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Food Security and Climate Change to 2050: Cambodia

A Policy Discussion Paper

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Timothy S. Thomas, Ph.D. Research Fellow

International Food Policy Research Institute, Washington, DC

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Acronyms & Abbreviations

CARD	the Council for Agricultural and Rural Development
CDRI	Cambodia Development Resource Institute
CGE	Economy-wide General Equilibrium model
FAO	Food and Agriculture Organization
GCMs	Global Climate Models
GDP	Gross Domestic Product
ha	Hectare(s)
IFPRI	International Food Policy Research Institute
IMPACT	International Model for Policy Analysis of Agriculture and Commodities Trade
MMT	Million Metric Tonnes
MT	Metric Tonne
RCM	Regional Climate Model
SRES	Special Report on Emissions Scenarios
U.N.	United Nations
UNPop	United Nations Population Division
USAID	the United States Agency for International Development

1. Introduction

Cambodia's population and economy are highly vulnerable to climate change. Food security is already a major concern in Cambodia, where 25 percent of the population suffered from undernourishment in 2004-2005, a higher proportion than in neighboring Southeast Asian countries (Shicavone 2010).[1] Some 80 percent of Cambodia's population is rural and agriculture accounts for 35 percent of GDP (World Bank 2009). Two-thirds of Cambodia's population is economically dependent on agriculture (FAO 2010; Shicavone 2010), and most farmers are poorly equipped to adapt to climate change (Royal Government of Cambodia 2006).

But the impacts of climate change on Cambodia do not exclusively come from changes in domestic production. Cambodia is a net rice exporter, so increased world prices could increase the total value of domestic rice produced. On the other hand, many farmers do not produce enough rice for their own consumption and they have to purchase food seasonally. For poor agrarian households, negative productivity shocks can simultaneously decrease farm income and increase food prices, leading to severe decreases in real income that can threaten the livelihood of current and future generations. This phenomenon was evidenced by fact that half of Cambodian households reduced food consumption during the 2008 food price crisis (Shicavone 2010). Because of international linkages through trade and prices, any complete analysis of the potential domestic effects of climate change must consider impacts on a global scale.

Against this background, the food security projections have been developed using the International Model for Policy Analysis of Agriculture and Commodities Trade (IMPACT).[2] The projections must by necessity build off of some perspective on plausible futures facing agriculture. Nine different climate change scenarios, which are agreed among scholars in the world, and three different economic/demographic scenarios, which predict different speeds of economic and population growth in the world, are designed to generate the model results. We highlight a set of model projections for global food prices and production, trade, and food security outcomes for Mainland Southeast Asia in this paper, and report projections of global rice and maize prices, two commodities important to Cambodia's food security and agricultural trade. We expect that such modeling results will lead to more discussions for better understanding the potential challenges of climate change faced by Cambodia in the future.

The simulation model results indicate that world rice and maize prices will both be higher under various climate change scenarios. Whereas the world price of maize is sensitive to different assumptions of global population and income growth, the world rice price is less sensitive in the simulation. Rice and maize yields in Mainland Southeast Asia are both projected to increase substantially from 2010 to 2050. Rice yield projections are more sensitive to climate change than projections for maize yields. Moreover, the model simulation results show that neither rice nor maize yields are very sensitive to different assumptions of population or income growth, indicating inelastic supply response to higher world prices. Cultivated rice area in Mainland Southeast Asia is projected to decline from 2010 to 2050, and cultivated maize area is projected to remain mostly unchanged. Neither rice nor maize area appears to be sensitive to different climate change scenarios, or to different assumption for demographic and economic growth.

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1 This is a massive improvement from the 41 percent of the Cambodian population suffering from malnourishment in 1990-1992 (Shiavone 2010).

2 See Nelson Forthcoming and Rosegrant 2008 for more details on the IMPACT model and how it has been adapted to consider climate change.

The combined result of yield and area effects is increased Mainland Southeast Asian maize production by 2050 that is not highly sensitive to climate change or differences in demographic and economic growth. Rice production does not unambiguously increase or decrease, and is sensitive to climate change as well as differences in demographic and economic growth. Mainland Southeast Asia as a whole is currently a net rice and maize exporter. Our projections indicate the region will continue to be a net rice exporter under all climate, demographic, and economic scenarios used for the model. However, the region will become a net maize importer by 2050, also under all climate, demographic, and economic scenarios used.

We find that food availability in Mainland Southeast Asia will increase under more optimistic scenarios of population and economic growth, but decrease under pessimistic scenarios. Likewise, the number of malnourished children in Mainland Southeast Asia will decrease under more optimistic scenarios of demographic and economic growth, but decrease under pessimistic scenarios. In all cases examined, climate change will negatively impact food security outcomes in the region.

2. Scenario analysis

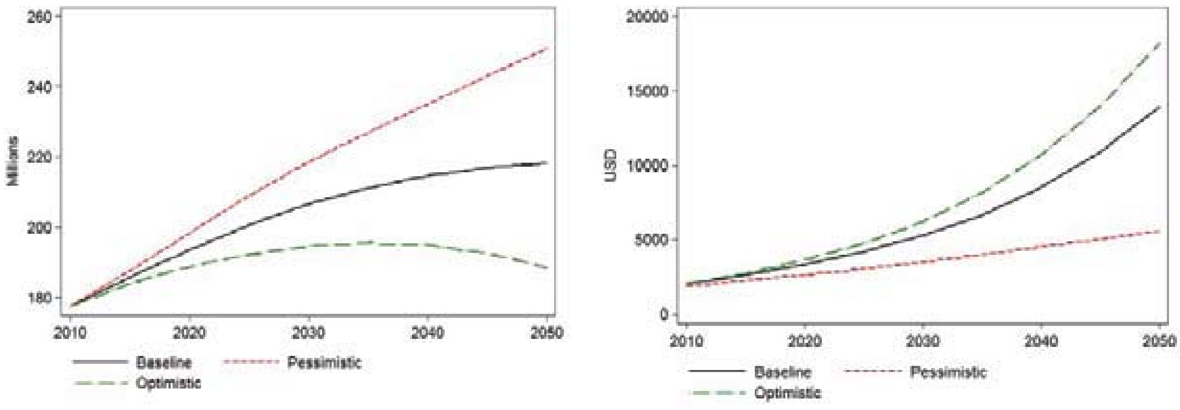
The above projections must by necessity build off of some perspective on plausible futures facing agriculture. The process of developing this perspective is called scenario development. The Millennium Ecosystem Assessment's Ecosystems and Human Well Being: Scenarios, Volume 2, Chapter 2 provides a useful summary definition of scenarios.

