•

AARES 53rd Annual Conference
February 10-13, 2009
Cairns, Northern Queensland, Australia

Climate Change and the Asia-Pacific Food System

Walter J. Armbruster
Farm Foundation, Emeritus
1709 Darien Club Drive
Darien, IL 60561 USA
(630) 271-1679

and

William T. Coyle
Economic Research Service,
U.S. Department of Agriculture
1800 M. St., NW, Room N-5162
Washington, DC 20036-5831 USA
(202) 694-5216

Climate Change and the Asia-Pacific Food System[1]

Walter J. Armbruster and William T. Coyle[2]

Despite the current focus on other issues, particularly the economic crisis gripping the world, there is increasing acceptance that climate change is a reality that must be dealt with over the longer time frame. The fourth assessment report of the International Panel on Climate Change made the case fairly emphatically. Climate change is expected to affect the Asia-Pacific food system from production through the supply chain in a variety of ways. The recent droughts in Australia and the frequency of extreme weather events elsewhere in the Asia-Pacific region create concerns that there is indeed significant climate change underway.

The food system is one of the sectors within the Asia-Pacific Region's economy most affected by climate change. It is broadly dispersed geographically and closely dependent upon climate and environmental factors. Rising average temperatures, changes in precipitation patterns and other weather factors affect agricultural productivity. The extent of impact varies by geographic area, types of agricultural activities and to what extent the private and public sectors make adjustments. There are potential longer term impacts on agriculture, food security and the broader food system. The nature of adaptive and mitigation measures implemented by government and the private sector will determine to what extent particular countries or regions maximize opportunities created by climate change and minimize potential adverse impacts. This implies that public sector and private sector leaders need the best available information to make informed decisions about climate change and its implications which may require new public policies and private sector strategies.

---

[1] This paper draws on *Pacific Food System Outlook 2008-2009: Climate Change and the Food System* which can be accessed at www.pecc.org/food.

[2] Walter J. Armbruster is President Emeritus, Farm Foundation, Oak Brook, IL, USA and Chairman of the Pacific Food System Outlook, a project of the Pacific Economic Cooperation Council. William T. Coyle is a senior economist with the Economic Research Service, U.S. Department of Agriculture, and Senior Coordinator of the Pacific Food System Outlook. The views expressed in this paper are those of the Pacific Food System Outlook project and do no necessarily reflect those of the authors' respective institutions.

This paper is based on the 12th Annual Pacific Food System Outlook meeting held in Honolulu in September 2008, and the resulting publication *Pacific Food System Outlook 2008-2009: Climate Change and the Food System*. We appreciate the very substantive contributions of Don Gunasekera of the Australian Bureau of Agricultural and Resource Economics, Ching-Cheng Chang of Taipei's Academia Sinica, Barry Smit of the University of Guelph and Jan Lewandrowski of the U.S. Department of Agriculture.

Greenhouse Gases, Climate Change and Agriculture

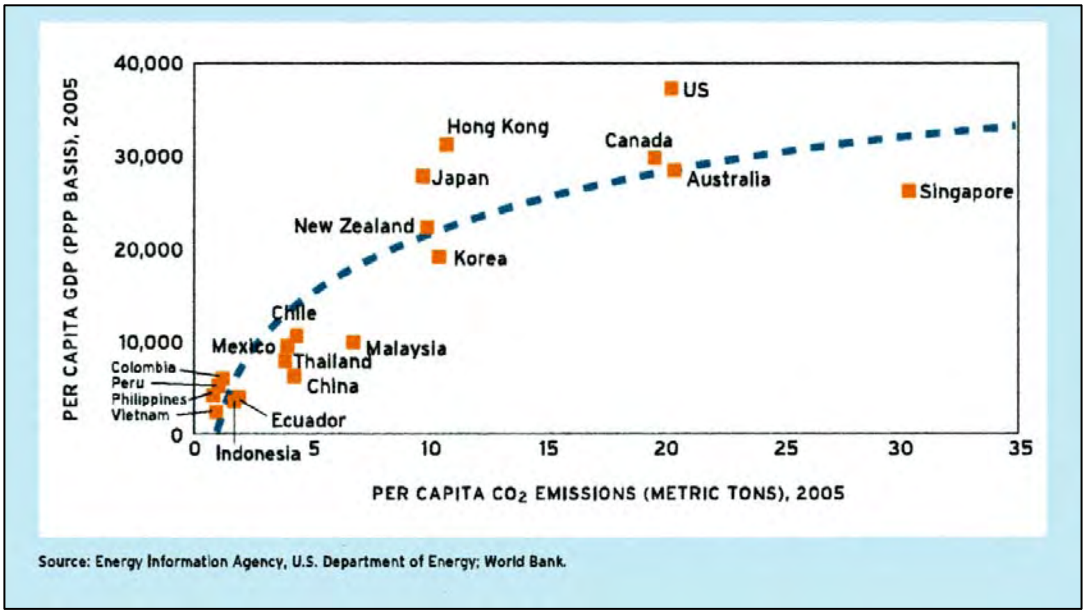
The Intergovernmental Panel on Climate Change (IPCC) 2007 report states that climate change is unequivocal and very likely caused by human activities. The IPCC is particularly concerned with activity that emits greenhouse gases (GHG). Carbon dioxide (CO_2) is the most important GHG at 77% of the total and atmospheric concentration of CO_2 has risen annually over the last 40 years. Other GHGs include methane at 14% of the total, nitrous oxide at 7.9% and F-gases at 1.1% which are refrigerant compounds used to replace ozone-depleting older compounds. Water vapor is present in far greater concentration that CO_2 but is considered part of the planet's feedback system, rising and falling with temperature and thus amplifying CO_2-driven global warming.

