BACKGROUND PAPER PH-6

Macroeconomic Modelling in the Philippines CCDR

PHILIPPINES

COUNTRY CLIMATE AND DEVELOPMENT REPORT

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Acknowledgments

This background note was prepared by Hector Pollitt. It incorporates inputs from Hasan Dudu, who led the CGE modelling, and Noe Reidt, who carried out the MRIO modelling. Soulemayne Coulibaly led the macro chapter in the CCDR and helped to shape the content. Comments and suggestions from the wider CCDR team, led by Stefano Pagiola, are gratefully acknowledged.

Acronyms and abbreviations

ADS	Accelerated Decarbonization Scenario
Agri	Agricultural
BaU	Business as Usual
Cap	capita
CCDR	Country Climate and Development Report
CGE	Computable General Equilibrium
CPAT	Carbon Pricing Assessment Tool
CPS	Current Policy Scenario
GDP	Gross Domestic Product
GHG	Greenhouse Gas
Ind	Industrial
MANAGE	Mitigation, Adaptation, and New technologies Applied General Equilibrium
MRIO	Multi-Regional Input-Output
NDC	Nationally Determined Contribution

Executive Summary

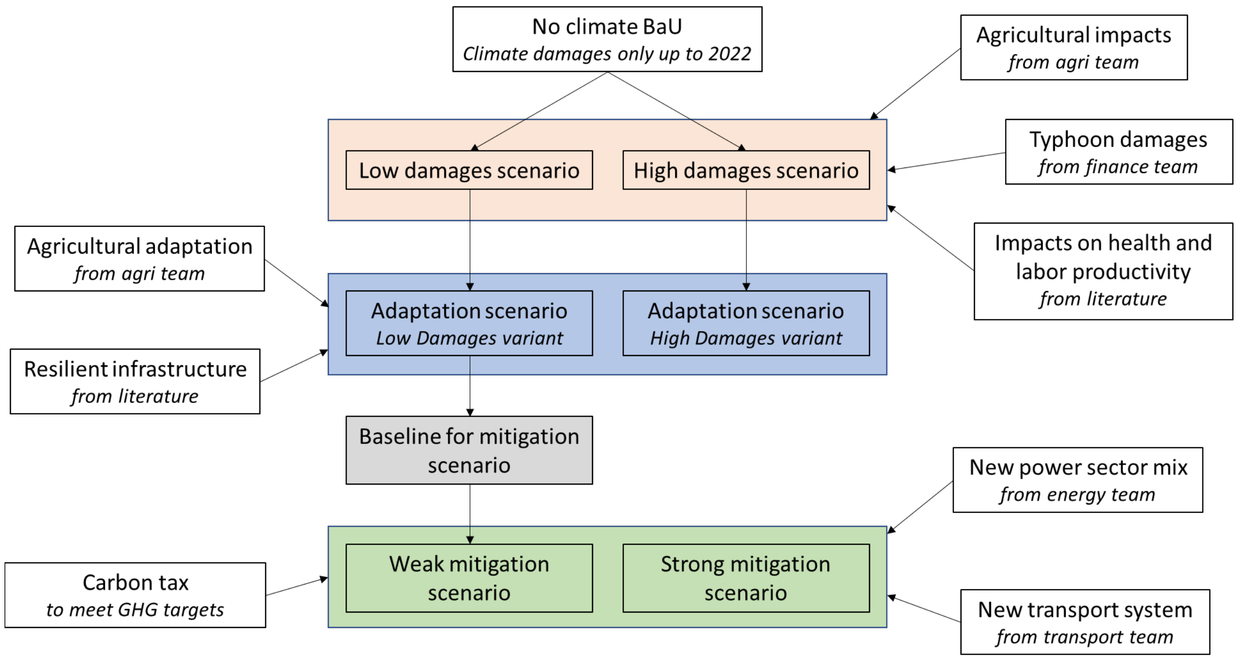
This background note describes the macroeconomic modelling that was carried out in Chapter 5 of the Philippines CCDR:

- Three main models were used: the MANAGE Computable General Equilibrium (CGE) model, a Multi-Regional Input-Output (MRIO) tool and the Carbon Pricing Assessment Tool (CPAT).
- The models provide complementary capabilities and different assumptions about how the economy works. The CGE model assumes that the economy is operating at full capacity, while the MRIO tool assumes there is always spare capacity available. CPAT provides results for indicators not covered by the other modelling tools.
- MANAGE is used to assess the impacts of climate damages. The model shows that by 2040 the impacts of a changing climate are likely to be 6-8 percent of GDP. However, the impacts could be as high as 14 percent of GDP.
- These damages could be reduced substantially if measures to adapt to a changing climate are taken. By 2040 the estimated impacts of climate change in the MANAGE model fall to around 2 percent of GDP, if measures are taken to strengthen infrastructure and improve agricultural resilience.
- The MRIO tool shows that a short-term stimulus from additional investment in adaptation measures could increase output in the construction sector by nearly 6 percent, and employment in the construction sector by 2 percent.
- The MANAGE model and MRIO tool were both applied to assess the effects of two climate mitigation scenarios that include power sector reform and carbon pricing. The first scenario assesses a case where a moderate set of policies is enacted to slow emissions growth (Current Policy Scenario, CPS). The second scenario includes a more ambitious set of policies that stabilizes emission levels around 2040 (Accelerated Decarbonization Scenario, ADS).
- Results from the MANAGE model show the importance of assumptions about how the revenues from carbon pricing are used. If the revenues are used for investment then GDP could increase by up to 0.5 percent compared to a baseline case by 2030. However, if the revenues are used for consumption, GDP woud decrease by up to 0.6 percent compared to the baseline case. In both cases, economic welfare could decrease by 1.5-2.5 percent.
- Results from the MRIO tool suggest that GDP could increase by 0.5-0.8 percent, compared to the baseline case, in the short run in the ambitious scenario, because of increased investment creating stimulus effects. Employment would also increase, particularly in the construction and engineering sectors.

1 Introduction

This background note describes the macroeconomic modelling work that was carried out to support the Climate Change Development Report (CCDR) for the Philippines. It covers both modelling of climate damages/adaptation and measures in the Philippines to mitigate climate change. Figure 1.1 summarizes the scenarios that are covered.

Figure 1.1: Summary of scenario inputs and linkages



The following section describes the main macro-level modelling tools that were used in the analysis that is presented in Chapter 5 of the CCDR (excluding the trade analysis, which is discussed separately). Sections 3 and 4 then present the data inputs used and the results from the analysis for damages/adaptation and mitigation measures. Section 5 summarizes the key messages from the analysis.

2 The modelling tools used in the analysis

Two main modelling tools were used in the analysis. Both tools are maintained internally at the World Bank. The following section describes the MANAGE model. The subsequent sections describe the CPAT tool and the MRIO model that has been developed by the World Bank's global climate economics team.

2.1 The MANAGE model

The World Bank's Mitigation, Adaptation, and New Technologies Applied General Equilibrium (MANAGE) Model is used throughout the analysis in this note. MANAGE is a recursive, dynamic single country Computable General Equilibrium (CGE) model that is designed to focus on energy, emissions, and climate change. In addition to the standard features of a single country CGE model, the MANAGE model includes a detailed specification of the energy sector that allows for capital/labor/energy substitution in production, intra-fuel energy substitution across all demand agents, and a multi-output, multi-input production structure.

The MANAGE model relies on behavioral assumptions that determine how economic agents react to various changes in the economy (e.g. prices, incomes or taxes) under well-defined constraints based on the availability of resources. The economic agents in MANAGE are households, production activities, government, and the rest of the world. Households are further disaggregated based on their socio-economic status and labor based on skill level, while production activities cover all sectors.

The model was calibrated using a 2018 Social Accounting Matrix and the macro aggregates (e.g. GDP, trade, consumption, etc.) were updated over time. The model's baseline and carbon tax scenarios incorporate results for the power sector from the more detailed modelling carried out by the energy team as part of the CCDR.

