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The Economywide Impacts of Climate Change on Philippine Agriculture

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FOR MOST COUNTRIES, HIGH PRODUCTIVITY GROWTH IN THE AGRICULTURAL SECTOR HAS BEEN A KEY DRIVER of structural transformation promoting 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 domestic commodity prices, ultimately having negative effects on both Philippine agriculture and the country's overall economy. Developing agricultural adaptation and growth strategies is of 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 and Mercedita A. Sombilla.

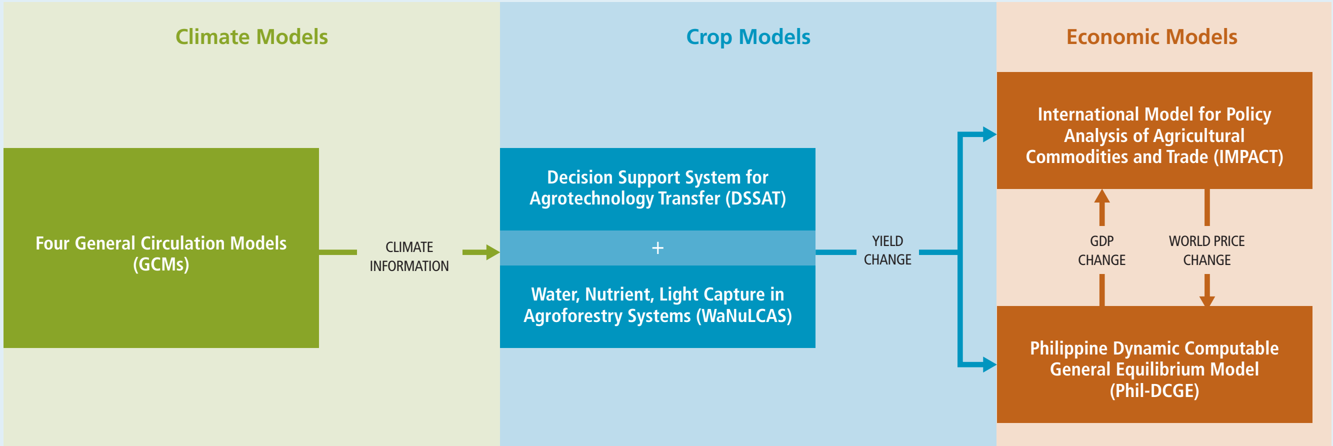
MODELING FRAMEWORK

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," in order to evaluate agricultural strategies to address climate change in the Philippines (Figure 1). The framework for the analysis integrates a range of macro- and microeconomic modeling components: (1) general circulation models (GCMs) that generate climate change scenarios; (2) 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; (3) partial equilibrium economic modeling of the agricultural sector using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT); and (4) economywide analyses using a dynamic computable general equilibrium model of the Philippines (Phil-DCGE).

GCMs are developed by scientists to determine how the 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 analyses presented in this policy note are 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); and

FIGURE 1 The interlinked modeling system used to assess the agricultural impacts of climate change on the Philippine economy



Source: Constructed by authors.

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).

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. These four models were chosen in order to cover the range of temperature and precipitation outcomes from the full set of GCMs.

DSSAT, developed by Jones et al. (2003), integrates crop, soil, and weather databases into standard formats for use in 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, light, and soil properties. These biophysical models are used to estimate the impacts of climate change and crop management and technology on crop yields; these estimates constitute inputs into IMPACT and the Phil-DCGE model 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 (with the exception of 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.

The Phil-DCGE model 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) and two locations (urban and rural) and by income quintile.

ANALYSIS AND RESULTS

The Impact of Climate Change on Commodity Production, Prices, and Economic Welfare

Globally, climate change has adverse impacts on crop yields. These yield changes result in reduced supply of crop and livestock commodities, 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 these positive and negative effects into account—and assuming the full transmission of higher world prices to domestic markets in the long run—average results across the four GCMs project a 1.7 percent contraction in total crop production in the Philippines in 2050 compared

with baseline levels (that is, without climate change). Cereal production is projected to fall by 6.1 percent in 2050 compared with baseline levels. The negative impact of climate change on corn production (a decline of 13.0 percent) is projected to be significantly higher than for rice production (a comparable decline of only 3.2 percent). Due to links with cereals used as feed, meat production is also projected to undergo a decline of about 0.9 percent. (Note that due to a lack of relevant models and data, the direct impacts of climate change on livestock were not calculated.)

