THE ECONOMYWIDE IMPACTS OF CLIMATE CHANGE ON PHILIPPINE AGRICULTURE

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It has been widely shown for most countries that high productivity growth in the agricultural sector is a key driver of structural transformation to promote long-term economic growth. Historically, low agricultural productivity growth has hindered economic growth and employment creation in the Philippines, where agriculture—which accounts for one-third of employment—remains a key sector. Climate change has the potential to disrupt crop productivity, and in turn affect domestic agricultural production, consumption, and food security. Moreover, the global impact of climate change could stimulate changes in international and national commodity prices that ultimately have negative effects on both Philippine agriculture and the country's overall economy. Developing agricultural adaptation and growth strategies is of the utmost importance not only to maintain domestic agricultural production, but also to underpin broader economic growth and structural transformation. Sustaining agricultural production growth to help achieve inclusive growth and poverty reduction is a key goal for the Philippine government.

This policy note summarizes the results of economic modeling analyses presented in the forthcoming International Food Policy Research Institute (IFPRI) and National Economic and Development Authority (NEDA) manuscript, The Future of Philippine Agriculture: Scenarios, Policies, and Investments under Climate Change, edited by Mark W. Rosegrant, Arsenio Balisacan, and Mercedita Sombilla.

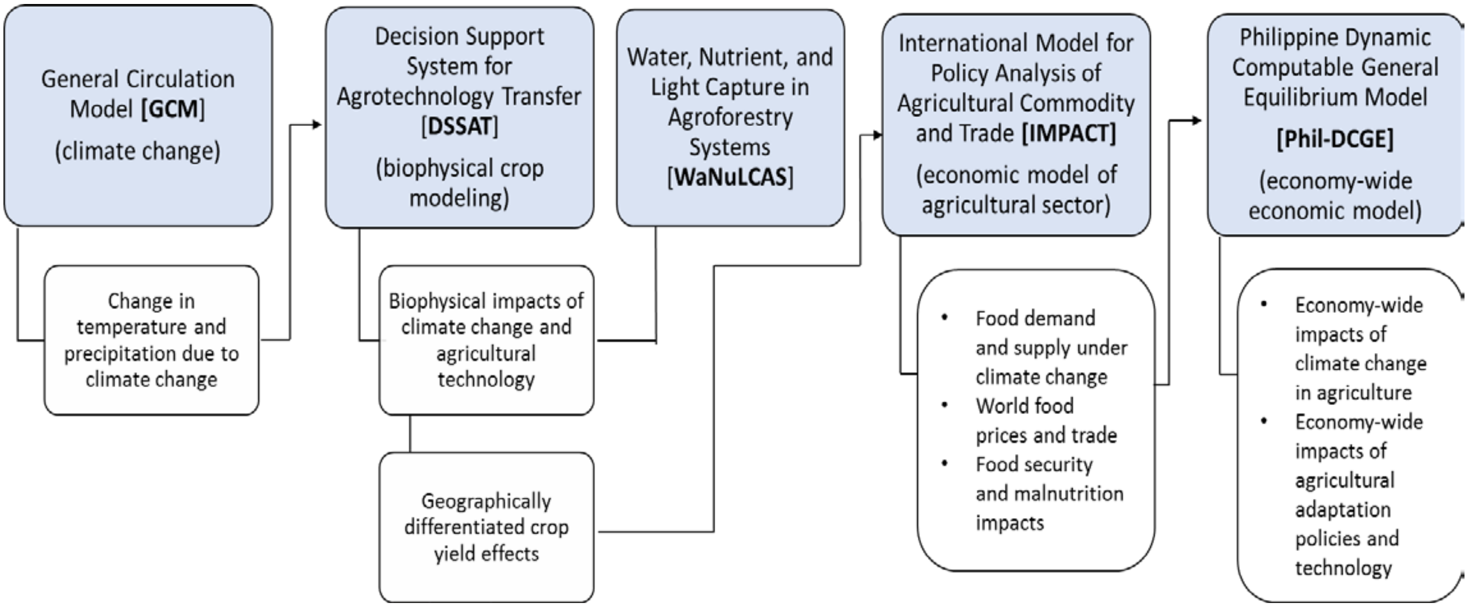
MODELING FRAMEWORK

The study on which this policy note is based used a linked modeling approach to assess the effects of alternative agricultural policies, technologies, and investments; macroeconomic policies and institutions; and climate adaptation strategies on agriculture under a range of simulated climate and socioeconomic "futures" to evaluate agricultural strategies to address climate change in the Philippines (Figure 1). The analytical framework for the analysis integrates a range of macro- and microeconomic modeling components, including general circulation models (GCMs) that generate climate change scenarios; biophysical crop modeling using the Decision Support System for Agrotechnology Transfer (DSSAT) for field crops and the Water, Nutrient, and Light Capture in Agroforestry Systems model (WaNuLCAS) for coconuts and bananas; partial equilibrium economic modeling of the agricultural sector using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT); and economywide analysis using a dynamic computable general equilibrium model of Philippines (Phil-DCGE).

GCMs are developed by climate scientists to determine how climate might change in response to greenhouse gas (GHG) accumulation in the upper atmosphere. The Intergovernmental Panel on Climate Change (IPCC) has a process by which teams submit models for use in IPCC assessment reports. Assessment Report 4 (AR4) incorporated 24 models, whereas Assessment Report 5 (AR5) included 61 models. The analysis presented in this policy note is based on the following four AR5 models:

