Economy-wide Analysis of Climate Change in Southeast Asia: *Impact, Mitigation and Trade-off*

Economy and Environment Program for Southeast Asia

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ECONOMY-WIDE ANALYSIS OF CLIMATE CHANGE IN SOUTHEAST ASIA: IMPACT, MITIGATION AND TRADE-OFF

Economy and Environment Program for Southeast Asia

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Contents

Foreword

The Economy and Environment Program for Southeast Asia (EEPSEA) is a regional organization tasked with developing the capacity of Southeast Asian researchers on the use of economic tools and techniques so that they may better inform environmental policy formulation in the region. The Program has helped develop the capacity of many Southeast Asian researchers throughout the years through its training and research grants program.

In July 2011, EEPSEA sponsored a training course on economic modeling for environmental and natural resource management that EEPSEA in Bandung, Indonesia, in partnership with the Center for Economics and Development Studies of Universitas Padjadjaran. The course provided the participants with the theoretical foundation of Computable General Equilibrium (CGE) Modeling and hands-on experience in running standard CGE models to answer specific research questions involving environmental issues. Participants were encouraged to submit research proposals to address policy relevant questions. EEPSEA provided funding to four such research projects, with the technical guidance provided by Dr. Arief Yusuf Anshory, then an EEPSEA Senior Economist. This book is a compilation of those four studies.

CGE modelling has wide applications. In this book, it was used to analyze the economic impacts of a given shock (climate change) in one sector and how changes in resource allocation and prices in that sector will in turn affect other sectors (see Philippine and Indonesian case studies). It was also used to analyze the inter-sectoral effect of subsidies (see case studies on the Indonesia's agricultural subsidy and on Malaysia's fuel subsidy). Finally, it was also used to analyze the economic impact of a regional agricultural development program, as demonstrated in the third case study from Indonesia.

Although strong assumptions are made in the CGE models applications, the tool has potential in supporting environmental policy making in the region. It can show the tradeoff between development objectives and environmental goals and can be used to show that a change in one sector will have impacts on other sectors given the large economic interdependency among the various sectors of society.

We hope that through this book other researchers will be encouraged to explore how they can assist their governments through the use of CGE modeling in particular, and other economic tools in general, in environmental policymaking and management.

Herminia A. Francisco
EEPSEA Director

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Overview

Arief Anshory Yusuf

Super Typhoon Haiyan, one of the strongest typhoons recorded on the planet, struck the Philippines on November 2013 leaving much destruction. *(Photo: Aftermath of Super Typhoon Haiyan by Medico International under creative commons license at https://www.flickr.com/photos/medico_international/11191053095*

INTRODUCTION

Many studies reveal that Southeast Asia (SEA) is among those most at risk from climate change impacts. It is estimated that the region would lose 6.7% of GDP by 2100, three times of the global average. Clearly, climate change poses significant threats to the sustainability of the region's economic growth, its poverty reduction endeavors, the achievement of the Millenium Development Goals, and long-term prosperity (ADB 2009).

SEA is vulnerable to various climate-induced natural hazards such as droughts, floods, typhoons, and sea level rise (Yusuf and Francisco 2010). The Philippines, for example, is found to have high exposure to tropical cyclones, floods, and landslides. Manila, the country's capital, is the most vulnerable province in the country and among the most vulnerable cities in the region. In Thailand, the provinces around Bangkok are highly exposed to the threats of sea level rise and frequent floods. The 2011 Bangkok flood was estimated to have reduced the country's economic growth by up to 1.7%. In Jakarta, Indonesia, some estimates suggest that the regular flood suffered costs billions of dollars.

Adding to the vulnerability of SEA countries are its long coastlines; large and growing population; high concentration of human and economic activities along coastal areas; importance of the agriculture sector in providing jobs and livelihoods for a large segment of people, especially those living in poverty; and some countries' dependence on natural resources and the forestry sector for growth and development (ADB 2009).

With a population of around 0.6 billion people in 2011, and a growth rate of about 1.4% per annum, the region's large population exacerbates its climate change vulnerability. The impact of climate change on agricultural productivity remains one of the region's biggest challenges. Several studies predict a possible decline in agricultural production potential in SEA due to climate change. This not only poses a significant challenge to the region's status as a major producer of grain and industrial crops but also threatens its food security.

On the other hand, SEA countries also contribute a significant share to global carbon emissions. The aggregate carbon emissions (excluding land use) from six ASEAN nations surpassed 1,300 million tonnes in 2010. Despite their relatively modest contribution to global emissions (at about 4%), the amount of emissions grew by 5.5% a year between 1990 and 2010, compared with only 0.7% from the OECD region.

The carbon emissions of three big SEA countries (i.e., Thailand, Malaysia, and Indonesia) grew by more than 6% per year for the period of 1971-2009 (Figure 1). Most of this growth is attributed to the growth of per capita income in these countries. It should also be noted that whenever Indonesia's and Thailand's carbon intensity of energy (carbon content) grew quite fast during the period, Malaysia's energy intensity showed a positive growth. On the other hand, Singapore's per capita income grew faster than these three countries yet its emission growth is a lot slower; it managed to reduce its emission intensity as well as lower the carbon intensity of its energy.

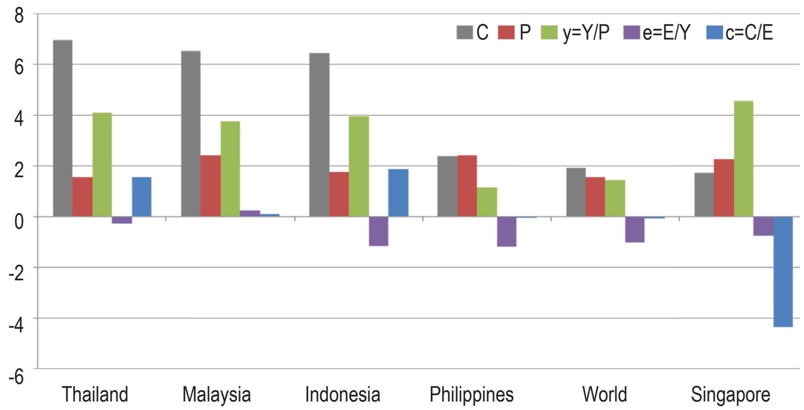

Figure 1. Decoupling Southeast Asian countries' emissions growth (annual percentage change), 1971-2009[1]

[1] *C = carbon emissions; P = population; E = energy – C = P(Y/P)(E/Y)(C/E) = P*y*e*c or in annual percentage change (underline means percentage change) C = P + y + e + c. This can be interpreted to mean that the growth in emissions can be decomposed into its four drivers, namely: 1) growth in population, 2) growth in prosperity (income per capita), 3) growth in emissions intensity, and 4) growth in carbon content of its energy.*

One possible reason for the slow growth in energy intensity improvement and renewable energy use is the fact that fossil fuel is subsidized in most SEA countries (Figure 2). Similarly, countries in many parts of the world still subsidize their fossil fuel consumption. It is estimated that subsidies related to fossil fuel consumption amounted to USD557 billion in 2008 (IEA 2010). A recent assessment projected that if these subsidies were phased out by 2020, it would result in a 5.8% reduction in primary energy demand at the global level and a 6.9% fall in energy-related carbon dioxide emissions, compared with a baseline in which subsidy rates remain unchanged (IEA, OPEC, OECD, World Bank 2010).

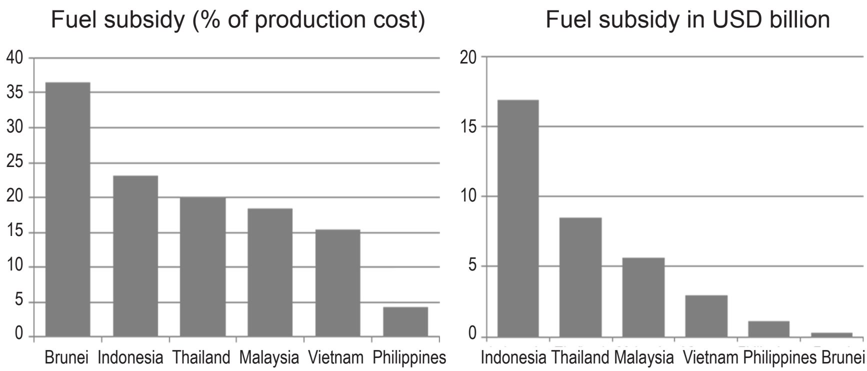

Figure 2. Fuel subsidy in Southeast Asian countries, 2011
Source: International Energy Agency

The aim of this book is twofold: to present comparative estimates of a common climate change impact using the cases of climate-induced impact on agriculture in the Philippines and Indonesia; and to explore some big challenges in the region's mitigation efforts through the case of fuel subsidy in Malaysia, and the case of deforestation-based emission in Indonesia.

COMPUTABLE GENERAL EQUILIBRIUM MODELING

The approach used in the four case studies presented in this book is economy-wide modeling, particularly the computable general equilibrium (CGE) model.

General equilibrium theory is a formalization of the observation that real-world markets are interdependent. The changes in supply or demand conditions usually have repercussions on the equilibrium prices on several other markets. CGE modeling is an attempt to use general equilibrium theory as an operational tool for empirically oriented analyses of resource allocation issues in market economies (Bergman 2005). The CGE model has been used as a tool for many aspects of economic policies and is popular among policy-oriented economists to analyze the impact of economic policy that may have large inter-sectoral effects. For example, Arrow (2005, p. 13) mentions that "in all cases where the repercussions of proposed policies are widespread, there is no real alternative to CGE".

Market equilibrium represents a market condition such that the quantity of goods demanded equals the quantity supplied at a price at which suppliers are prepared to sell and consumers are prepared to buy. Thus, the current state of exchange between buyers and sellers persists. When all markets in an economy are in an equilibrium state, it can be called a general equilibrium condition. A CGE model uses realistic economic data to model the condition as to how an economy reaches it general equilibrium condition. CGE then consists of a system of mathematical equations representing all agents' behavior, i.e., consumers' and producers' behaviors and the market clearing conditions of goods and services in the economy (Resosudarmo *et al*. 2009).

In the four case studies in this book, two different classes of CGE models are used: the CRUSOE model, which is a standard national CGE model based on the Australian version of the ORANI-G model, and the IRSA-INDONESIA-5, an interregional CGE model of the Indonesian economy.

ORANI-G/CRUSOE: A Stylized National CGE Model

The ORANI-G/CRUSOE CGE model was used in three of the four case studies in this book: the cases on climate-induced impact on Philippine and Indonesian agriculture, and the Malaysian fuel subsidy case. The ORANI-G model is a generic single-country CGE model first developed for the Australian economy. CRUSOE is a rather simplified version of ORANI-G taking out, for example, the margins from the model.

The ORANI-G model is widely applied and adapted by economists and academicians in the government and private sector for practical policy analysis, e.g., study of macroeconomic and sectoral shocks addressing competition and trade policies (Horridge 2003). It has been adapted to build models of South Africa, Pakistan, Sri Lanka, Fiji, South Korea, Denmark, Vietnam, Thailand, Indonesia, Philippines, and China.

The ORANI-G–based model is used in general equilibrium modeling because of the following advantages: 1) it allows for direct implementation of production and consumption shocks in the analysis; 2) it contains equations that explicitly link sectors of agriculture, manufacturing, and trade to other industries in the economy; and 3) it computes macroeconomic variables (e.g., GNP, imports and exports, among others) that allow an overall assessment of the impacts. In particular, the theoretical structure of ORANI-G consists of equations describing producers' demands for produced inputs and primary factors, producers' supplies of commodities, demands for inputs to capital formation, household demands, export demands, government demands, the relationship of basic values to production costs and to purchasers' prices, market-clearing conditions for commodities and primary factors, and numerous macroeconomic variables and price indices. Horridge (2003) presented a detailed guide of the ORANI-G model, its structure, assumptions and drawbacks, key relationships, and closures, among others.

Model's structure

The structure of the CRUSOE model is based on the ORANI-G model (Horridge 2003) with the theoretical structure that is conventional for static general equilibrium models. It includes of the following major components:

- Household consumption demand systems categories of consumer goods. These demand functions are derived from the linear expenditure system.

- The household supplies of skilled and unskilled labor are assumed to be exogenous.
- A factor demand system, based on the assumption of Constant Elasticity of Substitution (CES) production technology, which relates the demand for each primary factor to industry outputs and prices of each of the primary factors. This reflects the assumption that factors of production may be substituted for one another in ways that depend on factor prices and on the elasticities of substitution between the factors.
- A distinction between two kinds of labor, skilled and unskilled, which are 'nested' within the industry production functions. In each industry, both kinds of labor enter a CES production function to produce 'labor', which itself enters a further CES production function for industry output.
- Leontief assumptions for the demand for intermediate goods. Each intermediate good in each industry is assumed to be demanded in fixed proportion to the gross output of the industry.
- Demands for imported and domestically produced versions of each good, incorporating Armington elasticities of substitution between the two.
- A set of export demand functions, indicating the elasticities of foreign demand for exports.
- Rates of import tariffs and excise taxes across commodities.
- A set of macroeconomic identities, which ensures that standard macroeconomic accounting conventions are observed.

The demand and supply equations for private-sector agents are derived from the solutions to these agents' microeconomic optimization problems (cost minimization for firms and utility maximization for households). The agents are assumed to be price-takers, with producers operating in competitive markets with zero profit conditions, reflecting the assumption of constant returns to scale.

Database

The database for the CRUSOE model is shown in Figure 3. The basic information used for the construction of this database are: Input-Output data on flows of intermediate goods *c* ={1,...,*C*} from sources *s* ={dom, imp} to industries *i* ={1,...,*I*} used in *current* production (i.e., production in current period) (matrix V1BAS); commodity taxes on these intermediate goods (matrix V1TAX), including import duty on imported goods (matrix V0TAX); primary factors (labor, capital, land) used in current production (V1LAB, V1CAP, V1LND); production tax or subsidy (matrix V1PTX); and 'other costs ticket', which stands for miscellaneous items such as municipal taxes or charges (V1OCT).

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Other	Change in Inventories
	Size	←I→	←I→	←1→	←1→	←1→	←1→
Basic Flows	↑ CxS ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Taxes	↑ CxS ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					

C = number of commodities
I = number of industries
S = 2: domestic, imported
O = number of occupation types
M = number of commodities used as margins

	Joint Production Matrix
Size	←I→
↑ C ↓	MAKE

	Import Duty
Size	←1→
↑ C ↓	V0TAR

Figure 3. The CRUSOE flows database

If we sum up the columns of these matrices, we get the values of production in these industries. These values define the 'basic price' of commodities produced in these industries. To allow for multiple-product industries (mainly in the agricultural sector), we define a 'MAKE' matrix that shows which commodity is produced by which industry. Next, in addition to usage (as intermediate goods) in current production, each commodity can also have other uses: as investment goods for next production period (V2BAS); as final goods used for household and government consumption (V3BAS, V4BAS); as export goods (V5BAS); and as addition to inventory stock (V6BAS). There are commodity taxes (V2TAX, V3TAX, V4TAX, V5TAX) associated with all these uses (except inventory) but there are no primary factor inputs in these final consumption activities.

IRSA-INDONESIA-5: A Bottom-up Interregional CGE Model

The IRSA-INDONESIA-5 CGE model was used for the case of deforestation-based emission in Indonesia focusing on the impact of agricultural expansion in Papua Island.

Model's structure

As described in Resosudarmo *et al*. (2009), an interregional CGE model is that which models multi-region economies within a country. In this model, regions that consist of multiple sectors are typically inter-connected through trade, movements of people and capital, and government fiscal transfers.

In general there are two approaches to constructing an interregional CGE model: the top-down and the bottom-up approaches. The top-down interregional CGE model solves the general equilibrium condition at the national level, which means the optimization is done at that level. National results for quantity variables are broken down into regions using a shared parameter. This approach, therefore, recognizes regional variations in quantity but not in price.

The bottom-up model, on the other hand, consists of independent sub-regional equilibrium models that are interlinked and aggregated at the national level as an economy-wide system. In this approach, optimizations are done at the regional level. The results of these regional models are then combined to produce an aggregate economy-wide outcome. Therefore, this approach allows for both price and quantity to vary independently by region. By implication, this approach enables one to analyze the impact of a region-specific shock to an economy. The downside, however, is that the approach requires more data and computing resources compared to the top-down approach. Therefore, sectoral or regional details often need to be sacrificed in order to compensate for this drawback. IRSA-INDONESIA-5 falls under this category of interregional CGE models.

The flow of product in the IRSA-INDONESIA-5 can be best illustrated in Figure 4 where two regions (a subset of the five regions) connect with each other. In a purely national model, economic agents in one region can only buy products from the rest of the world, whereas in the interregional model they can also buy products from other regions.

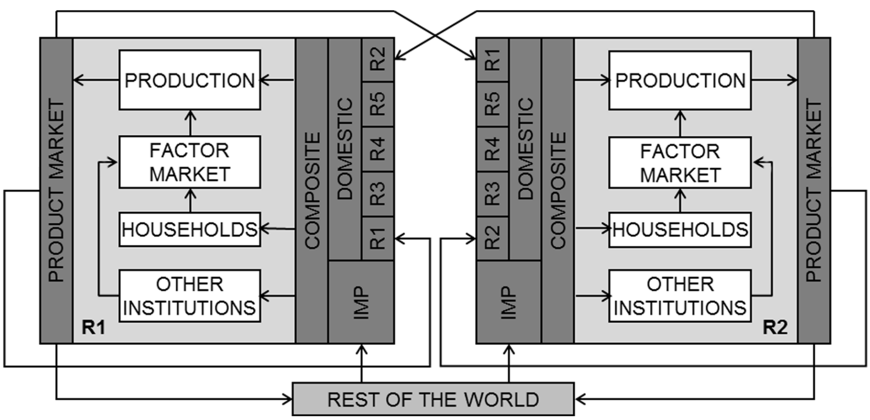

Figure 4. The product flow among regions in the IRSA-INDONESIA-5 model

This system of equations in IRSA-INDONESIA-5 model is divided into five blocks of equations (Resosudarmo *et al*. 2009), namely:

- ***The Production Block:*** Equations in this block represent the structure of production activities and producers' behavior.
- ***The Consumption Block:*** This block consists of equations that represent the behavior of households and other institutions.
- ***The Export-Import Block:*** This block models the country's decision to export or import goods and services.
- ***The Investment Block:*** Equations in this block simulate the decision to invest in the economy, and the demand for goods and services used in the construction of the new capital.
- ***The Market Clearing Block:*** Equations in this block determine the market clearing conditions for labor, goods, and services in the economy. The national balance of payments also falls within this block.

Database

The Social Accounting Matrix (SAM) serves as the database. In IRSA-INDONESIA-5, they used the interregional (sub-national) SAM that is published officially by the Indonesia Statistics Office (BPS). The 2005 Indonesia interregional SAM is based primarily on data provided by the 2005 Indonesia interregional Input-Output (I-O) table.

The interregional SAM constructed by Resosudarmo *et al*. (2009) consists of five regions: Sumatra, Java-Bali, Kalimantan, Sulawesi, and Eastern Indonesia. The activities in each of these regions were disaggregated into 35 production sectors, 6 labor classifications, 2 types of capital (labor and capital), 2 types of households (rural and urban), 2 types of other institutions (local government and companies), and other accounts such as tax, subsidies, and inventory.

Land-use changes were incorporated into the model via additional land area data that is needed to calculate for each region's cultivated area and natural forest area. Carbon content for each region from sector activity that use cultivated area (for paddy, crops, estate crops, and forest sector) and natural forest area was also incorporated.

IMPACT OF CLIMATE CHANGE ON PHILIPPINE AND INDONESIAN AGRICULTURE

The Philippines and Indonesia, with a population of 92 million and 240 million, respectively, depend largely on their domestic agriculture. Climate-induced impacts on their agriculture sector will be a big threat to both countries' food security. Various studies estimate that production of many important agricultural products in the Philippines will significantly decline as a result of these climate-induced impacts. These include important agricultural commodities such as paddy rice (-18%), corn (-16%), sugarcane (-32%), banana (-6%), and other crops (-15%) (SEARCA 2005). Studies from Indonesia reveal a similar story with declines in the following agricultural products estimated: paddy rice (-21%), beans (-12%), maize (-14%), and sugarcane (-8%) (Handoko and Hardjomidjojo 2009).

CGE analyses were undertaken for the Philippine and the Indonesian economies to understand the economy-wide impact of such a potential loss in agricultural production due to climate change. Results suggest that the climate-induced impact on agriculture would reduce Philippines' GDP by 1.8% and Indonesian GDP by 2.6%, relative to a baseline in which climate change does not happen. This would result not only because of decreased production in the agriculture sector but also because of decreased production in downstream sectors (e.g., manufacturing sector). In the Philippines simulation, for example, the overall manufacturing sector output is estimated to fall by 5.5%; in Indonesia, the rice-processing sector and the oil and fat sector are estimated to fall by 22% and 36.6%, respectively.

Further analysis of the Philippine agriculture simulation suggests that the negative impact from agricultural output decline could be mediated by boosting other food produczzts not as affected by climate change, such as fisheries. Recent studies suggest that the Philippine fisheries sector is not as vulnerable to climate change as that of other countries (Allison *et al*. 2009).

The Indonesian agriculture simulation also examined the relevance of agricultural subsidy in the midst of climate change. The country currently allocates USD1.8 billion for its agricultural subsidy. This subsidy is one of the country's strategies to improve food security and is among the government's choice instruments to increase productivity when it falls as a result of climate change.

The analysis suggests that the use of agricultural subsidies may be counter-productive. For example, based on the simulation results, introducing a 20% production subsidy to agricultural sectors and its downstream manufacturing sector to reduce their prices would not boost enough demand to compensate for the decline in output. Moreover, tax revenue from other sources would need to be raised to finance this subsidy. As a result, the rest of the economy would have to pay the cost, resulting in an even larger decline in its output. It is therefore recommended that the Indonesian government consider alternative forms of policy responses to climate change instead of the agricultural subsidy.

MITIGATION AND TRADE-OFF: FUEL SUBSIDY REDUCTION IN MALAYSIA AND DEFORESTATION IN INDONESIA

Indonesia and Malaysia contribute quite a large share to global carbon emissions. Indonesia's emissions from land use alone account for 4.7% of global emissions from all sources in 2005. As a result, Indonesia ranks fourth in the world in terms of its total emissions in 2005.

As part of the Copenhagen Accord, both Indonesia and Malaysia committed to the global community that they will contribute to the global concerted effort to reduce carbon emissions. Indonesia committed to reduce carbon emissions by 26% to 41%, relative to the business-as-usual, by 2020. For the last two years, the Indonesian government took several concrete steps towards this goal, such as mainstreaming climate change mitigation in its national development plan. Malaysia also pledged to contribute to global emissions reduction with a target of reducing emissions intensity (carbon emissions per dollar of output) by 40% (from the 2005 level) by 2020.

Despite the two governments' strong commitment towards global emissions reduction, some big issues continue to lessen the credibility of their commitment, particularly in terms of their continued fuel subsidization and deforestation. Indonesia and Malaysia still heavily subsidize their fuel consumption. In 2012, the Indonesian government spent as much as USD 22 billion for fuel subsidy. Fuel price in Indonesia and Malaysia are still artificially low compared to other countries in SEA. This fuel price subsidy policy is incompatible with their future commitment to carbon emissions reduction.

Rationalizing Malaysia's Fuel Subsidy

Fuel subsidy is a politically sensitive issue in Malaysia. The debates between those in favor of the subsidy and those against it are fierce. The supporters of the reform to discontinue the subsidy argue that it benefits the wrong target groups, with much of the benefits going to wealthier Malaysians. They also argue that the subsidy leads to the illegal smuggling of fuel, with subsidized diesel entering the black market even across borders. Moreover, the savings from the subsidy rationalization program could reduce the budget deficit, which could be invested in social services, infrastructure and community development.

On the other hand, opponents of fuel hikes assert that because Malaysia is a net fuel exporter, rising fuel prices have meant record profits for PETRONAS, the state-run energy company, and that the low income of the majority of Malaysians is reason enough for the Malaysian government to keep fuel prices low through subsidies. Some analysts say that Malaysia may have some room to delay price increases as it is a net oil exporter and would gain from strong crude oil markets. Moreover, reducing the fuel subsidy has proven to be an unpopular policy in Malaysia; when the crude oil price shot to its highest in 2008 and the government attempted to reduce the subsidy resulting in an increase in petrol prices, it lost many votes in the 2008 election.

Using a CGE model with disaggregated fuel commodities of the Malaysian economy, a reduction in fuel subsidy was simulated. The results suggest that reducing the subsidy would positively benefit the Malaysian economy. The negative impact is more than compensated by the positive impact of the government revenue reallocation. This indicates that the pre-reform fuel pricing policy has distorted resource allocation and that the departure from such a policy is a move towards a more efficient Malaysian economy. In addition, the neutral effect of the subsidy reduction across different types of labor suggests that the concern over the adverse distributional consequence of the reform is overrated.

Reducing Indonesia's Deforestation-based Carbon Emissions

Indonesia is geographically diverse, being an archipelago comprising approximately of 17,508 islands over an area of 1.9 million km^2. Such diversity more or less represents the diversity of development outcomes experienced in the different regions of the country.

Indonesia experienced high economic growth for the last 30 years. However, this improved prosperity is not shared equally among its different regions. The economic growth is mainly concentrated in the Java region leaving other regions, especially the eastern regions, behind. For example, while the poverty incidence in the most developed province, Jakarta, is 3.7%, in Papua Island, poverty incidence is still 29.9%.

With the aim to reduce this imbalance in regional development, the government implemented a large-scale cultivation project known as the Merauke Integrated Food and Energy Estates (MIFEE) in Papua Island. The idea is for MIFEE to serve as the center of the development of food and energy reserves in Eastern Indonesia. However, this project will use approximately 1.28 million ha, 90% of which (1.15 million ha) is covered by natural forest that has never been cultivated. An analysis using an interregional CGE model of the Indonesian economy was carried out to evaluate the extent by which this project can achieve its developmental objectives as well as the extent of its environmental consequences, particularly in terms of carbon emissions from deforestation.

The result of the simulation estimates that the MIFEE would increase GDP in Papua by 0.23% relative to the baseline in which the project is not implemented. It is estimated that the national GDP would only rise slightly (by 0.01%). The projected increase in Papua's output is dominated by an increase in the output of its estate crops sector (3.92%). The increase in the production of food crops, especially paddy and other food crops, would be lower.

The Java region would benefit from the expansion in Papua's agriculture sector through an expansion in its food, beverage, and palm oil processing sectors. However, Java would be the only region (other than Papua) that is estimated to benefit from the MIFEE project. Due to the nature of the interregional trade flows, other regions such as Sumatera, Kalimantan, and Sulawesi would not benefit from the agriculture expansion in Papua Island. This suggests that the project may reduce disparity between Java and Papua, but not necessarily that between Java and other regions.

The increase in the supply of agricultural products would reduce the market prices of agriculture and food products in Papua as well as nationally. Because most of low-income households spend more on food consumption, this declining market price would increase their real income and improve their welfare. It is estimated that poverty incidence in Papua would fall significantly by 4.01%; this would contribute a 0.280% reduction in national poverty incidence.

By taking into account the projected MIFEE land conversion and by incorporating region and sector-specific carbon content, the model estimated the carbon emissions that would result from the MIFEE project. The estimates suggest that the agriculture expansion project in Papua would increase Indonesian carbon emissions by 228 million tons of carbon dioxide equivalent. This is equivalent to an increase by 12.8% of Indonesian total carbon emission, a serious indication that the MIFEE agriculture expansion would hamper the government's credibility in its commitment to emissions reduction.

This analysis clearly illustrates the complexity of multiple objectives in development agenda. Many development plans, such as the MIFEE, do not take into account environmental considerations such as emissions reduction; economic growth and reducing interregional disparity are the MIFEE's priority. This analysis can help the government see the trade-off more clearly as it provides information on the estimated environmental impact of such a big development project. The impact analysis of this agriculture expansion in Papua shows the urgent need to re-prioritize the development agenda given the immense environmental cost of the project.

These case studies from Malaysia and Indonesia suggest that environmental objectives, particularly the emissions reduction agenda, can be hindered by the urgency of other development objectives (e.g., reducing interregional disparity through agricultural expansion in Indonesia) as well as the political economy of environmental reforms (e.g., unpopularity of fuel subsidy reduction in Malaysia). Hence, the responsibility of informing policymakers and political leaders about the benefits and consequences of the choice of development pathway or environmental reform to ensure the best political and policy decision from the societal perspective falls on scientists.

SUMMARY

This book presents comparative estimates of climate-induced impacts on Philippine and Indonesian agriculture as well as explores some big challenges in the region's mitigation efforts, as represented by the case of fuel subsidy in Malaysia, and deforestation-based emission in Indonesia.

CGE analyses were undertaken to understand the economy-wide impact on the Philippine and Indonesian economies of the potential loss in agricultural production due to climate change. The results suggest that climate-induced impacts on agriculture would reduce Philippine and Indonesian GDP by 1.8% and 2.6%, respectively, relative to a baseline in which climate change does not happen. This significant impact would result not only from decreased agricultural production but also from decreased production in downstream sectors such as manufacturing. In the Philippine simulation, for example, it is estimated that the overall manufacturing sector output would fall by 5.5% while in Indonesia, it is estimated that the rice-processing sector would fall by 22%, and the oil and fat sector by 36.6%.

The Indonesia analysis also looked into the relevance of agricultural subsidy as a policy instrument to increase agricultural productivity in the midst of climate change. The results suggest that the use of such an instrument may be counter-productive.

CGE analyses were also done to look into Malaysia's fuel subsidy and into an Indonesian development project, which involves the deforestation of 1.15 million ha of the country's natural forest. As part of the Copenhagen Accord, both Indonesia and Malaysia committed to contribute to the global concerted effort to reduce carbon emissions. Indonesia committed to reduce carbon emissions by 26% to 41% by 2020 while Malaysia pledged to reduce emissions intensity by 40% by 2020. However, some of these two countries' policies and programs are seen to lessen the credibility of their commitment to mitigate.

Both Indonesia and Malaysia still heavily subsidize their fuel consumption. Fuel price in both countries are still artificially low compared to other countries in the region. Their fuel price subsidy policy is incompatible with their future commitments to carbon emissions reduction. Using a CGE model with disaggregated fuel commodities of the Malaysian economy, a reduction in fuel subsidy was simulated. The results suggest that reducing fuel price subsidy in Malaysia would lead to a positive benefit to the country's economy. The negative impact is more than compensated by the positive impact of the government revenue reallocation.

Another Indonesian development project that is under fire vis-à-vis the country's mitigation commitment is the Merauke Integrated Food and Energy Estates (MIFEE) in Papua Island. While the project aims to improve the balance of economic development among the various regions of the country, it requires 1.15 million ha of natural forest to be deforested to increase the agricultural cultivation area. An analysis using an interregional CGE model of the Indonesian economy was carried out to evaluate the extent by which this project can achieve its objective to reduce interregional development disparity as well as to evaluate its environmental consequences, particularly the increase in carbon emissions from deforestation.

The result of the simulation shows that the MIFEE project in Papua would increase GDP in Papua by 0.23% relative to the baseline in which the project is not implemented. It is estimated that the national GDP would only rise slightly, by 0.01%. It is also estimated that the agriculture expansion project in Papua would increase Indonesian carbon emissions by 228 million ton of carbon dioxide equivalent, which is equivalent to an increase of 12.8% of Indonesian total carbon emission. This indicates that the agriculture expansion may seriously hamper the Indonesian government's credibility regarding its commitment to emissions reduction.

REFERENCES

ADB (Asian Development Bank). 2009. The economics of climate change in Southeast Asia: A regional review. ADB. Manila, Philippines.

Allison, E. H.; a.l Perry; M.C. Badjeck; W.N. Adger; K. Brown; D. Conway; A.S. Halls; G.M. Pilling; J.D. Reynolds; N.L. Andrew; and N.K. Dulvy. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries. 10(2):173-196.

Arrow, K.J. 2005. Personal reflections on applied general equilibrium models. T.J. Kehoe; T.N. Srinivasan; and J. Whalley (ed) In Frontiers in applied general equilibrium modeling. Cambridge University Press, Cambridge.

Bergman, L. 2005. CGE modeling of environmental policy and resource management. K.G. Maler and J.R. Vincent (ed) In Handbook of environmental economics. Elsevier.

Handoko, I. and H. Hardjomidjojo. 2009. Global Warming, Climate Change and Impacts to Food and Agriculture. Paper presented at a Seminar on "Climate Change Scenarios and Its Implication on Ecosystem and Biodiversity, Food Security and Health" held in Penang, Malaysia, 23-24 June 2009.

Horridge, M. 2003. ORANI-G: A generic single-country computable general equilibrium model: Practical GE modelling course edition. Centre of Policy Studies and Impact Project, Monash University. Melbourne, Australia.

IEA (International Energy Agency). 2010. World energy outlook. IEA. Paris, France. http://www.worldenergyoutlook.org/media/weo2010.pdf (Retrieved May 2012)

IEA, OPEC (Organization of the Petroleum Exporting Countries), OECD (Organisation for Economic Co-operation and Development), World Bank. 2010. Analysis of the scope of energy subsidies and suggestions for G-20 initiative: Joint report prepared for submission to the G-20 summit meeting. 26-27 June 2010. Toronto, Canada.

Resosudarmo, B.P.; A.A. Yusuf; D. Hartono; and D.A. Nurdianto. 2009. Regional economic modelling for Indonesia: Implementation of the IRSA-INDONESIA5. Departmental Working Papers 2009-21. The Australian National University, Arndt-Corden Department of Economics.

SEARCA (Southeast Asian Regional center for Graduate Study and Research in Agriculture). 2005. Assessment and management of risks due to natural calamities in support of QUEDANCOR lending operations. Final Report for Quedan and Rural Credit Guarantee Corporation.

Yusuf, A.A. and H.A. Francisco. 2010. Hotspots! Mapping climate change vulnerability in Southeast Asia. Economy and Environment Program for Southeast Asia. Singapore.

General Equilibrium Analysis of the Impact of Climate Change and its Adaptation on Indonesian Agriculture

Hermanto

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EXECUTIVE SUMMARY

The impact of changes in agricultural outputs under climate change, with either autonomous or policy adaptation, are not yet known. This study ascertained the macroeconomy (domestic output, employment, trade balance, trade, and, prices) and sectoral performance that emerged under changes in Indonesia's agricultural output due to climate change using computable general equilibrium models with 2008 Indonesian Input-Output data.

The analysis shows the large macroeconomic impact of climate change. Based on the results of the short-run analysis, GDP is expected to decrease by 5.62% with autonomous adaptation; in the long-run, the decrease would be 2.60%. On the other hand, if complemented with policy adaptation in the form of a 25% agricultural subsidy, GDP would also decrease by more—by 6.73% and 2.95% in the short-run and the long-run analyses, respectively. Some macro variables, such as the volume of exports will decline, while the import volume will increase.

Even with the government providing a subsidy of 25% to the agricultural sector and manufacturing sectors, agricultural production would still decline. The decline in the price level of a primary factor composite would not always be followed by an increase in the demand for these inputs. In addition, the increase in household demand for some agricultural sectors in the long-run was smaller than the increase in the short-run. Thus, the adaptation policy of implementing subsidies for sectors affected by climate change is not effective in encouraging the growth of macroeconomy, sectoral performance, and household demand in both the short-run and the long-run.

To reduce the vulnerability and enhance the resilience of Indonesian agriculture to climate change impacts, the study recommends, among others, that the government invest in improving sensing and communication technology as well as modeling techniques to provide sophisticated short-term forecasts. Also, policies that support the diffusion and interpretation of these forecasts in terms of their agronomic and economic implications should be put in place to help suppliers and users respond to the impacts of climate change.

INTRODUCTION

Background of the Study

Climate change is emerging as the most important environmental problem faced by modern society. Increases in atmospheric stocks of greenhouse gases (GHGs), which include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), because of human activities have been linked to global climate change (IPCC 1990, 2007a). The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity due to seawater absorbing heat and CO_2 from the atmosphere (UNFCCC 2007).

Climate change has wide-ranging effects on the environment and on socioeconomic and related sectors, including that of water resources, agriculture and food security, human health, terrestrial ecosystems, biodiversity, and coastal zones. However, agriculture may be the most vulnerable to climate change impacts because its productivity is highly dependent on natural weather patterns and climate cycles.

In Indonesia, for instance, global climate change has influenced agriculture as a result of the increased frequency of drought, from every four years on the average during the period of 1844-1960 to every three years during the period of 1961-2006 (UNDP Indonesia 2007). Moreover, almost all of the country's provinces have been affected by flooding. Of all the floods that have been accounted for, about 530 occurred during the period of 2001-2004 (UNDP Indonesia 2007). The average damage in flood-affected areas for 16 years (1991-2006) ranged from 37.977 ha to 32,826 ha. The floods have caused crop failure from 5.707 ha to 138.227 ha (MOA 2010).

