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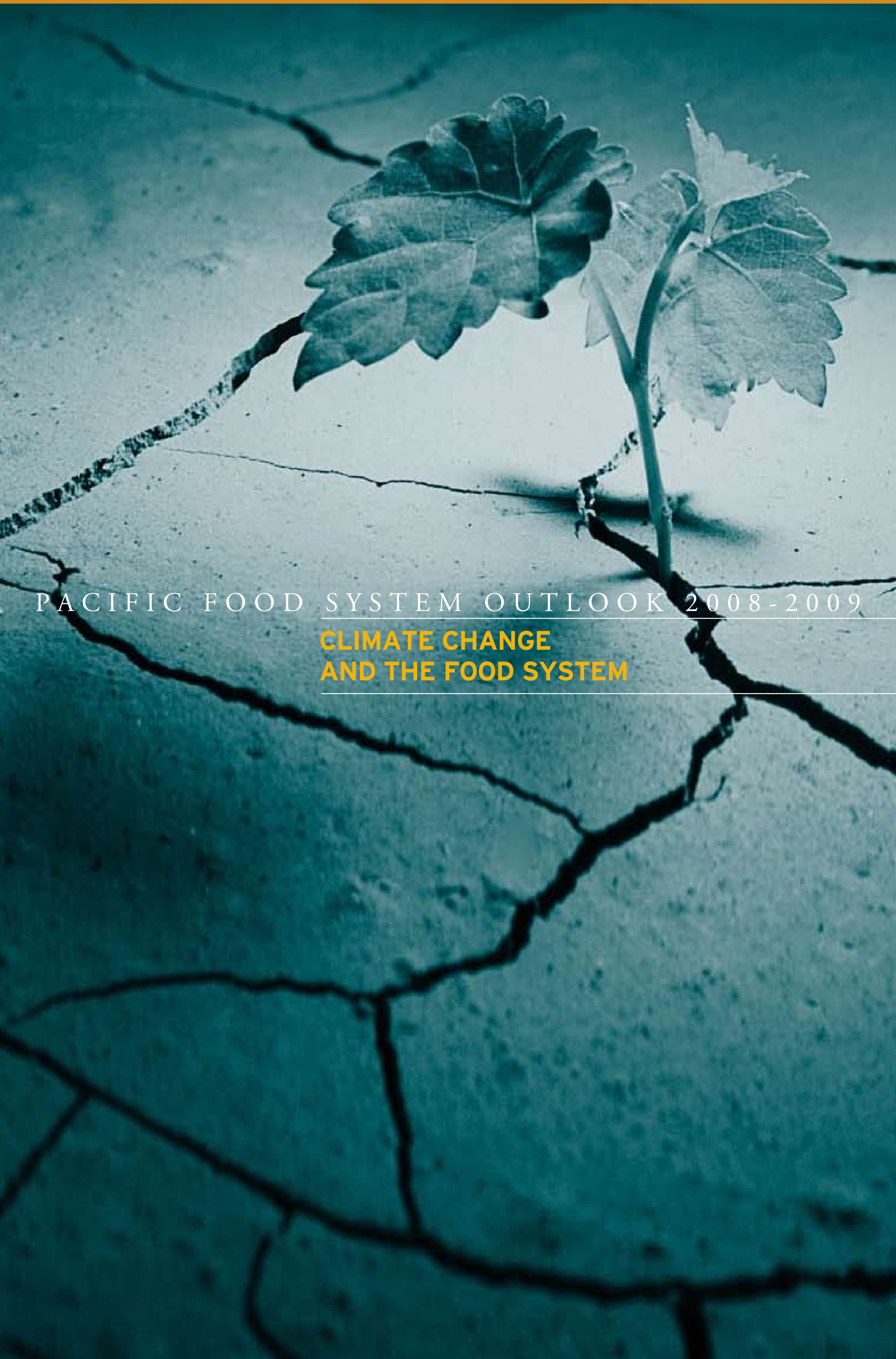

PACIFIC FOOD SYSTEM OUTLOOK 2008-2009

CLIMATE CHANGE AND THE FOOD SYSTEM

PACIFIC ECONOMIC COOPERATION COUNCIL

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CLIMATE CHANGE AND THE FOOD SYSTEM

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FOREWORD

This year's report focuses on climate change and its ramifications for the Asia-Pacific food system, arguably one of the most affected sectors in the region's economy. The report identifies the potential public and private sector responses to the daunting future challenges of this issue, the most complex of the issues we have addressed in the 12-year history of the Pacific Food System Outlook (PFSO).

The discourse on climate change has changed significantly over the past 10 years, from whether or not climate change is taking place to what can and should be done about it.

Public and private sector decision makers around the region need the best possible information if they are to make informed decisions about this issue. We examine recent evidence of climate change; the potential longer-term impacts on agriculture, food security, and the broader food system; and the nature of adaptive and mitigation measures the government and private sectors should consider to maximize opportunities and minimize potential adverse economic impacts.

Undertaking analysis of climate change again puts the PFSO front and center on a key issue that has implications for the region's food system. Our last report on rural development, as well as previous reports on infrastructure and biofuels (www.pecc.org/food), recently caught the attention of PECC leadership. We were invited to brief the PECC Standing Committee Meeting in Bangkok, July 25-26, 2008, on our project and future plans. Don Gunasekera, our Australian representative, participated in a special session at that meeting to address the timely issue of global food price inflation.

This year's meeting was held at the East-West Center in Honolulu, Hawaii. We are grateful for the very substantive contributions of Barry Smit of the University of Guelph, Don Gunsasekera of the Australian Bureau of Agricultural and Resource Economics, Ching-Cheng Chang of Taipei's Academia Sinica, and Jan Lewandrowski of the U.S. Department of Agriculture Climate Change Program Office. We are also grateful to Nancy Lewis, Director of Research, East-West Center, for her welcoming comments and participation in our opening session, to June Kuramoto for her excellent administrative support for our meeting, and to Charles Morrison for making the resources of the Center available to us. We would like to acknowledge and thank Betty Ip, Director of Public and Business Affairs, PECC International Secretariat, for her tireless efforts in supporting our project and administering our part of the PECC Web site. Our thanks are also extended to the Institute of Southeast Asian Studies in Singapore for publishing and disseminating our report throughout the Asia-Pacific region.

We are grateful to the team of individual economists and agri-food specialists representing the participating economies of the PECC region for their contributions. Special thanks to Brad Gilmour of Agriculture and Agrifood Canada for his rigorous review of early drafts of this report. We appreciate the work of Joe Yacinski and Carol Hardy of Yacinksi Design; Jane Sapp, for editorial review; and Mary Anne Normile and Cheryl Christensen of ERS for their important support for this project. As in previous years, the financial support of Farm Foundation and USDA's Economic Research Service, as well as the support from the country PECC committees, has made this unique multinational and multi-disciplinary project a continuing reality.

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CLIMATE CHANGE AND THE FOOD SYSTEM

The fourth assessment report of the International Panel on Climate Change (IPCC, 2007), the recent series of droughts in Australia, the increased frequency of extreme weather events in other parts of the region, and rising food prices in 2006-08 all underscore broad concerns about the earth's changing climate and the ramifications of these changes for the PECC region's economy.

Of all economic sectors, climate change has its most significant impacts on agriculture because of its broad geographic dispersion and obvious close dependence on climate and environmental factors. Rising average temperatures, changes in precipitation patterns, and other weather changes, are having and will continue to have a variety of impacts, some positive and others negative, on agricultural productivity in the PECC region. These impacts will vary by geographic location, the mix of agricultural activities, and the extent of private and public sector adjustments.

The short- and long-term impacts of climate change on the Asian-Pacific food system and possible responses are the primary focus of this report. The debate no longer centers on whether or not climate change is underway. The discussion here centers on where and how climate change manifests itself in the region's food system with a view to better informing strategies for adaptation, adjustment, and mitigation. The report draws on the two days of discussion at the 12th annual Pacific Food System Outlook meeting at the East-West Center in Honolulu in September 2008. The report also draws on numerous other reports based on research from universities, international and national governmental agencies, and nongovernmental organizations.

Of all economic sectors, climate change has its most significant impacts on agriculture because of its broad geographic dispersion and obvious close dependence on climate and environmental factors.

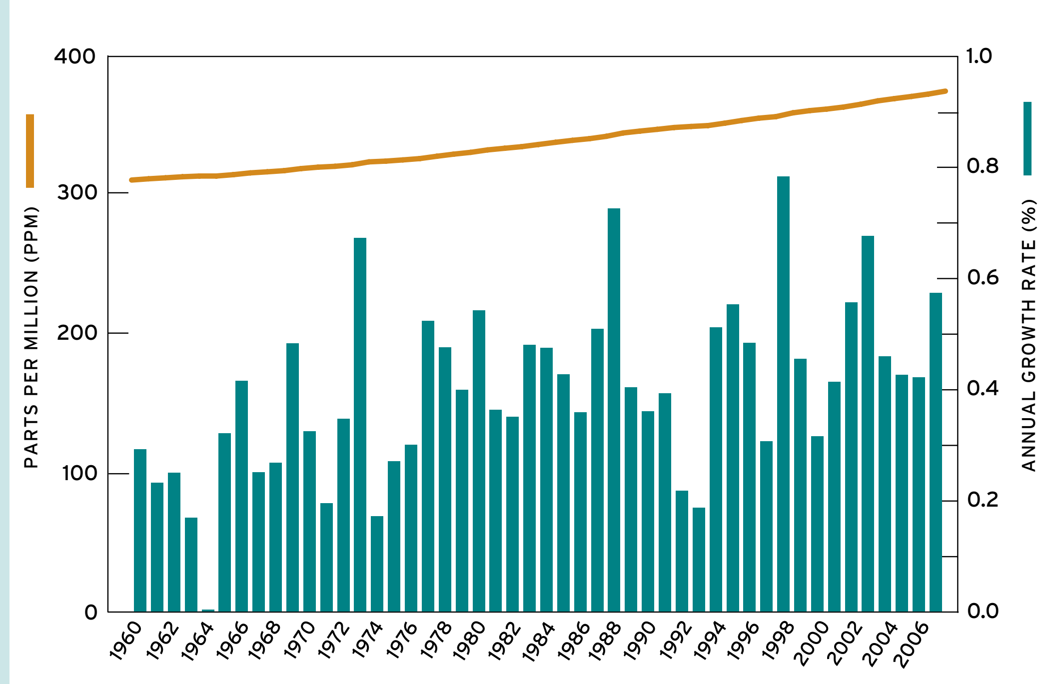
Greenhouse Gases, Climate Change, and Agriculture

The Intergovernmental Panel on Climate Change (IPCC) 2007 report states that warming of the climate system is unequivocal and "very likely" (90 percent probability) to be caused by human activities, particularly those that emit greenhouse gases (GHGs). Among the GHGs, carbon dioxide (CO_2) concentrations have risen 36 percent from pre-industrial (1750) levels, according to evidence based on satellite and other monitoring and measuring techniques as well as the analyses of ice cores and other proxy measures spanning hundreds of years. Annual growth in atmospheric concentration of CO2 has risen in the last 40 years (Figure 1).

