Alafranca and Huffman (2001). The authors conducted an empirical study to examine the effects of economic incentives and institutions on private agricultural R&D investments. They analyzed the relation between public and private R&D sectors and found that, in their sample economies, lagged public research capital reduces current agricultural private R&D expenditure.

Tokgoz (2006) analyzed the determinants of private agricultural R&D investments in the United States and the linkages between public and private R&D efforts. The empirical analysis showed that federal agricultural R&D obligations for basic research in the United States had a significant and positive impact on private agricultural R&D spending. Applied public R&D activity did not have a significant coefficient estimate. The study also employed an index of prices received by farmers in the United States and found that it does not have a significant impact on the resources allocated to agricultural R&D by the private sector.

## Economic Models Examining the Impact of Biofuel Production Expansion on Agricultural Markets

The recent expansion of biofuels has drawn great interest in their potential as an alternative source of energy and their impact on agricultural markets since the current primary feedstocks for ethanol and biodiesel production are field crops and their derived products. A number of studies have developed various quantitative models to measure the impact of biofuel production on the prices and trade of agricultural commodities.

Ferris and Joshi (2005) examined the impact of the renewable fuels standard (RFS) introduced in the Energy Policy Act of 2003 (EPACT03) on the U.S. agricultural sector between 2005 and 2015. They employed an econometric-simulation model to produce a baseline with a lower projection of ethanol and biodiesel consumption over the next 10 years, and then generated a scenario adopting higher levels of the biofuel mandate. Their results suggested that the expansion of biofuel production will increase crop prices. Harvested area of corn increases at the expense of other crops. Government payments to farmers are reduced as farmers' revenue increase with higher crop prices. However, their analysis shows that the higher agricultural commodity prices from ethanol production expansion will have very small impacts (about 1%) on food prices.

De La Torre Ugarte *et al*. (2006) assessed the potential impact of producing 60 billion gallons of ethanol and 1.6 billion gallons of biodiesel from renewable resources by 2030. The primary engine for this analysis is an agricultural simulation model (POLYSYS) along with an input-output model (IMPLAN). The POLYSYS model is structured as a system of interdependent modules including crop supply and demand, livestock supply and demand, and agricultural income. The authors generated a baseline by calibrating the POLYSYS output with publicly available projections, such as U.S. Department of Agriculture or FAPRI projections, and then imposed the high biofuel mandates in the models. They found that nearly 35 million acres (14.2 million hectares) will be used for renewable energy purposes. The 60 billion gallons of ethanol, however, will not only rely on field crops: commercialization of cellulosic ethanol by 2012 is a crucial key to make the targeted production of ethanol possible. If cellulosic ethanol were not commercially viable until 2015, significant pressure on corn prices could be expected. Like Ferris and Joshi, the authors believed that the development of the biofuel sector can create a great opportunity for rural areas.

Von Lampe (2005) analyzed the impacts of future growth in biofuel production on agricultural markets using the Organization for Cooperation and Development (OECD) partial equilibrium model (AGLINK) in connection with the Food and Agricultural Organization (FAO) model, and the OECD World Sugar Model. AGLINK is a dynamic model representing annual supply, demand and prices for the principal agricultural commodities in the OECD member economies and three non-OCED economies/regions (Argentina, China, and the Rest of the World). The principal agricultural commodities include temperate crops, dairy, livestock, and meat products. Through the prices of each commodity, AGLINK connects the feed, food and biofuel markets. This study incorporated the information on production technologies, costs and policies in major biofuel producing and consuming economies, including EU-15, the United States, Brazil, India, Thailand, China, Australia, Canada, and Japan. Three scenarios of biofuel expansion were evaluated: constant biofuels, policy-target, and high crude oil price scenarios. The author found that crude oil prices have an important influence on the development of the biofuel industry in these countries. Results also suggested that 10% of transport fuel consumption replaced by biofuel will generate significant area requirement for the feedstocks in the United States, Canada and the EU-15. In addition, the projected utilization of agricultural commodities is substantially affected by the growing biofuel production.

Koizumi and Ohga (2006) examined the impact of the Chinese fuel-ethanol program on world ethanol and corn markets. The model developed in this study includes a corn market in China, the United States, Argentina, Brazil, Korea, Japan, South Africa, and the Rest of the World. Each economy’s corn market is composed of the equations of production, consumption, trade, and ending stocks. The world market equilibrium and price are determined by equating world total exports and world total imports. The authors created a scenario where nine provinces in China implement an E-10 program (i.e., gasoline is blended with 10% ethanol) beginning in 2007/08. Through international corn and ethanol models, this study showed that Chinese corn imports will increase considerably and the world corn price increases in response. The U.S. farmers benefit from the higher prices and expand corn exports to meet the additional demand from China.

Tokgoz *et al*. (2008) generated a long-run prospect for biofuel expansion and its impact on planted acreages, crop prices, livestock production, trade, and retail food prices by using a multi-country, multi-commodity, and partial equilibrium models for U.S. and global crop and livestock markets. In these models, extensive market linkages exist, reflecting derived demand for feed in livestock and dairy sectors, competition for land in production, and consumer substitution possibilities for close substitutes such as vegetable oils and meat types. Results showed that expanded U.S. ethanol production will cause long-run crop prices to increase. If crude oil prices rise, the U.S. ethanol sector expands further. Ethanol expansion increases demand for corn, which in turn increases corn acreage and reduces soybean and wheat areas. All crop prices increase both in the United States and in the global markets.

Gohin (2008) applied a Computable General Equilibrium (CGE) framework to evaluate the impact of the European Union (EU) indicative biofuel promotion policy on the farm sector in the EU-15 economy. The author used the original Global Trade Analysis Project (GTAP) model to generate the baseline and then simulated the impacts of EU biofuel policy in the bioenergy and vegetable oil markets. GTAP is a multi-sector, multi-region CGE model, hence is capable of capturing the links between energy, transport and agricultural markets. The simulation results showed that the price and production of arable crops increase, while the livestock sector suffers because of the increasing production costs. The import demand for vegetable oil also rises to meet biodiesel production. The study finds a 3.3 billion Euros increase in farm income resulting from this biofuel policy.

Banse et al. (2008) modified the GTAP model to evaluate impact of biofuel policies on the agricultural sector, particularly emphasizing land-use change. The authors incorporated the energy-capital substitution in the GTAP model, that is, the substitution between different categories of oil, ethanol, and petroleum products is created in the value-added nest of the petroleum sector. With this nest structure, the biofuel demand is generally determined by the relative prices of crude oil versus agricultural commodities. The other key innovation of this extended GTAP model is that the land supply is not exogenous, but takes into account the land rental rate in each region. Like Gohin's study, the simulation results also suggested an increase in crop prices and farm income, leading to an increase in land use. The authors concluded that without the EU biofuel policy, the targets will not be reached as the EU Commission suggested.

To sum up the various analyses of the impacts of biofuels on agricultural markets, several conclusions can be generated:

- Biofuels production will be affected by petroleum prices significantly. A strong energy price will create economic incentives for the use of alternative fuels.

- Expansion of biofuel production from agricultural feedstocks will tend to increase land use and crop prices. However, the magnitude of the impact varies among studies, which will be influenced by technical factors such as crop yields.

- Commercialization of cellulosic ethanol from non-food feedstocks is essential for long-term expansion of biofuel markets.

## Agricultural Land Resource and Crop Yield in APEC Economies

To expand biofuel production in APEC economies would require an increase in the supply of feedstocks used for biofuels. One of the most important inputs to biofuels production is land. Table 5 shows the arable and agricultural area per capita in APEC economies for the year 2005 as well as the ratio of arable to agricultural area. Agricultural area includes arable land, land under permanent crops and permanent pastures (see Glossary for details). The arable area includes land under temporary crops and temporary meadows for mowing or pasture. This is the land on which crops for food, feed and fuel are grown. The data for arable land in Table 5 is not meant to indicate the amount of land that is potentially cultivable.[5]

Table 5. Agricultural Land Resource (2005)

| Economy | Arable area per capita (hectare/person) | Agricultural area per capita (hectare/person) | Ratio of arable area to agricultural area (%) |
|---|---|---|---|
| Australia | 2.4 | 22.0 | 11.1 |
| Canada | 1.4 | 2.1 | 67.6 |
| Chile | 0.1 | 1.0 | 12.8 |
| China | 0.1 | 0.4 | 25.8 |
| Indonesia | 0.1 | 0.2 | 48.1 |
| Mexico | 0.2 | 1.0 | 23.3 |
| New Zealand | 0.4 | 4.3 | 8.7 |
| Peru | 0.1 | 0.8 | 17.4 |
| Philippines | 0.1 | 0.1 | 46.7 |
| Russia | 0.8 | 1.5 | 56.5 |
| Thailand | 0.2 | 0.3 | 76.3 |
| United States | 0.6 | 1.4 | 42.1 |
| Viet Nam | 0.1 | 0.1 | 68.8 |

Source: FAOSTAT

In Table 5, we see that Australia has the most arable area per capita and the highest potential of expanding cultivation area. Economies like Canada, Russia and the United States also have relative high arable area per capita; however, their recent land use for food and feed crops has accounted for at least 40% of the total agricultural land. Economies like Chile, China, Indonesia, Viet Nam, Philippines and Peru have limited arable area per capita. The potential of land use expansion, however, varies among those economies. While Chile, China and Peru still have some potentials for increasing the land use for cultivation, Philippines and Viet Nam have little additional potential cultivation area. The ratio of arable area to agricultural area varies among APEC economies, ranging roughly from 9% in New Zealand to 76% in Thailand. This implies that the response of farmers will vary widely among APEC economies in response to

[5] According to the FAO, potential arable land includes land that is currently used for other purposes and thus may not be available. This includes grassland, forests, protected areas, buildings, infrastructure, etc.

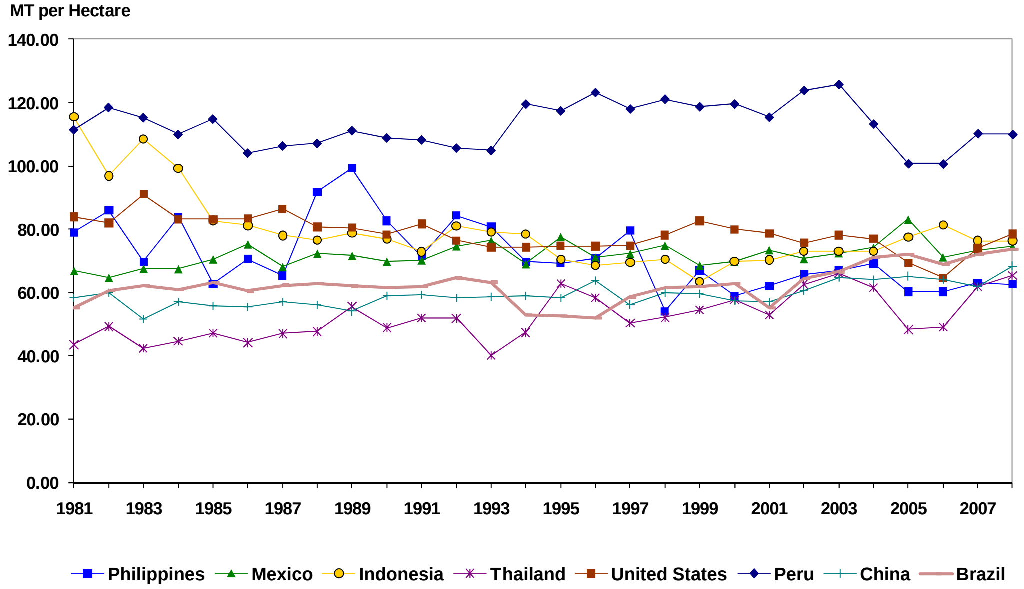
higher feedstock demand from biofuels, and higher crop prices, particularly in terms of land extensification. In economies with limited land, a critical way to increase agricultural supply may be through yield increases and through increased trade among APEC economies. However, in land-rich economies, other factors, such as water availability and infrastructure, may play an important role in determining how much area can expand.[6]

## Yield Trends in APEC Economies by Commodity

In addition to land, another major component in agricultural production is crop yield. In order to determine the yield growth potential in APEC economies, we first look at the historical growth in yields by major crops in these economies. We start with the most important crops for ethanol production at present (sugarcane and corn), continue with other crops that can be used for ethanol production (wheat, sorghum, rice and sugar beet), and conclude with oil crops used for biodiesel (palm, rapeseed and soybean).

### *Sugarcane*

Figure 1. Sugarcane Yields in Select Economies




Sugarcane yields in APEC economies have not shown much growth in the past few decades, with the exception of China, Indonesia and Thailand, which have experienced growths between 15% and 20% between 1999 and 2008. Ten-year average yields range as low as 58 metric tons per hectare in Thailand to 86 metric tons per hectare in Australia and 114 metric tons per hectare in Peru. Brazil, a major non-APEC sugarcane-producing economy, has an average sugarcane yield of 67 metric tons per hectare with a growth of 19% over the decade (from 62 metric tons per hectare in 1999 to 73.6

[6] As mentioned in the Introduction, land expansion comes with some environmental consequences from increased input use, direct and indirect land use change.

metric tons per hectare in 2008). Compared to crops such as sorghum and soybeans, yields for sugarcane have been relatively stable.

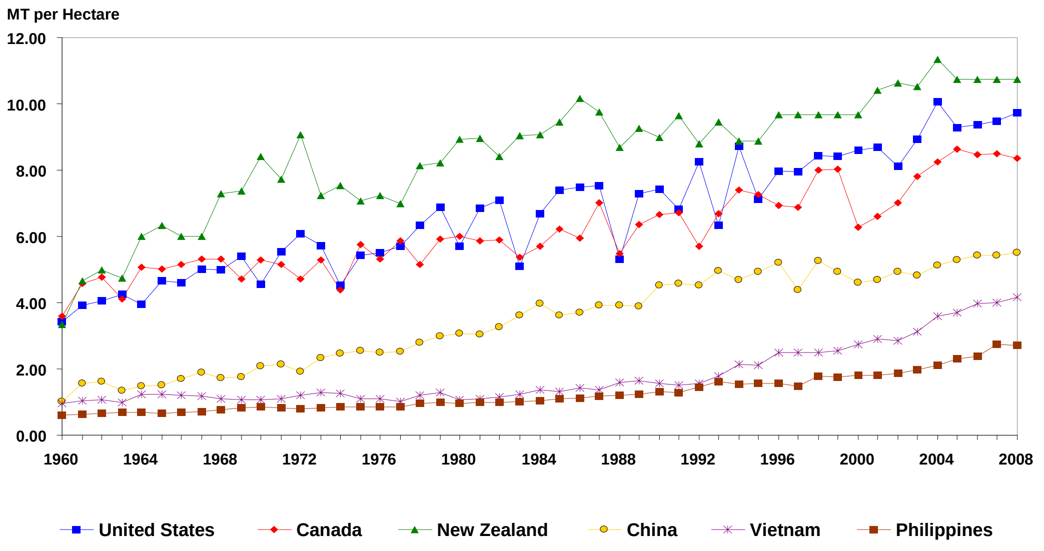
Table 6 shows the annual percentage changes for historical sugarcane yields for APEC economies as well as the average percentage change for 1998 through 2008. The 1998-2008 average of the annual rates of change for sugarcane ranges from -1.8 % in Australia to 3.1% in Thailand with an average of 0.3% across the range of economies shown. In comparison, the average percentage change in Brazil is 2.3%.

Table 6. Annual Percent Change in Historical Sugarcane Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | -3.88% | -0.77% | 0.89% | -20.29% | 2.56% | 15.18% | -8.28% | 8.03% | 3.39% | -6.79% | -9.41% | -1.76% |
| China | 6.83% | -0.89% | -3.74% | -0.33% | 6.10% | 6.69% | -1.00% | 1.81% | -1.86% | -3.21% | 10.42% | 1.89% |
| Indonesia | 1.34% | -9.83% | 9.88% | 0.75% | 3.85% | -0.08% | 0.27% | 6.01% | 4.97% | -6.17% | 0.00% | 1.00% |
| Japan | -2.17% | 21.06% | -5.65% | -15.07% | 7.39% | -15.11% | 4.68% | -10.84% | 10.54% | -4.65% | 0.00% | -0.89% |
| Malaysia | 0.00% | 0.98% | -7.59% | 4.63% | 0.29% | 0.38% | -0.38% | -2.00% | 2.04% | 0.00% | 0.23% | -0.13% |
| Mexico | 3.55% | -8.39% | 1.71% | 5.29% | -3.85% | 2.60% | 2.37% | 12.01% | -14.36% | 3.05% | 1.68% | 0.52% |
| Peru | 2.63% | -2.00% | 0.73% | -3.48% | 7.32% | 1.50% | -9.86% | -11.02% | -0.09% | 9.45% | -0.23% | -0.46% |
| Philippines | -32.05% | 23.93% | -12.18% | 5.56% | 5.79% | 2.15% | 3.17% | -12.95% | 0.01% | 4.64% | -0.80% | -1.16% |
| Thailand | 3.47% | 4.34% | 6.13% | -8.43% | 18.42% | 5.55% | -7.07% | -21.37% | 1.77% | 26.01% | 5.56% | 3.13% |
| United States | 4.49% | 5.69% | -3.24% | -1.56% | -3.79% | 3.27% | -1.60% | -9.76% | -6.98% | 14.63% | 5.94% | 0.64% |
| Average across economies | -1.58% | 3.41% | -1.31% | -3.29% | 4.41% | 2.22% | -1.77% | -4.01% | -0.06% | 3.70% | 1.34% | 0.28% |
| **Non-APEC Economy** | | | | | | | | | | | | |
| Brazil | 5.1% | 0.8% | 1.3% | -12.1% | 16.7% | 3.3% | 6.8% | 1.5% | -4.5% | 4.6% | 2.1% | 2.3% |

## *Corn*

Figure 2. Corn Yields in Select Economies



For corn, we see much more variation in yields among APEC economies, ranging from 2.7 metric ton per hectare in the Philippines to 10.8 metric ton per hectare in New Zealand in 2008 (Figure 2). The major corn-producing economy, the United States, has the second highest corn yields (9.7 metric ton per hectare) in the same year. The growth in corn yields is much stronger compared to wheat and other crops, since corn has benefited greatly from biotechnology and responds to fertilizer use more than other crops.

Table 7. Annual Percent Change in Historical Corn Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 10.67% | 26.03% | -29.95% | 5.40% | 5.14% | -3.96% | -16.16% | 20.19% | -2.04% | 16.19% | 0.41% | 2.90% |
| Canada | 16.54% | 0.27% | -21.85% | 5.44% | 6.02% | 11.49% | 5.42% | 4.66% | -1.79% | 0.36% | -1.66% | 2.26% |
| Chile | -16.24% | 19.63% | 0.41% | 11.94% | 1.86% | 2.61% | 1.38% | -0.96% | 1.11% | -2.84% | 3.51% | 2.04% |
| China | 20.07% | -6.13% | -7.02% | 2.20% | 4.80% | -2.26% | 6.39% | 3.26% | 2.77% | -0.21% | 1.50% | 2.31% |
| Indonesia | 3.34% | 1.74% | -4.84% | 1.69% | 0.00% | -0.78% | 9.95% | -9.99% | 3.39% | 3.76% | -0.58% | 0.70% |
| Japan | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Korea | -8.05% | 3.69% | 1.27% | 1.79% | 5.47% | -4.11% | 5.24% | 12.31% | -4.60% | 6.43% | -4.76% | 1.33% |
| Malaysia | 0.31% | 14.00% | 46.62% | -0.14% | -1.53% | -1.43% | 0.00% | 0.00% | 6.67% | 8.17% | 3.17% | 6.89% |
| Mexico | -6.05% | 17.63% | -5.82% | 4.55% | 4.59% | 3.37% | 1.15% | 2.42% | 3.19% | 1.69% | 0.18% | 2.45% |
| New Zealand | 0.00% | 0.00% | 0.00% | 7.71% | 2.22% | -1.03% | 7.59% | -5.15% | 0.00% | 0.00% | 0.00% | 1.03% |
| Peru | 18.20% | 12.49% | -5.69% | -1.66% | 12.87% | 3.03% | -5.34% | 6.64% | -4.23% | 4.17% | 0.00% | 3.68% |
| Philippines | 18.66% | -1.35% | 3.98% | -0.11% | 2.89% | 5.71% | 6.71% | 9.19% | 4.11% | 14.38% | -1.17% | 5.73% |
| Russia | -65.44% | 54.59% | 23.30% | -41.01% | 146.59% | 6.45% | 29.63% | -3.19% | -4.38% | -15.60% | 19.30% | 13.66% |
| Chinese Taipei | 2.63% | -3.68% | -7.63% | 29.43% | -8.33% | 2.22% | 2.72% | 0.68% | 0.00% | -5.41% | 0.00% | 1.15% |
| Thailand | -2.70% | 1.74% | 14.54% | -1.82% | -1.72% | -1.44% | 1.04% | -2.57% | 4.50% | 1.32% | 1.58% | 1.31% |
| United States | 6.11% | -0.48% | 2.30% | 0.96% | -6.40% | 9.96% | 12.75% | -7.73% | 0.79% | 1.31% | 2.58% | 2.01% |
| Vietnam | -0.35% | 2.27% | 8.29% | 5.77% | -1.71% | 8.95% | 15.78% | 2.71% | 7.09% | 0.96% | 4.17% | 4.90% |
| Average across economies | -0.13% | 8.38% | 1.05% | 1.89% | 10.16% | 2.28% | 4.96% | 1.91% | 0.97% | 2.04% | 1.66% | 3.20% |

Table 7 presents the annual percentage changes for historical corn yields for APEC economies as well as the average percentage change for 1998 through 2008. The average rates of change for corn range from about 0% in Japan to 13.7% in Russia with an average of 3.2% across the range of economies.

### *Wheat*

Figure 3 presents the historical yields for wheat in select APEC economies. There is considerable variation in wheat yields among the economies, with Mexico showing the highest yields in wheat despite the fact that it is not a major wheat producer. Peru shows the lowest wheat yields. Among the major wheat-producing economies, the United States and Canada have comparable yields at 2.5 to 3 metric ton per hectare in 2008, while China's wheat yields approach 5 metric ton per hectare in the same year. Wheat yield grows much faster in China compared to the United States and Canada. The Chinese agricultural sector uses high levels of fertilizer relative to other economies, which may explain the higher level and growth rate of wheat yields in China.