> *"Scenarios are plausible, challenging, and relevant stories about how the future might unfold, which can be told in both words and numbers. Scenarios are not forecasts, projections, predictions, or recommendations. They are about envisioning future pathways and accounting for critical uncertainties." (Raskin, et al. 2005)*

These scenarios can be developed over multiple dimensions. Nelson *et al*. (forthcoming) describes three "overall scenarios"– a baseline scenario that is "middle of the road", a pessimistic scenario that chooses driver combinations that, while plausible, are likely to result in more negative outcomes for human well-being, and an optimistic scenario that is likely to result in more positive outcomes.

To create the three overall scenarios for our model we used U.N. high, medium, and low variant population projections for the pessimistic, baseline, and optimistic scenarios, respectively (Figure 1, left). For income projections we used optimistic, baseline, and pessimistic GDP projections from the World Bank divided by the corresponding population projections from the U.N. (Figure 1, right). Note that because these are global projections they not only determine domestic demand in Cambodia or regional demand in Mainland Southeast Asia, but global demand which forms world prices.

Figure 1: Projections of population (left) and per capita income (right) for Cambodia to 2050

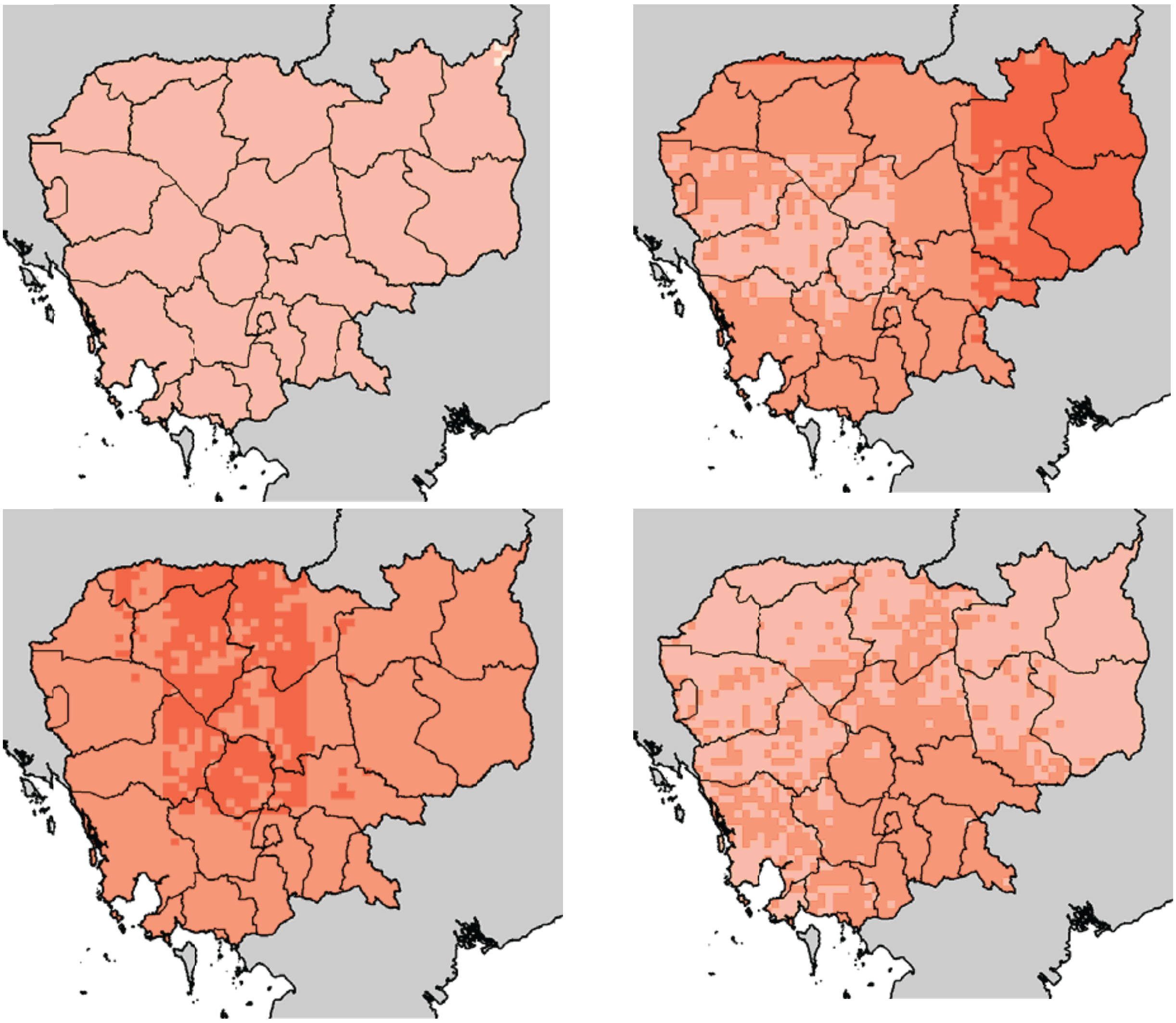


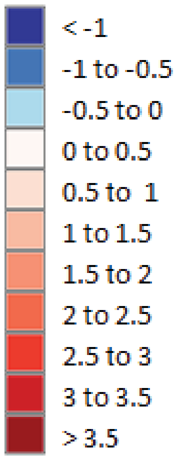
Source: UNPop and World Bank
Note: All dollar amounts are in constant 2000 $US.