CO_2 is by far the most important GHG, accounting for 77 percent of the global total. Others are methane (14.3 percent), nitrous oxide (7.9 percent), and F-gases[1] (1.1 percent). Taken together, emissions of these gases increased 71 percent between 1970 and 2004. Despite their relatively small concentration in the atmosphere (CO_2 accounts for only 0.038 percent of the atmosphere, while nitrogen and oxygen account for 78 and 21 percent, respectively), they are positive radiative "forcings" that trap heat and may remain in the atmosphere for many years. There are other forcings that may have a cooling effect (aerosols, for example). The net effect of all human-induced forcing agents is about 375 parts per million (ppm) of CO_2–equivalent

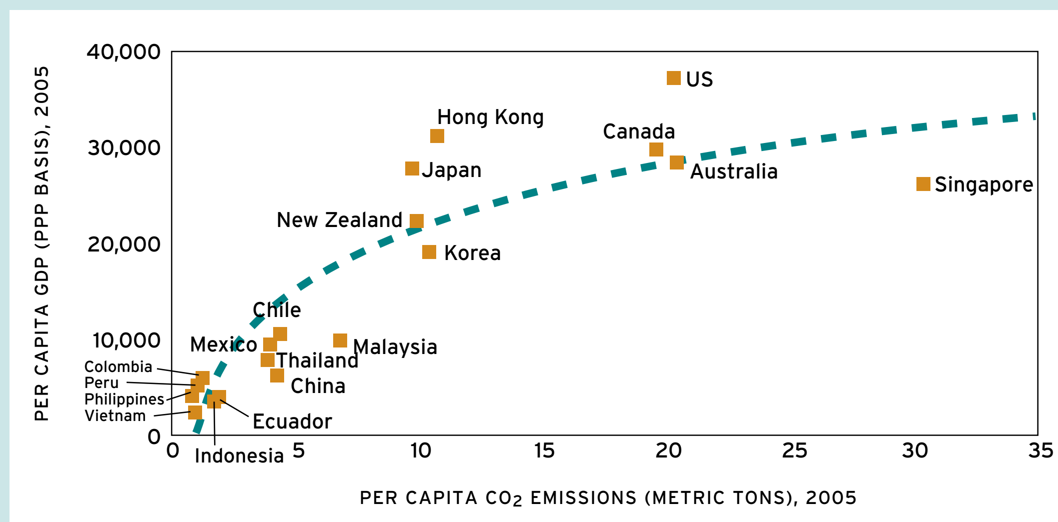
[1] F-gases—Compounds such as HFCs (hydrofluorocarbons) and PFCs (perfluorocarbons) are used in refrigerators, air conditioning, fire protection, and solvents. Over the last 20 years they have replaced ozone-depleting substances such as CFCs (chlorofluorocarbons) as a result of the 1987 Montreal Protocol to save the earth's ozone layer. But these alternative substances contribute seriously to the emission of greenhouse gases and therefore to climate change.

Figure 1 **Global Atmospheric Concentrations of CO_2 Rising**



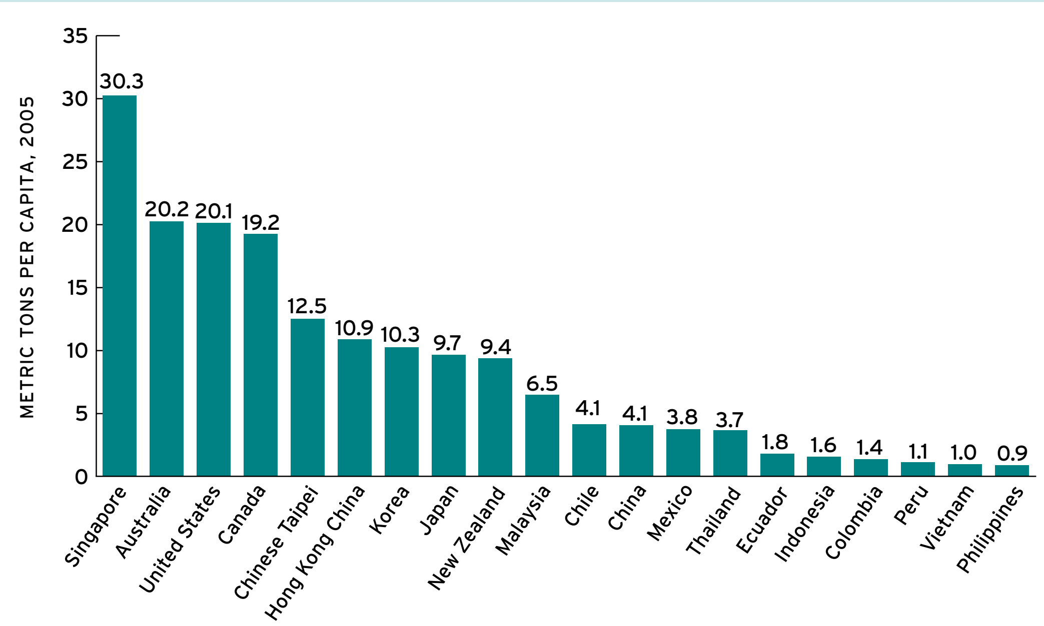
Source: Atmospheric CO_2 concentrations (ppmv) derived from in situ air samples collected at Mauna Loa Observatory, Hawaii; C.D. Keeling, T.P. Whorf, and the Carbon Dioxide Research Group, Scripps Institution of Oceanography (SIO), University of California, La Jolla, California USA 92093-0444.

Figure 2 **Per Capita CO_2 Emissions in PECC Region Rise with Per Capita Income**



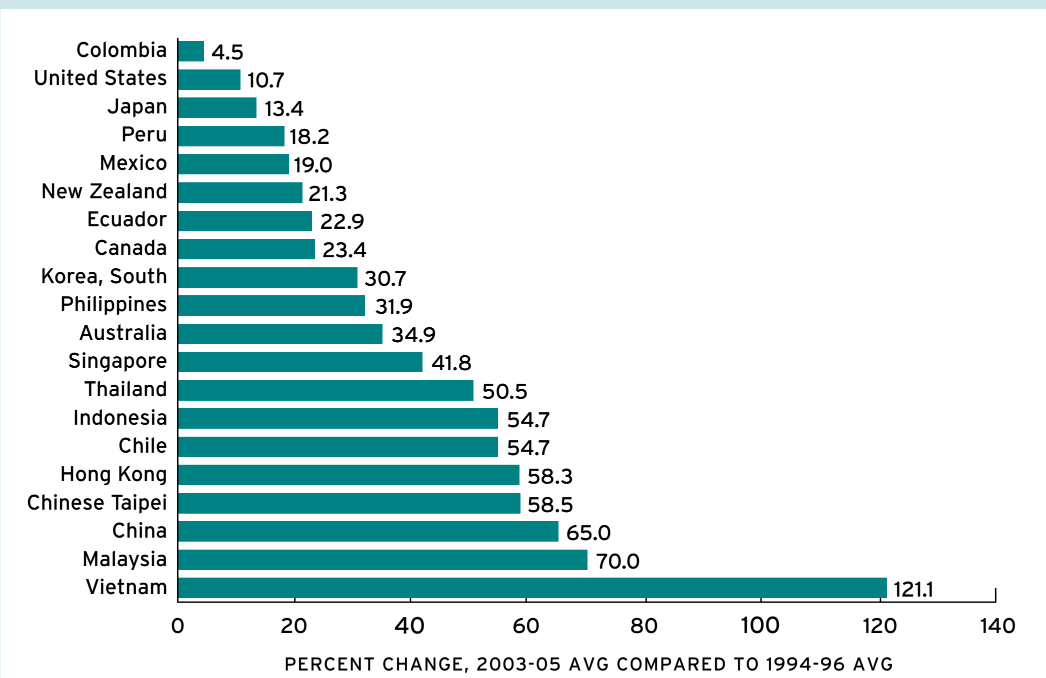
Source: Energy Information Agency, U.S. Department of Energy; World Bank.