Figure 3. Wheat Yields in Select Economies

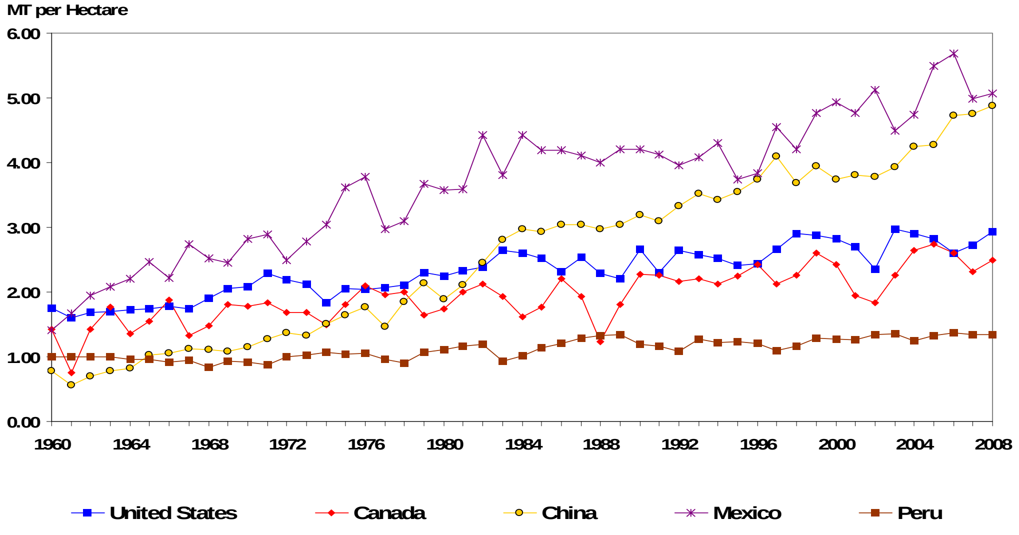


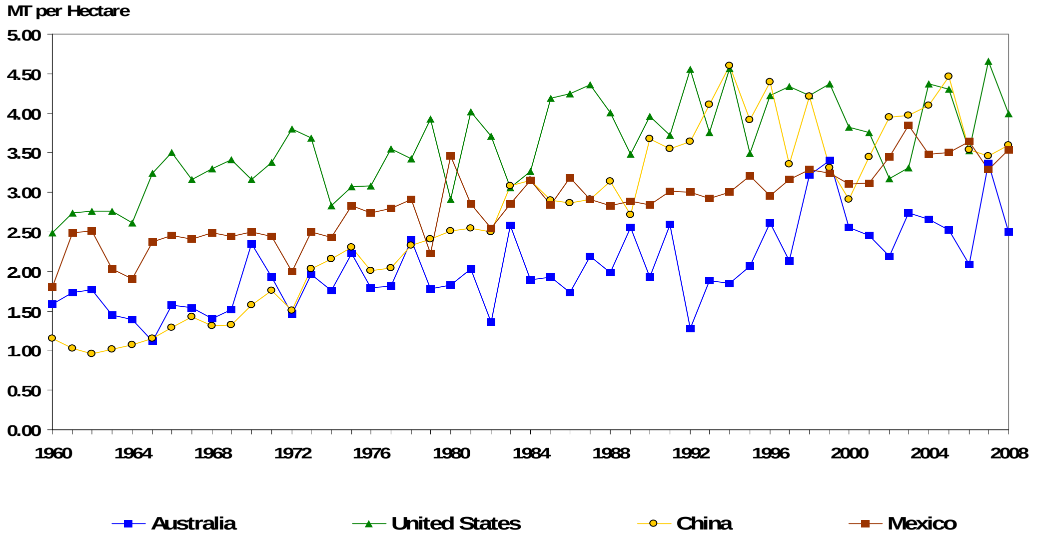

Table 8 shows the annual percentage changes for historical wheat yields for APEC economies as well as the average percentage change for 1998 through 2008. As can be seen in the case of Australia, weather plays a vital role in yield variation. Thus, the percentage change in yields varies over a wide range. The average rate of change for wheat over the last 11 years ranges from 0.4% in Korea to 10.2% in Australia with an average of 2.7% across the range of economies shown.

Table 8. Annual Percent Change in Historical Wheat Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 0.98% | 9.41% | -10.50% | 15.12% | -56.34% | 118.50% | -18.25% | 23.62% | -54.61% | 15.15% | 69.07% | 10.19% |
| Canada | 5.98% | 15.14% | -6.85% | -19.67% | -5.66% | 23.09% | 17.04% | 3.67% | -4.69% | -11.07% | 7.73% | 2.25% |
| Chile | -19.39% | 7.86% | 12.89% | -0.69% | 1.17% | 5.94% | -3.64% | 1.08% | -13.10% | 18.76% | -6.83% | 0.37% |
| China | -10.16% | 7.09% | -5.27% | 1.90% | -0.88% | 4.11% | 8.15% | 0.56% | 10.49% | 0.67% | 2.44% | 1.74% |
| Japan | -2.98% | -1.96% | 8.98% | -5.49% | 12.57% | 0.83% | 0.11% | 1.27% | -6.10% | 12.86% | -6.12% | 1.27% |
| Korea | 0.00% | -40.00% | -33.33% | 50.00% | 0.00% | 11.11% | -2.50% | 23.08% | -25.00% | 33.33% | -12.50% | 0.38% |
| Mexico | -7.28% | 13.14% | 3.40% | -3.12% | 7.40% | -12.23% | 5.45% | 15.72% | 3.52% | -12.28% | 1.58% | 1.39% |
| New Zealand | -8.47% | 20.75% | 1.87% | 20.77% | -3.21% | 3.82% | -12.07% | 17.47% | -0.21% | 0.00% | 0.00% | 3.70% |
| Peru | 6.33% | 10.74% | -0.30% | -1.65% | 6.79% | 0.35% | -7.99% | 6.93% | 2.93% | -1.54% | 0.00% | 2.06% |
| Russia | -39.02% | 30.29% | 10.17% | 32.71% | -0.19% | -21.73% | 21.86% | 0.10% | 0.88% | 6.43% | 8.31% | 4.53% |
| United States | 9.34% | -1.12% | -1.64% | -4.32% | -12.77% | 26.09% | -2.31% | -2.72% | -7.81% | 4.66% | 7.41% | 1.34% |
| Average across economies | -5.88% | 6.49% | -1.87% | 7.78% | -4.65% | 14.53% | 0.53% | 8.25% | -8.52% | 6.09% | 6.46% | 2.66% |

***Sorghum***

Figure 4. Sorghum Yields in Select Economies




The yields for sorghum also show variation over time as seen in Figure 4. The strongest growth is seen in Chinese sorghum yields. In 2008, U.S. sorghum yield is 4 metric ton per hectare, the highest among the four economies. China is a close second with sorghum yield at 3.6 metric ton per hectare, followed by Mexican sorghum yield at 3.5 metric ton per hectare and Australian sorghum yield at 2.5 metric ton per hectare in the same year.

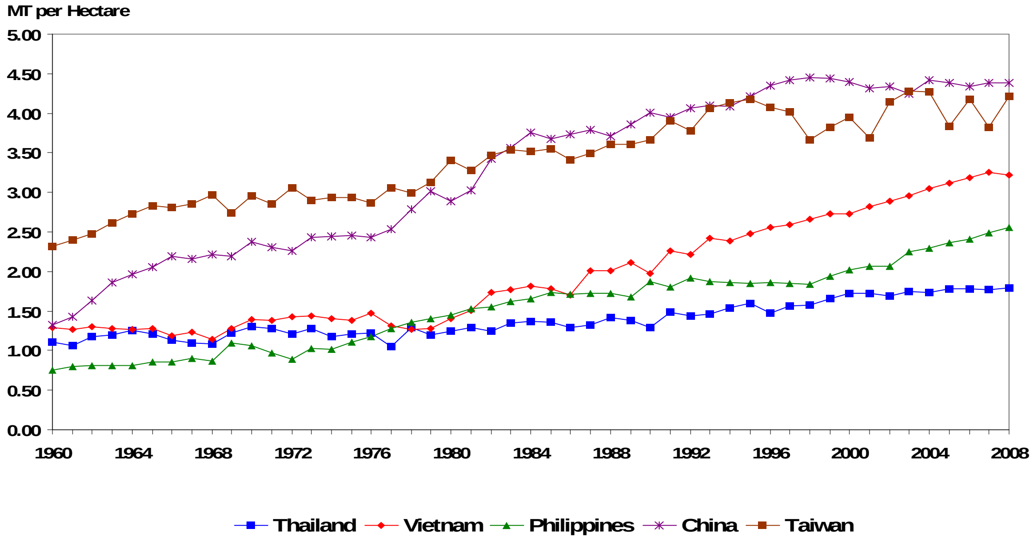
Table 9. Annual Percent Change in Historical Sorghum Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 51.09% | 5.60% | -24.96% | -3.80% | -10.56% | 24.62% | -2.68% | -5.46% | -16.89% | 60.72% | -25.68% | 4.73% |
| China | 25.61% | -21.49% | -12.00% | 18.35% | 14.43% | 0.55% | 3.29% | 8.98% | -20.89% | -2.24% | 4.21% | 1.71% |
| Mexico | 3.82% | -1.26% | -4.22% | 0.57% | 10.34% | 11.54% | -9.29% | 0.52% | 3.98% | -9.72% | 7.74% | 1.27% |
| Peru | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Chinese Taipei | 37.50% | -21.21% | -3.08% | 1.19% | 5.88% | 0.00% | -3.70% | -7.69% | 0.00% | 0.00% | 0.00% | 0.81% |
| Thailand | 0.34% | 8.44% | 6.68% | -0.36% | -6.07% | 15.51% | 37.24% | -27.30% | 1.80% | 4.62% | 0.00% | 3.72% |
| United States | -2.68% | 3.45% | -12.57% | -1.61% | -15.49% | 4.14% | 32.02% | -1.59% | -17.95% | 32.00% | -14.20% | 0.50% |
| Average across economies | 16.53% | -3.78% | -7.16% | 2.05% | -0.21% | 8.05% | 8.12% | -4.65% | -7.14% | 12.20% | -3.99% | 1.82% |

Table 9 shows the annual percentage changes for historical sorghum yields for APEC economies as well as the average percentage change for 1998 through 2008. The average rate of change for sorghum ranges from 0% in Peru to 4.7% in Australia with an average of 1.8% across the range of APEC economies.

## *Rice*

Figure 5. Rice Yields in Select Economies




Asian economies are important producers and exporters of rice. Figure 5 shows that the Chinese rice yields grow the fastest over time reaching 4.4 metric ton per hectare in 2008, the highest among the economies listed. Chinese Taipei has comparable yield levels, at 4.2 metric ton per hectare in 2008. Viet Nam also shows a strong growth path, with rice yield reaching 3.2 metric ton per hectare in 2008, followed by Philippines and Thailand.

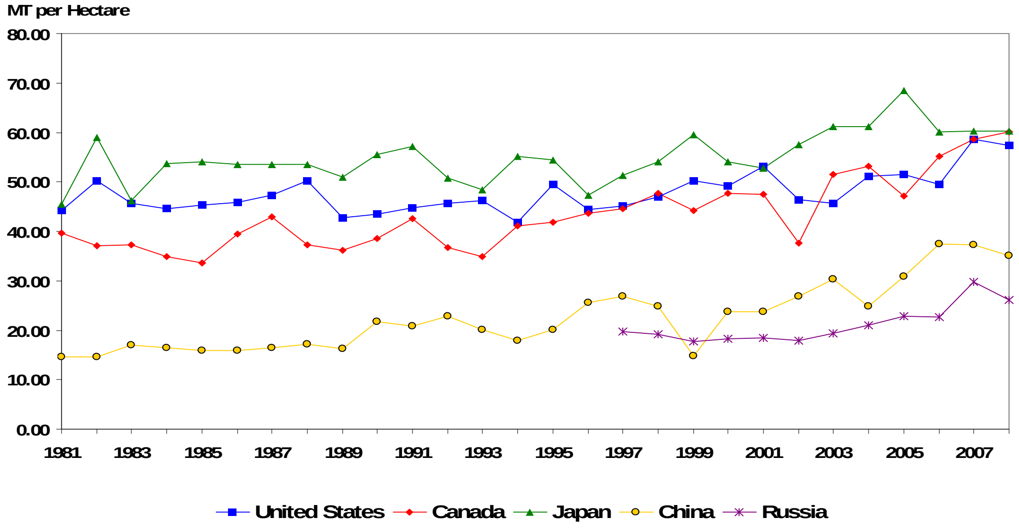
Table 10. Annual Percent Change in Historical Rice Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 2.16% | -10.09% | 12.19% | -9.00% | 12.64% | -12.04% | -6.63% | 25.61% | 16.10% | 16.56% | -36.84% | 0.97% |
| Brunei | 0.00% | 0.00% | 0.00% | 0.00% | -25.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -2.27% |
| Chile | 6.36% | 27.22% | -4.09% | 2.45% | -1.10% | -5.42% | -1.32% | 21.43% | -8.50% | 3.75% | 5.34% | 4.19% |
| China | 0.76% | -0.34% | -1.15% | -1.72% | 0.42% | -2.08% | 4.12% | -0.80% | -0.92% | 1.02% | 0.04% | -0.06% |
| Indonesia | 1.29% | 3.53% | 2.13% | 0.00% | 2.25% | 1.30% | 1.58% | -0.91% | 0.13% | 0.57% | 2.11% | 1.27% |
| Japan | -3.08% | 3.15% | 4.48% | -0.98% | -0.81% | -11.13% | 9.66% | 3.64% | -4.70% | 2.76% | 1.01% | 0.36% |
| Korea | -7.04% | 2.52% | -0.03% | 3.17% | -8.12% | -6.37% | 14.02% | -2.60% | 0.72% | -5.32% | 2.84% | -0.56% |
| Malaysia | 0.34% | -0.33% | 8.48% | -0.98% | 1.26% | 2.90% | -0.79% | 0.53% | -1.58% | 4.43% | 0.42% | 1.34% |
| Mexico | 4.33% | 2.31% | -15.02% | 6.21% | -19.28% | 47.78% | -8.79% | 10.67% | 0.00% | -19.97% | 0.03% | 0.75% |
| Peru | 6.35% | 27.20% | -1.00% | 3.23% | 1.24% | -0.34% | -2.45% | -1.80% | -2.25% | 6.25% | 0.00% | 3.31% |
| Philippines | -0.79% | 5.81% | 3.76% | 2.60% | -0.49% | 9.04% | 2.30% | 2.62% | 1.93% | 3.72% | 2.57% | 3.01% |
| Russia | 30.13% | -8.99% | 30.33% | -3.66% | 16.05% | -22.34% | 24.52% | 17.07% | -0.93% | 3.37% | 1.24% | 7.89% |
| Chinese Taipei | -8.89% | 4.36% | 3.28% | -6.68% | 12.40% | 3.37% | -0.32% | -9.98% | 8.92% | -8.69% | 10.41% | 0.74% |
| Thailand | 0.88% | 5.10% | 4.20% | 0.22% | -2.04% | 3.13% | -0.53% | 2.53% | -0.21% | -0.19% | 0.94% | 1.28% |
| United States | -3.91% | 4.01% | 5.56% | 3.66% | 0.57% | 5.11% | 4.75% | -5.73% | 4.53% | 3.93% | -0.95% | 1.96% |
| Vietnam | 2.56% | 2.91% | 0.02% | 3.05% | 2.44% | 2.51% | 3.12% | 2.11% | 2.21% | 2.21% | -0.93% | 2.02% |
| Average across economies | 1.97% | 4.27% | 3.32% | 0.10% | -0.47% | 0.96% | 2.70% | 4.03% | 0.97% | 0.90% | -0.74% | 1.64% |

Table 10 shows the annual percentage changes for historical rice yields for APEC economies as well as the average percentage change for 1998 through 2008. The average rate of change for rice ranges from -2.3% in Brunei to 7.9% in Russia, with an average of 1.6% across the range of economies shown.

***Sugar beet***

Figure 6. Sugar Beet Yields in Select Economies




In the economies presented in Figure 6, Russia has the lowest yields averaging 21 metric tons per hectare in the past decade. The United States, Canada and Japan hover around 60 metric tons per hectare. China and Russia have shown the strongest growth in sugar beet yields in the last 10 years, at around 40%.

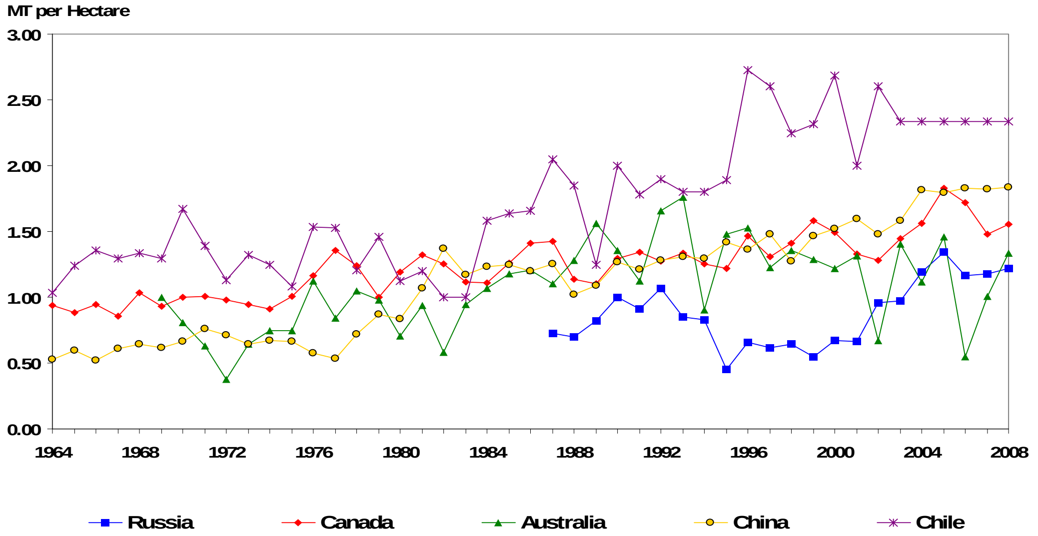
Table 11. Annual Percent Change in Historical Sugar Beet Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada | 6.68% | -7.20% | 7.97% | -0.54% | -20.82% | 36.83% | 3.53% | -11.35% | 16.85% | 6.16% | 2.68% | 3.71% |
| China | -7.40% | -40.28% | 59.77% | 0.00% | 13.29% | 12.73% | -17.54% | 23.64% | 21.74% | -0.88% | -5.91% | 5.38% |
| Japan | 5.20% | 10.07% | -9.05% | -2.41% | 8.94% | 6.34% | 0.04% | 11.90% | -12.35% | 0.47% | 0.00% | 1.74% |
| Russia | -2.45% | -8.24% | 4.00% | 0.10% | -2.50% | 8.17% | 8.27% | 8.88% | -1.10% | 31.95% | -12.16% | 3.17% |
| United States | 3.78% | 7.06% | -2.32% | 8.31% | -12.60% | -1.70% | 11.90% | 0.83% | -3.93% | 18.39% | -2.06% | 2.52% |
| Average across economies | 1.16% | -7.72% | 12.07% | 1.09% | -2.74% | 12.47% | 1.24% | 6.78% | 4.24% | 11.22% | -3.49% | 3.30% |

Table 11 shows the annual percentage changes for historical sugar beet yields for APEC economies as well as the average percentage change for 1998 through 2008. The average rate of change for sugar beet ranges from 1.7% in Japan to 5.4% in China with an average of 3.3% across the range of economies presented.

## ***Rapeseed***

Figure 7. Rapeseed Yields in Select Economies




Rapeseed is another crop we see variation in yields both over time and among economies, as shown in Figure 7. Despite not being a major producer, rapeseed yield is highest in Chile in 2008, at 2.3 metric ton per hectare. Canada is a major producer and exporter of rapeseed, with 2008 yield reaching 1.6 metric ton per hectare. China again shows a strong growth pattern in rapeseed yields, with yield reaching 1.8 metric ton per hectare in 2008. Australian rapeseed yields show a lot of variation due to weather disruptions. In 2008, Australian rapeseed yield is 1.3 metric ton per hectare and Russian rapeseed yield is 1.2 metric ton per hectare, the lowest yields relative to other economies.

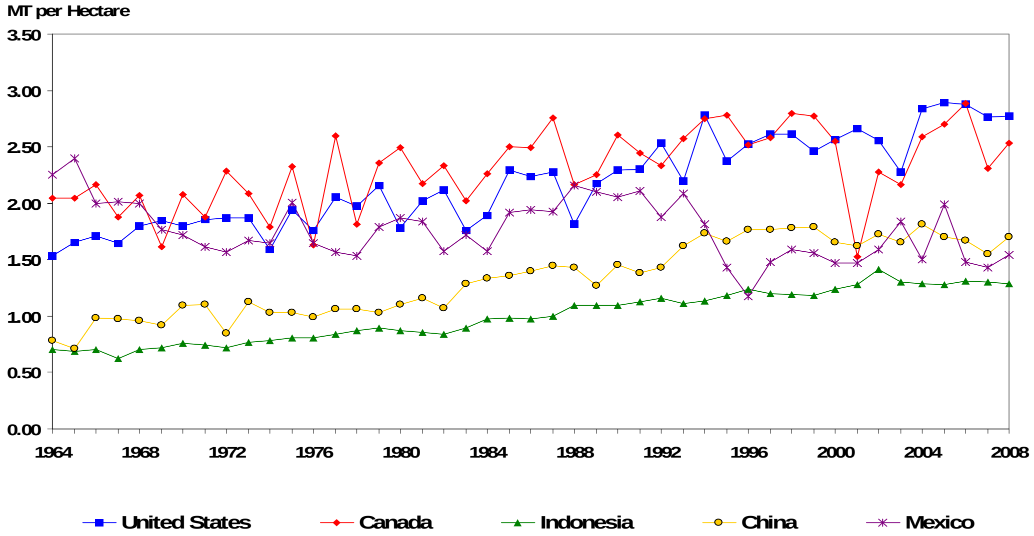
Table 12. Annual Percent Change in Historical Rapeseed Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 10.51% | -5.02% | -5.49% | 8.36% | -49.10% | 109.57% | -20.37% | 30.50% | -62.73% | 84.29% | 32.83% | 12.12% |
| Canada | 7.48% | 12.32% | -5.39% | -11.40% | -3.37% | 12.74% | 8.38% | 16.84% | -6.07% | -13.80% | 5.07% | 2.07% |
| Chile | -13.46% | 2.92% | 15.81% | -25.42% | 30.00% | -10.26% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.04% |
| China | -14.03% | 15.47% | 3.42% | 5.16% | -7.50% | 7.07% | 14.60% | -1.10% | 1.94% | -0.41% | 0.72% | 2.31% |
| Japan | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Korea | -50.00% | 0.00% | 100.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -50.00% | 0.00% | 0.00% | 0.00% |
| Russia | 3.83% | -14.04% | 22.09% | -0.90% | 43.75% | 1.70% | 22.06% | 12.70% | -13.12% | 1.42% | 3.05% | 7.50% |
| United States | 17.16% | -9.85% | 2.08% | 2.94% | -12.90% | 18.20% | 14.47% | -12.41% | -3.67% | -8.57% | 12.26% | 1.79% |
| Average across economies | -4.81% | 0.23% | 16.56% | -2.66% | 0.11% | 17.38% | 4.89% | 5.82% | -16.70% | 7.87% | 6.74% | 3.22% |

Table 12 shows the annual percentage changes for historical rapeseed yields for APEC economies as well as the average percentage change for 1998 through 2008. The 11-year average rate of change for rapeseed ranges from 0% in Chile to 12.1% in Australia with an average of 3.2% across the range of economies shown.

### *Soybeans*

Figure 8. Soybean Yields in Select Economies




The United States, a major producer and exporter of soybeans, has a soybean yield of 2.8 metric ton per hectare in 2008, followed by Canadian soybean yield at 2.5 metric ton per hectare, as seen in Figure 8. Yields in these economies show significant variation over time, especially in the case of Canada. Other economies, like China and Indonesia, have much lower soybean yields in history relative to the United States and Canada, but show much less variability in yields. Indonesian soybean yield is 1.3 metric ton per hectare in 2008, whereas Mexico’s yield is 1.5 metric ton per hectare and China’s yield is 1.7 metric ton per hectare in the same year.