These overall scenarios are crossed with a series of climate scenarios developed as follows. Three climate change scenarios (called Special Report on Emissions Scenarios, or SRES) are each developed quantitatively using four different global climate models (GCMs), plus one "perfect mitigation" scenario, for a total of 13 SRES-GCM pairs, which we refer to as simply climate scenarios (Nakicenovic, *et al*. 2000).[3] In this report we limit ourselves to the SRES A1B and B1 scenarios, and to two global climate models, CSI and MIR, plus one perfect climate change mitigation scenario, resulting in five climate scenarios of analysis. We use multiple GCM models and multiple scenarios to account for uncertainty, a dominating underlying theme in the science of climate change. There is considerable uncertainty over the future of greenhouse gas emissions, which is demonstrated by the differences in SRES scenarios. There is also uncertainty in how greenhouse gasses will impact climate change, as projections from different GCMs can vary substantially. For instance, Figures 2 and 3 show projections for changes in average mean temperature and precipitation from 2000 to 2050, respectively, between four different GCMs, all considering the same SRES scenario, A1B. This report presents results using the CSI and MIR GCMs, which are located in the top left and top right panels, respectively. The MIR GCM projects a slightly warmer (particularly in the East) and much drier Cambodia in 2050 than the CSI GCM under the A1B SRES.

3 In the "perfect mitigation" scenario, hypothetical technologies allow for perfect mitigation of all increases in greenhouse gas emissions. The climate change scenarios and GCMs are described in greater detail in the appendix of Nelson et al. (forthcoming). Although it is difficult to make broad generalizations about the differences between GCM model results, the MIR GCM scenarios result in a generally wetter future than the CSI GCM, with the exception of some regions, most notably Northeastern Brazil and the Eastern United States, for which the MIR GCM scenarios result in a much drier (Nelson et al. forthcoming).

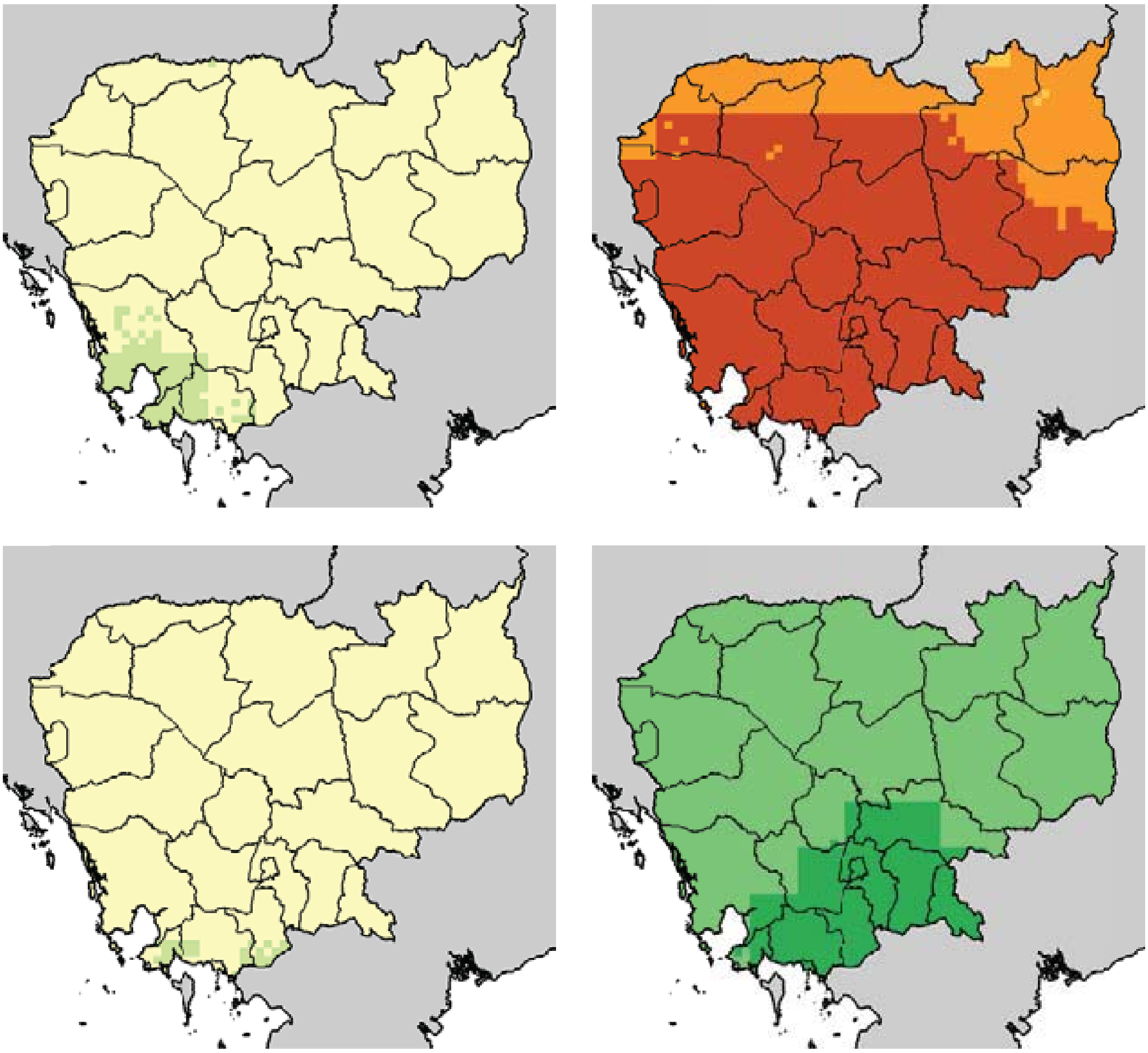
Figure 2: Maps showing changes in normal annual maximum temperature (in °C) for Cambodia between 2000 and 2050 using the A1B scenario



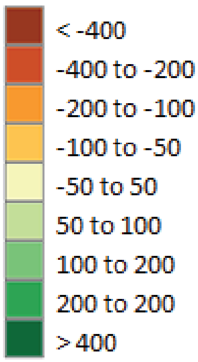


Source: IFPRI estimates.
Note: All maps assume the A1B scenario. The bottom left is from the CNRM-CM3 GCM; top left is from the CSIRO-MK3 GCM (CSI); top right is from the MIROC3.2 (MIR) GCM; bottom right is from the ECHAM5 GCM.

