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Challenges to Achieving Food Security in APEC

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KEY MESSAGES

Trends in global agricultural markets

Trends in agricultural demand and supply

1. The World Bank's global Food Price Index reached another historical high in July 2012, marking the third price rally in five years, and led by high prices for corn, soybeans, and wheat.
2. Anticipated supply shortages caused by adverse weather conditions in some major global producers and exporters of grains were among the main causes of the recent price spike.
3. Although price volatility is inherent in agricultural markets, three large swings in agricultural commodity prices in just five years is a symptom of a structural imbalance in global demand and supply.
4. There has been an upward shift in global demand for agricultural products due to rapid income growth resulting in diet diversification and increased use of agricultural products for non-food purposes such as biofuels. Indeed, the use of agricultural products for non-food purposes has surpassed the demand from food consumption for some products. Animal feed and industrial uses accounted for 74% and 22% of global production of primary oil crops and vegetable oils, respectively, in 1961. By 2008, these ratios had risen to 84% for primary oil crops and 43% for vegetable oils.
5. The capacity of production to expand quickly in response to the shift in demand is limited given resource constraints and increased cycles of adverse weather conditions. This has led farmers to devote more resources to produce commodities with higher growth potential – e.g., energy crops – at the expense of traditional staple food crops.
6. The trends in agricultural markets in the APEC region mirror the global trends, but are occurring at a relatively more accelerated rate.
7. Economic growth, including income growth, has been relatively stronger among developing APEC economies in comparison with the rest of the developing world. This has led to a dramatic shift of diet towards more livestock and dairy products, fats and oils.
8. The APEC region has also quickly emerged as the world's leading producer of biofuels, with its total share of global production increasing from 35% in 2000 to more than 60% in 2010.
9. Unlike other regions, land expansion in the APEC region is restricted. Since 1992, around 4% of the region's agricultural land (86 million hectares) has been allocated for other uses, while agricultural land has expanded by 5% in Africa and by 6% in South America.
10. With the intensification of energy and feed crops, harvested areas for other staple food crops such as wheat and rice have been growing more slowly, even contracting in some cases. Shrinking land resources, in combination with a slowdown in yield growth, have resulted in an overall slowdown in production growth for these crops. Wheat production in APEC actually stagnated during 2000-2007.
11. In some developing APEC economies, production growth has not kept pace with demand growth. This has been partly reflected by a tripling of the food trade deficit for developing APEC economies, from USD 13 billion in 1992 to USD 40 billion in 2010.

Implications for food security

12. The tight global agricultural market, stemming from the inability of production to grow fast enough to meet increasing and competing demands, has been reflected in the highly volatile prices for agricultural products witnessed recently.

13. Record food prices, against a backdrop of low income growth due to the Global Financial Crisis in 2008 and its continuing effects in 2011, have transformed into food crises in many cities around the world. An estimated 130-150 million people were in pushed into poverty as a direct result of the 2008 food crisis alone. Another 44 million were added in the 2011 episode.
14. The APEC region was not spared. Domestic food inflation reached double digits in many developing APEC economies in 2008. Of particular concern is that food inflation tends to be higher in those economies where households spend a greater proportion of total expenditure on food. For households living below the poverty line, food-related spending accounts for up to 70% of total expenditure.
15. Without any policy intervention, a 20% surge in food prices can increase the poverty rate in some APEC economies – e.g., Indonesia; Papua New Guinea; the Philippines; Viet Nam – by an estimated 3 percentage points.

Impact of current grain price spike on APEC economies

16. The impact of higher world prices for wheat, corn, and soybeans will not be uniform across APEC economies.
17. Based solely on the supply and demand for wheat, corn, and soybeans, Japan; Korea; Malaysia; Peru; Chile; and Mexico are relatively more vulnerable to a sustained increase in international prices since these economies source a large proportion of their grain supplies from the international market. Furthermore, these grains also account for a relatively larger proportion of total cereal consumption. In Mexico, for example, corn accounts for 60% of total cereal consumption and provides more than 40% of average daily calorie intake.
18. The current scarcity of global supply is even more severe among feed intensive crops with serious repercussions for animal protein, dairy, and processed food industries. Therefore, the transmission of high global grain prices will not be immediate. The full effect is expected to emerge in the first half of 2013 as the supply of some meat and dairy products is likely to shrink and as producers pass through higher input costs.

Addressing the challenges to food security: towards a more sustainable future

19. The global population will reach an estimated 9.3 billion in 2050, adding more than 2.3 billion people on the demand side for food.
20. Income growth resulting in diet diversification as well as increased industrial uses of agricultural products will also become more prominent drivers of increasing demand for agricultural products towards 2050.
21. On the supply side, natural resource constraints will become more stringent in the coming years, adversely impacting crop yields as well as the capacity to expand production.
22. Agricultural land per capita is projected to decline from its current level of 0.22 hectares in use per person to 0.18 in 2050, while the proportion of the population living in urban areas is forecast to rise from 50% to 70% by 2050.
23. Increased cycles of adverse weather conditions associated with climate change will cause yield declines for some important staple food crops, including rice and wheat. Developing economies in lower latitudes will be among the hardest hit.
24. In the absence of any policy intervention, the cost of food could rise substantially as a result of increasing demand and reduced production. Producers will also pass on the higher costs of adaptation to consumers.
25. Improving food security requires comprehensive and collaborative responses across a wide range of challenges: barriers to agricultural trade; vast amounts of food losses and waste;

declining agricultural investment growth in developed economies; and severe underinvestment in the agricultural sector in developing economies.

26. Agriculture is an important sector in many APEC economies, accounting for 13% of GDP in developing APEC. Sustainable expansion of production, via the adoption of new technologies, knowledge and skills as well the modernization of infrastructure, will not only help to address food security issues, but will also allow for the potential of the agricultural sector to be realized as an engine of growth. Technological progress will also help to increase production with fewer inputs, thus freeing up resources for other sectors of the economy.

Promote agricultural trade

27. Open trade in agricultural products helps to mitigate price volatility as well as improve agricultural competitiveness. However, many APEC members have adjusted their food security policies towards self-sufficiency in response to the recent food price spikes, particularly those economies that are net food importers.
28. Despite the clear benefits of increased agricultural trade, agricultural liberalization has proved to be one of the more contentious topics in multilateral trade negotiations at the WTO. The current Doha Development Agenda continues to be at an impasse and a timely and successful conclusion remains uncertain, jeopardizing the concessions that have so far been made.
29. In 2011, agricultural trade accounted for just 8.3% of the value of global goods trade. For the APEC region, agricultural exports as a share of total goods export value was only 5.8% in 2011. Intra-APEC trade in agricultural products, valued at USD 325 billion in 2011, comprised 68% of total agricultural export value from APEC members.
30. Liberalization of agricultural trade in the APEC region has been slow in comparison with non-agricultural goods trade. The average MFN applied tariff rate on agricultural products was 12.3% in 2011, in comparison with a 4.7% rate on non-agricultural products.
31. APEC members are also active in using non-tariff barriers such as technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) measures. Between 1995 and 2011, 30% of the 317 specific trade concerns raised against a TBT measure were related to an agricultural product, nearly half of which named an APEC economy as the maintaining member. An APEC economy was also named as a maintaining member in almost half of the 312 SPS concerns raised between 1995 and 2010, nearly all of which concerned an agricultural product.
32. These non-tariff trade barriers can have a disproportionately negative impact on food exports from developing economies as these economies often lack the necessary scientific and technical expertise and technologies.
33. International harmonization of standards and mutual recognition will help to ensure that TBT and SPS measures are applied transparently and fairly, while capacity building can help to reduce the costs of compliance for exporters in developing economies.

Reduce food losses and waste

34. In the short- to medium-term, reducing food losses and waste can be one of the most effective strategies to improve food availability and preserve critical natural resources.
35. Unfortunately, it is very difficult to measure exactly how much food is lost or wasted, especially as it moves along the supply chain, and data on food losses are extremely limited. It is vital that coordinated research be done in this area in order to better assess the problem.
36. Despite the data limitations, an estimated one-third of food produced globally is lost or wasted along the supply chain, amounting to around 1.3 billion tons per year. Nearly half of the global production of roots and tubers and of fruits and vegetables are lost or wasted along the entire supply chain – from primary production through consumer waste.

37. Along the food supply chain, primary production accounts for the highest amount of losses globally with an estimated 10% of the total supply quantity lost at this stage.
38. Although approximately 30% of food is lost in both developed and developing economies, the losses occur at different points along the supply chain.
39. Food losses are larger in low-income economies at the beginning of the food supply chain – from primary production through the post-harvest segments of handling, storage, and transportation – mainly due to insufficient infrastructure, particularly inadequate storage facilities, as well as a lack of technical and managerial skills on the part of the farmers.
40. In medium- and high-income economies, a significant amount of food is lost during consumption: around 222 million tons of food per year is wasted in these economies. Industrialized economies must strive to raise awareness of this issue.

Increase investments in agricultural infrastructure and R&D

41. For many developing APEC economies, there is evidence of underinvestment in agricultural infrastructure, resulting in food losses and lower crop yields.
42. In 2009, only half of the total area with the potential for irrigation was actually equipped for irrigation in developing APEC economies (excluding China).
43. Roads and ports in developing APEC economies are, on average, of poorer quality in comparison with those in industrialized APEC economies, reflected by their lower score in the responses to the Global Economic Forum's Executive Opinion Survey as to the quality of roads and port infrastructure.
44. In addition to infrastructure, agricultural capital stock is essential in the expansion of production and in reducing food losses. However, total agricultural capital stock in the APEC region grew by just 3.1% in real terms between 1992 and 2007, representing a meager growth rate of 0.2% per year.
45. Nearly all of the growth in agricultural capital formation in the APEC region came from developing APEC economies, with industrialized and developing APEC members accounting for equal amounts of the regional total of USD 2.4 trillion in 2007.
46. However, there is a wide disparity in agricultural capital stock per agricultural worker between the two groups – USD 1,822 per worker in developing APEC compared with USD 219,900 in industrialized APEC, highlighting the need for investment in developing APEC economies.
47. In addition, a large body of research has demonstrated the important role of R&D spending in enabling technological advances that increase productivity growth. Unfortunately, the current trends in global agricultural R&D expenditure underscore some urgent concerns.
48. Publicly funded agricultural research projects have been growing at a slower pace since the 1990s in industrialized APEC economies. Various studies have linked this slower pace of R&D spending to slower growth in agricultural productivity in these economies.
49. This slowdown in research spending in many developed economies that were traditionally the powerhouses of generating new and improved technologies, inputs, and knowledge also means that developing economies can no longer rely on the international spillovers of technological progress to the same extent as before.
50. Encouragingly, developing economies have progressively built up their research capacity. In fact, 2008 marked the first time when public R&D spending by developing economies was at par with developed economies.
51. Among developing APEC members, China stands out in its accomplishment of expanding research capacity, becoming a significant source of new technologies and knowledge.
52. Despite the enormous progress that has been made, many developing economies are still in the early stages of building agricultural research capacity. The research intensity ratio of

developing economies – as measured by the ratio of R&D spending to total agricultural output – was USD 0.54 in 2008, compared with a ratio of USD 3.07 in developed economies.

53. In addition, private R&D investment plays a very minor role in developing economies, accounting for less than 6% of the total research funding in these economies. In contrast, private R&D spending in developed economies has surpassed public funding, contributing 55% of total R&D expenditure in these economies in 2000.
54. The crucial role of agricultural investments in hard and soft infrastructure as well as in R&D in order to increase productivity and reduce food losses gives prominence to the need to secure sustainable funding.
55. An estimated USD 83 billion per year of additional investments in food, agriculture and rural development is required for food production to meet the expected growth in demand by 2050.
56. Given their typically large scale and significant outlays of capital, usually taking many years to realize, agricultural investments are often carried out by the public sector. However, due to competing demand for funds, the domestic public sector alone cannot sufficiently address all the investment needs.
57. For many developing economies, official development assistance (ODA) has also been an important source of funding. However, aid commitments to the agricultural and fisheries sectors in developing APEC have fallen by an annual rate of 4% in real terms between 1995-96 and 2009-10. The strong economic performance of many developing APEC economies in recent years indicates that ODA will no longer be a major source of funding in the region.
58. It is therefore necessary for APEC members to promote agricultural investment from the private sector, including foreign direct investment (FDI), which has been shown to increase the amount of capital available and raise the technological level in an economy.
59. To date, primary and processed agriculture have not been the most attractive sectors for FDI, accounting for just 5.4% of global FDI inflows during 2008-10. Of this amount, over 90% went to processed agriculture, indicating that much of the FDI is concentrated in the downstream agricultural activities of processing, manufacturing, and retail trade.
60. Notably, developed economies had a larger share of FDI inflows to these two sectors than did developing economies. However, developing economies had a much higher share of FDI inflows directed towards the primary agricultural sector than did developed economies.
61. The OECD's FDI Regulatory Restrictiveness Index reveals that investment barriers are generally higher in the primary agricultural and fisheries sectors than in other sectors for many APEC economies, with some having measures in place that fully restrict FDI in these sectors.
62. The key to increasing private agricultural investment lies in strategically improving the business environment by creating an attractive and viable investment climate that reduces the risks to investors that are typically associated with agricultural investments.
63. In developing economies, this requires providing a higher level of investor protection, strengthening intellectual property rights, and facilitating better access to credit.

APEC should address these food security challenges through the following:

- **APEC Policy Partnership on Food Security (PPFS) and public-private partnerships;**
- **capacity building and knowledge sharing;**
- **APEC's core focus of trade and investment liberalization and facilitation;**
- **alignment with other APEC initiatives such as the Supply Chain Connectivity Framework Action Plan (SCFAP) and the Ease of Doing Business (EoDB) Action Plan; and**
- **by developing partnerships with other organizations working in the area of food security.**

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1. INTRODUCTION

Food security has been a part of the APEC agenda since 1999 when Leaders endorsed the APEC Food System proposed by the APEC Business Advisory Council (ABAC). The APEC Food System seeks to establish a comprehensive food security strategy that addresses three main areas: (1) develop more extensive rural infrastructure (including both physical and human capital); (2) disseminate technological advances in food production and processing; and (3) reduce impediments to international food trade and investment[1]. APEC Ministers Responsible for Food Security met recently in Kazan, Russia in May 2012, reaffirming their commitment to these goals. In particular, Ministers stressed the importance of increasing agricultural production through advances in productivity and reductions of food losses by boosting investment and adopting innovative technologies as well as facilitating agricultural trade and developing food markets[2].

In 2011, the global population reached 7 billion, just 12 years after reaching 6 billion, and is predicted to rise to 9.3 billion by 2050, with the APEC region estimated to have 3 billion people, accounting for 32% of the world's population at that time[3]. Such rapid population growth has caused many to question whether there will be enough resources to meet the expected growth in food demand, especially since the predicted increase in population will require food production to rise by an estimated 60%[4]. However, population growth is not the only challenge that threatens global food security over the next few decades – climate change and demographic shifts also contribute to pressures on food production.

Climate change and increased competition for alternative uses of land and water resources will further constrain the ability of agricultural production to expand in the future. Higher and more variable temperatures and changes in rainfall patterns associated with climate change could have severely disruptive effects on agricultural yields[5]. Meanwhile, land resources, as measured by arable land per capita, have declined sharply since 1961 and are projected to fall further, from 0.22 hectares in use per person currently to 0.18 in 2050. In addition, the global use of agricultural crops for biofuels is expected to increase at an accelerated rate in the future, in line with many governments' policies pursuing clean energy. Demographic changes, including rapid urbanization, will also put pressure on the global food system. Today more than 50% of the global population lives in urban areas – a proportion that is forecast to rise to 70% by 2050. In addition, diet diversification associated with increased income will result in demand growth for agricultural products that outstrips the demand growth due to an increased population.

The APEC region plays a large role in global agriculture, accounting for over half of the global production of cereals, fruits and vegetables, and meat, including many staple commodities (Figure 1a). Agricultural production in the APEC region is dominated by China and the United States. In 2010, these two economies accounted for 70% of cereals production and 73% of meat production in the APEC region, while China alone comprised nearly three-fourths of APEC's production of fruits and vegetables. Despite its importance as a producer

[1] Anderson (1999).
[2] APEC (2012a).
[3] United Nations, Department of Economic and Social Affairs, World Population Prospects, the 2010 Revision.
[4] Alexandratos and Bruinsma (2012).
[5] For example, Easterling et al. (2007) found that if local temperatures were to rise by 5°C, then wheat yields in lower latitude economies in Asia and South America could fall by 40% while that of rice could decline by 20%.

of agricultural products, most of China's production is consumed domestically. Nevertheless, APEC is home to many major exporters of agricultural staples (Figure 1b). For instance, Thailand and Viet Nam account for nearly half of global rice exports, while the United States; Canada; and Australia comprise over 40% of global wheat exports.

Figure 1a. Share of global production in 2010

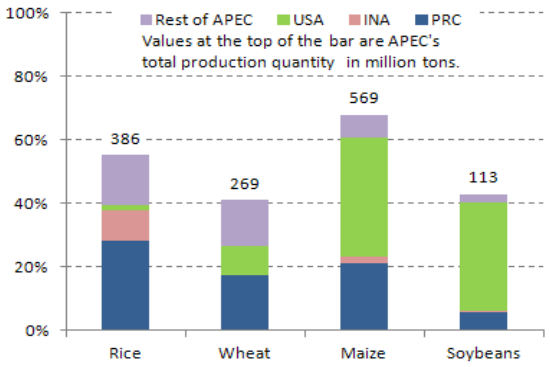
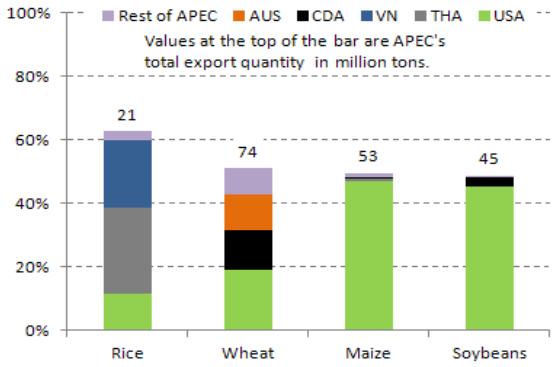


Figure 1b. Share of global exports in 2010

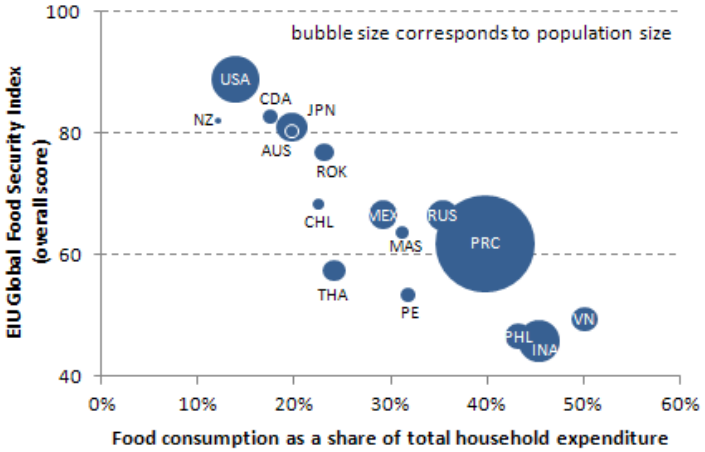


Source: FAOSTAT and PSU calculations.

Given the differences in the agricultural sectors among the APEC members, a study recently commissioned by the APEC Policy Support Unit (PSU) illustrates just how different the APEC economies are with respect to food security issues and the policies in place to address those issues[6]. The report shows how the food security issues facing industrialized APEC members are quite different from those facing developing APEC economies. In addition, the policies used to address those food security challenges differ significantly between those APEC members that are net importers of food products and those that are net exporters.

This diversity within the APEC region is also illustrated by the EIU's newly released Global Food Security Index (Figure 2). The index shows that industrialized APEC members score high on both the overall index as well as in the three pillars of affordability, availability, and quality and safety[7]. However, developing APEC members – especially the Southeast Asian APEC members – are ranked much lower on the index. Notably, there is an inverse relationship between an economy's overall score on the EIU Global Food Security Index and food consumption as a share of total household expenditure in that economy, underscoring the importance of food affordability.

Figure 2. EIU Global Food Security Index



Source: Economist Intelligence Unit (2012); World Bank, WDI.

[6] APEC Policy Support Unit (2012).

[7] Industrialized APEC members are Australia; Canada; Japan; New Zealand; and the United States. Developing APEC members are Brunei Darussalam; Chile; China; Hong Kong, China; Indonesia; Korea; Malaysia; Mexico; Papua New Guinea; Peru; Philippines; Russia; Singapore; Chinese Taipei; Thailand; and Viet Nam. In some of the analysis, the four newly industrialized Asian economies of Hong Kong, China; Korea; Singapore; and Chinese Taipei are discussed along with the five industrialized APEC members.

Rising prices for consumers clearly threaten food security across the APEC region. The recent global food price spikes in 2007-08 and again in 2011 highlighted the vulnerability of many economies to such price increases and put food security firmly back on the international agenda[8]. Given the increasing volatility of international food prices, which is driven by a number of factors, APEC members should therefore take firm steps to ensure food security for their populations. Although increases in the prices of agricultural products should create an incentive for producers to produce more – which in turn can contribute to improving food availability in the long-term – this issues paper looks at the underlying challenges to increasing food production. Food security is therefore defined as follows: "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"[9].