Table 13. Annual Percent Change in Historical Soybean Yields in APEC Economies

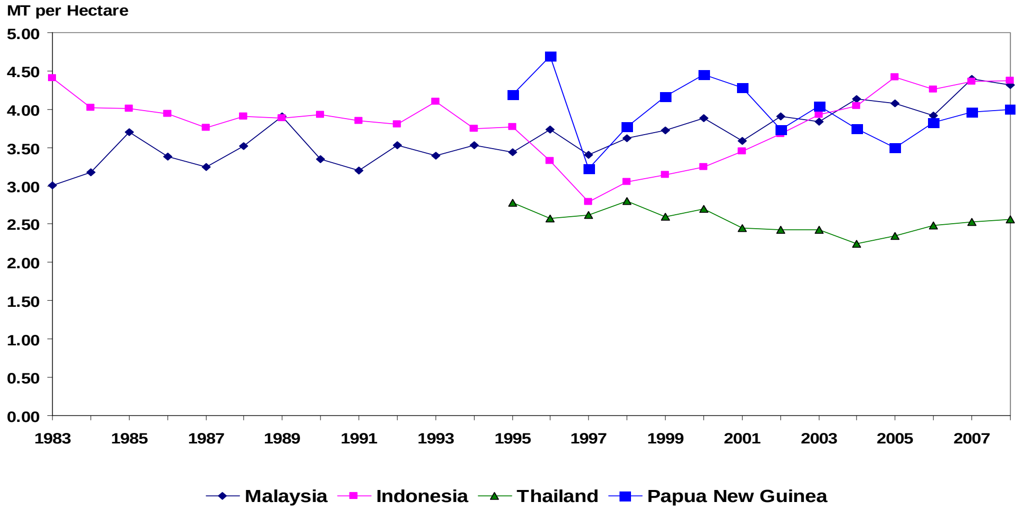
| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 34.57% | -17.43% | -20.81% | 32.59% | -23.81% | 48.15% | -25.00% | 37.50% | -21.45% | 0.43% | 43.42% | 8.01% |
| Canada | 8.12% | -0.80% | -8.04% | -39.96% | 49.15% | -4.98% | 19.54% | 4.36% | 6.63% | -19.96% | 9.77% | 2.17% |
| China | 1.01% | 0.21% | -7.30% | -1.84% | 6.40% | -4.43% | 9.77% | -6.04% | -2.02% | -7.10% | 9.69% | -0.15% |
| Indonesia | -0.91% | -0.45% | 4.62% | 3.63% | 10.68% | -8.22% | -0.96% | -0.70% | 2.53% | -0.94% | -0.74% | 0.77% |
| Japan | -17.03% | 19.45% | 10.34% | -1.50% | -4.35% | -15.20% | -22.05% | 41.75% | -6.05% | 2.90% | 0.00% | 0.75% |
| Korea | -8.42% | -6.67% | -1.45% | 15.14% | -6.15% | -7.55% | 24.59% | 6.58% | -0.55% | -13.46% | 5.88% | 0.72% |
| Mexico | 7.61% | -2.01% | -5.49% | -0.32% | 8.36% | 15.66% | -18.40% | 32.62% | -25.53% | -3.21% | 7.29% | 1.51% |
| Peru | 0.00% | 0.00% | 0.00% | 33.33% | -25.00% | 33.33% | -25.00% | 0.00% | 0.00% | 0.00% | 0.00% | 1.52% |
| Philippines | -33.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -3.03% |
| Russia | 14.27% | -3.94% | 32.21% | -17.15% | 40.22% | -16.13% | 2.04% | 5.03% | -5.72% | -7.13% | 4.99% | 4.43% |
| Thailand | 6.32% | -1.49% | -5.45% | 0.20% | -2.26% | 5.60% | 1.34% | 5.59% | -7.72% | 3.57% | 0.00% | 0.52% |
| United States | 0.02% | -5.86% | 3.97% | 4.01% | -4.03% | -10.95% | 24.75% | 1.79% | -0.59% | -3.71% | 0.16% | 0.87% |
| Vietnam | 6.89% | 0.00% | 5.45% | 5.22% | 0.62% | 4.18% | 0.19% | 7.79% | 2.80% | -0.49% | 0.00% | 2.97% |
| Average across economies | 1.47% | -1.46% | 0.62% | 2.56% | 3.83% | 3.04% | -0.71% | 10.48% | -4.44% | -3.78% | 6.19% | 1.62% |

Table 13 shows the annual percentage changes for historical soybean yields for APEC economies as well as the average percentage change for 1998 through 2008. The average of the annual rates of change for soybeans ranges from -3% in Philippines to 8% in Australia with an average of 1.6% across the range of economies shown.

### *Palm Oil*

Malaysia's palm oil yield grows more than 40% between 1983 and 2008, reaching 4.32 metric ton per hectare (Figure 9). During the same period, Indonesia's palm oil yield does not present significant growth. The yield remains stagnant for the first 10 years, drops significantly in 1996 and 1997, and then recovers to the 1983 level in 2008. Palm oil yield in Papua New Guinea fluctuates over the 1995-2008 period, ranging between 3.2 and 4.7 metric tons per hectare. Thailand's palm oil yield has decreased slightly, with an average of 2.5 metric tons per hectare over the same period.

Figure 9. Palm Oil Yields in Select Economies




Note: Yield data in Malaysia and Indonesia is generated from FAS/USDA; Thailand and Papua New Guinea data is calculated from Oil World Annual, ISTA Mielke GMbH.

Table 14 shows the annual percentage changes for historical palm oil yields for APEC economies as well as the average percentage change for 1998 through 2008. The average of the annual rates of change for palm oil ranges from -0.1% in Thailand to 4.3% in Indonesia with an average of 2.2% across the range of economies shown.

Table 14. Annual Percent Change in Historical Palm Oil Yields in APEC Economies

| Economy | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indonesia | 9.59% | 3.13% | 2.98% | 6.60% | 6.44% | 6.69% | 3.14% | 9.21% | -3.71% | 2.37% | 0.47% | 4.26% |
| Malaysia | 6.59% | 2.74% | 4.33% | -7.86% | 9.01% | -1.68% | 7.82% | -1.57% | -3.79% | 12.02% | -1.70% | 2.36% |
| Papua New Guinea | 17.01% | 10.42% | 6.85% | -3.90% | -12.59% | 8.22% | -7.40% | -6.61% | 9.43% | 3.39% | 1.01% | 2.35% |
| Thailand | 6.73% | -6.95% | 3.60% | -9.35% | -0.88% | 0.33% | -7.68% | 4.44% | 5.84% | 2.02% | 1.19% | -0.07% |
| Average across economies | 9.98% | 2.33% | 4.44% | -3.63% | 0.49% | 3.39% | -1.03% | 1.37% | 1.94% | 4.95% | 0.24% | 2.23% |

## **Yield Elasticities**

Table 15 presents yield elasticities with respect to a time trend variable for the major crops in APEC economies. These elasticities are calculated for the 2000-2004 base period and show the percentage change in yield for a change in the time trend variable. Negative elasticities imply that yields are declining on average over time. Positive elasticities indicate increasing trend in crop yields. For most, but not all, APEC economies the coefficient estimates are statistically significant. These numbers are used to provide a general overview of crop trends so the emphasis is not on the magnitude of the elasticity but on the relative response by crop among APEC economies. When comparing among crops, the table shows that corn yields have shown significant growth. Across APEC economies, China shows consistent yield response over time for all crops. As is evident from the table, there is wide variation of elasticities among economies and crops, which shows the potential for APEC economies to invest in agricultural productivity to achieve yield growth.

Table 15. Crop Yield Elasticities with respect to Trend for APEC Economies

| Economy | Sugarcane | Corn | Wheat | Sorghum | Rice | Sugar Beet | Rapeseed | Soybeans |
|---|---|---|---|---|---|---|---|---|
| Australia | 0.15 | 0.70 | 0.30 | 0.44 | 0.41 | 0.43 | 0.49 | 0.52 |
| Brunei | | | | | 0.23 | 0.60 | | |
| Canada | | 0.49 | 0.46 | | | 1.08 | 0.45 | 0.27 |
| Chile | | 0.87 | 0.79 | | 0.57 | | 0.66 | |
| China | 0.48 | 0.85 | 0.83 | 0.92 | 0.68 | | 0.78 | 0.55 |
| Hong Kong | | | | | | 0.50 | | |
| Indonesia | -1.20 | 0.62 | | | 0.64 | | | 0.49 |
| Japan | -0.10 | -1.84 | 0.41 | | 0.24 | | 0.06 | 0.24 |
| Republic of Korea | | 0.94 | 0.41 | 0.93 | 0.40 | | 0.47 | 0.61 |
| Malaysia | 0.69 | 0.27 | | | 0.34 | | | |
| Mexico | 0.19 | 0.78 | 0.61 | 0.36 | 0.59 | -0.11 | 0.59 | -0.14 |
| New Zealand | | 0.47 | 0.59 | | | | 0.52 | |
| Papua New Guinea | 0.35 | | | | | | | |
| Peru | -0.32 | 0.44 | 0.29 | -1.07 | 0.46 | 0.50 | | 0.39 |
| Philippines | 0.08 | 0.82 | | | 0.71 | | | 0.49 |
| Russia | | 0.19 | 0.15 | | 0.25 | | 0.36 | 0.03 |
| Singapore | | | | | | | | |
| Chinese Taipei | | 0.69 | | 0.40 | 0.36 | 0.25 | | |
| Thailand | 0.34 | 0.51 | | -0.04 | 0.37 | 0.43 | | 0.44 |
| United States | -0.24 | 0.57 | 0.39 | 0.32 | 0.43 | 0.60 | 0.11 | 0.42 |
| Viet Nam | 0.40 | 0.79 | 0.30 | | 0.67 | 1.08 | 0.49 | 0.67 |

## Conclusions

The emerging biofuel sector has drawn great interest as an alternative source of fuel. The expansion of biofuels greatly impacts world agricultural markets since the current primary feedstocks for ethanol and biodiesel production are field crops and their derived products. The long-term potential for developing first-generation biofuels in APEC economies depends on a large constant supply of feedstocks. This may be achieved in two ways: land extensification and land intensification. However, expansion of land area for production comes with a number of environmental challenges. Therefore, land intensification, i.e., yield growth, is generally seen as the critical factor for production expansion. If production increases are to come from intensification, then long-term sustainability is critical.

A review of the literature shows that yield growth can be achieved through a number of avenues such as increased input use, investments in agricultural R&D, better farm management practices, land improvements, farm programs, etc. Empirical analyses have found that higher input use has a positive and significant impact on crop yields, particularly for fertilizer application. They also showed that climate, measured by a variety of factors, has a considerable impact on the crop yields. The economic and biophysical factors, such as per capita GDP and latitude, also contribute to the variances in yield growth.

Yield response to price increases has also drawn significant interest. Biofuel expansion has created a perceived permanent increase in crop prices so there may be a yield response to price increases in the long run. Although there is a vast number of studies that analyze the impact of crop prices on yields, this literature is not conclusive, with results varying across crops, countries, and the time period used. Furthermore, these studies have mainly focused on crops in developed countries with very few studies looking at technology diffusion and yield growth in developing countries. Thus, the net impact on yields is an empirical question.

In the discussion on factors impacting yield growth, there has also been some debate on whether a yield plateau has been reached in developed countries, like the United States and Canada, for conventional crops. The literature on this topic is also inconclusive, with some studies showing that a yield plateau has been reached and others showing the opposite. Some studies conclude that the developed countries that are close to their yield plateau levels can still increase yields using biotechnology. Biotechnology is the most recent result of the agricultural R&D investments and it has contributed to gains in productivity and reduced costs of production in the agricultural sector. Other developing countries still have room to increase their crop yields for conventional crops, through diffusion of technology and other farm management practices that have been used in developed countries.

There is a growing literature that focuses on developing various quantitative models to measure the impact of biofuels production on the prices and the trade of agricultural commodities. These studies show that the expansion of biofuels production from agricultural feedstocks will tend to increase crop prices and therefore land use, though the magnitude of this impact varies among studies. They also illustrate the crucial role the crude oil prices play in determining the expansion rate of the biofuels sector.

Table 16. Historical Average Yield Growth per Year in APEC Economies, 1998-2008

| Economy | High growth rate (over 4% per year) | Medium growth rate (2%-4% per year) | Lower growth rate (less than 2% per year) | Negative growth rate |
|---|---|---|---|---|
| Australia | wheat, sorghum, rapeseed, soybeans | corn | rice | sugarcane |
| Brunei Darussalam | | | | rice |
| Canada | | corn, wheat, sugar beet, rapeseed, soybeans | | |
| Chile | rice | corn | wheat | rapeseed |
| China | sugar beet | corn, rapeseed | sugarcane, wheat, sorghum | rice, soybeans |
| Hong Kong, China | | | | |
| Indonesia | palm oil | | sugarcane, corn, rice, soybeans | |
| Japan | | | corn, wheat, rice, sugar beet, rapeseed, soybeans | sugarcane |
| Korea | | | corn, wheat, rapeseed, soybeans | rice |
| Malaysia | corn | palm oil | rice | sugarcane |
| Mexico | | corn | sugarcane, wheat, sorghum, rice, soybeans | |
| New Zealand | | wheat | corn | |
| Papua New Guinea | | | | |
| Peru | | corn, wheat, rice | sorghum, soybeans | sugarcane |
| Philippines | corn | rice | | sugarcane, soybeans |
| Russia | corn, wheat, rice, rapeseed, soybeans | sugar beet | | |
| Singapore | | | | |
| Chinese Taipei | | | corn, sorghum, rice, soybeans | |
| Thailand | | sugarcane, sorghum, palm oil | corn, rice | |
| United States | | sugar beet | sugarcane, corn, wheat, sorghum, rice, rapeseed, soybeans | |
| Viet Nam | corn | rice, soybeans | | |

Table 16 provides a summary of the average annual percentage changes for crop yields for the APEC economies categorized by yield growth. The table offers several insights. An economy, like the United States, which already has high yield levels for the majority of crops, experiences lower growth rates relative to other economies. On the other hand, economies like Philippines and Malaysia have relatively lower corn yields but high growth rates, which indicate a higher potential for increasing crop production through yield increases rather than land expansion. Yield growth rates for most crops in most APEC economies fall in the lower to medium range although there is significant variance in yields among the economies. This variation could be due to the fact that some economies have adopted mechanization and new technologies in their crop production whereas other economies rely heavily on labor and basic inputs. Hence, economies with high technical advantage have the potential to improve crop yields by continuous development in biotechnology. In contrast, economies with less technological resources may enhance crop yields through increasing input utilization including more capital intensive inputs.

Some critical implications can be generated from this study:

- Each economy should identify its own advantage in terms of productivity improvements for its agricultural commodities.

- Most of the long-term potential for biofuels as a major alternative to crude oil for transportation and other purposes depends on the commercialization of cellulosic ethanol from non-food feedstocks.

- To achieve yield growth, APEC economies should create an environment conducive to technological change and diffusion of new technology through public R&D and incentives for private R&D investments.

- While biofuel expansion will imply land extensification to increase feedstock production in the medium term, growth in feedstock yields will tend to mitigate the impact on crop prices and land use over the longer term.

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# APPENDIX: APEC Crop Yield Trends by Economy

## Australia

Australia is a major grain producer and exporter. Figure A1 presents the area harvested by crop. A large portion of the area is dedicated to wheat production, followed by barley. Although there is an upward trend in total area harvested over the years, there is significant variation primarily due to adverse weather conditions. Growth in area harvested has been noticeable for wheat, barley and sorghum and area has declined for rice and sunflower over the last 10 years. The weather conditions also impact yields negatively as can be seen in Figure A2, with significant variation particularly in the later years. This makes it difficult to project yield growth in Australia.

Figure A1. Australian Area Harvested by Crop

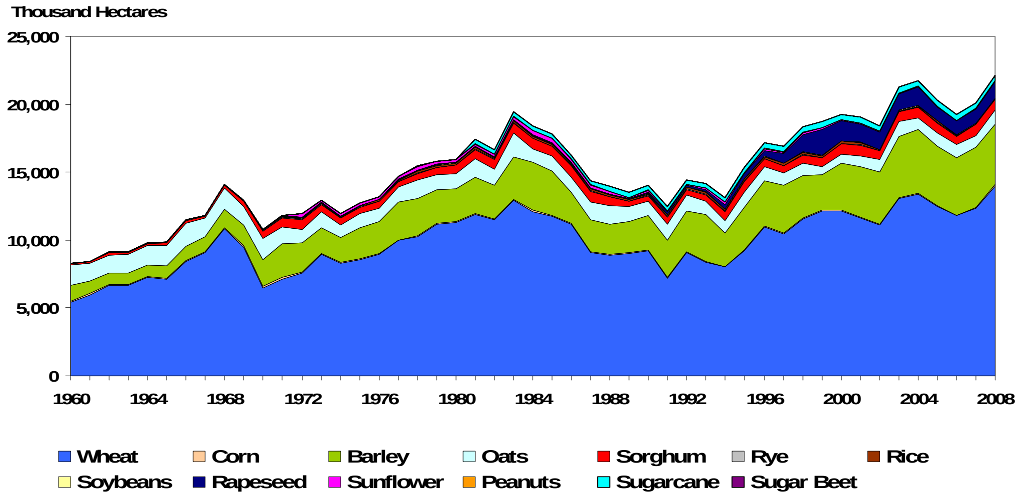
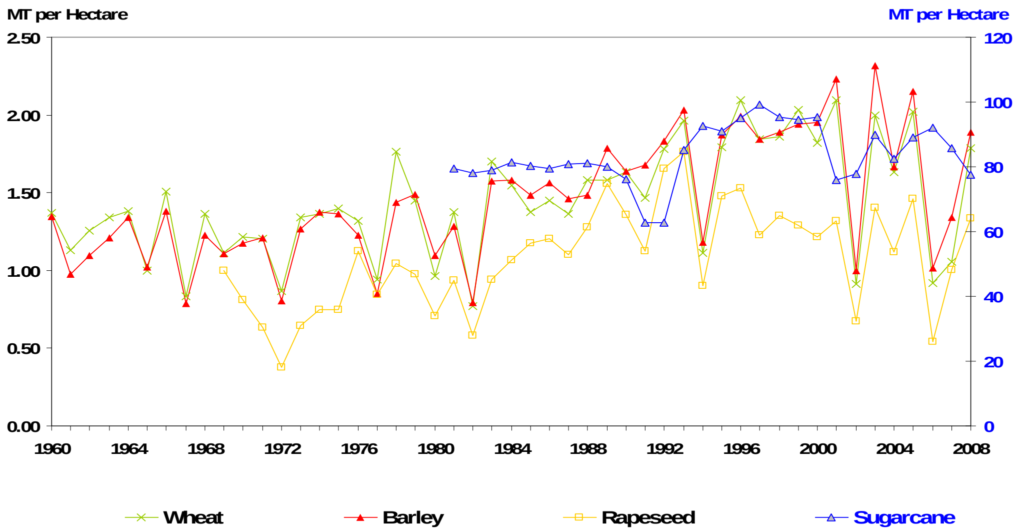



Figure A2. Australian Crop Yields



## Supply Projections

Table A1 shows supply projections for Australia for major crops in the next decade. The projections begin in 2009/10 and end in 2018/19. Yield growth is strongest for wheat, which makes up the largest share in terms of area, at over 29% over the projection period. This is followed by barley yield at 18.5%. The weakest growth in yield is experienced by rice at 2.4%. In the case of wheat, since area increases by only 3.4%, wheat production is projected to increase by about 34% by 2018/19. However, the projected growth for rice area harvested is significantly higher, increasing from 7,000 hectares to 24,000 hectares, an increase of 244%. This results in a 331% increase in rice production. Area harvested for crops like sorghum and rapeseed are projected to decline over the decade but since their yields are expected to increase by 16% and 5%, respectively, their production is projected to increase by 12.4% for sorghum and 1.3% for rapeseed. One crop which shows a reduction in production over the projected period is corn since its area declines by 8% while its yield increases by only 4% by 2018/19.

Table A1. Australian Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 13,000 | 13,158 | 13,258 | 13,314 | 13,378 | 13,408 | 13,416 | 13,420 | 13,436 | 13,432 | 13,440 |
| Yield | (MT/Ha) | 1.54 | 1.77 | 1.79 | 1.82 | 1.84 | 1.87 | 1.89 | 1.91 | 1.94 | 1.96 | 1.99 |
| Production | (000 MT) | 20,000 | 23,257 | 23,760 | 24,180 | 24,627 | 25,012 | 25,357 | 25,696 | 26,055 | 26,377 | 26,721 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 70 | 67 | 66 | 67 | 66 | 66 | 66 | 65 | 65 | 65 | 64 |
| Yield | (MT/Ha) | 5.71 | 5.74 | 5.76 | 5.78 | 5.80 | 5.82 | 5.84 | 5.86 | 5.88 | 5.90 | 5.92 |
| Production | (000 MT) | 400 | 382 | 381 | 385 | 383 | 382 | 383 | 383 | 383 | 382 | 381 |
| **Sorghum** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 800 | 746 | 761 | 762 | 763 | 764 | 767 | 768 | 770 | 772 | 773 |
| Yield | (MT/Ha) | 2.50 | 2.54 | 2.58 | 2.62 | 2.66 | 2.70 | 2.74 | 2.78 | 2.83 | 2.87 | 2.91 |
| Production | (000 MT) | 2,000 | 1,894 | 1,964 | 1,999 | 2,033 | 2,064 | 2,103 | 2,140 | 2,175 | 2,212 | 2,248 |
| **Barley** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 4,200 | 4,202 | 4,260 | 4,283 | 4,289 | 4,302 | 4,315 | 4,324 | 4,338 | 4,346 | 4,359 |
| Yield | (MT/Ha) | 1.55 | 1.62 | 1.64 | 1.67 | 1.69 | 1.72 | 1.74 | 1.76 | 1.79 | 1.81 | 1.83 |
| Production | (000 MT) | 6,500 | 6,811 | 7,007 | 7,142 | 7,254 | 7,380 | 7,503 | 7,621 | 7,749 | 7,867 | 7,993 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 7 | 18 | 31 | 34 | 31 | 29 | 27 | 26 | 26 | 24 | 24 |
| Yield | (MT/Ha) | 7.52 | 7.53 | 7.52 | 7.53 | 7.56 | 7.59 | 7.61 | 7.63 | 7.65 | 7.68 | 7.69 |
| Production | (000 MT) | 43 | 137 | 230 | 254 | 238 | 218 | 206 | 200 | 196 | 187 | 185 |
| **Rapeseed** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,200 | 1,193 | 1,174 | 1,165 | 1,161 | 1,156 | 1,154 | 1,153 | 1,153 | 1,153 | 1,154 |
| Yield | (MT/Ha) | 1.17 | 1.13 | 1.14 | 1.15 | 1.16 | 1.17 | 1.19 | 1.20 | 1.21 | 1.22 | 1.23 |
| Production | (000 MT) | 1,400 | 1,350 | 1,341 | 1,344 | 1,351 | 1,358 | 1,368 | 1,380 | 1,391 | 1,404 | 1,418 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 390 | 394 | 397 | 400 | 404 | 409 | 414 | 419 | 424 | 429 | 435 |
| Yield | (MT/Ha) | 87.18 | 88.36 | 89.28 | 90.04 | 90.72 | 91.36 | 91.96 | 92.55 | 93.14 | 93.71 | 94.29 |
| Production | (000 MT) | 34,000 | 34,790 | 35,457 | 36,034 | 36,668 | 37,345 | 38,042 | 38,767 | 39,502 | 40,247 | 40,999 |

Source: FAPRI Preliminary Projections (2008)

## Brunei Darussalam

Brunei Darussalam has limited agricultural production. Figures A3 and A4 present rice area harvested and rice yields respectively.