Figure 3: Changes in mean annual precipitation (in mm) for Cambodia between 2000 and 2050 using the A1B scenario



Source: IFPRI estimates.
Note: All maps assume the A1B scenario. The bottom left is from the CNRM-CM3 GCM; top left is from the CSIRO-MK3 GCM (CSI); top right is from the MIROC3.2 (MIR) GCM; bottom right is from the ECHAM5 GCM.



In this report we report model outcomes for Mainland Southeast Asia as whole. Disaggregated results for Cambodia are possible in the future. A description of the modeling methodology used for the Future of Food and Farming Project along with global results can be found in Nelson *et al.* (forthcoming), with more detail specific to the IMPACT model available in Rosegrant *et al.* (2008). The outcomes we present include world price, yield (including yield net of price effects, i.e. yield changes induced exclusively by climate change), production, and net trade.

3. Results

World Prices

In this report we present projections for world prices of rice and maize, two crops for which Cambodia is currently an exporter, with the potential for increasing export capacity in the future (Agrifood Consulting International 2002; Best 2009; FAO 2010; Shicavone 2010). The model projects prices for several internationally traded commodities; more results can be found in Nelson *et al.* (forthcoming).

Under the baseline overall scenario and perfect mitigation, the world price[4] of rice reaches $330/MT in 2050, nearly a 50 percent increase over the current price. Under the pessimistic overall scenario and perfect mitigation it reaches $378 (nearly as high as under climate change and the baseline overall scenario), and under the optimistic overall scenario and perfect mitigation the price only reaches $284 (Figure 4, left). This is because income elasticity of rice demand becomes very elastic when incomes increase. Consequently, the price can get very high when incomes are low and demand is high but drop quickly as incomes increase.

World maize prices are projected to increase more than other cereals in percentage terms, but are less sensitive to the overall scenario chosen. Under the assumption of perfect mitigation, the price of maize will increase by 64 percent from 2010 to 2050. Climate change makes this increase much more drastic, ranging from 91 to 132 percent depending on the climate scenario. Whereas future world maize prices are highly sensitive to climate change, they are rather insensitive to the overall scenario chosen. The price of maize in 2050 is most insensitive to the overall scenario chosen under perfect mitigation, ranging from $183 to $196 per MT. Under climate change the price of maize is slightly more sensitive to the overall scenario. The price is most sensitive under the CSI A1 climate scenario, but still only ranges from $222 to $246 per MT. There are two major offsetting factors that result in such small differences between overall scenarios: world population and world income. Under the optimistic scenario there are less people, decreasing demand, but those people have higher incomes and higher demand for meat, increasing demand for maize as feed (Figure 4, right).

The world prices of both rice and maize are lower under the perfect mitigation scenario than under any of the climate change scenarios under all three overall scenarios, indicating that the result of higher rice prices under climate change is robust to a variety of climate scenarios. The price of maize is more sensitive to the specific climate scenario chosen, and is particularly high under the MIR A1 scenario, which projects a much drier U.S. Corn Belt and Northeastern Brazil.

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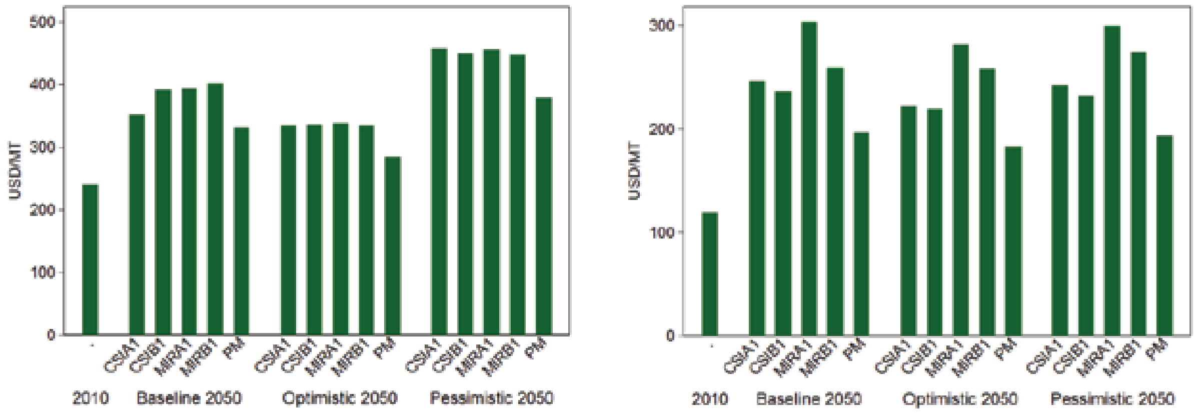
4 All prices and values in this report are given in constant 2000 dollars.

Figure 4: World rice (left) and maize (right) prices in 2010 and 2050 under different overall and climate scenarios