1. GFDL-ESM2M, which was developed by the National Oceanographic and Atmosphere Administration's General Fluid Dynamics Laboratory (GFDL) (Dunne et al. 2012, 2013)
2. HadGEM2-ES, the Hadley Centre Global Environmental Model (HadGEM), from the Met Office Hadley Centre (Collins et al. 2011; Martin et al. 2011)
3. IPSL-CM5A-LR, generated by Institut Pierre-Simon Laplace (IPSL) (Dufresne et al. 2013)
4. MIROC-ESM-CHEM, (MIROC), from the Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (University of Tokyo), and National Institute for Environmental Studies (Sakamoto et al. 2012).

Figure 1. Linked modeling system for the assessment of agricultural climate change impacts on the Philippine economy



Source: Constructed by authors.

GCMs provide monthly rainfall and temperature data under alternative climate change scenarios, the results of which are downscaled to the pixel level for input into the crop models.

DSSAT, developed by Jones et al. (2003), integrates crop, soil, and weather databases into standard formats for use by crop models and other applications. Weather statistics from climate models are incorporated in order to estimate crop yields under existing and various future climate scenarios. Similarly, WaNuLCAS (van Noordwijk, Lusiana, and Khasanah 2004) models daily plant growth, accounting for water, nutrients, and light, as well as the soil properties. These biophysical models are used to estimate the impacts of both climate change and crop management and technology on crop yields, the results of which constitute inputs into IMPACT under alternative scenarios.

IMPACT was originally developed by IFPRI to project food supply, demand, prices, trade, and security to 2020 and beyond (Rosegrant et al. 2012) and has been expanded to include the impact of water resources and climate change. It analyzes 62 crop and livestock commodities in 151 countries and regions of the world that together cover the earth's land surface (except Antarctica). The model also links national production and demand relationships through international trade flows and prices. Results from IMPACT are then fed into the Phil-DCGE model to assess economywide impacts of the agricultural sector outcomes.

Phil-DCGE is a dynamic computable general equilibrium model that was developed for this study to assess the economywide impacts of climate change in the agricultural sector and to explore policy alternatives to offset these effects. The model includes 14 agricultural subsectors, 2 mining subsectors, 14 food industry subsectors, 7 other manufacturing subsectors, and 2 service sectors; 5 factors of production (labor, land, agricultural capital, livestock capital, and nonagricultural capital); and 30 types of households, subdivided into the three regions (Luzon, Visayas, and Mindanao), two locations (urban and rural), and by income quintile.