GHGs are considered the driving radiative forcing agents which trap heat and may remain in the atmosphere for many years. Other forcing agents, such as aerosols, have cooling effects. The net effect of all human induced forcing agents is about 375 parts per million of CO_2-equivalent which has a warming effect.

GHG emissions rise with per capita income (Figure 1) since energy use is critical to economic growth and its combustion generates significant CO_2 in the Asia-Pacific region. Annual CO_2 emissions range from one ton per capita annually in the lowest income economies in the region to more than 20 tons per capita in the high-income economies. The CO_2 emissions growth rate over the last ten years was most rapid in China, Malaysia and Vietnam, reflecting their recent rapid economic growth. China contributed more than 50 percent and the U.S. 16 percent in total growth in CO_2 emissions in the last 10 years.

China became the world's largest GHG emitter in 2007. Indonesia was fourth behind the United State and the European Union when deforestation was fully accounted. Emissions in most developed economies have stabilized at high levels.

Figure 1—Per Capita CO_2 Emissions in Asia-Pacific Region Rises with Income



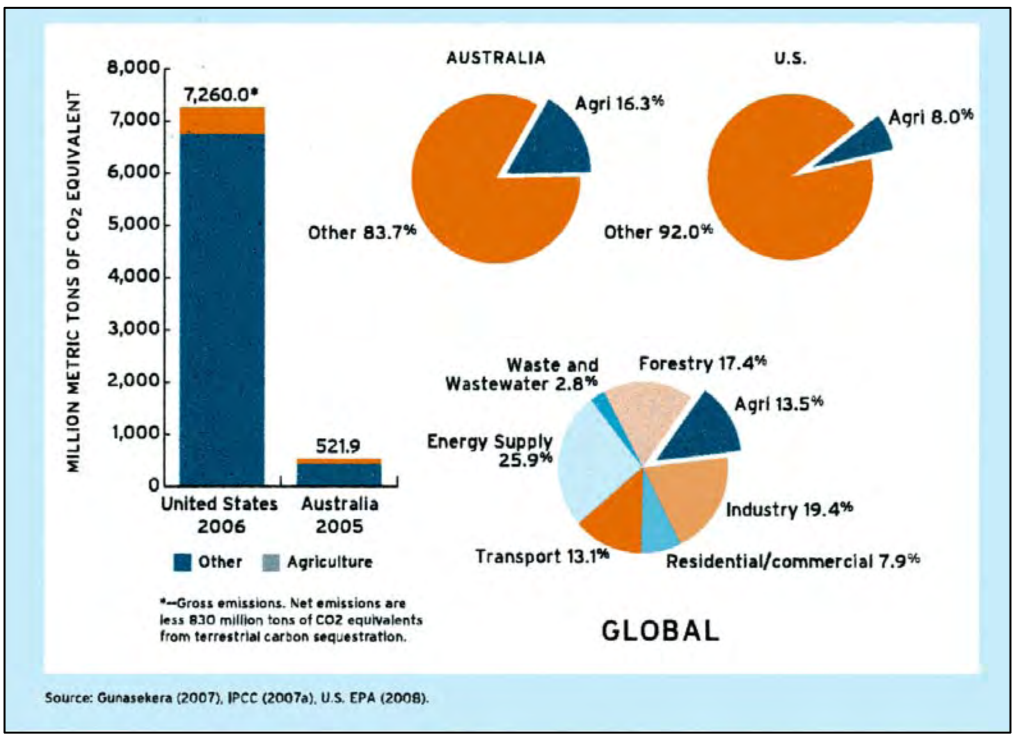
Agriculture's Role in Climate Change

Agriculture's contribution to global GHG emissions is 13.5% (Figure 2). The level varies within the Asia-Pacific region depending on agriculture's energy intensity and relative role in the economy (Pacific Economic Cooperation Council 2008). The levels are approximately 16% in Australia, 8% in the United States, 50% in New Zealand, 24% in Thailand and 2.5% in South Korea. These levels are disproportionately more than agriculture's role in the economy. In the case of New Zealand, overall emissions are very low while the country ranks among the top 20 emitters on a per capita basis (Bailey 2008).