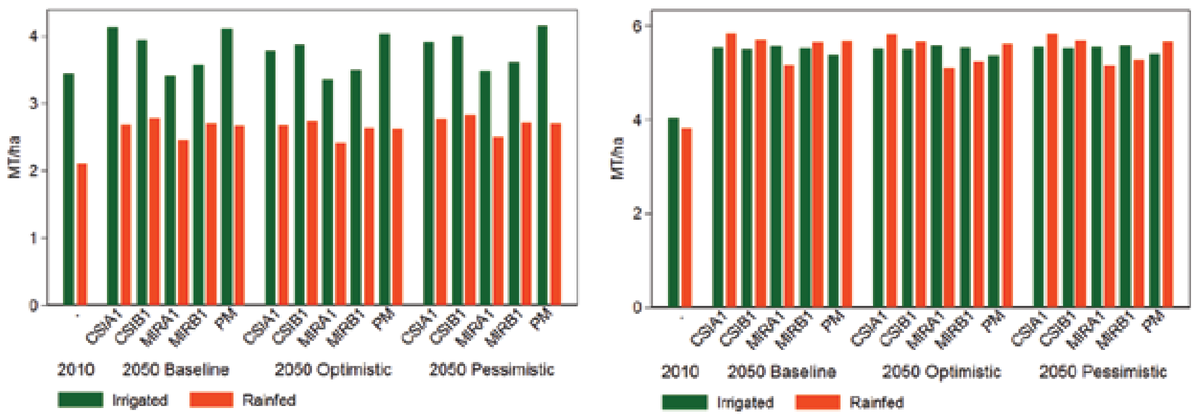


Source: IFPRI estimates

Yields

Irrigated rice yields are currently over 50 percent greater than rainfed rice yields in Mainland Southeast Asia. Our model projects that both will increase nearly equally in magnitude from 2010 to 2050. Under CSI GCM projections, climate change is not projected to have much of an impact on rice yields, whereas under MIR CGM projections climate change is projected to hinder yield growth. Our projections indicate that irrigated rice yields are projected to be slightly more affected by climate change than rainfed yields in magnitude (Figure 5, left). Although this may seem counterintuitive, note that rainfed and irrigated rice are not necessarily grown in the same areas of Mainland Southeast Asia, so the difference is more likely attributable to different geographies than differences in the two systems. Under the pessimistic scenario rice yields are projected to grow slightly more than under the optimistic scenario, indicating that rice producers can respond to higher prices, although supply is highly inelastic. Unlike for rice, rainfed and irrigated maize yields in Mainland Southeast Asia are nearly equal in 2010, and are projected to be nearly equal in 2050. Maize yields are not projected to be very sensitive to climate change, nor to the overall scenario (Figure 5, right).

Figure 5: Mainland Southeast Asian rice (left) and maize (right) yields in 2010 and 2050 under different overall and climate scenarios

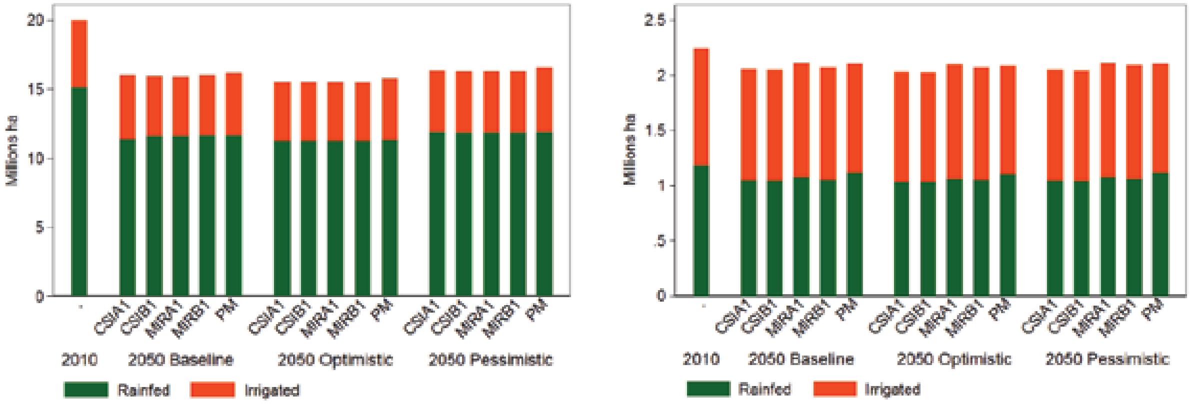


Source: IFPRI estimates

Cultivated Area

Our projections indicate that under all climate and overall scenarios the cultivated area of rice will decrease by over 20 percent from 2010 to 2050. The magnitude of this decrease is robust to the climate scenario chosen, but is slightly lower under perfect mitigation than under climate change. The decrease is also smaller under the pessimistic scenario, demonstrating that there is an area response to high prices, albeit a small one. Note that the decrease in yields comes almost exclusively from rainfed systems (Figure 6, left). The cultivated area of maize is currently about one tenth of that of rice, but unlike rice area is not projected to decrease much by 2050 (Figure 6, left). The stability of cultivated area in both rice and maize is highly robust to the climate and overall scenario chosen for the model.

Figure 6: Mainland Southeast Asian rice (left) and maize (right) cultivated areas in 2010 and 2050 under different overall and climate scenarios

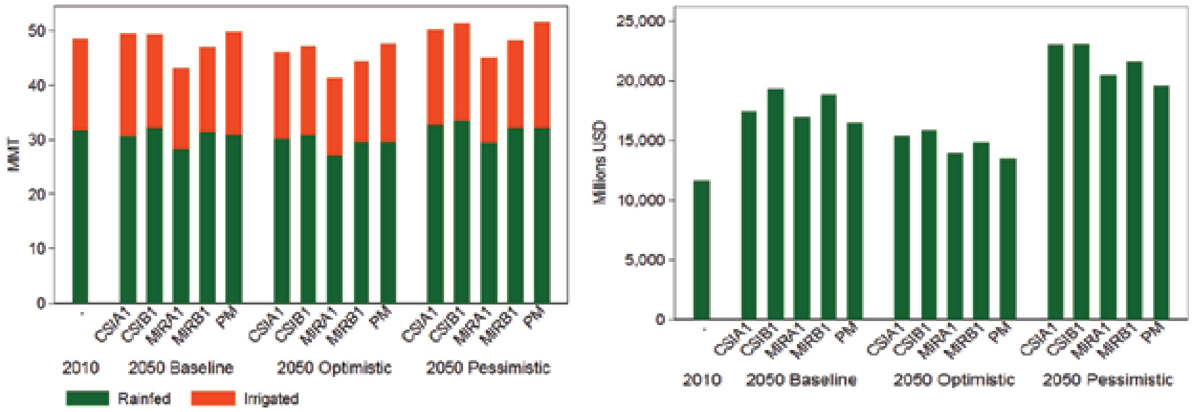


Source: IFPRI estimates

Production

In quantity terms, our model does not project major changes in Mainland Southeast Asian rice production. We do find that rice production is projected to be lower under MIR climate scenarios than under CSI climate scenarios or perfect mitigation, and lowest under the MIR A1 climate scenario. Production is projected to be slightly higher under the pessimistic overall scenario than the baseline overall scenario, and slightly lower under the optimistic overall scenario than the baseline overall scenario because of a price response in both area and yields (Figure 7, left). The value of rice production, however, is projected to increase dramatically from 2010 to 2050, by between 20 and over 100 percent depending on the scenario chosen (Figure 7, right). Based on projections for quantity produced, it is clear that increases in value of rice production are driven by price, rather than quantity, increase.