This issues paper will examine the following challenges to achieving food security that the APEC region currently faces:

- trends in agricultural markets (global and APEC), including the drivers of rising demand and the challenges in increasing agricultural production, and the implication on food prices and food security;
- agricultural trade barriers facing the APEC members given the importance of trade in ensuring supply and mitigating price volatility of agricultural products;
- the magnitude and underlying causes of food losses and food waste, highlighting a crucial aspect in addressing global food security;
- challenges in increasing agricultural investments, which are vital in order to increase agricultural productivity and reduce food losses; and
- some recommendations on the way forward for APEC to address the food security challenges currently facing the region.

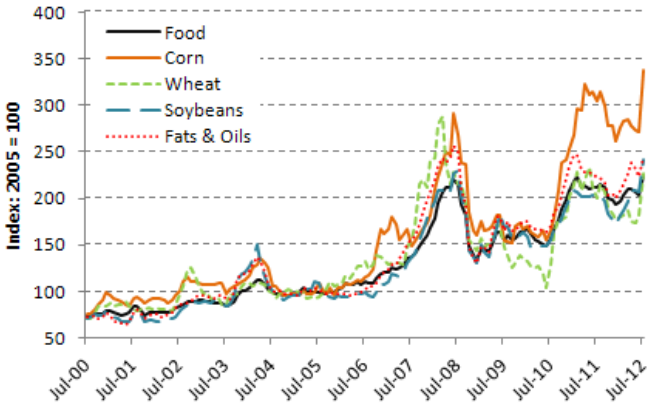
[8] For a comprehensive analysis of the impact of the 2007-08 price increases on APEC economies, see APEC Policy Support Unit (2009).
[9] FAO (2008).

2. CHALLENGES TO AGRICULTURAL PRODUCTION

A. RECENT TRENDS IN GLOBAL AGRICULTURAL MARKETS

Global agricultural commodity markets have become increasingly volatile in recent years, experiencing two price spikes between 2008 and 2011 [10]. After a brief period of moderation, the World Bank's global Food Price Index rose to another historical high in July 2012 (Figure 3). Corn, wheat, and soybeans led this most recent price spike with global corn and wheat prices increasing by 25% and soybeans by 17% in July.

Figure 3. Nominal price indices for selected grains



Source: World Bank, Commodity Price Data and PSU calculations.

One of the most immediate causes of the recent spike in food prices is a set of weather-induced production shortfalls experienced by large agricultural producers. In the United States, the unprecedented hot, dry summer in the central agricultural region inflicted severe damage on around two-thirds of U.S. corn, soybeans, and livestock production. Yields for corn and soybeans in the 2012/13 harvesting season are forecast to be 20% lower than in the 2010/11 season as a direct result of the drought. This means that for 2012/13, U.S. production of corn and soybeans is predicted to be around 15% lower, while the amount available for export is forecast to be about 30% lower, in comparison with 2010/11. Since the United States is a major producer and exporter of corn and soybeans, the projected fall in U.S. grain production accentuates the concern over near-term global grain supplies and pushes up prices for these products.

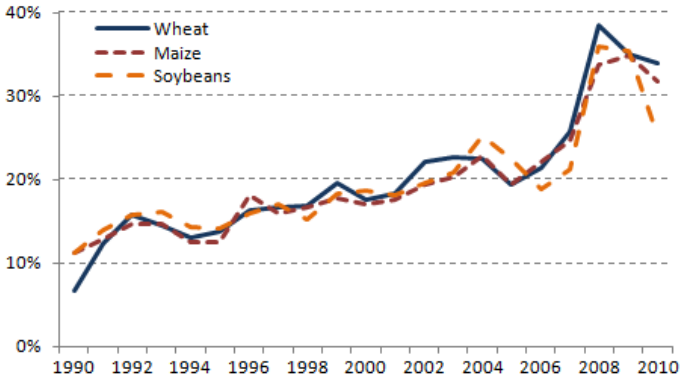
While corn and soybean crops have been heavily affected by adverse weather in the United States, the dry summer in the European Union, Russia, Ukraine, and Kazakhstan is also forecast to reduce harvest area and yields for wheat crops. Russia is expecting to harvest 30% less wheat in 2012/13 compared to 2011/12. This would reduce its exportable balance to 9 million metric tons, almost 60% lower than the 22 million metric tons that were available in 2011/12. In Kazakhstan and the Ukraine, the outlook for the 2012/13 harvest is not promising either, with wheat production set to fall by 47% and 37%, respectively, from their levels in the previous harvest season. In addition, with rising prices for soybeans, livestock producers have been using more wheat in their feed rations. The anticipated reduced global wheat production, together with the spillover effects from corn supply shortages, has caused wheat prices to also trend upward.

[10] Agricultural commodities include crops grown for both food and non-food purposes.

B. STRUCTURAL CHALLENGES IN GLOBAL AGRICULTURAL MARKETS

Inclement weather is undoubtedly one of the most significant contributors to the recent spike in international grain prices. As the severity of the worst U.S. drought in over 50 years appears to be peaking, this gives rise to the perception that increased food prices will be a short-term phenomenon and that its associated challenges will disappear over time with improved weather. However, the recent spike in grain prices underscores an urgent challenge: the current global agricultural system is highly susceptible to shocks which translate into volatile food prices.

Figure 4. Implied price volatility of selected products



Source: OECD/FAO (2011).

The implied food price volatility, which measures the magnitude and frequency of price fluctuations, has been increasing since the early 2000s. This indicates that the degree of uncertainty in agricultural markets is much greater now than it was in the 1990s (Figure 4). This greater level of uncertainty can be particularly damaging as it can result in inefficient investment decisions and/or discourage investment that is crucial to meeting growing global food demand. It can also complicate the formulation of policy responses as it is harder to make judgments about long-term food security based on short-term trends in global markets.

The large and frequent price fluctuations that have been experienced recently are symptoms of a structurally tight global agricultural market, stemming from the inability of agricultural production to grow fast enough to match the growth in demand. This mismatch in the supply and demand relationship is a cause for concern – without appropriate and timely responses, the sustainability of the entire global agricultural system could be in jeopardy as demand will continue to grow rapidly, while the ability to produce more is limited by the impact of shrinking natural resources and more frequent extreme weather patterns.

i. Trends in Global Demand for Agricultural Products

The world population has doubled in just 45 years, from around 3.5 billion in 1967 to around 7 billion today. This rapid rise in population has resulted in a corresponding rapid increase in global consumption of agricultural commodities, outstripping population growth for many products. For instance, the consumption of key staples such as rice and wheat has increased by 2.5 times between 1967 and 2012 (Figure 5a). For some agricultural products, the rise in demand has been even more prominent. Corn demand, for example, was growing at a similar rate with that of rice and wheat until the 1990s. However, global corn consumption then surged sharply upwards, more than tripling since 1967. The livestock sector has also experienced a similar leap in demand – consumption of pork has almost quadrupled while that of poultry has increased 14 times (Figure 5b). The relatively faster pace of growth in demand for some agricultural products, vis-à-vis the growth rate of the global population, reflects dramatic changes in agricultural markets around the world.

Figure 5a. Global population growth vis-à-vis growth in global consumption of selected grains

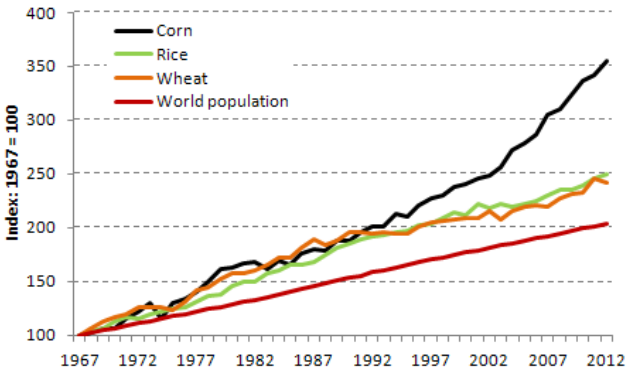
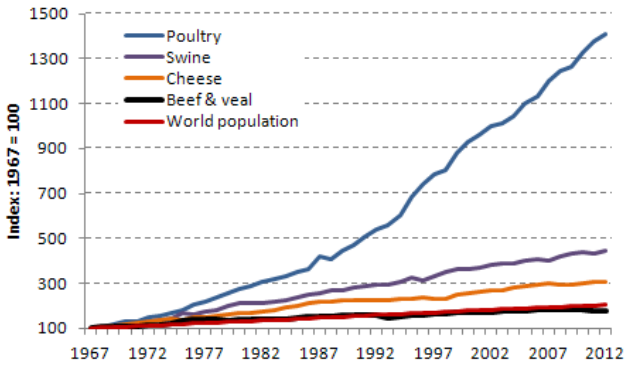


Figure 5b. Global population growth vis-à-vis growth in global consumption of selected livestock



Source: USDA, ERS and PSU calculations.

The world economy has grown approximately sixfold since 1960. While industrialized economies still dominate economic activity, accounting for 74% of the USD 42.5 trillion global GDP in 2011, a remarkable trend over the past 20 years has been the burgeoning role played by developing economies[11]. The real GDP growth rate in developing economies has almost doubled from an annual average of 3.1% in the 1980s to 6.0% per year in the 2000s. By contrast, the rate of economic growth in developed economies has halved from 3.3% per year in the 1980s to 1.6% per year in the 2000s. The strong economic performance in emerging economies has helped to improve household income with inflation-adjusted income levels more than doubling since 1980 to over USD 1,900 today.

Developments in the global macroeconomy have had inevitable consequences for agricultural markets. Strong income growth in developing economies has not only strengthened the demand for food, but has also led to structural changes in food consumption patterns. Studies show that households in developing markets with improved food purchasing power experience a change in dietary patterns such as increased consumption of meat and dairy products as well as a broad range of prepared food[12]. On the other hand, consumption levels in developed economies, which already had high calorie intakes of animal products, have barely changed since the 1990s.

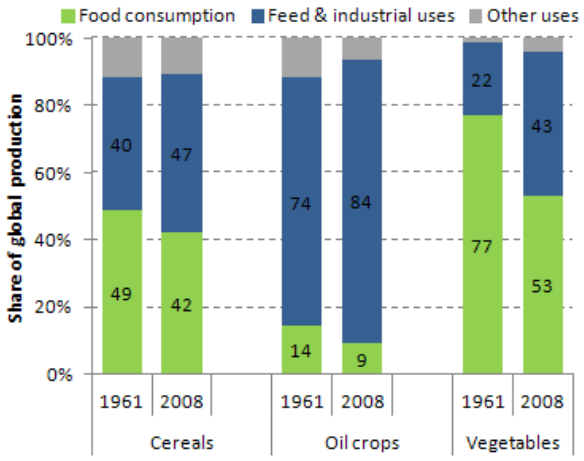
The rapidly growing demand for meat in developing economies has caused the livestock sector to become one of the fastest growing agricultural subsectors in those economies[13]. This evolution is accompanied by increased demand for the grains and proteins used in animal feed. Developing economies' share of the global use of cereals for animal feed has increased by more than one-half (to 55%) from the early 1960s. However, many developing economies are not able to produce enough feed crops to support the expansion of their livestock production, causing their share of global cereal imports to rise from 46% in 1961 to 61% in 2009. The shift towards diet diversification in developing economies has therefore also contributed to increased global demand for some cereal crops.

In addition, one of the most significant changes in the agricultural sector over the past decade has been the fast pace of expansion of the bioenergy sector. Higher oil prices and the search

[11] All GDP figures are calculated using GDP data (in constant 2000 USD) from the World Bank's World Development Indicators database.
[12] Seale Jr. et al. (2003).
[13] Thornton (2010).

for alternative fuels have led to a boom in the production of biofuels such as ethanol and biodiesel. Global production of ethanol and biodiesel increased almost four-fold, from 29 billion litres in 2000 to over 100 billion litres in 2010. The amplification of the biofuels sector has introduced a new source of demand for some agricultural commodities, including corn, sugar cane, and other oil-bearing seeds such as soybeans, rapeseed, and crude palm oil.

Figure 6. Demand allocation for selected agricultural commodities

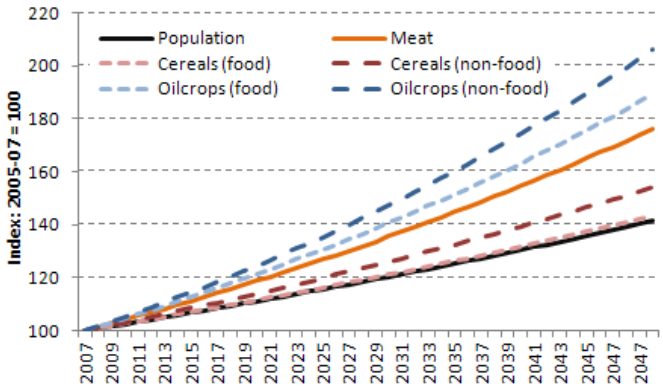


Source: FAOSTAT and PSU calculations.

Together, animal feed and other industrial uses, including bioenergy, have become a significant source of new demand for agricultural products, even surpassing the demand from food consumption for some products (Figure 6). For example, feed and industrial uses of cereals accounted for 40% of global production in 1961, while food consumption accounted for nearly half. By 2008, 47% of the global production of cereals was allocated for feed and industrial purposes, while the proportion for food consumption was reduced to 42%.

These trends in the global demand for agricultural products are projected to become even more prominent, putting further pressure on global agricultural production in the future. Diet diversification associated with real income growth is expected to drive the demand for meat, outstripping population growth (Figure 7). This, in addition to the increased demand from biofuels and other agricultural-derived industrial products, will result in non-food uses of some agricultural commodities to grow faster than that for human consumption.

Figure 7. Projected population growth and demand growth for selected agricultural products



Source: Alexandratos and Bruinsma (2012) and PSU calculations.

ii. Trends in Global Agricultural Production

Besides becoming an important new source of demand, income growth and biofuels have also introduced new challenges to agricultural production. One of the observed effects is that it creates incentives for producers to devote more agricultural resources to the production of energy and feed crops since they typically offer better returns than those obtainable from traditional farming. This is evident in the sudden and large jump in land devoted for energy crops in recent years. Globally, the harvested area for oil crops has expanded over 40% since 1992 to 267 million hectares in 2010. The harvested area for soybeans alone has contributed

to nearly two-thirds of this increase. Meanwhile, acreage for corn has increased by 18% over the same period.

In some parts of the world, increases in the harvested areas for primary crops were accelerated by significant arable land expansion. The largest arable land increases were recorded in Africa, followed by South America. Unfortunately, in the case of Africa, land expansion was not accompanied by rapid growth in agricultural production. This is partly due to the fact that new land often requires a greater amount of management in the form of fertilizers, pesticides, tractors, and labor as well as supporting infrastructure in order to yield the same level of productivity as already cultivated cropland. In Africa, the lack of investment and inefficient agricultural policies has resulted in sluggish yield growth, which in turn has hindered production growth. For example, since 1992 average yield growth for staple cereal crops (excluding corn) in Africa has declined to 0.5% per year, about one-third the average growth rate in the preceding two decades, while yield gaps between Africa and the rest of the world for oil crops have also increased (Figures 8a and 8b).

Figure 8a. Cereal crop yields

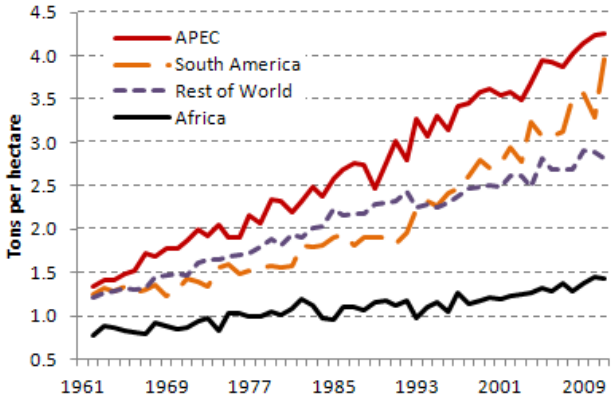
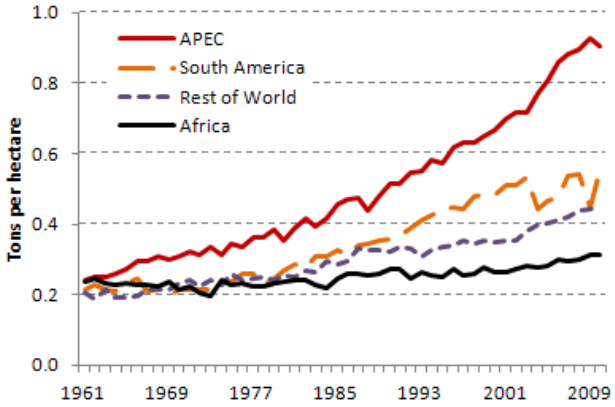


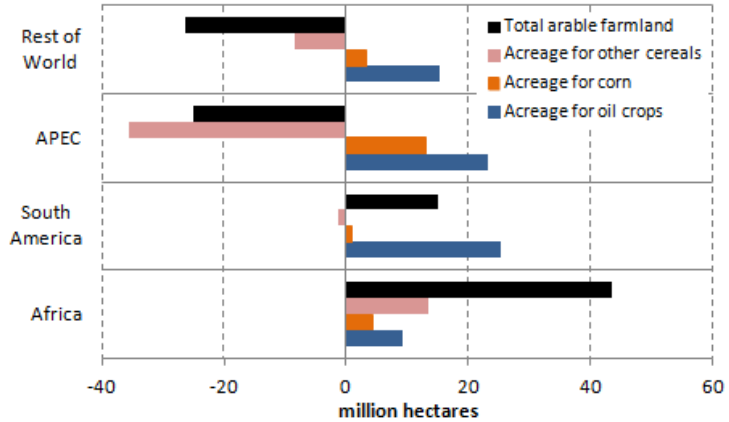
Figure 8b. Oil crop yields



Note: Chile and Peru are included in APEC, not in South America.
Source: FAOSTAT and PSU calculations.

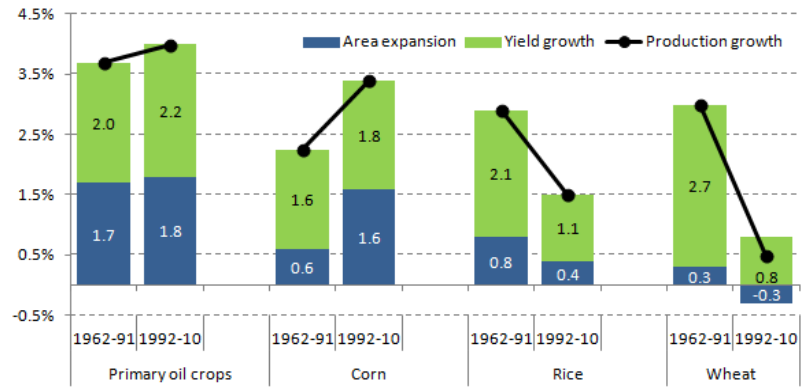
In other parts of the world, rapid urbanization, among other factors, has resulted in a shrinking of the land resources available for agriculture. Excluding Africa and South America, 5% (or 51 million hectares) of the world's arable land has been converted to other uses since 1992. Measures adopted by agricultural producers in response to shrinking land resources include rationalizing the harvested area among different crops. The fast rate of expansion of the acreage area for some energy and other high-value agricultural crops was therefore sometimes realized at the expense of staple food crops (Figure 9).

Figure 9. Net change in major land use between 1992–2009



Note: Chile and Peru are included in APEC, not in South America.
Source: FAOSTAT and PSU calculations.

Figure 10. Average annual growth in global production of selected crops



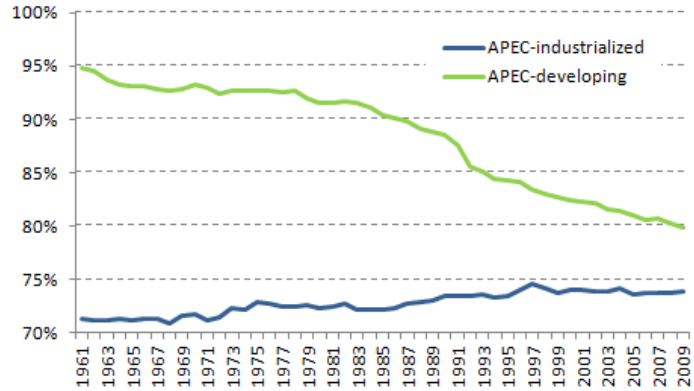
Source: FAOSTAT and PSU calculations.