Figure A3. Brunei Area Harvested by Crop

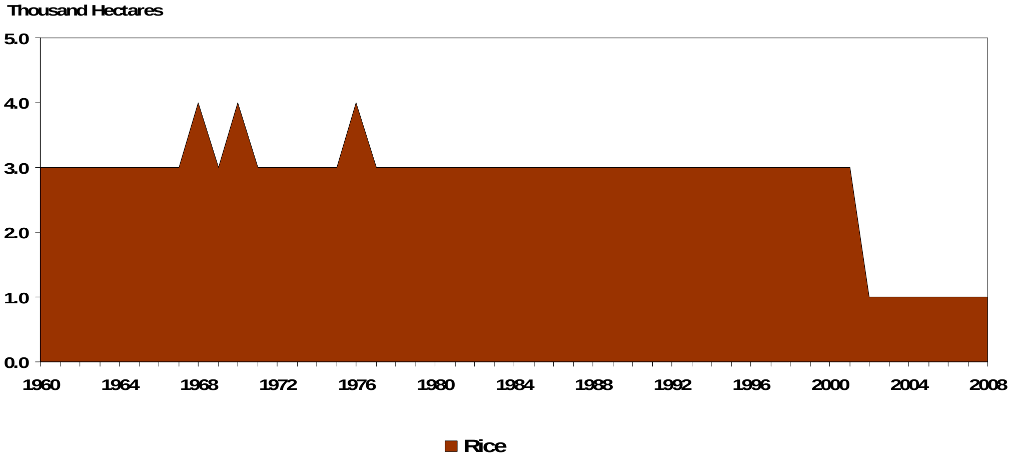
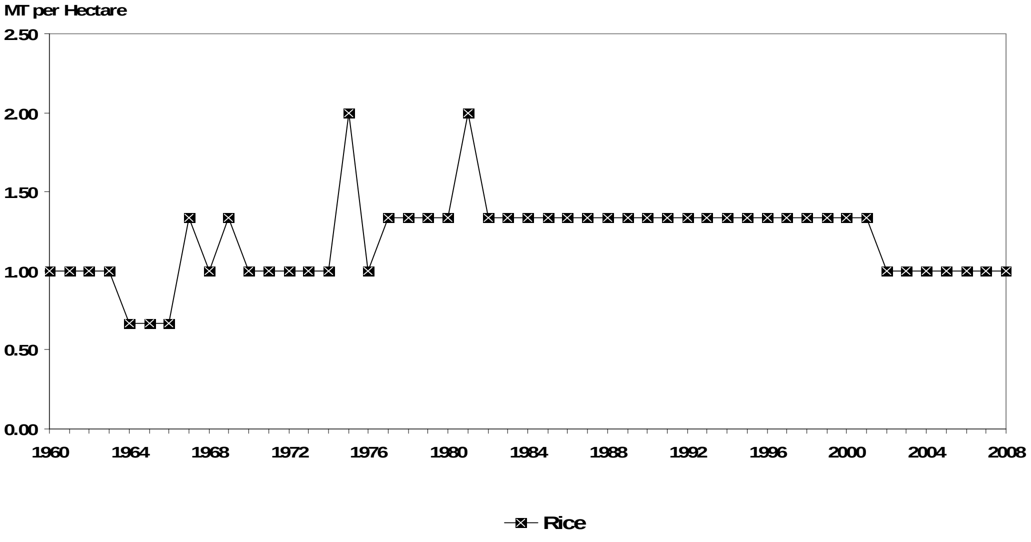



Figure A4. Brunei Crop Yield



## Canada

Canada is a major producer and exporter of grains and oilseeds. Figure A5 shows area harvested by crop. Wheat has the highest share of harvested area over the years. The other major crops are barley and rapeseed. In recent years, we see a downward trend in wheat and barley areas. This is due to the expansion in rapeseed and soybean areas. Figure A6 presents historical yields in Canada for wheat, barley, and rapeseed. It shows that despite the upward trend, yields fluctuate due to weather conditions.

Figure A5. Canadian Area Harvested by Crop

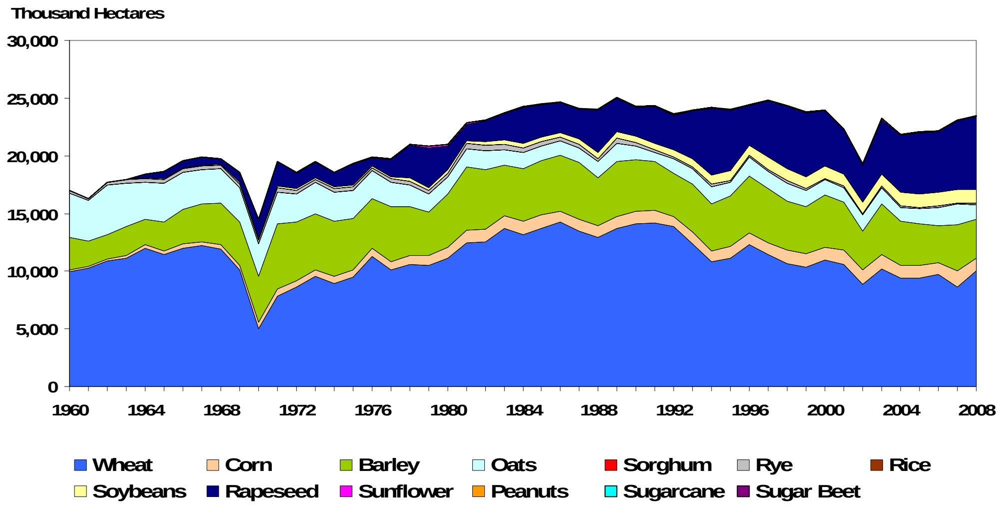
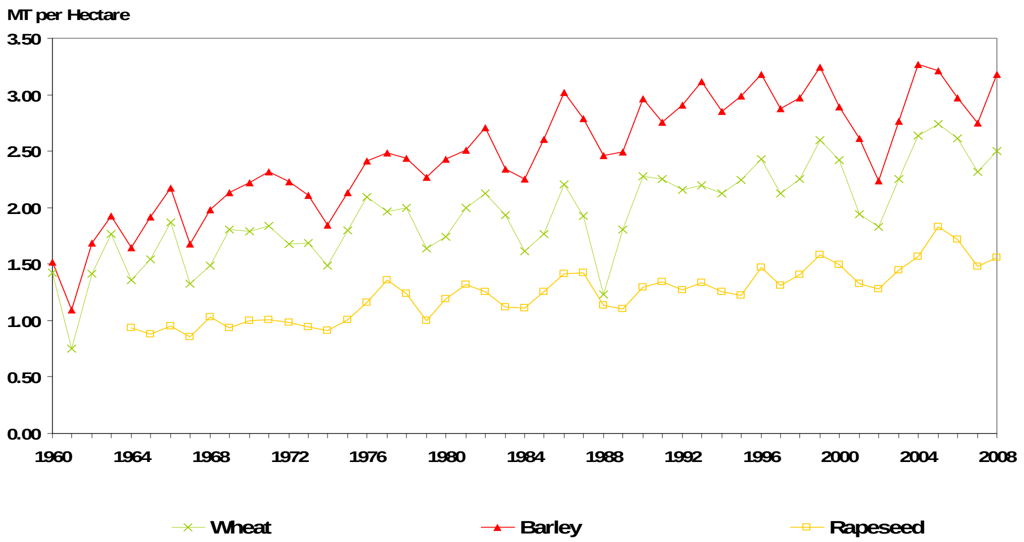



Figure A6. Canadian Crop Yields



## Supply Projections

Table A2 shows supply projections for Canada for major crops in the next decade. The projections begin in 2009/10 and end in 2018/19. Area expansion contributes to production increase for most of the crops, except for wheat and soybeans. Wheat has the highest share of area harvested among crops, above 40% throughout the projection period, despite the downward trend. Wheat production declines by only 1.9%, less than the decline in wheat area, due to a yield growth of 5.2%. Although soybean area declines over the next ten years, soybean production increases by 1.3%, because of the soybean yield growth of 4.5%. For other crops, we see that both area expansion and yield growth contribute to their production increase. Corn area expands the most among crops, at 14.3%.

Combined with a corn yield growth of 10.2%, this leads to a rise in corn production of 25.9%. Similarly, both area expansion (6.3%) and yield growth (8.7%) increase canola production (15.6%) in Canada over the next ten years. The highest yield growth between 2008/09 and 2018/19 occurs for corn (above 10%), followed by canola (8.7%), sugar beet (7.6%), wheat (5.2%), soybeans (4.5%), and barley (3.7%).

Table A2. Canadian Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 10,100 | 9,631 | 9,426 | 9,549 | 9,423 | 9,444 | 9,392 | 9,401 | 9,416 | 9,435 | 9,420 |
| Yield | (MT/Ha) | 2.70 | 2.67 | 2.68 | 2.70 | 2.72 | 2.74 | 2.76 | 2.78 | 2.80 | 2.82 | 2.84 |
| Production | (000 MT) | 27,300 | 25,670 | 25,300 | 25,807 | 25,656 | 25,900 | 25,952 | 26,168 | 26,398 | 26,637 | 26,780 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,180 | 1,295 | 1,338 | 1,340 | 1,333 | 1,328 | 1,331 | 1,342 | 1,349 | 1,355 | 1,349 |
| Yield | (MT/Ha) | 8.39 | 8.48 | 8.56 | 8.64 | 8.73 | 8.82 | 8.90 | 8.99 | 9.08 | 9.16 | 9.24 |
| Production | (000 MT) | 9,900 | 10,986 | 11,453 | 11,585 | 11,636 | 11,706 | 11,854 | 12,068 | 12,242 | 12,408 | 12,468 |
| **Barley** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 3,450 | 3,585 | 3,682 | 3,625 | 3,626 | 3,641 | 3,656 | 3,680 | 3,712 | 3,717 | 3,722 |
| Yield | (MT/Ha) | 3.25 | 3.16 | 3.18 | 3.21 | 3.23 | 3.25 | 3.28 | 3.30 | 3.32 | 3.34 | 3.37 |
| Production | (000 MT) | 11,200 | 11,347 | 11,727 | 11,623 | 11,706 | 11,838 | 11,974 | 12,139 | 12,327 | 12,427 | 12,526 |
| **Soybeans** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,210 | 1,212 | 1,176 | 1,160 | 1,163 | 1,168 | 1,177 | 1,183 | 1,182 | 1,175 | 1,173 |
| Yield | (MT/Ha) | 2.68 | 2.69 | 2.70 | 2.71 | 2.73 | 2.74 | 2.75 | 2.76 | 2.77 | 2.79 | 2.80 |
| Production | (000 MT) | 3,240 | 3,260 | 3,176 | 3,149 | 3,169 | 3,198 | 3,236 | 3,267 | 3,277 | 3,273 | 3,282 |
| **Canola** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 6,324 | 6,335 | 6,314 | 6,367 | 6,410 | 6,450 | 6,500 | 6,552 | 6,601 | 6,652 | 6,722 |
| Yield | (MT/Ha) | 1.72 | 1.70 | 1.70 | 1.72 | 1.74 | 1.77 | 1.79 | 1.81 | 1.83 | 1.85 | 1.87 |
| Production | (000 MT) | 10,900 | 10,765 | 10,739 | 10,967 | 11,179 | 11,389 | 11,618 | 11,852 | 12,082 | 12,320 | 12,595 |
| **Sugar Beet** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| Yield | (MT/Ha) | 57.06 | 57.51 | 57.95 | 58.39 | 58.82 | 59.25 | 59.68 | 60.11 | 60.54 | 60.97 | 61.40 |
| Production | (000 MT) | 718 | 726 | 741 | 754 | 767 | 777 | 785 | 792 | 800 | 810 | 820 |

Source: FAPRI Preliminary Projections (2008)

## Chile

As seen in Figure A7, Chilean crop area harvested declines over time. The major portion of area is allocated to wheat, followed by corn and oats. Figure A8 presents historical yields for major crops. Corn yield has a very strong growth rate, reaching 11.3 metric ton per hectare in 2008. Other crop yields also show a slight upward trend.

Figure A7. Chilean Area Harvested by Crop

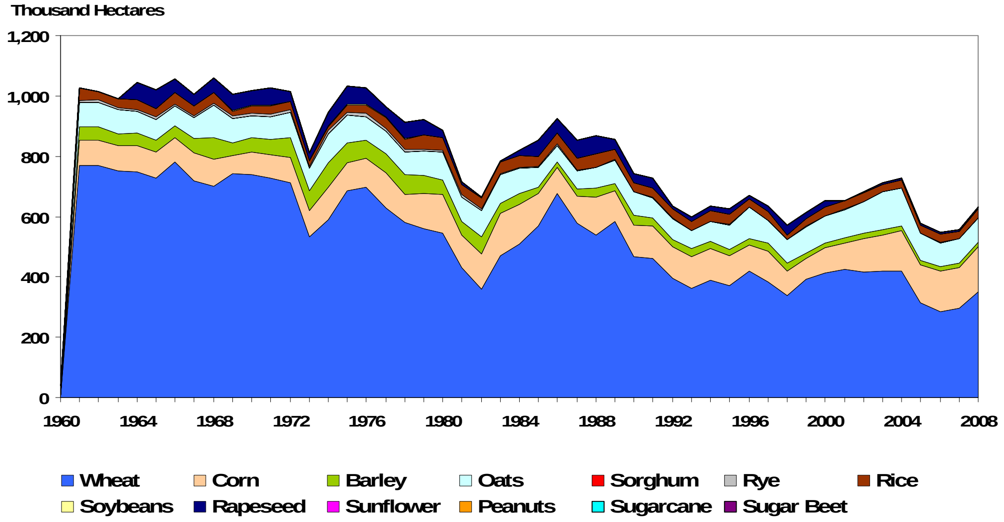
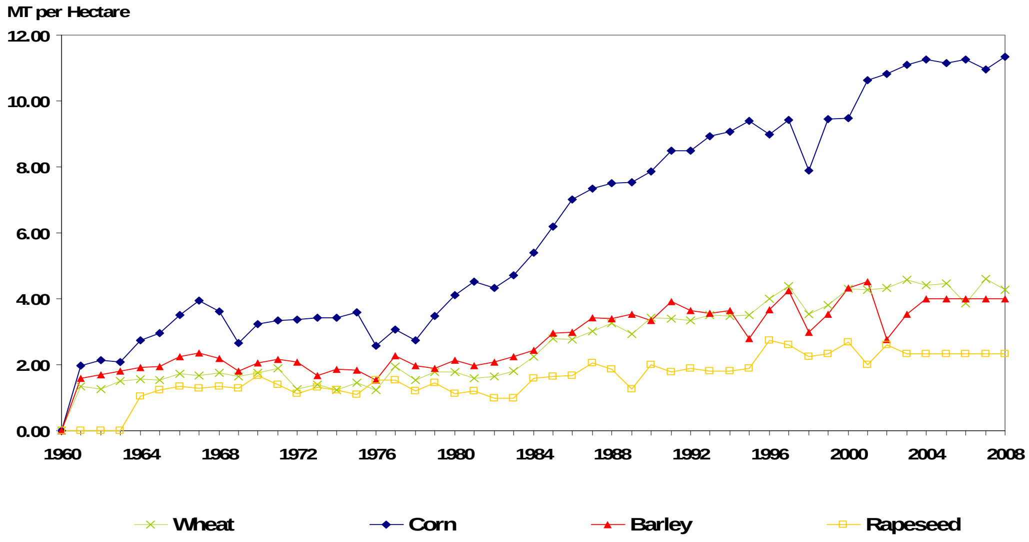



Figure A8. Chilean Crop Yields



## People's Republic of China

China has one of the largest total crop area harvested among APEC economies and one of the most diversified ones in terms of variety of the crops produced. We see from Figure A9 that total crop area increases in China particularly after 2003. The major crops produced are wheat, corn rice, soybeans, and rapeseed. In 2008, the major portion of area is allocated to rice followed by corn and wheat. Figure A10 presents the historical crop yields in China, which have a very strong upward trend. This is due to multiple factors, among which high fertilizer use and investments in agricultural R&D play a major role.

Figure A9. Chinese Area Harvested by Crop

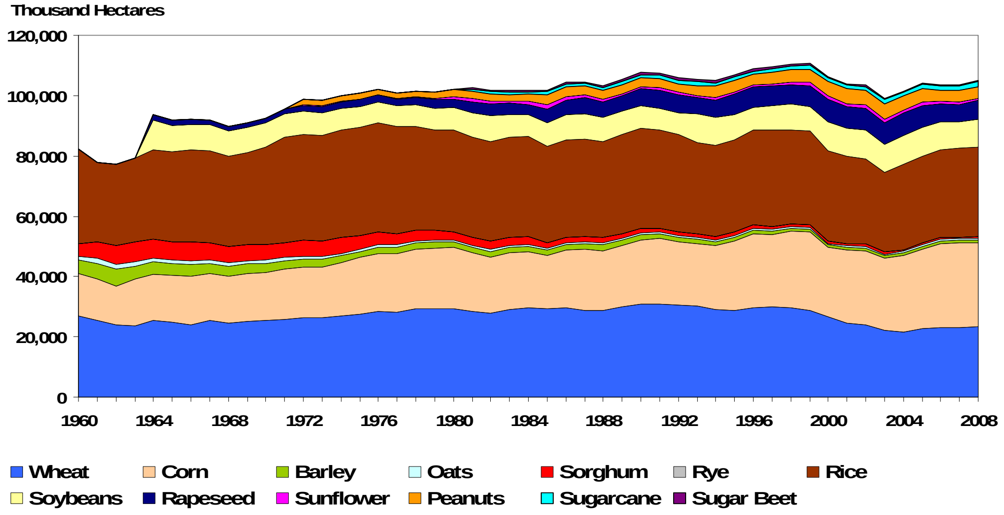
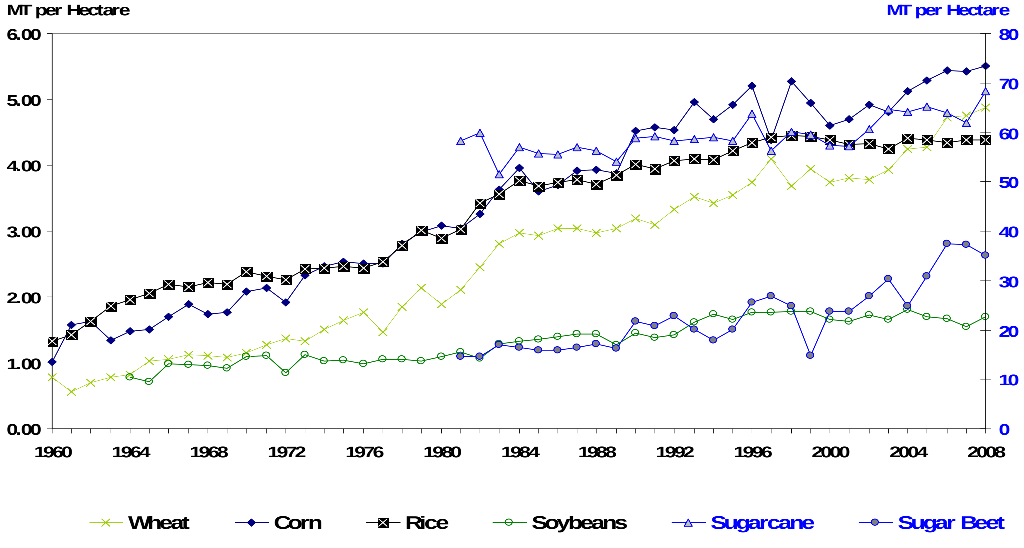



Figure A10. Chinese Crop Yields



## Supply Projections

Table A3. Chinese Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 24,000 | 23,682 | 22,856 | 22,837 | 22,599 | 22,466 | 22,280 | 22,095 | 21,923 | 21,738 | 21,492 |
| Yield | (MT/Ha) | 4.71 | 4.71 | 4.72 | 4.72 | 4.73 | 4.74 | 4.75 | 4.76 | 4.77 | 4.77 | 4.78 |
| Production | (000 MT) | 113,000 | 111,514 | 107,822 | 107,894 | 106,953 | 106,497 | 105,795 | 105,104 | 104,471 | 103,775 | 102,781 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 29,200 | 29,656 | 30,215 | 30,351 | 30,641 | 30,697 | 30,798 | 30,897 | 30,882 | 30,969 | 31,014 |
| Yield | (MT/Ha) | 5.34 | 5.41 | 5.47 | 5.53 | 5.59 | 5.65 | 5.71 | 5.77 | 5.83 | 5.89 | 5.95 |
| Production | (000 MT) | 156,000 | 160,455 | 165,252 | 167,801 | 171,218 | 173,360 | 175,763 | 178,160 | 179,925 | 182,280 | 184,401 |
| **Barley** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 960 | 982 | 999 | 1,003 | 1,008 | 1,010 | 1,011 | 1,011 | 1,014 | 1,015 | 1,018 |
| Yield | (MT/Ha) | 3.54 | 3.57 | 3.59 | 3.62 | 3.64 | 3.67 | 3.69 | 3.72 | 3.75 | 3.77 | 3.80 |
| Production | (000 MT) | 3,400 | 3,500 | 3,588 | 3,628 | 3,673 | 3,705 | 3,733 | 3,762 | 3,798 | 3,830 | 3,865 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 29,000 | 28,098 | 27,706 | 27,704 | 27,128 | 26,899 | 27,056 | 26,839 | 26,784 | 26,767 | 26,817 |
| Yield | (MT/Ha) | 4.60 | 4.67 | 4.73 | 4.74 | 4.73 | 4.78 | 4.83 | 4.86 | 4.90 | 4.93 | 4.98 |
| Production | (000 MT) | 130,900 | 131,128 | 130,913 | 131,434 | 128,418 | 128,557 | 130,634 | 130,467 | 131,186 | 131,956 | 133,422 |
| **Soybeans** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 9,300 | 9,217 | 9,122 | 9,073 | 9,052 | 9,035 | 8,996 | 8,982 | 8,956 | 8,894 | 8,821 |
| Yield | (MT/Ha) | 1.81 | 1.83 | 1.85 | 1.87 | 1.89 | 1.91 | 1.93 | 1.95 | 1.97 | 1.99 | 2.01 |
| Production | (000 MT) | 16,800 | 16,835 | 16,844 | 16,935 | 17,076 | 17,224 | 17,331 | 17,483 | 17,612 | 17,668 | 17,698 |
| **Rapeseed** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 6,400 | 6,367 | 6,382 | 6,346 | 6,234 | 6,150 | 6,098 | 6,075 | 6,053 | 6,019 | 5,979 |
| Yield | (MT/Ha) | 1.80 | 1.87 | 1.89 | 1.91 | 1.93 | 1.95 | 1.97 | 1.99 | 2.01 | 2.03 | 2.05 |
| Production | (000 MT) | 11,500 | 11,882 | 12,040 | 12,100 | 12,015 | 11,978 | 12,000 | 12,080 | 12,159 | 12,213 | 12,254 |
| **Sunflower** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 850 | 860 | 864 | 872 | 878 | 884 | 887 | 888 | 887 | 884 | 880 |
| Yield | (MT/Ha) | 1.76 | 1.78 | 1.79 | 1.80 | 1.81 | 1.82 | 1.84 | 1.85 | 1.86 | 1.87 | 1.88 |
| Production | (000 MT) | 1,500 | 1,527 | 1,545 | 1,570 | 1,592 | 1,613 | 1,629 | 1,642 | 1,650 | 1,655 | 1,658 |
| **Peanuts** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 4,000 | 4,114 | 4,164 | 4,145 | 4,126 | 4,099 | 4,079 | 4,063 | 4,046 | 4,020 | 3,988 |
| Yield | (MT/Ha) | 3.35 | 3.37 | 3.39 | 3.41 | 3.43 | 3.45 | 3.47 | 3.49 | 3.51 | 3.53 | 3.55 |
| Production | (000 MT) | 13,400 | 13,866 | 14,115 | 14,135 | 14,153 | 14,141 | 14,153 | 14,181 | 14,202 | 14,191 | 14,157 |
| **Sugar Beet** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 315 | 325 | 329 | 332 | 333 | 334 | 335 | 335 | 336 | 337 | 338 |
| Yield | (MT/Ha) | 35.24 | 36.29 | 36.96 | 37.46 | 37.89 | 38.29 | 38.68 | 39.06 | 39.43 | 39.81 | 40.18 |
| Production | (000 MT) | 11,100 | 11,778 | 12,176 | 12,430 | 12,619 | 12,786 | 12,943 | 13,100 | 13,261 | 13,424 | 13,593 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,620 | 1,640 | 1,656 | 1,666 | 1,675 | 1,683 | 1,691 | 1,700 | 1,709 | 1,719 | 1,729 |
| Yield | (MT/Ha) | 71.60 | 71.78 | 72.18 | 72.69 | 73.26 | 73.86 | 74.47 | 75.09 | 75.71 | 76.34 | 76.97 |
| Production | (000 MT) | 116,000 | 117,729 | 119,495 | 121,112 | 122,673 | 124,274 | 125,908 | 127,618 | 129,395 | 131,216 | 133,101 |

Source: FAPRI Preliminary Projections (2008)

Table A3 presents the 10-year supply projections of the major crops in China. China is another prominent example of reductions in area harvested coupled with significant increases in yields resulting in an increase in supply. This is the case for rice, soybeans, rapeseed and peanuts where area is projected to decline by 7.5%, 5.2%, 6.6% and 0.3%, respectively, by the end of the projection period (2018/19). Because yields are projected to increase by 8% for rice, 11% for soybeans, 14% for rapeseed, and 6% for peanuts, the production of these three crops will continue to increase.