ANALYSIS AND RESULTS

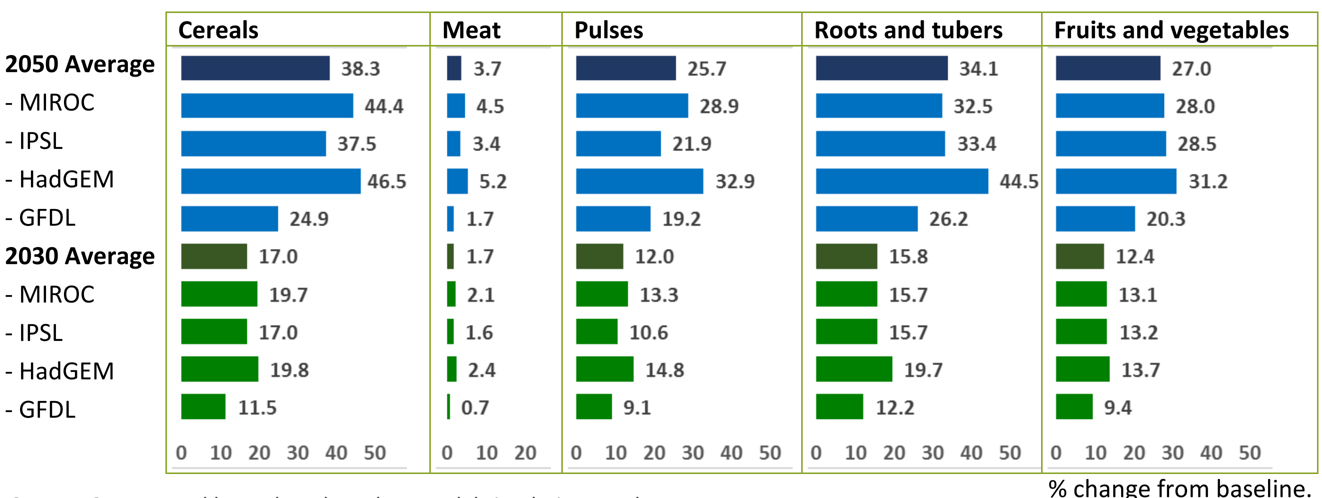
Climate Change Impact on Commodity Production, Prices, and Economic Welfare in Agriculture

Globally, climate change has adverse impacts on crop yields. These yield changes result in reduced supply, higher world commodity prices, and reduced food consumption. At the same time, higher commodity prices induce higher levels of farm production, partially offsetting the negative impact of climate change on yields.

Taking both these positive and negative effects into account, assuming the full transmission of higher world prices to domestic prices in the long run, and averaging the individual results of the four GCMs, total crop production in the Philippines is projected to be 4 percent lower under climate change in 2050 than it otherwise would be under baseline levels—that is, without climate change. Cereal production is projected to fall by 5 percent in 2050 compared with baseline levels. The negative impact of climate change on corn production, a decline of 13.6 percent, is projected to be significantly higher than for rice production, which has a projected decline of only 1 percent in 2050 compared to the baseline. Due to links with cereals used as feed, meat production is also projected to undergo a decline of about 0.8 percent. (Note that due to a lack of relevant models and data, the direct impacts of climate change on livestock were not able to be calculated.)

The resulting effects of reduced productivity and production on the accessibility of agricultural commodities for consumption are substantial. Prices of agricultural food commodities are projected to increase in 2030 and 2050 due to climate change, making them less accessible generally, but especially to poor people. Increases in consumer prices by 2050 are projected to be substantial for cereals (38 percent), roots and tubers (34 percent), and fruits and vegetables (27 percent) compared with baseline values (Figure 2). Meat prices are projected to increase by 4 percent; among cereals, rice prices are projected to increase by 26 percent, corn prices by 45 percent, and wheat prices by 15 percent. The decline in average per capita consumption in 2050 is projected to be 6 percent for fruits and vegetables, 5 percent for cereals, 5 percent for roots and tubers, 3 percent for pulses, and 0.4 percent for meat. Among cereals, per capita consumption of corn is projected to decline by 6 percent, wheat by 5 percent, and rice by 4 percent in 2050.

Figure 2. Changes in consumer prices of major agricultural commodities, 2030 and 2050.



Source: Constructed by authors based on model simulation results.

Notes: GFDL = General Fluid Dynamics Laboratory; HadGEM = Hadley Centre Global Environmental Model; IPSL = Institut Pierre-Simon Laplace; MIROC = Model for Interdisciplinary Research on Climate.

The Impact on Food Security, Childhood Malnutrition, and Hunger

Another impact of climate change is the effect of agricultural changes on food security, which in this analysis is measured by the prevalence of childhood malnutrition and the number of people experiencing hunger or at risk of hunger. Three million Philippine children were classified as malnourished in 2010. This number is projected to decline to 2.7 million in 2030 and to 2.2 million in 2050 under a baseline scenario (that is, without the effects of climate change). With climate change, however, an additional 70,000 children are projected to fall into the undernourished category in 2050, representing a 4-percent increase in 2050 due to climate change (based on average results from the four GCMs). The impact of climate change on the number of people at risk of hunger is estimated to be even more severe. Results averaged across the GCMs project an increase of 1.4 million people at risk of hunger in 2030 (9 percent) and 2.5 million more people at risk of hunger in 2050 (17 percent).