Further information about the MANAGE model may be found here (van der Mensbrugghe, 2020): https://mygeohub.org/groups/gtap/File:/uploads/MANAGERef.pdf

2.2 The Carbon Pricing Assessment Tool (CPAT)

The Carbon Pricing Assessment Tool (CPAT) is a spreadsheet-based tool that aims to support efforts to assess the effects of carbon pricing around the world. It allows for rapid estimation of the effects of carbon pricing and fossil fuel subsidy reforms along several economic and non-economic dimensions. These dimensions include key macroeconomic variables, energy consumption, local and global pollutants, 'development co-benefits', distribution/equity and poverty.

CPAT's primary objectives are to:

- Help decision-makers and analysts do quick diagnostics on the potential benefits from explicit carbon pricing and fossil fuel subsidy reforms to inform wider analyses and country strategies;
- Provide first estimates of benefits across different dimensions (from tax revenues to health) to start an engagement with national experts and to identify areas where more in-depth analyses are needed.

The tool is intended to supplement more detailed analyses and we use it in the CCDR alongside simulations from MANAGE and other modelling tools (e.g. the analysis of distributional impacts using the GIDD model).

CPAT is being developed by the World Bank in partnership and with contributions from the IMF. Background research for the various channels modeled has been completed by the CPAT team, notably through the studies "Benefits beyond Climate" and "Getting Energy Prices Right".

2.3 The MRIO tool

The multi-regional input-output (MRIO) tool (recently renamed 'MINDSET') was originally built as an extension to CPAT but is now used as an independent tool. It has been designed to provide analysis of sectoral economic and employment impacts, which are otherwise missing from CPAT. In terms of complexity the tool sits between CPAT as a rough-and-ready tool and a full macroeconomic model. As with the main CPAT tool, the focus is on carbon pricing, although the model framework can also be used to assess investment expenditures.

The rationale for the tool is that the aggregate economic effects of climate policy are of limited use to policy makers. For example, the GDP impacts of carbon pricing measures often lie in the range of 0-2 percent from a baseline case, indicating only modest impacts. However, at sectoral level the impacts may be much larger. Moreover, the sectors that are impacted by the most are often those that are location-specific, indicating much larger localized effects. Employment is a key indicator for policy makers because of its welfare implications. Being able to assess employment effects is therefore an important extension to both CPAT and the CGE modelling.

The model uses a basic input-output approach that has been enhanced to include price elasticities in the fuel sectors, building on CPAT results. It thus becomes possible to input price changes (i.e. carbon prices) to the model and to estimate the quantity effects on sectors that are directly affected, and their supply chains. The model also produces results for employment (without assuming full employment) and for the Philippines has been linked to micro-data to provide a high level of disaggregation in employment results.

The feedbacks in the MRIO model are limited, however, with no further response in prices to changes in quantity. The level of complexity in the model is therefore below that of a CGE model.

2.4 What is each model used for?

Not all the models can be used for the different types of scenarios covered in this note. Table 2.1 summarizes how the models are applied.

The MANAGE model is applied for all the different scenarios. CPAT is intended to assess carbon pricing measures and cannot be used for other types of analysis. The MRIO tool can also incorporate investment effects and therefore can provide at least a partial analysis of adaptation measures and investment in low-carbon technologies.

Table 2.1: Application of each model

	MANAGE	*CPAT*	*MRIO*
Climate damages and adaptation			
Climate damages	X		
Adaptation measures	X		X
Climate mitigation measures			
Carbon pricing	X	X	X
Other mitigation measures	X		X

2.5 Why use more than one modelling approach?

The macroeconomic modelling in this note is based primarily on the MANAGE model but in some cases the results are compared to those from CPAT and the MRIO tool. This comparison provides further potential insights to the impacts because the models are based on different underlying assumptions.

As a CGE model, MANAGE focuses on the allocation of resources in the economy. It assumes that agents are informed about their possible decisions and behave rationally. The constraints on the level of production are on the supply side, namely the factors of production. Any model inputs that change the levels of capital, labor or productivity in the economy will lead to changes in production levels. Prices in the model automatically adjust so that the level of demand matches the level of potential supply.

In contrast, the MRIO tool focuses on how the level of effective demand determines the use of factors of production in the economy, including labor. Prices in the model are mostly fixed and the model assumes that firms draw upon available capacity so that the level of supply matches overall demand. Furthermore, the multiplier effects that may be derived from the model mean that an initial increase in effective demand can create further demand, which again the level of supply adjusts to meet.

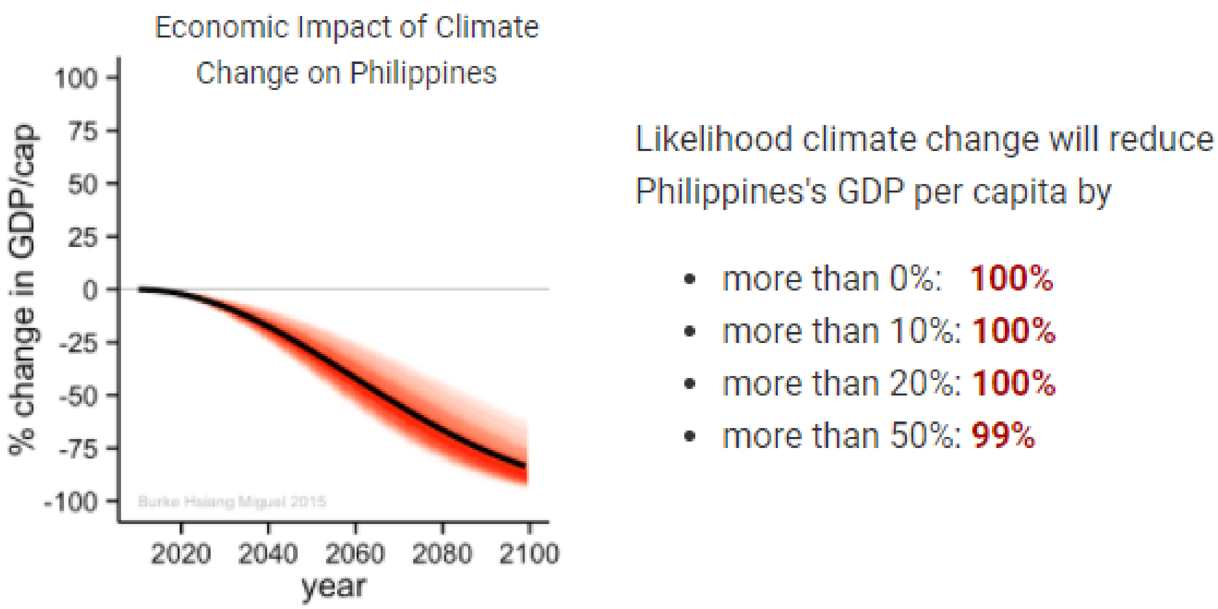
The two models thus present different interpretations of how the modern economy works. One model assumes that there is no spare capacity in the economy, while the other assumes that there are no capacity constraints. The true reality is likely to lie between these two outcomes. Having a range of different outcomes is thus useful for interpreting the results.

3 Climate damages and adaptation

3.1 Climate damages in the Philippines

The issue of economic damages resulting from climate impacts is highly important to the Philippines. The 2021 Global Climate Risk Index (Germanwatch, 2021) ranked the Philippines as the fourth most impacted country in the world by climate. Burke and others (2015) finds that under a very high climate scenario, GDP in SE Asia could be reduced by more than 25 percent by 2050 (see Figure 3.1). Under a scenario with global temperature increases of 3.2°C, Swiss Re (2021) estimated that GDP in the Philippines could be reduced by between 7 and 44 percent by 2050, depending on the severity of climate impacts (compared with a range of 1 to 5 percent under a Paris-compliant climate scenario).

Figure 3.1: Economic impact of climate change in SE Asia



Source: Burke and others (2015), see https://web.stanford.edu/~mburke/climate/map.php

Climate damages can take two broad forms: gradual decline from changing climate conditions or sudden shocks from extreme weather events. The Philippines is vulnerable to both, but particularly from sudden shocks and especially from shocks related to typhoons. According to Germanwatch (2021) the Philippines suffered from 317 climate events in the period 2000-2019. This total far exceeds the number of events suffered by other countries in the list of most vulnerable countries; Nepal is the next highest on the list with 191.