Partly as a result of changing land allocation, global production of energy crops has been growing at an accelerated rate over the past two decades, while that of staple grains has been decelerating (Figure 10). For some commodities, such as wheat, the slowdown in production growth reflects the combined effect of a contraction in the harvested area and a slowdown in the growth of average yields. Global wheat production was growing at an annual rate of 3.0% between 1962 and 1991, with yield improvements contributing 2.7 percentage points to this growth rate while area expansion contributed just 0.3 percentage points. However, between 1992 and 2010, global wheat output grew by 0.5% per year as yield growth slowed to 0.8% per year while harvested area shrunk by 0.3% per year. In contrast, corn crops have benefited from increased R&D efforts in the early 1990s, resulting in higher yield varieties and more modern production technologies[14]. As a result, yield growth for corn has continued to improve over time, contributing to faster expansion of corn production.

iii. Trends in Supply and Demand for Agricultural Products in APEC

Food demand in the APEC region over the past 20 years has been driven by a combination of rapid population growth, a high rate of urbanization, higher income growth, and growing demand for biofuels. Economic growth has been particularly strong among developing APEC economies, helping to increase real GDP per capita from USD 1,200 in 1990 to almost USD 2,900 in 2009. Consistent with the global trend, consumers in developing APEC economies are increasingly moving from a diet dominated by carbohydrates and vegetables to one that is higher in protein as a result of their increased income. In 1961, vegetable-based food made up 95% of the calorie intake of an average consumer in developing APEC (Figure 11). By 2009, this had been reduced to around 80%. In contrast, consumers in industrialized APEC economies have slightly increased the portion of vegetables in their daily food intake.

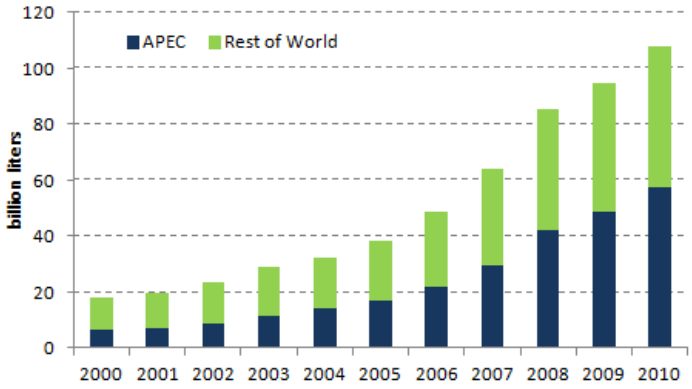
Figure 11. Ratio of vegetable-based products to animal-related products in daily food consumption



Source: FAOSTAT and PSU calculations.

[14] Gerpacio (2003).

Figure 12. Biofuels production



Source: US EIA and PSU calculations.

Regarding bioenergy, the APEC region has quickly emerged as the key player in this sector. The region's share of total world biofuels production increased from 35% in 2000 to more than 60% in 2010 (Figure 12). The majority of ethanol production in the APEC region is currently produced from corn and sugar cane, while that of biodiesel is produced from palm oil and soybeans. The United States is at the forefront of ethanol production, accounting for 57% of the world total. Currently, about 40% of U.S. corn supply is now used to produce ethanol. Since the United States is the world's largest producer of corn, this represents an estimated 15% of global corn production that is being diverted into biofuels. Largely in response to the growth in domestic consumption and, to a lesser extent, export opportunities, APEC's production of high-value agricultural commodities and bioenergy crops has grown significantly: production of both primary oil crops and of corn has increased at an average rate of 4.0% per year since 1992.

However, unlike the pre-1990s era when production increases were met partially through land expansion, options for exploring new land for agriculture are limited in many APEC economies. Since 1992, 86 million hectares of agricultural land in APEC (around 4%) has been allocated to other uses (see Figure 9). Facing land shortages, farmers have opted to increase intensification of current croplands and/or reduce the harvested area of crops that have lower demand growth. Between 1992 and 2009, harvested area in APEC for cereal crops (excluding corn) declined by 15% (35 million hectares). Over the same period, the acreage for oil crops increased by around 29% (23 million hectares), while that of corn increased by 19% (13 million hectares).

In addition to shrinking land resources, the supply of some key agricultural commodities in the APEC region is confronted by another challenge: slowing yield growth (Table 1). This is most visible in wheat with yield growth slowing from 2.6% per year between 1962 and 1991 to 1.0% per year between 1992 and 2010. This slower rate of yield improvement is not sufficient to offset the large contraction in harvested area. As a result, wheat production in the APEC region has stagnated. In fact, prior to the spike in global wheat prices in 2007-08, wheat production in the APEC region was actually declining at an annual rate of 0.3% between 1992 and 2007.

Table 1. Average annual growth in the production of selected crops in APEC

%	Wheat		Rice		Corn		Oil crops	
	1962-1991	1992-2010	1962-1991	1992-2010	1962-1991	1992-2010	1962-1991	1992-2010
Production	2.5	-1.0	3.3	1.0	2.4	2.7	4.0	4.0
area	-0.1	-2.0	0.8	0.2	0.6	1.0	1.5	1.0
yield	2.6	1.0	2.5	0.7	1.8	1.7	2.5	3.0

Source: FAOSTAT and PSU calculations.

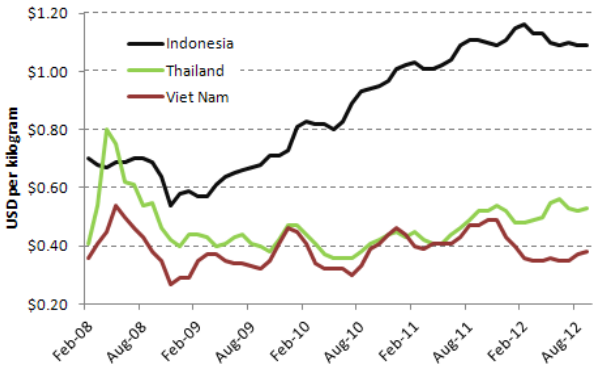
The slowdown in yield growth is also pronounced in rice. As a consequence, between 1992 and 2010, rice production in the APEC region grew at less than one-third the rate at which it grew during the 1962-1991 period, when it registered an annual growth rate of 3.3%. Given the importance of rice in many APEC economies, this slowdown is indeed cause for concern. However, addressing the numerous challenges that have caused rice productivity to decline can be difficult for many APEC economies (Box 1). These challenges to improving agricultural productivity will be examined in greater detail throughout this issues paper.

Box 1. Indonesia's agricultural productivity challenge

Concerned by its reliance on food imports, Indonesia has set itself the ambitious goal of being self-sufficient in rice, sugar, corn, soybeans, and beef by 2014. In the case of rice, Indonesia is one of the world's largest rice consumers with annual per capita consumption of 125 kilograms, in comparison with the world average of 53 kilograms. With the aim to encourage local production of rice, the government put a partial ban on rice imports, resulting in a large disparity between the international and domestic rice prices in Indonesia (Figure 13).

Under its self-sufficiency policy, Indonesia aims to produce a surplus of 10 million tons of paddy rice for total production of 75.7 million tons by 2014. Given that Indonesia produced 65.8 million tons of rice in 2011, production will need to increase by more than 7% per year over the next two years in order to achieve its target rice production by 2014 – a substantial jump over the average annual growth in production of 3.8% between 2006 and 2011. In addition, rice production is forecast to grow by 4.3% in 2012.

Figure 13. Comparison of domestic rice prices



Source: FAO GIEWS, Food Price Data and Analysis Tool.

Indonesia therefore needs to address the declines in rice yield growth which have become quite pronounced since 1990. Between 1961 and 1990, Indonesia's rice yield grew at an annual rate of 3.3%. However, this growth rate has fallen to just 0.8% per year since 1990. This decline in yield growth reflects a broader picture of stagnation in Indonesia's agricultural productivity since the 1990s. Low levels of both public and private investment in rural infrastructure and in R&D, including irrigation systems, has caused Indonesia's total agricultural productivity growth to fall from an annual average of 1.75% in the 1960s to 1.0% per year in the 1990s. In 2010, the Indonesian Directorate General for Water Resources found that 46% of the irrigation system is in disrepair[15]. Meanwhile, the government can meet only around 40-50% of the actual irrigation operational and maintenance funds required.

Since the early 2000s, public spending on agriculture in Indonesia has increased substantially in real terms, from IDR 11.0 trillion in 2001 to IDR 61.5 trillion in 2009, an average annual increase of 12%[16]. Agriculture's share of total government spending doubled from 3% in 2008 to 6% in 2011. However, this rapid growth in spending has not resulted in a corresponding rise in agricultural production, which increased by only 3% per year over the same period. This is due to the fact that most of the agricultural budget is directed towards subsidizing the costs of inputs such as fertilizers and seeds for farmers rather than towards infrastructure investment, for example, that could enhance productivity. In addition, total public and private spending on agricultural R&D was at 0.27% of agricultural GDP in 2007 compared with 1.92% in Malaysia. As a result, real value added per agricultural worker in Indonesia is quite low at USD 730 in 2010, compared with USD 1,119 in the Philippines and USD 6,680 in Malaysia.

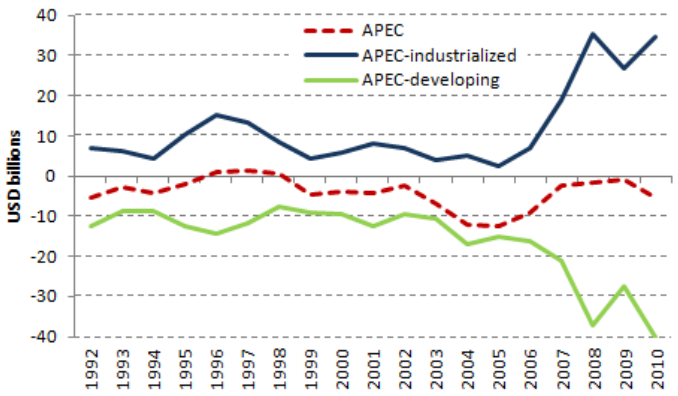
[15] USDA (2012).
[16] Armas et al. (2010).

C. IMPLICATIONS FOR FOOD SECURITY

Slowing production growth in the past two decades for some agricultural products, against a backdrop of accelerating demand growth, has created a tight agricultural market globally. Faced with sluggish growth in supply, distributors have had to prioritize the allocation of agricultural products among competing demands. For some commodities, the amount available for food consumption was sacrificed for other purposes, such as animal feed and bioenergy. The per capita food supply of cereals declined from a world average of 148 kg/year in the 1990s to 144 kg/year in the 2000s. Although this decline is partly the result of diet diversification away from staples by consumers in middle-income economies, it is also a reflection of failures to improve nutrition for households in food insecure areas.

Furthermore, the tight condition in the agricultural market has also made it more susceptible to supply and demand shocks. Before the Global Financial Crisis (GFC) in 2008, the 2000s had been a good decade for the world economy. Fast rising prosperity led to a sudden spurt in the demand for agricultural products. Since short-term supply is fairly inelastic, suppliers responded to the sudden spike in demand by using the stock reserves of some staple grains. This was particularly evident for rice, wheat, and corn in which lower stock levels in combination with higher utilization amounts pushed stock-to-use ratios to their lowest levels in more than 20 years. As bad weather severely affected many agricultural crops worldwide in the 2007/08 harvesting season and again in 2010/11, the low level of grain reserves impaired the ability of suppliers to stabilize food availability and prices. World grain prices soared 156% from December 2005 to June 2008, declining 47% by June 2010, and then jumping again 68% by February 2011.

Figure 14. Food trade balance



Source: FAOSTAT and PSU calculations.

Rising international prices for some key staple grains, including corn, wheat, and rice, translated into high food inflation in many economies around the world. Weak economic growth following the GFC turned rising food inflation into a broader food crisis as poor households were unable to cope with the twin effects of rising prices and falling incomes. The number of people suffering from hunger and living in poverty was raised significantly as a direct result of rising food prices. The World Bank estimated that higher food prices had pushed 130 million to 155 million people into poverty in 2008. The spike in grain prices in 2011 caused another 44 million people to be added to the 1.2 billion people already living below the extreme poverty line[17].

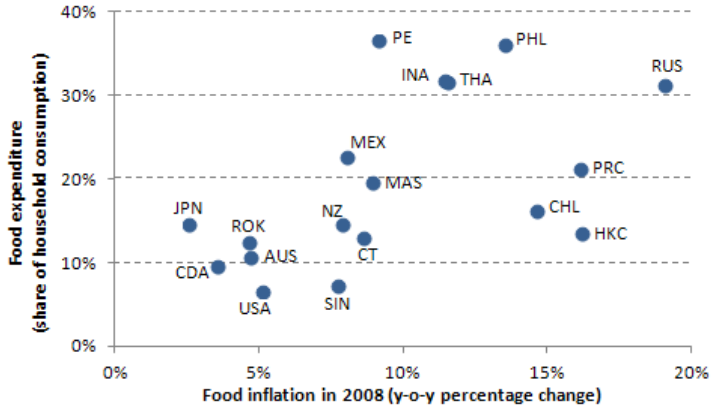
Many APEC economies were not spared from the tight conditions in global agricultural markets. Slowing production growth in the region has reduced the ability of supply to keep up with the growth in demand. This is particularly evident in developing APEC economies where strong economic growth since 2000 has strengthened food demand beyond their capacity to expand production, reflected by a substantial increase in their food import bills

[17] World Bank (2012a).

(Figure 14). The food trade deficit in these economies has more than tripled, from around USD 13 billion in 1992 to USD 40 billion in 2010.

When international prices of key staple grains rose substantially in 2008 and again in 2011, many APEC economies were affected. Domestic food inflation reached double digits in some economies. In Viet Nam, food inflation averaged 50.5% in 2008. Of particular concern is that food inflation was higher among less wealthy APEC economies where households tend to spend a greater proportion of their expenditure on food (Figure 15). For households living below the poverty line, food-related expenditure represents an even larger share: up to 60%-70% of the total budget among households living on less than USD 2 a day (in PPP terms) is spent on food. Therefore, higher food prices, stemming from higher international grain prices, have considerable social implications for low-income APEC economies. According to a study by the Asian Development Bank, the effects of food inflation on poverty are relatively higher in Indonesia; Papua New Guinea; the Philippines; Viet Nam; and among the rural poor in China (Table 2). For instance, a 20% increase in food prices is estimated to increase the poverty rate by more than 3 percentage points in these economies[18].

Figure 15. Food inflation and food expenditure in 2008



Source: Thomson Reuters; USDA, ERS.

Table 2. Impact of a 20% food price shock on poverty in selected developing APEC economies

	Poverty rate (2005)	Estimated change in poverty rate
	% of population	*percentage points*
China – Rural	22.3	4.3
China – Urban	0.9	0.5
Indonesia – Rural	23.8	4.8
Indonesia – Urban	21.5	3.2
Malaysia	0.0	0.2
Papua New Guinea	35.8	3.4
Philippines	22.6	3.2
Thailand	0.4	0.2
Viet Nam	16.9	3.9

Source: Asian Development Bank (2011a); World Bank, WDI.

D. IMPACT OF THE CURRENT GLOBAL GRAIN PRICE INCREASES

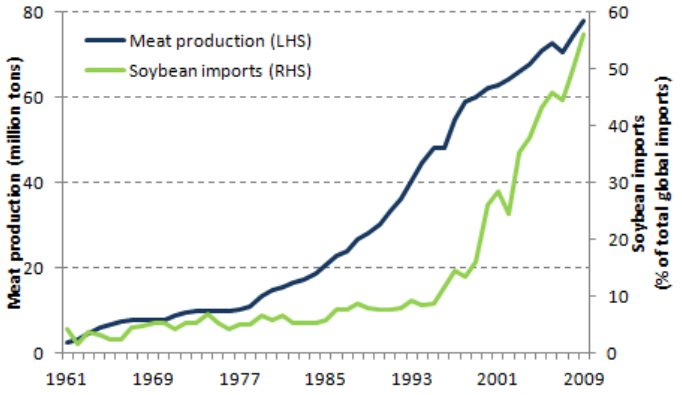
The recurrence of soaring international grain prices in the third quarter of 2012 is fuelling concerns over the possibility of another damaging food price spike. In this context, it is important to assess (1) the transmission channels of rising international grain prices into domestic markets and (2) the magnitude of the impact on overall food prices in APEC.

[18] The poverty rate is defined as the proportion of the population with less than $1.25 a day in purchasing power parity (PPP) terms.

i. Transmission of Rising International Grain Prices into the APEC Region

Given the heterogeneity in the production and consumption of agricultural commodities across the APEC region, the impact of rising international prices for wheat, corn, and soybeans will also not be uniform across the APEC members. The transmission of higher world prices for these commodities to domestic prices depends on a number of characteristics, such as the nature of supply and demand in the domestic market, the specific diet of the population, and the nature of domestic policies in response to such price shocks.

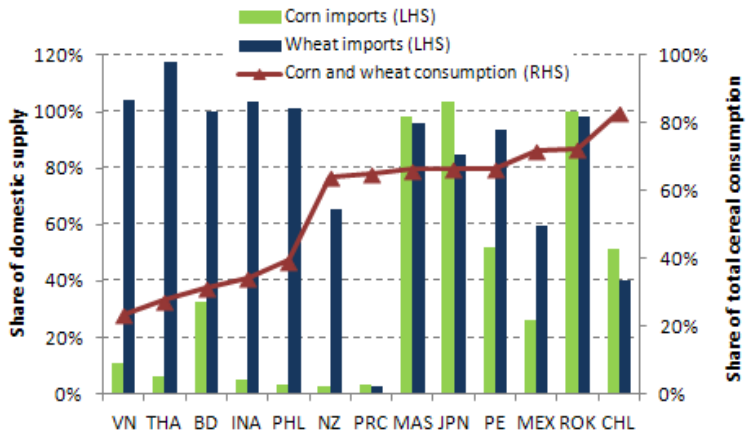
Figure 16. Meat production and soybean imports in China



Source: FAOSTAT and PSU calculations.

The APEC region produces over 40% of global wheat and soybeans. However, the production of these two commodities is concentrated in just a few economies – the United States; Canada; and China for wheat and soybeans, and Russia and Australia for wheat. Although China is a major producer of both wheat and soybeans, is not a major exporter of these products as its production is mostly consumed domestically. In fact, the rapidly growing feed requirement to fuel expanding meat production has turned China into the world's leading importer of soybeans (Figure 16). Of particular importance is the fact that the United States is the largest supplier of soybeans to China. Therefore, in the absence of any policy response, domestic prices for soybeans in China are highly susceptible to changes in the balance of U.S. soybeans that are available for export.

Figure 17. Corn and wheat imports and consumption



Source: FAOSTAT and PSU calculations.

With only a handful of wheat and soybean producers in the APEC region, many APEC economies are net importers. In Thailand; Indonesia; the Philippines; Brunei Darussalam; Korea; Malaysia; Peru; and Japan, at least 90% of the wheat available in the domestic market is met through imports (Figure 17). In some cases, the importance of wheat in the domestic food and animal feed industries highlights the vulnerability of these economies to rising international prices. Among net importers, wheat accounts for more than 20% of total cereal consumption in New Zealand; Chile; Brunei Darussalam; Peru; Korea; and Japan. In some other Asian economies, such as Thailand; Indonesia; and Viet Nam where rice has been the key staple, wheat-based foods are increasingly being consumed. Their growing prominence is largely driven by the rapid growth in per capita income in these

economies, bringing about the changing consumption patterns that often follow economic growth.

In comparison with wheat and soybeans, corn generally plays a relatively larger role in the food and animal feed industries in the APEC region. In some economies – such as the United States; Mexico; Korea; Japan; Chile; Peru; Malaysia; Canada; and China – corn accounts for more than 35% of total cereal consumption. On the supply side, the United States dominates the global corn trade, although exports account for only about 15% of U.S. corn production. The dominant role of the United States in the world corn market and the low share of its production that is exported implies that corn prices in the rest of the world are highly influenced by the supply and demand relationship for corn in the domestic U.S. market.

APEC is therefore home to some of the world's leading corn importers. For example, Japan is by far the world's largest importer of corn, with the United States supplying more than 90% of its 15 million tons of corn imports annually. Japan's corn imports are driven by its large livestock production, in which the biggest input is compound feed mix. As the feed manufacturing industry in Japan is consolidating production capacity following the earthquake and tsunami disaster in March 2011, demand for corn and other feed crops in Japan is likely to increase. Korea; China; and Mexico are also among the top five importers of corn. In China and Korea, corn is mainly used as a feed input. However, in Mexico, corn is also an important staple, accounting for 60% of its total cereal consumption – the highest among the APEC economies – and providing more than 40% of average daily calorie intake. Although corn is the most important crop in its agricultural sector, Mexico has also increased its imports in order to meet the growing food and animal feed demand.

Based solely on the supply and demand relationship of wheat, corn, and soybeans in each APEC economy, Japan; Korea; Malaysia; Peru; Chile; and Mexico are relatively more vulnerable to a sustained increase in international prices. However, the level of self-sufficiency in the production of these commodities is not the sole factor in determining the magnitude of price shocks that can be transmitted into the domestic market. Government policies, such as grain stock reserves and price interventions, are also critical.

For instance, while Thailand and Malaysia maintain price controls on essential food items, Indonesia provides direct subsidies for food. Some other APEC members also have a record of stipulating temporary policies in order to mitigate food price increases. Japan has a feed price stabilization program which pulls together government subsidies and industry funding to help absorb sudden surges in the compound feed price. This program was activated during the 2007-08 global food price crisis and again in the last quarter of 2010 to help curb feed price increases. In China, if faced with rising flour prices, the government has an option to instruct state owned grain reserve companies to supply wheat to designated mills and then require those mills to sell the product at a price set by the government. For these economies, the fiscal budget also shares the burden of an increase in world food prices.

ii. Impact of Increased Global Grain Prices on Food Prices in the APEC Region

So far, the impact of the surge in international prices for wheat, corn, and soybeans on domestic prices in APEC economies has varied since it depends on each economy's current level of reserves, local producing conditions, and the ability to source alternative supplies. Some large corn importers, including Korea; Japan; and Chinese Taipei, have increasingly

sourced feed inputs from South America as well as from producers in the Black Sea region. Farmers in Japan have also switched to cheaper feed inputs and reduced the use of corn in animal feed. It is therefore too early to reach a full conclusion as to the effects of the current global price rises on domestic food inflation in each APEC economy.