The Impact on Economic Welfare in Agriculture

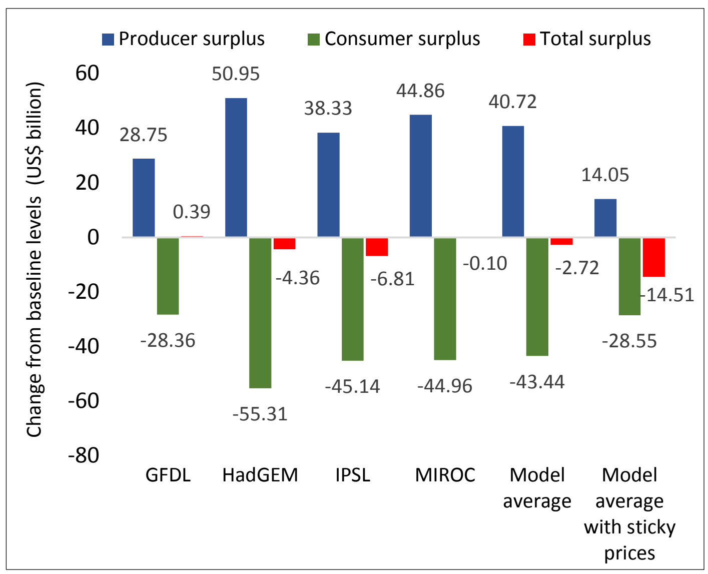
The estimates above of the impact of climate change on the supply and demand of agricultural commodities can be used to measure changes in the economic welfare of the Philippine population. The economic surplus framework estimates the producer and consumer surplus and net welfare changes induced by climate change in 2050, once again compared with a baseline scenario of no climate change, assuming full transmission of world prices to national prices, and averaging the individual results of the four GCMs (Table 1, Figure 3). Results project a net present value of welfare loss to the entire society of US$2.72 billion over 40 years or US$68 million per year. The net welfare loss to the agricultural sector due to climate change is thus equivalent to Php 3.2 billion per year. These costs are borne by consumers, with welfare losses of US$43.44 billion or US$1.1 billion per year, while producers gain US$40.72 billion or US$1 billion per year. Even though producers incur costs due to declines in production under climate change, they also benefit from the global impact of climate change on world food prices, if fully transmitted to domestic markets. Nevertheless, a large share of Philippine farmers—especially smallholders—are net consumers of food who purchase from the market. So farmers gain on the whole as producers, but also experience losses as consumers.

Table 1. Change in economic surplus due to climate change under four general circulation models, 2010–2050.

Climate model	Welfare measure		
	Producer surplus	Consumer surplus	Economic surplus
	(net present value, US$ billion)		
GFDL	28.75	–28.36	0.39
HadGEM	50.95	–55.31	–4.36
IPSL	38.33	–45.14	–6.81
MIROC	44.86	–44.96	–0.10
Model average	40.72	–43.44	–2.72
Model average with sticky prices	14.05	–28.55	–14.51

Source: Constructed by authors based on model simulation results.
Notes: Model averages are based on 100-percent price transmission from world to domestic prices; model averages with "sticky prices" are based on less than a 100-percent price transmission from world prices. GFDL = General Fluid Dynamics Laboratory; HadGEM = Hadley Centre Global Environmental Model; IPSL = Institut Pierre-Simon Laplace; MIROC = Model for Interdisciplinary Research on Climate.

Figure 3. Change in indicators of economic impact in agriculture due to climate change, based on four general circulation models, 2010–2050.



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Notes: Model averages are based on 100-percent price transmission from world to domestic prices; model averages with "sticky prices" are based on less than a 100-percent price transmission from world prices. GFDL = General Fluid Dynamics Laboratory; HadGEM = Hadley Centre Global Environmental Model; IPSL = Institut Pierre-Simon Laplace; MIROC = Model for Interdisciplinary Research on Climate.