3.2 Climate damages in the CCDR

Despite the widespread recognition of the importance of climate impacts in the Philippines, there is little available data that could be used in a modelling exercise. In the CCDR, we combine the results from three different analyses. Throughout this analysis we assume that global emissions trajectories follow current trends, with the climate impacts estimated accordingly.

The first set of inputs applies to the agriculture sector and is described in more detail in the accompanying background note to the CCDR. The impacts are modelled as a loss of productivity for four important crops (rice, corn, sugar cane and bananas), with a small productivity increase in coconuts. The changes in productivity are assumed to scale linearly over the projection period. There is also a 5.5 percent reduction in the amount of agricultural land available by 2050, again with linear scaling over time.

The second set of inputs relates to the effects of higher temperatures on human health and labor productivity. We use an updated set of data from Hallegatte and others (2016). By 2030, the impact to GDP from human health effects is -0.5 percent and from labor productivity it is -0.8 percent. Assuming a value of zero in 2020, an annual time series of impacts is estimated over the projection period using linear interpolation and extrapolation. The inputs to the MANAGE model are calibrated to match these GDP results.

The final set of inputs is the most important one for the Philippines and relates to typhoon damages. Here we use recent analysis that was developed in Hallegatte and others (2022). Estimates of the loss of capital stock are input to the MANAGE model. Because of the high degree of uncertainty about both the frequency/severity of typhoon events and how climate change might impact this frequency/severity, a separate stochastic analysis is also run (see Section 3.4), with the average results (taken from low and high sensitivity cases) used in the main modelling.

Table 3.1 summarizes the treatment of climate impacts in the macroeconomic modelling for the CCDR.

Table 3.1: Summary of climate damages in the CCDR modelling

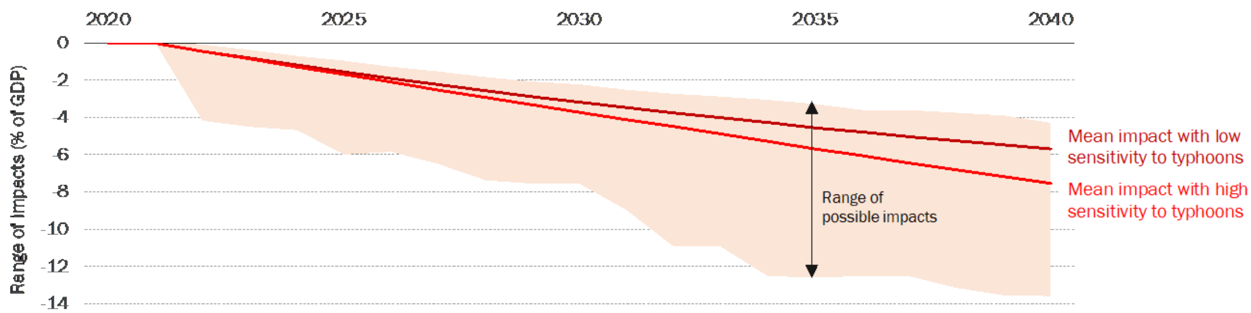
	Amount (%)	*Notes*
Gradual warming effects		
Agricultural land	-5.5	For 2050. Modelled as change in factor availability. Linear interpolation to 2050.
Rice yields	-26.3	Average loss up to 2050. Linear estimate of damages increasing over time from zero in 2020 used to get annual time series.
Corn yields	-43.2	Average loss up to 2050. Linear estimate of damages increasing over time from zero in 2020 used to get annual time series.
Coconut yields	3.4	Average loss up to 2050. Linear estimate of damages increasing over time from zero in 2020 used to get annual time series.
Sugar cane yields	-9.4	Average loss up to 2050. Linear estimate of damages increasing over time from zero in 2020 used to get annual time series.
Banana yields	-7.4	Average loss up to 2050. Linear estimate of damages increasing over time from zero in 2020 used to get annual time series.
Human health	-0.5	Impact on GDP by 2030, model calibrated to match by changing morbidity rates. Linear extrapolation beyond 2030.
Labor productivity	-0.8	Impact on GDP by 2030, model calibrated to match. Linear extrapolation beyond 2030.
Average typhoon damage		
Low sensitivity	-4.3	Average impact on the aggregate capital stock each year in the projection period.
High sensitivity	-6.4	Average impact on the aggregate capital stock each year in the projection period.

3.3 Results for climate damages from the modelling exercise

The modelling of climate damages and adaptation measures was carried out solely in the MANAGE model (see Section 2.1). The results presented in this section and Section 3.4 are therefore all from MANAGE (apart from the investment analysis at the end of Section 3.4.1).

Figure 3.2 shows the GDP impacts of the climate damages, with the low and high average sensitivities to damages from typhoons. Both lines include the same non-typhoon damages. The chart presents figures as percentage difference from a baseline case with no additional warming beyond 2022. The estimated loss of GDP by 2030 is between 3.2 and 3.7 percent, rising to 5.7-7.5 percent by 2040 and 7.4-11.0 percent by 2050. The substantial increase in annual costs over the projection period reflects the inputs to the modelling exercise, which mostly increase linearly (by assumption) over the projection period. The damages to the capital stock also accumulate over time. The impacts presented in the chart are on top of damages that we already see in 2022 with a warming of 1.2-1.3°C above pre-industrial levels.

Figure 3.2: GDP impacts of climate change in the Philippines
(percent from baseline)



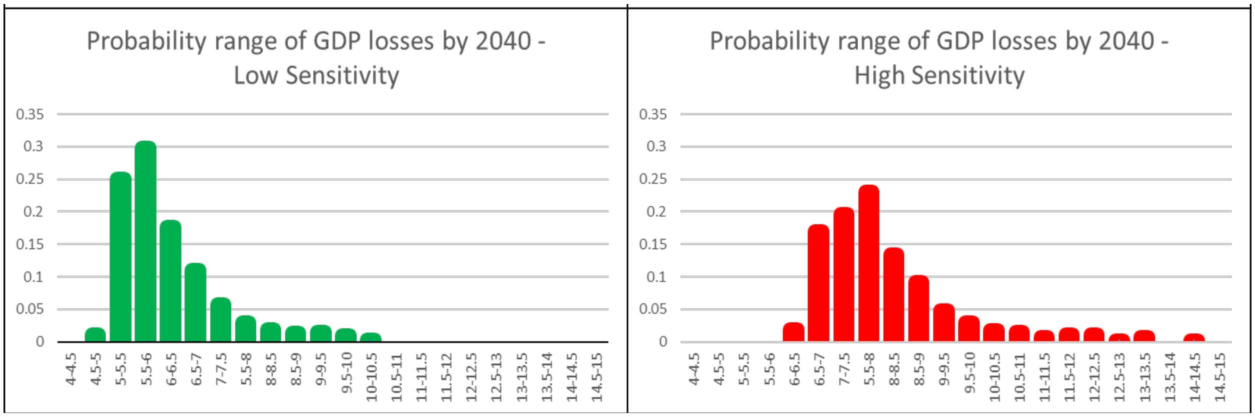
Note: The simulations estimate the possible effects of climate change on agriculture, human health, and labor productivity, combined with more severe typhoons, under different assumptions of economic sensitivity to typhoons. As typhoons are highly variable, a range of possible outcomes is estimated, as shown by the shaded area; the solid lines show the mean estimated outcomes.

Source: CCDR Team estimates based on MANAGE model

Given the high degree of uncertainty around the likelihood and strength of extreme weather events, a separate analysis was carried out using data on typhoons. These data go up to 2040, and the results of the analysis are presented in Figure 3.2. Again, two variants are modelled, with low and high climate sensitivities, and 500 scenario variants were tested in each case. Non-typhoon damages are added as described in Section 3.1. The figure shows the overall range of impacts (the shaded area), with the mean values for the variants with low and high climate sensitivity. The figure shows that in both cases the mean value lies at the lower end of the possible range of outcomes, indicating that there is a risk that the actual loss of GDP could be much higher than that presented by the means.