On the other hand, drought during the period of 1991-2006 has affected paddy rice areas from 28,580 ha to 867,930 ha per year. The drought has caused crop failure from 4.614 ha to 192.331 ha (Apryantono *et al*. 2009). The 1997-1998 drought (El Niño), Indonesia's worst drought in 50 years, occurred widely and affected crop productivity and quality. The greatest impact is on oil palm plantations thereby reducing their production by around 21-65% (MOA 2010).

Climate change will not only affect the productivity of agricultural products but will also lead to economic consequences on farm profitability, agricultural supply and demand, and trade price (Kaiser and Drennen 1993). It is likely to have multiple impacts across sectors and synergistic effects with other socioeconomic and environmental stresses, such as desertification, water scarcity, and economic restructuring. Thus, climate change impacts do not happen in isolation; impacts in one sector can adversely or positively affect another.

One approach in dealing with climate change is adaptation (UNFCCC 2007). Adaptation can occur before, during, or after any external stimulus or threat (Smith 1997). In fact, records show that some societies have used a range of practices to adapt to the impacts of weather and climate (i.e., crop diversification, irrigation, water management, disaster risk management, and insurance). However, some individuals and groups have inadequate capacity to adapt to climate change. The degree of adaptive capacity is determined by economic resources, technology, information and skills, infrastructure, institutions, and equity (Smith *et al*. 2001).

Adaptation to climate change refers to adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects that moderate harm or exploit beneficial opportunities (IPCC 2001; Stakhiv 1993). Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and policy adaptation.

So far, the impact of changes in agricultural outputs under climate change, with either autonomous or policy adaptation, are not yet known. The vulnerability of the agricultural sector to climate change makes it important to assess its impacts on the sector, especially those associated with macroeconomic parameters, sectoral performance, and household demand.

One approach is to undertake an analytical modeling exercise that will make it possible to assess complex interactions among the various sectors and factor markets in the system associated with climate change. The computable general equilibrium (CGE) model, which is a type of computer simulation model, has found wide use in such economic policy analysis. The CGE model is used as a basic framework of analysis because it can examine broad-spectrum problems such as those relating to the economic impact of climate change.

For this study, the CGE models adopted were based on the CRUSOE model, a simplified version of the ORANI-G. It was used to analyze the consequences of changes in agricultural output under climate change. This model was derived from the ORANI model that was first developed under the IMPACT Project at Monash University in Australia (Dixon *et al*. 1982; Dixon *et al*. 1992; Dixon and Rimmer 2002).

Statement of the Problem

The impacts of climate change in Indonesia have major implications for national food security. Without climate change adaptation (CCA), food crop production in 2050 is estimated to decline from 20.3% to 27.1% for paddy rice, 13.6% for maize, 12.4% for soybeans, and 7.6% for sugarcane, as compared to 2006 conditions. Potential reduction in paddy rice production is related to the decline of wetland area in Java by 113,003 ha to 146,473 ha; in North Sumatra by 1,314 ha to 1,345 ha; and in Sulawesi by 13,672 ha to 17,069 ha (Handoko *et al*. 2008; Handoko and Hardjomidjojo 2009; Syaukat 2011). Clearly, without CCA, the Indonesian agricultural system will suffer economic losses over time, until it will ultimately be no longer economically viable.

This study analyzes the impact of climate change on the agricultural sector with either autonomous and policy adaptation. Specifically, it ascertained the macroeconomy (domestic output, employment, trade, and prices) and sectoral performance that emerged under changes in agricultural output due to climate change.

The types of adaptation considered in the study are autonomous adaptation and policy adaptation. Autonomous adaptation is defined as adaptation by households and communities acting on their own without public policy interventions but within an existing public policy framework. Policy adaptation, on the other hand, is defined as adaptation that is the result of a deliberate policy decision. The policy adaptation considered in this study is the subsidy provided by the government to the agricultural sector.

Objectives

The overall study has two objectives:

1. To assess the consequences of changes in agricultural output under climate change on agricultural prices, trade, gross domestic product (GDP), and economic activity in other sectors; and
2. To analyze the economic impact of climate change, after the policy adaptation measures have been implemented, on the macroeconomy (domestic output, employment, trade balance, trade, and, prices) and sectoral performance.

Significance of the Study

Many studies on climate change in Indonesian agriculture have been conducted only at the local level, such as assessments of the impact of climate change on rice yields using a simulation model. Other studies have focused on single-sector impacts. So far, there has been no comprehensive investigation of climate change at the national level; much more so under changes in agricultural output considering a shock resulting from the impacts of climate change and involving autonomous and policy adaptation.

For this study, the consequences of changes in agricultural output under climate change were analyzed using the CGE models. In addition, the impact of climate change with policy adaptation on the macroeconomy (domestic output, employment, trade balance, trade, and, prices) and sectoral performance was analyzed.

The information generated in this study could provide important inputs into the policy making process, as government officials respond to various consequences of climate change. Such information could serve as a basic guideline for the Indonesian government to address various policy issues relating to climate change, particularly for the agricultural sector. In addition, this study could provide a framework for analyzing other climate change impacts on agricultural development and poverty issues.

LITERATURE REVIEW

Impact of Climate Change on Agriculture

The relationship between climate change and agriculture is complex and manifold. The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report analysis on climate change impacts estimates a general reduction of potential crop yields and a decrease in water availability for agriculture and for the population in many parts of the developing world (Table 1.1).

The main drivers of agricultural responses to climate change are biophysical effects and socioeconomic factors. Crop production is affected biophysically by changing meteorological variables, including rising temperatures, changing precipitation regimes, and increasing levels of atmospheric CO_2. Biophysical effects of climate change on agricultural production depend on the region and on the agricultural system, and the effects vary through time. Socioeconomic factors influence responses to changes in crop productivity, with price changes and shifts in comparative advantage. The final response depends on the adaptation strategies in each region and agricultural system.

The combination of biophysical and socioeconomic effects can result in: a) changes in the mix of crops grown, hence in the type of farming and rural land use; b) changes in production, farm income, and rural employment; and c) changes in rural income, contribution to national GDP and agricultural export earnings.

Table 1.1. Climate change and related factors relevant to agricultural production and food security

Climate factor	Direction of change	Consequences and factors that interact with agricultural production and food security
Sea level rise	Increase	Sea level intrusion in coastal (agricultural) areas and salinization of water supply
Precipitation intensity/ runoff	Intensified hydrological cycle, so precipitation intensity/ runoff generally increases but with regional variations	• Changed patterns of erosion and accretion; changed storm impacts • Changed occurrence of storm flooding and storm damage, water logging, and increase in pests
Heat stress	Increases in heat waves	Damage to grain formation; increase in some pests
Drought	Poorly known, but significantly increases temporal and spatial variability	• Crop failure, yield decrease • Competition for water
Atmospheric CO_2	Increase	Increased crop productivity but also increased weed productivity, hence competition with crops

Source: Iglesias (2005) elaborated from data and information of the IPCC (2001); Parry *et al*. (1999); Parry *et al*. (2004)

Agriculture in developing countries, including Indonesia, has received considerable attention recently with regard to climate change because of the high dependence of this sector on climate. Climate change has caused changes in seasons and rainfall in Indonesia. UNDP Indonesia (2007) reported that for several years now, farmers in Java and Sumatra villages have been talking about the abnormal seasons. Comparing the periods of 1961-1990 and 1991-2003, the onset of the wet season and the dry season in most of Sumatra is now 10-20 days later and 10-60 days earlier, respectively. Similar shifts have been seen in most of Java, and these patterns seem likely to continue.

Studies in Indonesia have shown that both the amount of rainfall and the rainy season in many locations have changed. However, those studies do not show the same results in changes of rainfall for the same locations (Kaimuddin 2000; Boer and Faqih 2004; Aldrian 2007). Handoko *et al*. (2008) found that some locations indicated increasing trends of rainfall while others showed decreasing trends. These findings indicate 'uncertainties' of the impact of climate change on rainfall.

Irawan (2002) estimated the impact of climate change, in terms of rainfall decrease and temperature increase, on crop production in Indonesia. He concluded that in the future, El Niño events (decrease in rainfall) will be a more serious climatic anomaly than La Niña (increase in rainfall) because of the former's increasing frequency, duration, and magnitude. The seven El Niño events from 1968 to 2000 have caused food production losses of 3.06%, on the average. Meanwhile, the five La Niña events have increased food production by 0.64% at the national level.

IPCC (2007a) used mathematical models to estimate the increase of air temperature. It estimated that the temperature for SEA will increase by about 2°C by 2050. Based on this data, Handoko *et al*. (2008) modeled the food balance situation in Indonesia by 2050 with and without climate change. The food balance was measured as the difference between food production and food consumption with and without climate change in 2050. The two climate components included in the model were temperature and rainfall. These two factors, whether individually or collectively, determine cropping areas, cropping intensity, and crop productivities, which then result in crop (food) production. On the other hand, the demand for food is determined by the total population and average food consumption.

Rainfall data were taken from 174 climate stations in four major Indonesian provinces that produce food crops (i.e., West Java, East Java, North Sumatera, and South Sumatera). Based on the database, rainfall varied from 501 to 6,400 mm per annum from 1971 to 2002, with 1 to 10 months of wet season and 1 to 11 months of dry season. Average data on these four provinces indicated declining rainfall. Handoko *et al*. (2008) assumed in their model that rainfall would decline by 246 mm/year. Based on the same database, temperature increased from 1°C to 4°C. Handoko *et al*. (2008) assumed temperature would increase by an average of 2°C. The temperature increase (2°C) and annual rainfall decrease (246 mm/year) by year 2050 were inputted into the model. Model inputs also included population growth and various adaptation options such as frequency of growing seasons, average crop yields, and consumption of each food per capita.

Table 1.2 presents the projected status quo condition by 2050 based on the analysis conducted by Handoko *et al*. (2008) and Handoko and Hardjomidjojo (2009). In this case, planting area, cropping intensity, and crop productivity were assumed to evolve at the current rates up to 2050. With these assumptions, it was found that crop production would decline by 7.6% to 27.1%.

Table 1.2. Projected food crop production by 2050 in Indonesia, without climate change adaptation

Commodity	Production (2006-base) (ton)	Decrease in production by 2050	
		tons	%
Wetland rice	51,647,490	10,473,764	20.3
Upland rice	2,807,447	761,522	27.1
Maize	11,609,463	1,574,966	13.6
Soybean	747,611	92,503	12.4
Cane sugar	1,279,070	97,453	7.6

Source: Handoko *et al*. (2008); Handoko and Hardjomidjojo (2009)

Furthermore, for all crops considered, a 2°C temperature increase had a higher impact on production compared to a 246-millimeter decrease in rainfall (Table 1.3). Decrease in crop production due to a 2°C temperature increase was 7 to 22 times higher than that of a 246-millimeter decrease in rainfall.

The baseline condition (Table 1.3) indicates crop surplus or deficit when the production system is under the current condition (status quo). Projected demand is increasing over time due to population growth. Both production and consumption levels are measured by 2050. This condition is becoming a benchmark on whether the food situation is improving or worsening with various adaptation programs. Even palm oil, which currently has a surplus of 7 million tons, could be deficit by 17 million tons by 2050 with climate change, *ceteris paribus*.

Table 1.3. Projected impacts of temperature increase and rainfall decline on food production by 2050, while keeping the cropping area constant

Commodity	Baseline (million tons)	Temperature increase (2°C)		Annual rainfall decline (246 mm)		Temperature increase and rainfall decline	
		Food balance (million tons)	% change	Food balance (million tons)	% change	Food balance (million tons)	% change
Husked rice	-65.0	-89.0	-36.9	-68.0	-4.6	-90.0	-38
Maize	-5.0	-27.0	-440.0	-6.0	-20.0	-27.5	-450
Soybean	-3.0	-23.0	-285.7	-3.8	-65.2	-25.2	-952
Cane sugar	-7.0	-28.0	-300.0	-8.2	-17.1	-30.0	-328
Palm oil	+7.0	-15.0	-314.2	+5.5	-21.4	-17.0	-343

Source: Handoko *et al*. (2008); Syaukat (2011)

There are many studies on the effects of climate change on agriculture. Potential impacts on world food supply have been estimated for several climate change and socioeconomic scenarios. Some regions would improve their agricultural production, whereas others would suffer yield losses. Hence, a reorganization of agricultural production areas may be required. Crops are expected to be affected differently in particular regions. This indicates the need for adaptations that support industries and markets, farm-level strategies, and rural development schemes.

Historically, agriculture has shown considerable adaptability to changing conditions, whether these stem from alterations in resource availability, technology, or economics. Many adaptations occur autonomously, without the need for conscious response by farmers and agricultural planners. However, the rate and magnitude of climate change will likely exceed that of normal changes in agriculture in at least some parts of the world, especially in developing countries. To avoid the most serious of effects, specific technologies and management styles will need to be adopted (World Bank 2011).

Adaptation to climate change, in addition to mitigation of climate change, is necessary to avoid unacceptable impacts of anthropogenic climate change (IPCC 2007b). Two broad types of adaptation are considered in this study: autonomous adaptation and policy-based adaptations (Iglesias 2006). Autonomous adaptations include changes in crop yields, land availability, and market incentives by altering cropping patterns, adopting different crop varieties where these are available, using different combinations of inputs, and perhaps pursuing opportunities for non-agricultural employment.

Policy-based adaptation, on the other hand, is designed to promote direct and indirect adaptation. Direct adaptation covers measures that are designed to offset the direct impacts of climate change on, for example, crop yields or land availability. These include investment in research and development to produce new crop varieties; the construction and extension of irrigation schemes; and the construction of dikes to protect land from inundation or salinization.

Indirect adaptation covers policies designed to offset the effects of climate change by promoting economic development that can generate income in place of agricultural income that may be lost. These include investing on transport and other infrastructure improvements; promoting non-agricultural business development in rural areas; and providing a combination of education and training to upgrade the skills of workers transferring from agriculture to other sectors.

This study examined a combination of these options. This is to be considered in the larger context of strategies to promote economic development. It is believed that the adverse impacts of climate change will be largely avoided by implementing adaptation programs. Therefore, this study was conducted based on the framework shown in Figure 1.1.

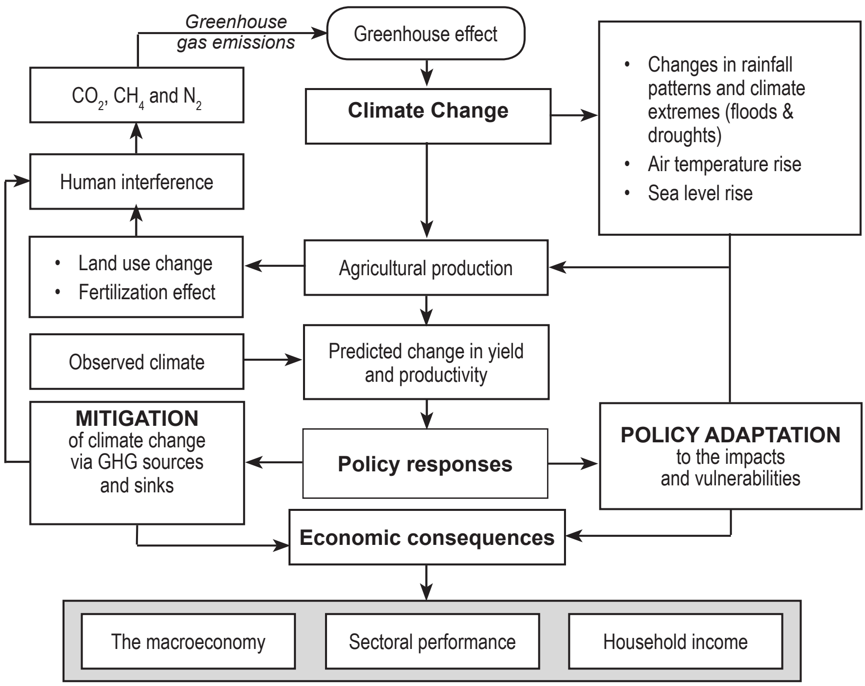

Figure 1.1. Conceptual framework of analysis in assessing the impact of climate change on agriculture

At least three major factors associated with global climate change affect the agricultural sector: a) changes in rainfall patterns and climate extremes (floods and droughts), b) increase in air temperature, and c) increase in sea level. In Indonesia, rainfall patterns have changed in several regions in the last few decades. For instance, the beginning of the rainy season has become delayed in some locations while it has become advanced in others. The effects of these shifts have been further affected by agricultural infrastructure resources, changes in planting seasons and cropping patterns, and land degradation. Similarly, frequency of extreme climate has also increased and caused the following, among others: a) failure of crops, thereby causing a decrease of crop index and reducing productivity and production; b) damage to agricultural land resources; c) increase in frequency, size, and intensity of drought; d) increase in humidity; and e) increase in the intensity of disruption of plant pests (Las *et al*. 2008).

Increased temperature has increased transpiration, which in turn has reduced the productivity of food crops (Las *et al*. 2008). Decrease in agricultural outputs could reach more than 20% when the temperature increase exceeds 4°C (Tschirley 2007).

The impact of sea level rise is also apparent in Indonesia. It has led to the increased shrinkage of farmland on the coast of Java, Bali, North Sumatra, Lampung, West Nusa Tenggara, and Kalimantan; damage to agricultural infrastructure; and increased soil and water salinity (Las *et al.* 2008).

Most of the models introduced above are to estimate the first-order impact of climate change, particularly on variables such as crop yields. Using the CGE models, the first-order impact in this study was used as input to estimate the second-order effects. The figures were then compared to the baseline (no climate change). For this study, the first-order impacts of climate change resulted from a series of research as conducted by Handoko *et al*. (2008), Handoko and Hardjomidjojo (2009), and Syaukat (2011).

Implementation of CGE Models

Evaluating the economic consequences of climate change requires a good understanding of both natural and socioeconomic processes. Computable general equilibrium (CGE) models are used for this purpose. The basic idea behind a CGE model is simple; one builds an analytically consistent mathematical model of an economy, collects data, and then uses the characteristics of the economy in a specific time period to solve the model numerically (Reed 1996).

In theory, the 'general equilibrium' in a CGE model refers to the complete balance between supply and demand in all markets described by the model. These complex interrelationships involve the linkages between different *sectors* of an economy (upstream/downstream; domestic/ foreign; infrastructure/ final production); different *agents* (consumers, producers, governments, investors, savers, importers, exporters); different *economies* (developing/developed); and different *generations* (current/future). Practically, the use of a CGE model is "to convert the Walrasian general equilibrium structure from an abstract representation of an economy into realistic models of actual economies" (Shoven and Whalley 1992). Thus, CGE models can be used for forecasting, counterfactual analysis, and policy evaluation (Challen and Hagger 1983).

The development of CGE models has become an operational tool in empirically-oriented economic analysis (Bergman 1990). Some experts like Dervis *et al*. (1982), Shoven and Whalley (1984), Dixon *et al*. (1992), and Bergman (1990) classify "general equilibrium" as an analytical approach, which looks at the economy as a complete system of interdependent components (industries, households, investors, governments, importers, and exporters).

For Indonesia, the CGE model became available at the end of the 1980s (Resosudarmo *et al*. 2009). Included among the first generation of Indonesian CGEs were those developed by Central Bureau of Statistics

(BPS), Institute of Social Studies (ISS) and Center for World Food Studies (CWFS) (1986), Behrman *et al*. (1989), Ezaki (1989), and Thorbecke (1991). The second generation Indonesian CGE models came out in the 2000s. For instance, Abimanyu (2000) and Warr (2005) developed an INDORANI CGE model and the Wayang model, respectively, which were all static. The INDORANI CGE model and the Wayang model are an application of the Australian ORANI model for Indonesia. Hermanto (2005) used these models to analyze the impact of the Indonesian commitments under the World Trade Organization (WTO) on the macroeconomy, sectoral performance, and household income.

Currently, the implementation of the CGE models to investigate the impact of climate change on various sectors has been developed. Winters *et al*. (1996) used CGE-multimarket models to analyze the impact of global climate change for Africa, Asia, and Latin America. Results show that all these countries would lose and that their agricultural outputs would fall; Africa would be the most severely affected. Rosenzweig and Parry (1994), Reilly *et al*. (2001), Butt *et al*. (2005), and Bosello and Zhang (2005) also used CGE models to examine the implications of climate change on the agricultural sector.

Hertel *et al*. (2009) used the poverty-extended version of the Global Trade Analysis Project (GTAP) model to explore the impacts of adverse climate change on different segments of the population living on USD 1/day across a sample of 15 developing countries. Under their adverse climate scenario for 2030 (an occurrence with only 10% probability), prices for global staple grains would rise by 10% to 60%, and agricultural returns would rise sharply in most regions.

Figure 1.2 illustrates the impact of climate change on the economy in general. Climate change decreases production, which in turn affects the demand for factors of production (i.e., capital and labor). The final result of this effect highly depends on the pattern of ownership of these production resources in the economy. The new optimal equilibrium re-allocates production resources within industries, hence affecting their demand for these resources. This change in demand affects both the labor demand and the capital of each operating industry.

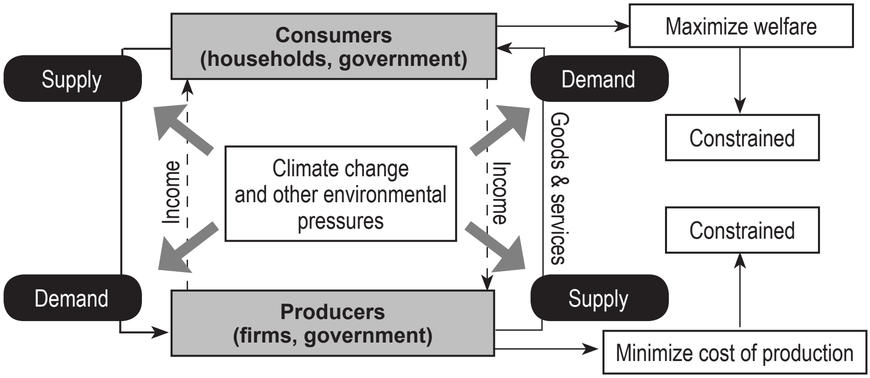

Figure 1.2. CGE models with climate change

CGE models consist of a set of parameters that describe observed economic data and relationships (such as inputs to production processes and trade flows) as well as fixed assumptions for behavioral responses (such as responses to changes in prices). CGE models typically assume a strong degree of substitutability in both production and consumption structures. Aggregate welfare measures, such as GDP and consumption, are driven more by assumed underlying growth in productivity than by changes in productivity because of a shift in structure away from the optimum.

For this study, the CGE models provided a framework for simulating how Indonesia's economy may change as a result of changes (sometimes known as "shocks") in one sector of the economy. In this case, the change involved shocks in the agriculture sector caused by climate change or the first-order impacts of climate change. The outputs of the first-order analyses were then used as basis to assess the second-order impacts using CGE models.

Theoretical Structure

In general, the CRUSOE Model has a theoretical structure that is typical of a static CGE model. It consists of the following sets of equations: a) producers' demands for produced inputs and primary factors; b) producers' supplies of commodities; c) demands for inputs to capital formation; d) household demands; e) export demands; f) government demands; g) the relationship of basic values to production costs and to purchasers' prices; h) market-clearing conditions for commodities and primary factors; and i) numerous macroeconomic variables and price indices.

A schematic outline of the theoretical structure of the models resembles the original ORANI specification that is summarized in Table 1.4, with the notations defined in Table 1.5. The equations are derived from orthodox microeconomic assumptions about the behavior of price-taking economic agents, e.g., producers minimizing costs and consumers maximizing utility subject to budget constraints. Overall, the model contains more variables than equations (Dixon *et al*. 1982).

Table 1.4. Schematic representation of the CRUSOE equations

Identifier	Commodity and factor demands	Equation	Number
1.1	Domestic commodities for domestic use	$d = f_d\ (z, c, p_1, p_2, q_d)$	n
1.2	Imported commodities	$m = f_m\ (z, c, p_1, p_2, q_m)$	n
1.3	Export demand	$e = f_e\ (p_1^*, q_e)$	n
1.4	Demands for primary factor	$l = f_l\ (z, p_3, q_l)$	k
1.5	Commodity supplies pricing [a]	$y = f_y\ (z, p_1, q_y)$	n
1.6	In production	$v(p_1, q_y) = w(p_1, p_2, p_3, q_w)$	h
1.7	In exporting	$p_1 = p_1^*\ \theta s$	n
1.8	In importing	$p_2 = p_2^*\ \theta t$	n
Market clearing			
1.9	For commodities	$d + e = y$	n
1.10	For primary factors	$l = l^*$	k
Other equations			
1.11	Balance of trade	$b = (p_1^*)e - (p_2^*)m$	1
1.12	CPI	$\xi = f_\xi\ (p_1, p_2)$	1
1.13	Wage indexation	$p_3 = f_{p3}\ (\xi, q_{p3})$	k
	Total	7n +h+3k+2	

Source: Dixon ***et al***. (1982)
Note: [a] denotes diagonal matrix

Table 1.5. Description of variables in the CRUSOE set of equations

Variable	Description	Number
d	Demands for domestically produced commodity	n
z	Activity levels for each industry	h
c	Aggregate real absorption	1
p_1	Local prices of domestic commodities	n
p_2	Local prices of imported commodities	n
m	Demand for imported commodities	n
e	Exports	n
p_1^*	Foreign currency price for exports	n
p_2^*	Foreign currency price for imports	n
l	Demands for primary factors	k
p_3	Prices for primary factors	k
y	Commodities output levels	n
θ	Exchange rate (IDR/USD)	1
t	One plus ad valorem rates of protection	n
s	One plus ad valorem rates of export subsidy	n
l^*	Factor employment levels	k
b	Balance of trade	1
ξ	Consumer price index	1
q_{P3}	Shift terms factor price equations	k
	Total	10n+h+4k+4
q_D, q_M, q_E, q_L q_Y, q_V , q_W	Large number of variables designed to assist in the simulation of exogenous changes in technology, export demands, household preferences and indirect taxes	

Source: Dixon ***et al***. (1982)

Commodity and factor demands

The CRUSOE models recognize five categories of demand for commodities: intermediate input demands, demands for inputs to capital formation, household demands, export demands, and other miscellaneous demands (e.g., inventory and government demands). Equations 1.1 and 1.2 in

Table 1.4 are aggregations over the five domestic sources of demand for the two n commodities recognized in the model (n domestically produced and n imported). Export demands are shown separately in Equation 1.3.

According to Equations 1.1 and 1.2, domestic demands depend on activity levels for each domestic industry (Z) and aggregate real absorption (C), called domestic activity variables (Z and C), taste and technology variables (Q_D *and* Q_M), and commodity prices. Following Armington's assumption, domestic output and imports of the same commodity class are treated as imperfect substitutes. Hence, the vectors of domestic (P_1) and import (P_2) prices appear in the demand functions for both domestic and imported commodities (Warr 2005).

Equation 1.3 indicates that the world prices of commodities exported by Indonesia are assumed to not be independent of Indonesia's export volumes. That is, the demand curves for Indonesian exports are downward sloping, not horizontal. The variable Q_E is usually exogenous and allows for shifts in the export demand.

The demand for primary factors (occupation-specific labor, industry-specific capital, and region-specific land) depends, according to Equation 1.4, on the domestic industry activity variables (Z), the technology variable (Q_L), and factor prices (P_3). The fact that P_3 is the only price variable included in Equation 1.4 reflects the ORANI assumption that, while primary factors can be substituted for each other, they cannot be a substitute for intermediate inputs. This also explains the absence of factor prices from the commodity demand Equations 1.1 and 1.2.

Commodity supplies

Equation 1.5 is an aggregation of the commodity output vectors across the h industries. Included in the CRUSOE models are products developed in more than one industry and multi-product industries. The vector of commodity outputs *(Y(j))* produced by industry *j* depends on *j*'s activity level *(Zj)* and domestic commodity prices *(P_1)*. Changes in relative commodity prices will cause industries to move around their product transformation frontiers. The variable Q_Y allows for shifts in transformation frontiers associated, for example, with technological changes.

Pricing

The activities recognized in the CRUSOE models are production, exportation, and importation. In each case, a condition of zero pure profit is imposed, implying that revenue per unit of activity is equal to costs per unit of activity. The production functions exhibit constant returns to scale. Therefore, costs and revenue per unit of production do not depend on the level of activity. Consequently, Equation 1.6 can be written without reference to production levels; output prices depend only on input prices (including rental prices on capital) and on technology. Equations 1.7 and 1.8 equate the domestic currency prices of exports and imports to the domestic currency equivalents of their foreign currency values plus any export subsidy or import tariff.

Market clearing

Equation 1.9 equates demand and supply for domestically produced commodities. In Equation 1.10, L^* is the vector of factor employment levels. Thus, Equation 1.10 amounts to saying that employment demands (L) are satisfied. Equation 1.10 does not necessarily impose full-employment assumptions. Although L^* could be set exogenously at full-employment (or any other) levels, an obvious alternative would be to set some or all factor prices exogenously and to let the model determine the corresponding elements of L^*.

Other equations

The CRUSOE models have many equations that are designed to facilitate their applications. Examples are Equations 1.11 and 1.12, which define the balance of trade and consumer price index, respectively. Equation 1.13 allows the introduction of different assumptions concerning wage indexation.

The Closure of Models

The term "closure" refers to prescribing which variables are endogenous and exogenous in a general equilibrium system. This study focused on analyzing the consequences of changes in agricultural output under climate change and the economic impact of CCA using short-run closure and long-run closure. In the CRUSOE model, the exogenous variables include: a) technical change variables; b) tax rate variables; c) household supplies of factors of production (i.e., labor, land, and capital) and the number of households *q*; d) foreign prices and the average rate of return omega; e) inventory changes; f) the exchange rate, which could serve as numeraire; and g) the household subsistence expenditure.

The typical long-run closure sets aggregate employment as exogenous, while endogenizing the overall wage shifter. The other industry-specific wage shifter variables remain exogenous, reflecting fixed wage relativities. This assumes that labor is mobile between industries and occupations. These labor-market modeling decisions are usually made at an economy-wide level but could be applied individually, and perhaps differentially, to different industries or types of labor.

RESEARCH METHODOLOGY

Scope of the Study

This study analyzed the impact of climate change with autonomous adaptation and policy adaptation, particularly on the agricultural sector. Specifically, using CGE models, this study ascertained the macroeconomy (domestic output, employment, trade balance, trade, and, prices) and the sectoral performance that emerged under changes in agricultural output due to climate change.

The Database

The database for the CRUSOE model is shown in Figure 1.3. The basic information used in constructing this database are: Indonesian

Input-Output data (2008) on flows of intermediate goods c ={1,...,C} from sources s ={dom, imp} to industries i ={1,...,I} used in current production (i.e., production in current period) (matrix V1BAS); commodity taxes on these intermediate goods (matrix V1TAX) including import duty on imported goods (matrix V0TAX); primary factors of production (labor, capital, land) used in current production (V1LAB, V1CAP, V1LND); production tax or subsidy (matrix V1PTX); and 'other costs ticket', which stand for miscellaneous items such as municipal taxes or charges (V1OCT).

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Other	Change in Inventories
	Size	←I→	←I→	←1→	←1→	←1→	←1→
Basic Flows	↑ CxS ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Taxes	↑ CxS ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					

C = number of commodities
I = number of industries
S = 2: domestic, imported
O = number of occupation types
M = number of commodities used as margins

	Joint Production Matrix
Size	←I→
↑ C ↓	MAKE

	Import Duty
Size	←1→
↑ C ↓	V0TAR

Figure 1.3. The CRUSOE flows database

If the columns of these matrices are summed up, the values of production in these industries are obtained. These values define the 'basic price' of commodities produced in these industries. To allow for multiple-product industries (mainly in the agricultural sector), a "MAKE" matrix is defined that shows which commodity is produced by what industry.

Next, in addition to usage (as intermediate goods) in current production, each commodity can also have other uses: as investment goods for the next production period (V2BAS); as final goods used for household and government consumption (V3BAS, V4BAS); as export goods (V5BAS); and as addition to inventory stock (V6BAS). There are commodity taxes (V2TAX, V3TAX, V4TAX, V5TAX) associated with all these uses (except inventory), but there are no primary factor inputs in these final consumption activities.

Data Collection

The secondary data used in this study were gathered from the Central Bureau of Statistics Indonesia (BPS), Indonesian Center for Agriculture Socio-Economic and Policy Studies (ICASEP), Indonesia Agro-climate and Hydrology Research Institute, the Asian Development Bank (ADB), and the UN Food and Agriculture Organization (FAO).

Methods of Analysis

The CGE model was used as a basic framework for analyzing the impact of climate change, with autonomous adaptation and policy adaptation, on the agricultural sector, particularly on macroeconomic variables, production, and prices. Changes in agricultural output because of climate change (or first-order impacts) were determined and then used as input to estimate the second-order effects, which were then compared to the baseline data. The simulation scenarios (Table 1.6) were made based on existing baseline data.

Based on Table 1.6, SIM1 and SIM2 provide information on the first-order impacts of climate change on the agricultural sector (autonomous adaptation). SIM3 and SIM4 provide information on the second-order impacts of climate change on the agricultural sector. All of these scenarios were analyzed using the GEMPACK software.

Table 1.6. Simulation scenarios of change in agricultural output

No.	Description
SIM1	Crop production is estimated to decline by around 20.1% for paddy rice, 13.6% for maize, 12.4% for soybeans, 7.6% for sugarcane, and 30% for oil palm **in the short-run with autonomous adaptation.**
SIM2	Crop production is estimated to decline by the same percentages as simulation 1 (SIM1) **in the long-run with autonomous adaptation.**
SIM3	Crop production is estimated to decline by the same percentages as SIM1 **in the short-run with policy adaptation.** The policy adaptation involves an increase in subsidy of about 25% for each of the following sectors: paddy rice, maize, soybean, sugarcane, oil palm, and manufacturing sectors (i.e., food, oil and fat, rice, flour, sugar, and other foods).
SIM4	Crop production is estimated to decline by the same percentages as SIM1 **in the long-run with policy adaptation.** The policy adaptation is the same as that in SIM3.

The GEMPACK software is an application for calculating accurate solutions of an economic model, starting from an algebraic representation of the equations of the model. These equations can be written as levels of equations, linearized equations, or a combination of these two. In this study, the CRUSOE equations in Table 1.4 (i.e., Equations 1.1 to 1.13) were linearized. The GEMPACK then automated the process of translating the model specification into a model solution program forming a text file using TABLO program.

The GEMPACK TABLO program then translated this text file into a model-specific program, which solved the model. TABLO is the GEMPACK program that translates the algebraic specification of an economic model into a form suitable for carrying out simulation with the model. The output from TABLO can either be computer files used to run the GEMPACK program GEMSIM or, alternatively, a FORTRAN program referred to as a TABLO-generated program. Either GEMSIM or the TABLO-generated program can be run to carry out simulations (Harrison and Pearson 2002). Figure 1.4 shows the main stages in the GEMPACK process.

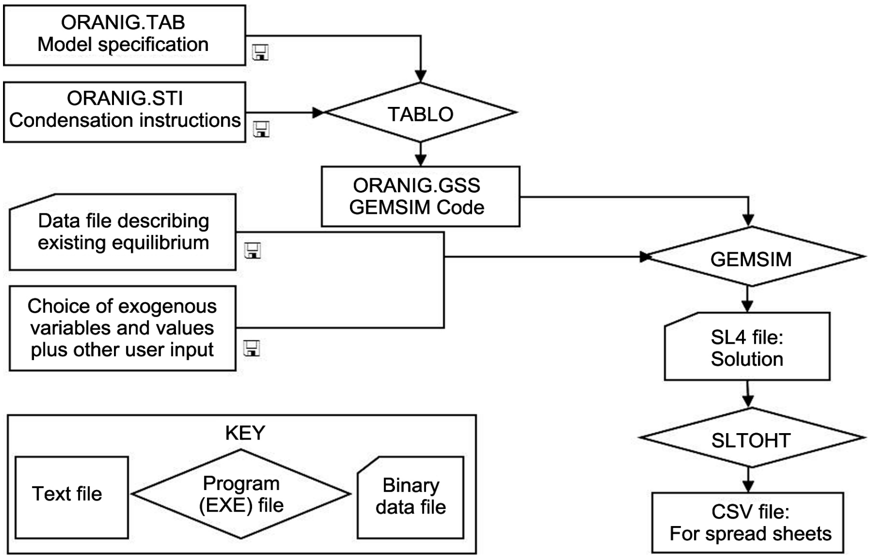

Figure 1.4. Stages in the GEMPACK process

Source: Horridge (2003)

The first and largest tasks for solving CRUSOE or ORANI-G models are the specification of the model's equations using the TABLO language. The model has too many equations and variables for efficient solution. Their numbers are reduced by instructing the TABLO program through a condensation process to omit specified variables from the system due to zero percentage change or to substitute specified variables using specified equations. The TABLO program will produce a GSS file that will then be used by the GEMSIM program to produce an SL4 (Solution) file of each simulation. The SL4 will be converted into a CSV file for spreadsheet (MS Excel) by the SLTOHT program. This program provides another way to generate a text file of results from the SL4 file.

In short, in solving the CRUSOE models, the specification of the models' equations need to be different. The specifications of the CRUSOE models are summarized in Table 1.7. In the CRUSOE model, the economic sector contains 66 industries (20 agricultural industries and 46 other industries). In terms of household characteristics, the model consists of one household (aggregated households).