Figure 3 **Per Capita CO_2 Emissions Vary Across the Region**



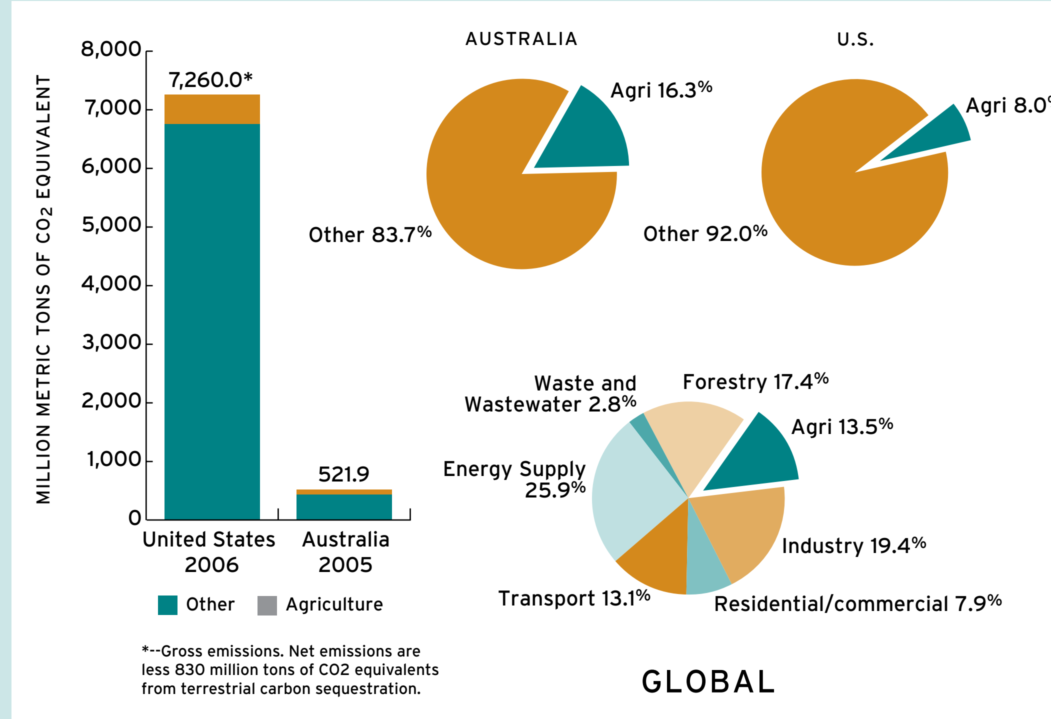
Source: Energy Information Agency, U.S. Department of Energy; Data for CO_2 emissions only from burning fossil fuels (oil, coal, and natural gas), not from deforestation or other sources.

Figure 4 **CO_2 Emissions Growing More Rapidly in Low- and Middle-Income Asian Countries**



Source: Energy Information Agency, U.S. Department of Energy, http://www.eia.doe.gov/oiaf/1605/ggrpt/excel/historical_co2.xls; Data for CO2 emissions only from burning fossil fuels (oil, coal, and natural gas), not from deforestation or other sources.

Figure 5 **Agriculture Is a Significant Contributor of GHG emissions**



Source: Gunasekera (2007), IPCC (2007a), U.S. EPA (2008).

with a net positive, or warming effect (IPCCa, 2007). Water vapor is also a GHG and, despite its far greater concentration than CO_2, is considered part of the planet's feedback system, rising or falling with the temperature, thus acting as an amplifier of CO_2-driven warming.

Since energy use is at the heart of economic growth, it is not surprising that CO_2 emissions from fossil fuel combustion are highly correlated with income. This is the case in the PECC region, as is shown in Figure 2. Annual CO_2 emissions range from 1 ton per capita per year for the lowest-income economies in the region (Philippines, Vietnam, Peru, and Indonesia) to more than 20 tons per capita in the high-income economies (Canada, U.S., Australia, and Singapore) (Figure 3). The rate of growth in CO_2 emissions in the last 10 years was most rapid in China, Malaysia, and Vietnam, reflecting their recent rapid economic growth, and slowest in Colombia, the U.S., and Japan (Figure 4). China alone contributed more than 50 percent and the U.S. 16 percent in total growth in the PECC region's CO_2 emissions in that period. China emerged in 2007 as the world's largest GHG emitter. Indonesia ranks fourth after China, the U.S., and the E.U. when the impact of deforestation is fully accounted (World Bank, 2007).

Emissions in most developed economies have stabilized at high levels. In the United States, emissions declined 1.1 percent in 2006 compared with 2005 because of a warmer winter, a cooler summer, a decline in fossil fuel consumption, and a rise in renewable energy use. By sector, the biggest GHG emitters in the United States in 2006 were industry (29 percent) and transportation (28), followed by commercial (17), residential (17), and agricultural (8). Total U.S. emissions were offset by 12.5 percent from carbon sequestration by net additions to various CO_2-absorbing biomass (U.S. EPA, 2008).

Agriculture's global contribution to GHG emissions is 13.5 percent (Figure 5) (IPCC, 2007a). In the PECC region, agriculture in Australia and the United States accounts for 16 percent (Australian Department of Climate Change, 2008) and 8 percent (U.S. EPA, 2008), respectively, of these economies' total GHG emissions, disproportionately more than agriculture's role in each nation's economy. About half of New Zealand's GHG emissions result from agricultural production. Although New Zealand's overall emissions are very low, agricultural production is a large component of the economy and exports; the economy ranks among the world's top 20 emitters on a per capita basis (Bailey, 2008). Emissions from Thai agriculture account for 24 percent of the economy's total (Tokrisna, 2008); and in Korean agriculture, primarily from rice and livestock production, they account for only 2.5 percent of the total (Kim, 2008). The level varies in the rest of the region depending on agriculture's energy intensity and relative role in the economy.

Across the PECC region, agriculture generates emissions of all three leading GHG gases. Carbon dioxide (CO_2) emissions are primarily related to land-use change, while emissions of methane (CH_4) and nitrous oxide (N_2O) are primarily related to livestock or crop production. The following three sources account for most of the region's agriculture-related emissions:

- The release of CO_2 caused by intensive land use and the exposure of soils that occurs when virgin land and forest area are converted to grazing and to food and feed production (Smil, 2001). Conversely, agriculture and rural areas have the potential for absorbing more CO_2 through the conversion of land to forestry and other less intensive uses.
- Higher rates of N_2O emission stimulated by naturally occurring bacteria from soil cultivation, use of nitrogenous fertilizers, and use of animal waste. The atmospheric concentration of this GHG has been increasing linearly for the past two decades (IPCC, 2007b).
- Higher rates of CH_4 emission from cultivation of rice fields and from enteric fermentation from expanding livestock production. Global atmospheric concentration levels now appear to have stabilized (IPCC, 2007b).

Major agricultural contributors to the region's GHG emissions are livestock and rice production, both emitters of CH_4. With rapid income growth in the developing parts of the PECC region, these economies are engaged in a process of dietary convergence with developed economies: consumers are shifting from staple grains to animal products, the latter of which are more resource-intensive and GHG-emitting. According to the Food and Agricultural Organization (FAO), the global livestock sector alone generates more GHGs as measured in CO_2 equivalents—18 percent—than the global transportation sector. Livestock accounts for about 35 percent of all human-induced CH_4, largely coming from the digestive systems of ruminants. The livestock sector also generates 65 percent of nitrous oxide, mostly from manure. According to the FAO report, livestock depends on vast land resources--about 30 percent of the earth's land surface, including permanent pasture and about one-third of global arable land for production of livestock feedstuffs (FAO, 2006).

Rice production, on the other hand, is growing more slowly. Production in the PECC region increased about 12 percent, with harvest area expanding only 1 to 2 percent, from 1990-92 to 2006-08 (USDA). Methane emissions from this source have likely stabilized while those from growth in the production of livestock products have expanded. Projections for Korea show a slight decline for GHG emissions from agriculture by 2015, with reductions from arable land more than offsetting rises from livestock production (Kim, 2008).

There is no doubt that significant changes have occurred in the region's climate (Table 1). Nevertheless, the productivity of the region's agriculture generally has risen in the last three decades.

Agricultural Productivity in the PECC Region, 1980-2008

There is no doubt that significant changes have occurred in the region's climate (Table 1). Nevertheless, the productivity of the region's agriculture generally

Table 1 **Evidence of Climate Change in the PECC Region**

Economy	Evidence of climate change	Sources
Australia	Average temperatures increased 0.4 to 0.7°C since 1950, along with more heat waves, fewer frosts, more rain in the Northwest, and less rain in the South and East. Intensity of droughts increased.	IPCC (2007c), Chapter 11.
Canada	Agriculture benefited from gradual warming and lengthening of growing seasons, but was adversely affected by increased frequency and intensity of heat waves and storms. Warmer conditions and more moderate winters have aided survival and spread of pests affecting agriculture and forestry, including the infestation of the pine beetle in western Canada. Melting glaciers have raised concerns about the need for more careful water management in the future.	Ileka et al. (2008)
Chile	In most of Latin America, there are no clear long-term trends in mean surface temperature. The few exceptions include a cooling trend in Chile. A declining trend in precipitation and in deglaciation in southern Chile may have contributed to negative trends in stream flows.	IPCC (2007c), Chapter 13
China	Short-duration heat waves and an increased number of warmer days and nights increased in frequency in recent decades. Extreme rains in western and southern regions were more frequent, summer rains more intense in east China, and floods seven times more frequent since the 1950s.	IPCC (2007c), Chapter 10
Indonesia	Average temperatures rose but not as fast as the global average. Rates of increase were moderated by the slow warming of equatorial waters surrounding the islands. Changes in rainfall patterns (rises in northern regions and declines in southern regions) and increased intensity of El Nino affected agriculture, including the timing of rice harvests. Changes in climate were also associated with increased insect infestations.	Natawidjaja (2008)
Japan	Average temperatures rose about 1.0°C in the 20th century. There was no significant trend in precipitation but variability increased.	IPCC (2007c), Chapter 10
Korea	Average temperatures rose 1.5°C in the last 100 years, faster than the global average. The warming trend is shifting northward, reducing production of apples, barley, and other crops and reducing livestock productivity.	Kim (2008)
New Zealand	Precipitation was heavier and more persistent in western parts of the economy. Conditions became drier in the East. More frequent droughts (four major droughts since 1992) had negative impacts on dairy and other agricultural production.	Bailey (2008)
Pacific Islands	The annual number of hot days and warm nights increased across the South Pacific during 1961- 2003. Small islands east of the dateline experienced rising incidence of tropical storms during an El Niño event.	IPCC (2007c) Chapter 16
Philippines	Average temperatures rose 0.14°C in 1971-2000, below the global average. Annual mean rainfall increased after the 1980s.	IPCC (2007c)
Chinese Taipei	Average temperatures rose 1 to 1.4°C, faster than the global average. The intensity of precipitation increased in the Northeast and declined in the South. There were severe impacts on rice and horticultural crops from more frequent extreme events (typhoons, flooding, frost, drought, and hail).	Chang (2008b)
Thailand	Average temperature rose 1°C in the last 45 years. Precipitation patterns changed, with greater frequency of flooding in the South and drought in the North and Northwest. Rainfed agriculture, including rice, in the North was most affected.	Tokrisna (2008)
United States	Average temperatures and precipitation increased, with significant regional variability. Heat waves increased in frequency and severe cold periods declined. Conditions became drier in the Southeast and West. Climate effects were greater on more sensitive horticultural crops. Impacts on grain and oilseed crops may be positive until optimal temperature levels are surpassed.	Lewandrowski (2008), IPCC (2007c)