Figure 3.3 illustrates this point by showing the likelihood of different GDP outcomes for the year 2040. The y axis shows the probability that the GDP loss will fall into the ranges presented on the x axis. Under the low sensitivity variant, the is an 80 percent chance that the loss of GDP will lie in the region of 5 to 7 percent. Under the high sensitivity variant, however, the distribution of losses is much wider, with a 15 percent chance that losses will exceed 9 percent of GDP.

Figure 3.3: Range of potential GDP impacts in the two damages scenarios
(percent from baseline)

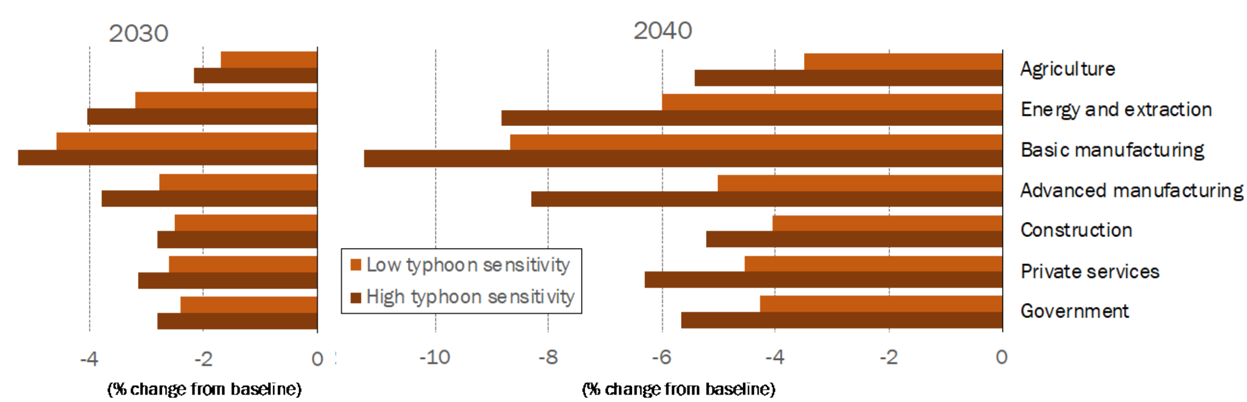


To summarize, the impacts of a changing climate on GDP in the Philippines are substantial and are likely to grow over time. Taking mean values (and applying some extrapolation over time), the cost could exceed 10 percent of GDP by 2050. However, the mean values tell only part of the story. There is a sizable risk that the costs could be even larger and could exceed 10 percent of GDP even by 2040. Furthermore, as discussed in Section 3.4.2, the modelling approach applied could under-estimate the true costs of sudden economic shocks from typhoons.

The sectoral costs of the climate impacts fall into two categories, which reflect the model inputs (Figure 3.4). First, the agriculture sector suffers specific effects from a loss of productivity and reduction in available land. Overall, agricultural production could be reduced by 2 percent by 2030 and 10 percent by 2040, relative to the baseline. The lost production would mostly be replaced by higher imports of food, although higher prices would also reduce demand (at the expense of consumer welfare, see below).

The other sectors that are most affected by climate impacts are those that are capital intensive because their capital is vulnerable to climate-related shocks (e.g. stronger typhoons). In the modelling, the sectors most affected are those that produce energy and manufacturing goods, which rely on expensive plants and equipment for production. However, all sectors rely on capital to some extent and there are also indirect effects, so the impacts are spread throughout the economy.

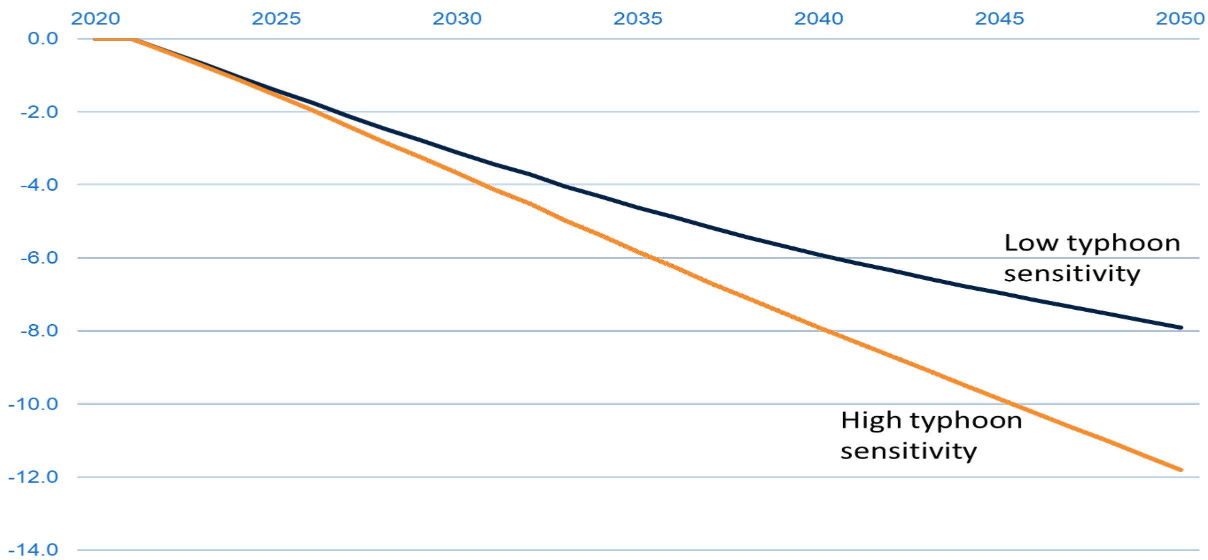
Figure 3.4: Sectoral impacts in 2030 and 2040



Source: CCDR Team estimates based on MANAGE model

The impacts on welfare in the scenarios are similar in scale to the impacts on GDP (Figure 3.5) but slightly higher overall. Increases in food prices have a disproportionate effect on welfare because they form an important part of the household consumption basket. The overall pattern of impacts matches that of the GDP results, however.

Figure 3.5: Welfare impacts of climate change
(percent from baseline)



3.4 Adaptation to climate change in the CCDR

Obtaining input data on climate impacts in the Philippines is difficult, but it is more difficult still to find data about the ways in which the Philippines could adapt to a changing climate and reduce the level of economic costs. A general literature review yields little insight on the cost and effectiveness of possible adaptation measures in the Philippine context.

For the agriculture sector, we can incorporate the findings from the sectoral analysis in the CCDR. The analysis finds that adaptation could:

- Reverse the loss of productivity (yield) from rice, generating an increase from current yields.
- Reverse the loss of productivity from corn, generating an increase from current yields.
- Negate the loss of available agricultural land.

The overall cost of these adaptation measures is estimated to be 0.06 percent of current GDP, which would be funded by the government. Although counted as investment in the modelling, the adaptation measures do not add to the stock of productive capital. The measures therefore do not add directly to the productive capacity of the economy, although they do have an indirect effect through preventing the destruction or degradation of other capital.

The options to limit the impacts on human health and labor productivity are limited and we were not able to find any data on costs or effectiveness of possible measures. The modelling therefore uses a working assumption that the measures used to reduce damage to the capital stock have the same proportional effect on human health and labor productivity. Given that health and labor productivity make up a relatively small share of total climate damages, the impact of this assumption on the aggregate results is limited.

For infrastructure, we can draw upon data that include estimates of future damages from extreme weather events (and earthquakes). Engineering studies (e.g. Miyamoto International, 2019) have attempted to derive the costs of making infrastructure more resilient from a bottom-up perspective. These values can be scaled up to national level by combining them with estimates of the amounts of total infrastructure currently in the country and the amount of infrastructure that will be needed in the coming decades (e.g. Rozenberg and Fay, 2019). The avoided damages resulting from the investment can also be estimated.

Hallegatte and others (2019) provides one such example of an analysis. The analysis provides annual time series of the estimated costs and benefits of increasing the resilience of infrastructure. The figures are aggregated for all low and middle-income countries but estimates for the Philippines may be derived by taking GDP shares. However, this assumption ignores the unusually high susceptibility of the Philippines to typhoon damage that is described above. The results of the calculations should therefore be reviewed as lower bounds; by 2030 they show annual costs of USD 0.9 billion and avoided damages of USD 1.2 billion. The benefits of implementing the adaptation measures start to exceed the costs from 2027.