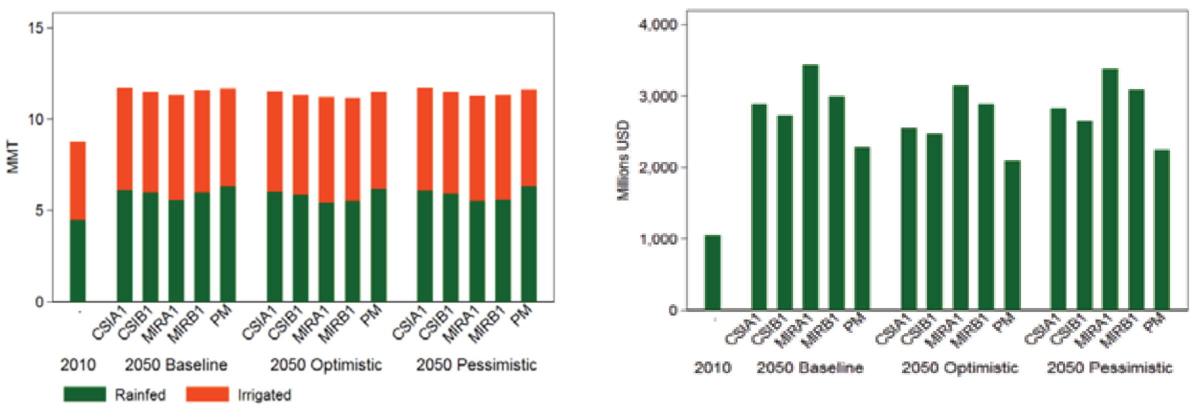
Figure 7: Mainland Southeast Asian rice production (left) and value of production (right) in 2010 and 2050 under different overall and climate scenarios



Source: IFPRI estimates

Unlike for rice, maize production in Mainland Southeast Asia unambiguously increases from 2010 to 2050 across climate and overall scenarios. Maize production is not sensitive to the climate or overall scenario chosen (Figure 8, left). The increase in the value of maize production, and differences in the increase across scenarios, is therefore driven mainly by price (Figure 8, right).

Figure 8: Mainland Southeast Asian maize production (left) and value of production (right) in 2010 and 2050 under different overall and climate scenarios

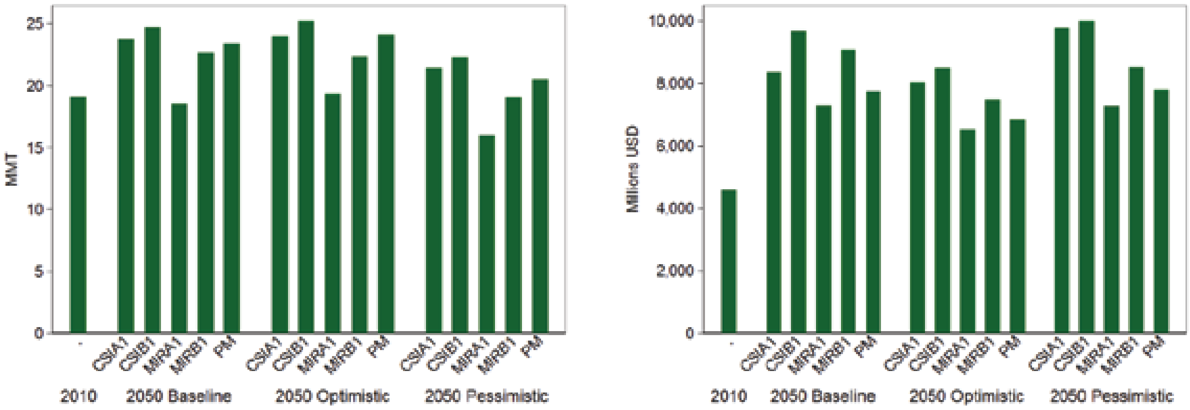


Source: IFPRI estimates

Trade

In recent years Cambodia has joined Thailand and Vietnam as a major rice exporting country in Mainland Southeast Asia (Shicavone 2010). Our model projections for the region indicate that the quantity of Mainland Southeast Asian net rice exports will increase under perfect mitigation and most climate scenarios, but will decrease under the MIR B1 climate scenario. Our results also show that the quantity of net rice exports is sensitive to differences in demographic and economic growth; under the pessimistic overall scenario rice net exports are projected to remain constant or even decrease from 2010 to 2050 (Figure 9, left). Because of price increases, the value of rice exports unambiguously increases under all climate and overall scenarios from between 70 to 125 percent (Figure 9, right).

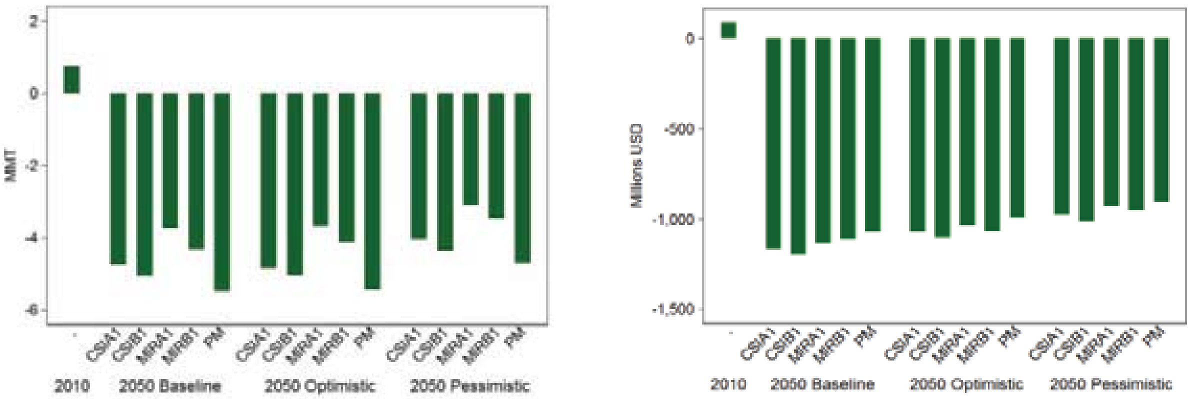
Figure 9: Quantity (left) and value (right) of Mainland Southeast Asian net rice exports in 2010 and 2050 under different overall and climate scenarios



Source: IFPRI estimates

Mainland Southeast Asia is currently a small maize exporter. While some analysts expect Cambodia to become the Corn Belt of Southeast Asia (Best 2009), these expectations are not reflected in net exports from Mainland Southeast Asia as a whole. Our projections indicate that by 2050 Mainland Southeast Asia will be a net maize importer on the order of 4 to 6 MMT (Figure 10, left) and 1 billion USD (Figure 10, right). Maize imports to the region are expected to be lowest under MIR climate change scenarios, largely because of high prices caused be decreased production in the U.S. and Brazil. The value of maize imports to Mainland Southeast Asia is mostly insensitive to climate change, and is expected to be lower under both the optimistic and pessimistic overall scenarios than the baseline overall scenario.