Table 2 **Average Yields of Leading Crops in the PECC Region**

Country/commodity	1980-89	1990-99	2000-08
	Metric tons per hectare		
Australia barley	1.4	1.8	1.7
Australia rice	4.9	6	6.9
Australia sorghum	2	2.3	2.6
Australia wheat	1.4	1.8	1.6
Canada barley	2.6	3	2.9
Canada corn	6	7	7.8
Canada rapeseed	6	7	7.8
Canada wheat	1.8	2.3	2.4
China corn	3.7	4.8	5.1
China rice	3.5	4.2	4.4
China wheat	2.7	3.6	4.2
Thai corn	2.3	3.1	3.8
Thai rice	1.3	1.5	1.8
Indonesia rice	2.7	2.8	2.9
Japan rice	4.3	4.5	4.7
Vietnam rice	1.8	2.4	3.0
Malaysia rice	1.8	1.9	2.2
Philippine rice	1.6	1.9	2.3
Mexico corn	1.5	2.3	2.9
US corn	6.6	7.7	9.1
US rice	4.1	4.6	5.3
US soybeans	2	2.5	2.7
US wheat	2.4	2.6	2.8

Source: USDA

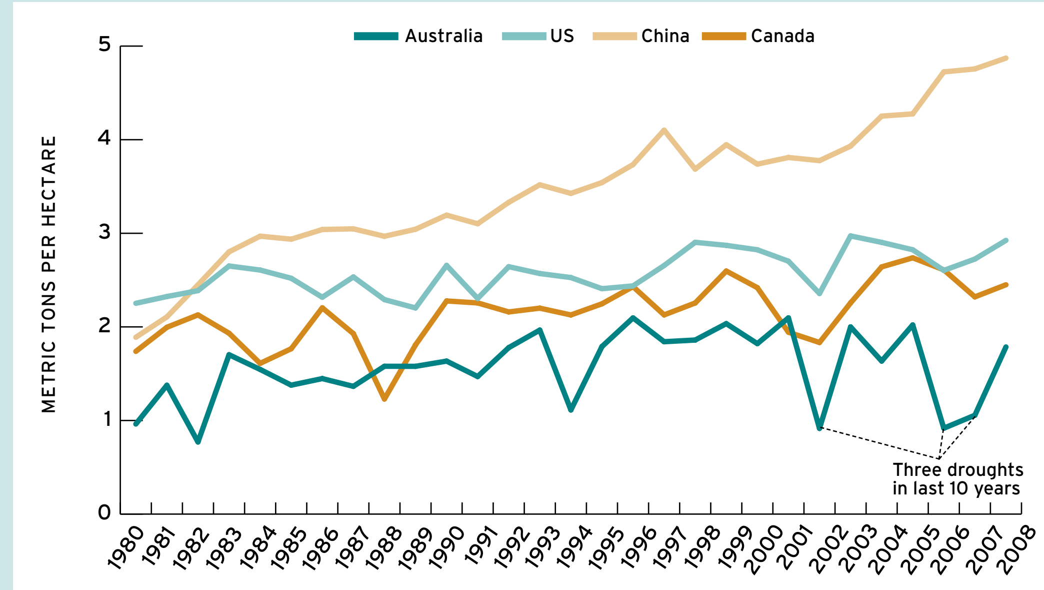
has risen in the last three decades. The impacts of climate change are, in many cases, obscured by other factors, such as the adoption of new technologies (better seed and other inputs), increased scale of operation, and improved farming practices. Climate change impacts can be isolated under experimental conditions in which temperature, moisture, and CO_2 concentration are carefully controlled, but impacts are difficult to identify under field conditions.

Reviewing yield data gives little indication of any significant discontinuities for the leading crops in the region over the past 30 years. Average yields in almost all cases have shown a rising trend, with the notable exceptions of Australian barley and wheat and Canadian barley (Table 2).

The pace of yield growth, however, has slowed in the last decade. This is a broad regional phenomenon except for U.S. corn, Thai rice, and Malaysian rice, where yield growth accelerated, and for Australian sorghum, U.S. wheat, Indonesian rice, and Japanese rice, where growth was stable in the last two decades. The overall slowing in yield growth is consistent with global trends: global aggregate yield growth averaged 2 percent per year in 1970-90 but declined to 1.1 percent in 1990-2007 and is expected to further decline to 1 percent in the next 10 years (Trostle, 2008). This slowing is explained by the waning effects of the green revolution which had its start in the 1960s (Cline, 2007). While conventional wisdom supports this view, some agribusinesses expect continued increases in yields; for example, U.S. corn yields are expected by some to rise by as much as 40 percent in the next 10 years (F.O. Licht, 2008).

There is also the possibility that economies with low grain yields can catch up by overcoming agronomic and marketing constraints, such as raising average China corn yields (5.1 mt/ha) closer to average U.S. yields (9.1 mt/ha) and raising rice yields in the Philippines and Malaysia closer to levels in Indonesia and Vietnam.

Figure 6 **Wheat Yields: Incidence of Drought Increased in Australia in 2000s**



Source: USDA.

Other trends affecting production are independent of climate change. The global dietary shift from food grains to feed grains in many of the region's emerging economies is reflected in regional patterns in which production of rice and wheat has remained relatively stable while feed grain production has grown considerably.

Of all the economies in the PECC region, Australia stands out as the one potentially most affected by climate change. The frequency of drought conditions increased in the last decade, from one per decade in the 1980s and 1990s to three in the last decade, with droughts in 2002, 2006 and 2007. Wheat yields in those years averaged about 1 ton, or about half the more typical 2 tons per hectare (Figure 6). One of the hardest hit agricultural areas was the catchment for Australia's two largest river systems, the Murray and the Darling, which account for about 50 percent of the economy's annual agricultural output, including a large share of horticultural crops (Gunasekera, 2007). Rice production, which is primarily irrigated, declined sharply, from 1.2 million tons in 2000 to practically nil in 2007 (Figure 7).

Climate Change Projections and the PECC Food System

The IPCC released its fourth assessment report in 2007.[2] This report and previous ones provide authoritative information about climate change, its causes, impacts, and future implications across various economic sectors and regions of the world. In the latest IPCC report the following key projections were made that are relevant to the PECC food system:

- Agricultural productivity impacts vary
- Food insecurity increases
- Sea level rise affects food supply chains

AGRICULTURAL PRODUCTIVITY IMPACTS VARY

Rising temperatures may increase agricultural productivity in some higher-latitude economies in the next century and reduce it in lower-latitude economies. This is a robust finding reflected in research spanning the last 15-20 years. A recent study that provides very detailed economy-by-economy impacts, using data from general circulation models (GCM) and a broad spectrum of agriculturally specific models, also confirms this result (Cline, 2007). According to this study, the net effect on PECC's agriculture of rising temperatures and other climate variables may be slightly positive, about 2 percent, by 2080 (Table 3). Moderate to medium

[2] The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization and the United Nations Environment Program. The 2007 IPCC report is the fourth (previous reports were issued in 1990, 1995, and 2001).

local increases in temperature (1 to 3 C degrees) in the higher latitudes and changes in precipitation, along with assumptions about carbon fertilization, are expected to have positive impacts on crop yields. Agricultural productivity increases are projected for Canada, the United States, China, Japan, Korea, and New Zealand. Above the 1-to-3 degree rise, impacts on agricultural productivity are expected to turn negative (IPCC, 2007c).

In lower latitudes, many economies are already at average temperatures that are close to or exceeding optimal levels for agriculture. In these economies, even moderate increases (1 to 2 degrees) are likely to have significant negative impacts on major crops. Agricultural productivity declines are projected to be most severe across the region's Latin American and Southeast Asian economies. Australia also is projected to be among the most negatively affected of the region's economies.

Precipitation is also projected to rise in most parts of the region, with the exception of Mexico, Chile, and the southern parts of Australia and the United States, where declines are projected. The increases tend to be the greatest in the northern latitudes or higher altitudes (Tibetan Plateau) and lowest in the equatorial parts of the region. While higher temperatures can lead to higher precipitation levels, they can also lead to the drying out of soil and the increased need for irrigation.