Table 1.7. Summary of the specifications of CRUSOE model

Items	Models
Economic sector	a) 66 industries: 20 agricultural industries and 46 other industries b) For each sector, it is assumed that there is constant elasticity of substitution (CES) production technology with diminishing returns to scale.
Closure	a) Short-run closure: - technical change variables - tax rate variables, mostly beginning with '*t*' - shift variables, mostly beginning with '*f*' - land endowments and the number of households *q* - industry capital stocks - foreign prices and the investment slack variable, inventory to sales ratios - the exchange rate serves as numeraire - household: subsistence expenditure - the industry-specific wage shifter and capital stock are exogenous b) Long-run closure: employment variable, rates of return to capital, and import prices are exogenous

To estimate the impact of climate change on the economy in the short-run, capital stock and real wages are often assumed to be exogenous, while the rates of return on capital and employment level are assumed to be endogenous. In contrast, in long-run simulations, capital stock and real wages are to be determined endogenously, while rates of return to capital and employment levels are given exogenously.

In some simulations, the agricultural output is allowed to change; hence, it is specified as endogenous. In others, it is constrained to some exogenous value and, hence, will be specified as exogenous. If agricultural output is exogenous, some other variable (such as government spending or technical change) must be 'swapped' with agricultural output, i.e., specified as endogenous, and vice versa.

RESULTS AND DISCUSSION

This section presents the results of the agricultural impact of climate change on the Indonesian economy. It presents the consequences of changes in agricultural outputs under climate change in both the short-run and the long-run with either autonomous adaptation or policy adaptation. Analyzed using a CGE model are the consequences on the macroeconomy (domestic output, employment, trade, and prices) and on sectoral performance.

Autonomous adaptation is defined as adaptation by households and communities acting on their own without public policy interventions but within an existing public policy framework. Policy adaptation is defined as adaptation that is the result of a deliberate policy decision. In this study, policy adaptation involves the government providing a subsidy of about 25% for each of the following sectors: paddy rice, maize, soybean, sugarcane, oil palm, and the manufacturing sectors (i.e., food, oil and fat, rice, flour, sugar, other foods). The subsidies are in the form of consumer prices obtained from the domestic budget through additional taxes levied on all economic sectors.

Impact on Macroeconomy

The effect of climate change on selected key macroeconomic variables, based on simulation results, is summarized in Table 1.8. The changes are measured as percentage change.

Gross domestic product (GDP). In the CGE model, the impact of changes in agricultural output under climate change in the short-run with autonomous adaptation would be a shock equivalent to a 5.62% decrease in GDP (SIM1) (Table 1.8). However, the decrease in GDP would be 2.60% (SIM2) in the long-run. This means that there would be an adjustment in the economy in response to climate change in the long-run. GDP would also decrease by 6.73% and 2.95% when climate change is complemented by policy adaptation in both the short-run (SIM3) and in the long-run (SIM4), respectively.

Table 1.8. Impact, in percent change, on the Indonesian macroeconomy using the CGE model

Description	SIM1	SIM2	SIM3	SIM4
Real GDP	-5.62	-2.60	-6.73	-2.95
Aggregate output	-5.09	-2.07	-6.28	-2.69
Real devaluation	-11.52	-5.51	-11.99	-4.00
Export volume	-15.46	-4.28	-20.73	-6.52
Import volume	6.84	6.63	5.40	5.34
Exports price	3.75	0.87	4.79	0.89
Imports price	0	0	0	0
Terms of trade	3.75	0.87	4.79	0.89
(Balance of trade)/GDP (change)*	-0.05	-0.03	-0.06	-0.03
GDP price index	13.02	5.83	13.62	4.17
Average real wage	0.00	-13.55	0.00	-17.96
CPI	16.89	11.71	14.57	7.89

Note: *Computed as an ordinary change in the nominal trade balance to GNP ratio.

Aggregate output. The model incorporated aggregate output into the analysis (Table 1.8). SIM1 would lead to a 5.09% decrease in aggregate output, while SIM2 would lead to a 2.07% decrease. The other variables would also cause a decrease in aggregate output, the highest (6.28%) coming from SIM3. Almost all of the hypothetical impacts would show that climate change with autonomous adaptation and policy adaptation would cause a decrease in the aggregate output of some sectors.

The trade balance and other aggregates. In the CGE model, the balance of trade is computed as an ordinary change in the nominal trade balance to GDP ratio, not a percentage change. Results show that the reduction in crop production because of climate change would cause ordinary change in trade balance.

SIM1 shows that ordinary change in the nominal trade balance to GDP ratio would be equal to -0.05 (Table 1.8). This means a nominal trade balance deficit in the short-run that would be equal to 5% of nominal GDP from the expenditure side. This deficit would be smaller in the long-run (SIM2) at 3%.

The deficit with policy adaptation would be equal to 6% and 3% in the short-run (SIM3) and in the long-run (SIM4), respectively. Therefore, based on the analysis, a 25% increase in subsidy for the agricultural sector and the manufacturing sector would not cause a surplus in the trade balance.

Other aggregate variables, such as terms of trade, export volume, import volume, export price, import price, CPI, real devaluation, GDP price, and real wage, were computed as percentage changes (Table 1.8). The impact of changes in agricultural output under climate change with autonomous adaptation and policy adaptation would cause the volume of exports to fall with the highest decrease of 20.73% (SIM3). In contrast, the import volume would increase in all of the scenarios. There would be no change in the price index of imports, while the price of exports would increase, causing the terms-of-trade to increase.

The impact of climate change with autonomous adaptation would directly cause an increase in the CPI in the short-run (16.89%) and in the long-run (11.71%). However, climate change with policy adaptation would show an increase in CPI by around 14.57% in the short-run (SIM3) and by 7.8% in the long-run (SIM4). This indicates that the impact of climate change on the increase in CPI would be greater in the short-run than in the long-run.

Increases in the CPI would cause an increase in the GDP price index from the expenditure side. With no change in the price index of imports, a decrease in real devaluation would be observed. All scenarios show that real devaluation would decrease after climate change with either autonomous adaptation or policy adaptation because of the increase in the GDP price index from the expenditure side.

Analysis shows that the macroeconomic impact of changes on agricultural outputs, under climate change with autonomous adaptation and policy adaptation, would be large (Table 1.8). This means that the impact of climate change on the agricultural sector would also have an impact on the macroeconomy.

Impact on Sectoral Performance

The impact of climate changes on sectoral performance was analyzed considering variables such as domestic output, primary factor composite, prices, and household demand. All these variables in the CGE models have complex interactions in the system associated with changes in agricultural output under climate change. Changes in some of the agricultural and manufacturing sectors, as per the results of this study's simulations, are presented in the next sections.

Output of commodities

The impacts on domestic output are also measured as percentage change. Table 1.9 shows that almost all agricultural outputs would decrease because of the impact of climate change. In the short-run with autonomous adaptation (SIM1), output would decrease in paddy rice, beans, maize, sugar cane, and oil palm. Output would also decline in some of the manufacturing sectors.

In the long-run with autonomous adaptation (SIM2), production would increase for a few industries in the agricultural sectors, such as vegetables and fruit, other food crops, rubber, tobacco, coffee, and cloves. This is because their production structures would be able to adapt naturally to climate change in the long-run. Thus, production capacity, even if it is still relatively small, would increase because of autonomous adaptation.

Results are different when the government implements policy adaptation using subsidy instruments in the consumer price form. In the short-run, decrease in production because of climate change (as indicated in SIM1) would be suppressed with policy adaptation (as in SIM3), such as for paddy rice from 21% to 20.35%; beans from 12.40% to 12.21%; maize from 13.60% to 13.37%; sugarcane from 7.6% to 5.24%; and oil palm from 30% to 25.83% (Table 1.9).

Table 1.9. Impact, in percent change, on domestic output in the agriculture and manufacturing sectors

No	Sectors	SIM1	SIM2	SIM3	SIM4
A	Agriculture				
1	Paddy	-21.00	-21.00	-20.35	-20.36
2	Beans	-12.40	-12.40	-12.21	-11.98
3	Maize	-13.60	-13.60	-13.37	-13.36
4	Root crops	-0.56	-0.04	-0.46	0.23
5	Vegetable and fruits	-1.24	0.10	-1.09	0.71
6	Other food crops	-0.67	0.02	-0.50	0.37
7	Rubber	-6.30	0.96	-12.40	-3.28
8	Sugarcane	-7.60	-7.60	-5.24	-5.59
9	Coconut	-10.87	-10.38	-9.01	-8.70
10	Oil palm	-30.00	-30.00	-25.83	-26.89
11	Tobacco	-1.09	0.65	-1.91	0.41
12	Coffee	-1.61	0.23	-2.27	0.31
13	Tea	-5.53	-3.96	-3.38	-1.29
14	Clove	-2.68	0.09	-3.55	0.17
15	Livestock	-1.39	-0.04	-0.79	0.99
B	Manufacturing				
1	Food	-3.75	-0.52	7.28	13.13
2	Oil and fat	-35.01	-36.64	-28.64	-31.73
3	Rice	-22.14	-22.18	-20.91	-20.93
4	Flour	-4.01	-2.75	0.30	1.99
5	Sugar	-8.12	-8.14	-5.43	-5.69
6	Other food	-7.40	-6.07	-4.15	-2.29

Similarly, for the manufacturing sector, policy adaptation would reduce the rate of decline in production for all of sectors; some sectors would even increase, such as the food manufacturing (7.28%) and the flour sector (0.30%) (Table 1.9). This shows that the subsidy provided to the manufacturing sector would raise demand in some products, which is then expected to enlarge demand in the upstream sector.

With policy adaptation, the same pattern is observed in both the long-run and the short-run. The decline of production in the long-run (as indicated in SIM2) would be more suppressed by policy adaptation (as in SIM4) such as the decrease in production of paddy rice from 21% to 20.36%; beans from 12.40% to 11.98%; maize from 13.60% to 13.36%; sugarcane from 7.6% to 5.59%; and oil palm from 30% to 26.89% (Table 1.9). Similarly, the decline in production of the manufacturing sector would be obscured; in fact, even the production would be enhanced through the implementation of policy adaptation. The food and flour sectors are examples of these cases.

The above results indicate that the impacts of climate change on the decline in output of each sector would be larger in the short-run compared to the long-run. Although the government has implemented policy adaptation in the form of a subsidy to the agricultural sector (i.e., paddy rice, maize, beans, sugarcane, oil palm) and the manufacturing sectors (food, oil and fat, rice, flour, sugar, other foods), agricultural production would still decline. Thus, subsidies to the agricultural sector affected by climate change would be ineffective in both the short-run and the long-run. Likewise, subsidies to the manufacturing sectors to encourage increased demand in agricultural production would also be less effective. This is because the elasticity demand of the agricultural sector is inelastic, hence changes in its demand are small.

For some of the agriculture sectors, simulation results show that the decline in commodity output would not always be followed by an increase in the demand for these outputs (Table 1.10). Examples of this are root crops (SIM1 and SIM 2), vegetables and fruits (SIM1 and SIM3), other food crops (SIM1), rubber (SIM1 and SIM3), sugarcane (SIM4), coconut (SIM1 and SIM3), oil palm (SIM4), coffee (SIM1 and SIM3), tea (SIM1 to SIM4), clove (SIM1 and SIM3), and livestock (SIM4). This is because the demand for the output of the commodity is influenced by a change in local demand (local market), replacement of imported goods by domestic goods (domestic share), and increase in exports (Table 1.11).

Table 1.10. Impact, in percent change, on price of output in the agriculture and manufacturing sectors

No	Sectors	SIM1	SIM2	SIM3	SIM4
A	Agriculture				
1	Paddy	137.39	140.82	208.86	213.95
2	Beans	3.27	3.46	4.12	4.26
3	Maize	291.93	313.46	369.91	397.69
4	Root crops	-0.65	-3.75	0.82	-2.85
5	Vegetable and fruits	-3.76	-0.97	-3.09	2.31
6	Other food crops	-2.80	-2.31	0.22	0.87
7	Rubber	-4.70	0.88	-14.32	-15.49
8	Sugarcane	72.73	101.01	134.94	184.96
9	Coconut	-43.54	-49.36	-39.37	-48.18
10	Oil palm	72.33	88.03	222.42	254.03
11	Tobacco	7.57	0.74	6.33	-2.89
12	Coffee	-0.18	-0.50	-3.81	-4.42
13	Tea	-13.94	-21.69	-6.09	-16.12
14	Clove	-14.30	-1.66	-20.80	-7.15
15	Livestock	15.92	13.25	12.53	9.87
B	Manufacturing				
1	Food	6.64	0.84	18.82	12.02
2	Oil and fat	10.30	11.06	38.73	40.01
3	Rice	84.91	85.06	85.81	85.83
4	Flour	20.16	15.68	15.82	9.57
5	Sugar	32.91	39.03	37.56	46.18
6	Other food	45.58	42.26	37.56	32.28

Table 1.11. Impact on a change in fan decomposition variables using the CGE model

No	Sectors	SIM1				SIM2				SIM3				SIM4			
		Local market	Import share	Export	Total	Local market	Import share	Export	Total	Local market	Import share	Export	Total	Local market	Import share	Export	Total
A	Agriculture																
1	Paddy rice	-20.63	-0.37	0.00	-21.00	-20.61	-0.38	0.00	-21.00	-19.41	-0.92	0.00	-20.33	-19.36	-0.98	0.00	-20.34
2	Beans	-4.23	-8.13	-0.04	-12.40	-3.45	-8.93	-0.01	-12.40	-0.81	-11.36	-0.04	-12.21	0.20	-12.17	-0.01	-11.98
3	Maize	-8.42	-5.14	-0.04	-13.60	-8.08	-5.51	-0.01	-13.60	-6.83	-6.49	-0.04	-13.37	-6.35	-7.00	-0.01	-13.36
4	Root crops	-0.52	0.01	-0.05	-0.56	-0.07	0.04	-0.02	-0.04	-0.40	-0.01	-0.05	-0.46	0.20	0.03	-0.01	0.23
5	Vegetables and fruits	0.71	-1.93	-0.03	-1.24	0.47	-0.36	-0.01	0.10	0.41	-1.48	-0.03	-1.09	0.03	0.69	0.00	0.71
6	Other food crops	-4.25	3.62	-0.04	-0.67	-2.96	2.99	-0.01	0.02	-0.10	-0.35	-0.05	-0.50	1.57	-1.19	-0.01	0.37
7	Rubber	-6.28	0.02	-0.05	-6.30	0.98	0.00	-0.02	0.96	-12.42	0.07	-0.05	-12.40	-3.35	0.08	-0.01	-3.28
8	Sugarcane	-7.45	-0.15	0.00	-7.60	-7.36	-0.24	0.00	-7.60	-4.87	-0.37	0.00	-5.24	-4.99	-0.61	0.00	-5.59
9	Coconut	-10.62	0.01	-0.26	-10.87	-10.30	0.01	-0.08	-10.38	-8.75	0.01	-0.27	-9.01	-8.68	0.01	-0.03	-8.70
10	Oil palm	-29.85	-0.08	-0.07	-30.00	-29.88	-0.10	-0.02	-30.00	-25.56	-0.20	-0.07	-25.83	-26.67	-0.22	-0.01	-26.90
11	Tobacco	-1.09	0.00	0.00	-1.09	0.65	0.00	0.00	0.65	-1.91	0.00	0.00	-1.91	0.41	0.00	0.00	0.41
12	Coffee	-2.34	0.01	0.71	-1.61	-1.86	0.02	2.07	0.23	-1.36	0.10	-1.01	-2.27	-0.68	0.11	0.87	0.31
13	Tea	-5.36	0.24	-0.40	-5.53	-4.20	0.38	-0.13	-3.96	-3.06	0.10	-0.42	-3.38	-1.53	0.29	-0.05	-1.29
14	Clove	-1.31	0.02	-1.39	-2.68	0.54	0.00	-0.46	0.09	-2.12	0.03	-1.46	-3.55	0.33	0.01	-0.18	0.17
15	Livestock	-1.40	0.11	-0.10	-1.39	-0.13	0.12	-0.03	-0.04	-0.73	0.04	-0.10	-0.79	0.95	0.05	-0.01	0.99

Table 1.11 continued

No	Sectors	SIM1				SIM2				SIM3				SIM4			
		Local market	Import share	Export	Total	Local market	Import share	Export	Total	Local market	Import share	Export	Total	Local market	Import share	Export	Total
B	Manufacturing																
1	Food	-0.90	0.35	-3.20	-3.75	-0.15	0.10	-0.47	-0.52	1.57	0.87	4.84	7.28	2.50	0.92	9.72	13.13
2	Oil and fat	-7.15	3.40	-31.26	-35.01	-7.33	3.48	-32.80	-36.64	-6.07	4.59	-27.17	-28.65	-6.48	4.58	-29.83	-31.73
3	Rice	-6.34	-15.79	-0.01	-22.14	-6.26	-15.92	0.00	-22.18	-4.43	-16.46	-0.01	-20.91	-4.43	-16.49	0.00	-20.93
4	Flour	-2.60	-0.89	-0.52	-4.01	-1.89	-0.69	-0.17	-2.75	1.34	-0.50	-0.55	0.30	2.28	-0.22	-0.07	1.99
5	Sugar	-3.29	-4.63	-0.19	-8.11	-2.71	-5.37	-0.06	-8.14	-0.70	-4.53	-0.20	-5.43	-0.02	-5.64	-0.02	-5.69
6	Other foods	-3.34	-3.15	-0.91	-7.40	-2.78	-3.00	-0.30	-6.07	-0.72	-2.48	-0.95	-4.15	0.03	-2.21	-0.12	-2.29

Primary factor composite

Analysis shows that climate change would change the price level of primary factor composite in agricultural sectors (Table 1.12). In the short-run with autonomous adaptation (SIM1), almost all of the agricultural sectors (with the exception of paddy rice, maize, sugar cane, oil palm and tobacco) would experience a decline in the price level of primary factor composite. The highest decrease would be for coconut at 60.75%. In contrast, the manufacturing sector, with the exception of the oil and fat and rice sector prices, would show increases. This condition is different from that which would occur in the long-run (SIM2), where all of primary factor composite would experience a decline in its price.

The impact of change in the price of primary factor composite would be different when the government undertakes policy adaptation. In the short-run (SIM3), the decrease in the price of composite primary would be smaller than the decline in prices with autonomous adaptation (SIM1). Some sectors that would experience increase in prices (from SIM1 to SIM3) include that of paddy rice, from 108% to 184.94%; maize, from 287.37% to 376.71%; sugarcane, from 76.35% to 158.39%; and oil palm, from 28.07% to 224.92% (Table 1.12). Price would also increase in the following manufacturing sectors: food, from 6.49% to 35.50%; flour, from 8.10% to 15.23%; sugar, from 1.10% to 4.16%; and other foods, from 0.51% to 5.47% (Table 1.12). Price would also change when policy adaptation is implemented in the long-run (SIM4).

For some agricultural sectors, the decline in the price of primary factor composite would not always be followed by an increase in the demand for these inputs (Table 1.13). Examples are beans (SIM1, SIM2, and SIM3), root crops (SIM1, SIM2, and SIM3), vegetables and fruits (SIM1 and SIM3), other crops (SIM1 and SIM3), rubber (SIM1 and SIM3), coconut (SIM1 to SIM4), coffee (SIM1 and SIM2), tea (SIM1 to SIM4), clove (SIM1 and SIM3), and livestock (SIM1 and SIM2). This is because the demand for primary factor composite would be influenced by the change in output demand such as change in local demand (local market), replacement of imported by domestic goods (domestic share), and increase in exports (see Table 1.11).

Table 1.12. Impact, in percent change, on the price of primary factor composite in the agriculture and manufacturing sectors

No	Sectors	SIM1	SIM2	SIM3	SIM4
A	Agriculture				
1	Paddy	108.80	112.49	184.94	190.61
2	Beans	-12.49	-12.45	-10.71	-10.36
3	Maize	287.37	310.19	376.71	406.82
4	Root crops	-1.70	-4.62	-0.73	-4.09
5	Vegetable and fruits	-5.23	-1.51	-4.93	1.92
6	Other food crops	-4.29	-2.75	-1.49	0.59
7	Rubber	-8.14	1.12	-23.51	-22.82
8	Sugarcane	76.35	109.89	158.39	219.40
9	Coconut	-60.75	-66.60	-56.76	-65.87
10	Oil palm	28.07	46.22	224.92	260.12
11	Tobacco	9.45	0.73	2.40	-9.16
12	Coffee	-3.24	-0.50	-11.38	-7.83
13	Tea	-17.81	-25.98	-9.14	-19.59
14	Clove	-18.43	-1.98	-27.20	-9.08
15	Livestock	-0.63	-3.94	4.12	1.14
B	Manufacturing				
1	Food	6.49	-4.63	35.50	18.50
2	Oil and fat	-47.23	-58.43	-38.38	-56.16
3	Rice	-54.96	-62.87	-52.93	-63.68
4	Flour	8.10	-8.41	15.23	-8.12
5	Sugar	1.10	-16.52	4.16	-19.91
6	Other food	0.51	-14.57	5.47	-15.39

Table 1.13. Impact, in percent change, on demand of the primary factor composite in the agriculture and manufacturing sectors

No	Sectors	SIM1	SIM2	SIM3	SIM4
A	Agriculture				
1	Paddy	108.80	112.49	184.94	190.61
2	Beans	-12.49	-12.45	-10.71	-10.36
3	Maize	287.37	310.19	376.71	406.82
4	Root crops	-1.70	-4.62	-0.73	-4.09
5	Vegetable and fruits	-5.23	-1.51	-4.93	1.92
6	Other food crops	-4.29	-2.75	-1.49	0.59
7	Rubber	-8.14	1.12	-23.51	-22.82
8	Sugarcane	76.35	109.89	158.39	219.40
9	Coconut	-60.75	-66.60	-56.76	-65.87
10	Oil palm	28.07	46.22	224.92	260.12
11	Tobacco	9.45	0.73	2.40	-9.16
12	Coffee	-3.24	-0.50	-11.38	-7.83
13	Tea	-17.81	-25.98	-9.14	-19.59
14	Clove	-18.43	-1.98	-27.20	-9.08
15	Livestock	-0.63	-3.94	4.12	1.14
B	Manufacturing				
1	Food	6.49	-4.63	35.50	18.50
2	Oil and fat	-47.23	-58.43	-38.38	-56.16
3	Rice	-54.96	-62.87	-52.93	-63.68
4	Flour	8.10	-8.41	15.23	-8.12
5	Sugar	1.10	-16.52	4.16	-19.91
6	Other food	0.51	-14.57	5.47	-15.39

Impact on Household Demand

Household demand (Table 1.14) would increase, except for maize, sugarcane, and livestock in both the short-run (SIM1) and in the long-run (SIM2). Increase in household demand would be highest in coconut. In the manufacturing sector, household demand would decrease with the exception of the food sector as well as the oil and fat sector. The largest decline would be in the rice sector with 5.51% in SIM1 and 5.99% in SIM2.

Table 1.14. Impact, in percent change, on household demand on the agriculture and manufacturing sectors

No	Sectors	SIM1	SIM2	SIM3	SIM4
A	Agriculture				
1	Paddy	1.65	0.79	1.64	0.53
2	Beans	1.15	0.29	5.20	3.78
3	Maize	-9.97	-10.38	-9.70	-10.23
4	Root crops	1.75	1.36	0.88	0.32
5	Vegetable and fruits	2.26	0.93	1.48	-0.39
6	Other food crops	2.10	1.13	0.97	-0.20
7	Rubber	2.90	1.38	2.88	0.93
8	Sugarcane	-4.92	-6.62	-5.46	-7.46
9	Coconut	13.67	15.14	10.71	12.81
10	Oil palm	1.65	0.79	1.64	0.53
11	Tobacco	0.55	0.68	0.12	0.33
12	Coffee	1.67	0.86	1.60	0.56
13	Tea	4.17	4.87	1.98	2.58
14	Clove	4.25	1.03	4.93	0.99
15	Livestock	-0.70	-1.33	-0.94	-1.88
B	Manufacturing				
1	Food	0.88	0.86	3.69	3.33
2	Oil and fat	0.24	-0.87	0.54	-0.96
3	Rice	-5.51	-5.99	-3.22	-4.00
4	Flour	-1.26	-1.58	4.25	3.81
5	Sugar	-2.88	-4.36	0.71	-1.69
6	Other food	-4.21	-4.67	0.71	0.04

With policy adaptation, the short-run analysis (SIM3) shows that household demand, with the exception of maize, sugarcane, and livestock, would increase. Similarly, with policy adaptation, the manufacturing sectors would experience increased household demand for almost all commodities (Table 1.14).

The increase in household demand for some agricultural sectors would be smaller with policy adaptation (SIM4) than with autonomous adaptation (SIM2). Examples are paddy rice (from 0.79% to 0.53%); root crops (from 1.36% to 0.32%); and vegetable and fruits (from 0.93% to -0.39%) (Table 1.14). This indicates that the subsidies granted to the agriculture and manufacturing sectors would not be able to increase whole household demand, especially in the long-run.

The decrease in household demand would cause a change in the prices of some sectors (Table 1.15). In the short-run analysis with autonomous adaptation (SIM1), the prices of some agricultural commodities would significantly increase, such as maize (291.93%), sugarcane (72.73%), tobacco (7.57%), and livestock (15.92%). The prices of most agricultural commodities and manufacturing products would also increase in the long-run (SIM2). This suggests that providing subsidies in both the short-run (SIM3) and the long-run (SIM4) would not effectively increase household demand.

Table 1.15. Impact, in percent change, on the price of commodity composite in the agriculture and manufacturing sectors

No	Sectors	SIM1	SIM2	SIM3	SIM4
A	Agriculture				
1	Paddy	0	0	0	0
2	Beans	3.27	3.46	-18.61	-18.37
3	Maize	291.93	313.46	267.36	289.71
4	Root crops	-0.65	-3.75	5.09	1.42
5	Vegetable and fruits	-3.76	-0.97	1.02	6.81
6	Other food crops	-2.8	-2.31	4.46	5.31
7	Rubber	0	0	0	0
8	Sugarcane	72.73	101.01	83.66	123.12
9	Coconut	-43.54	-49.36	-36.8	-45.9
10	Oil palm	0	0	0	0
11	Tobacco	7.57	0.74	10.82	1.38

Table 1.15 continued

No	Sectors	SIM1	SIM2	SIM3	SIM4
A	Agriculture				
12	Coffee	-0.18	-0.5	0.25	-0.22
13	Tea	-13.94	-21.69	-2.12	-12.44
14	Clove	-14.3	-1.66	-17.45	-3.06
15	Livestock	15.92	13.24	17.3	14.71
B	Manufacturing				
1	Food	6.64	0.84	-7.12	-12.29
2	Oil and fat	10.3	11.06	8.45	9.63
3	Rice	84.91	85.06	45.25	45.5
4	Flour	20.16	15.68	-9.46	-14.2
5	Sugar	32.91	39.03	7.54	14.45
6	Other foods	45.58	42.26	7.54	3.57

CONCLUSIONS

This study analyzed the impact on the macroeconomy, sectoral performance, and household demand of changes in agricultural output under climate change with autonomous adaptation and policy adaptation. The following are some conclusions drawn from the results:

1. The macroeconomic impact of changes in agricultural output under climate change would be large. With autonomous adaptation, for example, it would be equal to a 5.62% decrease in GDP in the short-run analysis (SIM1). However, in the long-run analysis, the decrease in GDP would be 2.60% (SIM2). When climate change is complemented by policy adaptation, GDP would also decrease by 6.73% and 2.95% in the short-run (SIM3) and in the long-run (SIM4), respectively.

2. Even with the government's implementation of a policy adaptation in the form of subsidies for the agricultural (paddy rice, maize, beans, sugarcane, oil palm) and manufacturing sectors (food, oil and

fat, rice, flour, sugar, other foods), decline in agricultural production would not be avoided.

3. With autonomous adaptation, almost all of the agricultural sectors (with the exception of paddy rice, maize, sugar cane, oil palm and tobacco) would experience a decline in the price of primary factor composite. For some agricultural sectors, this decline would not always be followed by an increase in the demand for these inputs. Likewise, the increase in household demand for some agricultural sectors would be smaller with policy adaptation than with autonomous adaptation.

4. The adaptation policy of implementing subsidies for the agricultural sectors affected by climate change in both the short-run and the long-run would not be effective.

POLICY RECOMMENDATIONS

The climate changes in Indonesia would affect the performance of the macroeconomy as well as sectoral and household demands. In the short-run with autonomous adaptation, climate change would decrease macroeconomic performance (i.e., GDP) and aggregate output. For domestic output, almost all of the agricultural outputs would decrease because of the impact of climate change.

Subsidies to agricultural and manufacturing sectors as an adaptation of climate change would be ineffective, both in the short-run and the long-run. Thus, governments need to consider other adaptation technologies to reduce vulnerability, or enhance the resilience, of natural and human systems to the impacts of climate change. Most adaptation measures involve the use of technology, which include not only infrastructure and equipment but also knowledge and practices.

Adaptation technologies can be classified as: a) hard technologies (e.g., new constructions, different types of equipment, seawalls and drip irrigation techniques, etc.); b) soft technologies (e.g., management options, knowledge, know-how, organizational capacity, etc.); and c) a combination of both (e.g., early warning systems that combine hard technologies, such as measuring devices and information technology, and soft technologies, like strengthening awareness and promoting evacuation). Many of these technologies are already available and widely used. These can be adapted with some modifications. Other technological advances to better cope with arid environments, such as introducing new crop hybrids and making better use of scarce water (e.g., drip irrigation system), can be considered.

Specific policy options that can be considered are the following:

a) ***Invest in public agricultural research and development.*** Increasing public agricultural research and development investments is essential. Investment is the major global engine of agricultural productivity and can lower food prices for the poor in the long-term (World Bank 2009). Such investments should target general improvements in agricultural productivity, resistance to more variable growing conditions, water use efficiency, and reduced input intensity.

b) ***Rebuild and expand public agricultural research capacity.*** New crop and trait combinations are required to meet the demands for global food security, while helping the country cope with or even mitigate climate change. Policymakers must fund and improve capacity for public agricultural research, especially of those facing severe climate changes. Thus, the government must also prioritize its own national agricultural research systems and ensure that these systems are functional. Investments must entail long-term commitments for infrastructure and human capital that are meaningful enough to attract and retain well-trained, cutting-edge scientists. This requires national agricultural research systems to provide stronger and more dynamic professional incentives for their researchers.

c) ***Invest in better information and forecasts.*** Continued investments in remote sensing and weather forecasting are as important as ever. Improvements in sensing and communication technology and in modeling techniques have brought sophisticated short-term forecasts to many parts of the world. More must be done to improve longer-term seasonal forecasts and to develop more effective forecasts of slow onset events such as drought. Policies to support the diffusion and interpretation of these forecasts in terms of their agronomic and economic implications are required to help both suppliers and users to respond well to new information.

d) ***Support competitive and responsive agricultural markets.*** Policies and institutions that encourage the development of competitive and responsive input and output markets in agriculture should take on added urgency in the face of climate change. Appropriate responses to new climate conditions or even seasonal weather forecasts require the ability to make efficient production adjustments in response to these changing conditions. The single best gauge of efficiency when making these adjustments is provided by price signals in functional markets. Market rigidities from government price policies, parastatal restrictions, and dominant buyers (which may be local cooperatives) all limit the ability of farmers and others to adapt and adjust to disequilibria in a more dynamic and variable world.

e) ***Encourage investments that improve spatial market integration.*** Poorly integrated markets arising from inadequate communication and transportation infrastructure, or other factors that create spatial frictions, impede the transmission of price signals to rural producers. This situation, in turn, limits the ability of rural producers to respond efficiently to policies. Hence, improvements in communication systems can enhance policy responses to climate change.

LITERATURE CITED

Abimanyu, A. 2000. Impact of agriculture trade and subsidy policy on the macroeconomy, distribution, and environment in Indonesia: A strategy for future industrial development. The Developing Economies. 38(4):547-571.

Apryantono; A. S. G. Irianto; Suyamto; Irsal Las; T. Sodaryanto; and T. Alamsyah. 2009. Indonesia Experience: Regaining Rice Self-Sufficiency. Jakarta: Indonesian Ministry of Agriculture.

Aldrian, E. 2007. Decreasing trends in annual rainfalls over Indonesia: A threat for the national water resources? Journal of Indonesian Meteorological, Climatological and Geophysical Agency. 7(2):40-49.

Behrman, J.R.; J.D. Lewis; and S. Lofti. 1989. The Impact of Commodity Price Instability: Experiments with a General Equilibrium Model for Indonesia. L. R. Klein and J. Marquez (ed) In Economics in Theory and Practice: An Eclectic Approach. Kluwer Academic Publisher, Dordrecht, the Netherlands. pp. 59-100.

Bergman, L. 1990. The Development of Computable General Equilibrium Modeling. L. Bergman, D.W. Jorgenson and E. Zalai (ed) In General Equilibrium Modeling and Economic Policy Analysis. Blackwell, Inc., Oxford, United Kingdom and Cambridge, USA. pp. 3-26.

Bosello, F. and J. Zhang. 2005. Assessing Climate Change Impacts: Agriculture. The Fondazione Eni Enrico Mattei. _http:// www.feem.it/Feem/Pub/Publications/WPapers/default.htm (Retrieved February 2, 2011)

Butt, A.T.; B.A. McCarl; J. Angerer; P.T. Dyke; and J.W. Stuth. 2005. The economic and food security implications of climate change in Mali. Climatic Change. 68(3):355-378.

Boer, R. and A. Faqih. 2004. Current and Future Rainfall Variability in Indonesia. AIACC Technical Report 021. http://sedac.ciesin.columbia.edu/ aiacc/ progress/AS21_Jan04.pdf (Retrieved February 12, 2011)

Challen, D. W. and A. J. Hagger. 1983. Macroeconometric Systems: Construction, Validation and Applications. Macmillan Press, University of Michigan. 235 pp.

Dervis, K .; J. De Mello; and S. Robinson. 1982. General Equilibrium Model for Development Policy. Cambridge University Press, Cambridge, USA. 526 pp.

Dixon, P.B.; B.R. Parmenter; J.M. Sutton; and D.P. Vincent. 1982. ORANI: A Multisectoral Model of the Australian Economy. North-Holland, Amsterdam, the Netherlands.

Dixon, P.B.; B.R. Parmenter; and A.A. Powell. 1992. Note and Problem in Applied General Equilibrium Economics. North-Holland, Amsterdam, the Netherlands. 392 pp.

Dixon, P.B. and M.T. Rimmer. 2002. Dynamic General Equilibrium and Modeling for Forecasting and Policy: A Practical Guide and Documentation of MONASH. North-Holland, Amsterdam, the Netherlands. 338 pp.

Ezaki, M. 1989. Oil price declines and structural adjustment policies in Indonesia: A static CGE analysis for 1980 and 1985. The Philippine Review of Economics and Business. 26(2):173-207.

Handoko, I.; Y. Sugiarto; and Y. Syaukat. 2008. Keterkaitan Perubahan Iklim dan Produksi Pangan Strategis: Telaah kebijakan independen dalam bidang perdagangan dan pembangunan. SEAMEO BIOTROP, Jakarta, Indonesia.

Handoko, I. and H. Hardjomidjojo. 2009. Global Warming, Climate Change and Impacts to Food and Agriculture. Paper presented at a Seminar on “Climate Change Scenarios and Its Implication on Ecosystem and Biodiversity, Food Security and Health” held in Penang, Malaysia, 23-24 June 2009.

Hermanto. 2005. A General Equilibrium Analysis of the Impact of the Indonesian Commitments under the World Trade Organization (WTO) on the Macroeconomy, Sectoral Performance, and Household Income. Unpublished Ph.D. Dissertation, College of Economics and Management, University of the Philippines Los Baños, Laguna, Philippines, July 15, 2005.

Harrison, W. J. and K.R. Pearson. 2002. An Introduction to GEMPACK. GEMPACK User Documentation GPD-1. IMPACT Project and KPSOFT. Australia.

Hertel, T.W.; M. B Burke; and D. B Lobell. 2009. The Poverty Implications of Climate-Induced Crop Yield Changes by 2030. Unpublished manuscript. Purdue University, USA.

Horridge, M. 2003. ORANI-G: A Generic Single-Country Computable General Equilibrium Model. Notes prepared for the Practical GE Modelling Course. June 23-27, 2003. Australia: Centre of Policy Studies and Impact Project, Monash University.

Iglesias, A. 2005. Tools and models for vulnerability and adaptation assessment for the agriculture sector. United Nations Framework Convention on Climate Change (UNFCCC), Mozambique.

Iglesias, A. 2006. Climate Change and Agriculture. Universidad Politecnica de Madrid, Spain. Paper contributed to the CGE Hands-on Training Workshop on V&A Assessment of the Asia and the Pacific Region held in Jakarta, Indonesia, 20-24 March 2006.

IPCC (Intergovernmental Panel on Climate Change).1990. Climate Change: The IPCC Scientific Assessment. Cambridge University Press. Cambridge, United Kingdom.