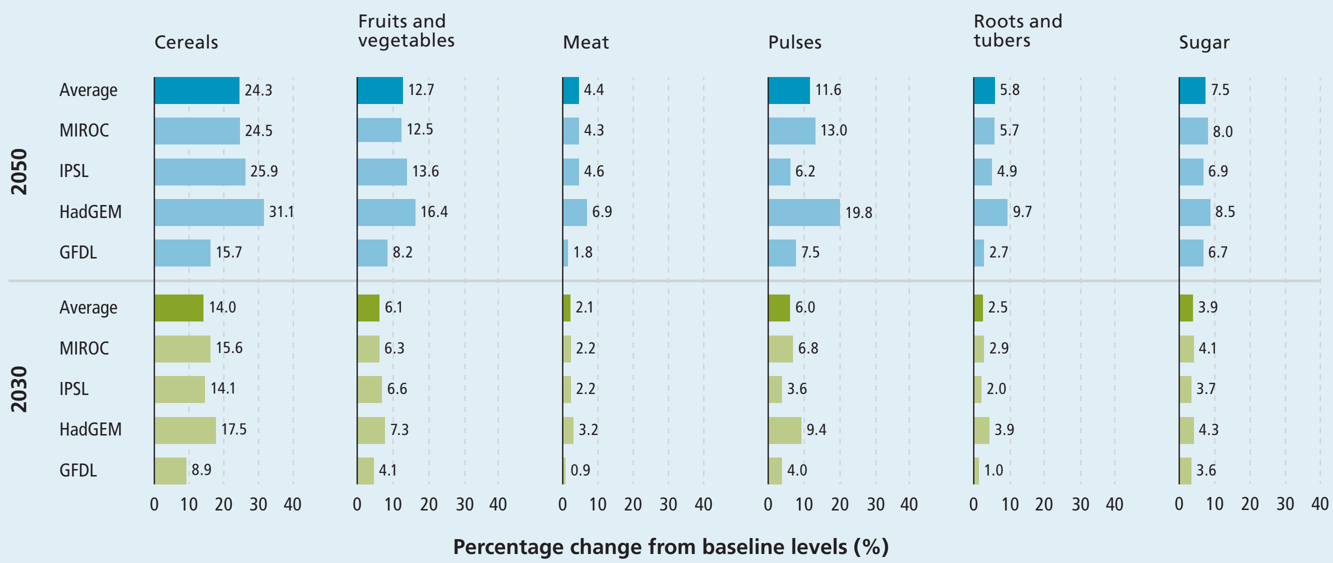
The resulting effects of reduced productivity and production on the accessibility of agricultural commodities for consumption are substantial. Agricultural food commodity prices are projected to increase in 2030 and 2050 due to climate change, making food commodities less accessible, especially for poor people. Substantial increases in consumer prices by 2050 are projected for cereals (24 percent), fruits and vegetables (13 percent), and pulses (12 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 17 percent, corn prices by 44 percent, and wheat prices by 11 percent. The decline in average per capita consumption in 2050 is projected to be 3.1 percent for cereals, 2.3 percent for fruits and vegetables, 2.4 percent for sugar, 0.9 percent for roots and tubers, 0.4 percent for pulses, and 0.3 percent for meat. Among cereals, per capita consumption of corn is projected to decline by an average of 5.6 percent, wheat by an average of 3.4 percent, and rice by an average of 2.9 percent in 2050.

The Impact of Climate Change 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 as the prevalence of childhood malnutrition and the number of people experiencing hunger or at risk of hunger. Three million children in the Philippines were classified as malnourished in 2010. Under a baseline scenario (that is, without climate change), this number is projected to decline to 2.7 million in 2030 and to 2.15 million in 2050, based on average results from the four GCMs; with climate change the number is projected to increase by 40,000 (2 percent) in 2030 and 50,000 (3 percent) in 2050. 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 in the number of people at risk of hunger of 1.3 million in 2030 (8 percent) and 2.0 million in 2050 (13 percent).

An indirect economic cost of climate change is loss of productivity, in terms of income generation, among the Philippine population due to escalating levels of malnutrition. The World Bank (2006) estimates such losses to be more than 10 percent of earnings over the course of a lifetime. A 10 percent loss

FIGURE 2 The impact of climate change on consumer prices of major agricultural commodities, 2030 and 2050



Source: Constructed by authors based on model simulation results.

Note: Data indicate percentage changes from baseline levels (that is, without climate change) from each of the four climate models, as well as averages of the results of all four models. GFDL = General Fluid Dynamics Laboratory; HadGEM = Hadley Centre Global Environmental Model; IPSL = Institut Pierre-Simon Laplace; MIROC = Model for Interdisciplinary Research on Climate.

in gross domestic product (GDP) per capita per year equates with approximately US$361, calculated in 2010 purchasing power parity (PPP) dollars. With an average of 1.29 million additional malnourished people per year resulting from climate change, the estimated yearly cost is US$470 million for the 40-year period to 2050, again in 2010 PPP dollars, which is equivalent to 21 billion Philippine pesos (Php).

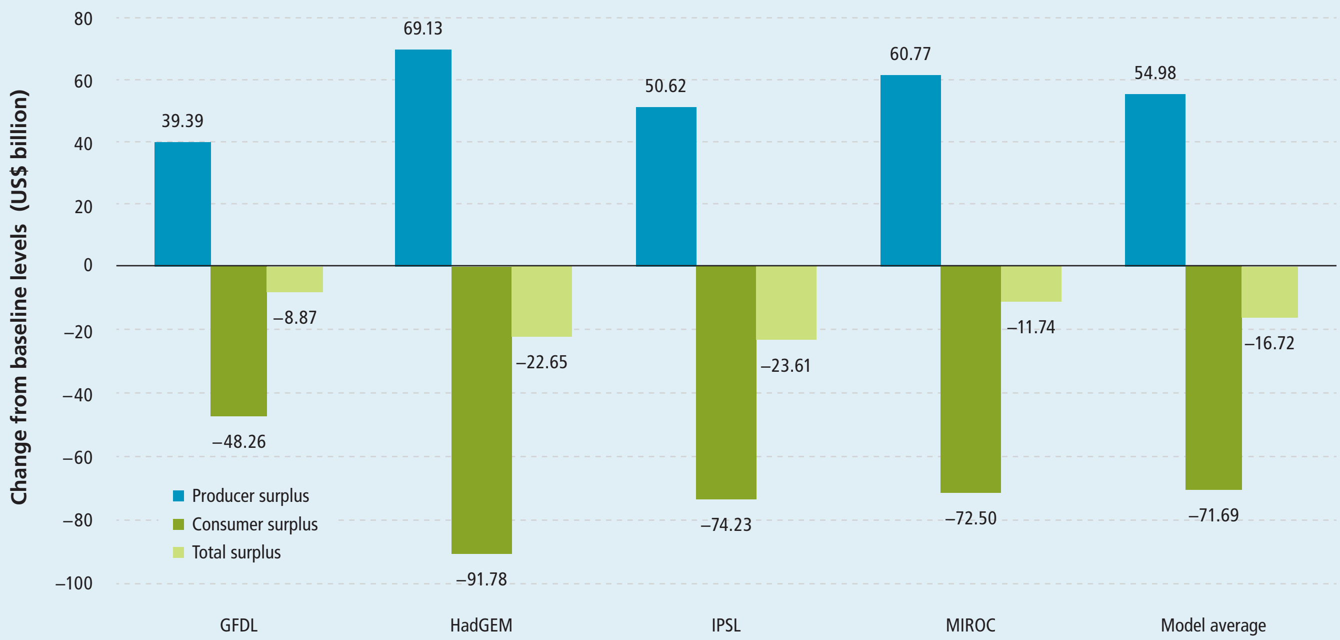
The Impact of Climate Change on Economic Welfare in Agriculture