Corn yields also increase significantly, by 11% so that, although area increases only by 6%, corn production is projected to increase by 18%. Wheat area harvested is expected to decline by 10.5% and since yields are projected to increase only modestly, by 1.6%, wheat production declines by 9% over the decade.  For the rest of the crops (barley, sunflower, sugar beet and sugarcane), yield growths are expected to be higher than the growth in their respective area harvested, thus resulting in double digit growth in crop production over the projection period.

## Hong Kong, China

Hong Kong has limited agricultural production. Figures A11 and A12 present rice area harvested and rice yields respectively.

Figure A11. Hong Kong Area Harvested by Crop

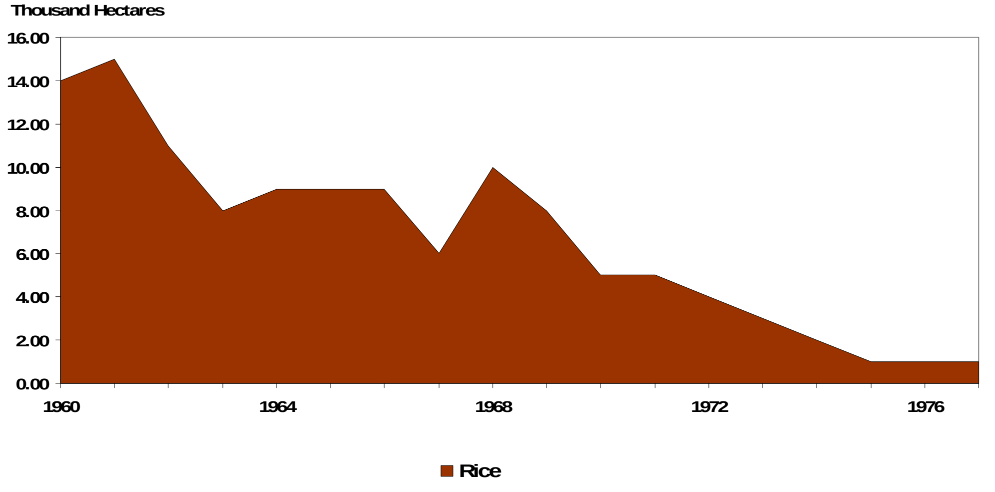
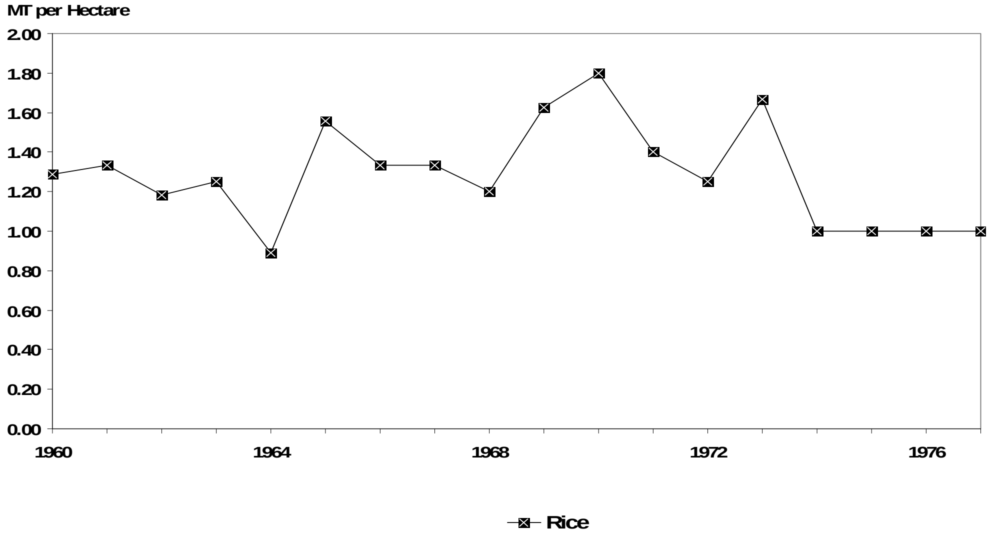



Figure A12. Hong Kong Crop Yield



## Indonesia

Figure A13 shows that total crop area harvested has increased over time in Indonesia. Most of this increase comes from the increase in rice area, which is the major crop produced. The second major crop in Indonesia is corn. Figure A14 demonstrates that yields for both corn and rice have increased considerably over time, whereas the yield for sugarcane has declined.

Figure A13. Indonesian Area Harvested by Crop

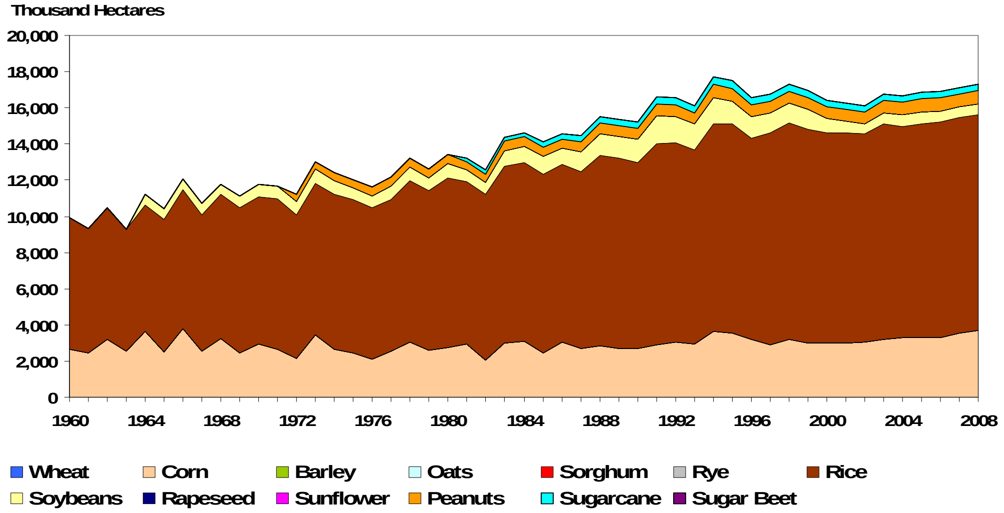
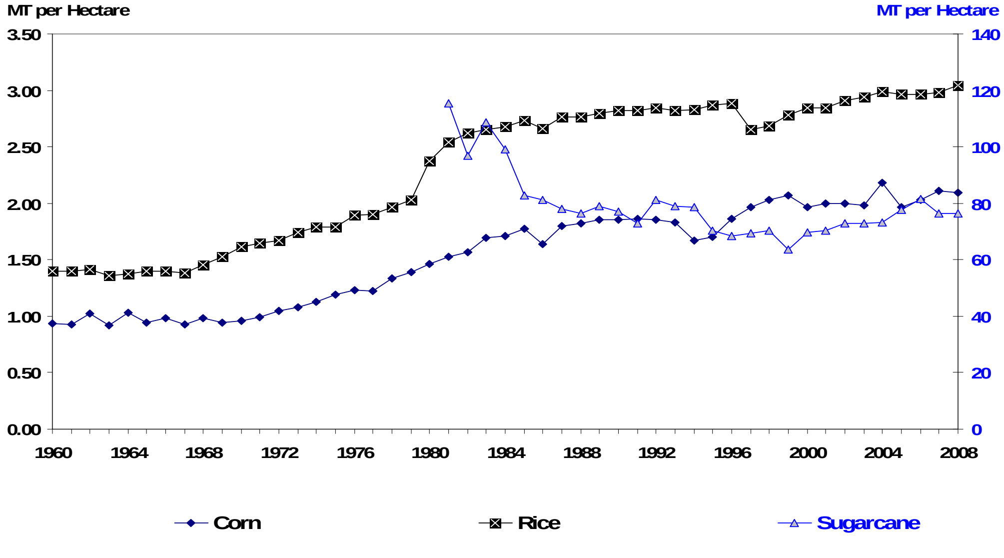



Figure A14. Indonesian Crop Yields



## Supply Projections

Table A4 shows supply projections for Indonesia for major crops in the next decade. The projections begin in 2009/10 and end in 2018/19. Area expansion contributes to production increase for corn, sugarcane, and palm, but not for rice. Corn area expands by 3.5% over the projection period. Combined with a yield growth of 7.1%, this leads to a production increase of 10.8%. Sugarcane production rises by 12.3% by 2018/19 because of both area expansion (5.6%) and yield growth (6.4%). Palm area and yield increases the most among crops; 18.3% for area and 11.6% for yield. This leads to a high production growth rate of palm at 32%. Despite growth in yields, rice production declines, due to a decline in area harvested. The highest yield growth between 2008/09 and 2018/19 occurs for corn (7.1%), followed by sugarcane (6.4%), and rice (3.9%).

Table A4. Indonesian Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 3,700 | 3,637 | 3,724 | 3,740 | 3,766 | 3,785 | 3,803 | 3,832 | 3,831 | 3,835 | 3,828 |
| Yield | (MT/Ha) | 2.09 | 2.11 | 2.12 | 2.14 | 2.15 | 2.17 | 2.18 | 2.20 | 2.21 | 2.23 | 2.24 |
| Production | (000 MT) | 7,750 | 7,673 | 7,911 | 8,001 | 8,112 | 8,209 | 8,307 | 8,425 | 8,481 | 8,547 | 8,589 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 11,900 | 11,911 | 11,854 | 11,840 | 11,835 | 11,844 | 11,842 | 11,871 | 11,890 | 11,893 | 11,875 |
| Yield | (MT/Ha) | 2.93 | 2.94 | 2.95 | 2.96 | 2.97 | 2.97 | 2.99 | 3.00 | 3.01 | 3.03 | 3.05 |
| Production | (000 MT) | 36,250 | 35,063 | 34,979 | 35,035 | 35,152 | 35,230 | 35,393 | 35,611 | 35,836 | 36,013 | 36,173 |
| **Palm** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 4100 | 4153 | 4207 | 4269 | 4336 | 4408 | 4489 | 4577 | 4666 | 4757 | 4850 |
| Yield | (MT/Ha) | 4.32 | 4.37 | 4.42 | 4.47 | 4.52 | 4.57 | 4.62 | 4.67 | 4.72 | 4.77 | 4.82 |
| Production | (000 MT) | 17700 | 18,135 | 18,584 | 19,071 | 19,584 | 20,134 | 20,728 | 21,360 | 22,010 | 22,678 | 23,364 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 340 | 348 | 351 | 353 | 354 | 355 | 355 | 356 | 356 | 358 | 359 |
| Yield | (MT/Ha) | 77.65 | 78.39 | 79.08 | 79.74 | 80.39 | 81.03 | 81.68 | 82.32 | 82.56 | 82.62 | 82.59 |
| Production | (000 MT) | 26,400 | 27,264 | 27,782 | 28,155 | 28,461 | 28,731 | 28,994 | 29,272 | 29,431 | 29,541 | 29,641 |

Source: FAPRI Preliminary Projections (2008)

## Japan

As seen in Figure A15, total crop area harvested has declined in Japan over the years. Japan's major crop production is rice, for which we see a slight upward trend in yield, as shown in Figure A16. Japan is a major importer of grains and oilseeds.

Figure A15. Japanese Area Harvested by Crop

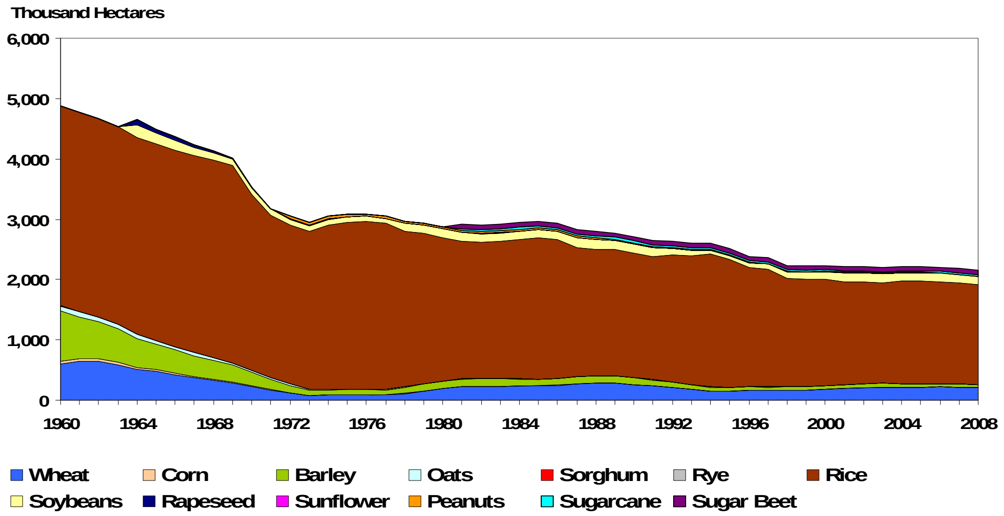
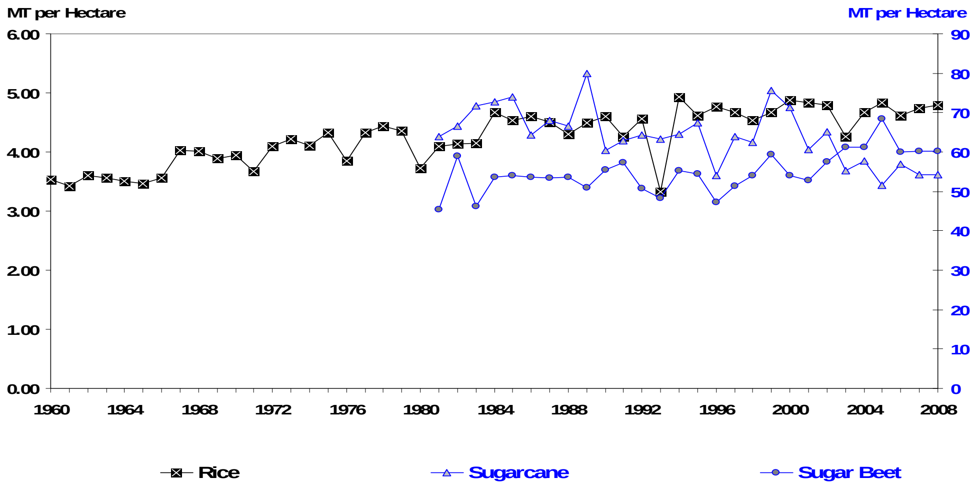



Figure A16. Japanese Crop Yields




### Supply Projections

Table A5 presents the supply projections between 2009/10 and 2018/19 for the major crops in Japan. Area harvest is projected to decline for most of the crops with the exception of sugar beet and sugarcane. The largest decline is in wheat area, which is projected to decline by 29%, followed by rapeseed (19.6%), soybeans (15.5%) and rice

(12.9%). Since the growth in yields for these crops is not expected compensate for the projected drop in area, production decreases by 27% for wheat, 11.5% for rapeseed, 7% for soybeans, and 8% for rice. Although area is also expected to decline for barley, by almost 2%, the 8% increase in yield over the projection period results in over 6% increase in the production of barley. The sugar crops are expected to show an increase in both area and yield. Area harvested is projected to increase by 6% and 7% for sugar beet and sugarcane, respectively, while yields are expected to increase by over 10% for sugar beet and by almost 12% for sugarcane. This results in a 17% increase in sugar beet production and almost 20% in sugarcane production by 2018/19.

Table A5. Japanese Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 210 | 205 | 178 | 158 | 153 | 149 | 149 | 149 | 149 | 149 | 149 |
| Yield | (MT/Ha) | 4.07 | 4.07 | 4.07 | 4.07 | 4.07 | 4.07 | 4.08 | 4.08 | 4.08 | 4.08 | 4.08 |
| Production | (000 MT) | 834 | 724 | 643 | 622 | 608 | 608 | 608 | 609 | 609 | 609 | 609 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | | | | | | | | | | | |
| Yield | (MT/Ha) | | | | | | | | | | | |
| Production | (000 MT) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Barley** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 52 | 50 | 48 | 47 | 48 | 48 | 49 | 50 | 50 | 51 | 51 |
| Yield | (MT/Ha) | 3.31 | 3.34 | 3.36 | 3.39 | 3.42 | 3.45 | 3.47 | 3.50 | 3.53 | 3.56 | 3.58 |
| Production | (000 MT) | 172 | 165 | 162 | 160 | 163 | 167 | 171 | 174 | 177 | 180 | 183 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,670 | 1,646 | 1,629 | 1,606 | 1,582 | 1,561 | 1,541 | 1,521 | 1,495 | 1,478 | 1,455 |
| Yield | (MT/Ha) | 4.84 | 4.90 | 4.93 | 4.96 | 4.97 | 4.98 | 5.01 | 5.02 | 5.02 | 5.04 | 5.05 |
| Production | (000 MT) | 8,000 | 8,072 | 8,038 | 7,964 | 7,866 | 7,780 | 7,716 | 7,636 | 7,507 | 7,452 | 7,348 |
| **Soybeans** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 138 | 124 | 116 | 113 | 114 | 115 | 116 | 117 | 117 | 117 | 117 |
| Yield | (MT/Ha) | 1.63 | 1.65 | 1.67 | 1.68 | 1.70 | 1.72 | 1.73 | 1.75 | 1.76 | 1.78 | 1.79 |
| Production | (000 MT) | 225 | 204 | 193 | 190 | 193 | 197 | 201 | 205 | 207 | 208 | 209 |
| **Rapeseed** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1.00 | 0.89 | 0.84 | 0.82 | 0.81 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 |
| Yield | (MT/Ha) | 1.00 | 1.01 | 1.02 | 1.03 | 1.04 | 1.05 | 1.06 | 1.07 | 1.08 | 1.09 | 1.10 |
| Production | (000 MT) | 1.00 | 0.90 | 0.86 | 0.85 | 0.84 | 0.84 | 0.85 | 0.86 | 0.87 | 0.88 | 0.88 |
| **Sugar Beet** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 69 | 69 | 70 | 70 | 71 | 71 | 72 | 72 | 73 | 73 | 73 |
| Yield | (MT/Ha) | 60.64 | 61.16 | 61.75 | 62.37 | 63.01 | 63.66 | 64.32 | 64.97 | 65.63 | 66.28 | 66.94 |
| Production | (000 MT) | 4,156 | 4,227 | 4,309 | 4,391 | 4,472 | 4,549 | 4,623 | 4,693 | 4,759 | 4,818 | 4,874 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 23 | 23 | 24 | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 25 |
| Yield | (MT/Ha) | 54.75 | 55.31 | 55.93 | 56.58 | 57.24 | 57.91 | 58.57 | 59.24 | 59.90 | 60.57 | 61.24 |
| Production | (000 MT) | 1,268 | 1,292 | 1,319 | 1,346 | 1,373 | 1,400 | 1,426 | 1,451 | 1,475 | 1,498 | 1,520 |

Source: FAPRI Preliminary Projections (2008)

## Korea

Figure A17 shows that total area harvested has declined in Republic of Korea over the years. The major crop produced is rice. We see a slight upward trend in Korean rice yield (Figure A18). Republic of Korea is a major importer of grains and oilseeds.