Rising temperatures and changing precipitation levels are likely to have significant impacts on the extent and quality of grasslands and rangelands as well, and on the survival and spread of pests—all factors affecting the productivity of agriculture (IPCC, 2007c).

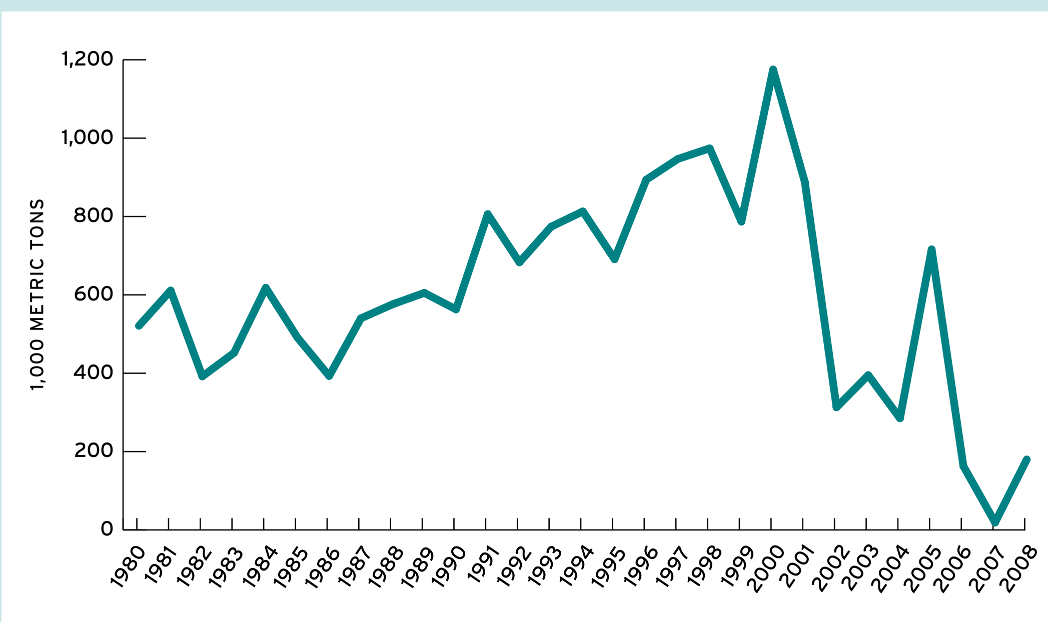
Warming may also mean that increased precipitation falls as rain instead of snow, leading to challenges for water management, hydropower, and agriculture in some parts of the region. Within the PECC region, large areas of China, Japan, Korea, Southeast Asia, the United States, and Mexico are dependant on irrigated agriculture. Water management could become a critical challenge for many economies if climate warming and changing precipitation patterns make water increasingly scarce.

The Himalayan Glaciers on the Tibetan Plateau are among the most affected of the world's glaciers by rising temperatures, projected to increase more rapidly than most other parts of the PECC region. This area supplies 40 percent of the world's population with water for agriculture and other uses through seven rivers, four of which flow through the Asian part of the PECC region: the Yellow, Yangtze, Mekong, and Salween.

According to the IPCC, scientists have high confidence that weather extremes will be more frequent and severe and have a more injurious effect on the region's agriculture in the future. Historical data show a large drying trend since the mid-1950s over much of the Northern Hemisphere and greater storm intensity since 1970 in some regions (IPCC, 2007d). Compared to the slowly rising mean trends of climate variables projected for the next century, events such as heat stress, drought, flooding, or outbreaks of pests or pathogens are difficult to predict and may come quickly, making it difficult for food producers to adjust.

Assumptions about the yield-enhancing impact of CO_2 are critical to the model-projected net regional outcome. Such assumptions can make the difference between an overall increase in the region's projected

Figure 7 **Australia's Irrigated Rice Production Declines Sharply**



Source: USDA.

Table 3 **Climate Change Projections and Impact on PECC Agriculture, 2080s**

	Farm area	Output per ha	Output	Estimated Impacts		Change in output	
				w/o carbon fert.	w/ carbon fert.	w/o carbon fert.	w/ carbon fert.
	1000 ha	2003 $	Mil of 2003 $	Percent	Percent	Millions of 2003 $	
Australia	455,722	29	13,060	-26.6	-15.6	-3,472	-2,034
Canada	67,502	254	17,131	-2.2	12.5	-365	2,150
Chile	26,502	246	6,517	-24.4	-13.1	-1,590	-851
China	153,956	1,381	212,550	-7.2	6.8	-15,341	14,243
Colombia	50,706	186	9,438	-23.2	-11.7	-2,188	-1,100
Ecuador	12,356	176	2,176	-28.8	-18.1	-627	-394
Indonesia	33,700	1,051	35,413	-17.9	-5.6	-6,330	-1,967
Japan	4,762	9,032	43,009	-5.7	8.4	-2,464	3,618
Korea	1,877	8,707	16,344	-9.3	4.3	-1,525	698
Malaysia	7,585	1,368	10,374	-22.5	-10.9	-2,336	-1,130
Mexico	183,839	136	25,043	-35.4	-25.7	-8,856	-6,428
New Zealand	15,640	254	3,979	2.2	17.5	87	697
Peru	35,382	171	6,058	-30.6	-2a0.2	-1,852	-1,221
Philippines	10,700	1,054	11,280	-23.4	-11.9	-2,639	-1,342
Thailand	19,367	738	14,295	-26.2	-15.1	-3,739	-2,156
United States	379,344	260	98,536	-5.9	8.0	-5,791	8,120
Vietnam	8,895	969	8,616	-15.1	-2.0	-1,300	-202
PECC Region	1,467,835	364	533,819	-11.3	2.0	-60,328	10,701
World	3,097,935	380	1,175,860	-15.9	-3.2	-186,510	-38,107

Source: William R. Cline (2007). *Global Warming and Agriculture, Impact Estimates by Country*. Center for Global Development, Peterson Institute for International Economics.

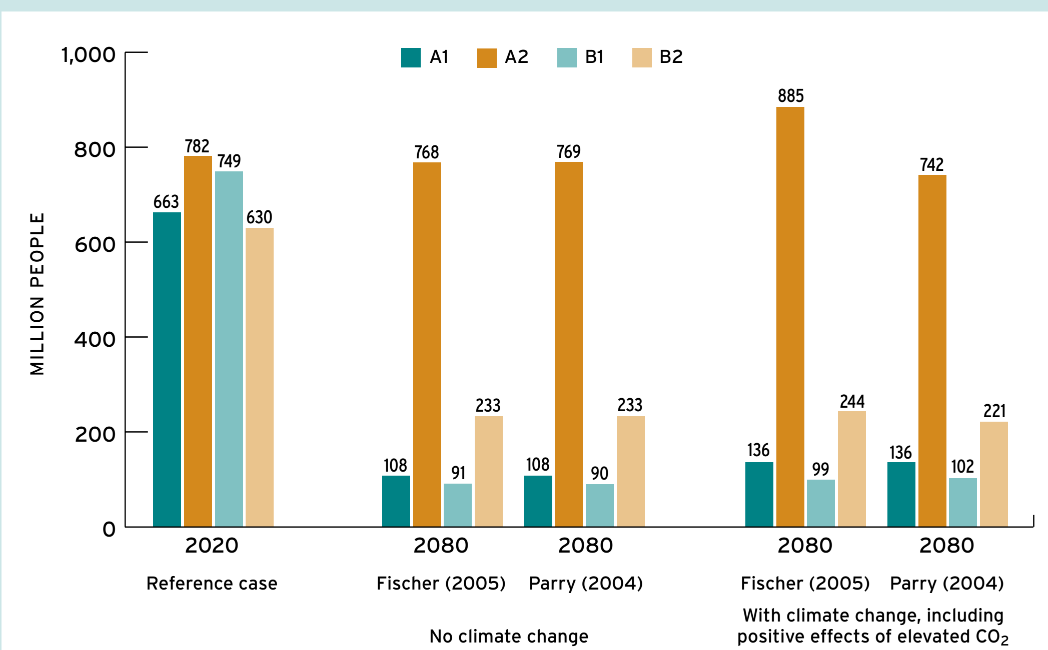
agricultural productivity (2 percent) versus a decline (-11 percent). The same holds for all individual economies, with the exception of New Zealand's agriculture, where productivity is projected to increase without the carbon fertilization assumption, but even more so with it.

For some time, researchers have noted that rising concentrations of atmospheric CO_2, the most important radiative forcing linked to global warming (IPCC, 2007a), seems to have a positive impact on many crops within a certain range of temperature increases. This should not be surprising in light of the indispensible role CO_2 plays in photosynthesis. But the magnitude of the impact has been subject to debate for some time (Cline, 2007).

According to the 2007 IPCC report, recent research justifies the scaling back of the yield-enhancing assumption of CO_2 atmospheric concentrations to 550 ppm, about 50 percent above current concentration levels. According to this research, yields for C3 crops[3] would increase 10-25 percent and for C4 crops[4] 0-10 percent. Cline assumes an average 15 percent increase in yield in his 2080 economy-by-economy projections of climate change impacts on agriculture. Estimates arising from Australia's Garnaut Commission, based on more recent scientific evidence, suggests that atmospheric CO_2 concentrations of 450 ppm probably constitute the upper bound for their "fertilization effect." This is considerably lower than previously assumed. Nevertheless, according to the 2007 IPCC report, the role of CO_2 is still an area of great uncertainty: "…the true strength of the effect of CO_2 on crop yields at field or regional scale, its interaction with higher temperatures and variable precipitation levels, and the level beyond which CO_2 saturation may occur remain largely unknown (IPCC, 2007c)."

[3] C3 crops include rice, wheat, soybeans, fine grains, legumes, and most trees. These crops may also benefit from increased efficiency of water use as a consequence of reduced stomatal conductance with rising CO_2. (Cline, p. 24).
[4] C4 crops include corn, millet, sorghum, and sugarcane (Cline, p. 24).