However, in the third quarter of 2012, food prices have indeed surged in some APEC economies. In Indonesia, rising soybean prices have exerted upward pressure on some important Indonesian staples, such as soybean cake and tofu, prompting the government to temporarily lift taxes on soybean imports. Retail prices for some grains and their downstream commodities have also increased in Chile; Peru; and Mexico. In Mexico, for instance, higher international grain prices have been passed on to domestic consumers in the form of higher prices for tortilla. It is important to note that besides the higher cost of imported food, domestic and seasonal factors (i.e., weather anomalies affecting domestic food production as well as festive seasons increasing food demand), have also played a significant role in increasing food inflation in these economies.

In other APEC economies, food inflation moderated in the third quarter of 2012. Even in the United States, where the severe drought has sent prices soaring, food inflation has continued its downward trend since January of this year. One of the key reasons is that there has not been a synchronized price spike across all food categories. In fact, global prices of many other important agricultural products have fallen sharply this year. Rice prices have also been relatively stable this year due to record global production. Higher inventory levels of wheat, corn, and soybeans in many APEC economies, compared with the previous period of food inflation in 2008, suggests that de-stocking could also provide a buffer against the passing on of higher grain prices to consumers. Moreover, the current global surge in grain prices is occurring against a backdrop of lower global growth, moderate energy prices, and weak consumer confidence, which together has helped to curtail any drastic increases in food prices in the APEC region.

Notwithstanding the current moderate pace of food inflation in several APEC economies, food prices may gain momentum in the coming months. It is estimated that the full effect of the increase in grain prices on packaged and processed foods that use grain as a major input (cereal, corn flour, etc.) will likely take 10 to 12 months to hit retail food prices[19]. Similarly, since corn and soybeans are major inputs in animal feed, higher prices for these commodities are affecting profitability in the livestock sector. Livestock producers, especially those in the United States, are thus being pressured to increase herd culling and suspend any expansion plans. In Mexico, higher grain prices are forcing consolidation among large dairy producers and the exiting of smaller producers. Thus, consumers will most likely be impacted by increases in retail prices for a wide range of meat and dairy products over the next few months as the supply of these products is likely to shrink in the medium-term and as producers pass through higher feed costs.

[19] Oxfam (2012).

3. AGRICULTURAL TRADE BARRIERS

A. OVERVIEW OF AGRICULTURAL TRADE

Since open trade in agricultural products helps to mitigate price volatility as well as improve agricultural competitiveness, APEC members should refrain from implementing trade barriers in response to rising food prices. In fact, such measures can be counterproductive: it is estimated that 45% of the world price increase for rice in 2006-08 and 29% of the price increase for wheat was due to changes in border restrictions used by economies as an attempt to insulate themselves from the initial price increases[20]. Nevertheless, a study on food security policies recently commissioned by the APEC PSU found that many APEC members adjusted their food security policies towards self-sufficiency in response to the recent food price spikes, particularly those economies that are net food importers[21]. Such policies can conflict with overall food security objectives, both domestically as well as globally. For instance, studies have shown that import bans hinder the competitiveness of the agricultural sector, thereby limiting agricultural productivity growth as well as increasing food costs for poor consumers who are net buyers of food staples[22].

Research also shows that agricultural trade distortions impose significant economic costs. A recent study found that removing the goods market distortions that remained in 2004 would potentially increase global economic welfare by USD 168 billion per year, of which about 70% would come from agriculture and food policy reform[23]. In addition, the share of global production of farm products that is exported would rise from 8% to 13% (excluding intra-EU trade), thereby reducing price volatility. Significantly for developing economies, the study also found that their share of the world's primary agricultural exports would rise from 55% to 64%, while net farm income in developing economies as a group would rise by 5.6%. It is important to note that agricultural trade liberalization would cause global food prices to rise, although this would raise farmer incomes, particularly in developing economies, as well as create an incentive for increased investment in the sector.

Agricultural liberalization has proved to be one of the more contentious topics in the current round of multilateral trade negotiations at the WTO, the Doha Development Agenda (DDA), which commenced in November 2001. The negotiations aim to reform agricultural trade in three main areas: improving market access, reducing domestic support, and eliminating export subsidies. Although conflicting priorities with respect to agricultural policy has resulted in several negotiating factions among the WTO members, substantial progress has been made in many topics under all three agricultural pillars. However, at the most recent conference in July 2008, members were unable to reach agreement on the threshold for the special safeguard mechanism (SSM), which would allow developing WTO members to impose a special tariff on certain agricultural goods in the event of an import surge or price drop. The talks continue to be at an impasse and a timely and successful conclusion to the DDA remains uncertain, jeopardizing the concessions that have so far been made.

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[20] Martin and Anderson (2011).
[21] APEC Policy Support Unit (2012).
[22] OECD (2012). For example, Warr (2011) estimates that as a result of Indonesia's import ban on rice since 2004, the price of rice within Indonesia relative to other prices has increased by about 40%.
[23] Valenzuela et al. (2008).

Despite its dominance in trade negotiations, agricultural trade accounted for just 8.3% of the value of global goods trade in 2011 (Figure 18a)[24]. Exports of agricultural products from APEC economies, valued at USD 475 billion in 2011, comprised 35% of the value of global agricultural exports. This is substantially lower than that of non-agricultural exports from APEC members, which was valued at USD 7.8 trillion and accounted for 53% of global non-agricultural export value. In fact, agricultural exports as a share of total goods export value from APEC economies was 5.8% in 2011.

Figure 18a. Global goods trade value in 2011

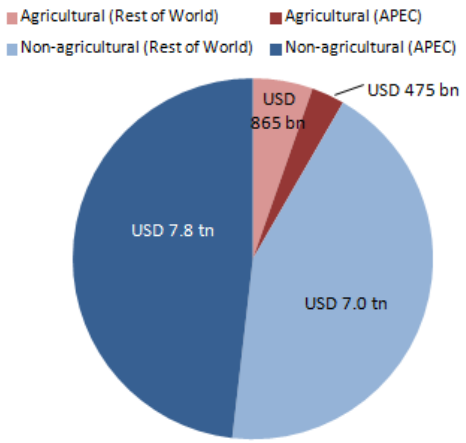
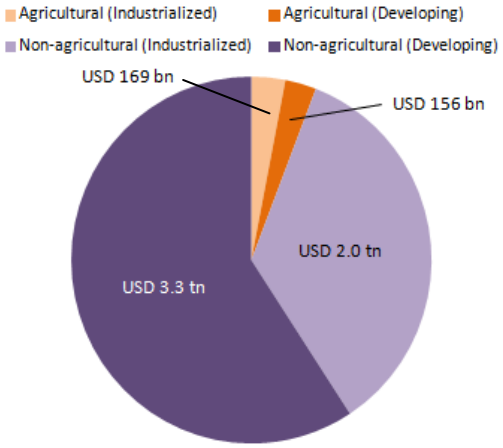


Figure 18b. Intra-APEC goods trade value in 2011



Source: International Trade Centre, Trade Map and PSU calculations.

Most of the agricultural exports from APEC economies went to other APEC members: intra-APEC trade in agricultural products, valued at USD 325 billion in 2011, comprised 68% of total agricultural export value from APEC members (Figure 18b). Meanwhile, intra-APEC trade of non-agricultural products, valued at USD 5.3 trillion, also accounted for 68% of total non-agricultural export value from APEC members. Interestingly, the value of agricultural exports as a share of total export value to other APEC economies is higher for industrialized APEC economies than for developing APEC economies: 8.0% compared with 4.5%.

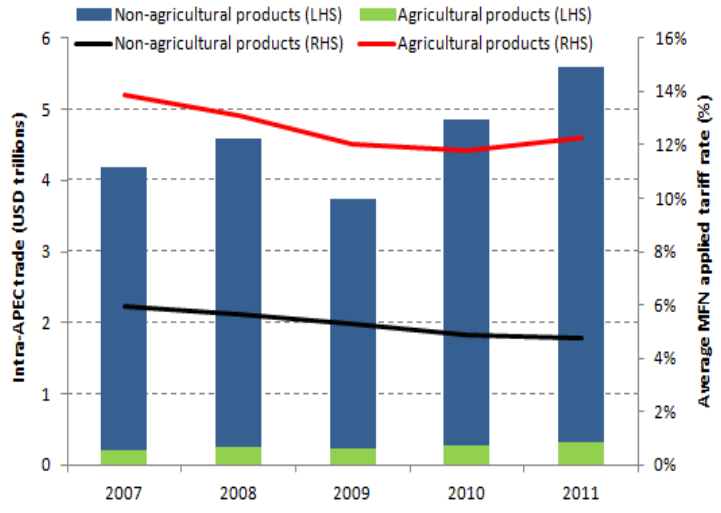
B. TARIFF AND NON-TARIFF BARRIERS

After four consecutive years of declines, the average MFN applied tariff rate on agricultural products in the APEC region rose to 12.3% in 2011 from 11.8% in 2010, mainly due to steep increases in the average tariff rates applied by Canada and Japan (Figure 19)[25]. In 2011, the average MFN applied tariff rate on agricultural products was 9.8% in industrialized APEC economies and 13.0% in developing APEC economies. Tariffs on agricultural products are not only higher than those applied to non-agricultural products, but are also slower to be reduced. From 2007 to 2011, the average MFN applied tariff rate on agricultural products in the APEC region decreased by 11.5%, while that for non-agricultural products fell by 20% to 4.7% in 2011.

[24] Agricultural products are defined as Chapters 01-24 of the Harmonized System (HS) trade nomenclature, while non-agricultural products are defined as all other Chapters.

[25] MFN (most-favored nation) applied tariff is the normal, non-discriminatory tariff rate imposed on imports, as opposed to preferential tariff rates under free trade agreements (FTA) and other schemes or tariffs charged inside quotas.

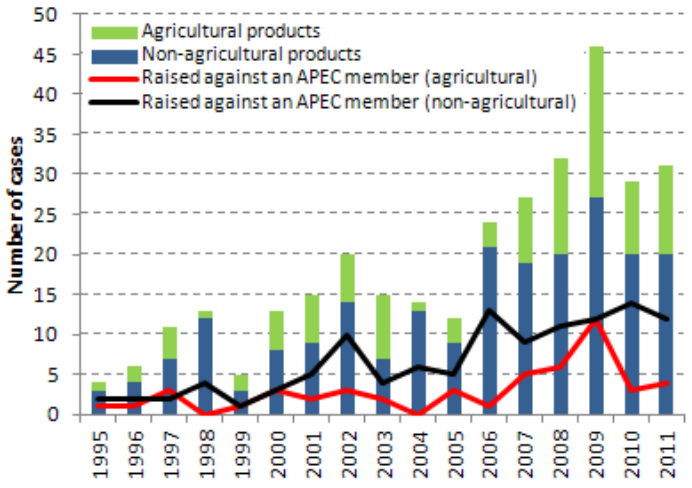
Figure 19. Intra-APEC trade and MFN applied tariff rates



Source: International Trade Centre, Trade Map; WTO, *World Tariff Profiles* and PSU calculations.

Given the generally downward trend in average tariff rates, greater attention is now being paid to non-tariff barriers – not only the more traditional ones such as import quotas, but also regulatory measures that reflect domestic public policy objectives, including technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) measures. In its *World Trade Report 2012*, which focuses on the issue of non-tariff measures (NTM), the WTO found that the use of TBT and SPS measures has indeed increased, both in absolute terms and relative to other measures. The WTO reports that the average economy imposes TBT measures on about 30% of products and trade and SPS measures on around 15% of products and trade. While some of these trade measures are legitimately used in the interest of food safety, there is an increasing concern that such regulations can also be used to protect domestic producers, raising issues of transparency.

Figure 20. Specific trade concerns raised against TBT measures



Source: WTO, TBT IMS and PSU calculations.

Between 1995 and 2011, there were 317 specific trade concerns raised by WTO members against a TBT measure, slightly over half of which concerned a measure that had been undertaken by an APEC economy (Figure 20). Looking more closely at the product level, around 30% of all TBT concerns raised between 1995 and 2011 were related to an agricultural product, nearly half of which named an APEC economy as the maintaining member[26]. Of those cases, the United States accounted for 20%, followed by Korea (14%) and Canada and China (12% each). Significantly, of the 50 TBT concerns regarding agricultural products that were raised against an APEC economy, 37 cases (74%) included another APEC economy as a raising member.

Furthermore, growth in the number of concerns raised over TBT measures that impact agricultural products has outpaced growth in those raised over measures that affect non-

[26] A 'maintaining' member is the economy that maintains the measure to which the specific trade concern has been raised. A 'raising' member is the economy (or one of the economies) that raised the specific trade concern.

agricultural products. In just the past six years (2006-2011), there were 59% more TBT concerns raised over a measure that affected an agricultural product than had been raised in the previous 11 years, compared with a 43% increase in the number of TBT concerns raised over a measure that impacted a non-agricultural product. Products classified as beverages accounted for the highest number of TBT concerns regarding an agricultural product (29%), followed by meat (24%) and live animals (14%). Many of these concerns were raised over packaging and labelling requirements, including measures that had been implemented in the protection of the environment as well as human health and safety.

There has also been an increasing number of regular and emergency SPS notifications reported to the WTO since 1995, peaking in 2010[27]. APEC members are especially active in submitting notifications concerning SPS measures to the WTO: 13 APEC members were responsible for nearly 70% of the regular SPS notifications from 1995 through the third quarter of 2011, while 12 APEC members accounted for 44% of the emergency SPS notifications. From 2009 through September 2012, APEC members submitted 2,146 regular SPS notifications and 121 emergency SPS notifications. The United States accounted for 26% of the regular notifications followed by China (20%) and Canada (12%), while the Philippines made 30% of the emergency notifications followed by the United States (16%).

Despite the increase in SPS notifications, the number of SPS concerns raised by WTO members has fallen since peaking during the five years between 2001 through 2005. In total, there were 312 specific trade concerns relating to SPS measures raised between 1995 and 2010, nearly all of which involved agricultural products, particularly meat products and live animals. An APEC economy was named as a maintaining member in nearly half of the SPS concerns that were raised. These concerns were dominated by SPS measures regarding meat products and fruits. Of the concerns raised against APEC members, the United States was named as a maintaining member 22% of the time, followed by Japan (15%), China (11%), and Australia (10%)[28]. Another APEC economy was one of the members raising the SPS concern in over half the cases raised against an APEC economy.

The WTO found that the diversity of TBT and SPS measures has a negative effect on trade in the agricultural sector, but that those effects can be mitigated by international harmonization of standards and mutual recognition, helping to ensure that TBT and SPS measures are applied transparently and fairly[29]. Also at issue is that technical barriers to trade, including SPS measures, can have a disproportionately negative impact on food exports from developing economies since these economies may not have the necessary scientific and technical expertise and technologies, thereby facing higher costs of compliance. A recent survey found that 60% of businesses in the agricultural sector in developing economies are negatively affected by NTMs, compared with 51% of businesses in the manufacturing sector, with exporters of agricultural products also reporting more problems related to TBT and SPS measures than exporters of manufactured goods[30]. Capacity building to address these challenges is necessary so that food exporters in developing economies are able to diversify their export markets, particularly to include developed economies[31].

[27] WTO (2011).
[28] A single SPS concern can be raised against more than one maintaining member.
[29] WTO (2012).
[30] Cited in WTO (2012) and based on the International Trade Centre's (ITC) NTMs survey of businesses conducted in 11 developing economies, one of which was Peru, in 2010.
[31] In the ITC survey, firms reported that around 75% of burdensome NTMs relate to TBT and SPS measures when the importing economy is developed versus about 50% when the importing economy is developing.

4. FOOD LOSSES AND WASTE

A. MAGNITUDE OF FOOD LOSSES

Strategies that seek to improve food availability often place an emphasis on the need to increase production, especially when food prices rise. However, there is a fundamental aspect of food security that has recently begun to attract intense attention: the need to reduce food losses and food waste[32]. A recent study commissioned by FAO estimated that one-third of food produced for human consumption is lost or wasted globally, amounting to around 1.3 billion tons per year[33]. To put this into perspective, a study commissioned by the UK government indicates that if this global loss estimate were halved, then existing production could be reduced by 25% and the food demand expected in 2050 would still be met[34].

In addition, the environmental resources, such as water, required for food production would also be reduced, as well as the greenhouse gas emissions that result from food production. A recent study, which estimated that 24% of all produced food is lost in the supply chain, found that approximately a quarter of the consumed resources (freshwater, cropland, and fertilizers) were used to produce those losses[35]. The study also asserts that halving these food losses would provide an extra one billion people with an adequate supply of food, in addition to preserving critical natural resources.

Given that the APEC region includes some of the world's largest producers and exporters of many food staples, it is crucial that APEC members address the issue of food losses. Reducing losses along the entire food supply chain is essential in order to increase food availability from existing levels of production. A food supply chain can be divided into three broad parts: (1) production and harvesting; (2) post-harvest, which includes handling and storage, transportation, processing and packaging, and distribution and marketing; and (3) post-consumer, which includes households, institutions, and the hospitality sector. It is, however, very difficult to measure exactly how much food is lost or wasted, especially as it moves along the supply chain. Data on food losses are extremely limited, and much of what is available is out of date. Furthermore, there is no standardized methodology for measuring food losses across the different agricultural products.

Despite the data limitations, an estimated 9% of the food supply in the APEC region is lost between the level at which production is recorded and before reaching the consumer – i.e., during the storage and transportation stages of the supply chain[36]. Looking more closely at specific agricultural products, an estimated 14% of roots and tubers are lost during these stages of the supply chain – the highest amount across the commodity groupings – followed by fish and seafood (11%) and oilseeds and pulses (10%) (Figure 21). Although food losses

[32] Food losses are defined by FAO as wholesome edible material intended for human consumption that is instead discarded, lost, degraded, or consumed by pests at any point along the food supply chain. In general, losses that occur at the production and post-harvest stages of the supply chain are referred to as 'food losses', while those that occur at the marketing and final consumption stages of the food supply chain are referred to as 'food waste'.

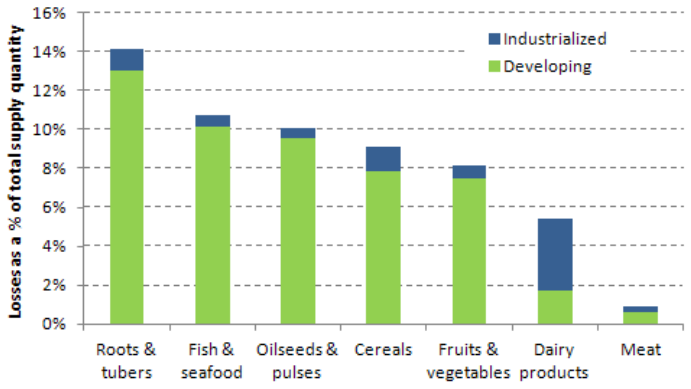
[33] Gustavsson et al. (2011).

[34] Foresight (2011).

[35] Kummu (2012).

[36] Using data from FAOSTAT 2009 Food Balance Sheets, waste is calculated as "Other Utilization" as a share of "Domestic Supply Quantity". Given limitations in data availability, these estimates should be taken as rough approximations (at the low end) of the actual food losses in the APEC region.

Figure 21. Food losses in APEC, by agricultural product



Source: FAOSTAT, 2009 Food Balance Sheets and PSU calculations.

in developing APEC economies account for most of the storage and transportation losses in the APEC region – with losses especially high in the Southeast Asian APEC economies – food losses can also be high in industrialized APEC economies for particular commodity groupings. For instance, the data indicate that losses in roots and tubers are above 10% in Canada and in the United States, while cereal losses are around 15% in Australia.

The Swedish Institute for Food and Biotechnology (SIK), commissioned by FAO, takes this analysis a step further and estimates the share of edible food that is lost or wasted at different stages along the supply chain – from primary production through consumer waste[37]. The data suggest that 10% of food is lost during primary production, followed by post-harvest, which includes handling, storage, and transportation (7.3%), and during consumption (7%) (Figure 22a). The data also reveal that nearly half of the total edible supply of roots and tubers is lost, closely followed by fruits and vegetables (Figure 22b). Food losses during primary production are largest for roots and tubers (15%), while these products also exhibit the largest amount of losses during the subsequent post-harvest stages (26%). Meanwhile, consumer food waste is largest for cereals (14%).