The estimates of the impact of climate change on the supply and demand of agricultural commodities presented above can be used to measure shifts in the economic welfare of the Philippine population based on changes in "economic surplus" to producers and consumers, and in terms of the overall net effect in 2050 (once again compared to a baseline scenario without climate change, assuming full transmission of world prices to the Philippines, and averaging the individual results of the four GCMs; Figure 3). Results project a total welfare loss to the Philippines of US$16.72 billion over the 40-year period or US$418 million per year (in net present value). The net welfare loss to the agricultural sector due to climate change is thus equivalent to Php 18.81 billion per year. These costs are borne by consumers, with welfare losses of US$71.69 billion over the 40-year period or US$1.79 billion per year, while producers gain US$54.98 billion or US$1.37 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, 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.

AGRICULTURAL TECHNOLOGIES FOR ADAPTATION AND PRODUCTIVITY GROWTH

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. The technologies examined included those existing and currently available (such as adding fertilizer in the case of low-fertilizer input farms, changing planting dates, and changing seed varieties) and emerging and new agricultural technologies, whether under development, being field-tested, or in limited release (such as technologies focusing on varietal traits—for example, drought and heat tolerance and nitrogen-use efficiency; farm-management technologies—for

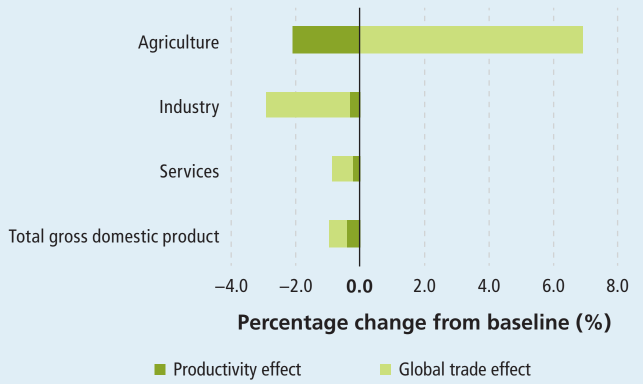
FIGURE 3 The impact of climate change on indicators of economic welfare, 2050



Source: Constructed by authors based on model simulation results.

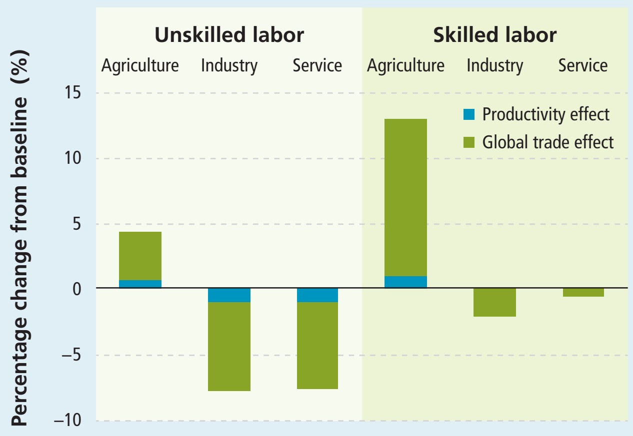
Note: Data indicate changes from baseline levels (that is, without climate change) from each of the four climate models, as well as averages of the results of all four models. GFDL = General Fluid Dynamics Laboratory; HadGEM = Hadley Centre Global Environmental Model; IPSL = Institut Pierre-Simon Laplace; MIROC = Model for Interdisciplinary Research on Climate.

FIGURE 4 The impact of climate change on Philippine GDP growth by sector, 2050



Source: Constructed by authors based on model simulation results.

FIGURE 5 The impact of climate change on the demand for labor by sector and type of labor, 2050



Source: Constructed by authors based on model simulation results.

Note: Results indicate the percentage change from baseline levels (without climate change).

example, precision and no-till agriculture and integrated soil fertility management; and improved crop protection).

Results show that these technologies have strong potential to deliver productivity gains. The combination of optimizing fertilizer use, crop variety, and planting date under climate change is projected to increase rice yields by up to 6 percent and corn yields by 4 percent. More advanced technologies have the potential to deliver considerably higher crop yields—meaning in excess of 20 percent—if successfully adopted (for more detail, see Policy Note 2 in this series). 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 (R&D) will be a key driver of 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, the private sector, and nongovernmental organizations—employing innovative methods such as information and communication technologies—can educate farmers in the adoption of the more complex technologies. 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

The study included an examination of the economywide impact of climate change in the agricultural sector by focusing on movements in labor markets and their long-term effect on economic growth and income distribution in the Philippines. The analysis employed the Phil-DCGE model, linked with DSSAT and IMPACT, in order to capture both the local and global effects of climate change. The first shock on yield changes is derived from the DSSAT model to show the local climate effect on Philippine agriculture. The world price shocks for agriculture, derived from IMPACT, were used to model international commodity price changes in the Phil-DCGE model as part of the global climate shock.

Climate Impacts

Climate change is projected to reduce GDP growth in the Philippines by 0.9 percent in 2050 (Figure 4). At the sectoral level, the global impact of climate change on trade—which results in higher prices—creates an incentive for farmers to increase their production of agricultural export commodities. However, the local productivity effect reduces the production of agricultural commodities due to reduction in yield for most of the crops, including rice.