Figure A17. Korean Area Harvested by Crop

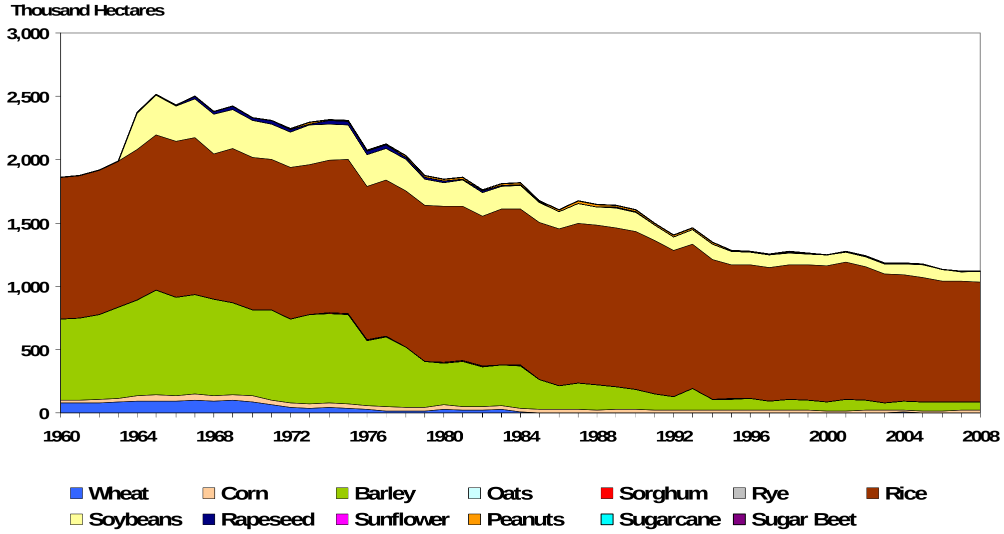
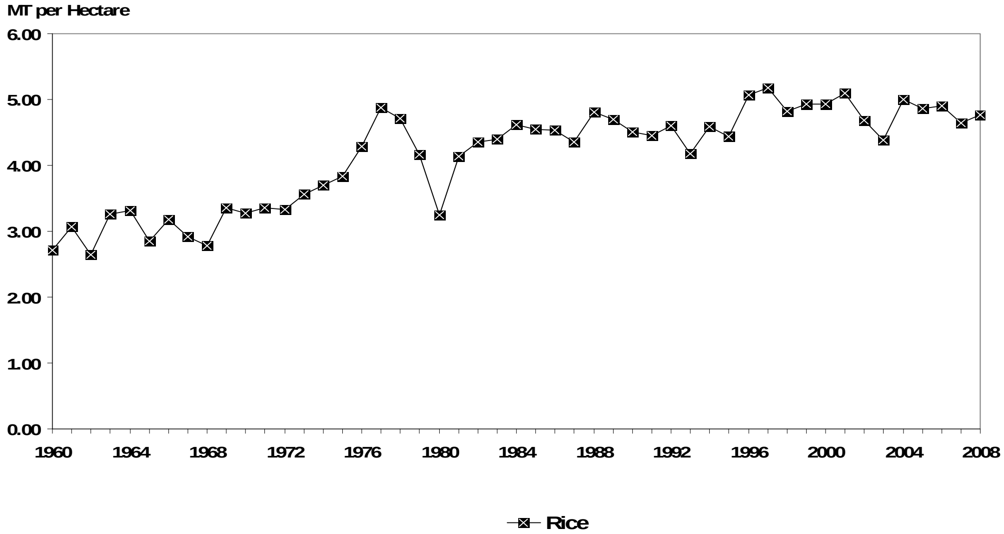



Figure A18. Korean Crop Yield



## Supply Projections

Table A6 shows supply projections for Republic of Korea (Korea) for major crops in the next ten years. The projections begin in 2009/10 and end in 2018/19. Republic of Korea is a very small producer of grains and oilseeds, and therefore a major importer. Rice is the major crop produced, followed by soybeans. Since area allocated to rice declines in the next decade (7.5%), rice production declines (6.2%), despite a yield growth of 2.9%. Soybean area harvested declines by 32.2%, more than the growth in yields (7.7%). Therefore, we see a decline of 26.9% in soybean production over the projection period.

Table A6. Korean Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Yield | (MT/Ha) | 3.00 | 3.00 | 3.01 | 3.01 | 3.01 | 3.01 | 3.02 | 3.02 | 3.02 | 3.02 | 3.03 |
| Production | (000 MT) | 9.00 | 9.01 | 9.02 | 9.02 | 9.03 | 9.04 | 9.05 | 9.06 | 9.07 | 9.07 | 9.08 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 |
| Yield | (MT/Ha) | 4.71 | 4.76 | 4.81 | 4.86 | 4.91 | 4.96 | 5.02 | 5.07 | 5.12 | 5.17 | 5.22 |
| Production | (000 MT) | 80 | 81 | 82 | 83 | 84 | 84 | 85 | 86 | 87 | 88 | 89 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 936 | 930 | 917 | 915 | 905 | 894 | 886 | 882 | 879 | 871 | 866 |
| Yield | (MT/Ha) | 4.84 | 4.84 | 4.85 | 4.87 | 4.87 | 4.88 | 4.89 | 4.91 | 4.94 | 4.96 | 4.98 |
| Production | (000 MT) | 4,600 | 4,502 | 4,451 | 4,454 | 4,407 | 4,365 | 4,338 | 4,336 | 4,337 | 4,319 | 4,314 |
| **Soybeans** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 85 | 78 | 71 | 70 | 70 | 70 | 70 | 71 | 70 | 70 | 58 |
| Yield | (MT/Ha) | 1.59 | 1.60 | 1.61 | 1.63 | 1.64 | 1.65 | 1.66 | 1.68 | 1.69 | 1.70 | 1.71 |
| Production | (000 MT) | 135 | 125 | 115 | 113 | 114 | 116 | 117 | 118 | 119 | 119 | 99 |

Source: FAPRI Preliminary Projections (2008)

## Malaysia

Malaysia produces mostly rice, as seen in Figure A19, along with some sugarcane and corn. Rice yield has increased mostly over the last five decades as shown in Figure A20.

Figure A19. Malaysian Area Harvested by Crop

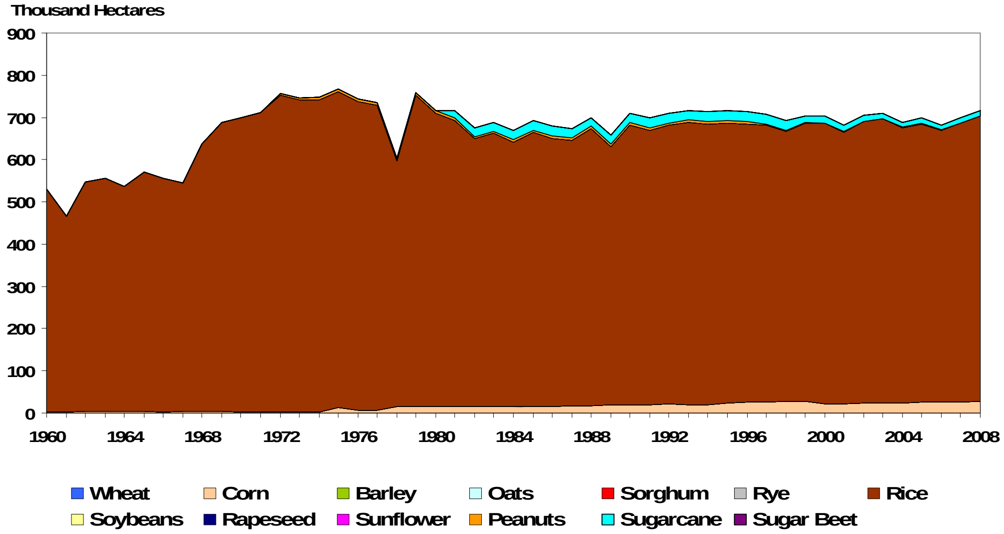
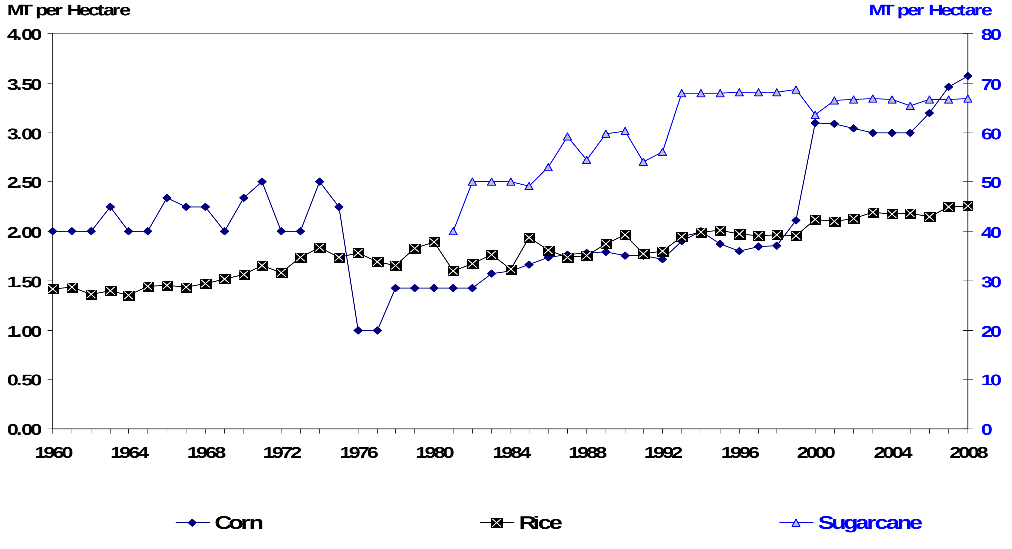



Figure A20. Malaysian Crop Yields



## Supply Projections

Malaysian ten-year supply projections for corn, rice, sugarcane, and palm are presented in Table A7. Area harvested is projected to decline for all corn, rice, and sugarcane by the end of the decade, but not for palm. Palm area expands nearly 29% over the next ten years. With a yield growth of 11.4%, palm production increases 43.5%. The largest area decline is seen in corn, which decreases by 18%. This is followed by sugarcane area, which is expected to decline by 4%. Rice area harvested, which represents the largest crop area, falls by 1.4%. Consequently, production decreases for both corn and sugarcane as yields increase by only 5.7% for corn and by 3% for sugarcane by 2018/19. However, rice production increases by 8.2% as rice yield is projected to increase by 9% by the end of the projection period.

Table A7. Malaysian Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 28.00 | 26.06 | 25.32 | 24.51 | 24.13 | 23.88 | 23.77 | 23.75 | 23.52 | 23.24 | 22.93 |
| Yield | (MT/Ha) | 3.57 | 3.59 | 3.61 | 3.63 | 3.65 | 3.67 | 3.69 | 3.71 | 3.73 | 3.76 | 3.78 |
| Production | (000 MT) | 100 | 94 | 91 | 89 | 88 | 88 | 88 | 88 | 88 | 87 | 87 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 675 | 682 | 683 | 682 | 681 | 679 | 677 | 674 | 671 | 668 | 666 |
| Yield | (MT/Ha) | 2.26 | 2.28 | 2.30 | 2.33 | 2.35 | 2.37 | 2.39 | 2.41 | 2.43 | 2.45 | 2.47 |
| Production | (000 MT) | 1,520 | 1,558 | 1,575 | 1,586 | 1,598 | 1,608 | 1,615 | 1,623 | 1,629 | 1,636 | 1,645 |
| **Palm** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 4500 | 4707 | 4860 | 4989 | 5104 | 5215 | 5327 | 5441 | 5556 | 5674 | 5794 |
| Yield | (MT/Ha) | 4.38 | 4.43 | 4.48 | 4.53 | 4.58 | 4.63 | 4.68 | 4.73 | 4.78 | 4.83 | 4.88 |
| Production | (000 MT) | 19700 | 20,842 | 21,761 | 22,588 | 23,365 | 24,135 | 24,919 | 25,723 | 26,547 | 27,393 | 28,260 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 11.72 | 11.66 | 11.57 | 11.48 | 11.40 | 11.35 | 11.31 | 11.28 | 11.25 | 11.23 | 11.21 |
| Yield | (MT/Ha) | 67.04 | 67.29 | 67.54 | 67.81 | 68.08 | 68.34 | 68.61 | 68.88 | 69.00 | 69.05 | 69.07 |
| Production | (000 MT) | 786 | 785 | 782 | 778 | 776 | 776 | 776 | 777 | 776 | 775 | 775 |

Source: FAPRI Preliminary Projections (2008)

## Mexico

Figure A21 shows that corn has the highest area share in Mexico followed by sorghum, wheat and sugarcane. Crop yields also show an upward trend, with the largest gain in corn yields (Figure A22). Total crop area has been somewhat stable over time, with some increase in the last three years.

Figure A21. Mexican Area Harvested by Crop

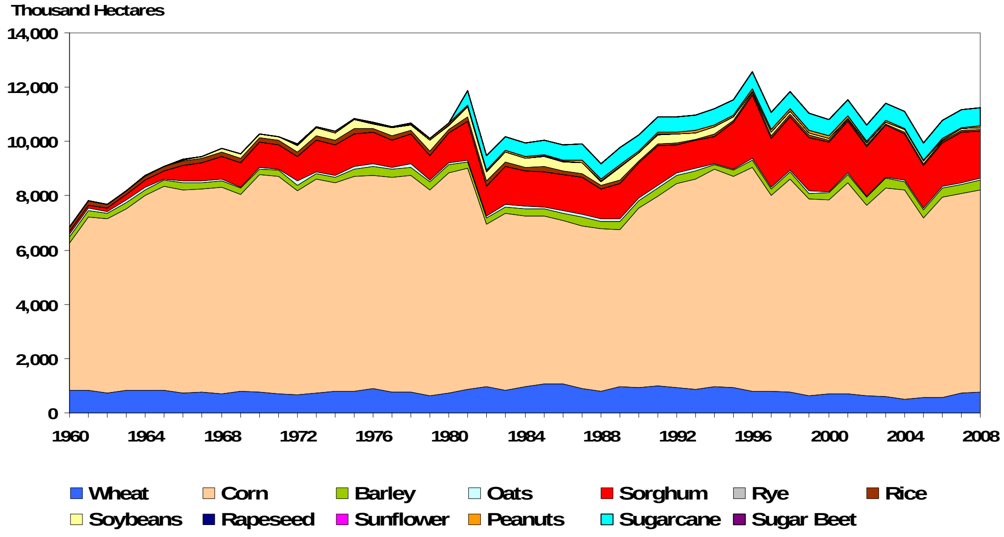
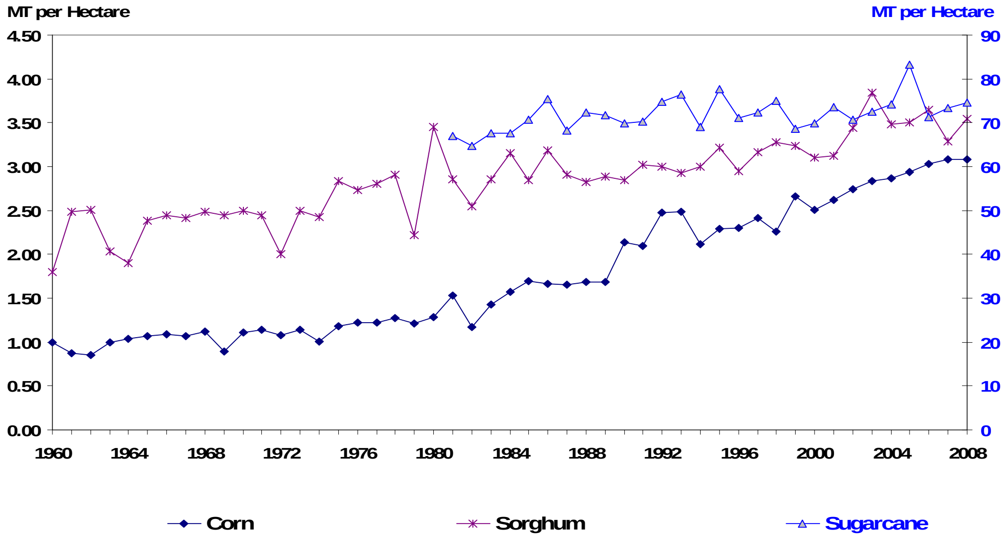



Figure A22. Mexican Crop Yields




### Supply Projections

Table A8 shows supply projections for Mexico for major crops in the next decade. The projections begin in 2009/10 and end in 2018/19. Area expands for sorghum, barley, soybeans, and sugarcane and declines for the remaining crops. Wheat production declines by 2.3%, despite a yield growth of 7.5%, since area decreases more (9.1%). Corn, rice, and peanuts production increase, although area allocated to these crops decline, due to high yield growth rates. For example, corn area decreases by 1.1% and yield increases by 2.7%, leading to a 1.7% increase in corn production. Sorghum, barley, soybeans, and sugarcane production expand both due to area expansion and yield growth. Soybeans have the highest production growth rate at 33.2%, with an area expansion of 23.2%. The highest yield growth between 2008/09 and 2018/19 occurs for barley (13.1%), followed by rice (11.1%), soybeans (8.1%), wheat (7.5%), sugarcane (7.3%), peanuts (6.4%), sorghum (5.1%), and corn (2.7%).

Table A8. Mexican Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 770 | 704 | 659 | 676 | 665 | 671 | 679 | 684 | 690 | 694 | 700 |
| Yield | (MT/Ha) | 5.06 | 5.10 | 5.14 | 5.18 | 5.22 | 5.25 | 5.29 | 5.33 | 5.37 | 5.40 | 5.44 |
| Production | (000 MT) | 3,900 | 3,591 | 3,388 | 3,503 | 3,470 | 3,525 | 3,591 | 3,643 | 3,704 | 3,749 | 3,811 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 7,450 | 7,243 | 7,312 | 7,315 | 7,347 | 7,364 | 7,380 | 7,395 | 7,382 | 7,382 | 7,371 |
| Yield | (MT/Ha) | 3.22 | 3.15 | 3.17 | 3.18 | 3.20 | 3.22 | 3.24 | 3.26 | 3.27 | 3.29 | 3.31 |
| Production | (000 MT) | 24,000 | 22,795 | 23,145 | 23,287 | 23,519 | 23,708 | 23,892 | 24,076 | 24,167 | 24,297 | 24,396 |
| **Sorghum** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,750 | 1,743 | 1,755 | 1,742 | 1,779 | 1,779 | 1,798 | 1,806 | 1,810 | 1,817 | 1,821 |
| Yield | (MT/Ha) | 3.54 | 3.53 | 3.55 | 3.58 | 3.60 | 3.62 | 3.64 | 3.66 | 3.68 | 3.70 | 3.72 |
| Production | (000 MT) | 6,200 | 6,159 | 6,239 | 6,229 | 6,396 | 6,436 | 6,541 | 6,607 | 6,662 | 6,726 | 6,777 |
| **Barley** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 350 | 348 | 358 | 361 | 367 | 372 | 375 | 378 | 380 | 381 | 383 |
| Yield | (MT/Ha) | 2.57 | 2.61 | 2.64 | 2.67 | 2.71 | 2.74 | 2.77 | 2.81 | 2.84 | 2.87 | 2.91 |
| Production | (000 MT) | 900 | 906 | 944 | 966 | 994 | 1,018 | 1,041 | 1,062 | 1,081 | 1,096 | 1,115 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 75 | 65 | 63 | 62 | 62 | 62 | 62 | 63 | 63 | 63 | 63 |
| Yield | (MT/Ha) | 3.66 | 3.71 | 3.75 | 3.81 | 3.84 | 3.90 | 3.98 | 4.04 | 4.03 | 4.07 | 4.07 |
| Production | (000 MT) | 209 | 241 | 235 | 237 | 239 | 242 | 248 | 253 | 253 | 255 | 256 |
| **Soybeans** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 65 | 69 | 70 | 71 | 72 | 74 | 75 | 77 | 78 | 79 | 80 |
| Yield | (MT/Ha) | 2.46 | 2.48 | 2.50 | 2.52 | 2.54 | 2.56 | 2.58 | 2.60 | 2.62 | 2.64 | 2.66 |
| Production | (000 MT) | 160 | 170 | 175 | 179 | 184 | 189 | 194 | 199 | 204 | 209 | 213 |
| **Peanuts** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 45 | 46 | 45 | 45 | 44 | 44 | 44 | 43 | 43 | 43 | 43 |
| Yield | (MT/Ha) | 1.56 | 1.57 | 1.58 | 1.59 | 1.60 | 1.61 | 1.62 | 1.63 | 1.64 | 1.65 | 1.66 |
| Production | (000 MT) | 70 | 73 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 668 | 671 | 673 | 675 | 678 | 681 | 684 | 685 | 686 | 688 | 690 |
| Yield | (MT/Ha) | 73.35 | 74.07 | 74.66 | 75.19 | 75.70 | 76.21 | 76.71 | 77.21 | 77.71 | 78.21 | 78.71 |
| Production | (000 MT) | 49,000 | 49,678 | 50,221 | 50,759 | 51,328 | 51,875 | 52,451 | 52,894 | 53,343 | 53,828 | 54,309 |

Source: FAPRI Preliminary Projections (2008)

## New Zealand

Total crop area in New Zealand is relatively small compared to other APEC economies, since pastureland takes a larger share of the total agricultural area (Figure A23). Wheat and barley yields are relatively high and have show significant increases in the last decade as seen in Figure A24.

Figure A23. New Zealand Area Harvested by Crop

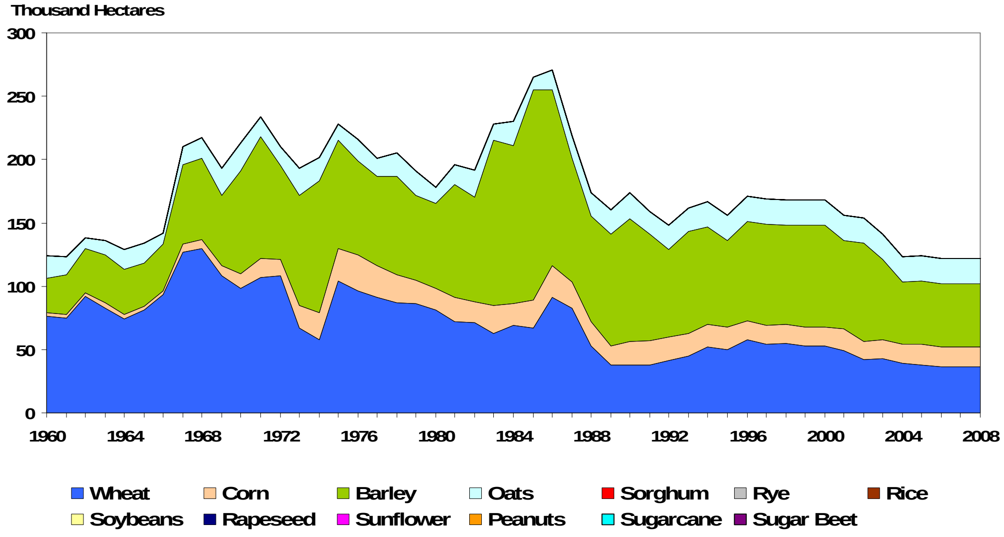
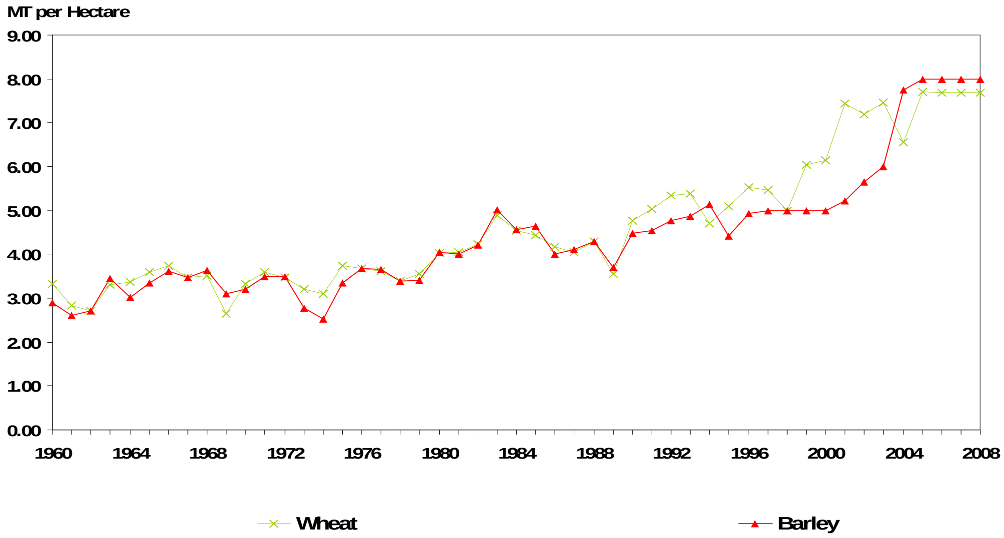



Figure A24. New Zealand Crop Yields



## Peru

The major crops produced in Peru are corn, rice, wheat and barley. Total crop area has been increasing over the years, especially since the 1990s, as seen in Figure A25. Crop yields are somewhat stable and show an upward trend in the last decade (Figure A26).