Figure 10: Quantity (left) and value (right) of Mainland Southeast Asian net maize exports in 2010 and 2050 under different overall and climate scenarios



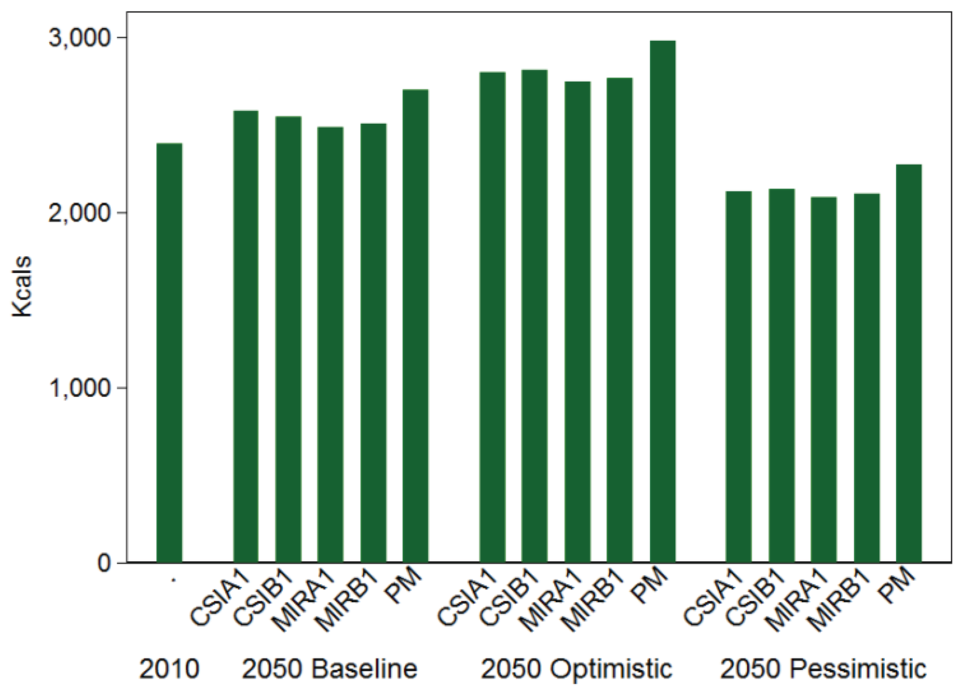
Source: IFPRI estimates

Food Security

Current estimates indicate that there are 3.6 million malnourished in Cambodia, and 27.5 million malnourished in Mainland Southeast Asia (Shicavone 2010). Malnourishment can come in the form of low calorie consumption, and micronutrient deficiencies. While a complete picture of malnourishment is not possible without both, data is typically only readily available for per capita calorie availability. This data is generated as national food availability (production less net exports) divided by population. Using 2000 levels of calorie availability as a baseline, our model generates projections for per capita calorie availability under different climate change and overall scenarios. In 2010, per capita calorie availability in Mainland Southeast Asia is much lower (around 2400 kilocalories) than it is in China (just over 3000), or the U.S. (just over 3500).

Our projections indicate that per capita calorie availability could either increase or decrease depending on the overall scenario chosen. Under the optimistic overall scenario per capita kilocalorie availability will reach between 2700 and 3000 kilocalories per day in 2050, depending on climate change. Under the baseline overall scenario per capita kilocalorie availability will reach between 2500 and 2700 kilocalories in 2050, depending on climate change, still an improvement from current levels. Under the pessimistic scenario, however, food availability is projected to be lower in 2050 than today, at between 2100 and 2300. Under all three overall scenarios, food availability is highest under perfect mitigation, in other words, the finding that climate change will decrease food availability in Mainland Southeast Asia is robust to the four climate change scenarios we use in our model (Figure 11).

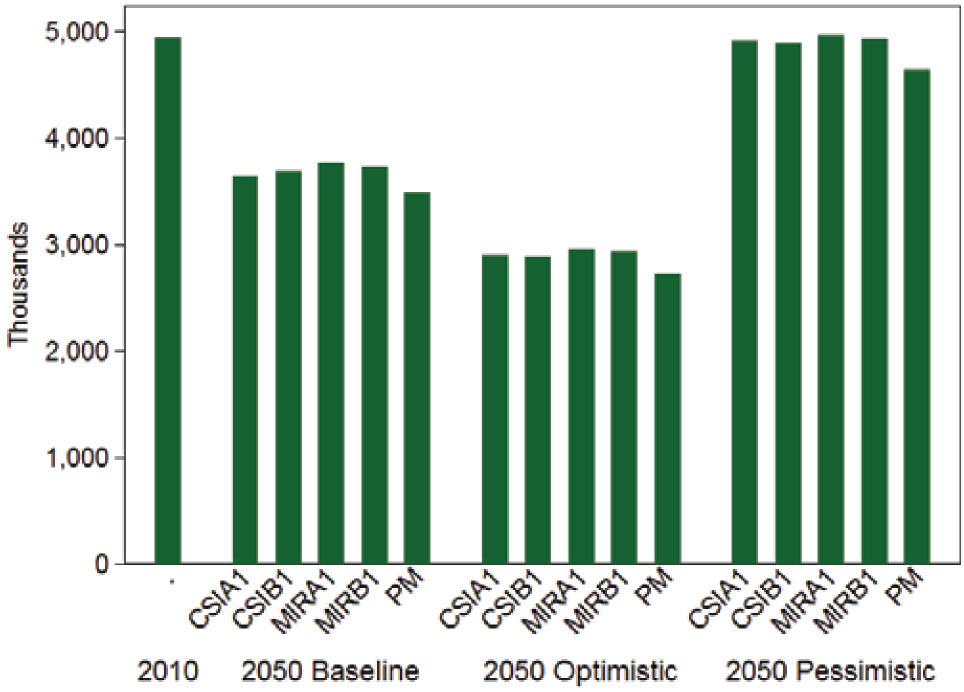
Figure 11: Per capita daily kilocalorie availability in Mainland Southeast Asia in 2010 and 2050 under different overall and climate scenarios