Figure 8 **Climate Change Projected to Have Modest Impact on Global Food Security**



Source: Table 5.6, page 299; IPCC (2007c). See description of IPCC scenarios in The Role Of Models in Assessing Climate Change Impacts, p.17.

FOOD INSECURITY INCREASES

The number of food-insecure people in the PECC region is about 11 percent, or 210 million people, with the greatest regional incidence in the poorest economies in Southeast Asia, South America, and parts of China (FAO food security statistics). The rate of food insecurity in the less developed parts of the PECC region is about half that in the rest of the developing world.

Climate change impacts on agricultural productivity in the PECC region will vary, with gains in the high latitudes and losses in tropical areas where most of the region's food-insecure population live. Food supplies in these tropical areas may be further threatened by more frequent extreme weather events, the effects of greater pest infestations, and the potential adverse impacts of sea level rise on coastal aquaculture and food production in low-lying areas, particularly in Southeast Asia.

Climate change impacts on agricultural productivity in the PECC region will vary, with gains in the high latitudes and losses in tropical areas where most of the region's food-insecure population live.

While projections of the impact of climate change on global food security are uncertain, economic growth can help to mitigate adverse effects. With or without climate change, big declines in the number of food-insecure people are expected from reference levels projected for 2020 (Figure 8). However, declines are not quite as sharp when climate change factors are considered (IPCC, 2007c).

For one scenario (A2), the global number of food-insecure people rises. This scenario assumes steadily expanding population, slower spread of technology, and slower income growth in developing economies (see description of IPCC scenarios in The Role of Models in Assessing Climate Change Impacts, p. 17).

Projections such as these demonstrate the greater sensitivity of the food security outcome to income growth relative to climate change per se, although the IPCC is careful to caution about the limitations of the models it uses. Nevertheless, this discussion underlines the importance of economic development in providing low-income subsistence households with the resources needed to adapt to climate and other changes through application of technology and diversification of economic and agricultural activities (Natawidjaja, 2008).

SEA LEVEL RISE AFFECTS FOOD SUPPLY CHAINS

Global average sea levels have been rising at an accelerating rate since 1961 (1.8 mm/year for 1961-2003 vs. 3.1 mm/year for 1993-2003), most likely because of thermal expansion of the oceans and other lesser factors. The IPCC projects sea level increases of 0.18 meters to 0.59 meters by 2100, depending on which model-based scenarios are used (IPCC, 2007a). Sea level rise is most threatening to agriculture, food system infrastructure, ports and related transport facilities, and population settlements in low-lying coastal areas (Antle, 2008). Southeast Asia, China, and a number of the Pacific Islands in the PECC region are particularly vulnerable.

Data show that sea level trends vary significantly in different parts of the world. The average sea level rise for Australia of 0.3 mm per year in the last 100 years is lower than the global average. There is also significant variation around Australia; for example, a 0.6-mm-per-year rise in Hobart versus a 1-mm-per-year decline in Geraldton in a recent 30-year period (http://www.ozcoasts.org.au/indicators/sea_level_rise.jsp).

A potential problem from rising sea levels is exacerbated by income growth in the developing parts of the region, leading to the migration of millions of people to coastal cities. The growth in human settlements within 30 kilometers of the coast is twice the global average (Brooks, 2006). This is the most significant demographic change expected in the PECC region in the next 50 years, as discussed in our 2003 report (PECC, 2003).

Among urban agglomerations with the largest populations potentially exposed to coastal flooding in the latter part of this century, 9 of the 20 most vulner-

Table 4 **Top 20 Cities Ranked by Population Exposed to Flooding in the 2070s**

Rank	Country	Urban agglomeration	Current 1,000s	Future 1,000s
1	India	Kolkata	1,929	14,014
2	India	Mumbai	2,787	11,418
3	Bangladesh	Dhaka	844	11,135
4	China	Guangzhou	2,718	10,333
5	Vietnam	Ho Chi Minh City	1,931	9,216
6	China	Shanghai	2,353	5,451
7	Thailand	Bangkok	907	5,138
8	Myanmar	Rangoon	510	4,965
9	USA	Miami	2003	4,795
10	Vietnam	Hai Phong	794	4,711
11	Egypt	Alexandria	1,330	4,375
12	China	Tianjin	956	3,790
13	Bangladesh	Khulna	441	3,641
14	China	Ningbo	299	3,305
15	Nigeria	Lagos	357	32,290
16	Cote D'Ivoire	Abidjan	519	3,110
17	USA	New York-Newark	1,540	2,931
18	Bangladesh	Chittagong	255	2,866
19	Japan	Tokyo	1,110	2,521
20	Indonesia	Jakarta	513	2,248
			24,096	142,253

Source: Nicholls, R.J., et al (2007); *Ranking the World's Cities Most Exposed to Coastal Flooding Today and in the Future*. Executive Summary. OECD Environment Working Paper No. 1. Paris: Organization of Economic Cooperation and Development

able are in the PECC region: Guangzhou, China; Ho Chi Minh City, Vietnam; Shanghai, China; Bangkok, Thailand; Hai Phong, Vietnam; Tianjin, China; Ningbo, China; Tokyo, Japan; and Jakarta, Indonesia (Table 4). A number of Pacific Islands also face extreme susceptibility to sea level rise in the next century because their land area is barely above sea level; these are coral atolls. The newer volcanic-based islands face less severe risks.

Among PECC economies, the agricultural impacts are potentially greatest for Vietnam, Mexico, and Chinese Taipei (Chang, 2008b), with absolute potential impacts greatest for China. About 3,000 kilometers of Vietnam's coastline is at or below one meter of elevation, potentially affecting almost 11 percent of the population, the largest percentage of affected population among 84 economies analyzed. Some of the same lands are Vietnam's most fertile, those in the Red and Mekong River delta regions, which represent a large share of the economy's rice-growing area (Dasgupta, 2007).

Public and Private Sector Responses

Public or private sector responses to climate change are predicated on an assessment of the future benefits and costs of doing something now versus the future benefits and costs of inaction. Such an assessment is necessarily complex and affected by many factors, including local conditions and the immediacy of expected adverse effects. Thus, a farmer's propensity to respond to climate change projections in Australia's Murray-Darling catchment is much higher than that of a farmer, say, in the U.S. Corn Belt. One is already facing manifestations of climate change in increased frequency of drought, and the other is not.

Farmers are accustomed to adjusting to changes in weather and growing conditions, as well as changes in the marketplace. This is a reality in agriculture. Weather variability is the most significant supply-side factor farmers must deal with on a regular basis.

Adapting to climate change is different. It implies the recognition that there are trends in climate-related variables. In any particular location these trends may include gradually increasing temperatures, slowly changing precipitation patterns, slowly rising sea levels and salt water intrusion on low-lying coastal areas, or increasing frequency of extreme weather events. The change is inevitable (Rose,

THE ROLE OF MODELS IN ASSESSING CLIMATE CHANGE IMPACTS

General circulation models (GCMs) are used extensively in projecting long-term global climate change. These are complex systems of equations that divide the planet into a three-dimensional grid, representing the dynamic physical attributes of the ocean, land surfaces and atmosphere.

Model projections are driven by assumptions about future atmospheric concentrations of greenhouse gases and other forcings. Future growth of GHG concentration levels can be assumed (such as 1 percent growth per year) or derived from various economic model-based scenarios. In the 2007 IPCC report, six families of scenarios are used:

- A1 (A1FI, A1B, and A1T): these assume rapid economic growth, a global population reaching 9 billion by 2050 before declining, income convergence between developed and developing economies, and different assumptions about energy use (A1FI, emphasis on fossil fuels; A1B, a balanced use of many energy sources; and A1T, emphasis on non-fossil fuels).
- A2: steadily expanding population, a less economically integrated world, slower spread of technological change, and less income convergence.
- B1: rapid growth as in A1, a global economy dominated by services and information, population rising to 9 billion in 2050 before declining, greater use of clean and resource-efficient technologies, and emphasis on a more integrated world.
- B2: steadily expanding population but slower than in A2; a less economically integrated world than in B1 and A1, with lower levels of economic development and less rapid and more fragmented technological change.

The output of weather variables from the GCM models can be mapped to different economies and then used in agricultural models to estimate the projected impacts these variables will have on the economy's agriculture. Another category of model, the integrated assessment model, provides broader insights about the potential economic and environmental impacts of climate change as well as a basis for evaluating different mitigation options (Gunasekera, 2008).

Much progress has been made in representing the planet's climate and likely changes in these GCM models, as well as in the use of various scenarios to determine future global GHG levels. Now there are many teams of climate specialists around the world supported by better computers, increased and more accurate data from satellites and other sources, and greater knowledge about the main forces and interrelationships affecting the climate.

Modelers have become more confident in ascertaining what is likely to happen, but many uncertainties remain, including:

- The effects of clouds. This is a significant area of uncertainty in climate models. Clouds have variable effects on the climate. One of the roles that clouds play is in cooling the surface, by reflecting sunlight back into space; another is warming, by increasing the amount of infrared radiation allowed through from the atmosphere to the earth's surface.
- The difficulty in quantifying episodic changes. For example, the infestation of the pine beetle in the forests of British Columbia, Canada, led to a large share of forestland quickly changing from being a net carbon sink to being a net carbon source (Running, 2008).
- The difficulty in accounting for changes in the value of *albedo*. The *albedo* value measures the earth's reflectivity, which ranges from 90 percent for fresh snow to about 4 percent for charcoal, with the earth's average being about 30 percent. The value is constantly changing with human activity, through changes in land use, such as expansion of urban areas and conversion of forestland to agricultural use. Climate change can also trigger a series of changes and feedbacks: if snow melts, the *albedo* decreases as the white reflective snow disappears, revealing the darker soil underneath. Thus, more sunlight is absorbed by the dark soil, and temperatures increase still further.
- The need for more information regarding climate change and its interaction with agriculture and economic variables in developing economies. A preponderance of climate change data and analyses now comes from the developed economies.