Figure 22a. Global food losses along the supply chain, by segment

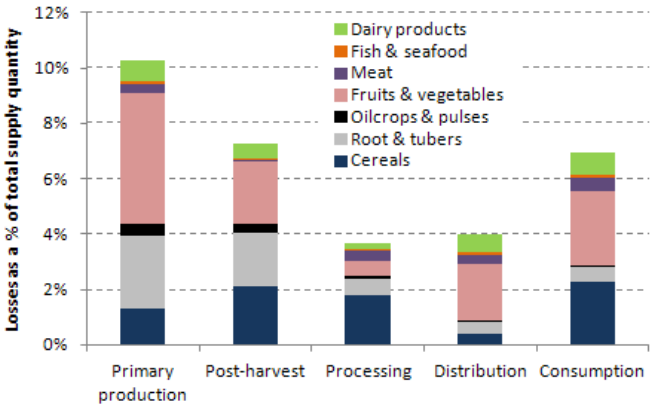
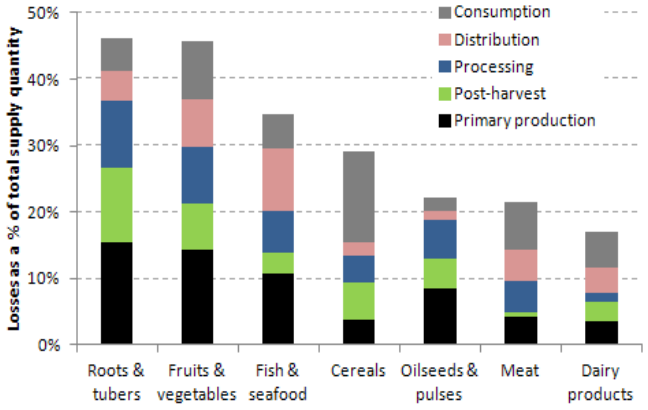


Figure 22b. Global food losses along the supply chain, by agricultural product



Source: Gustavsson et al. (2011) data provided by FAO and PSU calculations.

The study also reveals the differences between developed and developing economies in terms of food losses. Although approximately 30% of food is lost along the entire food supply chain in both developed and developing economies, the losses occur at different points along the supply chain. In general, food losses are larger in low-income economies at the beginning of the supply chain from primary production through the post-harvest segments, while food losses in high- and medium-income economies are larger at the marketing and consumption

[37] Gustavsson et al. (2011).

stages of the supply chain[38] (Figure 23a). An estimated 24% of food is lost in low-income economies from primary production through processing, compared with 19% of food lost in high- and medium-income economies during these stages. However, 14% of food is wasted during the distribution and consumption stages in high- and medium-income economies, compared with 7.6% waste during these stages in low-income economies.

Figure 23a. Global food losses, by supply chain segment and level of economic development

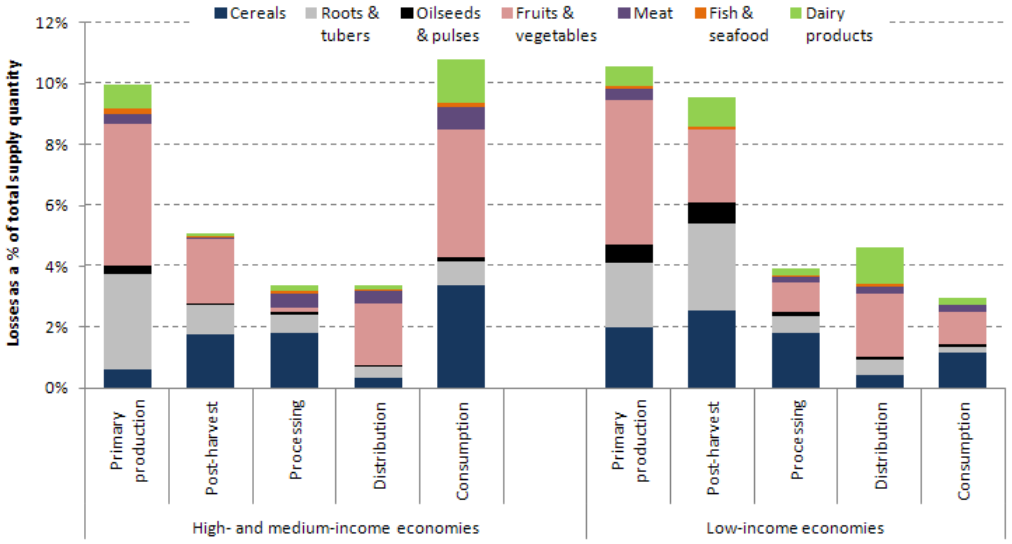
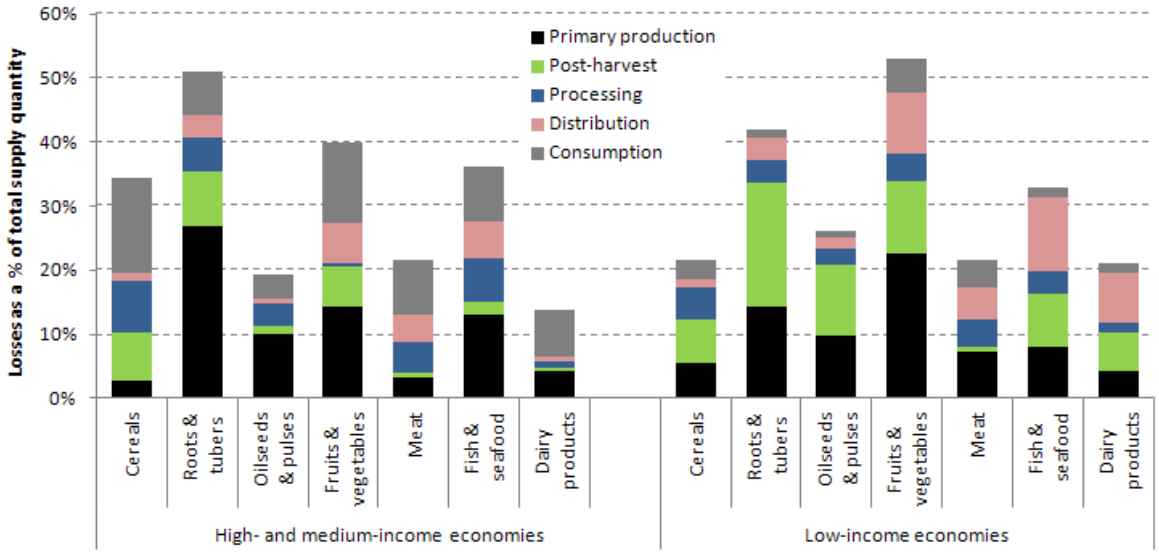


Figure 23b. Global food losses, by agricultural product and level of economic development



Source: Gustavsson et al. (2011) data provided by FAO and PSU calculations.

There are also revealing differences between the economy groupings in the amount of losses across agricultural products as they move along the supply chain. Over half of fruits and vegetables are lost in low-income economies, especially during primary production which accounts for nearly half of these losses (Figure 23b). Overall losses of oilseeds and pulses and of dairy are also higher in low-income economies, while losses of roots and tubers, cereals,

[38] Due to data limitations, the following APEC members are included in 'high- and medium-income economies': Australia; Canada; China; Japan; Korea; New Zealand; Russia; and the United States, while the following APEC members are included in 'low-income economies': Chile; Indonesia; Malaysia; Mexico; Peru; Philippines; Thailand; and Viet Nam.

and fish are higher in medium- and high-income economies. Although losses during primary production contribute substantially to the overall losses of roots and tubers and of fish and seafood, consumption losses account for nearly half of the cereal losses in medium- and high-income economies.

Despite the difficulties in measuring food losses and food waste, it is nevertheless clear that such losses are substantial and that reducing them is imperative to achieving global food security. In order to better assess the magnitude of food losses, particularly along the post-harvest segments of the supply chain, a unified methodology for assessing food losses needs to be developed. Comparable data across economies as well as across agricultural products would allow for better analysis of the issue in order to design coordinated approaches to the development of food market infrastructure and their logistical support, including measures to attract targeted investments, thereby reducing food losses along the supply chain.

B. CAUSES OF FOOD LOSSES

The underlying causes of food losses along the supply chain, and therefore the challenges that APEC economies face in reducing such losses, vary depending on the level of economic development. Food supply chains in industrialized economies are typically long and are characterized by close integration between producers, processors, distribution systems, suppliers, and markets (thereby ensuring greater economies of scale and efficiency), while those in developing economies are usually short and are often characterized by limited infrastructure and technologies, often using traditional methods and storage systems and with many intermediaries supplying local markets[39].

i. Primary Production Losses

According to the study commissioned by FAO, an estimated 15% of roots and tubers, 14% of fruits and vegetables, and 3.7% of cereal grains are lost globally during production and harvesting. These losses are typically the result of inadequate equipment as well as from insufficient technical and managerial knowledge on the part of the farmers. Extension services such as initiatives that train farmers in the most optimal growing and harvesting techniques are therefore essential to increase yields and reduce food losses during primary production, especially in developing economies. In addition, modern agricultural machinery and equipment and up-to-date techniques play an obvious and important role in increasing productivity and in limiting the amount of food losses during primary production. However, in 2007, developing APEC economies had a total of USD 171 billion worth of agricultural machinery and equipment used in primary production, while industrialized APEC economies had over three times that amount (USD 535 billion)[40].

Modern and well-maintained irrigation systems are also important in limiting losses during food production as well as in increasing yields. Although the total area equipped for irrigation has increased substantially across the APEC region – from 109 million hectares in 1995 to 128 million hectares in 2009 – its growth has recently slowed[41]. Between 2000 and 2004, the

[39] Parfitt et al. (2010).
[40] FAOSTAT. Data are the gross fixed capital stock (in constant 2005 prices) of agricultural machinery and equipment, which includes tractors (with accessories), harvesters and thrashers, milking machines, and hand tools.
[41] FAOSTAT.

total area equipped for irrigation grew at an average annual rate of 2.2%. However, this rate fell to just 0.5% per year between 2005 and 2009, mainly due to a large fall in the average growth rate in developing APEC economies. In addition, according to FAO estimates, around 75% of the total area with the potential for irrigation in developing APEC economies was actually equipped for irrigation in 2009 – excluding China, this share falls to just over half (Table 3). Furthermore, several APEC economies are faced with the challenge of addressing deteriorating irrigation systems. For example, the Indonesian government estimated in 2010 that 46% of the irrigation system is in disrepair and the ability to address its condition is limited due to lack of funds[42].

Table 3. Irrigation systems in selected APEC economies in 2009

1000 hectares	**Equipped area**	**Potential area**	**Share (%)**
Chile	1,900	2,500	76.0
China	64,504	70,000	92.1
Indonesia	6,722	10,886	61.7
Korea	806	1,782	45.2
Malaysia	365	414	88.2
Mexico	6,300	9,766	64.5
Peru	1,196	6,411	18.7
Philippines	1,540	3,126	49.3
Thailand	6,415	12,245	52.4
Viet Nam	4,600	9,400	48.9

Source: FAOSTAT; FAO AQUASTAT and PSU calculations.

ii. Post-harvest Losses

Following primary production and harvesting, food losses occur at four main stages along the supply chain before reaching the consumer: handling and storage, transportation, processing and packaging, and distribution and marketing. Data provided by FAO indicates that around 26% of roots and tubers, 23% of fruits and vegetables, and 12% of cereal grains are lost globally during these segments of the food supply chain. The data also reveal that post-harvest losses are larger in developing economies: 13.5% of food is lost in handling, storage, transportation, and processing in low-income economies compared with 8.5% along these stages of the supply chain in medium- and high-income economies. These losses tend to be the result of a lack of necessary post-harvest infrastructure as well as a lack of technical and managerial skills in post-harvest processing.

Post-harvest losses of non-perishable foods, such as cereal grains, are typically due to inadequate storage facilities, resulting in physical losses from spillage, consumption by pests and rodents, and incidents of fungus, as well as a more general loss in quality. Such grain losses can be quite high and APEC economies can face several challenges in addressing these losses (Box 2). Meanwhile, post-harvest losses of perishable foods, such as fresh fruits and vegetables, are often due to improper handling and/or packaging as well as inadequate transportation infrastructure resulting in spoilage. In this regard, cold storage facilities as well as advanced packaging technology to increase shelf life are vital in limiting losses of fresh produce, both of which are often severely lacking in developing economies.

Box 2. Tackling rice storage losses in Viet Nam

Viet Nam, the world's second largest rice exporter, produces nearly 40 million tons of paddy rice a year, half of which is grown in the Mekong Delta region. However, a lack of modern rice storage

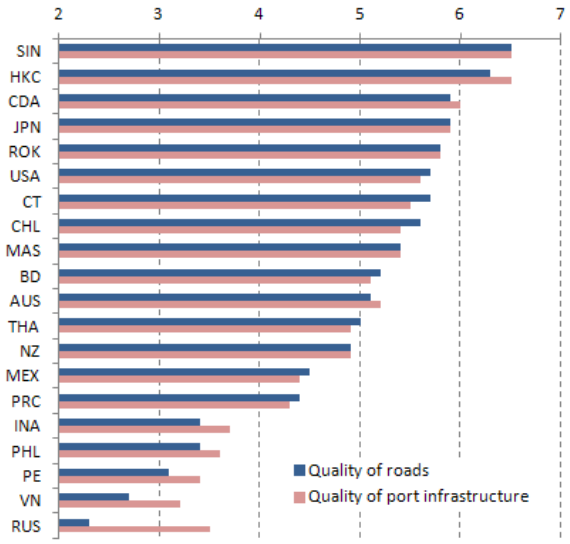
[42] USDA (2012).

facilities and drying machines in the region results in high amounts of post-harvest losses, averaging around 14% of production at a value of USD 650 million per year[43]. In 2010, Viet Nam's rice storage capacity, at 1.5 million tons, met only 30% of storage demand. In addition, many of the available storage facilities are inadequate, offering improper storage conditions due to old and basic equipment. It is estimated that modern rice storage facilities would enable Viet Nam to reduce post-harvest losses of rice by at least 3%.

In 2009, the Ministry of Agriculture and Rural Development embarked on a USD 390 million plan to build a rice storehouse system across the economy by 2012 that would raise storage capacity to 4 million tons. However, this plan has fallen behind schedule. By mid-2012 facilities with a combined storage capacity of nearly 1 million tons had been built, 60% short of the target of 2.5 million tons, causing the government to extend the completion schedule to late 2013. Despite the extension, shortages of capital and difficulties in site clearance continue to delay construction, challenging the ability to reduce rice storage losses in Viet Nam.

Significant losses also occur during transportation, mainly due to spoilage of perishable foods. Extensive and well-maintained road networks, especially in rural areas, are essential in getting fresh produce to markets quickly as well as in providing farmers with access to those markets, thereby raising their income potential. For instance, in a survey conducted among farmers in Papua New Guinea, 73% of respondents said that transport and road conditions were the biggest constraint in selling their fresh produce[44]. Modern and efficient port systems are also vital in limiting food losses, especially in the APEC region which includes many major food exporters. Unfortunately, there is a lack of hard data indicators across the APEC members that can accurately assess road and port infrastructure.

Figure 24. Quality of roads and ports



Note: 1=extremely underdeveloped 7=extensive (roads) / well developed (ports) and efficient by international standards.
Source: World Economic Forum, *The Global Competitiveness Report 2012-2013*.

One measure that can be used is the Executive Opinion Survey conducted by the World Economic Forum, which asks respondents to assess the quality of road and port infrastructure in their economies. Based on these results, industrialized APEC members have an average score of 5.5 (out of 7) for both roads and ports, compared with 4.6 (roads) and 4.7 (ports) for developing APEC members (Figure 24). However, excluding the newly industrialized Asian economies, the average scores for developing APEC members fall to 4.1 for roads and 4.3 for port infrastructure. (In fact, the quality of roads and port infrastructure in the newly industrialized Asian economies is assessed to be higher, an average score of 6.1 for both roads and port infrastructure, than in industrialized APEC economies.) The scores suggest that substantial improvements in roads and port infrastructure are needed across the APEC region, particularly in the Southeast Asian and Latin American APEC economies.

[43] Institute of Agricultural Engineering and Post-Harvest Technology (IAEPHT), as cited in *Viet Nam News* (2012).
[44] Fresh Produce Development Agency (2008).

Overall food losses during the distribution and marketing stage of the supply chain are not as large comparatively: 4.6% in low-income economies and 3.4% in medium- and high-income economies according to FAO data. However, the underlying causes are significantly different between developed and developing economies. In developed economies, which typically have modern food trade such as supermarkets, retail losses are often due to food being discarded once it is past its sell by date. In fact, Japan's Ministry of Agriculture, Forestry and Fisheries reported that 600,000 tons of unsold food was discarded by convenience stores and supermarkets in fiscal year 2003[45]. Better inventory management and demand forecasting as well as improved labelling of products would therefore help to reduce food losses during marketing in developed economies. Meanwhile, distribution and marketing losses in developing economies are often due to inadequate market facilities, resulting in food spoilage and damage as well as unsanitary market conditions, also causing unsafe food. Investments to modernize the food retailing systems are therefore essential in order to reducing marketing losses of food in developing economies.

iii. Consumption Losses

Finally, the amount of consumer food waste, mainly in developed economies, is staggering and contributes substantially to total food losses along the supply chain. In fact, data provided by FAO reveals that 11% of food is wasted during the consumption stage in medium- and high-income economies (222 million tons) compared with just 3% wasted in low-income economies during this stage. These losses are often caused by simply buying and preparing more food than is consumed as well as by confusion over sell by and use by dates, and are driven by the low price of food relative to disposable income and the high expectations of food cosmetic standards[46]. For instance, an estimated 14% of food is discarded at the household level in the United States at a cost of USD 43 billion each year[47]. APEC members, particularly those that are industrialized, should strive to raise awareness of the issue of food waste given its substantial impact on global food security.

[45] As reported by *Mainichi Daily News* on 6 June 2005.
[46] Parfitt et al. (2010).
[47] Jones (2006).

5. AGRICULTURAL INVESTMENT CHALLENGES

It is clear that investments in hard and soft infrastructure as well as in agricultural research and development (R&D) are crucial to increasing productivity and reducing food losses. Research shows that agricultural investments are positively correlated with production growth, poverty reduction, and food security. In fact, the World Bank found that agricultural investment, which leads to higher farmer incomes, is the most effective strategy for reducing poverty in rural areas[48]. Furthermore, increased agricultural productivity leads to increased food availability, which helps to keep consumer prices low, and reduces the vulnerability of food supplies to shocks, thereby improving food security.

Agricultural investments typically involve large-scale projects, usually requiring significant outlays of capital and taking many years to realize. For instance, this time lag for an agricultural R&D investment can range between 10 and 20 years. Given the inherent investment risks, such projects are often undertaken by the public sector. However, investment in the agricultural sector can come from many sources in addition to public investment, including domestic private investment, official development assistance, and foreign direct investment. Such investment can be directed towards primary agricultural production (e.g., R&D in seed technology or investment in irrigation infrastructure) or towards downstream agricultural activities (e.g., R&D in packaging technology or investment in retail infrastructure).

A. TRENDS IN AGRICULTURAL INVESTMENTS

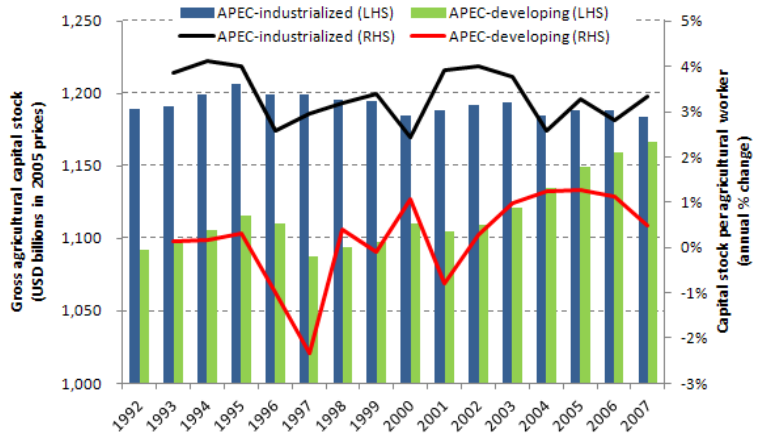
FAO reports that there has been a low level of investment in the agricultural sector of most developing economies over the past 30 years, resulting in low productivity and stagnant production of many staple crops[49]. If the current trend of declining productivity growth were to continue, the ability of the agricultural sector to meet demand in an increasingly resource constrained world will be significantly impaired. Unfortunately, there is evidence of underinvestment in the levels of agricultural investment in developing economies, particularly in public spending, over the past few decades.

i. Agricultural Capital Stock and Official Development Assistance

Physical agricultural capital stock is an indicator of the level of investment in the agricultural sector of an economy through its capital formation. Total agricultural capital stock in the APEC region grew by only 3.1% in real terms between 1992 and 2007, an annual rate of just 0.2%[50]. All of the growth in capital formation came from developing APEC members as the pace of capital accumulation in industrialized APEC economies has slowed down given their already high levels. In fact, agricultural capital stock in industrialized and developing APEC members accounted for nearly equal amounts of the regional total of USD 2.4 trillion in 2007 (Figure 25).

[48] World Bank (2008).
[49] FAO (2012b).
[50] Gross capital stock (in constant 2005 prices) includes land development; livestock (inventory and fixed assets); machinery and equipment (tractors, with accessories; harvesters and thrashers; milking machines; and hand tools); plantation crops; and structures for livestock.