More recent data that build on Hallegatte and others (2015) provide an alternative source of information. There are two ways in which adaptation costs for the Philippines may be estimated from the figures. The first is to take the estimates for adaptation costs in the East Asia-Pacific region and estimate a share for the Philippines using GDP weights. This approach finds that making infrastructure resilient would cost about 0.3 percent of GDP annually, which at USD 1.1 billion is at the high end of the estimates described above. However, the calculation method faces the same assumption as above in assuming that the Philippines is equally vulnerable to climate shocks as other countries in the region (although it does factor in that the East Asia-Pacific region is more vulnerable to climate change than many other regions).

From the same data set we can obtain explicit data for the Philippines for transport infrastructure. Using these figures, we find that building resilience would add 6.8 percent to investment costs. The Philippines spends around 5 percent of GDP on infrastructure (source: IMF) and if we extrapolate from transport to all infrastructure, the cost to GDP is around 0.6 percent each year. As described in the previous section, this higher estimate reflects the Philippines' high degree of vulnerability to climate shocks. Again, when entered into the MANAGE model, this investment is assumed not to add to the productive capital stock.

The figures suggest that the additional investment in resilience could reduce the damages caused by weather events by a factor of six. For non-transport infrastructure, it is assumed that the investment reduces damages by an arbitrary 50 percent. Combining the two calculations, the avoided damages to the overall capital stock are 68 percent. In the current modelling this rate is applied to both new and existing capital.

One important factor in these calculations is that it is important to identify which infrastructure is vulnerable to climate damages. Hallegate and others (2019) show that targeted investment could reduce the overall investment costs by an order of magnitude. A key conclusion from the literature is thus that identifying the vulnerable infrastructure should be a policy priority.

Table 3.2 summarizes the model inputs on adaptation.

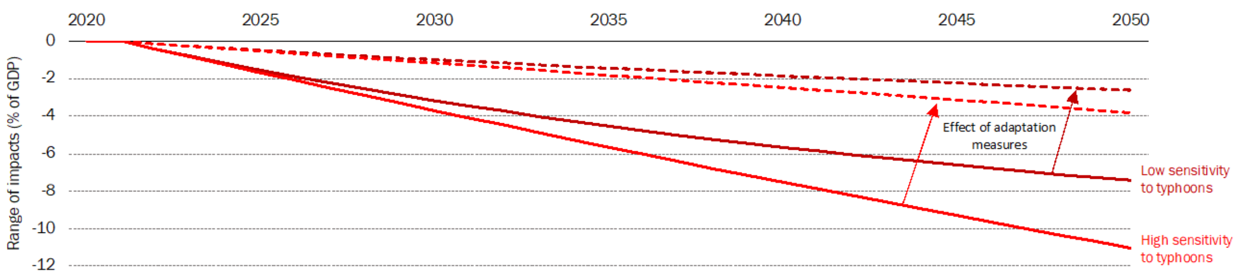
Table 3.2: Summary of adaptation measures in the CCDR modelling

Variable	*Amount (%)*	*Notes*
In the agricultural sector		
Agricultural land	0.0	The 5.5% loss of land from climate change is reversed, so that there is no overall impact on land availability.
Rice yields	1.9	The climate-induced loss of productivity is more than reversed so that yields increase compared to baseline.
Corn yields	0.05	The climate-induced loss of productivity is more than reversed so that yields increase compared to baseline.
Cost	0.06	As a share of GDP each year, maintained as an absolute level in real terms throughout the projection period.
In infrastructure		
Avoided loss of capital stock	68.0	The damages to capital stock from climate events are reduced by 68% compared to the climate damages scenario.
Cost	0.6	As a share of GDP each year, maintained proportionally throughout the projection period.

3.4.1 The impacts of adaptation measures in the modelling exercise

The adaptation measures described above reduce the negative climate impacts on both agriculture and the capital stock. The aggregate impacts on GDP of the climate damages are consequently reduced, as shown in Figure 3.6. The largest impact in 2030 falls from 3.7 percent to 1.2 percent. By 2050 the largest impact falls from 11.0 percent to 3.8 percent.

Figure 3.6: GDP impacts of climate change with adaptation measures

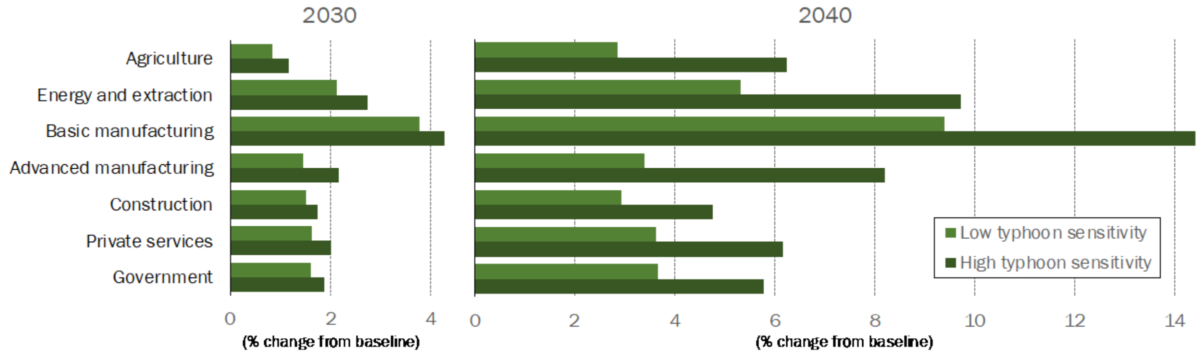


Source: CCDR Team estimates based on MANAGE model.

Compared to many other countries, the Philippines has a range of options to reduce the impacts of climate change. The agricultural sector benefits from the specific measures to boost rice and corn yields, but improving the resilience of the capital stock reduces the loss of output in all sectors. Importantly, as discussed in the previous section, a large share of the damages that result from typhoons could be offset with additional investment. As typhoons accounts for by far the largest share of climate damages in the Philippines, all sectors benefit from improvements to make the capital stock more resilient (Figure 3.7). The manufacturing sectors that produce the equipment needed for adaptation measures also benefit in the adaptation scenarios.

Nevertheless, some caveats on the adaptation results should be noted. The benefits of adaptation are greatest when measures are taken to identify the vulnerable infrastructure; without this knowledge the costs of adaptation could rise substantially. Some infrastructure that must be located on or near coastlines (e.g. ports) will be difficult to protect from typhoons. There may also be unexpected climate impacts that cannot be prepared for in advance.

Figure 3.7: Sectoral impacts of implementing adaptation measures



Source: CCDR Team estimates based on MANAGE model

The loss of welfare is also reduced in the adaptation scenarios. A maximum loss of 3.7 percent in 2030 is reduced to 1.0 percent if adaptation measures are taken. By 2050, the potential losses fall from 11.8 percent to 3.8 percent. In addition to the general benefits of higher GDP, welfare is increased by the lower food prices that result from higher production levels of rice and corn.

Table 3.3: Short-run adaptation investment impacts

	% from baseline		*% from baseline*
Output by sector			
Agriculture	0.0	Construction	5.8
Energy and extraction	0.5	Private services	0.3
Basic manufacturing	0.4	Government	0.0
Advanced manufacturing	0.6		
Employment by sector			
Agriculture	0.0	Construction	2.0
Energy and extraction	0.5	Private services	0.2
Basic manufacturing	0.2	Government	0.0
Advanced manufacturing	0.1		
Employment by occupation			
Managers	0.1	Skilled agricultural	0.0
Professional	0.1	Craft and trade-related	1.0
Technicians	0.1	Machine operators	0.2
Clerical support	0.1	Elementary occupations	0.4
Service and sales	0.1		
Employment by gender			
Male	0.4	Female	0.1

Source: CCDR Team estimates based on MRIO tool

Finally, the benefits of adaptation measures on GDP could be increased further if we relax the CGE model's assumptions about investment crowding out. The MRIO tool allows for the possibility of spare capacity and available finance in the Philippine economy. Under these conditions, investment in adaptation measures can create an economic stimulus effect because it does not displace other productive investment. It would, however, lead to higher debt levels and should only be considered as a short-term effect. Table 3.3 summarizes the model's results.The model suggests that there could be a short-term stimulus effect on GDP that is roughly equal to the value of the investment (0.7 percent of GDP), which comes on top of the benefits of the reduced climate damages estimated by the CGE model. The effects are greatest in the sectors that will contribute to improving the resilience of infrastructure, and these sectors' supply chains. The sector that benefits by far the most is construction. These are the sectors that will need to increase production capacity if the Philippines will meet its challenge of improving future resilience to climate change.