Figure A25. Peruvian Area Harvested by Crop

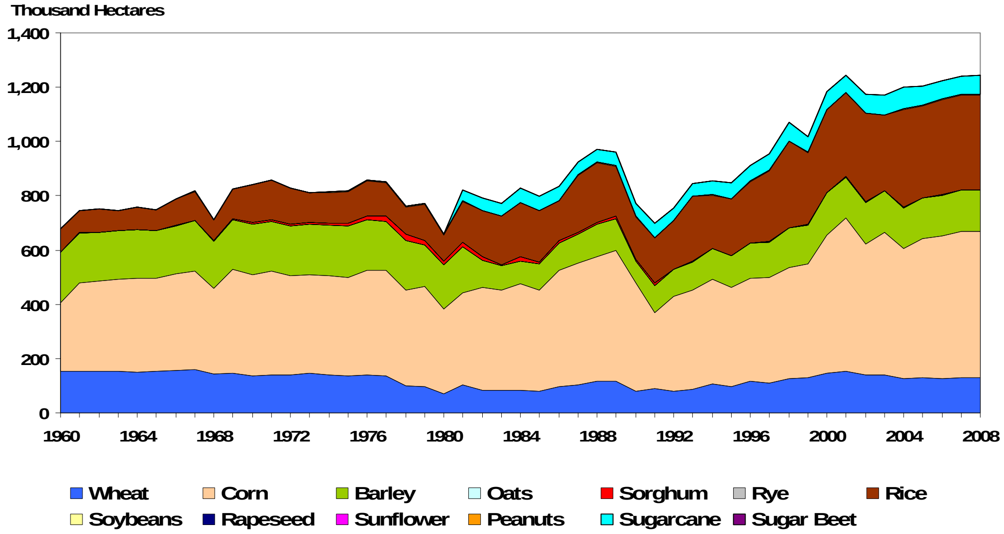
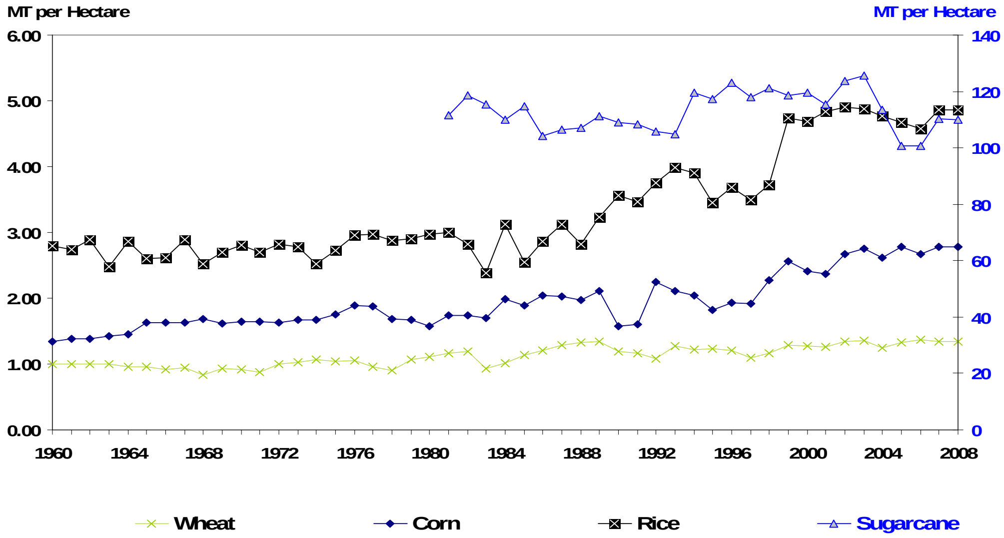



Figure A26. Peruvian Crop Yields



**Supply Projections**

Projections for Peruvian sugarcane area harvested, yield and production are presented in Table A9 for the period between 2009/10 and 2018/19. Area harvested is projected to increase by 9.8%, from 70,000 hectares in 2008/09 to 77,000 hectares in 2018/19. Sugarcane yield is expected to increase from 118.6 metric tons per hectare to 126.6 metric tons per hectare, an increase of 6.8% over the decade. This results in an increase of 17.3% in sugarcane production, reaching 9.7 million tons, by 2018/19.

Table A9. Peruvian Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 70 | 72 | 73 | 74 | 75 | 75 | 76 | 76 | 76 | 77 | 77 |
| Yield | (MT/Ha) | 118.57 | 118.09 | 118.48 | 119.26 | 120.21 | 121.24 | 122.30 | 123.37 | 124.45 | 125.53 | 126.61 |
| Production | (000 MT) | 8,300 | 8,479 | 8,673 | 8,855 | 9,015 | 9,148 | 9,268 | 9,385 | 9,501 | 9,619 | 9,734 |

Source: FAPRI Preliminary Projections (2008)

## Philippines

The major crop produced in the Philippines is rice followed by corn (Figure A27). Both crop areas have increased over the last few years. Figure A28 shows the historical yields for corn, rice and sugarcane. Both corn and rice yields have increased, while sugarcane yield has declined over the years.

Figure A27. Philippine Area Harvested by Crop

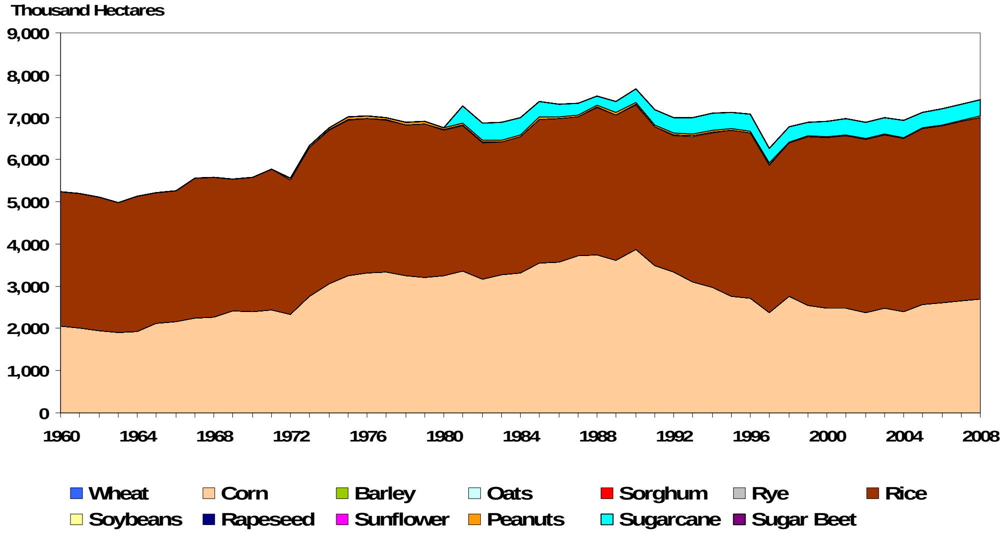
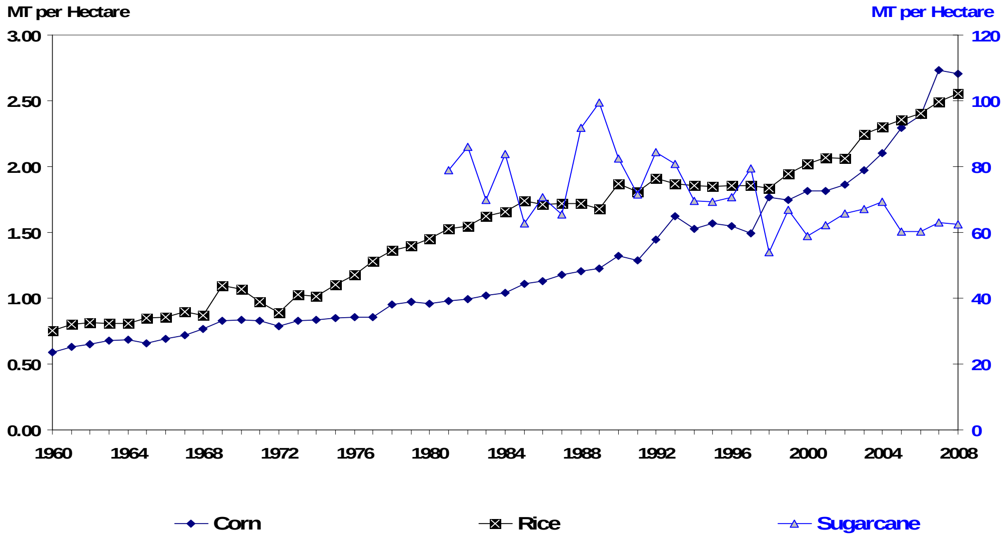



Figure A28. Philippine Crop Yields



## Supply Projections

Table A10 shows supply projections for Philippines for major crops between 2009/10 and 2018/19. Both area expansion and yield growth contribute to production increases for corn, rice, and sugarcane. The highest yield growth in the projection period occurs for rice (13.5%), followed by sugarcane (9.3%), and corn (9.3%). Rice has the highest production increase at 24.7%, with an area expansion of 5.5% and yield growth of 13.5%.

Table A10. Philippine Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 2,600 | 2,613 | 2,634 | 2,628 | 2,633 | 2,623 | 2,619 | 2,625 | 2,620 | 2,620 | 2,616 |
| Yield | (MT/Ha) | 2.50 | 2.52 | 2.55 | 2.57 | 2.59 | 2.62 | 2.64 | 2.66 | 2.69 | 2.71 | 2.73 |
| Production | (000 MT) | 6,500 | 6,592 | 6,706 | 6,752 | 6,825 | 6,860 | 6,912 | 6,987 | 7,034 | 7,094 | 7,144 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 4,300 | 4,353 | 4,382 | 4,396 | 4,408 | 4,429 | 4,454 | 4,480 | 4,505 | 4,524 | 4,538 |
| Yield | (MT/Ha) | 2.47 | 2.50 | 2.56 | 2.61 | 2.64 | 2.68 | 2.70 | 2.72 | 2.74 | 2.77 | 2.80 |
| Production | (000 MT) | 10,200 | 10,888 | 11,224 | 11,471 | 11,642 | 11,858 | 12,017 | 12,175 | 12,349 | 12,538 | 12,715 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 393 | 397 | 398 | 400 | 401 | 404 | 406 | 409 | 412 | 416 | 419 |
| Yield | (MT/Ha) | 62.34 | 62.81 | 63.47 | 64.22 | 65.02 | 65.83 | 66.65 | 67.48 | 67.86 | 68.03 | 68.11 |
| Production | (000 MT) | 24,500 | 24,912 | 25,288 | 25,669 | 26,096 | 26,571 | 27,081 | 27,614 | 27,979 | 28,276 | 28,540 |

Source: FAPRI Preliminary Projections (2008)

## Russia

As seen in Figure A29, Russia is an important producer of grains and oilseeds. The major portion of the crop area is allocated to wheat, followed by barley, sunflower, and oats. Although crop area has declined in the 1980s and the 1990s, it has been increasing in the last decade. Historical yields, as shown in Figure A30, have a lot of variation due to weather conditions. Although yields are increasing on average, the impact of weather makes it difficult to project crop yields for Russia.

Figure A29. Russian Area Harvested by Crop

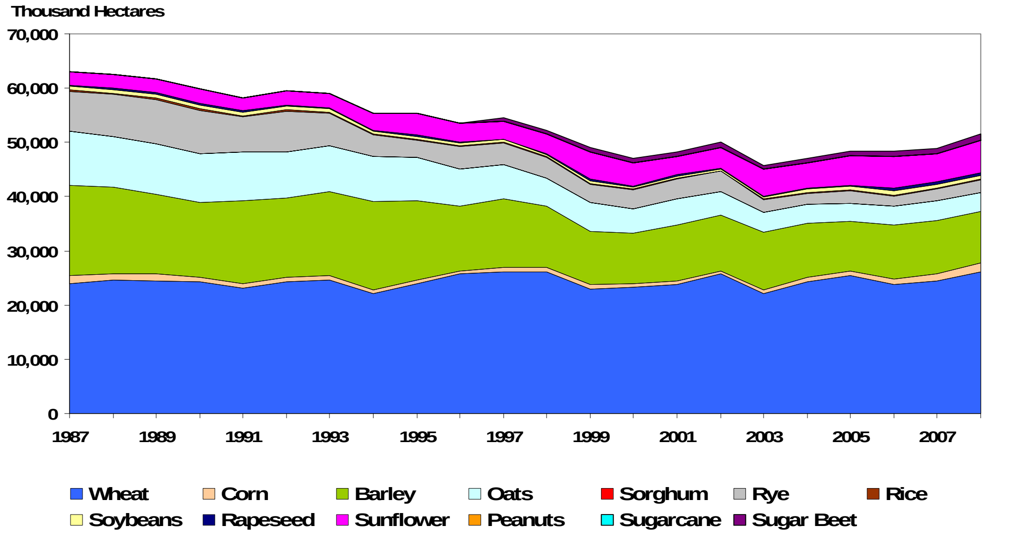
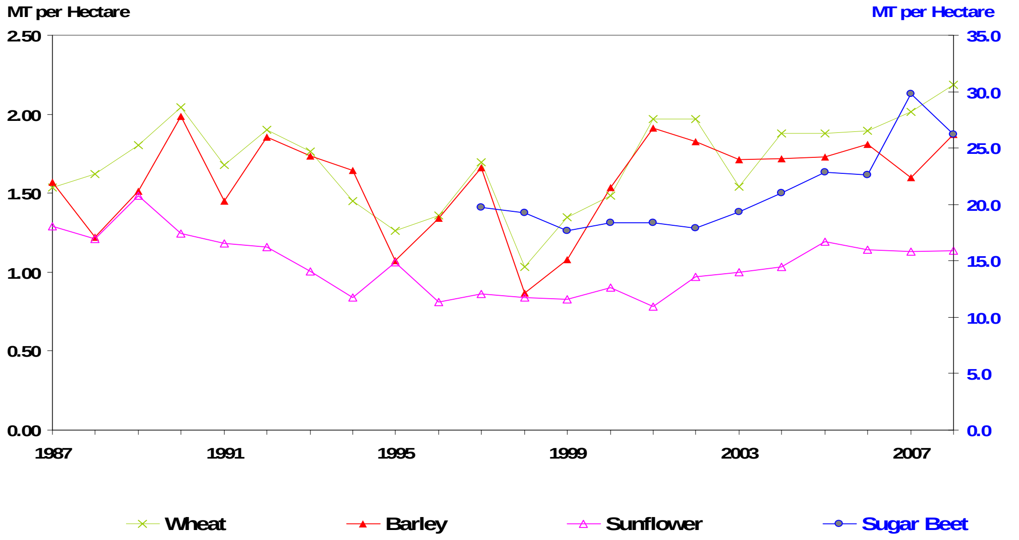



Figure A30. Russian Crop Yields



## Supply Projections

Table A11 shows supply projections for Russia for major crops in the next decade. The projections begin in 2009/10 and end in 2018/19. Projected yields for these crops are lower relative to 2008/09 yields, since 2008/09 yields were exceptionally good and average weather conditions are assumed for the projections. Since area expands for wheat (0.1%) and barley (3%), the production decline in these crops is less than the decline we see in their yields. Corn area harvested decreases by 21.3% and yield declines by 7.1%, leading to a decline of 26.9% in corn production.

Table A11. Russian Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 26,700 | 27,083 | 26,518 | 26,645 | 26,610 | 26,690 | 26,676 | 26,728 | 26,733 | 26,728 | 26,736 |
| Yield | (MT/Ha) | 2.36 | 2.12 | 2.14 | 2.15 | 2.17 | 2.19 | 2.21 | 2.22 | 2.24 | 2.26 | 2.27 |
| Production | (000 MT) | 63,000 | 57,459 | 56,702 | 57,407 | 57,787 | 58,413 | 58,838 | 59,406 | 59,871 | 60,312 | 60,784 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,600 | 1,296 | 1,276 | 1,267 | 1,264 | 1,263 | 1,264 | 1,265 | 1,262 | 1,261 | 1,259 |
| Yield | (MT/Ha) | 4.06 | 3.58 | 3.60 | 3.62 | 3.64 | 3.67 | 3.69 | 3.71 | 3.73 | 3.75 | 3.77 |
| Production | (000 MT) | 6,500 | 4,640 | 4,592 | 4,588 | 4,603 | 4,629 | 4,660 | 4,690 | 4,710 | 4,732 | 4,752 |
| **Barley** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 9,700 | 10,088 | 9,898 | 9,881 | 9,872 | 9,899 | 9,919 | 9,934 | 9,956 | 9,972 | 9,993 |
| Yield | (MT/Ha) | 2.32 | 1.93 | 1.94 | 1.95 | 1.96 | 1.97 | 1.98 | 1.99 | 2.00 | 2.01 | 2.02 |
| Production | (000 MT) | 22,500 | 19,446 | 19,173 | 19,236 | 19,317 | 19,468 | 19,606 | 19,736 | 19,877 | 20,008 | 20,149 |

Source: FAPRI Preliminary Projections (2008)

## Chinese Taipei

Total crop area harvested has been declining in Chinese Taipei over the years (Figure A31). This is due mainly to the decline in rice area, which is the major crop produced. Figure A32 shows the historical yields for rice, which have a strong upward trend. Chinese Taipei is a major importer of grains and oilseeds.

Figure A31. Chinese Taipei Area Harvested by Crop

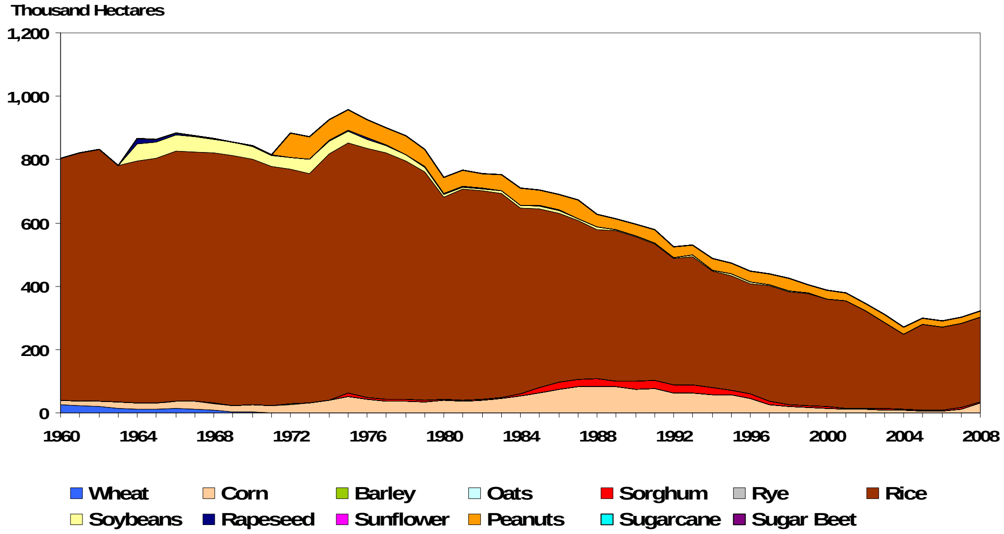
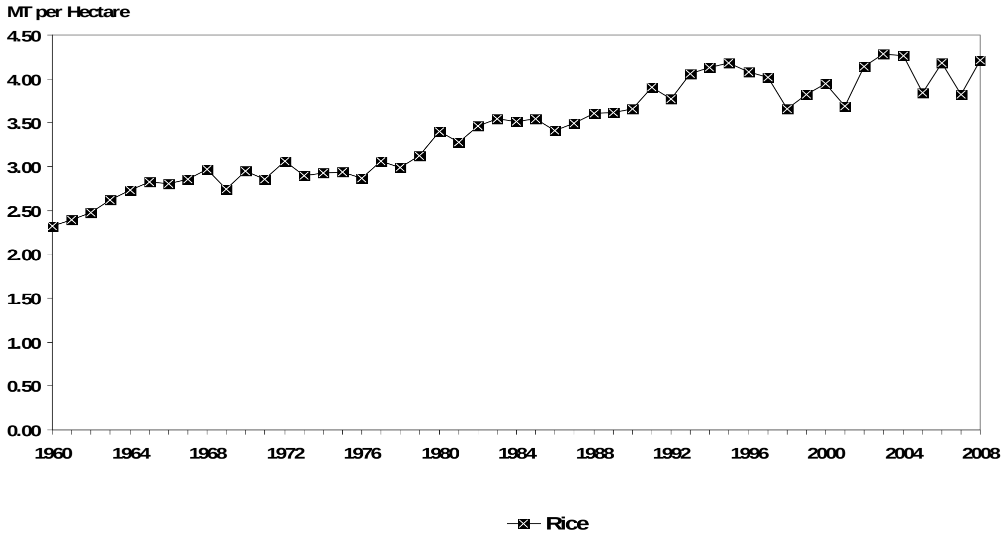



Figure A32. Chinese Taipei Crop Yield



### Supply Projections

Table A12 shows the supply projections for corn and rice for Chinese Taipei between 2009/10 and 2018/19. Area harvested of both crops is expected to decline, by 9% for corn and almost 11% for rice. Since yields increase by only 7% and 1.4% for corn and rice, respectively, production for both crops is projected to decrease by 2018/19. Corn production decreases by 2.5% while rice production declines by a little over 12%.

Table A12. Chinese Taipei Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 30 | 28 | 29 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 27 |
| Yield | (MT/Ha) | 5.00 | 5.04 | 5.07 | 5.11 | 5.14 | 5.18 | 5.21 | 5.25 | 5.29 | 5.32 | 5.36 |
| Production | (000 MT) | 150 | 142 | 147 | 145 | 146 | 146 | 147 | 148 | 147 | 147 | 146 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 268 | 266 | 261 | 258 | 254 | 251 | 248 | 246 | 244 | 241 | 240 |
| Yield | (MT/Ha) | 4.08 | 4.10 | 4.10 | 4.11 | 4.12 | 4.14 | 4.14 | 4.13 | 4.13 | 4.15 | 4.14 |
| Production | (000 MT) | 1,130 | 1,089 | 1,072 | 1,060 | 1,045 | 1,037 | 1,026 | 1,015 | 1,007 | 1,001 | 992 |

Source: FAPRI Preliminary Projections (2008)

# Thailand

Figure A33 shows that the major portion of crop area harvested is allocated to rice in Thailand. The other main crops produced are corn and sugarcane. We also see a strong upward trend in corn yields, as well as sugarcane yields, although the latter have experienced quite a bit of variability in the last two decades (Figure A34).