In addition to the case of full transmission of world prices, a scenario of "sticky prices" was also analyzed (Table 1, Figure 3). Domestic prices of food and agricultural commodities are said to be sticky when they do not fully adjust to changes in world prices—meaning that domestic markets are not fully connected with the world market. Studies have shown that, for the Philippines, agricultural prices may be sticky, with price transmission from world markets being less than 100 percent. Under this scenario, consumers are more shielded from the impact of climate change, but producer prices also don't increase as much. Estimated average welfare losses to consumers are projected to be reduced to US$28.55 billion (from US$43.44 billion) or US$714 million per year. Concurrently, producers' gains are projected to be reduced to US$14.05 billion or US$351 million per year. Total net welfare losses over 40 years—at US$14.51 billion (US$363 million per year or Php 16.5 billion per year at an exchange rate of Php 45.20 to US$ 1.00—are significantly higher than under the full price transmission scenario.

AGRICULTURAL TECHNOLOGIES FOR ADAPTATION AND PRODUCTIVITY GROWTH

Is there scope for reducing the negative crop yield impact of climate change? The analysis conducted for this study also assessed the potential of several technologies to compensate for the adverse effects of climate change on crop production and yields and to boost agricultural productivity growth. Technologies examined comprised those existing and currently available—including adding fertilizers in the case of low-fertilizer input farms, changing planting dates, and changing seed varieties—and emerging and new agricultural technologies, whether under development, field-testing, or limited release—including technologies based on varietal traits, such as drought and heat tolerance and nitrogen use efficiency; farm management technologies, such as precision and no till agriculture and integrated soil fertility management; and improved crop protection.

Results show that these technologies offer strong potential to deliver productivity gains. The combination of optimizing fertilizer use, crop variety, and planting date under climate change can increase rice yields by up to 11 percent and corn yields by 8 percent. More advanced technologies have the potential to deliver considerably higher crop yields if successfully adopted (in excess of 20 percent; see Policy Note 2 in this series for more detail). Selective investment in cost-effective irrigation expansion would also increase production and reduce vulnerability to climate change. Some of these technologies may take many years to come to fruition, but improved policies can facilitate adoption. Increased investment in agricultural research and development will be a key driver for technology development. Real-time weather information can assist farmers in making planting date and farm management decisions. The provision of effective agricultural extension by the government, private sector, and non-governmental organizations—employing innovative methods such as information and communication technologies—can educate farmers in the adoption of the more complex technologies. And a strong seed industry accessible to farmers would facilitate the adoption of variety-related technologies. With additional investment and policy reform, the adoption of technologies for adaptation and productivity can be further enhanced.

THE ECONOMYWIDE IMPACT ON AGRICULTURE

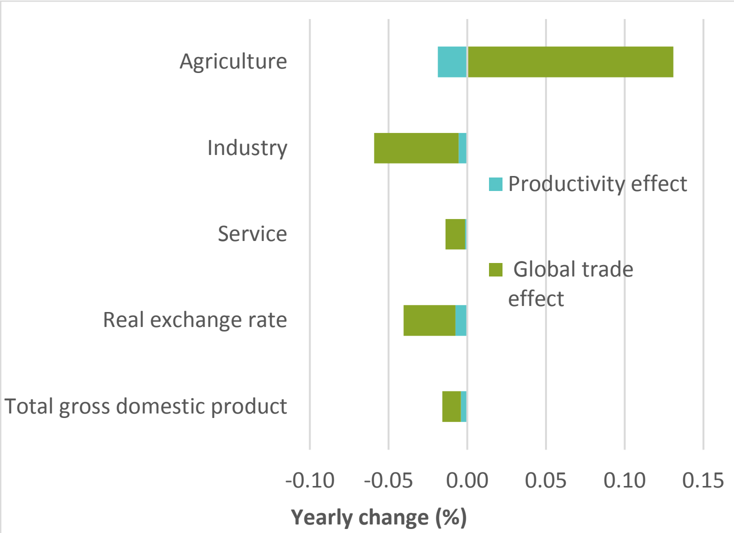
This section examines the economywide impact of climate change in the agricultural sector by assessing the impact of climate change effects on agricultural productivity and world commodity prices on the national economy. The model specification, combining the Phil-DCGE model with IMPACT, reflects similar socioeconomic conditions determined by income level and population growth, employing the commonly used Shared Socioeconomic Pathways framework for the 2010–2050 timeframe. The world prices for agriculture that are determined endogenously in the IMPACT model are used to drive the international commodity price changes in the Phil-DCGE model as part of the global climate shock. Similarly, the yield changes from the IMPACT model are used for the local climate shock that hits the agricultural sector.