Some of the higher output is met through increased labor productivity but there would also be increases in employment. Again, the impact is largest in construction and the nature of the work involved suggests that many of the jobs would involve manual labor defined as craft and trade-related in the data. Given current shares in occupations, the jobs would therefore likely be taken by men.

3.4.2 Limitations to the analysis

The results in this section were produced mostly using the MANAGE CGE model. The CGE approach is generally well suited to the assessment of climate impacts that develop gradually over time (in this analysis the impacts on agriculture, human health and labor productivity). The model describes in detail how the loss of factors of production and productivity affect the wider economy and how the economy may adjust to these impacts. The main limitation is the underlying assumption that both workers and capital can shift to more productive uses if it is beneficial for them to do so.

We have also used MANAGE to assess the effects of sudden shocks to the Philippines' economy through typhoons. Here the underlying assumptions in the model are more restrictive and some care should be applied when interpreting results. The CGE approach typically presents long-run outcomes in which the economy has fully adapted (via price changes) to the effects of a shock. The short-run impacts of a shock may be more severe because there is not time for this adjustment process to take place (i.e. there is a misallocation of resources as well as a shortage of resources). The model results may therefore underestimate impacts for a specific year.

The modelling also does not account for the potential effects of reconstruction. Often immediately after a disaster there is a boost to GDP because of repair and reconstruction efforts. However, the boost to GDP comes at the expense of higher debt levels. This is the representation provided by the MRIO tool. The tool is subject to its own restrictions about the availability of skilled workers and economic capacity to increase production levels.

The remaining limitations to the analysis relate to the uncertainty of the inputs used to the modelling. As noted in previous sections, data on both climate damages and adaptation benefits/costs are scarce and there is a high degree of uncertainty about true values. The estimates used in our analysis are in general conservative in nature, and may in some cases underestimate the scale of impacts. We expect these estimates to be revised as better data become available.

3.5 Mitigation

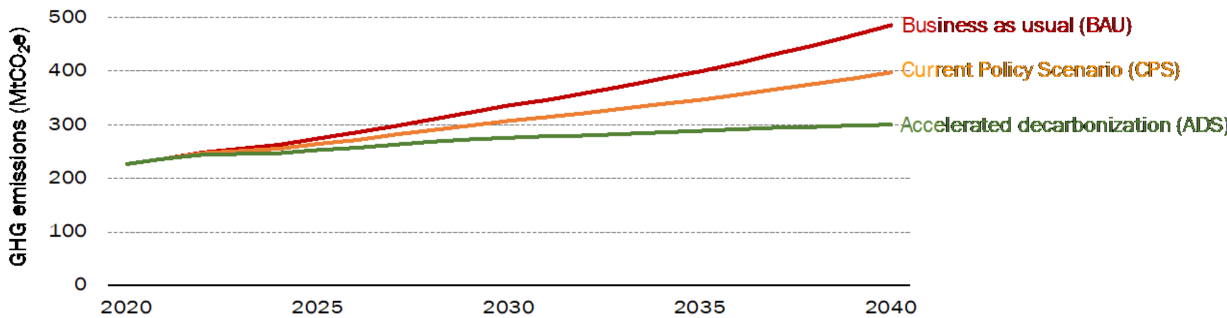
3.5.1 The mitigation baseline and the decarbonization scenarios

We now turn to the model-based assessment of measures to reduce greenhouse gas emission levels in the Philippines. For this analysis we adopt a new baseline case, which is the scenario in the previous section with low typhoon sensitivity plus measures to adapt to a changing climate. The previous baseline that excludes climate damages is from this point referred to as the BAU. In this section it is assumed that climate action by the Philippines alone will not impact on the global climate and therefore the costs of a warming climate for the Philippines will not change.

The choice of baseline does not make much difference to the model results and conclusions from this section, but the mitigation scenarios should be interpreted in the context of climate damages and adaptation measures being implemented.

Figure 4.1 presents the baseline trend in GHG emissions in the Philippines over the projection period. The unconditional NDC is met in the baseline. The conditional NDC, which is highly ambitious, is not met. In this section, the time horizon for the analysis is 2040, reflecting the period covered in the sectoral analysis for the energy sector. This analysis provides one of the key inputs to the macro modelling.

Figure 4.1: GHG emissions in the baseline and scenarios



Source: CCDR Team estimates based on MRIO model.

The results from two mitigation scenarios are compared to this baseline. The first scenario is based on a moderate reduction in GHG emissions, with a path that goes towards 30 percent below the BAU case (excluding the effects of climate damages) by 2050. This scenario is called the CPS (Current Policy Scenario) case.

In the second scenario, GHG emissions in the Philippines are on a pathway towards 60 percent reduction compared to the no-damages BAU case by 2050. This scenario is called the Advanced Decarbonization Scenario (ADS). In the ADS emission levels stabilize but it is important to note that further action still would be required for a deep reduction in emissions compared to 2020 levels (i.e. GHG emissions still increase slowly over time).

Both scenarios incorporate results from the energy and transport sector analysis. The findings from this analysis are incorporated into the MANAGE model as exogenous inputs in terms of:

- Emission savings
- Investment cost

The investment cost is also incorporated to the MRIO analysis.

A carbon tax is then added to all sectors of the economy and all greenhouse gas emissions. The rate of the carbon tax is set so that the emission reduction targets would be met by 2050, with a gradual reduction in emissions each year. The carbon tax rate is therefore increased throughout the projection period (see Table 4.1). It remains relatively modest in both scenarios up to 2040.

Two variants of each scenario are assessed. In the main variants, the revenues from the carbon tax are used to increase public investment, reflecting the development aspect of the scenarios. In the alternative variant, the revenues from the carbon tax are used to fund additional consumption. For many of the output indicators, the choice of variant does not affect the results and so only the main variant is shown. However, the choice of revenue recycling instrument is important for determining the macro-level results in both the MANAGE and MRIO models. In MANAGE, additional investment contributes to expanding the size of the capital stock, increasing productive capacity in the economy. In contrast, increasing consumption does not lead to higher production capacity in the model. In the MRIO tool, it is the import content of investment and consumption goods that matters; a larger stimulus is provided by the option that boosts domestic production by more.

The largest reductions in emissions come from the power sector (Figure 4.2). Emissions from manufacturing (both energy and process emissions) also fall by around half by 2040 in the ADS scenario. Other sectors see smaller reductions. The right-hand side of Figure 4.2 shows the relative weight of each sector in total emissions. It is notable that there is a large contribution of 'other' and non-CO_2 (mostly agriculture-based) emissions that are not reduced in the scenarios. By 2040 in the ADS, a large proportion of remaining GHG emissions is therefore non-CO_2.