Given interlinkages among the different sectors in the economy, the net productivity gains to the agricultural sector due to the increased demand for and prices of agricultural exports under climate change are insufficient to compensate for the negative impacts on the productivity of the nonagricultural sectors. The change in demand for all agricultural commodities due to climate change causes shifts in input markets that eventually drive a reallocation of resources. Key among these shifts is the movement of labor (especially unskilled labor) from agriculture to nonagricultural sectors. The climate change effect that is mainly driven by global trade adjustment

creates incentives to keep more labor working in the agriculture sector. This is reflected by higher demand for labor in the agriculture sector, which directly affects labor markets in nonagricultural sectors (Figure 5). Climate change is projected to increase the demand for unskilled labor in the agriculture sector by 4 percent, consequently reducing the absorption level of labor by the nonagricultural sectors on average by 6.5 percent in 2050. As a result, value-added in both industry and services declines in response to the contraction of available workforce to support production (Figure 4). Bigger changes in demand for skilled labor in agriculture do not have much impact, as the share of this type of worker employed in the agriculture sector is minimal, and only slightly affects the labor demand in nonagricultural sectors (Figure 5).

The movement of labor induced by climate change has a direct impact on the structural transformation process, a key indicator of which is the movement of labor out of the agricultural sector (Figure 6). The upward sloping trend line indicates how labor is being held back from moving out of the agriculture sector by higher demand of unskilled labor in response to climate change, whereas the downward sloping trend line indicates the resulting decline in GDP levels due to less labor being employed in nonagricultural sectors. This negative relationship reflects the reality in the country that, based on the average value of real wages, labor is five times less productive in agriculture than in industry or services. In this way, climate change creates the wrong incentives for the allocation of resources (especially unskilled labor), and in doing so deters the structural transformation process and impedes long-term economic growth.

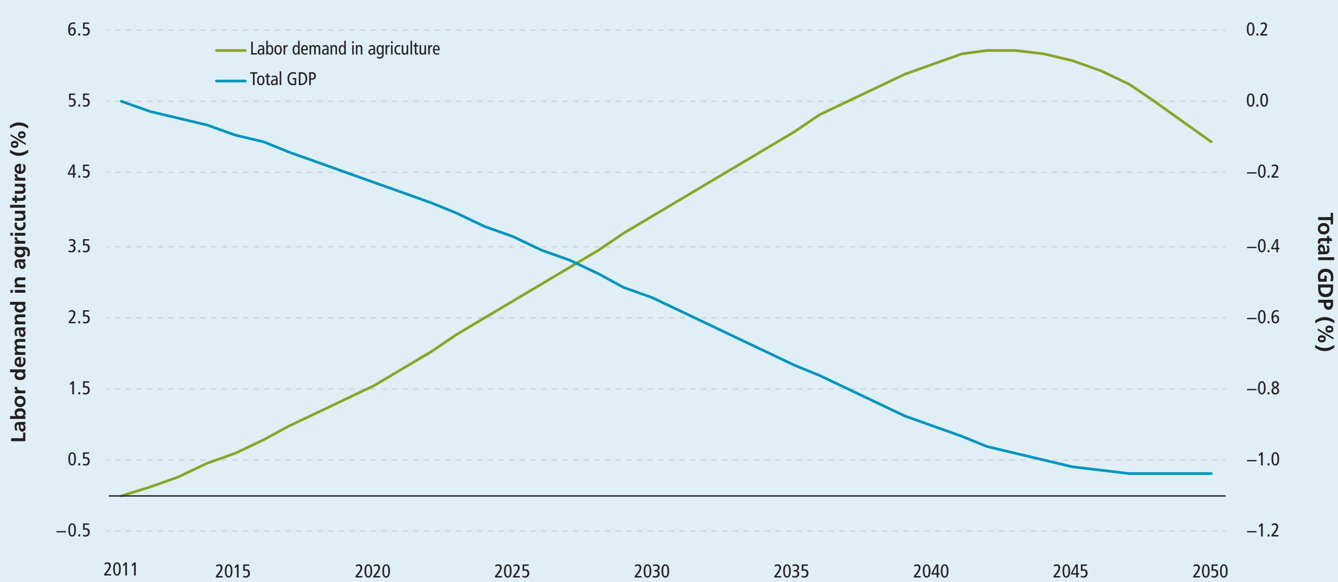
TABLE 1 The benefits or costs of climate change on average yearly absorption value in the Philippines, 2010–2050

Variable	Change from baseline level (Php billion)		
	Impact on productivity	Impact on global trade	Total impact
Private consumption	–42.5	–77.3	–119.5
Investment	–10.1	–198.8	–29.8
Government consumption	0.6	5.5	4.2
Yearly cost to economy	–53.3	–91.6	–145.1

Source: Constructed by authors based on model simulation results.
Note: Absorption value is a measure of national consumption and investment levels.

The economic cost of climate change can be calculated based on "real absorption value," which reflects consumption and investment levels in the Philippines. On this basis, climate change is projected to cost about Php 145 billion per year, mainly due to reduced levels of private consumption and total investment. The impact of global trade dominates this result, indicating the importance of international agricultural prices as drivers of resource allocation. The adverse impacts of climate change that drive labor to stay in agriculture are the main reason for the reduction in national income, and ultimately the reduction in consumption and investment levels (Table 1).

FIGURE 6 The impact of climate change on GDP through the demand for agricultural labor, 2011–2050



Source: Constructed by authors based on model simulation results.
Note: Results indicate the percentage change from baseline levels (without climate change).