IPCC. 2001. Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, United Kingdom.

IPCC. 2007a. Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC. Cambridge University Press. Cambridge, United Kingdom.

IPCC. 2007b. Climate Change 2007: The Physical Science Basis. Summary for Policy Makers. Intergovernmental Panel on Climate Change, Geneva. Cambridge University Press. Cambridge, United Kingdom.

Irawan, B. 2002. Multilevel Impact assessment and Coping Strategies against El Nino: Case of Food Crops in Indonesia. CGPRT Center Working Paper No 75. CGPRT Center. Bogor, Indonesia.

Kaiser, H.M. and T. Drennen. 1993. Agricultural Dimensions of Global Climate Change. St. Lucie Press. St. Lucie, Florida, USA.

Kaimuddin. 2000. Kajian Dampak Perubahan Iklim dan Tata Guna Lahan Terhadap Keseimbangan Air Wilayah Sul.Sel. Dissertasi Program Studi AGK-FPS IPB. Insitut Pertanian Bogor, Bogor, Indonesia.

Las, I.; E. Surmaini; and A. Ruskandar. 2008. Antisipasi Perubahan Iklim: Inovasi Teknologi dan Arah Penelitian Padi di Indonesia. Prosiding Seminar Nasional Padi 2008: Inovasi Teknologi Padi Mengantisipasi Perubahan Iklim Global Mendukung Ketahanan Pangan. Balai Besar Penelitian Padi (Indonesian Center for Rice Research), Subang, Indonesia.

MOA (Ministry of Agriculture). 2010. Indonesia Climate Change Sectoral Roadmap (ICCSR). Indonesian Ministry of Agriculture. Jakarta, Indonesia.

Parry, M.L.; C. Rosenzweig; A. Iglesias; G. Fischer; and M.T.J. Livermore. 1999. Climate change and world food security: A new assessment. Global Environmental Change. 9:S51-S67.

Parry, M.L.; C. Rosenzweig; A. Iglesias; M. Livermore; and G. Fischer. 2004. Effects of climate change on global food production under sres emissions and socio-economic scenarios. Global Environmental Change. 14:53-67.

Reed, G. 1996. The Use of CGE Modelling in the Analysis of Trade Policy Reform. Paper presented at the Conference on Implications of the Uruguay Round on the Arab Countrues held at the Cairo University, January 1996. 27 p.

Reilly, J.; J. Graham; and J. Hrubovcak. 2001. Agriculture: The Potential Consequences of Climate Variability and Change for the United States. Cambridge University Press. Cambridge, United Kingdom.

Resosudarmo, B.P.; A.A. Yusuf; D. Hartono; and D.A. Nurdianto. 2009. Implementation of the IR-CGE Model for Planning: IRSA-INDONESIA 5 (Inter-Regional System of Analysis for Indonesia in 5 Regions). CSIRO. Queensland, Australia.

Rosenzweig, C. and M.L. Parry. 1994. Potential impact of climate change on world food supply. Nature. 367:133-138.

Shoven, J.B. and J. Whalley. 1984. Applied general equilibrium models of taxation and international trade: An introduction and survey. Journal of Economic Literature. 22(3):1007-1051.

Shoven, J.B. and J. Whalley. 1992. Applying General Equilibrium. Cambridge University Press. Cambridge, United Kingdom. 299 pp.

Smith, J.B. 1997. Setting priorities for adapting to climate change. Global Environmental Change. 7:251-264.

Smith, B.; O. Pilifosova; I. Burton; B. Challenger; S. Huq; R. Klein; and G. Yohe. 2001. Adaptation to Climate Change in the Context of Sustainable Development and Equity. J. McCarthy, O. Canziana, N. Leary, D. Dokken and K. White (ed) In Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge, United Kingdom and New York. pp. 877-912.

Stakhiv, E. 1993. Evaluation of IPCC Adaptation Strategies. Draft Report. Institute for Water Resources, U.S. Army Corps of Engineers. Fort Belvoir, Virginia, USA.

Syaukat, Y. 2011. The impact of climate change on food production and security and its adaptation programs in Indonesia. Journal of the International Society for Southeast Asian Agricultural Sciences. 17(1):40-51.

Thorbecke, T. 1991. Adjustment, growth and income distribution in Indonesia. World Development. 19(11): 1595-1614.

Tschirley, J. 2007. Climate Change Adaptation: Planning and Practices. Presentation at the UNFCCC Workshop, Rome-Italy, 10-12 September 2007.

UNDP Indonesia (United Nations Development Programme). 2007. Sisi Lain Perubahan Iklim: Mengapa Indonesia harus beradaptasi untuk melindungi rakyat miskinnya. Keen Media Co., Ltd. Thailand.

UNFCCC (United Nations Framework Convention on Climate Change). 2007. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Information Services, UNFCCC Secretariat, Bonn, Germany.

Warr, P. 2005. Food policy and poverty in Indonesia: a general equilibrium analysis. The Australian Journal of Agricultural and Resource Economics. 49:429-451.

Winters, P.; R. Murgai; E. Sadoulet; A. de Janvry; and G. Frisvold. 1996. Climate Change, Agriculture, and Developing Economies. Working Paper No. 785. California Agricultural Experiment Station Giannini Foundation of Agricultural Economics. California, USA.

World Bank. 2011. Economics of Adaptation to Climate Change: Vietnam. The World Bank. Washington, D.C., USA.

World Bank. 2009. Development and Climate Change. The World Bank. Washington, D.C., USA.

II

Economy-Wide Estimates of Climate-Induced Impacts on Philippine Agriculture: A Computable General Equilibrium Analysis

Arvin B. Vista

Photo credit: Filipino farmers planting rice by Flordeliza Bordey

EXECUTIVE SUMMARY

This research assessed the impact of climate change on the Philippine economy and agriculture sector. In particular, it employed a computable general equilibrium model to analyze the likely extent of climate-induced impacts on the different subsectors of Philippine agriculture, as well as the total macroeconomic impact of climate-induced changes on agricultural productivity, fish consumption and manufacturing output. Five simulation scenarios were used: production shocks; consumption shocks; combination of production and consumption shocks; construction and manufacturing shocks; and selected combinations of these shocks.

The results reveal that: a) production and consumption shocks would have a contractionary effect on real GDP; b) reduced agricultural production and manufacturing output would explain most of the expected decline in real GDP and the expected increase in the general price level as measured by the consumer price index; c) climate-induced impacts would trigger improvements in production efficiency and input intensification, leading to possible increases in the average return to land allocated for sugarcane, rice, and corn, as well as increased employment in these sectors; and d) declining agricultural production would lead to substitution effects, thereby shifting some of the demand and consumption of land-based produce to fisheries and boosting real GDP, employment, exports, and imports in the fishery sectors.

Overall, climate-induced impacts would result in a net loss to the Philippine economy and its key agricultural sectors in the short run. Therefore, it is imperative for Philippine farmers to adopt adaptation measures that would lessen the impacts of climate change.

INTRODUCTION

The Philippines is a minor emitter of global greenhouse gases (GHGs) but its location and geography make it highly vulnerable to the impacts of climate change, especially natural disasters and periodic El Niño and La Niña events (Rincón and Virtucio 2008). In 2007, the Philippines was ranked as the 43rd largest emitter of carbon dioxide in the world, accounting for only 0.27% of the total global carbon dioxide emissions ($MtCO_2$ e), excluding land-use change (WRI 2011). Agriculture, forestry, and unsustainable land use were responsible for 56% of its emissions. Agriculture alone accounted for 33% of the country's emissions through rice cultivation and livestock production, use of fertilizers, and biomass burning (Habito 2002).

The Philippines is susceptible to the adverse impacts of climate change mainly due to high exposure to climate hazards (Yusuf and Francisco 2010). Its 832 coastal communities, bordering 33,900 km of discontinuous coastlines, are very vulnerable to climate hazards. In particular, an average of 20 typhoons hit the Philippine archipelago every year, of which five usually cause major damage in terms of both loss of lives and property damage. The World Bank (2008) estimated that about 85% of the country's USD 86 billion annual GDP is endangered because of climate risks.

There is an ongoing debate on whether the effects of climate change will result in a net gain or a net loss for Philippine agriculture. For example, according to the four Global Circulation Models (Republic of the Philippines 1999), doubling the CO_2 concentration scenario would generally increase yields and decrease the maturity period for rice, but would decrease corn yields. On the other hand, according to ADB (2009), 2°C to 3°C temperature increases in the country will result in loss of agricultural lands due to sea level rise, while temperature increases of 3°C to 5°C will reduce crop yields and delay cropping schedules.

There are varying estimates of the impacts of climate change on agricultural yields. However, there are still no economy-wide estimates of the implications of climate change on the Philippine agriculture sector and the feedback loop created by these climate-induced effects, from changes in production and prices to related sectors in the economy.

To date, there is no study yet that uses the computable general equilibrium (CGE) model to estimate economy-wide implications of climate change on Philippine agriculture. The earliest CGE models of the Philippines were done by Clarete (1984) on trade policy and Habito (1984) on fiscal policy and income distribution. Since then, quite a number of models have been constructed that evaluated impacts on welfare, poverty, outputs, prices, international trade, consumption, employment, pollution emissions, income distribution, food security, and agriculture, among others. For Philippine agriculture, CGE models were employed to assess the trade policies and impacts of avian influenza outbreak (Rodriguez *et al*. 2007); impacts of Philippines-USA free trade agreement (Rodriguez and Cabanilla 2006); biofuel (Rodriguez and Cabanilla 2008); agricultural policies (Habito 1986; Clarete and Warr 1992); poverty (Cororaton and Corong 2006); and welfare (Coxhead and Warr 1992).

This research is the first to assess the economy-wide estimates of climate-induced impacts on Philippine agriculture. Specifically, it determined the extent of climate-induced impacts on the different Philippine agriculture subsectors, and assessed the total macroeconomic impact of climate-induced changes on agricultural productivity, fish consumption, and manufacturing output.

The next section discusses the Philippine agricultural sector in the context of climate change, appraises the sector's vulnerability to climatic risks, and estimates the possible economic impacts of climate change on Philippine agriculture. It is followed by a description of the CGE model, the simulation scenarios employed in this study, and the model results. The paper concludes with recommendations for climate change adaptation (CCA) strategies.

PHILIPPINE AGRICULTURE IN THE CONTEXT OF CLIMATE CHANGE

Climate change is a serious threat to the Philippine economy, especially to its agricultural sector. Since agricultural production relies heavily on the environment, increased uncertainties and risks from natural calamities and disasters greatly affect the production of agricultural goods.

Among the three main sectors of the Philippine economy, the agriculture, forestry and fisheries (AFF) sector ranks the lowest in terms of share to GDP. Over the last 17 years, the share of the agricultural sector in the country's GDP decreased relative to the contribution of the industry and service sectors (Figure 2.1). In 2009, AFF accounted for 18% of the Philippine economy, a 4% decline from its 1994 level (Figure 2.2).

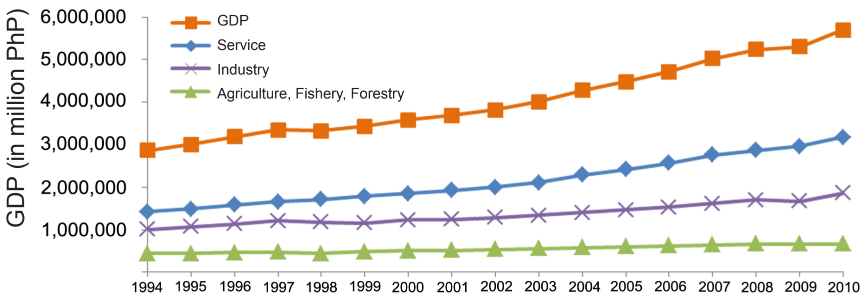

Figure 2.1. Philippines GDP and sectoral contributions to GDP (at constant 2000 prices), 1994-2010
Source: NSCB (2011)

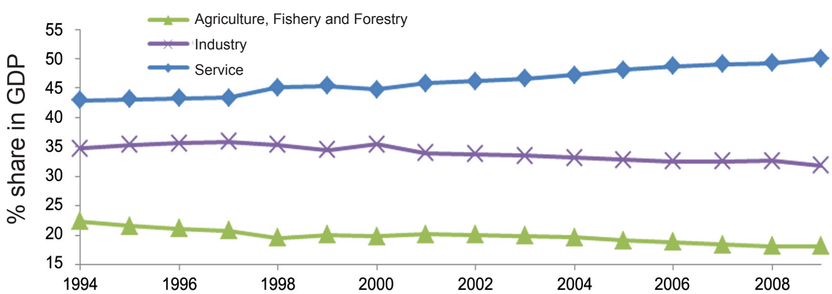

Figure 2.2. Shares of AFF, industry, and service sectors in Philippine GDP, 1994-2009
Source: NEDA (2011), NSCB (2011)

The decreasing share of agricultural output relative to its contribution to the country's GDP is manifested in the slow and declining annual growth rate of agricultural commodities production (Figure 2.3). From 1994 to 2009, the AFF sector posted an average annual growth rate of only 2.69%, partly due to damages caused by severe typhoons and natural disasters, along with other unfavorable weather conditions brought about by climate change. In 1998, agricultural output fell due to severe El Niño, resulting in a 6.8% contraction for the sector. The following year (1999), the sector recovered with a growth of 6.1%.

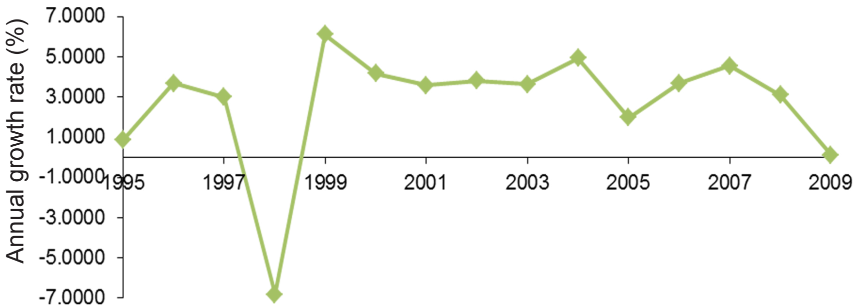

Figure 2.3. Annual growth rates of the AFF sector in terms of contribution to GDP, 1995-2009

Source: NEDA (2011), NSCB (2011)

Agricultural Crops Productivity

Crops

The crop subsector is the largest contributor to the Philippine agriculture sector in terms of volume and value. However, it is vulnerable to climate change threats because crop production is highly dependent on climate and weather conditions, particularly temperature, rainfall, solar radiation and CO_2 concentrations. Over the past 17 years, crop production in the Philippines has suffered repeated damages from natural disasters such as severe floods and droughts.

Among the various climate change threats, the increasing frequency and intensity of typhoons pose the greatest threat to Philippine agriculture (PCAARRD 2010). In the last decade, the average number of typhoons entering the Philippine Area of Responsibility (PAR) has increased substantially from 15 to 20. Strong winds and heavy rainfall from these typhoons have destroyed farms and plantations all over the country. Between 1994 and 2009, significant reductions in crop production were recorded in years when the country was hit by damaging typhoons (Figure 2.4). In 2009, crop production was reduced by damage to farms and irrigation facilities (NDCC 2009) from Tropical Storms Parma (PhP 27.29 billion) and Ketsana (PhP 11 billion), assigned as Typhoons Pepeng and Ondoy, respectively, when they entered the PAR (Figure 2.5). Moreover, yields of major crops (i.e., rice, corn, coconut, banana and sugarcane) mostly fell during El Niño and La Niña years (Rapera 2011). Nonetheless, despite its vulnerability to climate change impacts, the crop production subsector still managed to grow by 2.66% in 1994-2009.

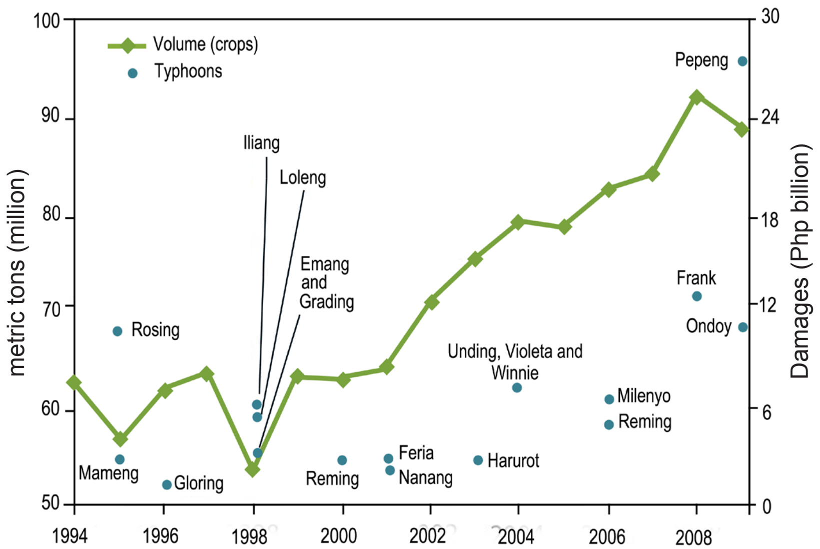

Figure 2.4. Volume of Philippine crop production and estimated damages brought about by typhoons, 1994-2009
Source: BAS (2011)

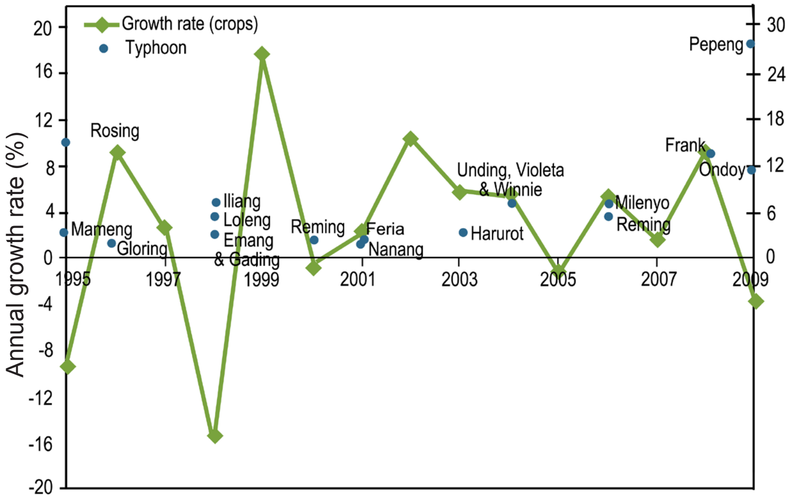

Figure 2.5. Annual growth rates of Philippine crops and estimated damages brought about by typhoons, 1995-2009
Source: BAS (2011)

From 1994 to 2009, land productivity in rice and corn areas showed an increasing trend (Figure 2.6). However, certain years were marked by sharp declines in crop production due to severe weather conditions (El Niño and La Niña). The El Niño phenomenon caused serious damages to rice and corn production in 1997-1998 and in 2009. According to De Guzman (2011), El Niño brought severe drought to about 70% of the country in 1998, completely damaging about 292,000 ha of rice and corn lands. Water shortages led to additional production losses of 622,106 mt of rice and 565,240 mt of corn, amounting to a total of PhP3 billion. In 2009, although the area harvested for rice expanded by 72,333 ha compared to 2008, yield dipped by 3.59 mt/ha due to severe drought and typhoons.

On the other hand, corn productivity has shown an upward trend because of corn farmers' adoption of hybrid corn technology and high yielding varieties (Catelo and Pabuayon 2011). According to Virola *et al*. (2008), La Niña events in 1996 and 1999 brought favorable rainfall conditions, which boosted rice and corn production.

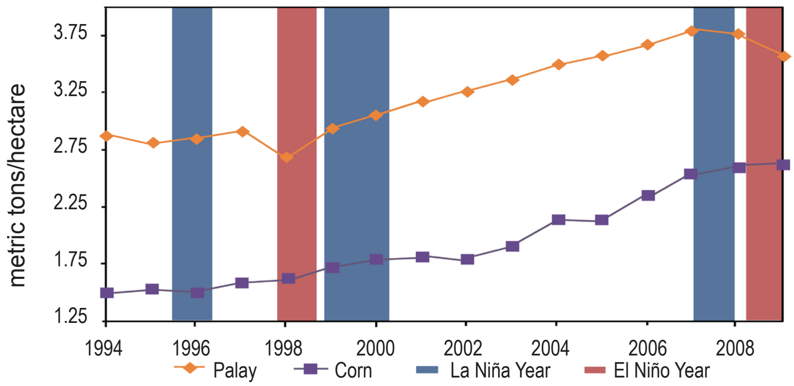

Figure 2.6. Rice and corn production in metric tons per hectare, 1994-2009
Source: BAS (2011)

Aside from rice and corn, coconut, banana and sugarcane are among the major crops produced in the Philippines. Coconut productivity grew slowly at 1.44% for the period of 1994-2009 (Figure 2.7). About 3.85% growth in banana was reported during the same period because of yield improvements and expansion of areas harvested (Rapera 2011). Sugarcane yields, however, showed an irregular trend and exhibited a negative growth (-0.29%) in the same period due to a combination of agronomical practices and climatic conditions. Sugarcane production fell during El Niño years (including 1997 and 2009).

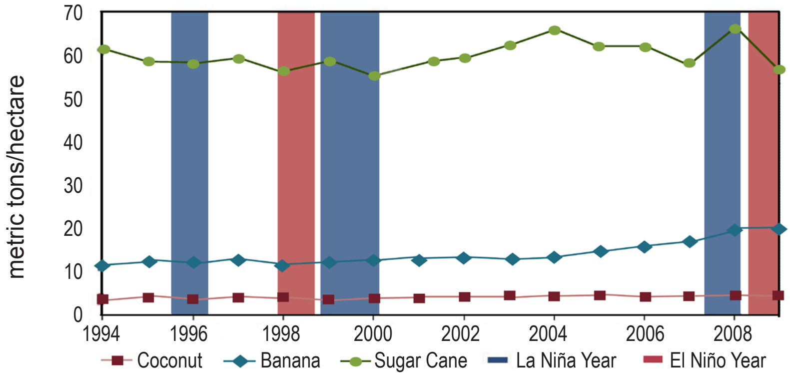

Figure 2.7. Sugarcane, banana and coconut production in metric tons per hectare, 1994-2009
Source: BAS (2011)

Livestock and poultry

The livestock and poultry subsector is one of the fastest growing agricultural subsectors, posting a production growth rate of 3.29%. In 2008, the livestock and poultry subsector contributed 26.47% to the country's total agricultural output (Figure 2.8). However, the subsector is now threatened by both direct and indirect[1] climate change impacts. Compared with crop production, the livestock and poultry subsector has shown an increasing trend in production output alongside a decrease in production growth rates from 1995 to 1998 and from 2002 to 2006. Livestock and poultry production growth rates decreased during the 1997/1998 El Niño year and after the 1999/2000 La Niña years, demonstrating the subsector's vulnerability to severe weather disturbances (Rapera 2011).

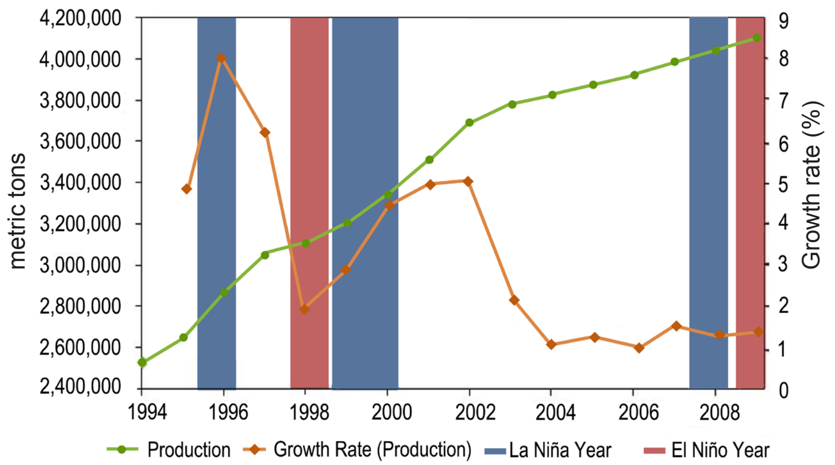

Figure 2.8. Volume of livestock and poultry production in metric tons, 1994-2009
Source: BAS (2011)

[1] *Direct climate change impacts include high environmental temperatures, excessive rainfall, flooding, and droughts. The indirect climate change impacts include low forage supply, high cost of feed grains, high cost of fossil fuel, and emergence of new diseases (PCARRD 2010).*

Fishery

Fishery production grew significantly at 4.28% from 1994 to 2009 (Figure 2.9). The effect of climate change on the production of fisheries is not as dramatic as that on crop production. During the same period, there were only two years (1996 and 1997) when fish production posted negative growth. During the severe 1997/1998 El Niño Southern Oscillation (ENSO) episode, elevated sea temperatures resulted in massive coral bleaching in various Philippine reefs. Severe red tide outbreaks also occurred after intense El Niño periods, adversely affecting fish production (Virola *et al*. 2008).

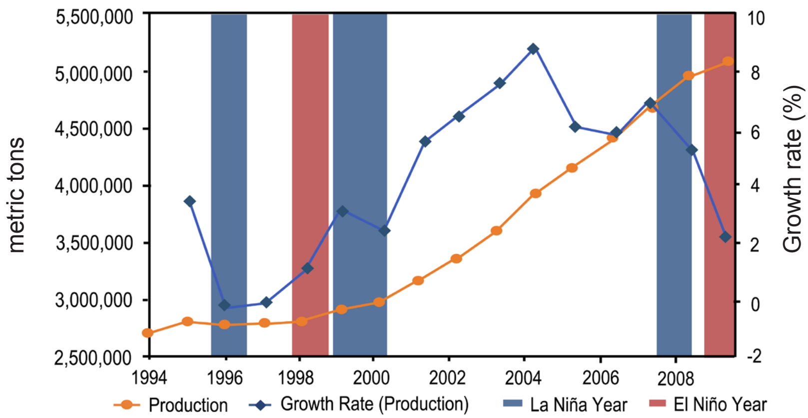

Figure 2.9. Volume of fisheries production in metric tons, 1994-2009
Source: BAS (2011)

Trends in Agricultural Employment

Although the AFF sector accounts for the lowest share to the Philippine economy, according to the 2008 Labor Force Survey, it employs about 35% of the country's 33.7 million labor force (Figure 2.10). Hence, a large part of the population relies heavily on agriculture for employment and income, particularly in rural areas. Since about three-fourths of the country's poor live in rural areas, agriculture is considered a key element in Philippine economic development and poverty reduction. AFF workers and their dependents are most likely to suffer losses due to extreme climatic events, which result in soil degradation, flooding, drought, and high temperatures.

Employment in the agriculture sector grew slowly at a rate of 0.58% compared to total employment (2.32%) from 1994 to 2009. Furthermore, the share of agriculture to total employment declined from 45% in 1994 to 34% in 2009. The decline in agricultural employment began in 1997, during the Asian financial crisis (Catelo and Pabuayon 2011).

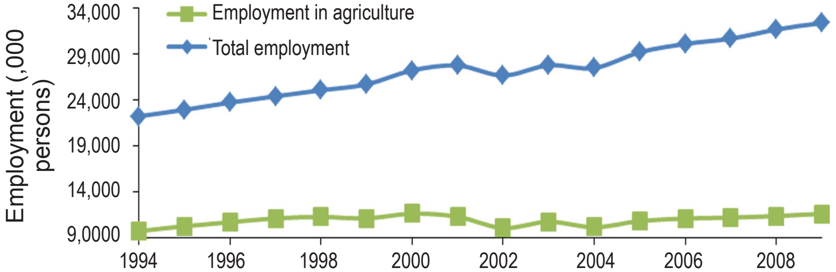

Figure 2.10. Total employment and agricultural employment, Philippines, 1994-2009
Source: BAS (2011)

Climate Change and Vulnerability of Philippine Agriculture to Climatic Risks

Combined risks from climatic disasters

Its location in the tropics makes the Philippines highly prone to risks[2] brought by natural and environmental disasters. Figure 2.11 shows a map of the combined risks from climate disasters in the country; this map represents the sum of the normalized and provincial risks to typhoons (super typhoons, typhoons, tropical storms and tropical depressions), drought due to El Niño, projected rainfall change, and projected temperature increase.

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[2] *SEARCA (2005) defined "risk" as the likelihood of disaster, loss or harm to occur in a certain area.*

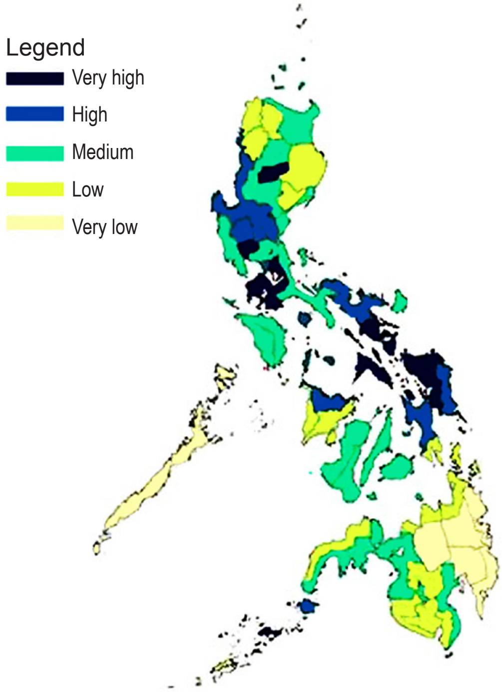

Figure 2.11. Map of the combined risk to climate disaster, Philippines
Source: Manila Observatory (2011)

Rincón and Virtucio (2008) reported that Albay, Pampanga, Ifugao, Sorsogon, Biliran, Rizal, Northern Samar, Cavite, Masbate, and Laguna are the ten provinces most prone to climatic disasters. In general, the Central Luzon and Bicol regions rank *high* to *very high* on the risk scale, indicating that these provinces are more prone to the risk of typhoons and projected change in rainfall (Rincón and Virtucio 2008). Furthermore, regions that ranked *very high* on the combined risk to climate disasters map are primarily agricultural areas and plantations. Thus, climate disasters threaten both the safety and livelihood of these regions' residents.

There was little difference between provinces' risk scores from El Niño and projected temperature increase, as compared to their risk levels from typhoons and rainfall change. This implies that El Niño and projected temperature increase will affect most regions in the country.

Vulnerability ranking of Philippine provinces

Recent and major climatic events and their impacts highlight the importance of identifying the vulnerability[3] levels of certain areas and segments of the Philippine population to collective hazards, which result in disasters. Yusuf and Francisco (2010) reported that Metro Manila (NCR), Benguet, Batanes, Ilocos Sur, Rizal, Bataan, Batangas, Bulacan, Abra and Albay are the ten Philippine provinces that are most vulnerable[4] to the impacts of climate change.

Rincón and Virtucio (2008) said that the country's vulnerability to natural hazards is closely linked to poverty and environmental degradation. Natural hazards worsen environment degradation and cause severe damages, especially in rural areas where agriculture is the main source of livelihood. ADB (2009) reported that the Philippines is particularly vulnerable because millions of people are concentrated along coastlines, which are exposed to rising sea levels. The future impacts of climate change, therefore, could hinder the country's development and ability to eradicate poverty.

Long term change in air temperature and rainfall

Rainfall and temperature are the two main contributing factors affecting agricultural production in the country. Increasing temperatures due to climate change result in: a) decreased crop yield due to heat stress; b) increased livestock deaths due to heat stress; and c) increased outbreak of insect pests and diseases. Rainfall variability (including the El Niño Southern Oscillation) results in: a) increased frequency of drought, floods, and tropical cyclones (associated with strong winds), causing damage to crops; b) changes in precipitation patterns affecting

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[3] "Vulnerability" is defined as the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes (IPCC 2001).

[4] The study's climate change vulnerability mapping followed the UN Intergovernmental Panel on Climate Change (IPCC) Framework, which assessed the country's exposure to climatic hazards; its sensitivity based on population density and number of protected areas; and its adaptive capacity based on socio-economics, current technology and existing infrastructure.

current cropping pattern, crop growing season, and sowing period; and c) increased runoff and soil erosion resulting in declining soil fertility and crop yields. Since these climate change effects and impacts are location-specific, vulnerability to climate change is commodity-specific and time-dependent.

The average annual temperature in the Philippines is about 27°C and ranges from 26.5°C to 28°C. Higher temperatures are observed during El Niño years, while lower temperatures are observed during La Niña years (Greenpeace 2005). Figure 2.12 shows that the country's temperature has generally increased during the last 36 years.

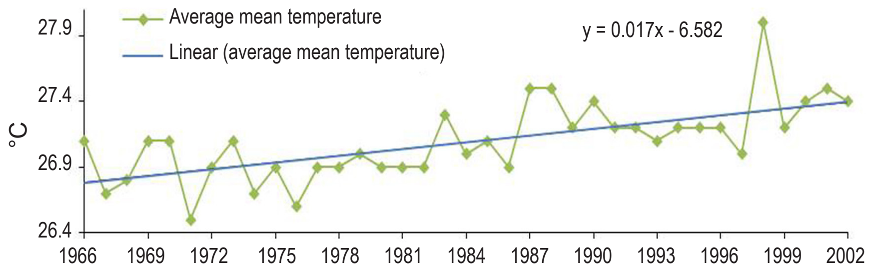

Figure 2.12. Average annual temperature, Philippines, 1966-2003
Source: NSCB (2004)

The Intergovernmental Panel on Climate Change (IPCC 2007, p. 475) reported that since 1971, average temperatures in the Philippines have increased by 0.14ºC per decade. This has led to increased annual mean rainfall (since the 1980s), increased number of rainy days (since the 1990s), and increased inter-annual variability of rainfall onset. This situation is most likely to continue since the Philippine Initial National Communication on Climate Change (PINCCC) (Republic of the Philippines 1999) has predicted an average increase of 2°C to 3°C in annual temperatures.

Meanwhile, Hulme and Sheard (1999) have projected a temperature increase of 1.2°C to 3.9ºC in the Philippines by 2080, using all the IPCC emission scenarios, while the World Bank (2010) has projected an annual temperature change from 1.4°C to 1.8°C in 2045-2065. Stern (2007) estimated that a 1°C to 2°C temperature change relative to the 1990 level may increase potential crop yields in selected Southeast Asian countries. However, a 2°C to 3°C increase in temperature in the region may result in the loss of agricultural lands due to sea level rise, while a temperature increase of 3°C to 5°C could decrease crop yields and further delay cropping schedules.

The mean annual rainfall in the Philippines is about 2,403 mm and ranges from 1,834 mm to 3,201 mm (NSCB 2004) (Figure 2.13). The rainy season usually starts in May and ends in November, with August being the month with the heaviest recorded rainfall. Meanwhile, the dry season starts in December and usually ends in April, with February being the driest month (World Weather and Climate Information 2012). The PINCCC (Republic of the Philippines 1999) predicted a 60% to 100% increase in annual rainfall in certain areas, such as Central Visayas and Southern Tagalog, but a decrease in annual rainfall for Northern and Northeastern Mindanao[5] if atmospheric CO_2 levels are doubled. Rainfall is often concentrated in upstream areas of watersheds.

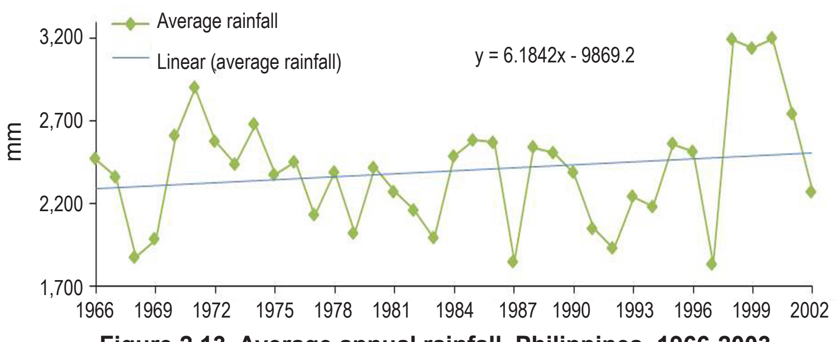

Figure 2.13. Average annual rainfall, Philippines, 1966-2003
Source: NSCB (2004)

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[5] Central Visayas includes the provinces of Cebu, Bohol, Negros Oriental and Siquijor; Southern Tagalog includes the provinces of Batangas, Cavite, Laguna, Quezon and Rizal; Northern Mindanao includes the provinces of Bukidnon, Camiguin, Lanao del Norte, Misamis Oriental and Misamis Occidental; and Eastern Mindanao includes the provinces of Agusan del Norte, Agusan del Sur, Surigao del Norte, Surigao del Sur, and Dinagat Islands.

Extreme climatic events

Amadore (2005) reported that extreme climatic events such as floods, droughts, forest fires and typhoons have increased in Asia. ADB (2009) reported that the number of floods and storms had risen dramatically from just below 20 during 1960-1969 to nearly 120 by 2000-2008.