Agricultural practices generate emissions of the three leading GHGs. CO_2 is generated 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. Nitrous Oxide emissions are stimulated by naturally occurring bacteria from soil cultivation, use of nitrogenous fertilizers, and use of animal manure. The atmospheric concentration of this GHG has been increasing linearly for the past two decades (IPCC 2007b). Methane emissions arise from cultivation of rice and from livestock production.

Asia-Pacific livestock production is growing rapidly, and methane from this source has expanded rapidly in the region even though it has stabilized at the global level. Rice production in the region is growing slowly and methane emissions from this source have likely stabilized. Rice production increased about 12%, with harvested area expanding only 1-2% from 1990-92 to 2006-08 according to the U.S. Department of Agriculture.

Figure 2—Agriculture is a Significant Contributor of GHG Emissions



Climate Change and Agricultural Productivity

The productivity of the region's agriculture has risen in the last three decades. Thus, the impacts of climate change have largely been obscured by other factors, including the adoption of new technologies such as better seed and other inputs, increased scale of operation, and improved farming practices. Climate change impacts are difficult to identify under field conditions but can be isolated under experimental conditions.

.

Average yields of major crops have shown a rising trend, though the general rate of yield growth has decreased. Notable exceptions where productivity has actually declined in recent years include Australian barley and wheat and Canadian barley (Table 1).

Table 1--Average yields of leading crops in the PECC region

	1980-89	1990-99	2000-08
Australia barley	1.4	1.8	1.7
Australia wheat	1.4	1.8	1.6
Australia sorghum	2	2.3	2.6
Australia rice	4.9	6	6.9
Canada wheat	1.8	2.3	2.4
Canada rapeseed	6	7	7.8
Canada barley	2.6	3	2.9
Canada corn	6	7	7.8
China wheat	2.7	3.6	4.2
China rice	3.5	4.2	4.4
China corn	3.7	4.8	5.1
US corn	6.6	7.7	9.1
US wheat	2.4	2.6	2.8
US soybeans	2	2.5	2.7
US rice	4.1	4.6	5.3
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
Malaysia rice	1.8	1.9	2.2
Philippine rice	1.6	1.9	2.3
Mexico corn	1.5	2.3	2.9

Source: USDA

Other trends affecting production are independent of climate change. There has been a dietary shift from food grains to livestock products in many of the region's emerging economies; production of rice and wheat has remained relatively stable while feed grain production has grown considerably.

Australia stands out as the Asia-Pacific country potentially most affected by climate change. The frequency of drought increased from one per decade in the 1980s and 1990s to three in last decade, in 2002, 2006 and 2007. Wheat yields in those years averaged about 1 ton, or about half the more typical 2 tons per hectare.

Implications for the Asia-Pacific Food System

The latest IPCC projections made several key projections important to the Asia-Pacific food system. Agricultural productivity impacts will vary among countries, food security will increase and sea level rises will affect food supply chains.

Agricultural Productivity Impacts Vary

Based on projections by IPCC (2007c) and Cline (2007), initial agricultural productivity increases in response to rising temperatures are projected in higher latitudes: Canada, the United States, China, Japan, Korea and New Zealand. The net effect on Asia-Pacific agriculture is about 2% increase in output expected by 2080. However, above a one-to-three degree rise in temperatures, impacts on agricultural productivity are expected to turn negative.

In lower latitudes, temperatures in many countries are already at levels that are beginning to adversely affect agricultural productivity, given current technology. Even one-to-two degree increases in temperature will likely have significant impact. Productivity declines in the region's Latin American and Southeast Asian economies are expected based on projected temperature changes. Australia also is projected to be among those countries most affected, as noted above. For example, wheat yields in the recent drought years averaged about 1 ton, or about half the more typical 2 tons per hectare.

Precipitation is projected to increase in most of the region except Mexico, Chile, and the southern parts of Australia and the United States. Precipitation changes will have variable effects in different countries and water management could become a critical challenge for some economies, if climate warming and changing precipitation patterns make water increasingly scarce.