Climate Impacts

Based on the modeling scenario described above, climate change is projected to reduce long-term economic growth in the Philippines by 0.02 percent per year, which equates to a 3.8-percent reduction in gross domestic product (GDP) in 2050 (Figure 4). This effect is muted somewhat over time as the structural transformation the country is projected to undergo in the next decades gradually reduces agriculture's share of the overall economy (that is, agricultural GDP as a share of total GDP). This is the first pathway by which climate change affects national productivity, reducing domestic agricultural production, but having only a relatively small impact on the rate of GDP growth. More significant impacts are experienced via the second pathway, however, whereby the impact of climate change occurs through increased world commodity prices that have a mixed effect on the Philippine economy.

On the positive side, higher commodity prices generate a windfall for the agricultural sector: producers have greater incentives and receive higher prices, especially for export crops. This drives agricultural GDP growth and higher rural household incomes. The downside, however, is that higher commodity prices also mean that imported foods become more expensive. Given the country's high import share and negative trade balance, a loss in terms of trade is projected to occur, reflected in a lower real exchange rate (Figure 4).

Figure 4. Climate impact on real exchange rate and growth in gross domestic product by sector.



Source: Constructed by authors based on model simulation results.

The adjustment of the real exchange rate driven by climate change is also projected to have more profound effects, causing the growth rate of other sectors to decrease. The high dependency of industry and services on imported inputs prompts significant adjustments as the exchange rate falls, forcing firms and factories to reduce their imported inputs and, consequently, to decrease their production levels. The economic cost of these indirect climate change impacts on the overall economy can be calculated based on the real absorption value, which reflects the country's total consumption and investment (Table 2). On this basis, climate change is projected to cost the Philippine economy Php 26 billion per year. This welfare loss primarily comes from the reduction of private consumption and total investment, mainly influenced by higher commodity prices and lower household income levels.

Table 2. Benefit or cost of climate change on total absorption in yearly net present value, 2010–2050.

Variable	Climate shock (Billion Php)		
	Productivity effect	Global trade effect	Total effect
Annual absorption	–5.7	–20.7	–26.2
Private consumption	–5.0	–16.5	–21.5
Investment	–0.7	–5.2	–5.8
Government consumption	0.0	1.0	1.1

Source: Constructed by authors based on model simulations results.

Adaptation Strategies

Given the strong interest of the Philippine government to increase rice production, two adaptation strategies intended to promote higher domestic rice production were analyzed. The first strategy is the country's rice self-sufficiency policy (Box 1). The rice self-sufficiency policy is introduced in the model by implementing rice subsidies to both consumers and producers as well as by restricting imports in order to attain a high rice self-sufficiency ratio. The second strategy involves investments to improve growth in rice productivity. Under this strategy, an increase in rice productivity is introduced based on the potential gains from new technology described above. The rice productivity strategy is analyzed both with and without the rice self-sufficiency policy. This analysis also facilitates an assessment of the policy's impact in mitigating the effects of climate change. A further two scenarios exclude the effects of climate change (all else being equal) as a means of assessing the full potential of the two policy options.

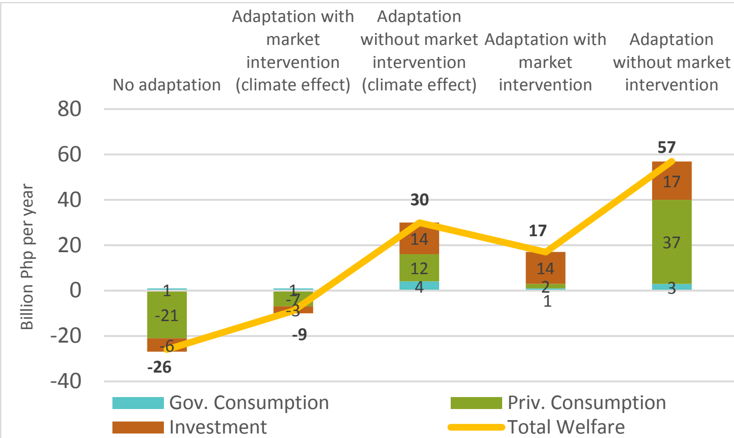
Box 1. Philippine rice self-sufficiency policy

Rice self-sufficiency through price intervention and trade restriction is one of the major policies promoted by the Philippine government. The National Food Authority (NFA) is mandated to provide subsidies to producers and consumers, and to restrict the amount of rice that is imported. Previous reviews of this program have indicated that it is extremely costly because the government must buy at high prices and sell at low ones in order to create incentives for farmers to plant more rice and provide cheaper food to consumers. Consequently, NFA is continuously at a loss in running the program—its debt has been estimated to reach PHP 180 billion in 2016 (Yap 2014). This loss adds to the country's fiscal deficit and could potentially create negative effect on economic growth in the future. This economic vulnerability could also diminish the country's capacity to adapt to climate change.