Although the impacts of El Niño and La Niña were great[6], the effects of strong typhoons that visit the country far outweigh them. Over the past 15 years, the Philippines was hit by the strongest typhoon ever recorded, the most destructive typhoon, the deadliest storm, and the typhoon that registered the highest recorded 24-hour rainfall (ADB 2009). These extreme typhoons brought heavy rains, causing landslides and flash floods, which claimed thousands of lives, destroyed billions of pesos worth of properties, and damaged the environment (Amadore 2005). Figure 2.14 shows that majority of Philippine disasters from 1905 to 2006 are related to weather events, typhoons and floods.

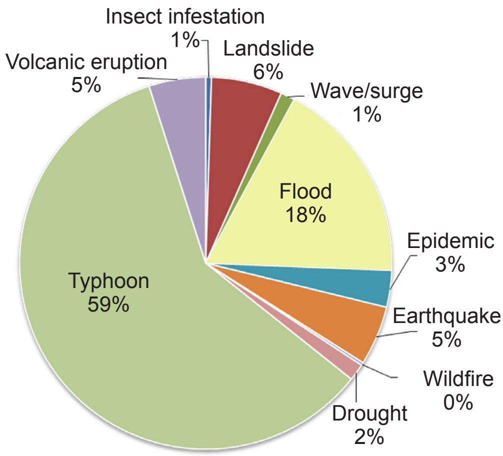

Figure 2.14. Disasters in the Philippines, 1905-2006
Source: ADB (2009)

[6] The damage resulting from the 1990-2003 ENSO-related droughts was estimated to be more than USD 370 million (Lasco et al. 2008).

Climate Change Impacts on Selected Philippine Agricultural Crops, Livestock and Fishery

Impacts on crops

There are varying estimates of yield reduction and production losses of selected Philippine agricultural crops[7] due to damages from the onslaught of climate-induced events, such as typhoons, floods, drought/El Niño, La Niña, and pests and diseases. In general, estimates point to the fact that overall impacts of climate change on crop production would be great and possibly permanent.

A temperature increase of 1°C is expected to reduce yields of major grain crops by 5% to 7% because of heat stress, decreased sink formation, shortened growing period, and increased maintenance for respiration (PCAARRD 2010). In particular, rice yields are expected to fall due to higher temperatures, with each 1°C rise in temperature expected to result in a 10% decline in rice yields (Peng *et al*. 2004). Crop modeling studies also predict that temperature increases of 2°C and 4°C would reduce rice yields by 22% and 75%, respectively (Escaño and Buendia 1994; ADB 2009). SEARCA (2005) estimated that yield reduction coefficients[8] would range from 10% to 90% due to typhoon, flood, drought and pest and diseases for selected Philippine agricultural commodities (Table 2.1). Moreover, Centeno (1995) projected a 14% decline in rice yield due to higher temperatures and CO_2 concentration. PCAARRD (2010) highlighted that exposing rice plants to temperatures above 35°C can increase spikelet sterility, leading to crop failure; while Sanchez (2002) reported that rice pollination would not occur at a high temperature of 40°C.

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[7] These crops were selected because they are the commodities with reported estimates of yield reduction due to climate change. Other commodities were not included in this paper due to unavailability of literature citing estimates of yield reduction due to climate change as of January 2012.

[8] Reduction coefficient (RC) is defined as: RC = (1-RT)(1-RF)*(1-RD)*(1-RP&D), where RT, RF, RD and RP&D are reduction coefficients for typhoon, flood, drought, and pests and diseases, respectively. RC is synonymous to the measure of risk due to climate-induced events. Yield loss = Potential yield * Reduction Coefficient*

Table 2.1. Reported yield reduction (%) and yield reduction coefficients (%) of selected agricultural crops in the Philippines

Commodity	Yield reduction (%)	Yield reduction coefficient (%)[a]			
		Typhoon	Flood	Drought	Pest & diseases
Rice	10% - 1°C[b] ↑ 15-27% - 2°C[c] ↑ 75% - 4°C[d] ↑	10	30-80	15	10
Corn	12-19%[e]	80-100	85	90	25-90
Banana			85	90	1-30
Cotton			85	90	20-99
Sugarcane			85	90	5-80
Tomato			85	90	10-70
Coffee			85	90	5-60

Source: [a]SEARCA (2005), [b]Peng *et al.* (2004), [c]Escaño and Buendia (1994), [d]ADB (2009), [e]Republic of the Philippines (1999)

On the other hand, there is a possibility that higher CO_2 levels could boost rice yields. The Canadian Climate Center Model (CCCM) scenarios estimated that doubling CO_2 concentrations would result in 3.15% and 5.38% yield increase in different rice varieties (Republic of the Philippines 1999). However, the positive effects of increased CO_2 on rice productivity can be negated by water shortages, heat stress, and increased pest incidence (Jaranilla-Sanchez *et al*. 2007). Typhoon/flood damages in rice fields are estimated to result in losses of about 2.6% to 62.54%; losses due to droughts are estimated at 1.5% while losses due to pests and diseases are seen at about 10% (Rincón and Virtucio 2008; SEARCA 2005) (Table 2.2).

Delos Santos *et al*. (2007) stressed the impacts of extreme climatic events on corn production in the Philippines. Based on reports from farmers, up to 70% of corn crops can be damaged by typhoons while flooding can wipe out entire corn farms (Table 2.2). Meanwhile, drought and La Niña episodes can result in yield losses of 50% to 70%, and 16%, respectively. On the other hand, Global Circulation Models (GCMs) predicted that corn yields would decline by 12.64% for the first crop of PS 3228 variety and 19% for the first crop of sweet corn (Republic of the Philippines 1999).

Table 2.2. Production losses (%) of selected agricultural crops in the Philippines

Commodity	Losses (% damages)			
	Typhoon/ Flood	Drought/El Niño	La Niña	Pest & diseases
Rice	2.60[a], 62.54[b]	1.50[a]		10.00[b]
Corn	70.00[c], 75.00[b]	27.00-70.00[c], 87.00[b]	16.00[c]	65.79[b]
Banana	5.50[b]	4.38[b]		9.42[b]
Cotton	76.67[b]	87.00[b]		72.73[b]
Sugarcane	18.33[b]	47.50[b]		30.00[b]
Tomato	43.88[b]	32.50[b]		27.03[b]
Coffee	44.23[b]	43.57[b]		25.67[b]

Source: [a]Rincon and Virtucio (2008), [b]SEARCA (2005), [c]Delos Santos *et al*. (2007)

Jaranilla-Sanchez *et al*. (2007) noted that increasing surface temperatures in the province of Albay led to increased incidence of pests and diseases in rice (Black rice bug), corn (Waya-waya) and abaca (Abaca bunchy top). Moreover, IPCC (2001) reported that climatic variability is expected to reduce crop yields and affect cropping schedules. These climate change impacts are also common in other Southeast Asian countries. For instance, the World Bank (2010) estimated that Vietnamese crop yields are expected to decrease by 2050. In particular, Northwest Vietnam rice yields are expected to decline by 11.1% to 28.2%, while yields of other crops are projected to shrink by 5.9% to 23.5% (World Bank 2010).

Impacts on livestock and poultry

Several studies have also emphasized climate change impacts on livestock and poultry. Most of the studies highlighted the effects of heat stress and heat exposure to productivity and efficiency of livestock and poultry animals, though production losses were reported for swine only.

The country's swine production losses due to typhoon/flood, drought/El Niño, and pests and diseases range from 8.0% to 23.8% (SEARCA 2005) (Table 2.3). Vega *et al*. (2002) reported that prolonged heat stress during the hot months of the year causes farrowing intervals and worsens non-productive days, a condition known as third quarter swine reproductive syndrome. Wettemen *et al*. (1979) also reported that exposing boars to temperatures of 32°C to 34°C for three days lowered sperm motility and increased the number of morphologically abnormal sperm cells. As temperatures rose from 15°C to 35°C, feed intake and weight gain of finishing pigs were reported to decline by almost 50% (Myers and Bucklin 2001).

Table 2.3. Production losses (%) of swine in the Philippines

Commodity	Losses (% damages)		
	Typhoon/Flood	Drought/El Niño	Pest & diseases
Swine	9.5	10.0-23.8	8.0-19.8

Source: SEARCA (2005)

For ruminants, persistent rainfall, floods and typhoons are believed to shorten grazing period, while droughts lengthen grazing activity and reduce heat-stressed animals' water supply for drinking and bathing (Jaranilla-Sanchez *et al*. 2007). On the other hand, exposing dairy cattle to severe heat stress leads to noticeably lower milk production and reproduction (Chase 2012). In Argentina, Valtorta (2002) reported a 10% to 14% decrease in milk production of dairy animals due to prolonged heat stress. This may be true for the Philippines as well. Jaranilla-Sanchez *et al*. (2007) reported that blue-tongue disease, which is known to affect livestock animals, is projected to spread in tropical areas. For broilers, heat stress can lead to decreased average feed consumption and total live weight (PCAARRD 2010).

Impacts on fishery

The Philippines is one of the largest fish producers in the world, ranking tenth in terms of marine and inland capture fisheries in 2006 (FAO 2009). However, fish production is now being threatened by the impacts of climate change. Despite this, only a few local studies have focused on the direct effects of climate change on fisheries. SEARCA (2005) reported that production losses in Philippine fisheries due to extreme climatic events range from 40% to 88% (Table 2.4). Furthermore, continuous typhoons and flooding can seriously damage aquaculture structures.

Table 2.4. Production losses (%) of selected fisheries, Philippines

Commodity	Losses (% damages)			
	Typhoon/ Flood	Drought/ El Niño	La Niña	Pest & diseases
Bangus (Milkfish)	88.0			
Tilapia	84.4			
Lapu-Lapu (Grouper)	72.8	40	40	65
Seaweeds	71.8	60		70

Source: SEARCA (2005)

However, Rapera (2011) raised the possibility that rising sea levels would create wider areas for brackish aquaculture. Using climate change models, Sarmiento *et al*. (2004) predicted that there would be a 0.7% to 8.1% increase in global primary production in the ocean.

Results of more recent studies disagree with this projection. For instance, MRAG (2010) reported a potential decrease in fisheries production due to several physical stressors brought about by climate change such as changes in sea surface temperature, ocean acidification and sea level rise. Cheung *et al*. (2010) predicted that catch potential in the tropical Pacific would decrease by up to 42% from 2005 levels. FAO (2012) also noted that aquatic animals are vulnerable to climate change, since changes in their body temperatures affect metabolism, growth, and susceptibility to diseases and toxins. In 2011, Rosario del Mundo of the Bureau of Fisheries and Aquatic Resources (BFAR) in Batangas province told the Philippine Daily Inquirer, a national newspaper, that the massive Taal Lake fishkill incident was the worst climate change disaster to hit the province.

METHODS

Overview of the Model

The analysis employed the AGRIK model, which was based on the ORANI-G, a generic single-country CGE model using Philippine input-output (IO) data. The ORANI was designed for comparative-static simulations. It is an applied general equilibrium (AGE) model of the Australian economy that is widely used and adapted by economists and academicians in the government and private sectors for practical policy analysis, e.g., study of macroeconomic and sectoral shocks addressing competition and trade policies (Horridge 2003). ORANI-G has been adapted to build models of South Africa, Pakistan, Sri Lanka, Fiji, South Korea, Denmark, Vietnam, Thailand, Indonesia, Philippines, and China. In particular, the Philippine's TARFCOM model is an adapted CGE model of ORANI-G with Philippines data (Rodriguez and Cabalu 2005).

The ORANI-G-based model was used in this study's general equilibrium modeling because of several advantages. First, the model allows for direct implementation of production and consumption shocks in the analysis. Second, it contains equations that explicitly link agriculture, manufacturing, and trade sectors to other industries in the economy. Finally, the model computes macroeconomic variables (e.g., GNP, imports and exports, among others) that allow for an overall assessment of the impacts.

In particular, the theoretical structure of ORANI-G consists of equations describing producers' demands for produced inputs and primary factors, producers' supplies of commodities, demands for inputs to capital formation, household demands, export demands, government demands, the relationship of basic values to production costs and to purchasers' prices, market-clearing conditions for commodities and primary factors, and numerous macroeconomic variables and price indices. Horridge (2003) presented a detailed guide of the ORANI-G model, its structure, assumptions and drawback, key relationships, and closures, among others.

The AGRIK model includes 25 industries and 25 commodities, 15 of which are agricultural. Moreover, the model identifies two sources (domestic and imported) and two occupation types (skilled and unskilled). Producers were assumed to be price takers operating in competitive markets for both their outputs and inputs. Furthermore, the model used the assumptions of constant returns to scale and marginal cost pricing to eliminate quantity variables from the industry zero pure profits condition.

Each industry produces a mixture of all the commodities using domestic inputs and imported commodities, labor types, land and capital. This mixture varies according to the relative prices of commodities. In addition, export commodities were distinguished from those for domestic use. There is no substitution between produced inputs, primary factors and other inputs or between inputs of different commodity categories. However, there is substitution between aggregate labor, capital and agricultural land, and between alternative sources (i.e., domestically produced goods and imports) of produced inputs of a given commodity category.

The 25 industries are also the investors themselves. Capital was assumed to be produced with domestically produced inputs and imported commodities. No primary factors were used directly as inputs to capital formation. Furthermore, the model includes market-clearing equations for locally-consumed commodities, both domestic and imported.

The Database of the AGRIK Model

The data used in the AGRIK model was based on the 2004 Philippine IO table from the Global Trade Assistance and Protection (GTAP) database (version 7), which has 57 GTAP commodities (Corong 2008). The 2004 Philippine IO was an updated 2000 IO table of the country with 240 commodities. The IO table contains data on payments made by various agents on the commodities and factor services provided by the other agents. The 2004 IO table from GTAP database has 57x57 sectors, which were aggregated into 25x25 sectors in the AGRIK model, following the commodity definition of the 2000 Philippine IO. Other data used in the model were obtained from the National Statistics Coordination Board (NCSB), the Bureau of Agricultural Statistics (BAS), and the UN Food and Agriculture Organization (FAO) Statistical Database.

Figure 2.15 shows the structure of the information contained in the IO table. Demanders identified in the column headings (i.e., the absorption matrix) include:

- domestic producers divided into *I* industries;
- investors divided into *I* industries;
- a single representative household;
- an aggregate foreign purchaser of exports;
- government demands; and
- changes in inventory.

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
	Size	←I→	←I→	←1→	←1→	←1→	←1→
Basic Flows	↑ CxS ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	↑ CxSxM ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	↑ CxS ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Production Tax	↑ 1 ↓	V1PTX					
Other Costs	↑ 1 ↓	V1OCT					

C = number of commodities
I = number of industries
S = 2: domestic, imported
O = number of occupation types
M = number of commodities used as margins

Size	Joint Production Matrix
	←I→
↑ C ↓	MAKE

Size	Import Duty
	←1→
↑ C ↓	V0TAR

Figure 2.15. The database

V1BAS(c, s, i) and *V2BAS(c, s, i)* represent the flow of commodity *c* in basic value, from source *s* to industry *i*, for intermediate use and investment, respectively. *V3BAS(c, s)* and *V5BAS(c, s)* represent the flow of commodity *c* in basic value from source *s* for household consumption and government consumption, respectively. *V4BAS(c)* represents the flow of export commodity *c* in basic value. *V6BAS(c, s)* represents the inventories basic flow of commodity *c* in basic value from source *s*.

V1MAR(c, s, m), V2MAR(c, s, m), V3MAR(c, s, m), V4MAR(c, s, m), and *V5MAR(c, s, m)* are the values of margin type *m* used to deliver commodity type *c* from sources *s* to/for producers (user 1), investors (user 2), households (user 3), exports (user 4), and government (user 5), respectively.

V1TAX(c, s, i) and *V2TAX(c, s)* represent the sales tax imposed on commodity *c* from source *s* for intermediate use and for investment use, respectively, by industry *i*. *V3TAX(c, s)* and *V5TAX(c, s)* represent the sales tax imposed on commodity *c* from source *s* for households consumption and for government consumption, respectively. *V4TAX(c)* represents the sales tax imposed on export commodity *c*.

V1LAB(i, o) represents the wage bill by industry *i* by occupation. *V1CAP(i)* represents the capital rentals by industry *i*. *V1LND(i)* represents the land rentals by industry *i*. *V1PTX* is an ad valorem production tax while *V1OCT(i)* represents the other costs incurred by industry *i*. The MAKE*(c, i)* represents the make matrix at the bottom of Figure 2.15 by commodity *c*, by industry *i*, i.e., the value of output of each commodity by each industry. *V0TAR(c)* represents the tariff revenue by commodity *c*.

Updating the 2004 Philippine Input-Output Table

The 2004 Philippine IO above may not be appropriate for policy analysis because it no longer reflects the present structure of the Philippine economy, which went through significant structural changes from 2004 to 2009. Table 2.5 shows the percentage changes in real aggregates from 2004 to 2009 from the demand and supply sides of the economy. The expenditure side includes household and government final consumption expenditures, capital formation, exports and imports; the supply side includes employment and population (or number of households). Gross value added of each major industry was used for the industry output (Table 2.6). Table 2.7 shows the employment by major industry groups in 2004 and 2009 and the corresponding percent change. Since the employment data is more aggregated for the agriculture sector, it is assumed that the changes in productivity within this sector are the same. Therefore, following Buetre and Ahmadi-Esfahani (2000), the Philippine IO table was updated from 2004 to 2009.

Table 2.5. The Philippines macroeconomic data for historical simulations

Variable	2004	2009	% Change
Household final consumption expenditure	903,814	1,152,6580	27.53
Government final consumption expenditure	75,455	101,163	34.07
Capital formation	234,065	243,052	3.84
Exports	539,950	574,284	6.36
Imports	628,911	621,543	(1.17)
Employment (1,000 persons)	31,613	35,061	10.91
Population	76,946,500	92,226,600	19.86
Gross national expenditure	1,252,331	1,654,936	32.15
CPI (1994 = 100)	121	160	32.67

Source: Philippine Statistical Yearbook (2004), Philippine Statistical Yearbook (2010)
Note: Expenditures are in million pesos, constant 1985 prices.

Table 2.6. Gross value added by industry group in the Philippines, 2004 and 2009

	Sectors	Simulations		
		1	2	3
1	Rice	38,767	43,500	12
2	Corn	12,900	16,762	30
3	Vegetables and oilseeds	26,034	27,605	6
4	Fruits and nuts	24,633	26,120	6
5	Sugarcane	6,160	5,812	(6)
6	Abaca	950	1,008	6
7	Cotton and other fiber crops	308	326	6
8	Banana	5,132	8,214	60
9	Other crops	9,144	9,696	6
10	Livestock	27,100	29,128	7
11	Other livestock products	25,085	26,727	7
12	Forestry	1,325	1,322	(0)
13	Ocean fishing	18,590	24,038	29
14	Fresh coast fishing	13,217	17,090	29
15	Aquaculture	17,072	22,074	29
16	Mining and quarrying	14,097	22,120	57
17	Manufacturing	278,624	314,398	13
18	Electricity, gas and water	36,752	44,544	21
19	Construction	48,718	71,908	48
20	Trade	192,691	239,119	24
21	Transportation, communication and storage	97,605	126,530	30
22	Finance	56,919	88,305	55
23	Private services	93,352	129,860	39
24	Government services	51,237	61,926	21
25	Dwellings	53,654	66,746	24
	Total	1,150,064	1,424,878	

Source: NSCB (2011)
Note: (1) In million pesos; at constant 1985 prices.

Table 2.7. Employment by major industry group in the Philippines, 2004 and 2009 (in 1,000 persons)

Major industry group	2004	2009	% Change
Agriculture, hunting and forestry	10,013	10,582	6
Fishing	1,368	1,461	7
Mining and quarrying	118	166	41
Manufacturing	3,061	2,894	(5)
Electricity, gas, water	120	142	18
Construction	1,700	1,891	11
Wholesale and retail, repair of motor vehicles, motorcycles and personal household goods	5,872	6,736	15
Hotel and restaurants	806	1,010	25
Transport, storage and communication	2,427	2,679	10
Financial intermediation	328	369	13
Real estate, renting and business activities	690	1,064	54
Public administration and defense, compulsory social security	1,491	1,749	17
Education	938	1,138	21
Health and social work	361	421	17
Other community, social and personal service activities	835	877	5
Private household with employed persons	1,487	1,880	26
Extraterritorial organizations and bodies	2	2	-
Total	31,613	35,061	

Source: NSCB (2010)

The procedure outlined in Buetre and Ahmadi-Esfahani (2000) in updating the database followed the simulation technique based on Dixon and McDonald (1993), which employed the CGE model. This macroeconomic historical simulation requires the following variables to be included in the database[9]: real household consumption *(x3tot),* aggregate real

[9] These variables are estimated from the respective changes in the expenditures on commodities in each of the five categories in the final demand. Hence, they are usually treated as endogenous in the model.

investment expenditure *(x2tot_i)*, export volume index *(x4tot)*, import volume index *(x0cif_c),* and aggregate real government demands *(x5tot)* from 2004 to 2009, as shown in Table 2.5. This inclusion requires the adoption of new closure[10]. In this regard, the following macroeconomic variables were endogenized:

- *a1primgen* - a general technological change or total factor productivity
- *ff_accum* - a general shifter for aggregate investment
- *twist_src_bar* - a general twister for import
- *f4q_general* - a general shifter for exports
- *f5tot2* - a general shifter for aggregate 'other' demand.

Moreover, the following shocks were introduced:

- employment *(employ_i)* = 10.91. This is the percentage change in aggregate employment in the Philippines during the period.
- number of households *(q)* = 19.86. This allowed for the changes in consumption to be measured in terms of per household basis.
- consumer price index = 32.67. This allowed the actual change in aggregate consumer price to be imposed exogenously, leading to an updated database expressed in 2009 values.

Simulation Scenarios

Five model simulations were implemented in the analysis (Table 2.8). In the first simulation, production shocks were simultaneously employed for rice (-18%), corn (-16%), sugarcane (-32%), banana (-6%), and other crops (-2%)[11]. The second simulation applied a 10% increase for fish consumption to capture the increase in per capita consumption[12] and the induced effect of increasing population. The third simulation

[10] A closure must be satisfied wherein the number of endogenous variables must equal the number of equations so that the CGE model will run and the equation system can be solved using GEMPACK.

[11] These assumptions are based on previous studies that provided such estimates, as presented in Tables 2.1 and 2.2.

[12] The per capita consumption of fish (milkfish or bangus) for the representative Filipinos has increased from 2.860 kg/year (1999-2009) to 4.21 kg/year (2008-2009), a 47% increase (BAS 2011).

simultaneously applied the production and consumption shocks employed in simulations 1 and 2 to serve as a benchmark in evaluating policy initiatives such as imports of selected agricultural commodities. In the fourth simulation, a 10% reduction in both construction and manufacturing was employed in order to analyze the induced impact of climate change on construction and manufacturing. Finally, the fifth simulation simultaneously applied the production shocks, consumption shocks, and construction and manufacturing sector shocks.

Table 2.8. Simulation scenarios

Simulation	Description
SIM1	*Production shocks:* Reduction in production of selected agricultural commodities: a) Rice – 18% c) Sugarcane – 32% e) Other crops – 2% b) Corn – 16% d) Banana – 6%
SIM2	*Consumption shock:* 10% increase in fish consumption
SIM3	*Production and consumption shocks (SIM1 and SIM2)*
SIM4	*Related-sector shock:* 10% reduction in construction and manufacturing sectors
SIM5	*Combination of SIM1, SIM2, and SIM4*

Since the AGRIK model discussed above has more variables than equations, closure rules were imposed so that the number of equations is equal to the number of endogenous variables. In solving the CGE model, both the short-run or long-run closure rules can be employed. In the short-run closure, capital stocks are held fixed, implying that these are not easily affected by short-run shocks. Likewise, real wages are held fixed in the short-run closure, accompanied by an endogenous level of aggregate employment. This assumes that firms do not substitute between different types of labor. A short-run closure rule assumes that a) unemployed resources exist and b) there will be a short period of time (1-3 years) needed for economic variables to adjust to new equilibrium (Horridge 2003).

On the other hand, the long-run closure rule allows the real wage rate to adjust to an exogenously determined level of aggregate employment.

This long-run scenario assumes that the economy is operating with full employment.

The most appropriate assumption, based on the given needs or timescale of the proposed simulations above, is the use of short-run closure. Hence, all the results below were treated as representatives of the short-run influence of climate-induced impacts on Philippine agriculture and economy.

Short-run closure was adapted in the implementation of the AGRIK model. The macro variables are swapped as follows:

- disconnecting government from household consumption by treating *x5tot* as exogenous variable instead of *f5tot2*;
- household consumption *x3tot* as exogenous variable rather than *w3lux*;
- inventory changes *delx6* as exogenous variable rather than *fx6*; and
- average real wage as exogenous variable rather than the overall wage shift, *f1lab_io*.

The AGRIK model was implemented using the General Equilibrium Modelling PACKage (GEMPACK) system. GEMPACK is a flexible system for solving CGE models and facilitates the automation process of translating the model specification into a model solution program.

SIMULATION RESULTS

Simulation results show that climate-induced impacts would likely reduce aggregate output of Philippine agricultural crops (Table 2.9). This can be seen from the 1.83% projected decline in real GDP accompanying the production shock (SIM1). On the other hand, results of fish consumption shock (SIM2) predict a 0.36% increase in real GDP.

The results from the combination of production and consumption shocks (SIM3) indicate a possible 1.63% reduction in aggregate output. This result suggests that the production shocks would more likely have a stronger impact on aggregate output than the consumption shock. Together with construction and manufacturing shocks (SIM4), these combined shocks (SIM5) would cause a 3.86% decline in real GDP.

Table 2.9. Simulation results in percent deviation from the base

Macro-impact	Code	Simulations				
		1	2	3	4	5
Real GDP at factor cost	x0gdpexp	-1.83	0.36	-1.63	-3.34	-3.86
Consumer's price index	p3tot	0.15	-1.22	-1.00	0.79	-0.12
Export (quantity)	x4tot	-6.54	1.20	-5.72	-21.17	-23.52
Import (quantity)	x0cif_c	-1.93	0.16	-1.89	-0.28	-1.14
Employment	employ_i	-4.91	0.96	-4.36	-8.64	-9.96
Average return to land	p1lnd_i	73.26	-2.07	75.27	-20.01	10.98

Note: AFF - agriculture, fishery and forestry (total of 15 sectors in the AGRIK model)

The production shock (SIM1) would raise the general price level (as measured by consumer price index) by 0.15%, while the consumption shock (SIM2) would reduce aggregate prices by 1.22%. The net effect of combining production and consumption shocks (SIM3) would lower aggregate prices by 1%. Moreover, the construction and manufacturing shocks (SIM4) would increase aggregate prices by 0.79%. These production, construction and manufacturing shocks would effectively cause a leftward shift in the supply curve in the commodities of these sectors, *ceteris paribus,* a trend that tends to raise prices and reduce output. However, combining the production, consumption, construction and manufacturing shocks (SIM5) would result in a 0.12% decline in aggregate prices (Table 2.9).

Detailed disaggregation of the results, presented in Table 2.10, shows a similar pattern. The reduction in activity level or value-added would be most significant in the manufacturing, banana, corn, and sugarcane sectors, which mimic the trends discussed in the introduction section of this chapter. The decline in productivity is reflected in the reduction of quantity exported by 6.54% and quantity imported by 1.93% (Table 2.9). Value-added for forestry would rise slightly by 0.12%. Fish consumption shocks (SIM2) would increase the value-added for all the sectors, with ocean fishing, freshwater/coastal fishing, and aquaculture mostly benefiting from its effects. Moreover, the combination of production and consumption shocks (SIM3) would cause the value-added of 18 sectors to decline. The construction and manufacturing shocks (SIM4) would positively affect the value-added of abaca and cotton/other fiber crops, while it would cause a 16.49% decline in manufacturing value-added. The combination of production, consumption, construction and manufacturing shocks (SIM5) would result in a decline in the value-added for all the 11 agricultural sectors and forestry sector, with sugarcane (-10.46%), corn (-10.28%), and rice (-9.79%) being the most affected sectors. The fisheries sectors (i.e., ocean fishing, freshwater/ coastal fishing, and aquaculture) are the only sectors that would gain positively (9.68%) from the combination of all shocks (SIM5).

In terms of aggregate employment, climate change impacts would result in a net decline of 9.96% (Table 2.9). Employment in the aggregated 21 sectors would decline due to the impacts of climate change (Table 2.11). Employment in the sugarcane, rice, corn, and forestry subsectors would increase by 98.58%, 29.88%, 15.97%, and 0.38%, respectively. Such increases are expected, since current reductions in sugarcane areas would raise sugar prices, which in turn would attract more farmers to engage in sugarcane production, *ceteris paribus*. This situation would lead to a substantial 73.26% increase in the average return to land with the production shock (SIM1) (Table 2.9), which is mainly contributed by the sugarcane, rice, and corn sectors. Climate-induced impacts on Philippine agriculture would most affect employment in the manufacturing sector, with a reduction of 18.02% (Table 2.11).

The consumption shock (SIM2) would reduce employment in four subsectors (i.e., ocean fishing, aquaculture, freshwater/coastal fishing, and dwellings). In the Philippines, climate change shortens the fishing season[13] as heavy rains and strong waves now begin as early as late March or early April. Small fishermen and their families who live near the coast

[13] *Heavy rains and strong waves in the Philippines coincide with the rainy/typhoon season, which commonly starts in June.*

are also displaced by rising sea levels, thus reducing employment for the four sectors mentioned.

Table 2.10. Simulation results in percent deviation for the sectoral activity level/value-added

Sectors	Simulations				
	1	2	3	4	5
Rice	-4.83	0.66	-4.48	-7.96	-9.79
Corn	-7.32	0.47	-7.09	-5.39	-10.28
Vegetable and oilseeds	-2.49	0.29	-2.22	-0.47	-2.62
Fruits and nuts	-2.49	0.29	-2.22	-0.45	-2.62
Sugarcane	-6.05	0.65	-5.76	-7.83	-10.46
Abaca	-3.72	0.25	-3.44	0.49	-3.00
Cotton and other fiber crops	-3.72	0.25	-3.44	0.49	-3.00
Banana	-7.55	0.31	-7.25	-0.50	-7.67
Other crops	-2.49	0.31	-2.20	-0.50	-2.61
Livestock	-3.11	0.45	-2.83	-4.60	-6.1
Other livestock products	-3.64	0.44	-3.40	-5.32	-7.07
Forestry	0.12	0.26	0.29	-2.71	-1.56
Ocean fishing	-0.17	10.02	9.86	-0.25	9.68
Freshwater/coastal fishing	-0.17	10.02	9.86	-0.25	9.68
Aquaculture	-0.17	10.02	9.86	-0.25	9.68
Mining and quarrying	-0.05	0.08	0.02	-0.13	-0.10
Manufacturing	-5.54	0.68	-5.18	-16.49	-18.80
Electricity, gas and water	-1.83	0.24	-1.70	-2.72	-3.53
Trade	-2.01	0.27	-1.86	-2.79	-3.69
Transportation, communication and storage	-0.44	0.36	-0.13	-0.96	-0.94
Finance	-0.39	0.14	-0.28	-0.69	-0.77
Private services	-0.45	0.41	-0.08	-0.87	-0.80
Government services	-0.03	0.03	-0.01	-0.12	-0.12
Dwellings	0.00	0.00	0.00	0.00	0.00
Number of AFF sectors with lower activity level/value added	23	0	18	22	21

Note: AFF - agriculture, fishery and forestry (total of 15 sectors in the AGRIK model)

Table 2.11. Simulation results in percent deviation for the sectoral employment

Sectors	Simulations				
	1	2	3	4	5
Rice	29.88	1.22	31.27	-12.78	13.38
Corn	15.97	0.86	16.67	-8.98	8.03
Vegetable and oilseeds	-0.97	0.54	-0.48	-0.85	-1.22
Fruits and nuts	-0.98	0.54	-0.48	-0.82	-1.21
Sugarcane	98.58	1.20	102.71	-12.6	55.07
Abaca	-3.16	0.46	-2.68	0.89	-1.90
Cotton and other fiber crops	-3.16	0.46	-2.68	0.89	-1.90
Banana	-3.51	0.57	-2.98	-0.90	-3.73
Other crops	-0.97	0.57	-0.45	-0.90	-1.19
Livestock	-5.37	0.82	-4.90	-7.75	-10.06
Other livestock products	-6.22	0.81	-5.83	-8.88	-11.49
Forestry	0.38	0.80	0.91	-7.34	-4.44
Ocean fishing	-0.89	-4.82	-5.47	-1.32	-6.14
Freshwater/coastal fishing	-0.89	-4.82	-5.47	-1.32	-6.14
Aquaculture	-0.89	-4.82	-5.47	-1.32	-6.14
Mining and quarrying	-0.24	0.38	0.12	-0.63	-0.46
Manufacturing	-18.02	2.35	-16.91	-25.76	-32.85
Electricity, gas and water	-8.93	1.19	-8.31	-13.22	-17.08
Construction	-0.06	0.08	0.01	20.00	20.03
Trade	-6.27	0.85	-5.82	-8.69	-11.40
Transportation, communication and storage	-1.62	1.32	-0.47	-3.55	-3.44
Finance	-1.51	0.55	-1.09	-2.65	-2.98
Private services	-1.01	0.93	-0.19	-1.97	-1.80
Government services	-0.04	0.04	-0.01	-0.13	-0.13
Dwellings	-0.04	-0.18	-0.24	-0.20	-0.43
Number of AFF sectors with lower employment	21	4	19	22	21

Note: AFF - agriculture, fishery and forestry (total of 15 sectors in the AGRIK model)

Simulations using a combination of production and consumption shocks (SIM3) indicate that, production shocks would have a stronger impact on employment than the consumption shock. Employment in 19 out of 25 sectors would decrease, with the manufacturing sector having the highest reduction in employment (-16.91%). Meanwhile, employment in the sugarcane sector would increase by 102.71% (Table 2.11).

Construction and manufacturing shocks (SIM4) would boost employment in construction (20%), but would reduce employment in manufacturing by 25.76%. The top three agricultural sectors that are most affected by construction and manufacturing shocks are rice (-12.78%), sugarcane (-12.6%), and corn (-8.98%) (Table 2.11).

Combining all the shocks (SIM5) would increase employment for the main cash crops: sugarcane (55.07%), rice (13.38%), and corn (8.03%) (Table 2.11). Employment in the manufacturing sector would to fall by 32.85% (Table 2.11), a situation that reflects the 23.52% reduction in the quantity of Philippine exports (Table 2.9).

CONCLUSIONS AND POLICY RECOMMENDATIONS

This research examined the economy-wide estimates of climate-induced impacts on Philippine agriculture and economy. In particular, this research used a CGE model of the country to analyze the impacts of climate-induced changes in agricultural productivity, fish consumption, and corresponding changes in manufacturing and construction sectors.

The simulation results indicate that the selected crop production shocks and fish consumption shocks would have a contractionary effect on real GDP. It is possible that climate-induced impacts would trigger improvements in production efficiency and input intensification, leading to an increase in the average return to land allocated for sugarcane, rice, and corn. On the macro level, climate-induced impacts would most affect the country’s exports, reducing employment especially in the manufacturing, trade, electricity/gas/water, and livestock subsectors.

Declining agricultural production and manufacturing output would account for most of the drop in real GDP and the increase in general price level (CPI). While value-added for all agricultural sectors would decline, employment would increase in the sugarcane, rice, and corn sectors. It is possible that some of the displaced workers from the manufacturing, trade, electricity/water/gas, and livestock sectors would seek short-term employment in the sugarcane, rice and corn sectors.

With reduced agricultural output and slightly increased prices of agricultural produce, the Philippine economy would benefit from substitution effects whenever demand or consumption of fishery products and services would increase. This substitution effect would shift some of the demand and consumption of land-based produce to fisheries. Simulation results indicate that the consumption shock would increase real GDP, employment, export, and import in the fishery sectors.

Therefore, boosting the fisheries sectors may lessen the impact of climate change on the Philippine economy. This is possible since the Philippine fishery sector is less vulnerable[14] to the impacts of climate change compared with those in 137 other economies (Allison *et al*. 2009). In 2009, commercial fisheries contributed PhP 58 million of the total fish production (27%), municipal fisheries contributed PhP 75 million (35%), and aquaculture contributed about PhP 81 million (38%) (BFAR 2009). Since climate change would have an impact on the greater number of municipal fishing operators[15], an increase in the capacity of commercial fishing and aquaculture operators may be encouraged.

Overall, climate-induced impacts would result in a net loss to the Philippine economy and its key agricultural sectors in the short run. Since production would be greatly affected and would have ripple and multiplier effects in the economy, it is imperative for Philippine farmers to employ

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[14] Vulnerability was measured based on the combined exposure, sensitivity and adaptive capacity of the country under IPCC scenario B2 (i.e., local development, lower emissions).

[15] In 2002, there were 1,371,676 municipal fishing operators compared with 16,497 commercial operators and 226,195 aquaculture operators (BFAR 2009).

adaptation measures to lessen the impacts of climate change. The use of organic farming practices is one of the strategies being advocated by the Philippine Department of Agriculture in response to climate change. Some government subsidies may be needed to promote indigenous and diversified farming practices in the countryside. Furthermore, going local and buying local produce may benefit the domestic economy in the short run. Finally, the Philippine government should establish safety nets for stakeholders who would be affected by declining employment and reduced food crop production.