Figure 25. Agricultural capital stock in APEC

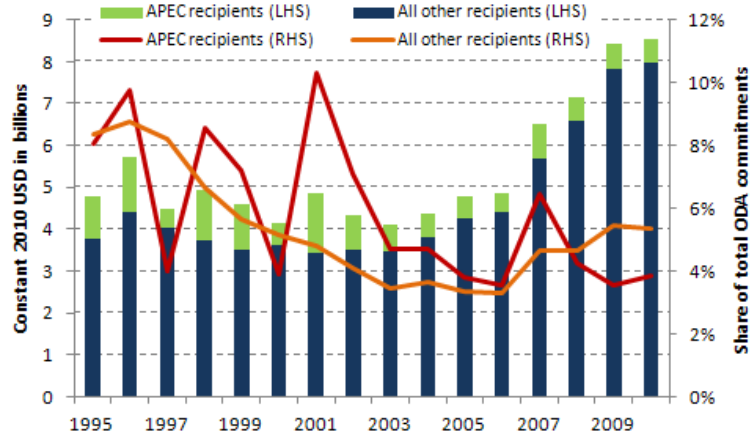


Source: FAOSTAT and PSU calculations.

However, agricultural capital stock per agricultural worker, an indicator which helps explain the difference in agricultural output per worker (a measure of productivity), varies significantly between industrialized and developing APEC members. Average capital stock per agricultural worker in industrialized APEC economies stood at USD 219,900 compared with USD 1,822 in developing APEC economies. It is noteworthy that capital stock per agricultural worker grew by 3.4% per year in real terms in industrialized APEC economies between 1992 and 2007, while it increased at an annual rate of just 0.2% in developing APEC economies. Whilst this can be partly explained by the number of agricultural workers falling by nearly 40% in industrialized APEC economies while growing by 3.5% in developing APEC economies over this period, it is nonetheless apparent that there is severe underinvestment in the agricultural sectors of developing APEC economies.

Official development assistance (ODA) has traditionally been an important source of funding in agricultural infrastructure in developing economies. Total ODA commitments to developing economies have increased substantially: annual average aid commitments amounted to nearly USD 163 billion in 2009-10, having grown by 7.3% per year from their annual average in 1995-96 (in real terms). However, total aid commitments to the agricultural and fisheries sectors have increased more slowly, at an annual rate of 3.5% between 1995-96 and 2009-10 to reach USD 8.5 billion (Figure 26) [51]. As a result, the agricultural and fisheries sectors now account for a lower share of total aid commitments, from an annual average of 9% in 1995-96 to 5% in 2009-10, as donor priorities have shifted away from agriculture for a number of reasons.

Figure 26. ODA commitments to the agricultural and fisheries sectors



Source: OECD, CRS.

[51] According to OECD (2010), ODA to the agricultural sector includes agricultural policy and programs; agricultural land and water resources; agricultural production and inputs; and agricultural education, training and research. ODA to the fisheries sector includes fishing policy and programs; fishery development; and fishery education, research and training. The analysis does not include the additional aid to the food-security related sub-sectors of rural development; food aid programs; and emergency food aid.

This trend is especially evident in the ODA going to developing APEC members[52]. Although the annual average aid commitments to developing APEC economies totalled USD 16.1 billion in 2009-10, having increased at a rate of just 1.6% per year since 1995-96, aid commitments to the agricultural and fisheries sectors in these APEC economies as a group actually fell by a rate of 4.6% per year from their level in 1995-96 to reach an annual average of USD 597 million in 2009-10 (in real terms). Thus, the share of total ODA commitments that went to these two sectors fell from an annual average of 9% in 1995-96 to 4% in 2009-10. Developing APEC economies now account for a much lower share of the total aid commitments to the agricultural and fisheries sectors, falling from 22% in 1995-96 to 7% in 2009-10. Whilst this decline is partly due to the strong growth these economies have experienced over the past 15 years, the trend is also quite clear that ODA will not be as significant a source of agricultural investment for these economies going forward.

ii. Agricultural Research and Development

In order to increase agricultural production so as to address the dual challenges of meeting the expected growth in demand as well as increasing its resilience against supply shocks, it is vital that agricultural productivity be improved in a sustainable way. R&D is an essential approach to improving agricultural productivity, as well as reducing food losses, through technological advances. New technologies resulting from R&D investments increase the quantity and quality of agricultural production as well as improve its sustainability. In addition, new technologies can lower production costs, thereby helping to reduce consumer food prices. R&D can also be used to reduce food losses through innovative techniques to avoid losses, quality deterioration, and losses during handling, storage, and marketing.

Extensive empirical evidence shows that investments in agricultural R&D contribute to agricultural development, economic growth, and poverty reduction in developing economies. Research also reveals that a fast rate of increase in R&D investments contributed significantly to the high growth rate of agricultural productivity between 1961 and 1990. Scientific advances, together with an expansion of the resource base, resulted in an increase in food production from 880 million tons in 1961 to 2.2 billion tons in 2000. However, since the 1990s, growth in global agricultural R&D spending has slowed, giving rise to concerns over an emerging slowdown in the long-term trajectory of agricultural productivity growth. In particular, declining productivity growth for several major crops in recent years has been attributed to less new technology being introduced as a result of the decline in the growth of agricultural research spending[53].

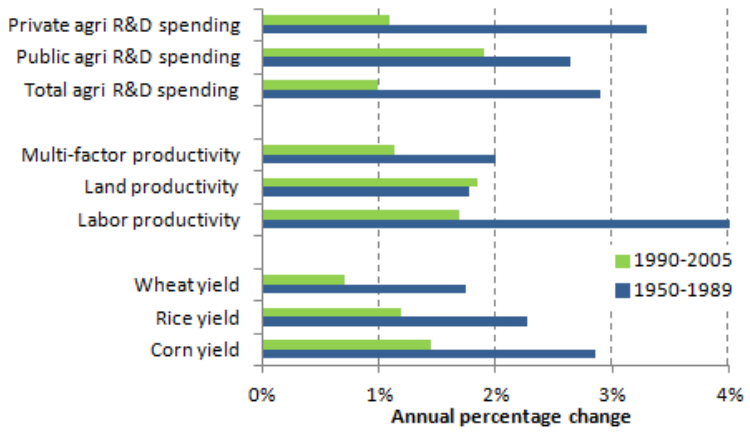
Trends in Industrialized APEC Economies

Industrialized APEC economies play an important role in the world's agricultural research. In 2000, the United States; Japan; Australia; and Canada were among the top ten agricultural R&D spenders globally. However, since 1990 there has been a slowdown in public agricultural R&D spending in those economies. This trend has been most pronounced in Japan where public spending on agricultural R&D actually contracted in real terms from USD 2.2 billion in 1991 to USD 1.7 billion in 2000[54]. The scale-back in agricultural research

[52] The analysis includes the following 10 developing APEC economies: Chile; China; Indonesia; Malaysia; Mexico; Papua New Guinea; Peru; Philippines; Thailand; and Viet Nam.
[53] Alston et al. (2010).
[54] Pardey et al. (2006). Figures are in international dollars at 2000 prices.

by many industrialized APEC economies is often cited as one of the factors causing the failure of the agricultural sector to maintain its historically high rate of productivity growth.

Figure 27. Agricultural R&D spending and productivity indicators in the United States



Source: Pardey (2009).

In the United States, the pace of inflation-adjusted growth in public R&D investment has slowed from 3.6% per year during 1950-69 to 1.8% during 1970-89 and down again to 1.0% during 1990-2005[55]. In addition to the slowdown in R&D spending, the focus of agricultural research in the United States has also shifted away from on-farm productivity enhancements towards food safety and quality as well as industrial uses of agricultural commodities. In 1976, around 65% of public research spending was oriented towards raising farm productivity, a ratio that fell to 53% by 2009. Recent research linked the slowdown in R&D spending in the United States and the reorientation of its focus to a slower rate of productivity growth between 1990 and 2005 relative to that between 1950 and 1989 (Figure 27).

In Australia, total public expenditure on agricultural R&D grew from AUD 140 million in 1953 to almost AUD 830 million in 2007 in real terms[56]. However, strong growth rates were recorded only until the mid-1970s and have been essentially static since. A recent study attributed this stagnation in public agricultural research spending, as well as other factors such as climate change, to reduced productivity growth in the Australian broadacre industries – from an average annual growth rate of 2.2% during 1980-89 to 2.0% in 1989-98 to then contracting by 1.4% per year between 1998-07 (Table 4)[57].

Table 4. Multi-factor productivity in Australia

annual % change	All broadacre	Cropping	Crops & Livestock	Beef	Sheep	Public agricultural R&D spending
1980-1989	2.2	4.8	2.9	-0.9	0.4	-0.3
1989-1998	2.0	1.9	1.4	1.6	-1.2	0.6
1998-2007	-1.4	-2.1	-1.9	2.8	0.5	-8.6

Source: Nossal and Gooday (2009); OECD (2011).

In Canada, public R&D expenditure for agricultural research has exhibited no growth since 1990, while growth in total factor productivity of the prairie crop sector fell to an annual average of 0.5% during 1990-2004, which is much lower than historic rates of close to 2% per year.[58] It has been argued that more effective research spending would help to avert a more pronounced slowdown in agricultural productivity growth in Canada.

[55] Pardey and Alston (2012).
[56] Amounts (in constant 2008 dollars) exclude public R&D expenditure in the forestry and fisheries sectors.
[57] Sheng et al. (2010).
[58] Veeman et al. (2007).

The slowdown in public spending on agricultural R&D in industrialized APEC economies reflects a broader trend of slowing agricultural R&D investment in developed economies as a whole. For this group, rapid growth in public R&D spending during the 1970s and 1980s gave way to a dramatic slowdown since the 1990s: growth in R&D spending fell from 2.0% per year in 1980-1990 to 1.3% in 1990-2000 and down again to 0.8% per year during 2000-08. The slowing R&D spending in developed economies has broader implications on food production and food security beyond their own markets.

Traditionally, the bulk of the world's agricultural science and innovation has taken place in developed economies. Two industrialized APEC economies – the United States and Japan – accounted for 31% of global public agricultural R&D investments in 1981 (in international dollars) and 27% in 2000[59]. Such spending in developed economies has led to improved inputs such as seeds as well as improved technologies and production skills that were eventually disseminated worldwide, playing a crucial role in increasing global productivity. In fact, research reveals that the transfer of technology across borders has contributed to more than half of global productivity growth for some crops[60]. Thus, the decelerating growth in public agricultural R&D spending in developed economies implies that the international spillovers from such research will be curtailed to an extent, negatively impacting future gains in productivity.

Trends in Developing APEC Economies

Developing economies have historically played a small role in global agricultural research, accounting for only 37% of global public R&D spending in 1981. However, in recent years, developing economies have stepped up efforts in agricultural research. R&D spending among the middle-income economies has accelerated progressively since 1981, from 2.7% per year in 1981-1990 to 3.0% in 1990-2000 and to an impressive annual rate of 4.4% in 2000-2008. This strong growth has resulted in a shift in the geographic balance of global public R&D spending with developing economies' expenditure in 2008 almost at par with developed economies (in purchasing power parity terms). Some large developing economies, such as China, Brazil, and India have significantly expanded their own research capacity, reducing their reliance on technology transfers from developed economies, and becoming a significant source of new technologies for other agricultural markets (Box 3).

Box 3. Improving agricultural productivity through public R&D spending in China

It is hard to understate the remarkable transformation of China's agricultural sector since the 1978 reform. With less than 9% of global land, China has succeeded in producing enough food to meet the requirements of 20% of the global population. Between 1978 and 2007, per capita grain output increased from 319 kg to 381 kg, while per capita meat and milk output increased from 9 kg and 1 kg to 40kg and 26kg, respectively. Technological progress, originating from increased agricultural R&D investment, is among the chief factors driving this achievement. China's public agricultural R&D spending has been steadily rising since 1981. By 2008, its annual R&D spending had increased by more than six-fold to reach $6 billion, resulting in China's share of global R&D spending rising from 3.8% in 1981 to 12.8% in 2008 (in 2005 international dollars).

Research consistently demonstrates the pay-off for China from its commitment to innovation as an

[59] Alston et al (2009).
[60] Alston (2002).

engine of agricultural growth: about 45% of agricultural growth in China from 1995 to 2000 can be attributed to new technologies emanating from agricultural R&D[61]. Technological progress has also helped China to increase its agricultural output with a lesser amount of inputs. Before 1979, about 95% of the increase in China's agricultural GDP could be attributed to an increase in inputs, while only 5% could be attributed to growth in productivity[62]. However, between 1979 and 1999, the contribution of productivity growth to output growth increased to 71%. A recent study found that the acceleration in China's agricultural R&D investment strongly correlates to total factor productivity growth of 2.8% per year in 2001-09, well above the global average of 1.8% per year[63].

Studies also highlight the significant role of increased research spending in improving food security and alleviating poverty in China. For example, Chinese scientists have introduced hybrid rice and wheat seed which have substantially increased the production of these two commodities, thereby lowering food prices. Furthermore, it's been asserted that the wheat breeding research reduced the number of rural poor in China by 2.7 million in 1982 and 1.7 million in 1998[64]. Other studies have also shown that agricultural research contributes to achieving greater equality among farmers and among different regions[65].

However, it is important to stress that increasing R&D spending alone is not a sufficient condition to increasing agricultural productivity. Rather, it should be taken in combination with appropriate institutional and policy reforms in the agricultural sector. In China, these included economic and market reforms such as the establishment of a patent system that improved incentives and a market for technology that encouraged diversification. These reforms undoubtedly helped to increase the effectiveness of China's agricultural R&D spending.

Table 5. Public agricultural R&D spending in selected developing APEC economies

	Total spending			Growth rate		
	1991	1997	2002	1991-1997	1998-2002	1991-2002
	(2005 international dollars in millions)			*(percentage)*		
Chile	66	145	124	14.7	-2.9	6.7
China	1,124	1,457	2,540	5.5	12.1	8.5
Indonesia	n/a	200	129	n/a	-7.0	-4.4
Malaysia	239	318	447	5.0	8.0	6.3
Mexico	369	417	449	3.5	1.5	2.6
Papua New Guinea	20	26	20	5.1	-5.2	0.4
Philippines	81	138	141	9.8	0.7	5.6
Viet Nam	8	26	56	22.6	19.8	21.3
Sample total (excluding Indonesia)	1,906	2,527	3,777	5.4	8.5	6.8

Source: Agricultural Science and Technology Indicators (ASTI) and PSU calculations.

There is also evidence of developing APEC economies increasing their public agricultural R&D investment. Unfortunately, the data are limited and the most comprehensive source for developing APEC economies provides public agricultural R&D spending between 1991 and 2002 for seven APEC members (Table 5). Over this period, spending on public agricultural R&D for this group almost doubled in real terms, from USD 1.9 billion to USD 3.8 billion, representing an average annual growth rate of 6.8%. Of particular importance is the acceleration in the rate of R&D spending in recent years: during 1991-97, R&D spending grew at an annual rate of 5.4%, increasing to 8.5% per year during 1998-02. China is the

[61] Chen and Zhang (2011).
[62] Fan (2000).
[63] Fuglie (2012).
[64] Fan et al. (2003).
[65] See Pray et al. (2001); Pray (2001); Jikun and Rozelle (1996); Lin (1992).

main driver of R&D spending in developing APEC, accounting for more than 65% of the total amount in 2002. Some smaller APEC economies, such as Mexico; Malaysia; and Viet Nam, have also realized impressive growth in agricultural research spending. The strong growth in spending by developing economies since the early 2000s has brought total global R&D expenditure to USD 31.7 billion in 2008 (in purchasing power parity terms) from USD 26.1 billion in 2000. This corresponds to an average annual growth rate of 2.4%, a marked improvement from the average growth rate of 1.9% per year in the 1990s.

While the recent efforts of developing economies in building research capacity are encouraging, they have yet to overcome the problem of chronic underinvestment in agricultural research. The regional and global trends hide a troubling reality – the growth in agricultural R&D spending among developing economies is concentrated in just a few large economies. Almost half of the total public agricultural research spending in developing economies in 2008 was undertaken by China, India, and Brazil, up from 32% in 1981. In several developing APEC economies, public agricultural R&D spending has stagnated and has even contracted in Indonesia; Chile; and Papua New Guinea, where agriculture plays a relatively important role in the economy. Furthermore, it is vital that any increased R&D spending is used efficiently and effectively so that the agricultural sector may fully benefit.

The research intensity ratio, as measured by the ratio of R&D spending to total agricultural output, reveals further evidence of underinvestment in research. Developed economies spent an average of USD 3.07 on public agricultural R&D for every USD 100 of agricultural output in 2008, a sizable increase from USD 1.52 in 1981. In comparison, developing economies spent an average of just USD 0.54 on public agricultural R&D for every USD 100 of agricultural output in 2008, a meagre increase from USD 0.51 in 1981. Given a recommended ratio of agricultural R&D spending to agricultural GDP of 1%, the wide gap in the research intensity ratio between developed and developing economies is clear. Further increases in R&D spending in developing economies would therefore have a positive impact on agricultural productivity. Even in China, which had the most impressive growth rate of agricultural R&D spending in recent years, its research intensity ratio was 0.5 (an equivalent of USD 0.50 per USD 100 of agricultural output). It is recommended that China increase this ratio to 1.5% by 2020 and to 2.0% by 2050 in other to maintain its yield growth in the face of growing challenges[66].

Trends in Private R&D Spending

Given the trends in declining public agricultural R&D investment in many APEC economies, it is essential that APEC members encourage private investment in this area. In recent years, agricultural research conducted by the private sector has helped to bridge the gap in agricultural spending, particularly in improving inputs used in agricultural production, food processing, and product development. In 2000, the private sector spent USD 13 billion (in 2000 international dollars) in food and agricultural research, accounting for 36% of total R&D spending worldwide. However, 93% of global private agricultural R&D investment is conducted by companies based in high-income economies, accounting for more than half of total agricultural research spending in those economies.

In comparison, just 6% of agricultural research in developing economies is privately funded. Although the private sector has become more active in agricultural R&D in developing

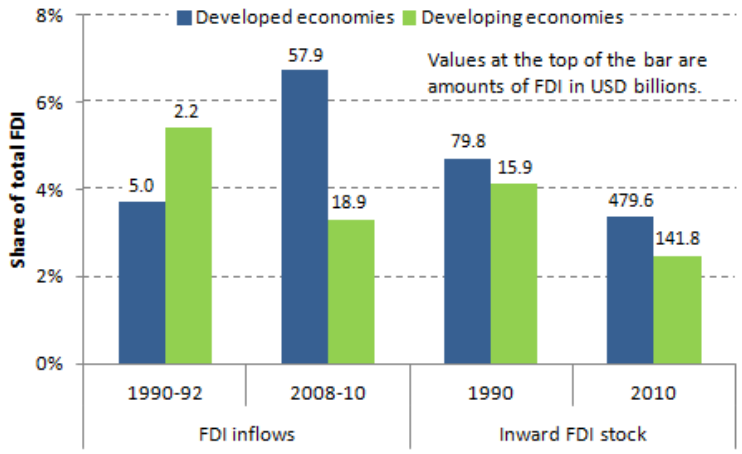
[66] Chen and Zhang (2011).

economies since 2000, their contribution to overall research spending in those economies continues to be limited. Even in China and India where there has been significant growth in private sector involvement, the public sector still provides more than 80% of total research funding. Thus, there is considerable potential for developing economies to further build their agricultural research capacity by creating an attractive investment climate to encourage more private sector R&D investment in agriculture.

iii. Foreign Direct Investment

Foreign direct investment (FDI) is an important source of funds in the agricultural sector. Such investment has been shown to increase the amount of capital available as well as raise the technological level in an economy, ultimately leading to increased economic growth and poverty reduction. However, FDI can also raise issues relating to land ownership, environmental degradation, and social disruption. These aspects, which can also occur with domestic private investment, must be carefully considered when developing investment strategies in the agricultural sector to ensure that they are sustainable and inclusive. Nevertheless, despite the many benefits of FDI and the urgent need for increased investment in agricultural infrastructure in many APEC economies, FDI flows to the agricultural sector are relatively low compared to other sectors.

Figure 28. FDI in primary and processed agricultural sectors



Source: UNCTAD (2012) and PSU calculations.

An annual average of USD 76.8 billion of global FDI inflows went to the primary and processed (food and beverages) agricultural sectors during 2008-10, accounting for just 5.4% of total inflows. A larger share of FDI flows to developed economies went to these two sectors – an annual average of 6.7% during 2008-10 compared with an annual average of 3.3% in developing economies (Figure 28). Of the global amount of FDI inflows to the primary and processed agricultural sectors, an annual average of only 8.2% (USD 6.3 billion) went to primary agriculture, indicating that much of the FDI in agriculture is concentrated in the downstream agricultural activities of processing, manufacturing, and retail trade. However, in developing economies, a much larger share of FDI flows go to the primary agricultural sector than to the food and beverage sector – an annual average of 31% compared with just 0.9% going to this sector in developed economies.

The trends of inward FDI stock in the agricultural sectors are similar to those of FDI inflows. Global inward FDI stock in the primary and processed agricultural sectors amounted to USD 621 billion in 2010, accounting for just 3.1% of the world total. Developed economies see a slightly greater share of inward FDI stock in their agricultural sectors – 3.4% compared with 2.5% in developing economies. However, developing economies have a much higher share of

inward FDI stock in agriculture in their primary agricultural sector: 27% compared with just 3.6% in developed economies.