Source: IFPRI estimates

Following the method of Smith and Haddad (2001), we calculate changes in the number of malnourished children from changes in per capita calorie availability. The results show that the number of malnourished children decreases from 2010 to 2050 by over 20 and 30 percent under the baseline and optimistic overall scenarios, respectively. The number of malnourished children will stay at 2010 levels under the pessimistic scenario at nearly 5 million. The result that climate change will decrease the decline in childhood malnourishment is robust across overall scenarios, although the difference between outcomes under climate change and the perfect mitigation scenarios is slight (Figure 12).

Figure 12: Number of malnourished children under five in Mainland Southeast Asia in 2010 and 2050 under different overall and climate scenarios



Source: IFPRI estimates

4. Potential Areas of Future Research

There are several possible ways to apply the IMPACT model to better assess the potential impacts of climate change on Cambodian agriculture, trade, and food security. Here we offer a few potential avenues for the future research. First, IMPACT can be useful for creating projections of how the world food economy would react to certain exogenous shocks. Until present, the model has been used to test the impacts of improvements in commercial maize productivity, improvements in developing country wheat productivity, a regional drought in South Asia, global improvement in water basin efficiency, and changes to trade policy (see Nelson forthcoming). Such simulations may be useful for examining policies relevant to Cambodia, for example improvements to rice productivity, or policies banning rice exports when world food prices spike.

One foreseeable (and relatively easy) adaptation would be to desegregate the countries of Mainland Southeast Asia to allow for Cambodia-specific projections. This is especially important considering the heterogeneity of the region, and the relatively small size of Cambodia's population compared to Thailand and Vietnam.

Another possibility is to generate agricultural productivity changes using a Regional Climate Model, such as the PRECIS model developed by the Hadley Center for Climate Prediction and Research.[5] For a small country with a small area to coastline ratio, using climate projections using an RCM rather than a GCM offers much better resolution, and more accurate projections of crop productivity. While IMPACT currently uses a GCM to form projections, it could foreseeable be adapted to use an

5 Details of the PRECIS model can be found at http://precis.metoffice.com/new_user.html.

RCM for certain countries of interest.

A difficult topic throughout the realm of climate modeling is how to deal with changing variability in climate. Currently, IMPACT models changes in crop productivity coming from long term changes in mean rainfall and precipitation. Many of Cambodia's concerns over vulnerability of the agricultural sector due to climate change, however, come from the possibility of increasing extreme events such as droughts and floods (Royal Government of Cambodia 2006). Incorporating extreme events and changes in weather variability is currently being discussed by IMPACT developers, and such an improvement may prove very useful in generating projections for countries like Cambodia that are particularly susceptible to both drought and floods.

More research also requires to further identify various impact channels through which both existing climate variability and longer-term climate change may affect food security and future economic development, including economic growth, poverty reduction and vulnerability at national and sub-national levels, and assess which impact channels are more important in the case of Cambodian agriculture. To accomplish this, an economy-wide general equilibrium model (CGE) may be necessary. Such models can assess how the impacts of climate change on energy (including hydropower), rural and coastal infrastructure (including roads), and other sectors that are highly sensitive to the climate change and important to agriculture affect agriculture (including fisheries, livestock and agro-forestry). By incorporating price and yield projections from the IMPACT model, a CGE model can better assess impact of climate change on the local economy through both domestic and international market channels. This type of research will not only be necessary for understanding the magnitude of climate change impact, but also helpful for planning future infrastructural investments including development of new irrigation systems. While climate change is a long-term and gradual process, attention will also need to given to the observed impacts of past extreme weather events (floods, droughts and windstorms), given that the frequency of such extreme events may increase with climate change. Learning from past experiences of coping with extreme events at community, sub-national and national level will be helpful for designing practical plans and policy interventions addressing adaptation and mitigation measures.

References

Agrifood Consulting International. 2002. “Rice Value Chain Study: Cambodia.”

Best, P. 2009. “Cambodia could become an Asian maize belt.” *WATTAgNet.com*, December 9.

Nakicenovic, N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin, K. Gregory, A. Grubler, T. Jung, and T. Kram. 2000. *Special report on emissions scenarios: a special report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge UK: Cambridge University Press.

Nelson, G.C., M.W. Rosegrant, A. Palazzo, I. Gray, C. Ingersoll, R. Robertson, T. Zhu, T. Sulser, C. Ringler, and S. Msangi. Forthcoming. “Food Security and Climate Change Challenges to 2050: Key Messages from the Future of Food and Farming Quantitative Scenarios.” Washington D.C., International Food Policy Research Institute.

Raskin, P., F. Monks, T. Ribeiro, D.v. Vuuren, and M. Zurek. 2005. Global Scenarios in Historical Perspective, ed. S. Carpenter,P. Pingali,E.M. Bennett, and M. Zurek, vol. 2. Washington DC, Island Press.

Rosegrant, M., C. Ringler, S. Msangi, T. Sulser, T. Zhu, and S. Cline. 2008. “International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model Description.” International Food Policy Research Institute.

Royal Government of Cambodia. 2006. *National Adaptation Programme of Action to Climate Change*. Phnom Penh: Minstry of the Environment.

Shicavone, A. 2010. “Trade and climate change implications for food security in mainland Southeast Asia.” International Institute for Sustainable Development.

Smith, L., and L. Haddad. 2001. “How important is improving food availability for reducing child malnutrition in developing countries?” *Agricultural Economics* 26(3):191-204.

World Bank. 2009. World Development Indicators.