Table 4.1: Carbon tax rates in the scenarios

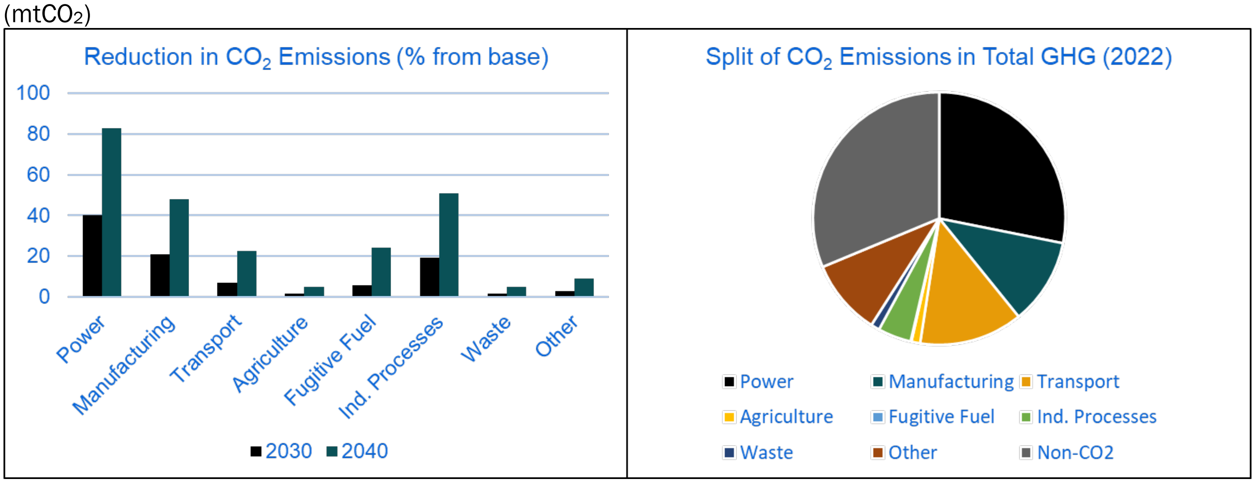
(USD/tCO_2)

	CPS	*ADS*
2025	2.6	7.5
2030	5.0	16.0
2035	11.1	32.8
2040	17.4	62.5

The revenues from the carbon tax are used for public investment, including investment in measures to reduce emissions and to adapt to the effects of climate change. It is assumed that 25 percent of the investment is used to replace stranded assets and therefore does not make a net addition to the productive capital stock.

Figure 4.2: Reduction in GHG emissions in the ADS

($mtCO_2$)



The same carbon price is used in the analysis in the CPAT model. The results for changes in energy prices are passed from CPAT to the MRIO tool, which also incorporates the additional investment in the power and transport sectors. Using this approach we end up with two sets of model results for the overall mitigation scenarios.

3.5.2 Economic impacts of the CPS and ADS

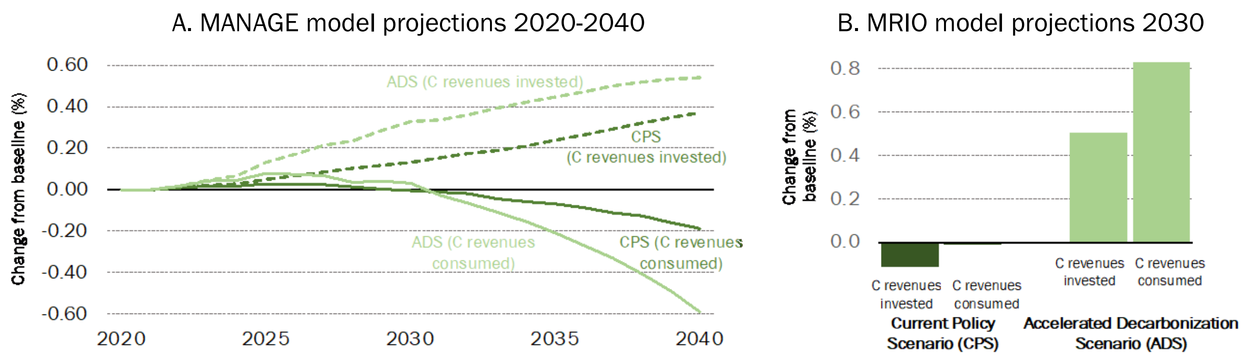
In the results from the MANAGE model, both the CPS and ADS show small increases in GDP compared to the baseline, if the revenues are used to increase public investment levels (Figure 4.3, LHS). If the revenues are instead used to increase consumption, there is a neutral effect up to 2030 and a negative effect thereafter. Whether there is a 'double dividend' effect thus depends on the choice of revenue recycling method and, ultimately, whether the economic trajectory increases or decreases the size of the capital stock. This effect outweighs any potential loss of productivity from a non-optimal allocation of resources.

However, whichever method is chosen, the net impact is small overall; plus or minus 0.6 percent compared to the baseline case by 2040 in the ADS scenario. In the CPS scenario the range of impacts is +0.4 percent to -0.2 percent by 2040.

The results from the MRIO tool also show positive economic impacts for the ADS but not for the CPS scenario. In the MRIO modelling, additional investment in the power and transport sectors creates a stimulus effect that boosts levels of economic production, drawing on available economic capacity while increasing net debt levels. The reason that the ADS produces better results is that it includes substantial additional investment in transport equipment that is not included in the CPS scenario.

Again, the way that revenues from the carbon tax are recycled into the economy is important. In the MRIO model, however, the consumption variant produces a more positive GDP impact. The reason is that consumption goods (e.g. food, housing) typically have a much larger domestic component than investment goods (e.g. machinery). The domestic stimulus effect is therefore higher in the consumption variant of the two scenarios.

Figure 4.3: Economic impacts in the two scenarios



Source: CCDR Team estimates based on MANAGE and MRIO models.

It should be noted that neither model includes the impacts of improvements to air quality in its results. It is anticipated that a reduction in coal use would improve air quality and improve labor productivity, which could boost GDP further.

The different mechanisms in the two models provide insights for policy makers in the Philippines. The MRIO modelling assumes that there is available capacity in the economy, which allows the additional investment to have a stimulus effect. In contrast, the MANAGE CGE model assumes that the economy is already at full capacity, but a switch from consumption to investment increases future capacity. The actual outcome may depend on the position within the economic cycle, but the two models are showing alternative ways to find modest increases in economic production.

The MRIO tool can also give estimates of increases in employment. Again, the model must assume that there is spare capacity available in the labor market (i.e. not full employment) but this assumption is reflected in the available data. Table 4.2 presents the results from the analysis. In total, around 80,000 net additional jobs could be created in the ADS, with the new jobs mostly appearing in the construction and advanced manufacturing sectors. Like the adaptation scenario, the nature of the additional work means that many of the new jobs are in manual work and will likely be taken by men.

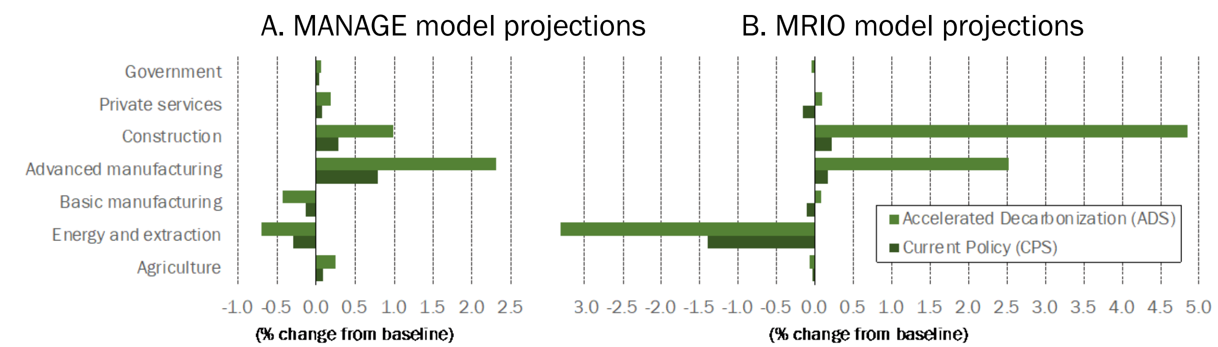
Both models provide estimates of the sectoral impacts of the additional investment and carbon pricing, although the MRIO tool gives a wider spread of impacts. The sectors that show the largest increases in output are those that are involved in producing the capital goods required for the transition to a low-carbon economy. These are principally the advanced manufacturing and construction sectors. Basic manufacturing features in the supply chains of these sectors but is also carbon-intensive and suffers from a loss of competitiveness. There are reductions in energy production, reflecting a fall in energy intensity in the economy.