Adaptation Strategies

The study also explored opportunities for the Philippine government to mitigate the adverse impacts of climate change through policy interventions designed to promote higher economic growth and better income distribution. Three adaptation strategies have the potential to promote higher domestic rice production into the future. The first strategy focuses on rice productivity by increasing investments in R&D; the second targets investment to expand irrigation infrastructure; and the third reduces agricultural tariffs.

Each of these three options is analyzed under climate change, with and without the country's existing rice self-sufficiency policy (Box 1). The policy, which is administered by the National Food Authority (NFA), provides rice subsidies to producers and consumers, while restricting rice imports. Including scenarios with and without the NFA's rice self-sufficiency policy helps to shed light on how the policy affects the impact of the three adaptation strategies.

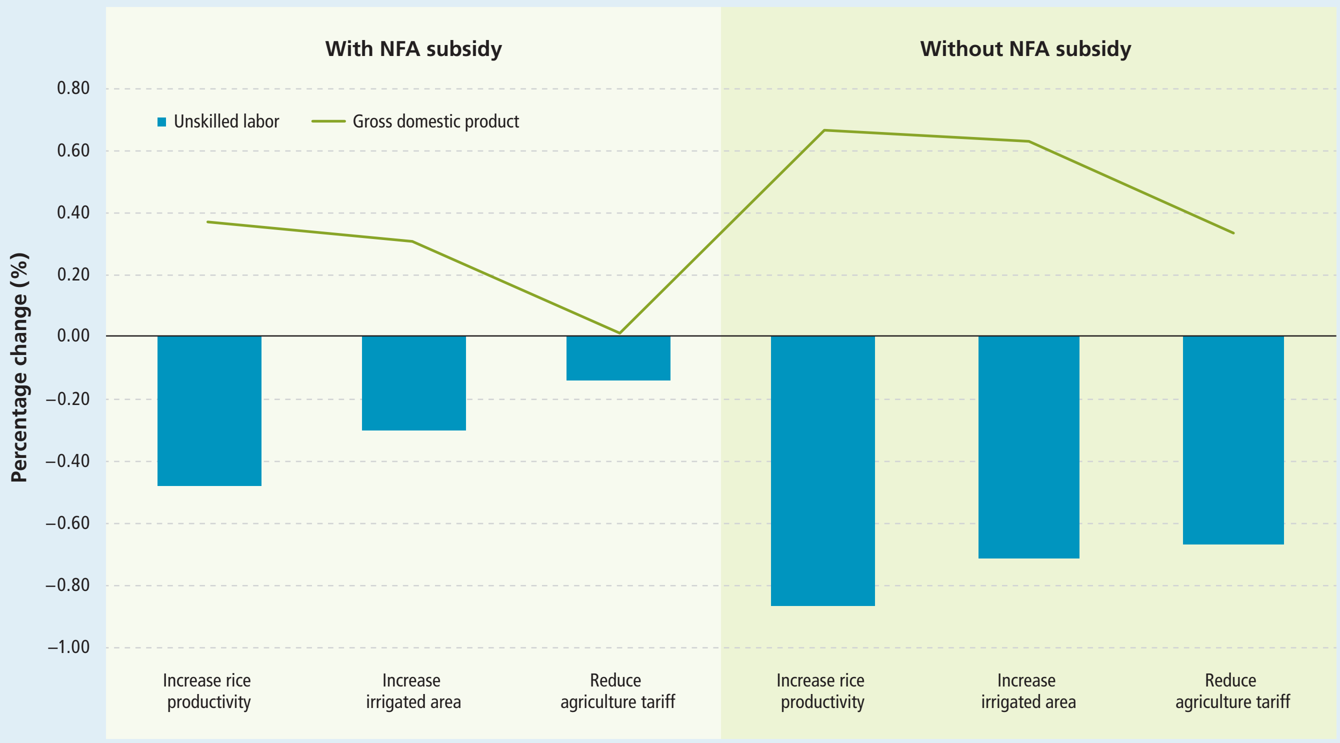
Modeling results show that all three adaptation strategies have a positive effect on the economy, reflected in higher GDP levels compared with those projected under climate change without the introduction of adaptation strategies (Figure 7).

BOX 1 The 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 prices in order to create incentives for farmers to plant more rice and provide cheaper food to consumers. Consequently, the NFA continually runs the program at a loss—it is estimated that the NFA's debt will reach Php 180 billion in 2016 (Yap 2014). This loss adds to the country's fiscal deficit and has the potential to negatively affect the country's future economic growth. This vulnerability could also diminish the Philippines' capacity to adapt to climate change.

Source: Authors.

FIGURE 7 The impact of three adaptation strategies on GDP and the demand for unskilled labor in agriculture, 2050



Source: Constructed by authors based on model simulation results.

Note: Data reflect percentage changes from the levels projected under a scenario of climate change without adaptation strategies. NFA = National Food Authority.