According to the IPCC, weather extremes are widely expected to be more frequent and extreme and thus likely to be detrimental to agricultural productivity. The sudden onset of heat stress, drought, flooding or outbreaks of pests or pathogens are difficult to predict and may may require expensive adjustments.

Assumptions about the fertilization effects of increasing concentrations of CO_2 are crucial to projected outcomes. There remains considerable uncertainty about the impact of CO_2 atmospheric increases. According to the IPCC (2007c), "…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".

Food Insecurity Increases

The number of food-insecure people in the Asia-Pacific region is about 210 million people, with the greatest regional incidence in the poorest economies in Southeast Asia, South America, and parts of China (FAO 2008). This represents about half the incidence of food insecurity estimated for the rest of the developing world.

Climate change impacts on agricultural productivity are expected to be greatest in tropical areas where most of the region's food-insecure populations live. Economic growth can partially mitigate adverse effects of climate change by providing low-income subsistence households with resources needed to adapt to climate and other changes. The needed economic development might be achieved through application of technology and diversification of economic and agricultural activities (Natawidjaja 2008).

Sea level rise may affect 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…" (PECC 2008, p. 15).

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 the Pacific Islands are potentially the most vulnerable.

Income growth and migration of millions of people in developing parts of the Asia-Pacific region to coastal cities potentially exacerbates the problem. Human settlements within 30 kilometers of the coast are growing at twice the global average. It turns out that 9 of the 20 most populous urban agglomerations with the greatest vulnerability to coastal flooding are in the Asia-Pacific region: Guangzhou, China; Ho Chi Minh City, Vietnam; Shanghai, China; Bangkok, Thailand; Hai Phong, Vietnam; Tianjin, China; Ningbo, China; Tokyo, Japan; and Jakarta, Indonesia. The growth of these sea coast urban areas is expected to be the most important demographic change in the Asia-Pacific region over the next 50 years (PECC 2003). The agricultural impacts of sea level rise are potentially greatest for Vietnam, Mexico, and Chinese Taipei (Chang 2008) and the absolute potential impacts are greatest for China. The largest percentage of potentially affected population of 84 economies analyzed is Vietnam. And the potentially most affected land in Vietnam is among its most fertile, 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

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

Farmers regularly adjust to changes in weather, in growing conditions and in the market. However, adapting to climate change is more challenging. It requires recognition of trends, such as 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 (Rose and McCarl 2008).

Adaptive measures will be needed to reduce costs or take advantage of benefits of climate change. The costs are always positive and the size of the costs depends on the speed of climate change (Quiggin and Horowitz 2003). If 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 will depend on the extent of climate change and capacity to adapt. A wealthy farmer in Australia is 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 lack of resources (Natawidjaja 2008).

Mitigation measures are more significant because they are focused on reducing net GHG emissions or on undertaking carbon sequestration strategies. National level mitigation measures include carbon taxes, cap-and-trade systems, or other mechanisms. Agriculture stands to be affected either directly or indirectly. The costs of cap-and-trade programs are reduced by broad sectoral participation. Agriculture may be excluded because of geographic dispersion and difficulties in monitoring large numbers of farms, each emitting small quantities of GHGs. However, farms may be able 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).

Local 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. However, changes in farmer behavior are most likely to occur when they are in the economic interests of the producer.

Some Asia-Pacific region governments are promoting production of biofuels as a mitigation strategy. Biofuel’s GHG offsets vary, depending on the biomass used, how it is processed, and the extent to which land use changes are undertaken. Ethanol from sugar cane or cellulosic sources reduces GHG emissions more than ethanol from wheat or corn, and electricity production using switch grass offsets more GHG emissions than corn ethanol used as a fuel (McCarl 2008).

National initiatives to reduce GHG emissions are often difficult because of lack of broad cooperation across countries. 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 countries and not reducing overall global emissions. Australia’s cap-and-trade proposal, scheduled for introduction in 2010, reflects disincentives faced by a small 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).

The global nature of climate change requires international initiatives, such as the 1992 U.N. Framework Convention on Climate Change, the 1997 Kyoto Protocol, and the 2007 Major Economies Process. The latter is now focused on reaching 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 yet are likely to be most affected by climate change. Policy initiatives are presumably based on the best available information which is provided by modeling to assess climate change impacts. General circulation models are used extensively to project long-term climate change. Integrated assessment models provide broader insights about the potential economic and environmental impacts of climate change and provide a basis for evaluating different mitigation options (Gunasekera and Tulloh 2008).

Implications for Decision Makers

The Pacific Food System Outlook project (PECC 2008) identified a number of implications that may improve the Asia-Pacific food system adaptation and mitigation responses to climate change.