Source: Authors.

Modeling results indicate that both adaptation strategies work well; the welfare loss from climate change diminishes with the application of either strategy (Figure 5). Nevertheless, the difference between the two scenarios clearly shows that the rice self-sufficiency program actually suppresses the positive effect of any improvements in rice productivity. With the rice self-sufficiency policy, the welfare loss from climate change under higher productivity growth is only projected to be reduced by Php 17 billion, keeping a negative impact of climate change of Php 9 billion per year. Without the rice self-sufficiency policy, the welfare gain is projected to be Php 30 billion per year. The difference between the two scenarios, which is about Php 40 billion per year, can be interpreted as the cost of implementing the rice self-sufficiency program.

Figure 5. Welfare impact from different adaptation strategies with and without climate change effect, 2010–2050.



Source: Constructed by authors based on model simulation results.

Private consumption and investment are significantly lower in the presence of the NFA subsidy. This negative impact on investment demonstrates that the rice self-sufficiency program creates a "crowding out" effect because resources that should be used to fund investment—including investment in agricultural productivity growth— are diverted to finance the subsidy. Official data indicates that, on average, 70 percent of funds that NFA uses to finance their operations actually come from the private sector (SEPO 2010). This is reflected in the analysis by reduced investment, which creates a negative effect to the rest of the economy. By eliminating the NFA subsidy, as in the second scenario, government consumption is projected to increase by Php 2 billion, while private consumption increases due to better overall economic conditions, whereby the market is fueled by higher rice productivity and more efficient resource allocation. This analysis clearly illustrates that the pursuit of rice self-sufficiency through the NFA subsidy is not only costly, but also ineffective in adapting to the impacts of climate change.

Table 3 breaks down the results by sector and household type. The results confirm that the economy generates a lower GDP growth rate with the rice self-sufficiency policy in place (Table 3). This is mainly due to lower rates of growth in the industry and services sectors, which are negatively affected by the crowding out of investment due to the misallocation of resources to fund the subsidy. Results also indicate the detrimental effects of rice self-sufficiency policy, which distorts the economic development process by suppressing potential future growth even without the added impacts of climate change.

The higher rate of growth in the agricultural sector driven by the rice self-sufficiency program has negative implications for nonagricultural growth because it diverts potential investment from productive sectors in order to finance the subsidy. As noted above, this policy has significant economic costs of Php 40 billion per year, which is about 3.2 percent of the country's agricultural GDP. Abolishing this policy may harm some vulnerable households, but the gain to the middle class is much higher (Table 3). In total, it would cost less than Php 3 billion per year to compensate lower income households and maintain their welfare status were the rice subsidy halted. This demonstrates the feasibility of removing the subsidy and compensating vulnerable households with a direct transfer or special assistance program.

Table 3. The impact of climate change and adaptation strategies on GDP and economic welfare.

Indicators	Total Climate Effect	Adaptation			
		With climate change		Without climate change	
		With NFA subsidy	Without NFA subsidy	With NFA subsidy	Without NFA subsidy
Rice Self-sufficiency Rate	**96.2**	**96.4**	**94.1**	**95.9**	**93.3**
GDP growth (%)	**-0.02**	**0.00**	**0.01**	**0.01**	**0.03**
Agriculture growth (%)	0.12	0.18	0.18	0.06	0.03
Manufacture growth (%)	-0.06	-0.05	-0.04	0.01	0.02
Services growth (%)	-0.01	-0.01	0.01	0.00	0.03
Total Welfare (Billion peso per year)	**-26.2**	**-9.3**	**30.0**	**17.4**	**57.1**
Share of GDP (%)	-0.3	-0.1	0.3	0.2	0.6
Share of Agriculture GDP (%)	-2.1	-0.7	2.4	1.4	4.6
Household welfare (Billion peso per year)	**-20.6**	**-7.4**	**16.2**	**13.1**	**37.8**
Rural	25.4	26.5	23.9	0.1	-3.6
Rural lower income	3.0	3.8	1.5	0.6	-1.8
Rural higher income	22.3	22.7	22.3	-0.5	-1.8
Urban	-46.0	-33.9	-7.7	13.1	41.4
Urban lower income	1.6	2.2	0.9	0.4	-0.9
Urban higher income	-47.7	-36.1	-8.6	12.6	42.2