2008).[5] And adaptive measures are needed to reduce the costs or take advantage of the benefits of the change. The costs of adaptation are always positive, and the extent of these costs depends on the speed of climate change (Quiggen and Horowitz, 2003). If the change is too rapid or extreme, adaptation may require moving to a more attractive location, seeking off-farm opportunities, or abandoning agriculture altogether.

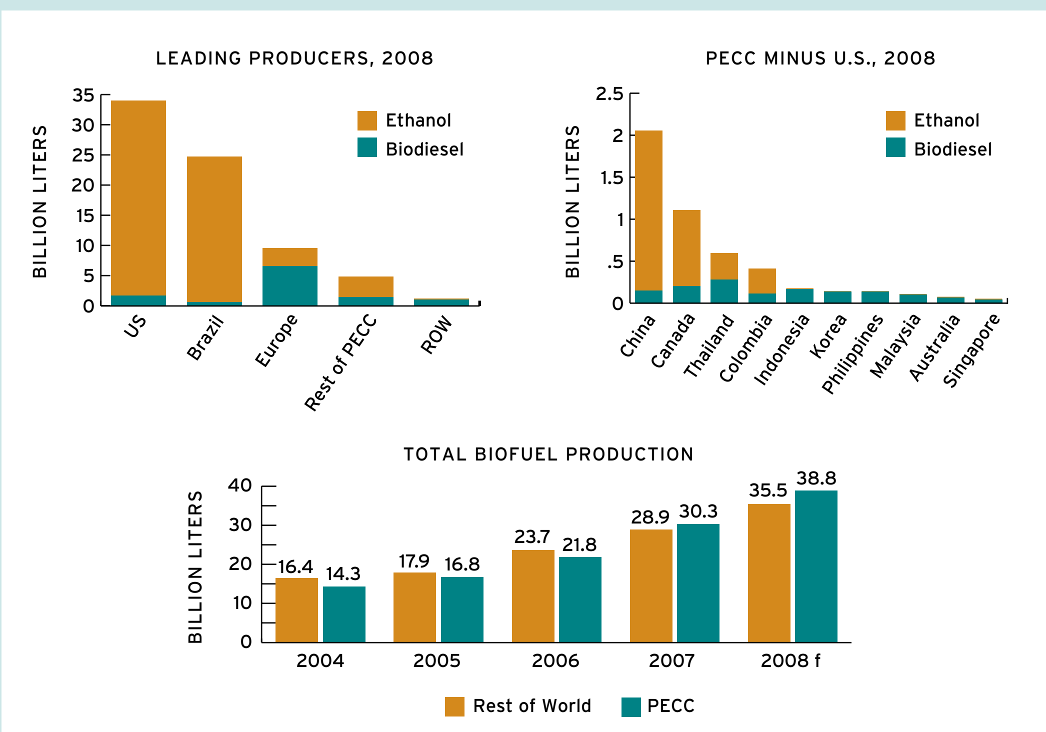
The degree of adaptation depends on the extent of climate change and the capacity to adapt. A wealthy farmer in Australia may be more able to adapt to slowly rising temperatures by using more drought-resistant seed varieties, while a poor rice farmer in Southeast Asia may find it difficult to adapt because of isolation and the lack of resources (Natawidjaja, 2008).

Policy intervention may be required to assist poor farmers in undertaking adaptive measures. Aid may simply be the providing of information, such as China's recent advice to farmers in certain locations to delay the harvest of corn and the sowing of winter wheat this year because of explicit concerns about the effects of global warming on the economy's agriculture (Interfax-China, 2008).

Mitigation policy is more significant because it is focused on actually reducing net GHG emissions or on undertaking carbon sequestration strategies. Mitigation measures, usually promoted by governments, include the use of direct payments, a carbon tax, or a cap-and-trade system to cut GHG emissions. These approaches are likely to be economy-wide, affecting agriculture directly or indirectly according to the scope

5 Even if concentrations were fixed at 2000 levels, average temps would rise .3 to .9 degrees by 2090-2099 regardless of the seriousness of mitigation. Steven K. Rose and Bruce A. McCarl (2008). "Greenhouse Gas Emissions, Stabilization and the Inevitability of Adaptation: Challenges for U.S. Agriculture." Choices, first quarter.

Figure 9 **PECC Biofuel Production Concentrated in U.S., But Expanding in Other Countries**



Source: F.O. Licht.

BIOFUELS: A VIABLE GHG MITIGATION STRATEGY?

In recent years, biofuels have been promoted on the basis of their potential contribution to energy security and rural development, as well as their environmental benefits. Biofuel production in the PECC region has expanded rapidly but is concentrated primarily in the United States, with much less production in China, Canada, Thailand, and Colombia (Figure 9). Many PECC economies have developed policies to promote expanded use.

Biofuels have an advantage over fossil fuels because their combustion is carbon neutral. While both biofuels and fossil fuels give off CO_2 when burned, biofuels recycle CO_2 recently absorbed from the atmosphere by the crops used to produce them. Fossil fuels, on the other hand, are adding to atmospheric CO_2 concentrations by giving off CO_2 that was absorbed and trapped in plant material millions of years ago.

When taking a broader perspective using "life-cycle" analyses, we see that the advantages of biofuels in reducing GHG relative to fossil fuels per kilometer traveled vary from an 18 percent reduction for U.S. corn ethanol to a 90 percent reduction for Malaysian biodiesel from palm oil (Figure 10). The variability arises from differences in the feedstocks used, the cultural practices employed to produce them, and the kinds of inputs used to process them into biofuel. Using bio-feedstock for producing electricity also potentially has a high percentage offset (85-96 percent) of net GHG emissions (McCarl, 2008).

Recent analyses have raised questions about the GHG implications of land use changes that result from expanding biofuel production (Searchinger et al., 2008; and Fargione, et al., 2008). These studies consider the global GHG impacts of converting land now covered with trees, grass, and other natural "carbon sinks" into farmland for growing higher-priced crops for biofuel production. According to these studies, when emissions from land use changes are considered in estimates of direct emissions for corn ethanol, the total becomes higher than for fossil fuels.

It is clear that biofuels now are very land-intensive but progress is being made in making them less so. First-generation biofuel yields per hectare range from 608 liters for U.S. soybeans to 3,740 liters for U.S. corn and 5,600 liters for Malaysian palm biodiesel. Given U.S. corn yields and current ethanol conversion rates, meeting U.S. demand for gasoline (570 billion liters), for example, would require the cultivation of over 200 million hectares of U.S. farmland—more land area than currently is in U.S. crop production.

Higher biomass yields and biofuel conversion rates for first-generation biofuels and the commercialization of cellulosic ethanol hold promise for raising per-hectare biofuel yields to more than 9,000 liters, thus reducing the land-intensity of production and raising GHG offsets.

Increasingly, regional attention, primarily in the United States, Canada, China, Japan, Australia, New Zealand, and Thailand, is being focused on commercializing cellulosic ethanol. Many small companies, sometimes in collaboration with large companies and universities, are investing billions of dollars of private venture capital and public grants in this effort. Cellulose is the most widely available biological material in the world, present in such low-value materials as wood chips and wood waste, fast-growing grasses, crop residues such as corn cobs and sugar cane bagasse, and municipal waste. Some of these sources could be produced on marginal lands and not in direct competition with food crops.

Converting cellulose to ethanol is not currently economical and is not likely to be so for another two to three years, by the most optimistic forecasts. Estimated production costs are still significantly higher than for first-generation biofuels. A public role will likely continue, given the high cost of finding and reducing the costs of enzymes and increasing the supply of biomass, including crop varieties bred for higher yields per hectare. Research is also focused on finding or developing crop varieties that grow well on marginal lands, have drought and pest resistance, are inexpensive to harvest, and are more easily converted to ethanol.

Questions remain about what effects harvesting grasses, trees, and crop residues would have on erodibility and fertility of land resources. There are also questions regarding logistical and environmental costs of harvesting, transporting, and storing large volumes of bulky cellulosic feedstock for processing into ethanol.

of the program. The costs of a cap-and-trade program are reduced by broad sectoral participation. Agriculture, however, may be excluded because of its geographic dispersion and the difficulties involved in monitoring a large number of farms, each emitting a very small quantity of GHGs. On the other hand, farms may be allowed to participate in a cap-and-trade system by voluntarily reducing emissions or increasing sequestration and providing offset credits to those required to participate (e.g., power generating plants). CO_2 cap-and-trade programs are being used in New Zealand and Europe. Australia and parts of the United States and Canada are planning to introduce programs in the next several years. Cap-and-trade programs are a common feature of recent U.S. legislative proposals regarding climate change (Lewandrowski, 2008).

Governments can encourage reduction or sequestration of GHG emissions at the farm level by promoting minimum tillage, expansion of forestry areas, the more efficient use of fertilizer to reduce nitrous oxide emissions, and the use of anaerobic digesters in livestock operations to capture methane for on-farm energy use. One way governments can do this is to provide information about the GHG consequences of applying these different practices (Lewandrowski, 2008). Nevertheless, these changes are most likely to occur when they are in the economic interests of the producer.

Governments in the PECC region have also promoted the production and use of biofuels (Figure 9) as a mitigation strategy. Biofuels can offset GHG emissions in varying degrees, depending on what biomass is used, how it is used, and the extent to which land use changes are undertaken. Ethanol from sugar cane or cellulosic sources, for example, reduces GHG emissions more than ethanol from wheat or corn, and electricity production using switchgrass offsets more GHG emissions than corn ethanol used as a fuel (McCarl, 2008)[6].