LITERATURE CITED

ADB (Asian Development Bank). 2009. The economics of climate change in Southeast Asia: A regional review. Asian Development Bank.

Allison, E. H.; A.L. Perry; M.C. Badjeck; W.N. Adger; K. Brown; D. Conway; A.S. Halls; G.M. Pilling; J.D. Reynolds; N.L. Andrew; and N.K. Dulvy. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries. 10(2):173-196.

Amadore, L. A. 2005. Economic and social impacts of tropical cyclones and the warning system: The Philippine situation. Final Report to World Meteorological Organization-Tropical Cyclone Programme, Manila.

BAS (Bureau of Agricultural Statistics). 2011. Volume of production, area harvested and employment, 1994-2009. http://countrystat.bas.gov.ph (Retrieved November 20, 2011).

BFAR (Bureau of Fisheries and Aquatic Resources). 2009. Philippine Fisheries Profile. BFAR, Department of Agriculture.

Buetre, B. L. and F.Z. Ahmadi-Esfahani. 2000. Updating an input-output table for use in policy analysis. The Australian Journal of Agricultural and Resource Economics. 44(4):573-603.

Catelo, S. P. and I.M. Pabuayon. 2011. Overview of Philippine agriculture, 1990-2009. Los Baños, Laguna: University of the Philippines Los Banos - College of Economics and Management.

Centeno, M. G. 1995. Rice production in the Philippines under current and future climates. In R. B. Matthews; M. J. Kropff; D. Bachelet; and H. H. van Laar (ed) Modelling the impact of climate change on rice production in Asia. Philippines and United Kingdom: International Rice Research Institute and CAB International.

Chase L. E. 2012. Climate change impacts on dairy cattle. http://www.climateandfarming.org/pdfs/FactSheets/III.3Cattle.pdf. (Retrieved January 4, 2012).

Cheung W.W. L.; V.W.Y Lam; J.L. Sarmiento; K. Kearney; R. Watson; D. Zeller; and D. Pauly. 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. Global Change Biology. 16(1):24-35.

Clarete, R. 1984. The costs and consequences of trade distortions in a small open economy. University of Hawaii. PhD Dissertation.

Clarete, R. and P. Warr. 1992. The theoretical structure of the agricultural policy experiments (APEX) model of the Philippines. APEX Project.

Corong, E. 2008. GTAP 7 data base documentation - Chapter 7 I-O: Philippines. Created by G. Batta. Center for Global Trade Analysis. Department of Agricultural Economics, Purdue University, Indiana, USA.

Cororaton, C. and E. Corong, 2006. Agriculture-sector policies and poverty in the Philippines: A computable general equilibrium analysis. MPIA Working Paper 2006-Poverty and Economic Policy (PEP) Research Network.

Coxhead, I. and P. Warr, 1992. Poverty and welfare effects of technical change: A general equilibrium analysis for Philippine agriculture. APEX Working Paper No. 3.

De Guzman, R. G. 2011. Impacts of drought in the Philippines. Paper presented at the International Workshop on Drought and Extreme Temperatures: Preparedness and Management for Sustainable Agriculture, Forestry. http://www.wamis.org/agm/meetings/etdret09/WOS2-de%20Guzman.pdf. (Retrieved December 15, 2011).

Delos Santos *et al*. 2007. Linking corn production, climate information and farm-level decision-making: A case study in Isabela, Philippines, Chapter 16A. Sivakumar, M. and J. Hansen (ed) In Climate prediction and agriculture: Advances and challenges. Springer Berlin Heiderlberg, NY. 157-164.

Dixon, P.B. and D. McDonald. 1993. Creating 1990-91 input-output tables for Australia by ORANI simulations. Paper presented at the 17th Annual Conference of Australia-New Zealand Regional Science Association, Armidale, December 1993.

Escaño, C.R. and L.V. Buendia. 1994. Climate impact assessment for agriculture in the Philippines: Simulation of rice yield under climate change scenarios. C. Rosenzweig and A. Iglesias (ed.) In Implications of climate change for international agriculture: Crop modeling studies. US Environmental Protection Agency, Office of Policy, Planning and Evaluation, Climate Change Division, Adaptation Branch, Washington, D.C., USA.

FAO (Food and Agriculture Organization). 2009. The state of world fisheries and aquaculture: 2008. FAO Fisheries and Aquaculture Department. Rome.

FAO. 2012. Climate change will have strong impact on fisheries. http://www.fao.org/newsroom/en/news/2008/1000876/index.html. (Retrieved January 5, 2012).

Greenpeace. 2005. Crisis or Opportunity: Climate change impacts and the Philippines. Greenpeace.

Habito, C.F. 1984. Equity and efficiency trade-offs in Philippine tax policy: A general equilibrium approach. Harvard University. PhD Dissertation.

Habito, C.F. 1986. A general equilibrium model for Philippine agricultural policy analysis. Journal of Philippine Development. 23(1):208-225.

Habito, C.F. 2002. Climate change and national development. Paper presented at the Meeting on Climate Change and National Development in the Philippines. November 8, 2002. Manila, Philippines.

Horridge, M. 2003. ORANI-G: A generic single-country computable general equilibrium model. Practical GE Modelling Course Edition. Centre of Policy Studies and Impact Project, Monash University, Australia.

Hulme, M. and N. Sheard. 1999. Climate change scenarios for the philippines. Climatic Research Unit, Norwich.

IPCC (Intergovernmental Panel on Climate Change). 2001. Climate change 2001 synthesis report. Cambridge University Press, Cambridge, United Kingdom and New York NY, USA.

IPCC. 2007. IPCC Fourth Assessment Report: Climate Change 2007. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch10s10-2-2.html (Retrieved April 29, 2015).

Jaranilla-Sanchez, P.A.; R.D. Lasco; G.B. Villamor; R. Gerpacio; G. Nilo; and K.L. Villegas. 2007. A primer on climate change adaptation in the Philippines. World Agroforestry Centre (ICRAF). Laguna, Philippines.

Lasco, R. D.; F.B. Pulhin; P.A. Jaranilla-Sanchez; K. Garcia; and R. Gerpacio. 2008. Mainstreaming climatic change in the Philippines. World Agroforestry Centre (ICRAF). Laguna, Philippines.

Manila Observatory. 2011. Combined risk to climate disaster map. http://www.observatory.ph/vm/images/CW_hires/risk_CW.jpg. (Retrieved December 18, 2011)

MRAG (Marine Resources Assessment Group). 2010. Monitoring the vulnerability and adaptation of Pacific coastal fisheries to climate change. Marine Resource Assessment Group (Asia-Pacific). Consultancy Report, Secretariat of the Pacific Community. Noumea, New Caledonia.

Myers, R. and R. Bucklin. 2001. Influence of hot-humid environment on growth performance and reproduction in swine. University of Florida Institute of Food and Agricultural Sciences (IFAS) Extension. http://edis.ifas.ufl.edu/an107 (Retrieved April 29, 2015).

NEDA (National Economic and Development Authority). 2011. Gross domestic product of the Philippines, 1994-2000. http://neda.gov.ph (Retrieved November 20, 2011).

NSCB (National Statistical Coordination Board). 2004. 2004 Philippine Statistical Yearbook. Makati: NSCB.

NSCB. 2011. Gross domestic product of the Philippines, 2001-2010. http://www.nscb.gov.ph/secstat/d_accounts.asp. (Retrieved November 20, 2011).

PCARRD (Philippine Council for Agriculture, Forestry and Natural Resources). 2010. Philippines' science and technology agenda on climate change (PSTACC). Laguna, Philippines.

Peng, S.; J. Huang; J.E. Sheehy; R.C. Laza; R.M. Visperas; X. Zhong. 2004. Rice yields decline with higher night temperature from global warming. Proceedings of the National Academy of Sciences. Washington, DC. 101:9971-9975.

Rapera, C. L. 2011. Trends in food crops production: Policy implications for sustainability and climate change adaptation and mitigation. Paper presented at the Metro Manila Commission Professorial Chair.

Republic of the Philippines. 1999. The Philippines' initial national communication on climate change (PINCCC).

Rincón, M.F.G. and F.K. Virtucio, Jr. 2008. Climate change in the Philippines: A contribution to the country environmental analysis. World Bank.

Rodriguez, U. and H. Cabalu. 2005. A user's guide to the TARFCOM Model. John Curtin Institute of Public Policy. Western Australia, Australia.

Rodriguez, U. and L. Cabanilla. 2006. The impact of a Philippines-USA FTA: The case of Philippine agriculture. PIDS Discussion Paper Series No. 2006-06.

Rodriguez, U. and L. Cabanilla. 2008. Sugar as a biofuel: Implications for Philippine agriculture and food security. The Philippine Agricultural Scientist. 91(4):459-468.

Rodriguez, U.; Y. Garcia; R. Tan; and A. Garcia. 2007. Can trade policies soften the economic impacts of an avian influenza outbreak? Simulations from the CGE model of the Philippines. Asian Journal of Agriculture and Development. 4(2):41-50.

Sanchez, P. 2002. The Climate change–soil fertility–food security nexus. Proceedings of the Sustainable Food Security for All by 2020. 4–6 September 2002. Bonn, Germany.

Sanchez, P. 2006. The Climate Change–Soil Fertility–Food Security Nexus. . Proceedings of the Sustainable Food Security for All by 2020. Bonn, Germany, 4–6 September 2002.

Sarmiento, J.L.; R. Slater; R. Barber; L. Bopp; S.C. Doney; A.C. Hirst; J. Kleypas; R. Matear; U. Mikolajewicz; P. Monfray; V. Soldatov; S.A. Spall; and R. Stouffer. 2004. Response of ocean ecosystems to climate warming. Global Biogeochemical Cycles. 18: GB3003, doi:10.1029/2003GB002134.

SEARCA (Southeast Asian Regional Center for Graduate Study and Research in Agriculture). 2005. Assessment and management of risks due to natural calamities in support of QUEDANCOR lending operations. Final Report for Quedan and Rural Credit Guarantee Corporation.

Stern, N. 2007. The Economics of Climate Change. The Stern Review. Cambridge: Cambridge University Press.

Valtorta, S. E. 2002. Animal production in a changing climate: Impacts and mitigation. Proceedings of the 16th Congress of Biometeorology. Kansas City, Missouri, USA.

Vega, R.S.A.; E.M. Agsibit, Jr.; A.T. Calub; and E.C. Villar. 2002. The third quarter reproductive syndrome as experienced by commercial farms. Animal Husbandry & Agriculture Journal. March 2002.

Virola, R.A.; E.V. Domingo; G.V. Amoranto; and E.P. Lopez-Dee. 2008. Gearing a national statistical system towards the measurement of the impact of climate change: The case of the Philippines. Paper presented at the Conference on Climate Change and Official Statistics. April 14-16, 2008, Oslo, Norway. United Nations Statistics Division. 38 pp.

Wettemann R.P.; M.E. Wells; and R.K. Johnson. 1979. Reproductive characteristics of boars during and after exposure to increased ambient temperature. Journal of Animal Science. 49(6):1501-1505.

World Bank. 2008. Integrating disaster risk reduction into the fight against poverty. World Bank. Washington, D.C., USA.

World Bank. 2010. Economics of Adaptation to Climate Change: Vietnam. World Bank. Washington, D.C., USA.

World Weather and Climate Information. 2012. Average weather in Manila. http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine, Manila, Philippines (Retrieved January 9, 2012).

WRI (World Resources Institute). 2011. Climate analysis indicators tool version 5.0. http://cait.wri.org. (Retrieved August 15, 2011).

Yusuf, A.A. and H. Francisco. 2010. Hotspots! Mapping climate change vulnerability in Southeast Asia. Economy and Environment Program for Southeast Asia (EEPSEA). Singapore.

III

Economic Development, Carbon Emissions and Inter-Regional Disparity: An Inter-Regional CGE Analysis of Agriculture Expansion in Papua, Indonesia

Irlan Adiyatma Rum and Ahmad Komarulzaman

The Merauke Integrated Food and Energy Estate Project is projected to increase agricultural production but increase would be dominated by estate crops. *(Photo: Palm oil plantation in Indonesia by Michael Thirnbeck under creative commons license at https://www.flickr.com/photos/thirnbeck/4638439227/)*

EXECUTIVE SUMMARY

Papua Island's forest is Indonesia's last frontier. Despite being mineral-rich, it is among the less developed regions in the country. When the Indonesian government implemented the Merauke Integrated Food and Energy Estate (MIFEE) project, the region faced a twin dilemma of development versus conservation. This study analyzed the effect of MIFEE on economic, social, and environmental development. The analysis looked at the national impacts as well as those on Papua and on the country's other regions. A five-region bottom-up interregional computable general equilibrium of the Indonesian economy, which also explicitly models carbon emissions from land-use change, was used to simulate the agriculture expansion project.

Study results suggest that the MIFEE project would reduce Indonesian interregional disparity. The project would increase agriculture production in Papua by almost 4% relative to baseline. However, the increase would be dominated by estate crops rather than food crops. The downstream food industry, especially in industry-based islands such as Java, would also be positively affected. National GDP would increase slightly and national poverty would decrease. The impact on Papua would be even greater. Regional GDP would increase and poverty incidence would fall sharply by around 4%. However, land-use conversion from natural forest into agricultural land would increase CO_2 emissions by around 228 thousand tons of CO_2 equivalent. This is clearly a contradiction to the country's commitment to reduce national carbon emissions by 26% by 2020.

INTRODUCTION

Eastern Indonesia, comprised of Nusa Tenggara, Maluku and Papua, has the lowest Gross Regional Domestic Product (GRDP) from 2004-2011. In 2010, Eastern Indonesia's GRDP was about 5% of that of the Java-Bali region, indicating that Eastern Indonesia is less developed than Western Indonesia (Table 3.1).

Table 3.1. Indonesia's regional outlook

Region	GRDP (trillion IDR)	Population (million)	
		2000	2010
Sumatra	1223.12	43.31	50.63
Java-Bali	3140.95	167.82	191.13
Kalimantan	484.85	11.33	13.79
Sulawesi	239.50	14.95	17.37
Eastern Indonesia	205.43	12.73	15.35

Source: BPS (2011)

Eastern Indonesia had a population of only 12.73 million in 2000. This increased slightly to 15.35 million in 2010. In sharp contrast, the Java-Bali region had a population of 167.82 in 2000, which increased to 191.13 million in 2010 making population even more concentrated in this region (Table 3.1). This significant increase in Western Indonesia's population is mainly because of its high urbanization rate; few people move to Eastern Indonesia because it is poor and underdeveloped, which clearly indicates the unbalanced economic development between these two regions.

Faced with this trend, the Indonesian government recognized the need to further improve regional development and reduce disparities between regions, which can affect national stability. This entails the development of infrastructure trade linkages between regions to allow industries to improve their comparative advantages.

One of the government's responses to reduce regional disparity is the Merauke Integrated Food and Energy Estate (MIFEE) project, which was planned for by the Merauke district in 2007. This mega project is being carried out in the three districts of Papua: Merauke, Mappi, and Boven Digul. It aims to expand the eastern region's agricultural area to increase the country's agro-food and energy production for export. The project includes approximately 1.28 million hectares of land, 90% of which (1.13 million hectares) are natural forest areas that have never been cultivated.

MIFEE became part of the 100-day agenda of the national cabinet. The Indonesian Ministry of Agriculture coordinated with the Merauke district-level government during project planning. The project was launched in 2010 with an initial area of 202,343 ha and with the first harvest expected in 2012. This area is divided into five clusters and will be managed by more than 30 companies who have obtained principal licenses and will operate in a range of plantation sectors (i.e., palm oil, sugar cane, and corn). The project also involves the construction of the following: a 700-kilometer road in the district, 1,500 km of connecting roads to the province of West Papua, three ports, and irrigation systems. These infrastructures require government investments of around USD 3 million and private investments (both local and foreign) of more than USD 60 million.

According to the Indonesian Forum for the Environment (WALHI - Friends of the Earth Indonesia), more than 100,000 ha of forest has already been cut down for MIFEE. This includes the sago forest, which the locals depend on for their livelihood (Rochmi 2011). The Indonesian forest is the world's third largest tropical rainforest, covering 120 million hectares or 62% of the total Indonesian land area, with a total carbon storage of 60 gigatons. However, Indonesia's deforestation rates are significant; more than 7 million hectares of forest have been lost in the last 10 years. Java, Sumatra and Kalimantan have already lost most of their forests. With the MIFEE's advance, the deforestation of Papua forests, which are among the country's last pristine rainforest (Figure 3.1), is expected to occur. It is expected that MIFEE will convert an additional one million hectares of forest under a business-as-usual (BAU) scenario. MIFEE could also endanger Indonesia as it allows companies rather than farmers to control the food supply.

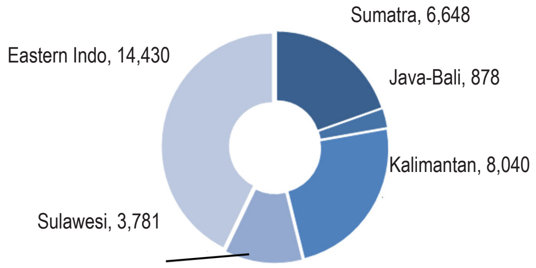

Figure 3.1. Natural forest area (thousand hectares) in Indonesia
Source: Ministry of Forestry (2005)

While MIFEE is a response to the increasing global demand for pulp and paper and palm oil, and a growing local demand for food crops, the project also contradicts with the country's commitment to limit greenhouse gas (GHG) emissions. Indonesia committed to a 26% reduction of GHG emissions by 2020 (or up to 41% with international support) compared to BAU (Figure 3.2). Since MIFEE will convert natural forests for agro-food and energy production, the project may further increase Indonesia's GHG emissions. Deforestation accounts for about 18% of global GHG emissions, which is higher than the contribution of the global transportation sector.

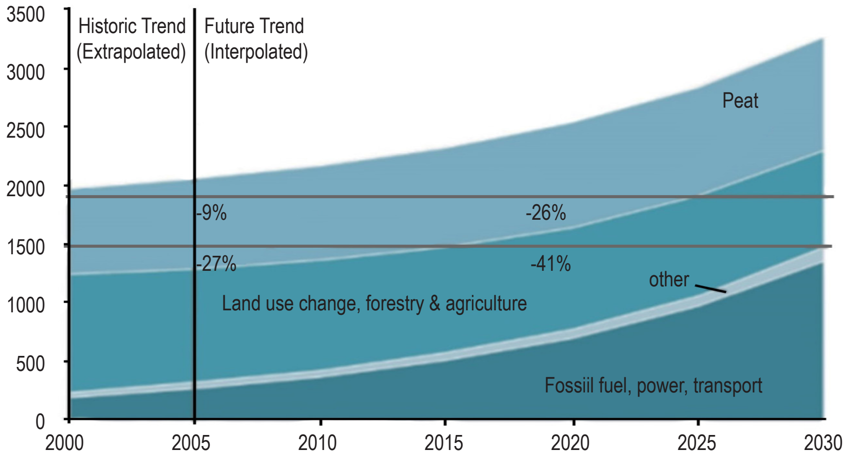

Figure 3.2. A BAU scenario for Indonesia's GHG emissions based on current trends ($MtCO_2e$/year)
Source: World Bank (2011)

The local population's resistance to MIFEE, which is supported by various environmental groups, is a sign of its activities' potential damage to the environment. It is therefore crucial to sufficiently investigate and analyze the impact of this project to the reducing emissions from deforestation and forest degradation (REDD) efforts, specifically in terms of the sustainable management of forests to ensure the conservation and enhancement of carbon stocks. Hence, this research investigated the impact of agricultural expansion in Papua on economic development, carbon emissions, and interregional disparity. Specifically, the study answered the following research questions:

a) What is the impact of this planned agricultural expansion in Papua on the region's economy and poverty?
b) To what extent does the agricultural expansion in Papua reduce interregional disparity in Indonesia?
c) What is the impact of these developments on carbon emissions from land-use change in Papua?
d) What are the key strategies to mitigate the emissions impact of these developments?

THE COMPUTABLE GENERAL EQUILIBRIUM MODEL

The cause for the largest carbon dioxide emission (75%) in the forestry sector is deforestation and land conversion followed by forest-related energy consumption, and forest-related industrial processes (DFID 2007). Deforestation and land conversion have put Indonesia among the top three largest GHG emitters in the world.

One of the main reasons why forests are destroyed is the short-term economic benefits they provide. However, there is a big difference between extraction costs and the market price the government receives when agricultural expansion takes place in a natural forest. Because of global environmental concerns and the increased need for long-term sustainable forestry, concessions on the conversion of natural forests no longer have an ethical and economic function. Secondary economic impacts of deforestation may be worse than deforestation itself.

Indonesia has already experienced significant losses with deforestation due to climate change, such as prolonged drought, increased frequency of extreme weather events, and heavy rainfall leading to big floods. Experience has pointed to the fact that the economic costs of flood relief, health costs, floodplain farming loss, and housing repair can never be compensated by the conversion of natural forests. Forests, which have been undervalued because their economic benefits are passive, are not included when settling prices.

The deterioration of forest resources and the poor economic performance in Indonesia, especially in Papua, calls for a serious rethinking of economic policies addressing both environmental and economic objectives. Recent economic literature suggests the possibility of combining both macroeconomic growth and sustainability in natural resource use. Hence, to examine the economy-wide effects of Papua's agriculture expansion and the plausibility of attaining sustainable growth, a computable general equilibrium (CGE) model that incorporates land-use change, adopted from Resosudarmo *et al.* (2009), was developed.

General equilibrium theory is a formalization of the simple but fundamental observation that markets in real world economies are mutually interdependent. The theories of general equilibrium have provided important insights about factors and mechanisms that determine relative prices and the allocation of resources within and between market economies (Bergman and Henrekson 2003).

The development of the CGE model for Indonesia started with the Indonesian CGE model developed by the Indonesian Statistics Office (BPS), Institute of Social Studies (ISS), and Center for World Food Studies (CWFS) in 1986. The three agencies built a static CGE model for the national economy based on the national Social Accounting Matrix (SAM.) Abimanyu (2000), Warr (2005), and Resosudarmo and Yusuf (2008) developed the succeeding Indonesian CGE models. They derived the CGE model of Indonesia's economy using the Australia ORANI model and worked on the GEMPACK platform. The CGE models they developed were used to analyze environmental policies concerning carbon emissions.

The most recent interregional CGE model for Indonesia, the IRSA-INDONESIA-5, was developed by Resosudarmo *et al.* (2009). This model can be used for static and dynamic analysis. The model divides Indonesia into the following regions: Sumatra, Java, Kalimantan, Sulawesi and Eastern Indonesia. The regions are interconnected by the flow of commodities, flow of factors of production, and flows of interregional transfers. This model is designed to estimate the impact economic policy has on various regional and national economic indicators of poverty and environmental quality. In this study, this interregional CGE model was used to analyze the impact of agriculture expansion on Indonesia's economic development, carbon emission, and interregional disparity.

IRSA-INDONESIA-5 AND DATA USED

This study's simulation utilized a static interregional CGE model called IRSA-INDONESIA-5 developed by Resosudarmo *et al*. (2009). The basic information for the benchmarking and calibration was derived from the Interregional SAM with 2005 as the base year. All results were derived from a version of the model with 35 sectors and 5 regions.

The 35 sectors are represented by a set of nested constant elasticity of substitution (CES) production functions. At the top level of the production structure (Figure 3.3), in the final goods sectors, firms maximize profit by choosing an optimal combination of intermediate input and value added. The inputs are assumed to be perfect complements so that the elasticity of substitution between the two factors equals zero, as dictated by a Leontief function. Based on the demand for intermediate input and value added, the firms on the second level of the production tree again minimize costs by choosing a combination of inputs that are supplied by firms on the second lower production level. However, the intermediate inputs can be produced domestically or can be imported. Because this model uses a bottom-up approach, the model recognizes a different economy for each region.

The government derives revenues from a number of sources: indirect tax revenue, tariff revenue, corporate income tax, transfers from the rest of the world, household direct tax revenue, and from the ownership of factors of production. Government revenues equal the sum of government expenditures and government savings.

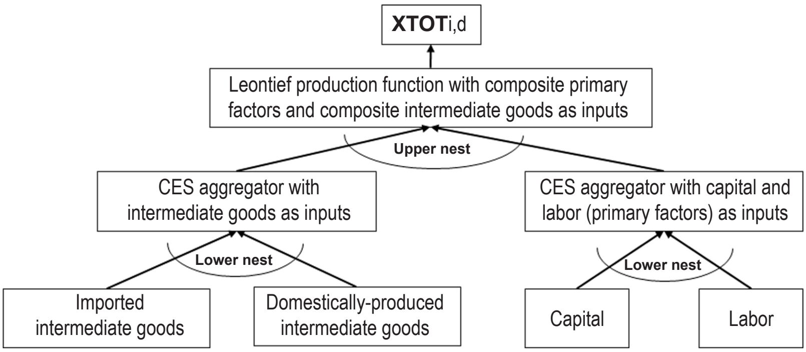

Figure 3.3. Production structure of IRSA-INDONESIA-5

IRSA-INDONESIA-5 uses the standard assumption for an open economy model, called the Armington assumption. It assumes that imperfect substitution can have different prices in different regions (Plassmann 2004). This assumption can allow the price of input factors to differ across regions. If the market is competitive, then difference in input price will lead to differences in output prices. The pattern of optimization problem for households is similar with production in which the commodities that they demand can come from domestic sources and imports. In the model, the household maximizes utility, represented by a Stone-Geary utility function, which is subjected to their budget constraint.

To close the model, there is a need to ensure that the number of equations is equal to the number of unknown variables. There are some closures that are imposed to guarantee that the system of equations is solvable. These are: all factor supplies are exogenous; world import prices are exogenous; indirect tax rates are exogenous; and output price index is set as a numeraire.

The interregional (sub-national) SAM that is published officially by BPS was used as the database for this CGE modeling. The 2005 Indonesia interregional SAM is based primarily on data provided by the 2005

Indonesia interregional Input-Output (I-O) table. The interregional SAM constructed by Resosudarmo *et al*. (2009) consists of five regions: Sumatra, Java-Bali, Kalimantan, Sulawesi, and Eastern Indonesia. The activities in each of these regions are disaggregated into 35 production sectors, 6 labor classifications, 2 types of capital (labor and capital), 2 types of households (rural and urban), 2 types of other institutions (local government and companies), and other accounts such as tax, subsidies, and inventory.

Land-use changes were incorporated into the model via additional land area data that was calculated for each region according to cultivated area and natural forest area. Carbon content for each region from sector activity that uses cultivated forest area (i.e., paddy rice, crops, estate crops, and forest sector) and from natural forest area (Table 3.2) was also incorporated.

To include the calculation of carbon emission from land use, it is important to start by inserting the calculated value inside the model through the lower nest of production function, as previously explained. However, this calculation is based on the value of land extracted from interregional SAM, while this study tried to calculate the physical land-use change. Initially this inclusion of physical land supply was tried by endogenizing the land supply into the model, which was calculated as a complement to the existing value of land equation. However, this approach made it difficult to make the model converge.

Another approach was chosen in which land supply was collated as an extra module outside the model, just like the typical carbon emission calculation. The change of land area was calculated from the percentage change of demand for land multiplied by the physical total land area for each sector. Physically, the total of land was assumed to be fixed. The supply of land physically comes from the natural forest area, while the users are restricted to only four sectors: paddy rice, crops, estate crops and forest products. In addition, this factor of production was assumed to be mobile among these four sectors.

Table 3.2. Land area (thousand hectares) and carbon content (ton per hectare)

	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
Land Area					
Paddy Rice	3,055.47	5,521.26	879.74	1,247.66	540.67
Crops	1,642.01	4,565.70	200.50	745.58	830.95
Estate Crops	9,334.12	2,459.94	2,255.14	2,239.24	1,344.67
Forest	7,204.00	1,055.00	18,144.00	3,227.00	20,481.00
Natural Forest	6,648.00	878.00	8,040.00	3,781.00	14,430.00
Carbon Content					
Paddy Rice	322.10	217.09	435.64	411.99	258.42
Crops	394.04	301.46	404.30	430.69	423.48
Estate Crops	275.65	356.72	264.21	356.99	437.35
Forest	661.47	377.65	701.39	635.06	661.36
Natural Forest	657.76	361.69	767.15	656.70	722.96

Once land use was determined, carbon emission from land use was then calculated. Emission was measured from the carbon content from land used for each sector multiplied by its total land area. This includes the calculation of carbon stock contained in the natural forest. Hence, the actual total carbon emission was from the natural forest's carbon stock after deducting the carbon emission from the four land use sectors.

MODEL BASELINE AND SIMULATION SCENARIO

This study assessed the effect of agriculture expansion in Papua on economic development and the environment using the IRSA-INDONESIA-5 CGE model. It was predicted that agriculture expansion under the MIFEE project can affect the extent of deforestation and cause an increase in the volume of GHG emission. The MIFEE project required the government to supply land to the land-based agriculture sectors (i.e., paddy rice, crops and estate crops). Hence, an application of an increase in land supply for agricultural sectors in Papua was considered and its likely impact on the equilibrium was simulated.

First, it was assumed that land supply from natural forest would increase by the percentage of land needed under MIFEE project plan for total cultivated land area. This was done by increasing the land supply rate imposed on land-based sectors by the percentage of its baseline value. Second, it was assumed that the land supply from the forest production sector would increase by the percentage of land-use change to the total forest production area. This was done by reducing the land demand rate imposed on the forest production sector by the percentage of its baseline value.

The agriculture expansion explained above disturbed the equilibrium of the system since more agriculture land was required. In order to preserve the general equilibrium condition in the model, the needed agriculture lands were taken by the government from natural forest and forest production areas. Therefore, the government's excess land from the agriculture expansion was redistributed proportionally according to its demand function. This mechanism ensured that the additional land obtained by the government for agriculture expansion would be matched exactly by its loss of natural forest area, hence, keeping the total land area fixed in each region. The implication of this is that there will be an improvement in the welfare of the economic agents considered in the model since they have access to the expansion. This change in welfare is addressed by the model's simulation.

The MIFEE project planned to open around 1.283 million hectares of land area in Papua. In order to get a more comprehensive picture of how agricultural expansion in Papua region affects the aggregate economy, two steps of shock in this scenario were considered:

a) 90% of the land expansion (about 1.155 million hectares) would be from the natural forest area; and
b) 10% of the land expansion (about 0.128 million hectares) would be from the forest production area.

Since the total cultivated area in Papua is 23.197 million hectares, then the percentage change of additional land to the total cultivated area from natural forest would be 4.97%. The percentage change of additional land to the total cultivated area from forest production would be 0.62 %. These percentages were used as the nominal shock that were inputted into the model. Table 3.3 shows how the shock value was calculated.

Table 3.3. Calculation for the shock value

Description	Cultivated area		Natural forest area
	Paddy rice, crops, and estate crops	Forest production	
Area before MIFEE Project (1000 ha)	23197.29	20481.00	14430.00
Proportion to MIFEE Project (%)		10.00	90.00
Area of MIFEE Project (1000 ha)		(1283.00)	
Proportion area to MIFEE (1000 ha)		(128.30)	(1154.70)
Area after MIFEE Project (1000 ha)	24480.29	20352.70	13275.30
Percentage change of additional land to the total cultivated area (%)		0.6264	4.9777

The combination of the shocks obtained from the scenario enabled a more comprehensive perspective of the distributional impact of the shock introduced by expanding the agriculture land. Therefore, these impacts can be used as a guide in assessing policy practice when agriculture land in Papua is expanded. Under this scenario, the central government will lessen the natural forest area and the forest production area by 4.97% and 0.62%, respectively, and reallocate this additional land supply to its other agriculture sectors according to their supply-demand function. More specifically, this is done by including the following equation as one of the closures used for simulating the system: (1) factor supply for land in Eastern Indonesia would be increased by 4.97 % from the baseline value; (2) demand for land for forest production in Eastern Indonesia would be reduced by 0.62 % from the baseline value.

RESULTS

This section presents the CGE simulation results along with the economic rationale behind the figures presented.

Table 3.4 presents the impact of Papua's agricultural expansion on the regional sectors considered in the model. It shows the response of sectoral output in terms of percentage change. Expansion of land area for certain sectors would increase their activities in Papua where the project is being operated. The output of paddy rice, crops and estate crops would experience an increase by 0.70%, 1.38%, and 3.92%, respectively. However, as some land for the MIFEE project came from the forest production sector, its output would decrease by 3.96%.

Table 3.4. Percentage change in sectoral output

Sector	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
Paddy rice	0.0079	0.0395	0.0211	0.0271	0.7026
Crops	-0.0055	-0.0251	-0.0090	-0.0162	1.3778
Estate crops	-0.0107	-0.0566	-0.0175	-0.0190	3.9209
Forest	0.0056	0.0071	0.0033	0.0051	-0.3958
Palm oil man.	0.0133	0.0312	0.0123	0.0125	0.5246
Food & beverage man.	0.0110	0.0159	-0.0015	-0.0053	0.4090
Woods man.	-0.0118	-0.0157	-0.0021	-0.0094	-0.1560

The effect of agriculture expansion would cause a spill over effect on downstream sectors, such as palm oil, food & beverage, and woods manufacturing. The first two sectors would be positively affected by the project because of the increase in upstream production. On the other hand, the decrease in forest production output would, in turn, reduce woods manufacturing by 0.16% (Table 3.4).

These results show that a 1.283 million hectare-agricultural land expansion would increase output of land-based sectors, except for the forest sector. This is what the government expects from the MIFEE project, when the Papua region becomes the main agricultural production center in the future. Output for paddy rice, crops, and estate crops would experience an increase. The simulation further indicates that the output change of paddy rice and crops would still be below the output of estate crops. Forest production and other related sectors would experience a decrease, indicating that land would be utilized more for estate crop production. Hence, this indicates that if the MIFEE project aims to increase paddy rice output, then the central government needs to make further restrictions in the land-use policies.

Besides Papua, other regions would also experience impacts from the MIFEE agriculture expansion, although impact magnitude is expected to be very small based on simulation results. Downstream sectors in other regions would experience an increase in their output (Table 3.4); this is because a huge increase in agricultural output would increase the demand from downstream production sectors, especially in the palm oil sector. Paddy rice production would also initiate an increasing demand from its downstream production (i.e., food & beverage processing industries). However, the Papua forest sector would cause downstream sectors (such as wood manufacturing) in some regions to experience a decrease in production. It is also interesting to note that the increase in Papua's agriculture sectors would likely cause a decline in the production of Kalimantan's and Sulawesi's food & beverage processing industries.

Table 3.5 presents the expected percentage change in purchaser price, from their baseline, by sector under the simulation. As indicated, Papua is expected to experience the greatest decline in purchaser price from agriculture production. This is because of the increase in output from these sectors due to the agricultural expansion in the region. The estate crop price would decrease by 1.06%; this is followed by crops (-0.37%) and paddy rice (-0.35%). However, the price of forest production commodities would increase by 0.13% followed by its downstream industry, wood manufacturing (0.04%).

Table 3.5. Percentage change in sectoral purchaser price

Sector	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
Paddy rice	-0.0328	-0.0304	0.0215	0.0193	-0.3534
Crops	-0.0539	-0.0933	-0.0805	-0.0608	-0.3727
Estate crops	-0.0421	-0.0925	-0.0708	-0.0528	-1.0581
Forest	0.0526	0.0616	0.0476	0.0624	0.1260
Palm oil man.	0.0003	-0.0004	-2.68E-05	0.0003	-0.0009
Food & beverage man.	-0.0084	-0.0087	-0.0080	-0.0070	-0.0174
Woods man.	0.0065	0.0073	0.0057	0.0147	0.0395

Other regions would also experience a decline in the purchaser price of agricultural commodities. This result is important for the central government to justify how agriculture expansion in Papua under the MIFEE project would reduce agricultural commodity purchaser price in other regions. The results show that paddy rice commodities would experience a decline in the Java-Bali and Sumatra regions. Crops and estate crops would experience a decline in all regions, including Kalimantan and Sulawesi. If most of the household income is spent on food, then this declining price would improve their real income and increase their economic welfare.

Table 3.6 shows the percentage change in the supply of production factors under the simulation. It indicates that Papua would experience the highest impacts in the supply of production factors. Because a shock in land supply was imposed in the model, the percentage change in this production factor is the nominal shock that was given (i.e., 4.97%) under the simulation. Note that there will be no mobility in land supply across the regions.

All other production factors would respond to the increase in land supply in Papua. There would be an increase in formal agricultural labor, skilled formal labor, and unskilled formal labor in Papua. This would happen because the greater supply of agricultural land available in Papua would cause other factors of production to increase their supply to fulfill the new level of output.