SUMMARY AND CONCLUSIONS

The impact of climate change on agriculture is projected to cost the Philippine economy about Php 26 billion per year through 2050. This adverse impact is even more threatening when the indirect effects are taken into consideration, disrupting long-term economic growth and slowing down the structural transformation process. Adaptation strategies that increase the productivity of rice and other crops are projected to have significant impact in reducing the negative effects of climate change. However, the rice self-sufficiency policy creates negative effects by absorbing significant resources that could be used to fund investment and finance other government programs, costing the economy a projected Php 40 billion per year. Reducing expenditures on the NFA subsidy and redirecting funds to agricultural research and development and rural infrastructure to promote technological change and productivity growth in agriculture would generate large economic benefits. Supporting climate change adaptation policies are also needed, including development of real-time weather information systems to support farmers decision-making; improved agricultural extension employing innovative methods such as information and communication technologies; and a stronger seed industry to facilitate the adoption of new varieties.

REFERENCES

Collins, W., N. Bellouin, M. Doutriaux-Boucher, N. Gedney, P. Halloran, T. Hinton, J. Hughes, et al. 2011. "Development and Evaluation of an Earth–System Model—HadGEM2," Geoscience Model Development 4 (4): 1051–1075.

Dufresne, J.-L., M.-A. Foujols, S. Denvil, A. Caubel, O. Marti, O. Aumont, Y. Balkanski, et al. 2013. "Climate Change Projections Using the IPSL–CM5 Earth System Model: From CMIP3 to CMIP5," Climate Dynamics 40 (9/10): 2123–2165.

Dunne, J., J. John, A. Adcroft, S. Griffies, R. Hallberg, E. Shevliakova, R. Stouffer, et al. 2012. "GFDL's ESM2 Global Coupled Climate–Carbon Earth System Models Part I: Physical Formulation and Baseline Simulation Characteristics," Journal of Climate 25 (19): 6646–6665.

Dunne, J., J. John, E. Shevliakova, R. Stouffer, J. Krasting, S. Malyshev, P. Milly, et al. 2013. "GFDL's ESM2 Global Coupled Climate–Carbon Earth System Models. Part II: Carbon System Formation and Baseline Simulation Characteristics," Journal of Climate 26 (7): 2247–2267.

Jones, J., G. Hoogenboom, C. Porter, K. Boote, W. Batchelor, L. Hunt, P. Wilkens, et al. 2003. The DSSAT Cropping System Model. European Journal of Agronomy 18 (3-4): 235–265.

Martin, G., N. Bellouin, W. Collins, I. Culverwell, P. Halloran, S. Hardiman, T. Hinton, et al. 2011. "The HadGEM2 Family of Met Office Unified Model Climate Configurations." Geophysical Model Development 4: 723–757.

Rosegrant, M., and the IMPACT Development Team. 2012. International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) Model Description. Washington, DC: International Food Policy Research Institute.

Sakamoto, T., Y. Komuro, T. Nishimura, M.Ishii, H. Tatebe, H. Shiogama, A. Hasegawa, et al. 2012. "MIROC4h: A New High-Resolution Atmosphere–Ocean Coupled General Circulation Model." Journal of Meteorology Society of Japan 90 (3): 325–359.

SEPO (Senate of the Philippines). 2010. Subsidizing National Food Authority: Is it a Good Policy. Policy Brief PB-10-04. Manila: Senate of the Philippines.

Van Noordwijk, M., B. Lusiana, and N. Khasanah. 2004. WaNuLCAS Version 3.1, background on a model of water nutrient and light capture in agroforestry systems. International Center for Research in Agroforestry (ICRAF). Bogor, Indonesia.

Yap, L. 2014. "Philippine to Consider More Rice Imports, Ending Subsidy." Bloomberg Business. Accessed month year. www.bloomberg.com/news/articles/2014-07-07/philippines-to-consider-more-rice-imports-ending-subsidy-1-.

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