Table 4.2: Short-run employment impacts

(MRIO model, percent change)

	CPS	*ADS*
Employment by sector		
Agriculture	0.0	0.0
Energy and extraction	-0.5	-0.7
Basic manufacturing	0.0	0.1
Advanced manufacturing	0.0	0.7
Construction	0.1	1.7
Private services	0.0	0.1
Government	0.0	0.0
Employment by occupation		
Managers	0.0	0.1
Professional	0.0	0.0
Technicians	0.0	0.1
Clerical support	0.0	0.0
Service and sales	0.0	0.1
Skilled agricultural	0.0	0.0
Craft and trade-related	0.0	1.0
Machine operators	-0.1	-0.1
Elementary occupations	0.0	0.3
Employment by gender		
Male	0.0	0.3
Female	0.0	0.1

Figure 4.4: Sectoral production impacts in the two scenarios (2030, percent from baseline)



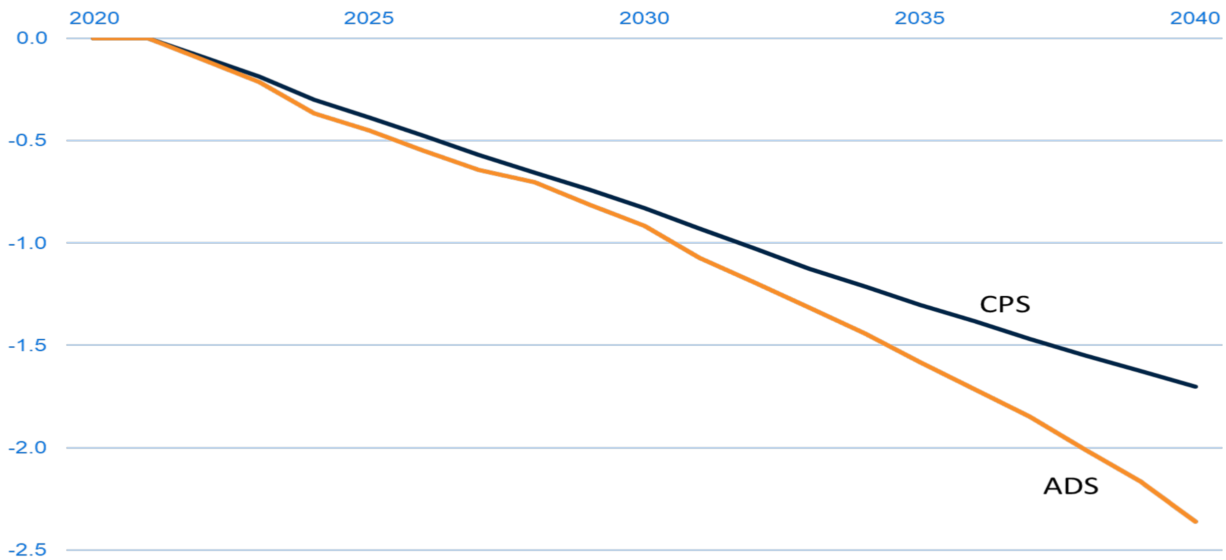
Source: CCDR Team estimates based on MANAGE and MRIO models.

There is little impact on the other main sectors of the economy. The MANAGE results show a similar pattern for 2040 as for 2030. The consumption variants of the scenarios also show a similar pattern of results.

The results from MANAGE also give estimates of welfare impacts. Welfare is different from GDP in that it focuses principally on consumption and excludes investment. It therefore focuses on present-day outcomes rather than future benefits.

The CPS and ADS both include substitutions from current consumption to investment and therefore the positive GDP results are not reflected in higher welfare (Figure 4.5). Higher prices reduce consumer surpluses and real incomes, resulting in lower welfare outcomes. In the CPS scenario, the loss of welfare by 2040 is 1.7 percent. In the ADS it is 2.4 percent.

Figure 4.5: Welfare impacts in the two scenarios
(percent from baseline)



Source: CCDR Team estimates based on MANAGE model.

3.5.3 Limitations to the analysis

This analysis was carried out primarily using the MANAGE Computable General Equilibrium (CGE) model. Although CGE models are widely used for analysis of climate policy, they include some assumptions that are important to consider when interpreting the results.

The CGE modelling framework is based on assumptions about rational (optimizing) behavior and market prices that respond perfectly to changes in supply or demand. When combined, these assumptions ensure that all available economic resources are used in production, meaning that the economy always operates at full capacity. Investment plays a special role in the model because it increases the amount of capital available and the production capacity of the economy. However, other policies will usually lead to a loss of production in the model because they introduce inefficiencies compared to a market mechanism that is assumed to operate with perfect efficiency.

The model implicitly works with a fixed set of technologies and the assumption of rationality implies that agents in the model are aware of all technological options. Typically, it takes companies time to learn about new behaviors and technologies, but the model assumes there is an instant adjustment to a new equilibrium outcome. As a result, impacts may take longer to occur than is predicted in the model results.

Finally, the model makes specific assumptions about how the financial system operates. A fixed money supply means that additional investment in low-carbon equipment must be funded either by displacing ('crowding out') other investment or through increased savings and reduced consumption. There is therefore no possibility for the financial sector to play a positive role in the transition. Conversely, potential issues relating to a lack of access to finance are also not covered by the model.

The CPAT model and the MRIO tool are both subject to their own strong assumptions. In an MRIO framework there are no supply-side restrictions, the required resources for production are assumed to be always available, and it is assumed that higher levels of production may take place without any feedbacks to price mechanisms. The economic structure and the set of technologies in the model are fixed to match the available base year (although the CPAT tool allows some modification in energy sectors). Like the CGE model, the timing of effects is not considered in detail, and it is largely assumed that the impacts of shocks to the model are instantaneous.

Standard MRIO analysis does not include investment beyond an exogenous component of final demand. The MRIO tool used here allows investment to increase in line with production, according to a fixed elasticity. This treatment adds to the potential multiplier effects in the model, again with no consideration of potential supply-side constraints.

4 Overall conclusions

This background paper has summarized the macroeconomic modelling that was carried out for the Philippines' Country Climate and Development Report. It covers climate impacts, potential measures to adapt to a changing climate, and possible policies to reduce greenhouse gas emission levels in the Philippines.

At every stage in the analysis, the modelling team has encountered considerable uncertainty. There are major gaps in data, particularly relating to climate impacts. The modelling tools available are based on stringent assumptions and are far from perfect. Nevertheless, it is possible to identify three clear conclusions from the model results.

The first conclusion is that the Philippines is at substantial risk from a changing climate. This finding confirms the results from previous analysis. The main vulnerability in the country is to typhoons, which could become both more frequent and more intense in a world with a warmer climate. However, there will also be impacts on agricultural production and human health. Our central estimate (assuming a high sensitivity of typhoons to a warming climate) is that GDP in 2040 could be 8 percent lower than in a world without further warming. However, there is a long tail of risks in which the loss of GDP could be 10-15 percent. The costs are also expected to keep accumulating beyond 2040. In addition, the nature of the model used means that we may be underestimating the costs of sudden economic shocks, as large typhoons would deliver.

However, the second conclusion is that there are measure that the Philippines could take to reduce these potential losses. The vulnerability to typhoons means that most of the costs come in the form of damage to, or destruction of, infrastructure. By taking steps to make this infrastructure more resilient, losses could be reduced substantially. While it is difficult to quantify how much the damages could be reduced by, our estimates suggest that the overall reduction could be around two-thirds. It will be important to identify the vulnerable infrastructure to avoid unnecessary increases in construction costs.

Finally, the need to reduce its own GHG emissions could provide an economic opportunity for the Philippines. The modelling finds that it will be difficult to reduce emissions from today's absolute levels, in part because of the growing contribution from the agriculture sector. However, the model results suggest that measures to reduce GHG emissions will also improve air quality, with beneficial effects for human health and labor productivity. As such it may be possible to achieve a 'double dividend' of reducing emissions while simultaneously boosting jobs and incomes. Both the models used in this analysis found potential double dividend effects, albeit for different reasons.

The overall conclusions from the modelling are thus of challenges that lie ahead, but also of economic opportunity. The Philippines must find ways both to reduce its own emissions and to adapt to the climate change that has resulted from other countries' emissions. However, if done in an effective manner, the result could a more resilient and productive economy.

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