Figure A33. Thai Area Harvested by Crop

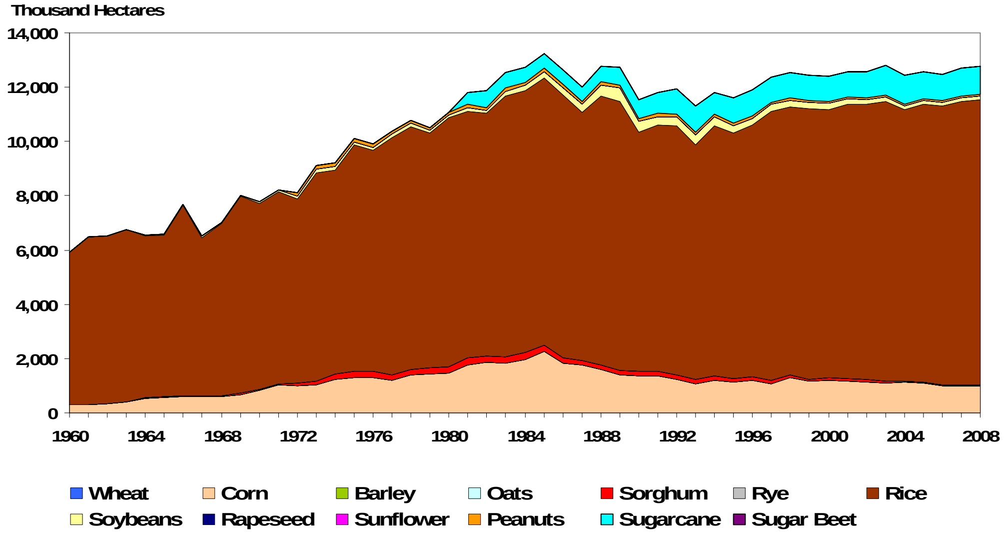
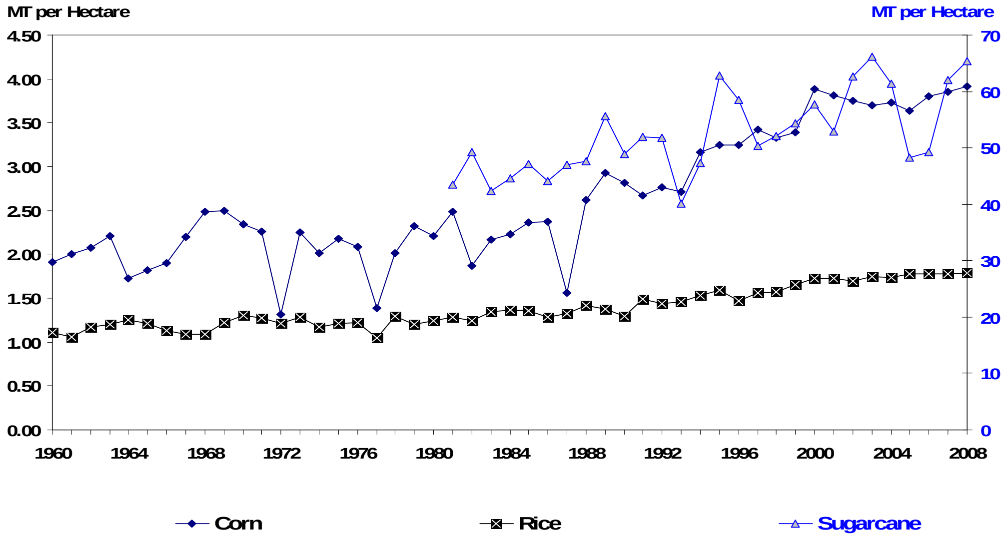



Figure A34. Thai Crop Yields



## Supply Projections

The Thai supply projections between 2009/10 and 2018/19 for corn, rice and sugarcane are presented in Table A13. Rice represents the largest area at about 10.7 million hectares in 2008/09. Rice area harvested is projected to decline slightly over the projected period (by 0.7%) while yield is expected to increase by 8.7%. As a result, rice production increases by 8.8%. Sugarcane area is projected to increase by almost 10% over the decade. With yields projected to increase by 6%, sugarcane production increases by 16.3% by 2018/19. Similarly for corn, both area and yield are projected to increase, by 2.7% and 13%, respectively, and thus corn production increases 16% by the end of the projection period.

Table A13. Thai Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,020 | 1,017 | 1,020 | 1,027 | 1,037 | 1,039 | 1,042 | 1,046 | 1,047 | 1,048 | 1,047 |
| Yield | (MT/Ha) | 4.02 | 4.04 | 4.09 | 4.15 | 4.21 | 4.26 | 4.32 | 4.37 | 4.43 | 4.49 | 4.54 |
| Production | (000 MT) | 4,100 | 4,109 | 4,178 | 4,263 | 4,364 | 4,431 | 4,500 | 4,578 | 4,637 | 4,703 | 4,756 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 10,700 | 10,629 | 10,602 | 10,566 | 10,545 | 10,573 | 10,631 | 10,660 | 10,658 | 10,673 | 10,629 |
| Yield | (MT/Ha) | 1.84 | 1.86 | 1.88 | 1.90 | 1.90 | 1.92 | 1.94 | 1.95 | 1.97 | 1.98 | 2.00 |
| Production | (000 MT) | 19,500 | 19,754 | 19,899 | 20,028 | 20,045 | 20,330 | 20,604 | 20,795 | 20,954 | 21,112 | 21,221 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,000 | 1,034 | 1,054 | 1,066 | 1,074 | 1,079 | 1,083 | 1,086 | 1,090 | 1,094 | 1,099 |
| Yield | (MT/Ha) | 74.00 | 74.38 | 74.79 | 75.22 | 75.65 | 76.10 | 76.54 | 76.99 | 77.43 | 77.88 | 78.33 |
| Production | (000 MT) | 74,000 | 76,931 | 78,857 | 80,211 | 81,253 | 82,120 | 82,887 | 83,619 | 84,375 | 85,190 | 86,064 |

Source: FAPRI Preliminary Projections (2008)

## United States

The United States has one of the highest and most diversified crop areas among APEC economies. The major crops produced are corn, soybeans, wheat, and sorghum (Figure A35). The United States is a major exporter of these crops in the world markets. Figure A36 presents the historical crop yields in the United States, which have a very strong upward trend. Corn yield has the strongest growth among all crops, followed by rice. Agricultural R&D and biotechnology, which is widely adopted in the United States, is one of the factors that have contributed to this upward trend in crop yields. The other factors include high input use, farm management practices, and farm programs.

Figure A35. U.S. Area Harvested by Crop

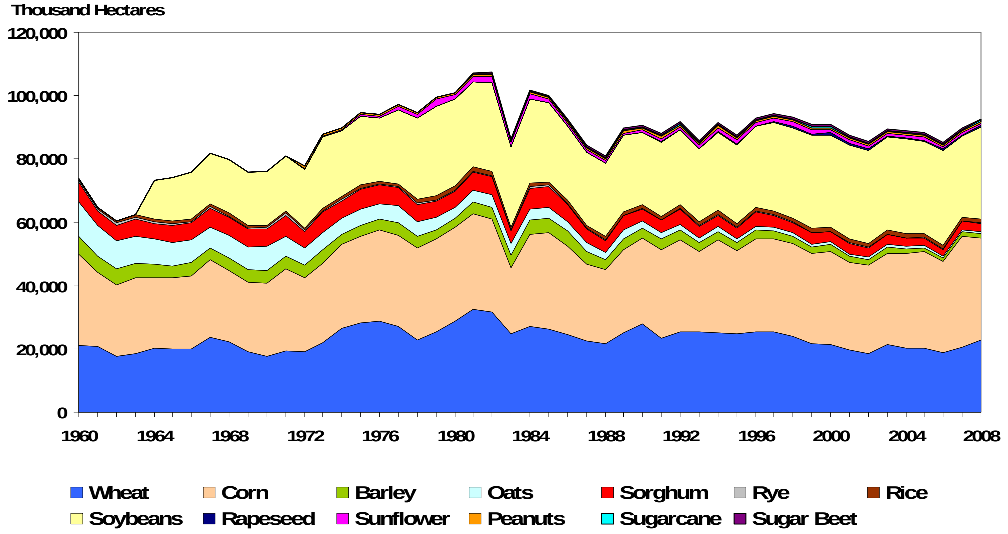
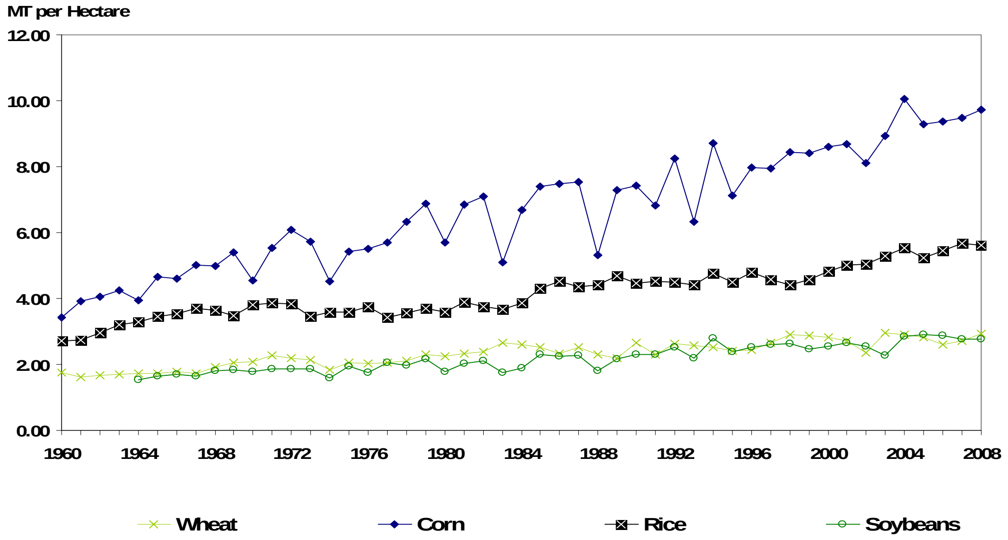



Figure A36. U.S. Crop Yields



## Supply Projections

Table A14. U.S. Crop Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 22,535 | 21,143 | 20,452 | 20,659 | 20,265 | 20,391 | 20,175 | 20,112 | 20,106 | 20,013 | 20,019 |
| Yield | (MT/Ha) | 3.02 | 2.89 | 2.92 | 2.94 | 2.96 | 2.98 | 3.00 | 3.03 | 3.05 | 3.08 | 3.10 |
| Production | (000 MT) | 68,026 | 61,146 | 59,666 | 60,721 | 59,956 | 60,774 | 60,562 | 60,875 | 61,393 | 61,644 | 62,158 |
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 31,637 | 33,430 | 33,704 | 33,401 | 33,873 | 34,083 | 34,594 | 35,161 | 34,984 | 35,030 | 34,916 |
| Yield | (MT/Ha) | 9.65 | 9.72 | 9.85 | 9.98 | 10.10 | 10.22 | 10.34 | 10.48 | 10.62 | 10.75 | 10.88 |
| Production | (000 MT) | 305,319 | 324,831 | 331,937 | 333,347 | 341,988 | 348,338 | 357,869 | 368,438 | 371,536 | 376,546 | 379,846 |
| **Sorghum** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 2,989 | 2,589 | 2,573 | 2,411 | 2,463 | 2,389 | 2,404 | 2,404 | 2,390 | 2,385 | 2,368 |
| Yield | (MT/Ha) | 3.95 | 4.03 | 4.04 | 4.05 | 4.06 | 4.07 | 4.08 | 4.09 | 4.11 | 4.12 | 4.13 |
| Production | (000 MT) | 11,818 | 10,423 | 10,389 | 9,767 | 9,994 | 9,716 | 9,799 | 9,829 | 9,814 | 9,822 | 9,775 |
| **Barley** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,524 | 1,629 | 1,519 | 1,491 | 1,517 | 1,496 | 1,490 | 1,478 | 1,448 | 1,429 | 1,403 |
| Yield Actual | (MT/Ha) | 3.42 | 3.43 | 3.47 | 3.50 | 3.53 | 3.57 | 3.60 | 3.63 | 3.66 | 3.70 | 3.73 |
| Production | (000 MT) | 5,214 | 5,589 | 5,268 | 5,225 | 5,361 | 5,338 | 5,363 | 5,364 | 5,306 | 5,283 | 5,234 |
| **Oats** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 565 | 630 | 589 | 571 | 562 | 550 | 537 | 525 | 520 | 515 | 508 |
| Yield Actual | (MT/Ha) | 2.28 | 2.25 | 2.26 | 2.27 | 2.29 | 2.30 | 2.31 | 2.32 | 2.33 | 2.34 | 2.36 |
| Production | (000 MT) | 1,287 | 1,419 | 1,334 | 1,300 | 1,283 | 1,262 | 1,240 | 1,218 | 1,213 | 1,206 | 1,198 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,183 | 1,272 | 1,264 | 1,168 | 1,150 | 1,097 | 1,093 | 1,161 | 1,177 | 1,215 | 1,225 |
| Yield | (MT/Ha) | 5.50 | 5.59 | 5.65 | 5.71 | 5.75 | 5.81 | 5.86 | 5.90 | 5.95 | 5.99 | 6.04 |
| Production | (000 MT) | 6,507 | 7,113 | 7,141 | 6,670 | 6,618 | 6,371 | 6,404 | 6,850 | 7,003 | 7,280 | 7,396 |
| **Soybeans** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 30,099 | 28,707 | 28,989 | 29,399 | 29,566 | 29,756 | 29,709 | 29,557 | 29,750 | 29,761 | 29,869 |
| Yield | (MT/Ha) | 2.64 | 2.82 | 2.85 | 2.88 | 2.90 | 2.93 | 2.96 | 2.99 | 3.02 | 3.04 | 3.07 |
| Production | (000 MT) | 79,487 | 81,032 | 82,618 | 84,623 | 85,871 | 87,232 | 87,847 | 88,229 | 89,703 | 90,611 | 91,716 |
| **Canola** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 399 | 431 | 428 | 453 | 435 | 439 | 447 | 461 | 475 | 487 | 501 |
| Yield | (MT/Ha) | 1.70 | 1.62 | 1.64 | 1.66 | 1.68 | 1.70 | 1.72 | 1.74 | 1.77 | 1.79 | 1.81 |
| Production | (000 MT) | 677 | 700 | 703 | 753 | 733 | 748 | 770 | 804 | 839 | 869 | 904 |
| **Sunflower** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 965 | 817 | 802 | 819 | 817 | 811 | 810 | 810 | 815 | 818 | 822 |
| Yield | (MT/Ha) | 1.62 | 1.58 | 1.60 | 1.62 | 1.63 | 1.65 | 1.66 | 1.68 | 1.70 | 1.71 | 1.73 |
| Production | (000 MT) | 1,567 | 1,293 | 1,282 | 1,324 | 1,333 | 1,336 | 1,348 | 1,362 | 1,384 | 1,403 | 1,423 |
| **Peanuts** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 605 | 589 | 575 | 572 | 579 | 566 | 570 | 566 | 565 | 563 | 561 |
| Yield | (MT/Ha) | 3.75 | 3.45 | 3.49 | 3.51 | 3.54 | 3.58 | 3.61 | 3.64 | 3.67 | 3.70 | 3.73 |
| Production | (000 MT) | 2,265 | 2,034 | 2,004 | 2,012 | 2,051 | 2,024 | 2,055 | 2,057 | 2,071 | 2,080 | 2,090 |
| **Sugar Beet** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 426 | 492 | 474 | 467 | 473 | 481 | 486 | 497 | 490 | 489 | 490 |
| Yield | (MT/Ha) | 60.07 | 58.23 | 58.89 | 59.58 | 60.35 | 61.11 | 61.87 | 62.63 | 63.34 | 64.08 | 64.81 |
| Production | (000 MT) | 25,564 | 28,660 | 27,927 | 27,810 | 28,571 | 29,426 | 30,084 | 31,105 | 31,049 | 31,331 | 31,737 |
| **Sugarcane** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 331 | 332 | 341 | 334 | 314 | 299 | 282 | 283 | 282 | 280 | 278 |
| Yield | (MT/Ha) | 77.28 | 77.35 | 78.29 | 78.53 | 78.66 | 78.89 | 79.08 | 79.91 | 80.53 | 81.04 | 81.58 |
| Production | (000 MT) | 25,545 | 25,665 | 26,669 | 26,259 | 24,734 | 23,628 | 22,305 | 22,594 | 22,740 | 22,662 | 22,707 |

Source: FAPRI Preliminary Projections (2008)

Table A14 shows supply projections for United States for major crops between 2009/10 and 2018/19. Area harvested decreases for wheat (11.2%), sorghum (20.8%), oats (10%), and sugarcane (15.8%). Although there are increases in the yields of these crops, they are not high enough to increase their production. Therefore, production decreases for wheat (8.6%), sorghum (17.3%), oats (6.9%), and sugarcane (11.1%). For some crops, despite an area decline, production grows due to yield increases. For example, although barley area declines (7.9%), its production increases by 0.4% due to a yield growth of 9.1%. Soybean production also shows a similar pattern, with soybean area declining by 0.8%, and yield growing by 16.3%.

Thus, we see a 15.4% increase in U.S. soybean production. For corn, rice, canola, and sugar beet, both area expansion and yield growth lead to production increase. Corn area grows by 10.4% and its yield increases by 12.8%, leading to a production increase of 12.8%. Similarly for rice, both area expansion (3.5%) and yield growth (9.8%) contribute to production growth (13.7%). The highest yield growth between 2008/09 and 2018/19 occurs for soybeans (16.3%), followed by corn (12.7%), rice (9.8%), barley (9.1%), sugar beet (7.9%), sunflower (6.7%), canola (6.4%), sugarcane (5.6%), sorghum (4.4%), oats (3.4%), and wheat (2.9%).

## Viet Nam

Total crop area harvested has been increasing in Viet Nam over the years as seen in Figure A37. Although rice is the major crop produced, corn area has been increasing steadily. Figure A38 presents the yields in Viet Nam for corn and rice. We see that major gains have been made in yields, particularly for corn.

Figure A37. Vietnamese Area Harvested by Crop

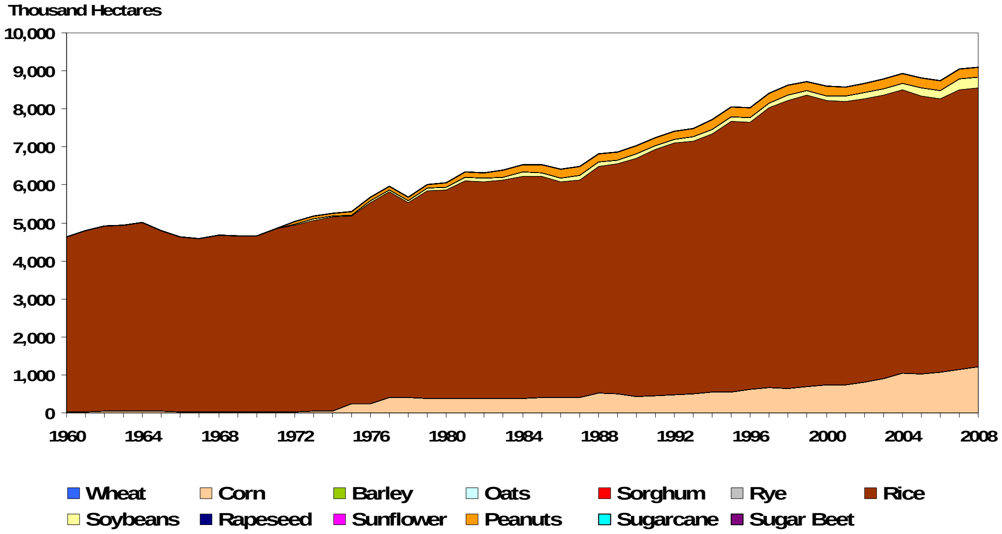
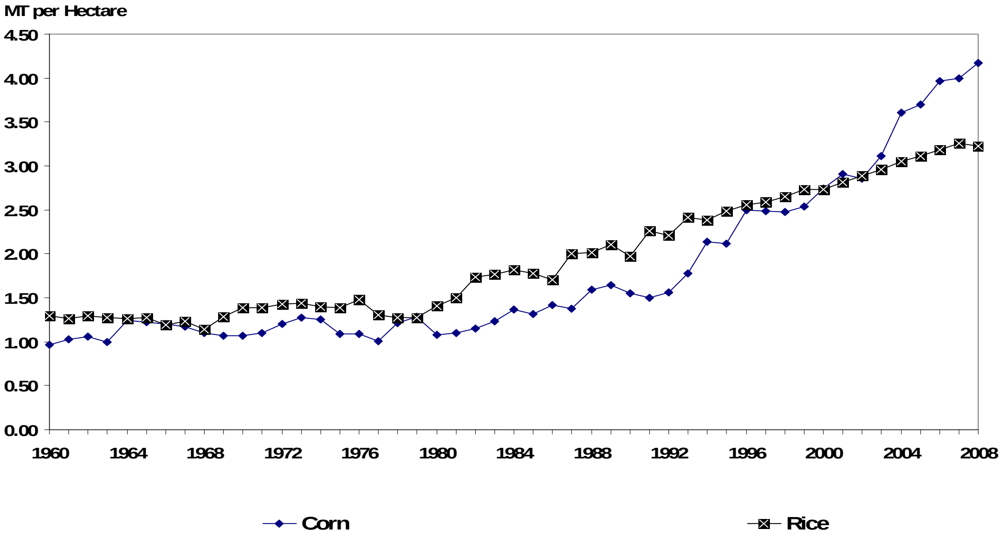



Figure A38. Vietnamese Crop Yields



## Supply Projections

Table A15 shows supply projections for Viet Nam for major crops in the next decade. The projections begin in 2009/10 and end in 2018/19. Area allocated to both corn and rice declines over the next ten years. The yield growth for corn is 6.1% between 2008/09 and 2018/19, but it is not high enough to increase the production of corn. Rice yield grows by 10.6%, leading to a production increase of 9.9%, despite the projected decline in area.

Table A15. Vietnamese Supply Projections

| | | 08/09 | 09/10 | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 1,200 | 1,153 | 1,153 | 1,141 | 1,134 | 1,129 | 1,128 | 1,128 | 1,124 | 1,120 | 1,116 |
| Yield | (MT/Ha) | 4.17 | 4.19 | 4.22 | 4.24 | 4.27 | 4.29 | 4.32 | 4.34 | 4.37 | 4.39 | 4.42 |
| Production | (000 MT) | 5,000 | 4,834 | 4,860 | 4,840 | 4,838 | 4,846 | 4,872 | 4,901 | 4,910 | 4,923 | 4,932 |
| **Rice** | | | | | | | | | | | | |
| Area Harvested | (000 Ha) | 7,290 | 7,286 | 7,286 | 7,297 | 7,295 | 7,289 | 7,282 | 7,276 | 7,271 | 7,259 | 7,245 |
| Yield | (MT/Ha) | 3.22 | 3.24 | 3.26 | 3.34 | 3.36 | 3.40 | 3.43 | 3.45 | 3.49 | 3.51 | 3.56 |
| Production | (000 MT) | 23,500 | 23,574 | 23,730 | 24,341 | 24,524 | 24,793 | 24,957 | 25,127 | 25,394 | 25,494 | 25,825 |

Source: FAPRI Preliminary Projections (2008)