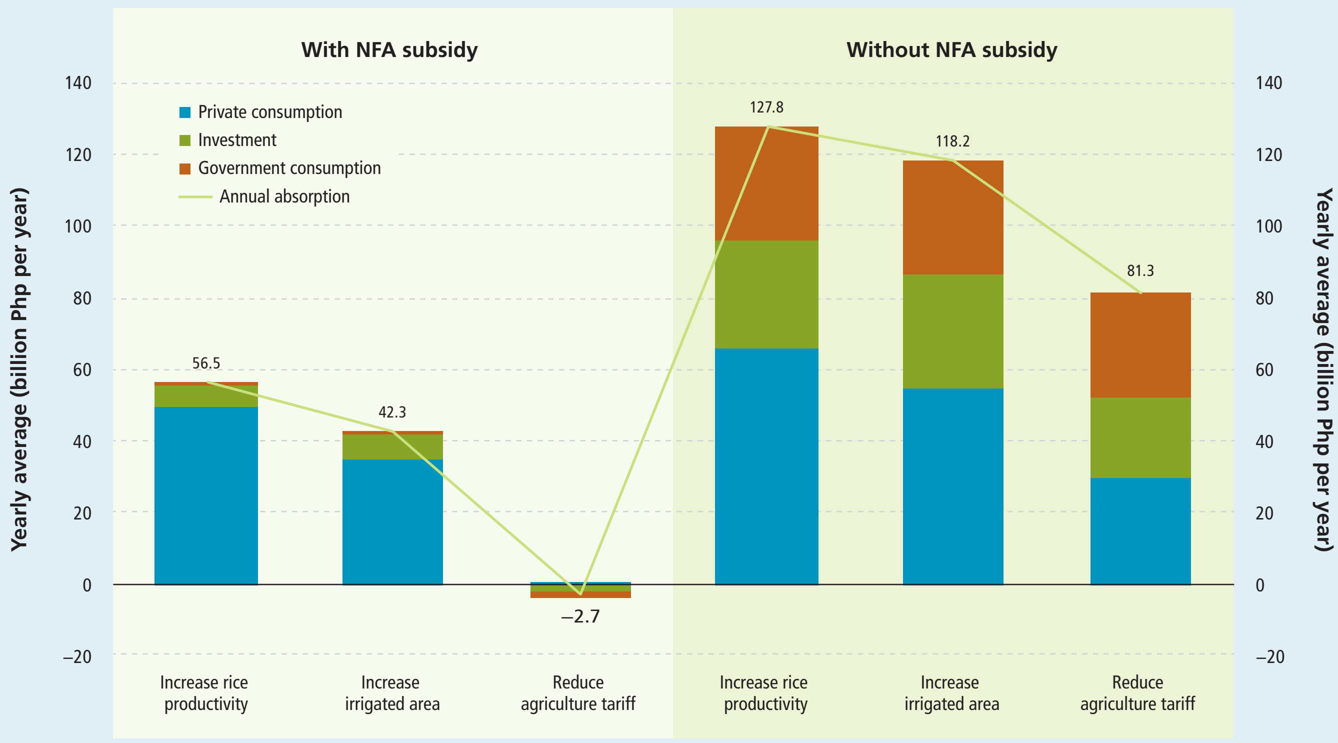
Increasing rice productivity has the largest impact, followed by expanding irrigated area and reducing agricultural tariffs. One of the main reasons why rice productivity has such a high impact is because it constitutes the largest share of agricultural value-added.

Looking at the impact of the Philippine rice self-sufficiency policy, projection results indicate that it significantly dampens the benefits of each of the three adaptation strategies (Figure 7). The success of the strategies in mitigating the adverse impacts of climate change and increasing GDP growth is projected to contract by half or more when the NFA rice subsidy is in effect. The key reason for this is the incentive the subsidy creates for farmers to grow more rice, which induces more unskilled labor to remain in the agricultural sector. As previously discussed, lack of available labor for use in the more productive nonagricultural sectors impedes the structural transformation process, and thus long-term economic growth.

Similarly, by mitigating the adverse impacts of climate change, all three adaptation strategies are projected to have significant net welfare benefits (Figure 8). No single strategy is projected to mitigate the full financial cost of climate change (estimated to be about Php 145 billion per year), but gains of up to Php 84 billion per year are projected when the NFA rice subsidy is eliminated. Comparing results with and without the rice subsidy, increasing rice productivity, for example, is projected to mitigate welfare losses by Php 57 billion per year with the rice subsidy in place but by Php 128 billion per year when it is eliminated. Eliminating this policy alone could potentially reduce the negative impact of climate change by Php 71 billion per year. The highest gains from eliminating the policy occur when it is combined with the strategy of reducing agricultural tariffs, where welfare is increased from Php –3 billion to Php 81 billion, creating a gain by Php 84 billion per year.

Given the significant resources diverted to fund the rice subsidy, government consumption and investment are substantially lower with the NFA subsidy in place. Official data indicate that, on average, 70 percent of the funds used to finance the NFA's operations are derived from the private sector (SEPO 2010). This reality is reflected in the analysis through reduced investment, which has a negative flow-on effect to the rest of the economy. When the NFA subsidy is eliminated, government consumption is projected to increase

FIGURE 8 The impact of three adaptation strategies on net welfare, with and without the NFA rice subsidy, 2011–2050



Source: Constructed by authors based on model simulation results.
Note: NFA = National Food Authority.

TABLE 2 Average net yearly impact of adaptation strategies on household welfare by location and income group, with and without the NFA subsidy, 2011–2050

Indicator	With NFA subsidy			Without NFA subsidy		
	Adaptation strategy					
	1	2	3	1	2	3
Rice self-sufficiency rate	0.2	0.1	0.0	–1.4	–1.6	–3.3
Total welfare gain	56.5	42.3	–2.7	127.8	118.2	81.3
Household welfare gain	45.8	34.1	1.9	65.2	56.6	32.2
Rural	4.3	6.3	–2.1	–0.5	1.6	–6.7
Lower income	3.0	2.6	–0.2	0.1	–0.3	–2.6
Upper income	1.2	3.7	–1.9	–0.5	1.9	–4.0
Urban	41.5	27.8	4.0	65.7	55.0	38.8
Lower income	2.1	1.8	0.1	0.9	0.6	–0.7
Upper income	39.4	26.0	3.9	64.8	54.3	39.6

Source: Constructed by authors based on model simulation results.
Note: 1 = increase rice productivity; 2 = expand irrigation; 3 = reduce agricultural tariffs. Total welfare and household welfare are measured in billion Php per year.

by Php 32 billion per year and private consumption increases by 66 billion due to improved economic conditions from higher rice productivity and more efficient resource allocation that stimulates the market (Figure 8). This analysis clearly illustrates that the pursuit of rice self-sufficiency through the NFA subsidy is not only costly but also ineffective in addressing the adverse impacts of climate change.