In addition, UNCTAD data on Greenfield FDI indicates that the primary and processed agricultural sectors accounted for just 4.4% of such new investment in 2011, amounting to USD 39.4 billion[67]. This low share has remained relatively the same each year since 2003. Of particular note is the incredibly low share that went to primary agriculture – just 0.3% of the total Greenfield FDI into agriculture went to primary production in 2011, indicating that such investment typically occurs in downstream agricultural processing activities. In fact, the share of primary agriculture in Greenfield investment has steadily fallen since 2003 when it comprised 4.1% of total Greenfield investment in agriculture. The average value of a Greenfield FDI project in primary agriculture has also fallen, from an annual average of USD 270 million per project in 2003-05 to USD 33 million per project during 2009-11. Meanwhile, the average value of a Greenfield FDI project in processed agriculture has risen slightly over the same period, from USD 36 million to USD 46 million per project.

A recent FAO study also found that between 2003 and mid-2011 Europe was both the largest source of Greenfield investment in agriculture, accounting for nearly half of the USD 143 billion recorded to have been invested globally, and destination, receiving 37% of the investment flows[68]. Asia followed as the second largest destination for FDI flows into agriculture (and the third largest source of investment flows), with the Americas as the third largest destination (and the second largest source). China accounted for the largest share of agricultural investments into Asia (USD 14.2 billion) over the 2003 to mid-2011 period. Among the APEC members, Viet Nam followed with USD 4.1 billion and Indonesia with USD 3.6 billion. Japan was the top source of FDI flows into Asia (USD 6.3 billion), followed by China (USD 4.7 billion) and Thailand (USD 4 billion). Agricultural investments into the Americas were primarily destined for Brazil and the United States. While the United States was the largest source of FDI globally, with agricultural investments of over USD 29 billion, China was the largest outside investor in the Americas (USD 4.1 billion).

Figure 29a. FDI Regulatory Restrictiveness Index, agricultural sector in selected APEC economies

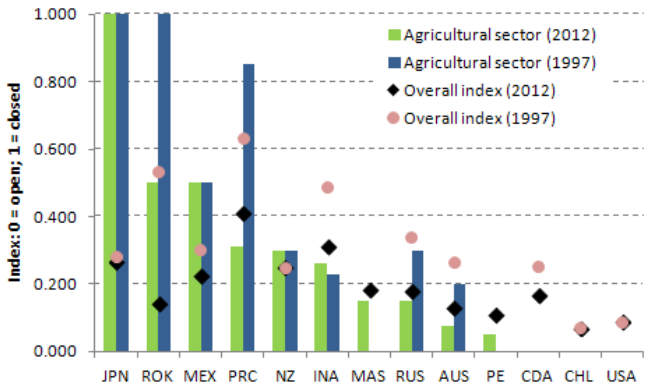
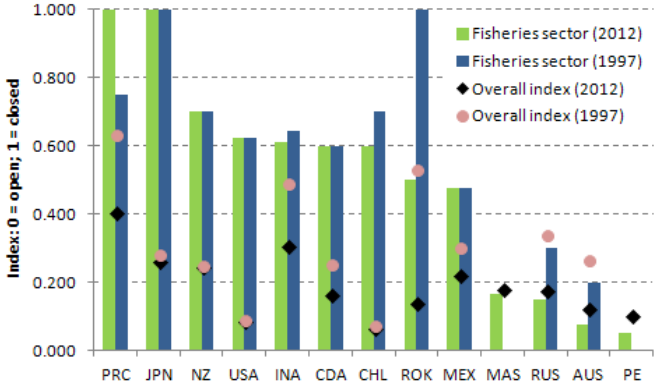


Figure 29b. FDI Regulatory Restrictiveness Index, fisheries sector in selected APEC economies



Note: 1997 data are unavailable for MAS and PE.
Source: OECD, FDI Regulatory Restrictiveness Index.

[67] Greenfield FDI is a form of foreign investment in which a parent company starts an entirely new venture by constructing new operational facilities. It is the alternative to Brownfield FDI in which an investor purchases or leases existing production facilities to launch a new production activity or expand existing activities.
[68] FAO (2012b).

Given the importance of FDI in increasing the amount of capital and in technology transfer, APEC members should ensure that regulatory measures in the agricultural and fisheries sectors are efficient and transparent. The OECD's FDI Regulatory Restrictiveness Index 2012 reveals that investment barriers are generally higher in the primary agricultural and fisheries sectors than in other sectors for many APEC economies. While there are no regulatory impediments to FDI in the agricultural sector in some APEC economies (Canada; Chile; United States), other economies have measures in place that either partially or fully restrict FDI in the sector (Figure 29a). Such measures typically concern prior approval requirements and foreign equity restrictions as well as other operational restrictions such as land acquisition.

Compared with the agricultural sector, the index reveals that there is a very high level of regulatory impediments to FDI in the fisheries sector of most APEC economies. In fact, there are measures in place in all APEC economies that restrict FDI in the sector (Figure 29b). These measures primarily concern foreign equity restrictions as well as prior approval requirements and rules for key personnel. In contrast to the primary agricultural and fisheries sectors, there are far fewer regulatory impediments to FDI in the processed food sector, and those measures that do exist usually concern prior approval requirements. In fact, the FDI Regulatory Restrictiveness Index reveals that there are four APEC members with no regulatory impediments to FDI in this sector (Chile; Korea; Malaysia; United States).

B. IMPORTANCE OF THE BUSINESS ENVIRONMENT

FAO estimates that investments in food, agriculture and rural development need to increase by 50% (an additional amount of USD 83 billion per year) in order for food production to meet the expected growth in demand by 2050[69]. Public investment will continue to play an essential role in providing the necessary conditions to enable agricultural sector development, including essential infrastructure and institutions as well as other public goods such as education and training and extension services. However, given the current trends in agricultural investments discussed above, there is a clear need for increased private sector investment in the agricultural sector. APEC members should therefore foster the conditions necessary to attract such long-term investments into their agricultural sectors in order to address the food security challenges facing the region.

Table 6. Ease of Doing Business 2013

rank	**Overall**
Australia	10
Brunei Darussalam	79
Canada	17
Chile	37
China	91
Hong Kong, China	2
Indonesia	128
Japan	24
Korea	8
Malaysia	12
Mexico	48
New Zealand	3
Papua New Guinea	104
Peru	43
Philippines	138
Russia	112
Singapore	1
Chinese Taipei	16
Thailand	18
United States	4
Viet Nam	99

Note: 185 economies are ranked.
Source: World Bank (2013).

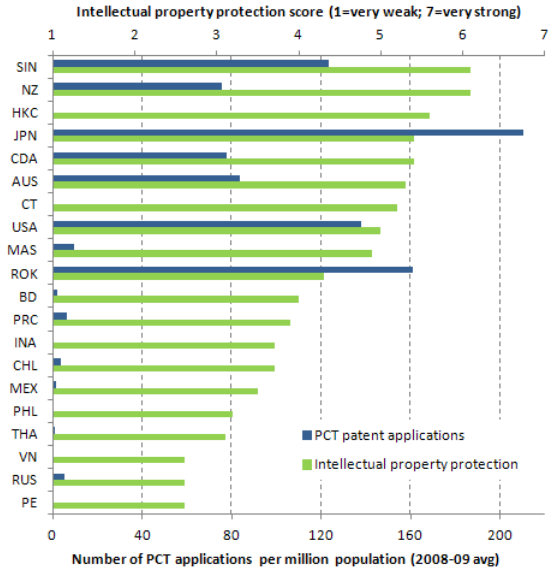
Nevertheless, there is a great extent of diversity among the APEC economies when it comes to their domestic business environment. The latest Ease of Doing Business rankings illustrate this disparity (Table 6). While many of the top performers in the overall index are APEC members, there are also many members which are not ranked as high. Unfortunately,

[69] FAO (2009a).

many of these economies also score relatively lower on the EIU's Global Food Security Index (see Figure 2) and are therefore the economies in which investments in their agricultural sectors are so urgently needed. Although the required reforms are specific to each economy, it is clear that significant policy changes are required in many developing APEC economies in order to improve their business environments. Given the nature of agricultural investments, three business conditions in particular are important in order to increase private investment in the agricultural sector: investor protection, intellectual property rights, and access to credit.

In order to influence the private sector's decision to invest, governments need to create a viable and attractive investment climate, thereby reducing the risks associated with long-term agricultural investments. A high level of investor protection, including the safeguarding and enforcing of the rights and claims of the investor, is therefore an important condition in order to attract private sector investment in the agricultural sector. Given that it often takes several years before the returns from agricultural investments are realized, investors need certain assurances that their interests will be protected throughout the investment period. Using the Ease of Doing Business 2013 rankings, six APEC members are among the top ten economies in the 'protecting investors' component of the index: New Zealand; Singapore; Hong Kong, China; Canada; Malaysia; and the United States. However, many APEC economies, particularly those developing economies where agricultural investment is most needed, are ranked much lower. The importance of building efficient and transparent legal and regulatory frameworks, particularly in developing APEC economies, in order to provide investors with the necessary confidence to invest in the agricultural sector cannot be understated.

Figure 30. Intellectual property protection and PCT patent applications



Note: Data on PCT patent applications for HKC and CT are unavailable.

Source: World Economic Forum, *The Global Competitiveness Report 2012-2013*.

Robust intellectual property rights are clearly another essential business condition as investors will be unwilling to spend on R&D in economies where such protection is lacking. Based on the World Economic Forum's Executive Opinion Survey, which asks respondents to rate intellectual property protection in their economies, there is a clear divide between industrialized and developing APEC members. Industrialized APEC members (including the newly industrialized Asian economies) have an average score of 5.4 (out of 7), while developing APEC members have an average score of 3.4 (Figure 30). The importance of this is highlighted by the number of PCT patent applications filed in the economy – there is a higher number of PCT patent applications filed in those economies that are assessed to have better intellectual property rights than in those that are not[70]. It is therefore vital that developing APEC

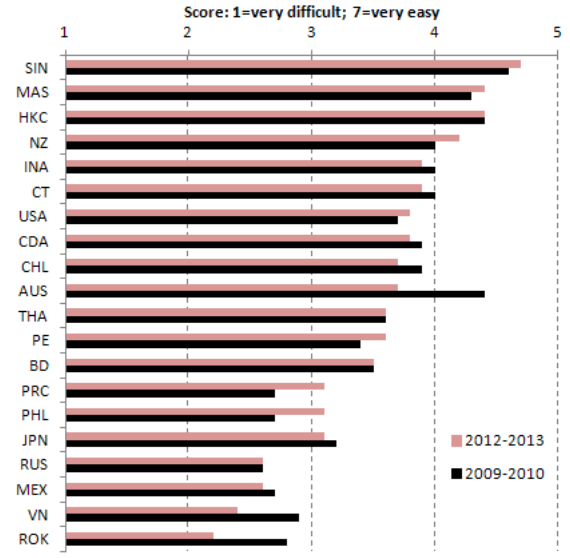
[70] A PCT application is a patent application under the Patent Cooperation Treaty to simultaneously seek protection for an invention in up to 117 economies.

members strengthen their protection of intellectual property in order to attract private sector investment so as to develop agricultural innovations in their economies.

Finally, research has found that much of the private investment in the agricultural sector comes from the farmers themselves. A recent study reveals that annual private investment in on-farm agricultural capital stock exceeds public investment by more than three to one and exceeds other resource flows by a much larger margin[71]. Access to credit is therefore another essential business condition to enable increased private investment in the agricultural sector. This is especially important in those developing economies where smallholder farmers are more prevalent. Globally, there are an estimated 500 million smallholder farms in developing economies, cultivating most of the agricultural land and supporting two billion people[72]. These farmers face extreme difficulty in financing investments that require large initial outlays of capital or that take many years before the benefits can be realized. In addition, smallholder farmers in particular face many challenges in obtaining access to credit since they often have few assets that can be used as collateral. Thus, ensuring access to credit for these smallholder farmers would enable them to make investments that would increase agricultural productivity as well as reduce food losses, thereby also improving their competitiveness and raising their incomes.

Based on the World Economic Forum's Executive Opinion Survey, which asks respondents to rate how easy it is to obtain a bank loan in their economies (with only a business plan and no collateral), there is an average score of 3.5 (out of 7) on the ease of access to credit across the APEC region (Figure 31). Although industrialized APEC members, including the newly industrialized Asian economies, score slightly higher than developing APEC members – 3.8 compared with 3.3 – the difference is not substantial, indicating that access to loans is rather limited across the APEC region. In fact, although some APEC economies witnessed large improvements in their scores between the published survey results in 2012-2013 and in 2009-2010 (namely China and the Philippines), many other members experienced significant declines in their rating. Much of this perceived decline in access to loans across the APEC region can be attributed to the recent Global Financial Crisis and the subsequent tightening of credit markets across much of the APEC region. Nevertheless, facilitating better access to credit is clearly essential to increasing private sector investment in the agricultural sector and APEC economies should ensure that such access is not overly constrained.

Figure 31. Ease of access to loans



Source: World Economic Forum, *The Global Competitiveness Reports 2012-2013* and *2009-2010*.

[71] Lowder, et al. (2012 forthcoming). As cited in FAO (2012b).
[72] Smallholders are farmers that operate farms of less than one hectare.

6. THE ROLE FOR APEC

This issues paper has examined a wide range of interrelated food security challenges currently facing the region and which APEC is in a position to address. To summarize, these challenges include the following:

- increasing and competing demands for agricultural products;
- declining production growth of many staple food crops, including wheat and rice;
- increasing use of non-tariff measures impeding agricultural trade;
- substantial amount of food losses due to inadequate infrastructure and techniques;
- declining agricultural investment growth in industrialized economies; and
- underinvestment in agricultural R&D and infrastructure in developing economies.

Although there are numerous specific actions that APEC members can take at the domestic level to address these issues, this section will focus on the role that APEC can play in addressing these food security challenges. APEC is already actively involved in the area of food security and has several groups working directly on topics relating to agriculture, including the Agricultural Technical Cooperation Working Group (ATCWG) and the Ocean and Fisheries Working Group (OFWG). However, given its cross-cutting nature, many aspects of food security are covered by a wide variety of committees and sub-fora within APEC. Such issues covered by other fora that also relate to food security include agricultural trade and technical standards, investment promotion and facilitation, and technological innovation and dissemination.

Therefore, through its **Policy Partnership on Food Security** (PPFS) launched in May of this year, APEC has a unique opportunity to consolidate its food security agenda. This forum has within its objectives to create multi-sector partnerships and networks including government, private sector (including local farmers), agriculture-related industry organizations, non-profit organizations, and academia and researchers to address food security issues. As a major agricultural player, APEC therefore has a real opportunity to address the food security challenges facing not only the region, but also the rest of the world, through this forum.

APEC economies face many challenges in increasing agricultural investments, especially from the private sector, which are urgently needed to boost agricultural production and productivity and reduce food losses along the supply chain. Public-private partnerships (PPP) will be vital to addressing these challenges, thereby ensuring long-term food security in the APEC region. Such partnerships contribute to reducing the cost of large-scale infrastructure projects and also reducing the risk of agricultural R&D and assuring its relevance. APEC members can provide support for these partnerships through the provision or guarantee of loans, tax incentives, technical assistance, as well as other means of assistance.

Capacity building and knowledge sharing is another area in which APEC is actively engaged. As this paper has illustrated, there are several challenges to food security that are simply due to a lack of technical or managerial know-how, especially relating to food losses along the supply chain. Capacity building to address this issue is imperative and APEC could take a more active role to specifically address this challenge through the ATCWG. Knowledge sharing to promote agricultural investments would also be very useful. For

example, providing financial incentives for agricultural R&D investment can be an effective mechanism to promote private investment. However, the complexity of designing, for example, tax credits for R&D investment, can deter many developing economies from adopting such schemes.

This paper has also placed a heavy emphasis on the need to **promote agricultural trade and increase agricultural investments** as a way to address the food security challenges affecting the region – two areas which are the core focus of APEC. A focus on reducing the non-tariff barriers to agricultural trade can come from the Committee on Trade and Investment (CTI). More specifically, the Sub-Committee on Standards and Conformance (SCSC) can work towards harmonization of the various food standards among members, which disproportionately affect exports from developing economies. A capacity building component should also be included so that developing APEC members are no longer hindered by their inability to meet technical requirements.

APEC should also consider how addressing the various food security challenges examined in this paper could be **aligned with other APEC initiatives**. For instance, through the CTI's Supply Chain Connectivity Framework Action Plan (SCFAP), APEC has an opportunity to address food losses along the supply chain, which limit food availability. Although not specified explicitly in SCFAP, food losses along the supply chain could potentially be addressed under Chokepoint 2, which seeks to address inefficient or inadequate transport infrastructure, including through knowledge sharing for the establishment of public-private partnerships.

APEC is also actively involved in improving the business environment among its members. Through the Economic Committee's (EC) Ease of Doing Business (EoDB) Action Plan, members should activity address those business conditions that impact private sector investment in the agricultural sector, including intellectual property protections and access to credit. In addition, APEC's Intellectual Property Rights Experts Group (IPEG) as well as its Policy Partnership on Science, Technology and Innovation (PPSTI) could include a specific focus that addresses these issues as they relate to agricultural R&D.

Finally, food security is a global issue and addressing the difficult challenges in achieving it will require concerted international efforts. In this regard, APEC should continue to **build partnerships with other organizations** working in the area of food security, not only to address the challenges, but also to avoid duplication. Encouragingly, the APEC Food Safety Cooperation Forum (FSCF) has signed a Memorandum of Understanding (MOU) with the World Bank in building capacity to better ensure food safety. APEC should expand on such worthwhile efforts. For instance, APEC could work with ASEAN to support the ASEAN Plus Three Emergency Rice Reserve (APTERR), an initiative to secure food security in the region in case of an emergency caused by a temporary and large-scale calamity.

In conclusion, APEC is well-placed to address the challenges to food security that have been examined in this issues paper through several channels, including: (1) the PPFS and public-private partnerships; (2) capacity building and knowledge sharing; (3) APEC's core focus of trade and investment liberalization and facilitation; (4) other APEC initiatives such as SCFAP and EoDB; and (5) developing partnerships with other organizations working in the area of food security. Building on these strengths and harnessing the opportunities provided to address food security challenges facing the region will help to ensure food security not only for the APEC region, but also for the rest of the world.

REFERENCES

Agricultural Science and Technology Indicators (ASTI), online database, facilitated by International Food Policy Research Institute (IFPRI), Washington, DC.

Alexandratos, Nikos and Jelle Bruinsma (2012). "World agriculture towards 2030/2050: the 2012 revision", ESA Working Paper No. 12-03, Agricultural Development Economics Division, FAO, Rome, June 2012.

Alston, Julian M. (2002). "Spillovers", *Australian Journal of Agricultural and Resource Economies*, Vol. 46, pp. 315-346, September 2002.

Alston, Julian M. and Philip G. Pardey (2009). "Theme Overview: Agricultural Productivity and Global Food Security in the Long Run", *Choices*, 24(4), 4th Quarter 2009.

Alston, Julian M., Jason M. Beddow, and Philip G. Pardey (2009). "Mendel Versus Malthus: Research, Productivity and Food Prices in the Long Run", Staff Paper Series, InSTePP Paper 09-01, International Science & Technology Practice & Policy, September 2009.

Alston, Julian M., Bruce A. Babcock, and Philip G. Pardy, editors (2010). "The Shifting Patterns of Agricultural Production and Productivity Worldwide", The Midwest Agribusiness Trade Research and Information Center, Iowa State University, Ames, Iowa.

Alston, Julian M. (2011). "Global and U.S. Trends in Agricultural R&D in a Global Food Security Setting", presentation at the OECD Conference on "Agricultural Knowledge Systems: Responding to Global Food Security and Climate Change Challenges", Paris, 15-17 June 2011.

Anderson, Kym and Will Martin, editors (2006). "*Agricultural Trade Reform and the Doha Development Agenda*", The World Bank and Palgrave Macmillan, Washington, DC.

Anderson, Kym (1999). "Towards an APEC Food System", report prepared for New Zealand's Ministry of Foreign Affairs and Trade, Wellington, October 1999.

Anderson, Kym (2010). "Globalization's effects on world agricultural trade, 1960-2050", Philosophical Transactions of the Royal Society B, vol. 365 no. 1554, Theme Issue "Food security: feeding the world in 2050", pp. 3007-3021, 27 September 2010.

Anderson, Kym, John Cockburn, and Will Martin, editors (2010). "*Agricultural Price Distortions, Inequality, and Poverty*", The World Bank, Washington, DC.

Anriquez, Gustavo, Hartwig de Haen, Oleg Nivyevskiy, and Stephan von Cramon-Taubadel (2009). "Investment in developing countries' food and agriculture: Assessing agricultural capital stocks and their impact on productivity", presentation to FAO Expert Meeting on "How to Feed the World in 2050", Rome, 24-26 June 2009.

Armas, Enrique Blanco, Camilo Gomez Osorio, and Blanca Moreno-Dodson (2010). "Agriculture Public Spending and Growth: The Example of Indonesia", *Economic Premise*, Number 9, Poverty Reduction and Economic Management Network (PREM), The World Bank, April 2010.

APEC (2010). "Niigata Declaration on APEC Food Security", 2010 APEC Ministerial Meeting on Food Security, Niigata, Japan, 16-17 October 2010.

APEC (2012a). "Kazan Declaration on APEC Food Security", 2012 APEC Ministerial Meeting on Food Security, Kazan, Russia, 30-31 May 2012.

APEC (2012b). "Policy Partnership on Food Security – Action Plan for 2012-2013", Policy Partnership on Food Security – Management Council Meeting, Vladivostok, Russia, 3 September 2012.