Table 3.6. Percentage change in the supply of production factors

Production factors	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
Land	-	-	-	-	4.9700
Formal agri. labor	-0.0089	-0.0111	-0.0110	-0.0088	0.9655
Skilled formal labor	-0.0014	0.0049	-3.77E-05	-0.0104	0.0756
Unskilled formal labor	-0.0007	0.0087	0.0006	-0.0041	0.2126

Table 3.7 shows that there would be a 0.63% decline in the demand for land in the forest sector, which is the nominal shock that was imposed in this simulation. In response, demand for land in other agriculture sectors would increase. In Papua, there would be an increase for land demand in paddy rice (16.64%), crops (17.40%), and estate crops (20.02%). For paddy rice, this increase in land demand in Papua would cause other regions to increase their demand for land.

Table 3.7. Percentage change of demand for land

Sector	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
Paddy rice	0.0181	0.0608	0.0517	0.0496	16.6403
Crops	0.0008	-0.0147	-0.0009	-0.0112	17.3995
Estate crops	-0.0040	-0.0511	-0.0152	-0.0154	20.0259
Forest	-	-	-	-	-0.6300

Table 3.8 shows the percentage change in the income of production factors under the simulation. Results indicate that Papua would experience the most impact from the agricultural expansion policy. Land owners—in this case the locals—would experience a 10.53% loss in their income from land ownership. However, all other production factors would experience an increase in their income, especially for agricultural and unskilled labor. Informal agricultural labor would receive higher incomes (5.13%) than formal agricultural labor (0.96%). This result is also true for unskilled and skilled labor, where informal labor would receive

more income than formal labor. Capital owners in Papua—in this case the investors—would also experience an increase in their income from the capital ownership by 0.33%. This result indicates that agricultural expansion would offer income improvement to all production factors, except land owners. Labor in formal-informal agriculture sectors would benefit the most.

Table 3.8. Percentage change in the income of production factors

Production factors	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
Capital	0.0021	0.0080	0.0020	-0.0047	0.3266
Land	0.0036	-0.0253	0.0060	-0.0001	-10.5261
Formal agri. labor	-0.0089	-0.0111	-0.0110	-0.0088	0.9655
Informal agri. labor	-0.0524	-0.0685	-0.0401	-0.0226	5.1267
Skilled formal labor	-0.0014	0.0049	-	-0.0104	0.0756
Skilled informal labor	-0.0049	0.0017	-0.0002	-0.0061	0.3051
Unskilled formal labor	-0.0007	0.0087	0.0006	-0.0041	0.2126
Unskilled informal labor	-0.0030	0.0038	0.0015	0.0100	0.4347

Table 3.9 presents the percentage change in land area under the simulation. Results indicate that natural forest area would be reduced by 4.5% and forest production area by 0.35% from their baseline, indicating that the MIFEE project would cause natural forest deforestation. However, the loss in natural forest area would be compensated by an increase in cultivated area for estate crops, crops, and paddy rice. Cultivated area for estate crops would increase by as much as 28.75%. This means that agriculture expansion will initiate a greater demand for land for estate crops, creating a new equilibrium of estate crop land area.

Table 3.9. Percentage change in land area

Sector	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
Paddy rice	0.014	0.044	0.045	0.041	23.891
Crops	0.001	-0.019	-0.001	-0.013	24.981
Estate crops	-0.005	-0.065	-0.017	-0.018	28.752
Forest	0.000	0.000	0.000	0.000	-0.355
Natural forest	0.000	0.000	0.000	0.000	-4.500

Agriculture expansion would increase land use by the crops and estate crops sectors more as compared to the paddy rice sector. The estate crops sector would use almost 53% of the total extension area, followed by the crop sector (29%). Paddy rice would only occupy 18% of the land extension. This provides further evidence that the paddy rice and the crop sectors, as the main food commodities, would not be optimally utilized in the planned agriculture expansion in Papua.

As discussed earlier, this simulation also captures the impact of deforestation in Papua in terms of carbon emission (Table 3.10). Simulation results indicate that national carbon emission is expected to increase by 228,293 ton CO_2E. This means that agricultural expansion would cause more damage to the environment as more carbon emissions are produced. This contradicts the government plan to reduce national carbon emission by 26% without international intervention under the moratorium. Papua's carbon emission would increase by 228,107 ton CO_2E. This high emission indicates that Papua would experience a huge environmental resource loss.

Table 3.10. Changes in CO_2 emission (ton CO_2E)

National	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
228,293.4	-21.7363	294.8106	-66.8404	-20.5112	228,107.7

There would also be changes in the national import and export for land-based sectors (i.e., forest, estate crops, crops and paddies). Figure 3.4 shows that all sectors, except for forest production, would experience an increase in their national export and a decline in their national import. This shows that agricultural expansion in Papua would likely increase the export of agricultural commodities and reduce its import. Being able to reduce the import and increase the export of these commodities benefits the central government's plan. But this also underlines the importance of sustainable agricultural production, especially since the Indonesian population would likely continue to increase at a rate higher than food production. Creating a new center of agricultural production besides Java-Bali is recognized as an alternative solution to this problem. But, as pointed out earlier, while this would benefit the economy, it would lead to unfavorable consequences, such as environmental problems.

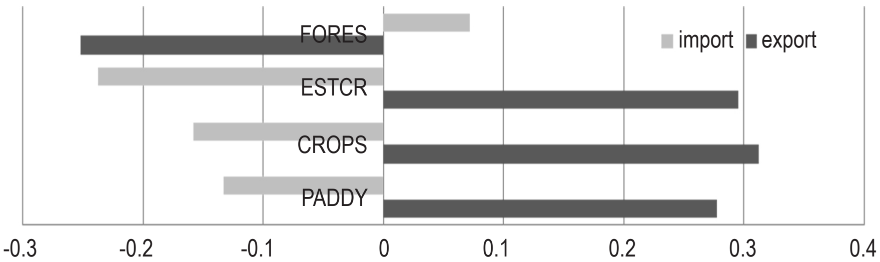

Figure 3.4. Percentage change in import and export

Table 3.11 lists the macro indicators in rural and urban areas based on simulation results. As indicated, total national GDP is expected to increase by 0.01%, which is not very significant. However, Papua would experience a GDP increase of 0.23%. This means that this agriculture expansion would likely only increase the economic welfare of the people in Papua, resulting in a small rate of increase for the whole economy.

Table 3.11. Macro indicators

Indicator		National	Sumatra	Java-Bali	Kalimantan	Sulawesi	Eastern Indonesia
GDP		0.01	-0.00	0.00	-0.00	-0.02	0.23
Poverty Incidence	Total	-0.05	0.01	-0.02	0.00	0.01	-0.90
	Rural	-0.06	0.02	-0.01	0.01	0.02	-1.06
	Urban	-0.02	-0.02	-0.01	0.00	0.00	-0.47

At the national level, poverty incidence is expected to decline by 0.05% (Table 3.11). Papua's poverty incidence would decline by 0.9%, while Java-Bali's poverty incidence would decline by 0.02%. On the other hand, other regions such as Sumatra and Sulawesi would both experience an increase in total poverty incidence by 0.01%.

An interesting finding is that rural areas are expected to experience a greater decline in poverty incidence than urban areas, indicating that Papua's agricultural expansion would give greater benefits to people in rural areas rather than in urban areas. This, in turn, indicates an impact on the disparity among the regions and the rural-urban areas. To further confirm this implication, the coefficient of variation of these macro indicators was calculated to measure the change in disparity before and after imposing the expansion shock.

Table 3.12 presents the coefficient of variation of macro indicators, among the five regions, before and after imposing the expansion shock. The change is the difference between the coefficients of variation. If the value under change is positive, it means that regional disparity became greater compared to the baseline. A negative value means that regional disparity became narrower compared to the baseline.

As shown in Table 3.12, the sign of change is negative for all the macro indicators, which means that the agricultural expansion project supports the government's goal to decrease economic disparity among regions. However, disparity in GDP per capita among the regions results in a small change. This means that, even if GDP per capita in Papua increases by 0.23%, the MIFEE agricultural expansion would not significantly lessen the disparity in GDP among the regions.

Moreover, disparity in terms of poverty incidence among the regions would experience a decline indicating that agricultural expansion in Papua would likely narrow the disparity between the poor and the rich. The coefficient of variation on poverty incidence in rural areas is slightly more negative than in urban areas, indicating that agricultural expansion would benefit rural areas, where most of the poor live and work.

Table 3.12. Coefficient of variation

Indicator		Coefficient of variation		
		Ex-ante	Ex-post	Change
GDP per capita		1.07	1.06	-0.01
Poverty Incidence	Total	0.33	0.31	-0.02
	Rural	0.30	0.27	-0.02
	Urban	0.41	0.40	-0.01

CONCLUSION

Agricultural expansion has caught national attention, especially in light of recent food price increases. Limited agricultural land is considered to be one factor behind food price hikes. The study's simulation shows that an agricultural land expansion of 1.15 million hectares in Papua would increase the national sectoral output of estate crops, crops and paddy rice. However, the output from estate crops would still be greater than that of paddy rice and crops. Hence, if the government wants to increase food production, then they need to impose other policies that can control land use.

Results also indicate that the market for these commodities would ensure that all regions would experience a decline in their purchaser price. If much of the household income is spent for food then this declining price would raise their real income and economic welfare.

Simulation results also indicate that agriculture sectors would experience an increase in their national export and a decrease in their national import. This supports the government's goal of attaining sustainable agricultural production.

Increasing agricultural output is also expected to increase the demand for production factors (i.e., land, labor, capital). Except for land, all production factors would experience an increase in their income, especially for formal and informal agricultural labor in Papua; but it doesn't necessarily mean this is from Papua's local labor force. Simulation results show that as more regions supply labor to Papua, other regions would experience loss in their labor supply. This finding indicates that agricultural expansion would create labor movement from other regions to Papua, which means that Papua's local labor force cannot use the higher labor demand to increase their real wage rate.

The MIFEE agricultural expansion would result in environmental consequences given the planned reduction of the natural forest area by 1.12 million hectares. This loss would be compensated by an increase in agriculture land. Land use for estate crops would increase by 28.75% and land use for crops would increase by 24.98%; the paddy rice sector would only get 23.89% from the baseline. Clearly, the MIFEE agricultural expansion would favor land use for the estate crops sector instead of the paddy rice sector.

Furthermore, agricultural expansion, which would lead to a decrease in natural forest area, would increase national carbon emission by 228,293 ton CO_2E. This contradicts the government's commitment to reduce national carbon emissions by 26% without international intervention.

Finally, the study proves that agricultural expansion in Papua would support the government goal to decrease economic disparity among the regions. However, while Papua would experience an increase in GDP per capita by 0.23%, national GDP would only increase at a small rate. Hence, while agricultural expansion would create a big impact in increasing the economic welfare of the people of Papua, it would not improve national welfare. Simulation results also indicate that poverty incidence would decline in the Papua and Java-Bali regions, whereas the opposite will happen in Sumatra and Sulawesi. Moreover, simulation results indicate that rural areas would experience a greater decline in poverty incidence compared to urban areas.

LITERATURE CITED

Abimanyu, A. 2000. Impact of Agriculture Trade and Subsidy Policy on the Macroeconomy, Distribution, and Environment in Indonesia: A Strategy for Future Industrial Development. The Development Economies, 38(4), 547-571.

Bergman, L. and Henrekson, M. 2003. CGE modelling for environmental policy and resource management. Working Paper. Stockholm School of Economics.

Department for International Development (DFID). 2007. Executive summary: Indonesia and climate change. Working Paper on Current Status and Policies: March 2007.

Elson, D. 2011. Reducing emissions from land-use change in Indonesia, PROFOR BBL, World Bank, Washington DC, retrieved from https://www.profor.info/profor/sites/ profor.info/files/WB_BBL_Elson_21%3D04%3D11_v2.pdf

Indonesia Statistic Office, Institute of Social Studies, and Center for World Food Studies (BPS, ISS, and CWFS). 1986. Report on Modeling: The Indonesian social accounting matrix and static disaggregated model. Jakarta: BPS

Indonesia Statistics Office (BPS). 2008. 2008 Statistical yearbook of Indonesia. Jakarta: BPS

Indonesia Statistics Office (BPS). 2009. 2009 Statistical yearbook of Indonesia. Jakarta: BPS

Indonesia Statistics Office (BPS). 2011. 2011 Statistical yearbook of Indonesia. Jakarta: BPS

Resosudarmo, B.P. and Yusuf, A.A. 2008. Mitigating distributional impact of fuel pricing reform: The Indonesia experience. ASEAN Economics Bulletin, 25(1), 32-47.

Resosudarmo, B.P., Yusuf, A. A., Hartono, D. & Nurdianto, D.A. 2009. Regional economic modeling for Indonesia: Implementation of the IRSA-INDONESIA-5. Departmental Working Paper 2009-21, Australian National University, Arndt-Corden Department of Economics.

Rochmi, Nur. 2011. Papua MIFEE project faces criticism, Tempo Interactive. Retrieved from http://www.tempointeractive.com/hg/nasional/2011/08/15/brk,20110815-351921,uk.html

Plassmann, F. 2004. The advantage of Avoiding the Armington Assumption in Multi-Region Models. Working Paper 0206: (3) 2004.

Warr, P. 2005. Food policy and poverty in Indonesia: A general equilibrium analysis, The Australian Journal of Agricultural and Resource Economics, 49, 429-451.

IV

Valuing the Impact of Rationalizing Malaysia's Fuel Subsidies on its Macroeconomic Performance

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EXECUTIVE SUMMARY

The current fuel subsidy given by the Malaysian government is seen as the primary cause of the nation's ballooning fiscal deficit, which threatens to force the country to an unsustainable position. Thus, the reduction or removal of the current fuel subsidy has become a national mission. This study investigated the impact of a fuel subsidy reduction on the macroeconomic performance of Malaysia in terms of real gross domestic product (GDP), household consumption, government expenditure, exports and imports, industrial output, and employment by industry.

The analysis employed the CRUSOE-MY model, a computable general equilibrium model that included fuel subsidies. Five simulations were run to examine the economic impact of fuel subsidy reductions by way of fuel price increases on producers and users. SIM1 observed the impact of a price increase on producers. SIM2, SIM3 and SIM4 investigated the impact of a price increase in petrol, diesel and other fuels (separately), respectively, on all users. SIM5 examined the impact of a tax on all fuel commodities (altogether) on all users.

The results of SIM1 show that all types of occupations would experience a contraction in employment ranging between 3.177% and 3.547%. The results of SIM2, SIM3 and SIM4, on the other hand, show an expansion of employment for all types of occupations ranging from 0.005% to 0.012%. The results show that an increase in diesel price (SIM3) would have more impact on the expansion of employment by occupation than an increase in the prices of petrol (SIM2) and other fuels (SIM4). The expansion of employment by occupation for SIM3 (diesel) reflect that the industrial sector (i.e., producers) would be the most affected in terms of employment generation compared to SIM2 (petrol) and SIM4 (other fuels).

This study found that a price increase for producers (SIM1) would result in a varying impact on macroeconomic variables, a contraction of employment by occupation, and diminishing output and employment by industry. Not surprisingly, it is predicted that the land transport, water transport, and air transport industries and other transport services would show large contractions in output and employment. Meanwhile, an increase in price for fuel users, which the government would expense as tax, would reduce household consumption and government expenditure, expand employment by occupation, but lower output and employment in some industries of the Malaysian economy.

Most industries in the agriculture, manufacturing and services sectors would experience large contractions in employment. The results of all the simulations show that the reduction in employment by industry would be larger than that of output reduction. The tax increase on producers would have a larger impact on employment due to reductions in labor input as producers would try to compensate for the increase in firm costs. This implies that firms would likely utilize labor more efficiently in order to deal with the increased costs of production.

The contraction in output by industry would be larger among industries in the manufacturing sector compared to the agriculture and services sectors. A larger contraction in output would be seen for oils and fats; basic chemicals; other chemical products; sheet glass and glass products; cement, lime and plaster; finishing of textiles; and clay and ceramic products. The manufacturing sector would experience the highest output reductions from an increase in diesel costs. This is because more than 50% of Malaysia's fuel subsidies is for diesel while the subsidies on petrol and other fuel products make up less than 40% and 20%, respectively.

This study concludes that a fuel price increase on producers would lower output and employment by industry, employment by occupational category, and the macroeconomic performance of Malaysia. However, a price increase impacting all users (by type of fuel commodity) would compensate for current government expenditure on the subsidies and would result in a positive impact on GDP, exports, imports, and employment by occupation. Some industries would show output expansions while others would exhibit output reductions. In order to achieve sustainable development, this study highlights the need to find renewable sources of energy to meet Malaysia's energy demands, thereby reducing Malaysia's dependency on fossil fuel and fuel subsides.

BACKGROUND AND RATIONALE OF THE STUDY

High global fuel prices are likely to continue in view of the continuing turmoil in the Middle East, the potential interruption to the global supply, and the rising demand from fast emerging economies. This puts pressure on Malaysia's ability to stimulate the economy, both in the short and mid-term.

Malaysia's financial capacity could become unsustainable since subsidies to maintain low fuel prices constitute a huge portion of the government's annual budget. When the crude oil price shot to its highest in 2008, the total fuel subsidy borne by the Malaysian government was MYR 15 billion. In normal circumstances, when the crude oil price hovers between USD 65 and USD 85 per barrel, the estimated fuel subsidy is between MYR 9 billion and MYR 11 billion annually (EPU 2008).

Amidst the global rise in fuel prices, the Malaysian government has been struggling with a budget deficit for over a decade as it tries to balance its revenue and expenditure. The government has found it necessary to subsidize fuel prices not only to ease the burden on the lower income sectors, but also to reduce possible class tensions that may arise as a result of rising income inequalities. The government has, however, cited the ever-increasing subsidy bill as the main cause of its perennial budget deficit.

The fuel subsidies are blamed as the primary cause of the nation's ballooning fiscal deficit, which threatens to force Malaysia down to an unsustainable position. The fiscal deficit, which was about 5.5% of Malaysia's GDP in 2000, declined to 2.7% in 2007 before it climbed very rapidly to 7.0% in 2009 due to rising fuel prices and the consequent increase in subsidies and public expenditure. Thus, the reduction or removal of the fuel subsidies has become a national mission. Besides straining the nation's budget, fuel subsidies divert funds away from productive spending, discourage energy efficiency, boost demand for fossil fuel, and drive prices even higher in the long term. In fact, the government has recognized that much of the benefit from subsidized petrol for private vehicle owners does not go to the poor but instead benefits wealthy Malaysians who can afford large automobiles and high energy-consuming goods.

The Tenth Malaysia Plan (2011-2015) includes the rationalization of subsidies to promote economic growth (EPU 2010). Specifically, the government introduced a subsidy rationalization plan in July 2010 and proceeded to raise fuel prices in December 2010 and January 2011. Although officials have said that most of the burden of the fuel increases will fall on commercial and industrial users, with 75% of citizens unlikely to be directly affected by the volume-based rise in electricity prices, it is expected that the impact of the hikes will still be passed on to the general public as production costs increase.

Following the implementation of its subsidy rationalizing programme in the second half of 2010, the government managed to narrow its fiscal deficit to 5.6% of the GDP at the end of 2010. It aimed to further reduce this to 5.4% in 2011 and 5.2% in 2012 (EPU 2010).

However, a reduction in fuel subsidies will result in a jump in inflation. Almost instantly after the government hiked the fuel price from MYR 1.92 per liter to MYR 2.70 per liter in 2008, the prices of electricity, food, transportation and raw materials spiked. Inflation reached about 5.5% in 2008, which was above the threshold. The prices never came down thereafter, even though the petrol price was subsequently reduced to the lowest limit of MYR 1.80 in December 2008[16].

The rationalization of fuel subsidies has sparked mixed reactions from various segments of society. Basically, the reactions fall under two opposing views. Fuel subsidy reduction proponents argue on the premise of efficiency, i.e., subsidy reduction will remove market distortions, and, thus, consumption and investment decisions will be made based on true price signals. Furthermore, improving the government's balance sheet, providing more money for better healthcare and education, and increasing the wages of the poor by setting a minimum wage standard are valid reasons to justify subsidy reform. On the other hand, opponents of

[16] *http://blog.galvintan.com/malaysian-fuel-price-history/*

the subsidy reduction argue on the basis of equity, i.e., the reduction or removal of the subsidies will adversely affect the lower income groups. Both arguments have their merits. Deciding on the appropriate course of action to be taken entails an in-depth investigation into how the phasing out of fuel subsidies will impact the overall welfare of society.

The Fuel Subsidies and the Subsidy Rationalization Programme

Malaysia produces and exports oil but it is not a major oil producing country nor a member of the Organization of Petroleum Exporting Countries (OPEC). As such, Malaysia has no influence on how oil price is determined in the international market.

So far, Malaysia's oil prices are among the lowest in the world. Among the ASEAN countries, fuel prices in Malaysia are much cheaper than in Thailand and Singapore (Table 4.1). To ensure the low price of petrol, diesel and cooking gas in Malaysia, in addition to providing subsidies, the government has exempted diesel and petrol from sales tax. With the combination of subsidies and tax exemptions, the public can enjoy more affordable public and private transport.

Table 4.1. Comparison of fuel prices within the ASEAN

Country	Petrol (MYR/liter)	Diesel (MYR/liter)	LPG (MYR/kg)
Malaysia	1.62	1.28	1.45
Thailand	2.37	2.08	1.65
Singapore	3.91	2.61	-
Philippines	2.21	1.95	1.25
Indonesia	1.68	0.96	-
Bruinei	1.22	0.71	1.40

Source: EPU (2008)

Three types of fuel are used in Malaysia: petrol/gasoline, gas for natural gas vehicles (NGV), and diesel. The first two are usually used by households while diesel is favored for vehicles. The government provides fuel subsidies for these three fuels to keep the prices lower than actual international prices. Collectively they constitute the second largest amount of subsidy at MYR 23.5 billion out of the total government budget for subsidy of MYR 74.5 billion (2009)[17]. The total government budget for subsidy is equivalent to 4.5% of the country's GDP (EPU 2004-2010). As a result, the government is bearing a huge subsidy bill, which increases the national debt and also compromises the sustainability of the economy in the long term.

With this high amount spent on fuel subsidies, the Cabinet announced that, effective 16 July 2010, subsidies for fuel, specifically petrol, diesel, and liquefied petroleum gas (LPG), would be reduced as the first step of a gradual subsidy rationalization programme. Subsidies for RON95 and diesel were reduced by 5 cents per liter. The LPG subsidy was reduced by MYR 0.10[18] per kilogram while RON97 was no longer subsidized but was subjected to a managed float where the price would be determined by an automatic pricing mechanism[19].

The decision for the subsidy rationalization programme was founded on the realization that the then existing subsidy programme was typically benefitting the wrong target groups, with much of the benefits going to wealthier Malaysians, foreigners and corporate businesses that could well afford to pay unsubsidized prices. About 71% of fuel subsidies was going to middle or high-income groups rather than the poor (EPU 2004-2010).

Moreover, the decision to reduce subsidies for fuel was based on the fact that reducing them will have the greatest impact on government spending. The savings from a subsidy rationalization programme could reduce the budget deficit, and the saved money could be invested in social services, infrastructure and community development, providing long-term benefits for future generations and supporting more sustainable economic growth. The highly subsidized prices of fuel products has, in addition, led to illegal smuggling of these goods, with subsidized diesel entering the black market even across borders, and the depletion

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[17] Other subsidies are divided into: social (MYR 42.8 billion), infrastructure (MYR 4.8 billion) and essential food (MYR 3.4 billion).

[18] 1 USD is roughly equivalent to 3 MYR.

[19] http://blog.galvintan.com/malaysian-fuel-price-history/

of domestic fuel resources. It is vital to rationalize fuel use as well as develop new energy technologies as a matter of economic, energy and national security.

However, the opponents of fuel hikes assert that because Malaysia is a net fuel exporter, rising fuel prices would mean record profits for Petronas, the state-run energy company, and that the low incomes of the majority of Malaysians justify why the government should keep fuel prices low through subsidies. Some analysts say that Malaysia may have some room to delay price increases as it is a net oil exporter and would gain from strong crude oil markets.

Compared with the subsidy rationalization plan proposed by the government's Performance Management and Delivery Unit (PEMANDU) in May 2010, the current deductions in fuel subsidies are taking place at a more gradual pace (Table 4.2). This may indicate that the government is more likely to remove its subsidies gradually over the next three to five years.

Table 4.2. Changes in crude oil and petrol prices in Malaysia, 2004–2011

Date	Crude oil price per barrel (USD)	Petrol price (MYR)
1st May 2004	37.38	1.37
1st Oct 2004	49.07	1.42
1st March 2005	51.68	1.42
1st May 2005	49.72	1.52
31st July 2005	60.57	1.62
28th Feb 2006	61.41	1.92
5th June 2008	127.79	2.70
23rd Aug 2008	114.59	2.55
24th Sept 2008	105.73	2.45
15th Oct 2008	81.60	2.30
1st Nov 2008	67.81	2.15
18th Nov 2008	55.49	2.00
3rd Dec 2008	47.00	1.90
16th Dec 2008	47.50	1.80

Table 4.2 continued

Date	Crude oil price per barrel (USD)	Petrol price (MYR)
1st Sept 2009	70.00	2.05
15th July 2010	77.00	2.10
2nd Nov 2010	83.00	2.15
1st Dec 2010	84.10	2.30
5th Jan 2011	89.40	2.40
31st Jan 2011	89.30	2.50
1st April 2011	106.70	2.70
5th May 2011	109.20	2.90

Source: Finance, twitter.com

OBJECTIVES OF THE STUDY

This research was designed to address the issue of a possible fuel subsidy reduction in Malaysia. The objectives of the study are as follows:

a. To provide an overview of government fuel subsidies in Malaysia. The research questions here were:
    - What is the cost of the fuel subsidies?
    - What types of fuels are being subsidized by the Malaysian government?
    - To what extent do the subsidies affect government expenditure?

b. To investigate the impact of a reduction in fuel subsidies on macroeconomic factors, namely:
    - Real gross domestic product (GDP)
    - Household consumption
    - Government expenditure
    - Exports and imports
    - Industrial output
    - Employment by industry and occupation

c. To provide recommendations to the government in terms of fuel subsidy policies.

LITERATURE REVIEW

Fuel subsidy reduction or removal in Malaysia has been a constant topic of debate between its proponents and opponents since 2003 against the backdrop of international oil price increases. Several studies have been conducted in developed and developing countries to analyze the fuel subsidy problem by using computational general equilibrium (CGE) or non-CGE approaches. Although there have been studies done on the fuel subsidy problem in Malaysia, none of them have addressed the welfare effects of fuel subsidies by employing the CGE model. Khalid, Zakariah and Khairul (2010) used the Energy Intensity and Price Spread Model and the Input-Output Tables Malaysia of 2000 to estimate the effects of an increase in energy prices on food prices. They revealed that energy intensity played an important role in affecting the material input of the food industry production chains.

For other countries, researchers have investigated the impact of the removal or reduction of subsidies, especially from the perspective of welfare effects on households. Yusuf and Resosudarmo (2008) studied the mitigation of distributional impacts of fuel pricing reform on Indonesian households. Using the CGE model, the study disaggregated households into higher and lower income categories. It was found that cutting the subsidy on vehicle fuel prices would be progressive reform. However, they also found that inequality between the rich and the poor in urban areas increased when the price of domestic fuel (kerosene) increased. This differs from the findings of Coady *et al*. (2006) who studied the removal of subsidies in Bolivia, Ghana, Jordan, Mali and Sri Lanka. The study concludes that although the removal of fuel subsidies was regressive, it was still the case that a substantially higher proportion of the aggregate burden was borne by the higher income groups.

Other studies also found that reduction in fuel subsidies adversely affected the poor. Granado *et al*. (2010), in their study on the effects of fuel subsidies on the welfare of households in developing countries, revealed that an increase in oil prices of USD 0.25 per liter would reduce the real income of households by about 5.9%. This represented a substantial adverse effect on the welfare of households arising from the indirect effects of rising oil prices on the higher prices of other goods and services used by households. They also proved that low-income groups bore a large welfare loss. Similarly, Oktaviani *et al*. (2007) found that Indonesian households lost income following a reduction in fuel subsidy, which then decreased their welfare. The number of households living under the poverty line grew significantly, particularly in rural areas. Incomes were not evenly distributed within society and an increase in inflation reduced the real GDP of the country. Furthermore, they found that a reduction in the fuel subsidy increased the prices of industrial outputs that were highly dependent on fuel, such as from the transportation and fishery sectors. The wages of skilled labor, land rent and capital rent declined steadily in response to the change in fuel price.

On the other hand, other studies found that fuel subsidies were strongly biased towards higher-income households. El Said and Leigh (2006) found that higher-income households benefitted from about 33% of the total fuel subsidy amount while poor households benefitted only by 13%. The study of Granado, Coady and Gillingham (2010), concerning the benefits of fuel subsidies for developing countries, showed that, on average, the burden of subsidy reform was neutrally distributed across income groups; fuel subsidies were thus found to be a costly approach to protecting the poor due to substantial benefit leakage to higher income groups. The study by Adriamihaja and Vecchi (2007) also found that although fuel price increases hurt the poor in terms of percentage, the leakage of fuel subsidies provided many benefits to high-income households. They found that higher oil prices increased household expenditure and that approximately 60% of this expenditure increase was due to indirect effects, mostly through higher food prices.

In contrast, Hartono and Resosudarmo (2006) found different results from their study in Indonesia. Based on the dynamic CGE model for the Indonesian energy sector, they found that a reduction in subsidies, whether followed or not followed by an escalation in energy utilization efficiency, caused GDP growth and improvement of income distribution. They also found that a reduction in fuel subsidies caused domestic trade on energy to decrease, import of energy to increase, and export of energy to decrease.

Meanwhile, Motlagh and Farsiabi (2007) studied the environmental damage that occurred as a result of a reduction in subsidies. By using the analytical Environment Cost-Benefit Analysis (ECBA) model, they found that reducing energy subsidies for each energy form was very worthwhile. In addition, price increases could be the basis for redistribution of income, increased government revenue, and economic growth in the long run. Baig *et al*. (2007) suggested several approaches related to oil price increases to protect the welfare of poor households. Among them were liberalizing the domestic petroleum price setting or setting an automatic adjustment formula, incorporating improvements in the package price, and targeted actions to reduce the negative effects on the poor.

Birol *et al*. (1995) studied the impact of phasing out subsidies in three oil-exporting developing countries: Algeria, Iran and Nigeria. Using econometric methods, the study found that the policy of phasing out subsidies entirely, together with an increase in autonomous energy-efficiency improvements led to even higher savings in petroleum use of 13%, 20% and 19% in the three countries, respectively. A similar study by Breisinger *et al*. (2011) recognized that petroleum subsidy reform was increasingly being seen as an opportunity to consolidate public finances and foster sustainable economic development in Yemen. They put forward that although the economy was projected to grow with a reform of petroleum subsidies, the design of the reform was critically important for the poor. A promising strategy, according to them, involved the combination of subsidy reduction with direct transfers to the poorest households and enhanced public investment.

However, in contrast, Allaire and Brown (2009) postulated that the proposed elimination of oil and gas subsidies in the United States would have little impact on oil and natural gas markets, energy security and the economic activity of the country. They also estimated that there would be a decline in US oil production by the year 2030 while the effect of a change in use would increase the vulnerability of the US economy to oil supply disruptions.

OVERVIEW OF THE MALAYSIAN ENERGY INDUSTRY

The Malaysian economy has registered a growth of less than 5% in recent years, amidst continuous global financial and economic instability. Robust domestic demand has sustained private consumption and strong public spending has supported the growth in recent years. Growth has been driven by the robust performance of the services sector with further support coming from the manufacturing sector. Nevertheless, the deterioration in global economic conditions has led to a deceleration in external demand, which has resulted in a weakened performance of those sectors most directly exposed to global demand, particularly the electronics and electrical industry.

As can be seen in Table 4.3, the total final energy demand increased by 17.3% from 34,586 ktoe (kilotonne of oil equivalent) in 2003 to 44,901 ktoe in 2008. The primary energy supply increased by 31.1% in 2008 to register at 75,490 ktoe, compared to 57,565 ktoe in 2003. The increase was led by higher production of coal, coke and natural gas, especially from 1990 to 2000 (Table 4.4). Coal and coke production increased to 2,486 ktoe in 2000. Natural gas production increased to 20,194 ktoe in 2000 due to the increase in demand from the transport and industrial sectors, which is attributable to the fuel price hike in 2008. Meanwhile, crude oil production registered a small increase of 5.7% from 2003 to 2008. The crude oil reserves in the country registered at 5.46 billion barrels or a 22-year lifespan as of January 2008. Meanwhile, natural gas reserves of 88.01 trillion standard cubic feet (tscf) is sufficient to cover 28 years of gas output at current production levels.

Table 4.3. Trends in final energy demand, primary energy supply, and GDP in Malaysia, 1990–2008

Year	Final energy demand (ktoe)	Primary energy supply (ktoe)	GDP (MYR Million)
1990	13,217	21,471	189,059
1991	14,560	26,335	205,312
1992	16,185	29,291	221,319
1993	17,468	29,925	239,792
1994	19,287	31,662	261,951

Table 4.3 continued

Year	Final energy demand (ktoe)	Primary energy supply (ktoe)	GDP (MYR Million)
1995	22,164	33,879	283,645
1996	24,167	37,840	312,017
1997	26,168	43,173	335,556
1999	27,228	44,534	328,194
1999	27,228	44,534	328,194
2000	29,699	50,710	356,401
2001	31,515	51,979	358,246
2002	33,290	53,196	377,559
2003	34,586	57,565	399,414
2004	37,323	62,358	426,508
2005	38,285	66,188	449,250
2006	40,324	67,878	475,526
2007	44,268	72,384	505,919
2008	44,901	75,490	528,311

Source: Ministry of Energy, Green Technology and Water (2009)

Table 4.4. Commercial energy supply in Malaysia, 1990–2008

Year	Coal and coke (ktoe)	Natural gas (tcf[1])	Petroleum products & others (ktoe)	Crude oil (barrel)
1990	1,326	5,690	3,651	8,783
1991	1,564	6,675	4,165	9,443
1992	1,640	8,545	5,100	10,175
1993	1,352	7,729	5,814	10,135
1994	1,563	8,977	2,446	13,605
1995	1,612	11,064	610	16,159
1996	1,677	12,339	1,099	18,225
1997	1,622	14,108	3,802	17,916
1998	1,731	14,549	1,920	17,133
1999	1,940	15,893	1,807	17,643
2000	2,486	20,194	-1431	21,673
2001	2,970	20,032	-1,917	23,590
2002	3,642	21,802	-521	22,647
2003	5,316	20,878	-1,391	25,344
2004	6,631	21,409	-37	25,335

Table 4.4 continued

Year	Coal and coke (ktoe)	Natural gas (tcf1)	Petroleum products & others (ktoe)	Crude oil (barrel)
2005	6,889	24,783	-75	24,339
2006	7,299	26,704	-1,474	24,909
2007	8,848	27,362	-995	26,571
2008	9,782	27,800	-2,282	26,776

Source: Ministry of Energy, Green Technology and Water (2009)
Note: [1]trillion cubic feet

The Ministry of Energy, Green Technology and Water (2009) states that the total refinery output registered at 26,482 ktoe in 2008 where diesel accounted for the highest share (35.4%), followed by motor petrol (19.1%), non-energy (16.9%), automatic transmission fluid (ATF) and air vehicles (AV) gas (11.9%), fuel oil (7.5%), LPG (4.6%), refinery gas (3.7%), and kerosene (0.9%). Currently, Malaysia's total refinery capacity is 492,000 barrels per day. The share of energy demand of 44,901 ktoe was highest for the industrial sector at 42.6%, followed by the transport sector at 36.5%, the residential and commercial sector at 13.8%, the non-energy sector at 6.4%, and the agriculture sector at 0.6%. The industrial energy intensity was 89 ktoe/MYR million in 2008.

Overall, both supply and demand factors have driven growth in the energy sector. The supply growth was driven by the changes in crude oil production and import levels of coal for power generation. Oil and gas still dominate energy supply and are expected to continue to play a dominant role in Malaysia's primary energy mix. On the demand side, almost all sectors have shown growth in their consumption of energy, albeit at a much slower pace due to the economic slowdown experienced in recent years.

Overview of Fuel Subsidies and Energy in Malaysia

The largest share of fuel subsidies goes to diesel, which has made up more than half of all subsidized fuels for most years. As can be seen in Table 4.5, in 2004, 69.84% of fuel subsidies were for diesel, 13.39% for petrol, and 16.77% for LPG. However, the share of fuel subsidies for diesel declined to 50.48% in 2007 and to 44.23% in 2010, while the share of fuel subsidies for petrol increased to 32.21% in 2007 and to 37.97% in 2010. Meanwhile, the fuel subsidy for LPG hovered around 13%–18% for the period of 2004–2010.