On average, even though the rice self-sufficiency rate slightly decreases, adaptation strategies are projected to provide welfare gains in the range of Php 81–128 billion per year when the NFA rice subsidy is abandoned (Table 2). Looking at how these potential gains are distributed across household types, results confirm that abolishing the policy may negatively affect some vulnerable households (Table 2). However, compensating these lower-income households to maintain their welfare status would cost, on average, less than Php 4 billion per year, which is much less than the total welfare gain observed in any of the three adaptation strategies. This demonstrates the feasibility of removing the subsidy and compensating vulnerable households with a direct transfer or special assistance program by reallocating the increase in government consumption.

Cost-Benefit Analysis

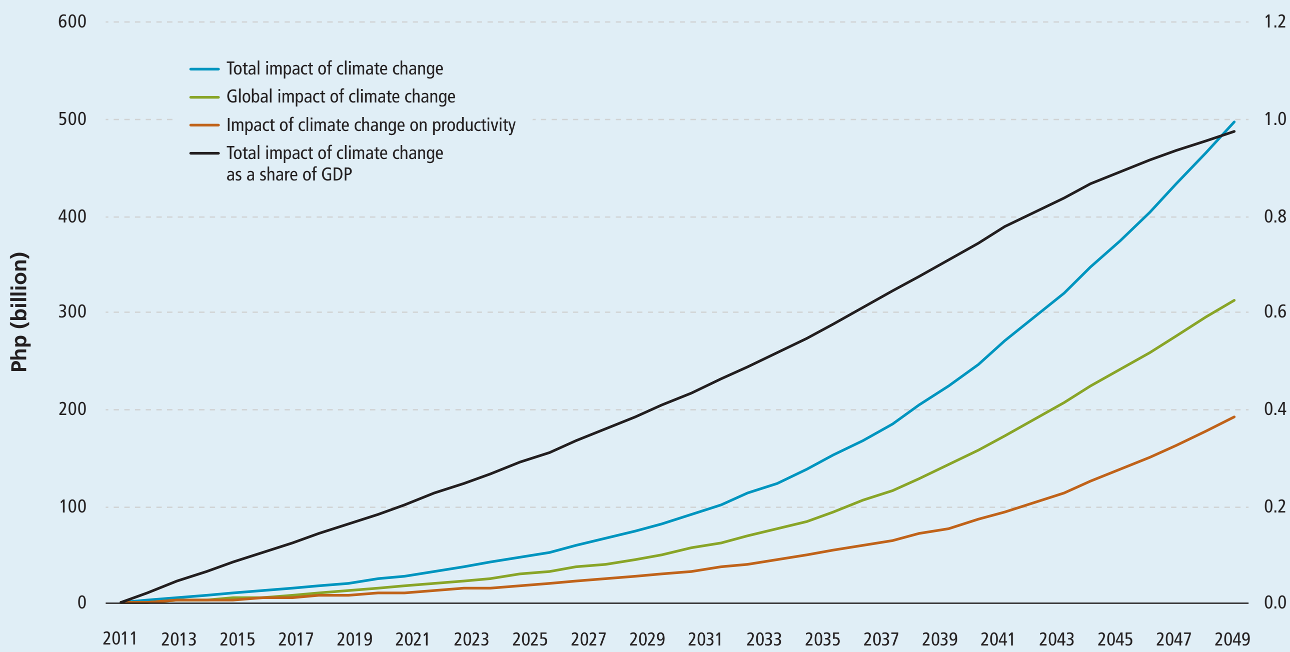
The impact of climate change is not linear over time. Considering the trend over time in the cost-benefit analysis is essential to an understanding of the returns to investments in climate change adaptation strategies. The global and domestic trends in the impact of the three climate change adaptation strategies are similar during the 2011–2050 period (Figure 9). The total cost of climate change is projected to rise from about Php 90 billion in 2030 to Php 500 billion in 2050. The steady trend of this cost as a share of GDP indicates how the cost of climate change continues to grow, reaching almost 1 percent of GDP in 2050, despite positive economic growth.

Of the three adaptation strategies, increasing rice productivity provides the greatest benefits, followed by expanding irrigated area. Given the limitation of data, this study only calculated the cost-benefit ratio for investment in irrigation infrastructure. The ratio is based on a comparison of the economic benefits of expanding irrigation to mitigate the impacts of climate change with the economic costs of developing the infrastructure according to the master plan of the National Irrigation Administration.

The estimated cost of expanding irrigation infrastructure to cover about 90 percent of the country's irrigable area is around Php 451 billion, calculated in net present value (NIA 2014). This is the total cost during 2014–2028, representing a targeted increase in irrigated area of around 1 million hectares. This cost includes both building new dams and restoring or improving old ones; it is therefore assumed that no significant incremental cost would be incurred in maintaining either old or new dams once the infrastructure improvements are completed—that is, from 2028 until 2050 (Figure 10). Hence the benefit (or cost) is calculated as the difference between the total cost of building and restoring dams and irrigation systems and the net yearly benefits of mitigating the adverse impacts of climate change.

The positive impact of expanding irrigation infrastructure increases over time, mainly because of higher crop productivity due to the increased availability of irrigation (Figure 10). These results also illustrate the difference in the net benefits of investing in irrigation infrastructure over time—that

FIGURE 9 The cost of climate change and its share of GDP, 2011–2050



Source: Constructed by authors based on model simulation results.