APEC Policy Support Unit (2009). "Improving Food Markets in APEC Economies: Can the Cost of Food be Lowered?".

APEC Policy Support Unit (2012). "Food Security Policies in APEC".

Asian Development Bank (2008). "Food Prices and Inflation in Developing Asia: Is Poverty Reduction Coming to an End?", Special Report, Economics and Research Department, April 2008.

Asian Development Bank (2009). "Operational Plan for Sustainable Food Security in Asia and the Pacific", December 2009.

Asian Development Bank (2011a). "Global Food Price Inflation and Developing Asia", March 2011.

Asian Development Bank (2011b). "*Food for All: Investing in Food Security in Asia and the Pacific – Issues, Innovations, and Practices*".

Asian Development Bank (2012). "Food Security and Poverty in Asia and the Pacific: Key Challenges and Policy Issues", April 2012.

Beintema, Nienke, and Howard Elliott (2009). "Setting Meaningful Investment Targets in Agricultural Research and Development: Challenges, Opportunities and Fiscal Realities", paper prepared for FAO Expert Meeting on "How to Feed the World in 2050", Rome, 24-26 June 2009.

Beintema, Nienke M. and Gert-Jan Stads (2010). "Public Agricultural R&D Investments and Capacities in Developing Countries: Recent Evidence for 2000 and Beyond", ASTI Background Note, March 2010.

Beintema, Nienke, Gert-Jan Stads, Keith Fuglie, and Paul Heisey (2012). "ASTI Global Assessment of Agricultural R&D Spending: Developing Countries Accelerate Investment", International Food Policy Report, October 2012.

Boto, Isolina, Ronalee Biasca, and Filippo Brasesco (2012). "Addressing Food Waste in Times of Crisis", Brussels Rural Development Briefings, European Commission, Briefing No. 28, Brussels, 26 June 2012.

Cervantes-Godoy, Dalila and Joe Dewbre (2010). "Economic Importance of Agriculture for Poverty Reduction", *OECD Food, Agriculture and Fisheries Working Papers*, No. 23, OECD Publishing.

Chen, Kevin Z., and Yumei Zhang (2011). "Agricultural R&D as an engine of productivity growth: China", commissioned as part of the UK Government's Foresight Project on Global Food and Farming Futures, UK Government Office for Science.

Dessus, Sébastien, Santiago Herrera, and Rafael de Hoyos (2008). "The Impact of Food Inflation on Urban Poverty and Its Monetary Cost: Some Back-of-the-Envelope Calculations", Policy Research Working Paper 4666, The World Bank, Washington, DC, July 2008.

Easterling, W.E., P.K. Aggarwal, P. Batima, K.M. Brander, L. Erda, S.M. Howden, A. Kirilenko, J. Morton, J.-F. Soussana, S. Schmidhuber, and F.N. Tubiello (2007). "Food, fibre and forest products", in *Climate Change 2007: Impacts, Adaptation and Vulnerability; Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, Cambridge University Press, pp. 273-313.

Economist Intelligence Unit (2012). Global Food Security Index, online dataset.

Elliott, Kimberly A. (2007). "Agriculture and the Doha Round", CGD/IIE Brief, Center for Global Development, Institute for International Economics, Washington, DC, January 2007.

Escaler, Margarita, and Paul Teng (2011). "'Mind the Gap': Reducing Waste and Losses in the Food Supply Chain", *NTS Insight* June 2011, RSIS Centre for Non-Traditional Security (NTS) Studies, Singapore.

Fan, Shenggen (2000). "Research Investment and the Economic Returns to Chinese Agricultural Research", *Journal of Productivity Analysis*, Vol. 14, Issue 2, pp. 163-182, September 2000.

Fan, Shenggen, Cheng Fang, and Xiaobo Zhang (2003). "Agricultural Research and Urban Poverty: The Case of China", *World Development*, Vol. 31, Issue 4, pp. 733-741, April 2003.

FAOSTAT online database.

FAO AQUASTAT online database.

FAO GIEWS (Global Information and Early Warning System), Food Price Data and Analysis Tool.

FAO (2008). "An Introduction to the Basic Concepts of Food Security", Food Security Concepts and Frameworks, EC-FAO Food Security Programme.

FAO (2009a). "Investment" discussion paper, High Level Expert Forum on How to Feed the World in 2050, Rome, 12-13 October 2009.

FAO (2009b). "Global agriculture towards 2050" discussion paper, High Level Expert Forum on How to Feed the World in 2050, Rome, 12-13 October 2009.

FAO (2009c). "How to Feed the World in 2050", report prepared for the High Level Expert Forum on How to Feed the World in 2050, Rome, 12-13 October 2009.

FAO (2012a). "Global Initiative on Food Loss and Waste Reduction", Rome.

FAO (2012b). "Trends and Impacts of Foreign Investment in Developing Country Agriculture: Evidence from case studies", Rome, November 2012.

FAO (2012c). "Statistics on private and public investment in agriculture: government expenditure, capital stocks and other FAOSTAT datasets", Asia and Pacific Commission on Agricultural Statistics, 24th Session, Da Lat, Viet Nam, 8-12 October 2012.

FAO/OECD (2012). "Sustainable Agricultural Productivity Growth and Bridging the Gap for Small-Family Farms", Interagency Report to the Mexican G20 Presidency, 12 June 2012.

FAO, WFP, and IFAD (2011). "*The State of Food Insecurity in the World 2011: How does international price volatility affect domestic economies and food security*", FAO, Rome.

FAO, WFP, and IFAD (2012). "*The State of Food Insecurity in the World 2012: Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition*", FAO, Rome.

Fergusson, Ian F. (2011). "World Trade Organization Negotiations: The Doha Development Agenda", Congressional Research Service, December 2011.

Foresight (2011). "The Future of Food and Farming: Challenges and choices for global sustainability", Final Project Report, The Government Office for Science, London.

Fresh Produce Development Agency (2008). "Report on the 2008 FPDA Socioeconomic Survey", FPDA Papua New Guinea, October 2008.

Fuglie, Keith O. and Paul W. Heisey (2007). "Economic Returns to Public Agricultural Research", Economic Brief No. 10, USDA, Economic Research Service, September 2007.

Fuglie, Keith O., Paul W. Heisey, John L. King, Carl E. Pray, Kelly Day-Rubenstein, David Schimmelpfennig, Sun Ling Wang, and Rupa Karmarkar-Deshmukh (2011). "Research Investments and Market Structure in the Food Processing, Agricultural Input, and Biofuel Industries Worldwide", Economic Research Report No. ERR-130, USDA, Economic Research Service, December 2011.

Fuglie, Keith O. (2012). "Productivity Growth and Technology Capital in the Global Agricultural Economy", chapter in *Productivity Growth in Agriculture: An International Perspective*, K.O. Fuglie, S.L. Wang, and V.E. Ball, editors, Oxfordshire, UK, CAB International.

Gerpacio, Roberta V. (2003). "The roles of public sector vs. private sector in R&D and technology generation: the case of maize in Asia", *Agricultural Economics*, Vol. 29, Issue 3, pp. 319-330, December 2003.

Giordani, Paolo E., Nadia Rocha, and Michele Ruta (2012). "Food Prices and the Multiplier Effect of Export Policy", Staff Working Paper ERSD-2012-08, Economic Research and Statistics Division, World Trade Organization, April 2012.

Global Harvest Initiative (2012). "2012 GAP Report: Measuring Global Agricultural Productivity", Washington, DC.

Gouel, Christophe, Cristina Mitaritonna, and Maria Priscila Ramos (2010). "The Art of Exceptions: Sensitive Products in the Doha Negotiations", CEPII Working Paper No. 2010-20, Centre D'Études Prospectives et D'Infomations Internationales, October 2010.

Gustavsson, Jenny, Christel Cederberg, Ulf Sonesson, Robert van Otterdijk, and Alexandre Meybeck (2011). "Global Food Losses and Food Waste: Extent, Causes and Prevention", study commissioned by FAO and conducted by the Swedish Institute for Food and Biotechnology (SIK) for the Save Food! international congress co-organized by Interpack2011 and FAO in Düsseldorf, Germany, 16-17 May 2011.

Gutierrez, L. and M. Gutierrez (2002). "International R&D Spillovers and Productivity Growth in the Agricultural Sector: A Panel Cointegration Approach", paper presented at the Xth EAAE Congress 'Exploring Diversity in the European Agri-Food System', Zaragoza, Spain, 28-31 August 2002.

Hartwich, Frank, Jaime Tola, Alejandra Engler, Carolina González, Graciela Ghezan, Jorge M.P. Vázquez-Alvarado, José Antonio Silva, José de Jesús Espinoza, and María Verónica Gottret (2007). "Building Public-Private Partnerships for Agricultural Innovation", Food Security in Practice technical guide series, International Food Policy Research Institute, Washington, DC.

Heerman, Kari, and Charlotte Hebebrand (2007). "The Doha Round Agriculture Negotiations: An Overview", Briefing Note prepared for the seminar "Realizing the Doha Development Agenda as if the Future Mattered", Salzburg, Austria, 16-21 February 2007.

International Trade Centre (ITC), Trade Map online database.

Jikun, H. and S. Rozelle (1996). "Technological change: Rediscovering the engine of productivity growth in China's rural economy", *Journal of Development Economics*, Vol. 49, No. 2, pp. 337-369, May 1996.

Jones, Timothy W. (2006). "Food Loss and the American Household".

Josling, Tim and Charlotte Hebebrand (2011). "Doha and Beyond: Continuing the Reform of the International Trade System for Food and Agricultural Products", Position Paper, International Food & Agricultural Trade Policy Council, June 2011.

Kader, A.A. (2005). "Increasing Food Availability by Reducing Postharvest Losses of Fresh Produce", in Proceedings of the 5th International Postharvest Symposium (Verona, Italy, 6-11 June 2004), F. Mencarelli and P. Tonutti, editors, International Society for Horticultural Science, Leuven, Belgium.

Kummu, M., H. de Moel, M. Porkka, S. Siebert, O. Varis, and P.J. Ward (2012). "Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use", *Science of the Total Environment*, Volume 438, pp. 477-489, 1 November 2012.

Le, Trong Hai (2012). "The Rice Situation in Viet Nam", Technical Assistance Consultant's Report for the Asian Development Bank, Project Number: TA 7495-REG, January 2012.

Lin, Justin Yifu (1992). "Rural Reforms and Agricultural Growth in China", *The American Economic Review*, Vol. 82, Issue 1, pp. 34-51, March 1992.

Lowder, Sarah K., and Brian Carisma (2011). "Financial resource flows to agriculture: A review of data on government spending, official development assistance, and foreign direct investment", ESA Working Paper No. 11-19, Agricultural Development Economics Division, FAO, December 2011.

Lowder, Sarah K., Brian Carisma, and Jakob Skoet (2012 forthcoming). "Who invests in agriculture and how much? An empirical review of the relative size of various investments in agriculture in low- and middle-income countries", Working Paper No. 12-XX, Agricultural Development Economics Division, FAO, Rome.

Lundqvist, J., C. de Fraiture, and D. Molden (2008). "Saving Water: From Field to Fork – Curbing Losses and Wastage in the Food Chain", SIWI Policy Brief, Stockholm International Water Institute.

Martin, Will and Kym Anderson (2011). "Export Restrictions and Price Insulation during Commodity Price Booms", Policy Research Working Paper 5645, The World Bank, May 2011.

McKinsey Global Institute (2012). "*The archipelago economy: Unleashing Indonesia's potential*", September 2012.

Naseem, Anwar, David J. Spielman, and Steven Were Omamo (2010). "Private-Sector Investment in R&D: A Review of Policy Options to Promote its Growth in Developing-Country Agriculture", *Agribusiness*, Vol. 26 (1), pp. 143-173.

Nossal, Katarina and Peter Gooday (2009). "Raising productivity growth in Australian agriculture", issues insights 09.7, Australian Bureau of Agricultural and Resource Economics, November 2009.

OECD. International Development Statistics (IDS) online database, Creditor Reporting System (CRS) online dataset.

OECD, FDI Regulatory Restrictiveness Index, online dataset.

OECD (2010). "Measuring Aid to Agriculture," Paris, April 2010.

OECD (2011). "*Fostering Productivity and Competitiveness in Agriculture*", OECD Publishing.

OECD (2012). "Review of Agricultural Policies: Indonesia", Paris, October 2012.

OECD/FAO (2011). "*OECD-FAO Agricultural Outlook 2011-2020*", OECD Publishing and FAO.

OECD/FAO (2012). "*OECD-FAO Agricultural Outlook 2012-2021*", OECD Publishing and FAO.

Oxfam (2012). "Food crises doomed to repeat until leaders find courage to fix problems", Media Advisory, August 2012.

Pardy, Philip G., Nienke Beintema, Steven Dehmer, and Stanley Wood (2006). "Agricultural Research: A Growing Global Divide?", Agricultural Science and Technology Indicators Initiative, International Food Policy Research Institute, Washington, DC, August 2006.

Pardey, Philip G. (2009). "Putting U.S. Agricultural R&D and Productivity Developments in Perspective", presentation at the Farm Foundation Conference, *Agricultural Research and Productivity for the Future*, Washington, DC, 28 April 2009.

Pardey, Philip G., Julian M. Alston, and Vernon W. Ruttan (2010). "The Economics of Innovation and Technical Change in Agriculture", chapter in *Handbook of the Economics of Innovation*, Vol. 2, pp. 939-984.

Pardey, Philip G. and Julian M. Alston (2011). "Agricultural R&D as an Investment", presentation at Reframing the Food Security Agenda, A National Forum on Food Security to 2050, University of Adelaide, School of Economics, 13 February 2011.

Pardey, Philip G. and Julian M. Alston (2012). "For Want of a Nail: The Case for Increased Agricultural R&D Spending", American Enterprise Institute, Washington, DC, July 2011.

Parfitt, Julian, Mark Barthel and Sarah Macnaughton (2010). "Food Waste within Food Supply Chains: Quantification and Potential for Change to 2050", Philosophical Transactions of the Royal Society B, vol. 365 no. 1554, Theme Issue "Food security: feeding the world in 2050", pp. 3065-3081, 27 September 2010.

PMSEIC (2010). "Australia and Food Security in a Changing World", The Prime Minister's Science, Engineering and Innovation Council, Canberra, Australia, October 2010.

Pray, Carl E. (2001). "Public-Private Sector Linkages in Research and Development: Biotechnology and the Seed Industry in Brazil, China and India", *American Journal of Agricultural Economics*, Vol. 83, No. 3, pp. 742-747, August 2001.

Pray, Carl, Danmeng Ma, Jikun Huang, and Fangbin Qiao (2001). "Impact of Bt Cotton in China", *World Development*, Vol. 29, No. 5, pp. 813-825.

Rolle, Rosa S., editor (2006). "Postharvest Management of Fruit and Vegetables in the Asia-Pacific Region", reports of the APO seminar on "Reduction of Postharvest Losses of Fruit and Vegetables" (India, 5-11 October 2004) and "Marketing and Food Safety: Challenges in Postharvest Management of Agricultural/Horticultural Products" (Islamic Republic of Iran, 23-28 July 2005), FAO, Asia Productivity Organization, Tokyo, Japan.

RSIS Centre for Non-Traditional Security (NTS) Studies (2011a). "Public Forum and Workshop on Securing Food Futures in the Asia-Pacific: Evaluating Regional Frameworks for Food Security" in Canberra, Australia, Report, Singapore, 6-9 October 2010.

RSIS Centre for Non-Traditional Security (NTS) Studies (2011b). "International Conference on Asian Food Security 2011 – Feeding Asia in the 21st Century: Building Urban-Rural Alliances", Official Conference Report, Singapore, 10-12 August 2011.

Schmidhuber, Josef, Jelle Bruinsma, and Gerold Boedeker (2009). "Capital Requirements for Agriculture in Developing Countries to 2050", paper presented at FAO Expert Meeting on "How to Feed the World in 2050", Rome, 24-26 June 2009.

Seale Jr., James, Anita Regmi, and Jason Bernstein (2003). "International Evidence on Food Consumption Patterns", Technical Bulletin No. TB-1904, USDA Economic Research Service, October 2003.

Sheng, Yu, John Denis Mullen, and Shiji Zhao (2010). "Has growth in productivity in Australian broadacre agriculture slowed?", Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) conference paper 10.01.

Sheng, Yu, John Denis Mullen, and Shiji Zhao (2011). "A turning point in agricultural productivity: consideration of the causes", Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) research report 11.4 for the Grains Research and Research and Development Corporation, Canberra, May 2011.

Smil, Vaclav (2004). "Improving Efficiency and Reducing Waste in Our Food System", *Journal of Integrative Environmental Sciences*, 1:1, pp. 17-26.

Swanson, Burton E. and Riikka Rajalahti (2010). "Strengthening Agricultural Extension and Advisory Systems: Procedures for Assessing, Transforming, and Evaluating Extension Systems", Agriculture and Rural Development Discussion Paper 45, The World Bank, Washington, DC.

Teignier, Marc (2012). "The Role of Trade in Structural Transformation", 5 April 2012.

Teng, Paul and Sally Trethewie (2012). "Tackling urban and rural food wastage in Southeast Asia: Issues and interventions", Policy Brief No. 17, RSIS Centre for Non-Traditional Security (NTS) Studies, Singapore, October 2012.

Thornton, Philip K. (2010). "Livestock production: recent trends, future prospects", Philosophical Transactions of the Royal Society B, vol. 365 no. 1554, Theme Issue "Food security: feeding the world in 2050", pp. 2853-2867, 27 September 2010.

Tokarick, Stephen (2008). "Dispelling Some Misconceptions about Agricultural Trade Liberalization", *Journal of Economic Perspectives*, Volume 22, Number 1, Winter 2008, pp. 199-216.

UNCTAD (2009). "*World Investment Report 2009: Transnational Corporations, Agricultural Production and Development*", New York and Geneva, United Nations.

UNCTAD (2012), "*World Investment Report 2012: Towards a New Generation of Investment Policies*", New York and Geneva, United Nations, online annex tables.

United Nations, Department of Economic and Social Affairs, Population Division, Population Estimates and Projections Section. World Population Prospects, the 2010 Revision online database.

USDA, Economic Research Service (ERS) online datasets.

USDA Foreign Agricultural Service (2012). "Indonesia Grain and Feed Annual Report 2012", Global Agricultural Information Network (GAIN) Report Number ID1212, 13 April 2012.

United States Energy Information Administration (US EIA), online data.

Valenzuela, Ernesto, Dominique van der Mensbrugghe, and Kym Anderson (2008). "General equilibrium effects of price distortions on global markets, farm incomes and welfare", Agricultural Distortions Working Paper 73, The World Bank, September 2008.

Veeman, Terry, Jim Unterschultz, and Bryce Stewart (2007). "Canadian and Prairie Agricultural Productivity: Measurement, Causes, and Policy Implications", presentation at CAES Conference on Food and Fuel: The Implications for Agricultural Research Policy, Saskatoon, Saskatchewan, Canada, 4-6 June 2007.

Viet Nam News (2012). "Delta suffers high post-harvest loss", 22 September 2012.

Warner, Michael, David Kahan, and Szilvia Lehel (2008). "Market-oriented agricultural infrastructure: appraisal of public-private partnerships", Agricultural Management, Marketing and Finance Occasional Paper 23, FAO, Rome.

Warr (2011). "Indonesia: why food self-sufficiency is different from food security", East Asia Forum, 28 April 2011.

World Bank, Commodity Price Data (a.k.a. Pink Sheet), online data.

World Bank. World Development Indicators (WDI) online database.

World Bank (2008). "*World Development Report 2008: Agriculture for Development*", Washington, DC.

World Bank (2010). "Revitalizing agriculture in Indonesia", Indonesia rising: policy priorities for 2010 and beyond, The World Bank, Washington, DC.

World Bank (2012a). "The Global Food Crisis Response: A Quick Response, But Long-Term Solutions", Full Brief, Global Food Crisis Response Program (GFRP), Washington, DC, April 2012.

World Bank (2012b). "Responding to Higher and More Volatile World Food Prices", Economic and Sector Work, Report No. 68420-GLB, Washington, DC, May 2012.

World Bank (2012c). "*Food Price Watch August 2012*", Poverty Reduction and Equity Group.

World Bank/IMF (2012). "*Global Monitoring Report 2012: Food Prices, Nutrition, and the Millennium Development Goals*", World Bank, Washington, DC.

World Bank (2013). "*Doing Business 2013: Smarter Regulations for Small and Medium-Size Enterprises*", Washington, DC, World Bank Group.

World Economic Forum (2009). "*The Global Competitiveness Report 2009-2010*", Geneva.

World Economic Forum (2012). "*The Global Competitiveness Report 2012-2013*", Geneva.

World Economic Forum, "Putting the New Vision for Agriculture into Action: A Transformation is Happening", prepared in collaboration with McKinsey & Company.

WTO, Technical Barriers to Trade Information Management System (TBT IMS) online database.

WTO, *World Tariff Profiles*, various annual editions.

WTO (2011). "Overview Regarding the Level of Implementation of the Transparency Provisions of the SPS Agreement", Committee on Sanitary and Phytosanitary Measures, G/SPS/GEN/804/Rev.4, 13 October 2011.

WTO (2012). *World Trade Report* 2012, "Trade and public policies: A closer look at non-tariff measures in the 21st century", Geneva, World Trade Organization.