Governments must assume responsibility to disseminate data targeted to local needs and circumstances 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 information regarding climate change effects must be integrated into extension programs and economic development planning.

Public support is needed for research and development targeted at farm-level adaptation, such as:

- Development and introduction of drought-tolerant crops;
- Combating spread of 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 or plant varieties 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.

Economic development is a critical component in low-income areas, since farmers need resources to adapt to climate change. Higher income households are more capable of adapting to climate change.

There is increasing agreement that concerted and coordinated private and public sector efforts are necessary to address climate change. Programs to reduce GHGs must:

- Be implemented on a regional, or preferably global, scale through APEC, the U.N., or similar institutions.
- Achieve broad sectoral and individual economy participation to avoid 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 mechanism. This will reduce use of fossil fuels, decrease GHG emissions, and provide incentives for development and commercialization of alternative low-carbon energy sources.

Increasing production of biofuels is a strategy in which agriculture can play an important role in GHG mitigation. This requires that bioenergy is produced in ways that lead to net reductions in 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.

Given uncertain and variable long-term effects of climate change and increased likelihood of extreme events such as droughts and floods, policymakers should promote the greatest possible openness in the region's food system to reduce risk of food supply disruptions. Allowing the free play of comparative advantage will assure the most efficient allocation of food system resources and least cost in adapting the food system to climate change.

References

Antle, John M (2008). "Climate Change and Agriculture: Economic Impacts." *Choices,* 23 (1), first quarter.

Bailey, Peter (2008). "Climate and Production: The Impact of Climate on Agricultural Production in New Zealand." Presentation at 12th annual Pacific Food System Outlook meeting, Honolulu, September 16-17.

Chang, Ching-Cheng (2008b). "Climate Change and Agricultural Implications in Chinese Taipei." Presentation at 12th annual Pacific Food System Outlook meeting, Honolulu, September 16-17.

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

Dasgupta, Susmita, et al. (2007). *The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis.* World Bank Policy Research Paper 4136, February.

Food and Agricultural Organization (2008). Food security statistics; number of undernourished persons, http://www.fao.org/faostat/foodsecurity/index_en.htm (accessed in August 2008).

Garnaut, Ross (2008). "Supplementary Draft Report: Targets and Trajectories." Garnaut Climate Change Review. Canberra, September.

Gunasekera, Don, and Catherine Tulloh (2008a). "Impact of Climate Change on Agriculture and the Food System." Presentation at 12th annual Pacific Food System Outlook meeting, Honolulu, September 16-17.

Gunasekera, Don, Melanie Ford, and Catherine Tulloh (2007). "Climate Change, Issues and Challenges for Australian Agriculture and Forestry." *Australian Commodities,* September quarter.

IPCC (2007a). *An Assessment of the Intergovernmental Panel on Climate Change: Executive Summary.*

IPCC (2007b). "Changes in Atmospheric Constituents and in Radiative Forcing". Chapter 2 in *An Assessment of the Intergovernmental Panel on Climate Change: The Physical Science Basis.*

IPCC (2007c). *An Assessment of the Intergovernmental Panel on Climate Change*: *Impacts, Adaptation, and Vulnerability*.

IPCC (2007d). "Has there been a change in extreme events like heat waves, droughts, floods, and hurricanes?" 3.3 in *An Assessment of the Intergovernmental Panel on Climate Change*: *Frequently Asked Questions.*,

Lewandrowski, Jan (2008). "Impact of Climate Change on Agriculture and the Food System: A U.S. Perspective." Presentation at 12th annual Pacific Food System Outlook meeting, Honolulu, September 16-17.

Natawidjaja, Ronnie S. (2008). "Impact of Climate Change on Food System in Indonesia." Presentation at 12th annual Pacific Food System Outlook meeting, Honolulu, September 16-17.

McCarl, Bruce A (2008). "Bioenergy in a Greenhouse Mitigating World." *Choices,* 23(1),first quarter.

Pacific Economic Cooperation Council (2003). *Pacific Food System Outlook 2003-04: Where Demographics Will Take the Food System.* Singapore.

Pacific Economic Cooperation Council (2008). *Pacific Food System Outlook 2008-2009: Climate Change and the Food System*. Singapore.

Quiggin, John and John Horowitz (2003). "Costs of Adjustment to Climate Change." *The Australian Journal of Agricultural and Resource Economics*, 47:4, pp.429-446.

Rose, Steven K., and Bruce A. McCarl (2008). "Greenhouse Gas Emissions, Stabilization and the Inevitability of Adaptation: Challenges for U.S. Agriculture." *Choices,* 23(1), first quarter..