Note: GDP = gross domestic product. Costs and benefits are presented in net present value in 2014, with a 5 percent discount rate. PhP = Philippine pesos.

is, based on an early investment (2014–2050) versus a late investment (2025–2050). The incentive to take immediate action to develop irrigation infrastructure may be low, based on the time lag until the investment pays off, but the long-term benefits are significant and actually higher than the associated cost. In total, the welfare gain from developing irrigation infrastructure to mitigate the adverse impact of climate change is projected to be Php 467 billion, whereas the total cost is estimated to be Php 339 billion (both in net present value). The resulting cost-benefit ratio is 1.38, indicating that Php 100 billion invested by the government would generate benefits of Php 138 billion. Under the late-response investment option, even though the total cost is lower (Php 198 billion)—and the initial investment is lower—the total benefits are also lower (around Php 212 billion). Based on these results, the cost-benefit ratio of the late-response option is only 1.07. This emphasizes the significant benefit of acting quickly to mitigate the adverse impact of climate change, despite the high cost in the initial years.

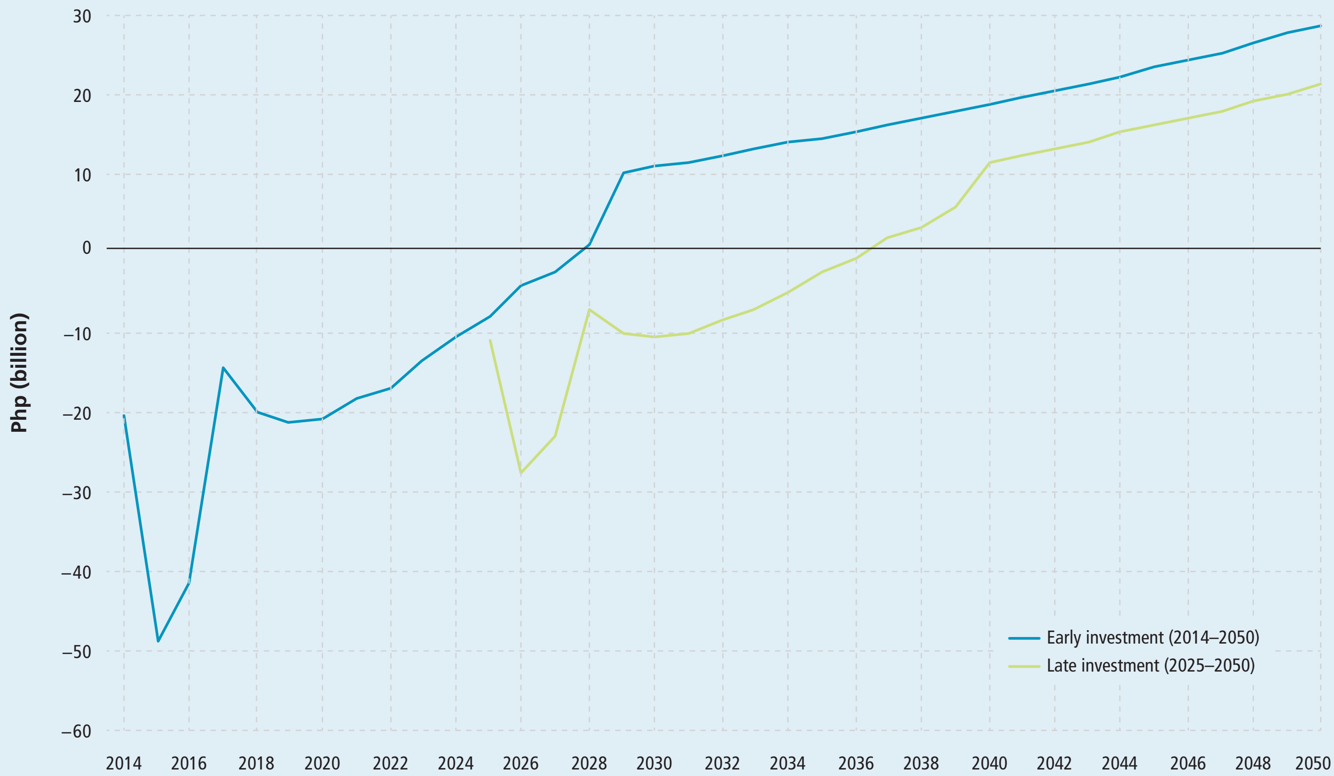
SUMMARY AND CONCLUSIONS

The impact of climate change on agriculture is projected to cost the Philippine economy about Php 145 billion per year through 2050. The three adaptation strategies analyzed under this study have the potential to significantly mitigate the high costs of climate change, and their impact is projected to be much higher if the Philippines abandons its current rice subsidy policy, which introduces economic incentives that impede the process of structural transformation. The rice subsidy is also extremely costly and, as many studies have indicated, has been inefficiently implemented.

The results of cost-benefit analyses indicate that investments in increasing rice productivity and expanding irrigation infrastructure have the highest impact in mitigating climate change effects. Estimates of the return to investments in irrigation infrastructure indicate a cost-benefit ratio of 1.38, but only if the government acts quickly. Delaying investment reduces the overall cost of this adaptation strategy, but also its benefits.

Additional strategies to further mitigate the impact of climate change include developing real-time weather information systems to support farmers' decision-making processes; improving the provision of agricultural extension services through innovative methods, such as information and communication technologies; and supporting a stronger seed industry to facilitate the adoption of new varieties. In taking steps to achieve food security under climate change, the focus of policy needs to include not only R&D on productivity- and efficiency-enhancing measures but also investments to develop technologies appropriate to

FIGURE 10 The net benefit or cost of expanding irrigation area, 2014–2050 vs. 2025–2050



Source: Constructed by authors based on model simulation results.

Note: Costs and benefits are presented in net present value in 2014, with a 5 percent discount rate.

local conditions, irrigation infrastructure, and systems for controlling floods. Finally, food security policy needs to be oriented toward facilitating—rather than inhibiting—trade, competition, and crop diversification to achieve inclusive access to food, while generating long-term productivity and income growth.

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