Since the atmosphere is shared by all economies, individual or national initiatives to reduce GHG emissions are often challenging because of the lack of broad cooperation. If one economy imposes strict abatement policies on itself and others do not, this may adversely affect the competitive position of the initiating economy, while shifting GHG-emitting industries to other economies and not reducing overall global emissions. Recent economic cost estimates of Australia's cap-and-trade proposal, scheduled for introduction in 2010, reflect the disincentives faced by an economy trying to act independently. According to Australian estimates, if the government cut GHG by 10 or 25 percent by 2020, GDP would be 1.1 percent or 1.6 percent less than otherwise would be the case, versus 0.9 percent with a program that did not undertake to cut GHG emissions (Garnaut, 2008).

Recognition of the global nature of climate change is reflected in international initiatives, such as the UN Framework Convention on Climate Change (1992), the Kyoto Protocol (1997), and the Major Economies Process (2007). The latter is now focused on reaching an international consensus on reducing GHG emissions after the Kyoto Protocol expires in 2012. These efforts will continue to be challenged by equity concerns, that developing economies are the least responsible for the rising concentration of GHGs in the atmosphere yet are likely to be most affected by climate change (Table 2).

Since the atmosphere is shared by all economies, individual or national initiatives to reduce GHG emissions are often challenging because of the lack of broad cooperation.

Implications for Decision Makers

Governments have a responsibility to collect and disseminate data related to long-term climate change and its potential effects. A top priority must be to provide climate change data targeted to local needs and circumstances. This is necessary to aid farmers' and other food system participants' adaptation to gradual and short-term changes, as well as to the increased likelihood of more frequent extreme weather and climatic events.

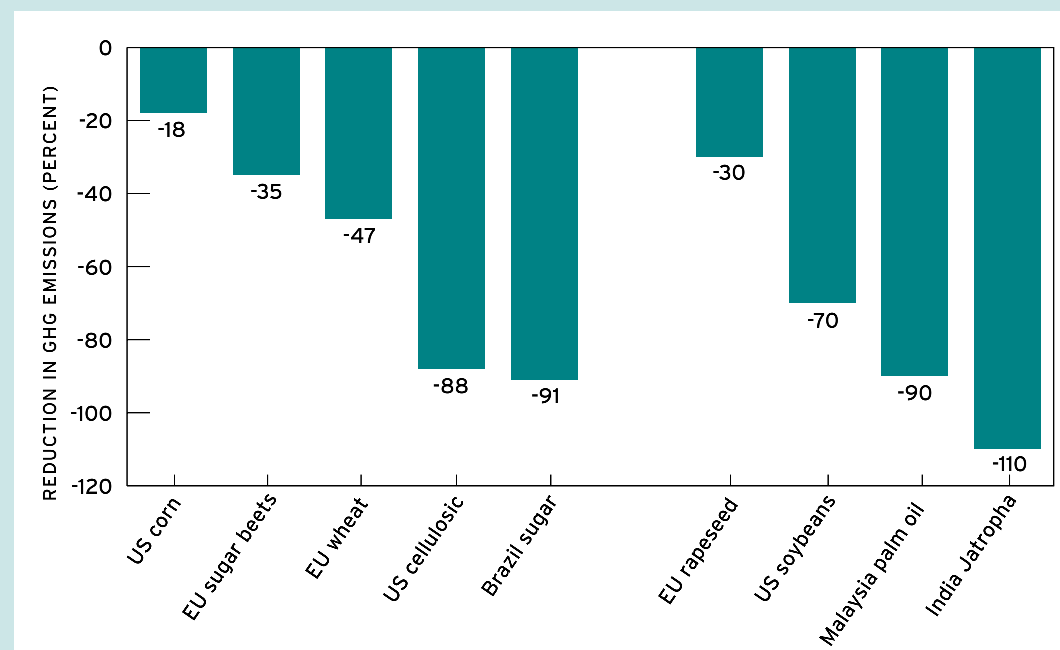
Public support is needed for research and development targeted at farm-level adaptation, taking account of unique differences in climate factors in different geographic locations within an economy. Such support may include development and introduction of drought-tolerant crops; combating the spread of various pests due to warmer temperatures; support for better water management and new, more efficient irrigation systems; measures to protect low-lying rice-producing areas from sea level rise; introduction of livestock breeds that do better in drier conditions; advice on adjusting farm management practices; and introduction of insurance programs and other income protection schemes to reduce the risk from increased frequency of extreme climate events. It is important that these initiatives do not distort agricultural markets in ways that negatively affect production and trade of farm products domestically and internationally. Public information regarding climate change effects must be integrated into extension programs and economic development planning.

Promoting economic development will be a critical component in low-income areas because farmers will need additional resources to adapt to climate change. Higher-income households have a longer time horizon and greater capacity to adapt and adjust to climate and other changes, helping to reduce negative economic effects.

There is now much more agreement about the need for concerted and coordinated private and public sector efforts to address climate change. Programs to reduce GHGs require broad participation and long-term orientation, since mitigation strategies will only slowly affect climate change and will benefit the entire region. While some economies might undertake mitigation programs to provide leadership by example, to be effective in the long run they must:

- Be implemented on a regional, or preferably global, scale through APEC, the UN, or similar institutions.

Figure 10 **Some Biofuels Provide Significant Opportunity for GHG Offsets**



Source: IMF, 2007. Percent reduction in GHG emissions is defined as the change in life cycle greenhouse gas emissions per kilometer traveled by replacing fossil fuels with biofuels in conventional vehicles. "Life cycle" refers to emissions measured over the entire production cycle of the fuel.

- Achieve broad sectoral and individual economy participation to avoid accrual of economic advantages to non-participants. As a significant GHG emitter and potential carbon sink, the food system must be included.
- Provide a clear and sustained signal regarding the high cost of carbon emissions through implementation of a carbon tax, a cap-and-trade system, or other mechanisms. These actions will lead to reductions in the use of fossil fuels and decreases in GHG emissions and will provide economic incentives for the development and production of alternative low-carbon energy sources. This will also help avoid crossing irreversible thresholds leading to even greater climate change.

Increasing production of biofuels in a cost-effective manner is one strategy in which agriculture can play an important role in GHG mitigation. Many PECC economies already encourage the blending of biofuels with fossil fuel. Care must be exercised, however, to be sure the bioenergy is produced in ways that actually reduce GHG emissions relative to fossil fuels by taking account of all emissions related to land use change, feedstock production, conversion processes to biofuels, and distribution to final consumers.

Finally, given the uncertain and variable long-term effects of climate on agricultural productivity across the PECC region, policymakers should promote the greatest possible openness in the region's food system to reduce the risk of food supply disruptions. The potential for gains in agricultural productivity in higher-latitude economies and decreases in lower-latitude economies over the next century, along with the increased likelihood of extreme events such as droughts and floods, suggest the potential for increased dependence on trade in the future. Allowing the free play of comparative advantage will assure the most efficient allocation of food system resources and the least cost in adapting the food system to climate change.

ABBREVIATIONS USED IN THE PACIFIC FOOD SYSTEM OUTLOOK

APEC– Asia Pacific Economic Cooperation
CH_4– Methane
CO_2– Carbon dioxide
FAO– Food and Agriculture Organization
GDP– Gross Domestic Product
GHG– Greenhouse gas
IMF– International Monetary Fund
IPCC– International Panel on Climate Change
N_2O– Nitrous oxide
PECC– Pacific Economic Cooperation Council
PPP– Purchasing power parity
UN– United Nations
USDA– U. S. Department of Agriculture

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PACIFIC ECONOMIC COOPERATION COUNCIL

Overview

The Pacific Economic Cooperation Council (PECC) is an independent, multi-stakeholder organization committed to the promotion of cooperation and dialogue in the Asia Pacific. Founded in 1980, the PECC is a network of member committees composed of individuals and institutions dedicated to promoting cooperation across the region. The Council is one of the three official observers of the APEC process.

PECC was formed in 1980 at the initiative of Mr. Masayoshi Ohira and Mr. Malcolm Fraser, then Prime Ministers of Japan and Australia.

Membership

Currently PECC has a total of 26 member committees representing the economies of Australia, Brunei Darussalam, Canada, Chile, China, Colombia, Ecuador, Hong Kong, China, Indonesia, Japan, Korea, Malaysia, Mexico, Mongolia, New Zealand, the Pacific Islands Forum, Peru, the Philippines, Singapore, Chinese Taipei, Thailand, the United States, Vietnam, and France Pacific Territories and institutional members: the Pacific Trade and Development conference (PAFTAD) and Pacific Basin Economic Council (PBEC).

Member Committees comprise representatives from business, government, academic, media and civil society who initiate and/or participate in PECC work program while undertaking their own activities to promote Asia Pacific cooperation in their respective economies.

Governance

PECC's governing body is its Standing Committee which consists of the chairs of each member committee. The Standing Committee meets once a year. Day-to-day operations are managed by PECC's International Secretariat situated in Singapore.

Projects

PECC signature projects are decided on by the Standing Committee and undertaken by its member committees. In addition PECC's member committees also collaborate on a number of international projects.

For more information, contact the PECC International Secretariat, Lobby A, Seventh Floor, 29 Heng Mui Keng Terrace, Singapore 119620, Tel: 65-6737 9822, Fax: 65-6737 9824, email: info@pecc.org

The *Pacific Food System Outlook* represents the first regionwide coordinated effort to provide the outlook for the Pacific food system. The food system includes not just production agriculture, but also the whole complex of economic relationships and linkages that tie the region's food consumers to producers. The goal of the *Pacific Food System Outlook* is to help increase knowledge about the diverse components of this vital segment of the global economy.

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