Table 4.5. Subsidy by type of fuel

Product	2004	2005	2006	2007	2008	2009	2010
Petrol							
MYR million	641	2674	1859	2825	5250	2340	3459
Share in total subsidy (%)	13.39	32.75	25.53	32.21	34.14	41.84	37.97
Domestic price (Petrol premium/ RON 97) (MYR/liter)	1.37	1.52	1.92	1.80	1.80	1.80	2.30
Domestic price (Petrol premium/ RON 95) (MYR/liter)	-	-	-	-	-	1.80	2.30
Diesel							
MYR million	3344	4399	4287	4427	7873	1533	4030
Share in total subsidy (%)	69.84	53.88	58.88	50.48	51.20	27.41	44.23
Domestic price (MYR/liter)	0.781	1.081	1.58	1.58	1.70	1.70	1.75
LPG							
MYR million	803	1091	1135	1518	2255	1720	1622
Share in total subsidy (%)	16.77	13.36	15.59	17.31	14.66	30.75	17.80
Domestic price (MYR/kg)	1.35	1.45	1.75	1.75	1.75	1.75	1.85
Total (MYR million)	**4,788**	**8,164**	**7,281**	**8,770**	**15,378**	**5,593**	**9,111**

Source: Economic Planning Unit (2004-2010)

Since mid-2004, the price of crude oil has increased significantly in the world market. (As indicated in Table 4.2, the crude oil price per barrel increased from USD 37 in May 2004 to USD 52 per barrel in March 2005, USD 128 in June 2008 and USD 109 in May 2011.) The large increase in oil prices has affected the price of petroleum products (petrol, diesel and cooking gas/LPG) in Malaysia.

Table 4.5 shows that the domestic price for petrol increased from MYR 1.37 per liter in May 2004 to MYR 1.52 per liter in March 2005, MYR 1.80 per liter in June 2008, and MYR 2.30 per liter in May 2010. The domestic price for diesel increased from MYR 0.781 per liter in 2004 to

MYR 1.58 per liter in 2006, MYR 1.70 per liter in 2008, and MYR 1.75 per liter in 2010. Meanwhile, the domestic price for LPG increased from MYR 1.35 per liter in 2004 to MYR 1.75 per liter in 2006, but remained at this level until reaching MYR 1.85 per liter in 2010. The trend of price increases in petrol, diesel and LPG is visualized in Figure 4.1, and the subsidies for these three types of energy can be seen in Figure 4.2.

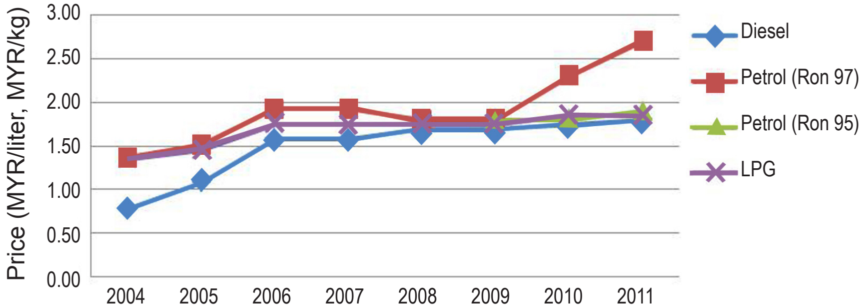

Figure 4.1. Prices of petrol, diesel and LPG in Malaysia
Source: extracted from Table 4.5

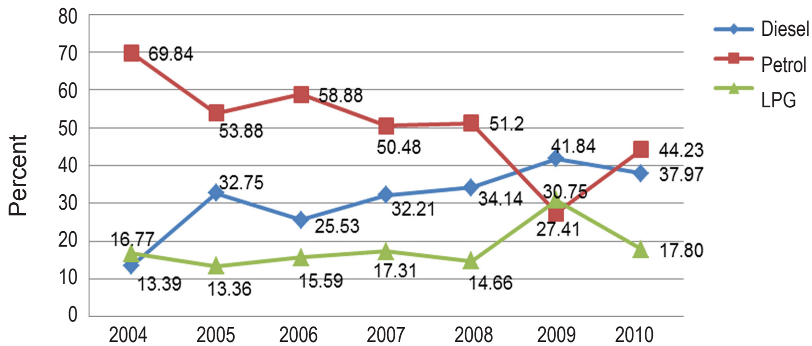

Figure 4.2. Petrol, diesel and LPG subsidies in Malaysia
Source: extracted from Table 4.5

The Magnitude of Fuel Price Subsidies in Malaysia

A subsidy is defined as money paid by the government to producers or retailers of a given product in order to lower the retail price of the product as a form of assistance for a given industry or segment of society (EPU 2005). Hence, a fuel price subsidy could be defined as the difference between the reduced price of fuel with government support and the price of the good in the absence of such support.

Table 4.6 shows that, today, Malaysians are paying a subsidized rate of MYR 1.62 per liter for the petrol RON 97. Without the subsidy, the actual cost should be MYR 2.45 per liter. Hence, the government is bearing MYR 0.83, which is MYR 0.59 in the form of taxes forgone and MYR 0.24 in subsidies. For diesel, Malaysians are paying MYR 1.28 per liter, but the actual cost is MYR 2.07 per liter. The subsidy is MYR 0.59 per liter with a forgone tax of MYR 0.2 per liter. The unsubsidized price for cooking gas (LPG) is MYR 2.39 per kilogram, but Malaysians pay MYR 1.45 per kilogram; thus the subsidy is MYR 0.94.

Table 4.6. Subsidized and non-subsidized prices of petrol, diesel and LPG

Product	Price without tax and subsidies	Sales tax forgone	Subsidy	Retail price
Peninsular Malaysia				
Petrol (sen/liter)	244.82	58.62	24.20	162.00
Diesel (sen/liter)	206.87	19.64	59.13	128.10
LPG (sen/kg)	238.92	-	93.92	145.00
Sabah				
Petrol (sen/liter)	244.26	58.62	25.64	160.00
Diesel (sen/liter)	206.31	19.64	58.27	128.40
LPG (sen/kg)	253.32	-	100.32	153.00
Sarawak				
Petrol (sen/liter)	243.41	58.62	23.79	161.00
Diesel (sen/liter)	205.46	19.64	58.02	127.80
LPG (sen/kg)	252.48		99.48	153.00

Source: Economic Planning Unit (2005)
Note: 100 sen = 1 MYR

The higher the fuel prices and the more fuel consumers use, the higher the amount of subsidies borne by the government. Table 4.7 shows that subsidies in 2001 were MYR 2.4 billion based on the average WTI[20] crude oil price of USD 25.24 per barrel. In 2008, the subsidies increased

[20] *West Texas Intermediate (WTI) is a light crude oil also known as Texas light sweet. This is used as a benchmark in crude oil pricing.*

to MYR 15.3 billion based on the average international oil price of USD 127.79 per barrel. By allowing an increase in the retail prices of diesel and petrol, the government will save on subsidies.

Table 4.7. Total petroleum subsidies in MYR billion, 2001–2010

	2001	2004	2005	2008	2009	2010
Fuel price (USD per barrel)	25.24	41.6	51.68	127.79	70.00	89.40
Subsidy (MYR billion)	2.40	4.8	8.16	15.38	5.59	9.11

Source: Ministry of Energy, Green Technology and Water (2011)

The Role of Subsidies in the Economy and Options for Rationalization

To understand and evaluate the potential impact of rationalizing fuel subsidies on Malaysia's macroeconomic performance, income distribution and poverty, it is important to analyze the role of subsidies in the economy by looking at the linkages between subsidies, the government budget, production, consumption and households.

The federal government's budget and subsidies

Since 1970, Malaysia has experienced difficulties in balancing its budget. The budget has been in deficit for all the years since then except for five in the early 1990s. This budget deficit trend is closely related to the level of commitment that the government has put into sustaining the economy as reflected in Table 4.8. The continued deficit from 3.9% of GNP in 1970 to 7.1% of GNP in 1980 reflects the government's direct and active role in the country's social and economic development process. The government undertook high expenditure to support the country's New Economic Policy (NEP).

The government's participation in the economy expanded further in the early 1980s as it pursued an expansionary counter-cyclical fiscal policy to ride out the effects of the global recession at the time. The counter-cyclical policy led to higher deficits of 16.1%, 17.36% and 10.55% of GDP in 1981, 1982 and 1983, respectively (EPU 2010). Confronted with

Table 4.8. The Malaysian government's fiscal accounts, 1970–2010

Items	1970	1980	1990	2004	2005	2006	2007	2008	2009	2010
Revenue	2,400	13,926	29,521	99,397	106,304	123,546	139,885	159,793	158,639	159,653
Operating expenditure	2,163	10,292	25,026	91,298	97,744	107,694	123,084	153,499	157,067	151,633
Current surplus/ deficit	237	3,634	4,495	8,099	8,561	15,852	16,801	6,294	1,573	8,020
Development account										
Gross devt expenditure	725	7,470	10,689	28,864	30,534	35,807	40,564	42,847	49,515	52,792
Less loan recoveries	13	132	2,757	1,346	3,250	846	3,105	959	519	1,496
Net devt expenditure	712	7,338	7,932	27,518	27,284	34,961	37,459	41,889	48,996	51,296
Overall surplus/deficit	-475	-3,704	-3,437	-19,419	-18,724	-19,109	-20,658	-35,594	-47,424	-43,275
% to GNP	-3.9	-7.1	-3	-4.3	-3.8	-3.4	-3.3	-4.9	-7.1	-5.9
% to GDP	-3.8	-6.8	-2.9	-4.1	-3.6	-3.3	-3.2	-4.8	-7.0	-5.6
GNP (1987=100)	12,181	52,370	114,017	449,646	498,503	557,146	628,065	719,438	665,298	739,451
GDP (1987=100)	12,534	54,286	119,081	474,048	522,445	574,441	642,049	742,470	679,938	765,965
GNP current price	-	-	-	449,646	498,503	557,146	628,065	719,438	665,298	739,451
GDP current price	-	-	-	474,048	522,445	574,441	642,049	742,470	679,938	765,965

Source: Malaysia Treasury Statistics (www.treasury.gov.my) the increasing deficit, the government implemented comprehensive structural programmes to reduce spending and adjusted national objectives to become consistent with domestic resource availability. Among the most significant new directions was the promotion of the private sector as the main engine of growth. This resulted in a reduction of government commercial activities through a privatization programme. The shift in emphasis towards private sector-driven growth contributed to a significant improvement in the government's financial position, a lower fiscal deficit position recorded during the late 1980s, and even a fiscal surplus for five years, from 1993 to 1997.

Due to the Asian financial crisis in 1997, an expansionary counter-cyclical fiscal policy resulted in a fiscal deficit of 1.76% of GDP in 1998. The deficit emerged again after surpluses for five years. As global economic uncertainties persisted, the 1999-2009 budgets maintained an expansionary stance, hence, the fiscal deficit continued from 3.2% of GDP in 1999 to 4.8% of GDP in 2008 and 7.0% of GDP in 2009. The fiscal deficit was estimated at 5.6% of GDP in 2010.

Subsidies impact government finances in several ways. First, they result in an increase in operating expenditure. Second, if the savings from cut subsidies are not used to reduce deficit, they could instead be utilized for development. Third, if the government can reduce its deficit, it means that it can reduce its borrowing. Subsidies of MYR 9.1 billion in 2010 represented 6.0% of the operating expenditure. The increase in fuel prices caused subsidies to increase, and, therefore, increased the operating expenditure, as reflected in Tables 4.8 and 4.9.

Between 2004 and 2010, the operating expenditure growth was about 7.5% per year, which was mainly due to the growth in petroleum subsidies of about 9.6% per year. Without subsidies, the fiscal deficit could be reduced. Fuel subsidies amounting to MYR 9.1 billion would reduce the fiscal deficit from 5.6% of GDP to 4.5% of GDP for 2010, which, in turn, would strengthen the country's financial position (EPU 2010). The savings from a reduction in or removal of subsidies could also be utilized for development. This can be done by incorporating petroleum subsidies in the development expenditure under the economic services category.

Table 4.9. Proportion of the total federal government operating expenditure: A functional classification

Sector	2004	2005	2006	2007	2008	2009	2010
Economic services	7.56	8.97	12.57	8.08	9.01	7.44	9.58
Agriculture and rural development	1.80	1.84	3.13	1.77	3.27	2.76	2.29
Public utilities	0.12	0.07	0.45	0.19	0.06	0.26	0.08
Trade and industry	2.48	3.84	4.19	2.05	2.36	1.46	4.30
Transportation	2.88	3.17	4.76	4.00	3.24	2.89	2.83
Communications	0.07	0.05	0.05	-	0.04	0.04	0.04
Other economic services	0.21	0.00	0.01	0.07	0.03	0.03	0.03
Social services	35.48	35.04	35.86	37.33	35.56	37.08	38.10
Education and training	23.57	23.59	23.76	24.73	23.80	25.03	24.94
Health	7.68	7.68	8.07	7.94	7.55	7.76	8.39
Housing	0.98	0.26	0.29	0.76	0.64	0.78	0.74
Other social services	3.25	3.51	3.74	3.90	3.57	3.50	4.03
Defense	7.71	7.93	7.85	7.76	6.90	7.20	6.43
Internal security	5.64	5.46	5.67	5.35	5.16	5.27	5.89
Petroleum subsidies	5.24	8.35	6.76	7.13	10.02	3.56	6.01
General administration	13.87	8.05	7.73	9.37	8.11	17.27	10.12
Other expenditure	24.50	26.21	23.55	24.99	25.25	22.19	23.88
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Economic Planning Unit (2004-2010)

Comparing the amount spent on petroleum subsidies with other expenditure will give an indication of the substitution size of the petroleum subsidies. Table 4.10 shows that in 2010, petroleum subsidies made up 14.7% of the total development expenditure, more than the combined total spending on agriculture and rural development, communications, health and housing (14.1% in total). Petroleum subsidies were slightly higher than the spending on trade and industry (11.3%), and transportation (14%) but lower than the spending on education and training (19.5%). In fact, the allocation for petroleum subsidies was the highest among the expenditure items in the economic services category. This clearly indicates that there is potentially high savings from a cut in petroleum subsidies, which could be allocated to other sectors.

Table 4.10. Malaysia's development expenditure, in percent

Sector	2004	2005	2006	2007	2008	2009	2010
Economic services	49.4	59.7	57.3	58.6	63.1	58.1	56.9
Agriculture and rural development	8.6	6.4	9.3	7.8	7.2	10.0	4.7
Public utilities	2.8	3.8	5.2	4.8	4.8	5.3	8.5
Trade and industry	3.6	8.3	7.9	9.9	7.9	8.9	11.3
Transportation	19.7	19.8	18.0	17.2	15.8	17.1	14.0
Communications	0.4	0.3	0.0	0.2	0.6	1.1	1.1
Petroleum subsidies	14.2	21.1	16.9	17.8	26.4	10.1	14.7
Other economic services	0.2	0.0	0.0	0.8	0.4	5.5	2.5
Social services	30.5	19.3	22.1	26.1	23.6	31.6	33.6
Education and training	12.8	9.7	12.4	12.7	13.6	19.6	19.5
Health	7.0	3.2	3.0	3.0	2.8	4.7	6.1
Housing	4.7	2.8	3.1	6.0	3.1	2.5	2.2
Other social services	5.9	3.6	3.6	4.4	4.1	4.7	5.9
Defense	11.0	10.5	8.2	8.3	7.1	4.8	4.3
Internal security	1.3	1.9	3.0	3.2	2.8	2.3	2.1
General administration	7.8	8.6	9.5	3.8	3.4	3.1	3.1
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Economic Reports 2004-2010, Ministry of Finance, Malaysia

Specifically, if the savings from the cut in petroleum subsidies is used for agriculture and rural area development, it will have a considerable effect on poverty reduction as most of the poor are living in rural areas and are closely involved in agricultural activities. Throughout the years, the spending for agriculture and rural area development has been low, recorded at less than 10% of total expenditure. Moreover, more spending on transportation is needed; there is a broad consensus that investing in economic infrastructure is a key ingredient for achieving long-term growth, economic diversification and sustainable poverty reduction.

For the period of 2004–2010, the share of the petroleum subsidy was highest in 2008 (Table 4.10). This was primarily due to the huge increase in the world price of fuel. This expansion of cost for the subsidy came at the expense of other sectors. For example, spending on agriculture and rural development, trade and industry, transportation, housing and general administration was lower in 2008 than in previous years. In fact, spending for health in 2008 was recorded as the lowest compared to other years.

In recent years, in an attempt to reduce the budget deficit, besides the scaling down of several large projects, fuel subsidies were cut and government-controlled fuel prices were allowed to increase. Table 4.2 shows that between May 2004 and June 2008, Malaysian fuel prices rose six times from MYR 1.37 per liter in May 2004 to MYR 2.70 per liter in June 2008. The budget deficit was down from 4.1% of GDP in 2004 to 3.2% of GDP in 2007 (Table 4.8). However, the 18% increase in government expenditure in the Ninth Malaysia Plan from the previous plan, as well as the high fiscal cost to sustain the fuel subsidy due to the tremendous increase in the world fuel price, resulted in a large budget deficit in 2009, at about 7% of GDP (Table 4.8).

This scenario has pushed Malaysia's policymakers to reconsider the future of the fuel subsidy policy. Past deficits were supported by substantial petroleum revenues and high domestic savings. These resources provided low cost borrowing. Nevertheless, the slower economic growth rate, lower fiscal revenue, and rising subsidy bill from 2008 onwards prompted the government to consider the need for further fuel subsidy reform. Without further reform, the rise in subsidies would jeopardize the government's ability to sustain fiscal viability. It was hoped that the petroleum subsidy reform would result in an improvement in the management of the budget.

The deficit

In determining whether the size of a fiscal deficit is manageable, among the considerations is the ability of revenue to meet operating expenditure. A constant surplus in the current account reduces the long-term risks for the country. Malaysia's higher net revenue has enabled the current surplus to be maintained for most years.

However, the operating expenditure has expanded rapidly since 2004, as can be seen in Table 4.11. Between 2004 and 2009, the operating expenditure growth of 9.5% was far higher than the growth of 7.4% during the previous period, 2000–2003. More importantly, the operating expenditure growth exceeded the total revenue growth of 8.1%. If this trend continues, Malaysia will reach a point of deficit where revenues will not be sufficient to cover operating expenditure. As discussed earlier, the rapid growth in operating expenditure is mainly due to the rise in fuel prices, and as the world fuel price is still at a high and uptrend level, a further cut in fuel subsidies is seen as necessary.

Table 4.11. Malaysia's growth in total revenue and expenditure, 2000–2009

	2000-2003		2004-2009	
	Average share (%)	Growth (%)	Average share (%)	Growth (%)
Revenue	-	10.6	-	8.1
Operating expenditure	65.6	7.4	76.1	9.5
Devt. expenditure	34.3	8.9	23.9	9.4
Total expenditure	-	7.9	-	9.5

Source: Economic Reports 2000-2009, Ministry of Finance, Malaysia

Subsidies, sectorial economics and households

The impact of subsidies affects economic sectors and households differently, depending on the respective share of fuel in production and consumption. Households consume about 3.63% of all fuel while most of the fuel is consumed as intermediate inputs in manufacturing (32.61%), transport and communication (8.81%), and electricity, gas and water (8.47%) (Table 4.12). Agriculture, fishery and forestry together consume about 0.75%, mostly for irrigation. The transport sector, as the second biggest consumer of fuel, plays an important role in other sectors; industry and services for instance, are the most transportation-intensive sectors.

Table 4.12. Fuel consumption by sector in the Malaysian economy

Sectors	Share in total fuel consumption (%)
Manufacturing	32.61
Transport and communication	8.81
Electricity, gas and water	8.47
Wholesale and retail trade	4.95
Mining and quarrying	4.66
Households	3.63
Finance and insurance	3.10
Hotel and restaurants	2.86
Construction	2.48
Business and private services	2.07
Government services	1.01
Agriculture, fishery and forestry	0.75
Real estate and ownership of dwellings	0.65
Others	27.59

Source: Department of Statistics (2010)

In general, the direct effects on households from subsidy rationalization relate to their consumption of fuel products whereas the indirect effects relate to the change in real household incomes because of the higher costs of goods and services. Table 4.13 indicates that direct expenditure for fuel is low at MYR 129.09 per capita per year or about 1.15% of household expenditure. The private consumption of fuel is more important; in considering the case of transportation, share of private consumption in transportation (which is fuel intensive) is about 1.32% (Department of Statistics 2010).

Table 4.13. Private consumption of crude oil and petroleum refinery products

	Per capita expenditure	Share in total expenditure
Fuel	129.09	1.15
Transport	148.54	1.32
Fuel plus transport	277.63	2.46

Source: Department of Statistics (2010)

In summary, petroleum subsidies make up a significant share of government expenditure and has important direct and indirect impacts on real household incomes. Subsidy reform is expected to reduce household welfare and increase the production costs of economic activities in the short run while freeing up substantial resources that can be used for alternative expenditure.

The computable general equilibrium model

The study's analysis used the CRUSOE-MY model, a CGE model with additional information on fuel subsidies by industry from the Input-Output Tables Malaysia and employment. The information on fuel subsidies was divided into two types of fuel consumption: a) petrol/gasoline, which is usually used by households or passenger vehicles; and b) diesel, used more by industry and the transport sector. Energy commodities included petrol, diesel oil, coke and coal, and natural gas.

The second information category pertained to employment, which was classified into two sub-categories: skilled and unskilled labor. In this respect, the model had nine sub-categories of labor, categorized by occupation (Ministry of Human Resources 2009) (Table 4.14). This was to capture the impact of a subsidy reduction or an increase in fuel (petrol and diesel) prices on industries as well as households as represented by employment.

The GEMPACK software was used for running the CGE model (Harrison and Pearson 1994). The software automates the process of translating model specifications into a model solution program.

Table 4.14. Employment by type of occupation

Category	Occupation	
Skilled	1. Senior officials and managers	3. Technicians and associate professionals
	2. Professionals	
Unskilled	4. Clerical workers	7. Craft workers
	5. Service workers	8. Plant and machine operators
	6. Skilled agriculture workers	9. Elementary workers

Source: Ministry of Human Resources (2009)

a) Source of data

This study used the Input-Output Tables Malaysia 2005, the latest available tables at the time of the study, published by the Malaysian Department of Statistics (2010). The data consisted of 120 industries/commodities. However, for this study, the subsector of petroleum refinery products was disaggregated into three categories based on the Malaysian Industrial Standard Classification (Department of Statistics 2000), namely: petrol products; diesel oil products; and other fuels, consisting of coke, coal and gas.

The structure of the CGE model based on the Malaysian database construction of each flow matrix is presented in Figure 4.3. The information for the absorption matrix was obtained by combining Tables 22, 4, 6 and 7 in the Input-Output Tables 2005, which can be seen in Table 4.15. The basic structure of the tables was incorporated into a TABLO input file using ordinary algebraic notation.

		Absorption Matrix				
		1	2	3	4	5
		Producers	Investors	Household	Export	Government
	Size	I	I	H	1	1
Basic Flows: Domestic	C	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS
Basic Flows: Imported	C	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS
Taxes	CxS	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX
Labor	O	V1LAB				
Capital	1	V1CAP				
Land	1	V1LND				
Other Costs	1	V1OCT				

Figure 4.3 The structure of data construction in the CRUSOE-MY model

There are 122 commodities and 120 industries covered in this paper. The 44th commodity is disaggregated into three (i.e., petrol, diesel and other fuels) for analysis. The Input-Output Tables describe the behavior of the agents below for certain time periods:

i. Producers' demands for intermediate inputs and primary factors;
ii. Producers' supplies of produced output/commodities;
iii. Producers' demands for inputs for capital formation;

iv. Household demand;
v. Export demand; and
vi. Government demand.

Table 4.15. Source of data construction

Number	Coefficient	Source
1	V1BAS(domestic)	Table 22 (first quadrant)
	V1BAS(imported)	Table 4 (first quadrant)
2	V2BAS(domestic)	Table 22 (second quadrant)
	V2BAS(imported)	Table 4 (second quadrant)
3	V3BAS(domestic)	Table 22 (second quadrant)
	V3BAS(imported)	Table 4 (second quadrant)
4	V4BAS(domestic)	Table 22 (second quadrant)
	V4BAS(imported)	Table 4 (second quadrant)
5	V5BAS(domestic)	Table 22 (second quadrant)
	V5BAS(imported)	Table 4 (second quadrant)
6	V1TAX	Table 6-7 (first quadrant) + fuel subsidy
7	V2TAX	Table 6-7 (second quadrant)
8	V3TAX	Table 6-7 (second quadrant)
9	V4TAX	Table 6-7 (second quadrant)
10	V5TAX	Table 6-7 (second quadrant)
11	V1LAB	Table 22 (third quadrant)
12	V1CAP	Table 22 (third quadrant)
13	V1LND	33% of V1CAP (agriculture), 0 for other sectors
14	V1OCT	Table 22 (third quadrant)

Source: Input-Output Tables Malaysia 2005, Department of Statistics (2010)

Therefore, six demand agents of input and outputs appear in a column in this matrix:

i. *Domestic producers*, divided into *I* industries;
ii. *Investors*, divided into *I* industries;
iii. *Households*, divided into *H* representative households;
iv. *Foreign purchasers of export,* in aggregate;

v. *"Other"* demands category broadly corresponding to government, in aggregate; and
vi. *Change in inventories,* in aggregate.

The last five demand agents are recognized as the final ones for commodities. Meanwhile, the supply side is represented by rows in the absorption matrix and make matrix. The CRUSOE model involves many equations that show the linkages between economic activities. In particular, the CRUSOE model analyzes the following:

i. Producers' demand for intermediate and primary inputs (capital, labor and land);
ii. Producers' demand for investment goods in generating capital;
iii. Supply of commodities offered by producers;
iv. Household consumption demand;
v. Export demand;
vi. Government expenditure;
vii. Relationships between production value, production cost and selling price;
viii. Market clearing conditions for commodity as well as for primary input; and
ix. Other macro-indicators and price indices.

The interaction between agents (producers, investors, households, government and exporters) represents the whole economy. Since the interaction between agents can be illustrated by equations, the whole economy can be represented by several block equations in the CRUSOE model. The linkages between blocks represent the interactions between agents and are illustrated in Figure 4.4.

Labor data was disaggregated into type of employment by occupation. From type of labor by occupation, this study disaggregated labor into skilled and unskilled categories (Table 4.14). Some of the labor information was obtained from Malaysia's Ministry of Human Resources. The data for land was obtained from the National Agricultural Survey in 2005 by Malaysia's Ministry of Agriculture and Agro-Based Industry. Fuel data was disaggregated into petrol/gasoline and diesel. These two types of fuel have a larger consumption among households and industries. The data was obtained from the 2005 National Energy Balance, published by the Malaysian Ministry of Energy, Water and Communications (2006).

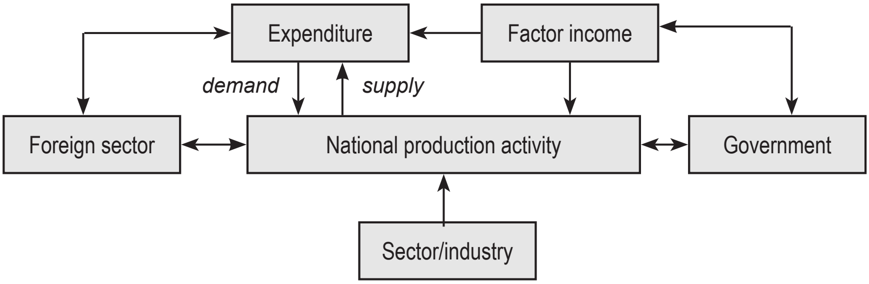

Figure 4.4. The linkages between blocks representing the interaction between agents
Source: Abimanyu (2000)

b) Simulation strategy

Table 4.16 shows the five simulation scenarios that were analyzed in this study. The purpose of all the simulations was to investigate the impact of fuel price increases, which directly represented subsidy reductions in government expenditure.

Table 4.16. The five simulation scenarios

	Scenario	Explanation
SIM1	f1tax_csi is increased by 1%	Tax on producers is increased by 1%
SIM2	f0tax_s("C44aPetrol") is increased by 1%	Tax on all petrol users (i.e., producers, households, investors, government and exporters) is increased by 1%
SIM3	f0tax_s("C44bDiesel") is increased by 1%	Tax on all diesel users is increased by 1%
SIM4	f0tax_s("C44cOthFuel") is increased by 1%	Tax on all users of other fuels is increased by 1%
SIM5	f0tax_s("all fuels") is increased by 1%	Tax on all users of all fuels is increased by 1%

RESULTS AND DISCUSSION

Table 4.17 shows the impact on selected macroeconomic variables, employment by occupation and industry, and industry output of a 1% commodity tax increase on fuel commodities for producers (SIM1). Results show that real GDP, exports, and imports would decrease. Conversely, household expenditure and government expenditure, in nominal terms, would increase. All types of occupations would experience contractions in employment, ranging between 3.177% and 3.547% (Table 4.17). Skilled workers (i.e., senior officials and managers) and professionals, would have a relatively high reduction in employment at 3.490% and 3.424%, respectively. The clerical and service occupations would have a larger percent reduction in terms of unskilled workers, at 3.438% and 3.547%, respectively.

An increase in the tax of petroleum refinery products represents an increase in the price of fuel commodities, which would result in a decrease in output for most industries of the Malaysian economy (Table 4.17). These results are similar to those for employment by industry, which would also show a decrease. The decrease in the output of petrol products, diesel products and other fuel products would be 1.322%, and employment would decrease by 12.006% for petrol products and other fuel products, and by 12.005% for diesel products.

Other industries closely related to the petroleum refinery sector would also show a reduction in both output and employment (Table 4.17). These industries would include land transport (-1.121% for output and -2.140% for employment), air transport (-0.841% for output and -1.271% for employment) and electricity and gas (-1.068% for output and -11.891% for employment). The water transport, waterworks, and real estate industries would also experience big contractions in employment of -8.631%, -8.508% and -11.804%, respectively. Similarly, other transport services would show a percentage reduction in output and employment of -0.913 and -3.490, respectively. These results indicate that an increase in tax on fuels would result in a decrease in output and employment by industry in the Malaysian economy.

Other industries in the manufacturing sector expected to experience a large reduction in output would be producers of rubber glove products (-4.342%); TV, radio receivers and transmitters (-4.386%); and semi-conductor devices and circuit board products (-3.603%). In the agriculture sector, the reduction in the metal ore mining industry is expected to be -2.431% while reduction would be -1.864% in the vegetable industry (Table 4.17).

The results further show that most industries would experience a larger contraction in employment compared to output (Table 4.17). A few industries in the manufacturing sector that are expected to record big contractions in employment are animal feeds (-10.528%), rubber processing (-15.282%), and semi-conductor devices and circuit board products (-10.758%). The agriculture sector would see a contraction for other livestock (-8.372%), metal ore mining (-7.658%), and forestry and logging (-6.546%).

Table 4.17. SIM1 results for macroeconomic variables, employment and industry, in percent

Macroeconomic Variables	
Gross Domestic Product (real)	-0.962
Household expenditure	0.422
Government expenditure	0.765
Export	-1.757
Import	-1.059
Employment	
1. Senior officials and managers	-3.490
2. Professionals	-3.424
3. Technicians and associate professionals	-3.293
4. Clerical workers	-3.438
5. Service workers	-3.547
6. Skilled agriculture workers	-3.331
7. Craft workers	-3.177
8. Plant and machine operators	-3.244
9. Elementary workers	-3.346

Table 4.17 continued

Industry	*Output*	*Employment*
Agriculture		
1. Paddy	-1.309	-2.443
2. Food crops	-1.410	-2.858
3. Vegetables	-1.864	-3.077
4. Fruits	-1.265	-2.265
5. Rubber	-0.497	-2.224
6. Oil palm	-1.366	-2.999
7. Flower plants	-0.915	-2.156
8. Other agriculture	-1.012	-3.300
9. Poultry farming	-1.393	-2.978
10. Other livestock	-1.208	-8.372
11. Forestry and logging	-1.064	-6.546
12. Fishing	-0.687	-2.949
13. Crude oil and natural gas	-0.033	-2.160
14. Metal ore mining	-2.431	-7.658
15. Stone clay and sand quarrying	-0.648	-1.836
16. Other mining and quarrying	-0.404	-2.271
Manufacturing		
1. Meat and meat production	-2.269	-3.183
2. Preservation of seafood	-1.856	-7.150
3. Preservation of fruits and vegetables	-1.069	-6.302
4. Dairy production	-0.956	-6.914
5. Oils and fats	-1.385	-7.495
6. Grain mills	-1.293	-4.795
7. Bakery products	-0.582	-1.573
8. Confectionery	-0.882	-7.082
9. Other food processing	-1.253	-5.655
10. Animal feed	-0.970	-10.528
11. Wine and spirits	-1.344	-6.041
12. Soft drinks	-0.546	-2.272
13. Tobacco products	-1.356	-6.788
14. Yarn and cloth	-1.179	-6.686
15. Finishing of textiles	-1.179	-6.686

Table 4.17 continued

Industry	*Output*	*Employment*
Manufacturing		
16. Other textiles	-2.100	-6.479
17. Wearing apparel	-1.119	-4.017
18. Leather industries	-1.345	-4.144
19. Footwear	-1.708	-4.655
20. Sawmilling and planning of wood	-0.569	-1.880
21. Veneer sheets, plywood, laminated and particle board	-1.016	-3.500
22. Builders' carpentry and joinery	-1.681	-3.051
23. Wooden and cane containers	-1.821	-3.466
24. Other wood products	-0.893	-2.572
25. Paper and paper products and furniture	-1.499	-5.274
26. Publishing	-1.166	-4.163
27. Printing	-0.757	-2.735
28. Petrol products	***-1.322***	***-12.006***
29. Diesel producers	***-1.322***	***-12.005***
30. Other fuel products	***-1.322***	***-12.006***
31. Basic chemicals	-1.502	-8.894
32. Fertilizers	-1.975	-7.309
33. Paints and varnishes	-1.191	-5.031
24. Pharmaceuticals, chemicals and botanical product	-1.508	-5.019
35. Soap, perfumes, cleaning and toilet preparations	-0.783	-6.528
36. Other chemical products	-0.635	-6.424
37. Tyres	-1.667	-3.733
38. Rubber processing	-2.765	-15.282
39. Rubber gloves	-4.342	-6.693
40. Rubber products	-2.254	-5.232
41. Plastic products	-1.757	-5.696
42. Sheet glass and glass products	-1.943	-5.208
43. Clay and ceramics	-0.959	-2.961
44. Cement, lime and plaster	-0.729	-2.867
45. Concrete and other non-metallic mineral products	-0.607	-1.683
46. Iron and steel products	-1.956	-7.424
47. Basic precious and non-ferrous metals	-1.836	-7.087

Table 4.17 continued

Industry	*Output*	*Employment*
Manufacturing		
48. Casting of metals	-2.639	-8.650
49. Structural metal products	-1.202	-3.686
50. Other fabricated metal products	-1.777	-5.262
51. Industrial machinery	-1.405	-8.069
52. General purpose machinery	-1.378	-6.541
53. Special purpose machinery	-0.989	-4.690
54. Domestic appliances	-1.877	-8.132
55. Office, accounting and computing machinery	-1.316	-7.256
56. Electrical machinery and apparatus	-3.213	-5.392
57. Other electrical machinery	-1.067	-6.701
58. Insulated wires and cables	-2.509	-8.733
59. Electric lamps and lighting equipment	-2.193	-6.526
60. Semi-conductor devices, tubes and circuit boards	-3.603	-10.758
61. TV, radio receivers and transmitters, and assoc. goods	-4.386	-7.989
62. Medical, surgical and orthopaedic appliances	-1.131	-4.283
63. Measuring, checking and industrial process equipment	-3.619	-6.799
64. Optical instruments and photographic equipment	-1.283	-5.149
65. Watches and clocks	-1.505	-5.163
66. Motor vehicles	-0.515	-1.300
67. Motorcycles	-2.051	-4.797
68. Ship and boat building, bicycles and invalid carriages	-2.001	-7.930
69. Other transport equipment	-0.695	-3.565
70. Other manufacturing	-1.180	-4.309
Services		
1. Recycling	-0.175	-3.983
2. Electricity and gas	-1.068	-11.891
3. Waterworks	-0.908	-8.508
4. Residential	0.437	0.662
5. Non residential	0.565	0.862
6. Civil engineering	0.040	0.067
7. Special trade works	-0.625	-1.069
8. Wholesale and retail trade	-1.525	-4.350

Table 4.17 continued

Industry	*Output*	*Employment*
Services		
9. Accommodation	-0.721	-1.950
10. Restaurants	-0.797	-1.198
11. Land transport	-1.121	-2.140
12. Water transport	-1.279	-8.631
13. Air transport	-0.841	-1.271
14. Other transport services	-0.913	-3.490
15. Port and airport operation services	-0.619	-1.681
16. Highway, bridge and tunnel operation services	-0.919	-3.569
17. Communication	-0.819	-4.652
18. Banks	-1.037	-3.723
19. Financial institutions	-0.663	-3.967
20. Insurance	-0.519	-2.673
21. Other financial institutions	-0.696	-3.793
22. Real estate	-1.089	-11.804
23. Ownership of dwellings	0.000	0.000
24. Rental and leasing	-0.009	-0.014
25. Computer services	-1.147	-1.601
26. Research and development	-0.071	-0.093
27. Professional	-1.520	-2.079
28. Business services	-0.942	-1.818
29. Public administration	-0.366	-0.427
30. Education	-0.300	-0.421
31. Health	0.051	0.102
32. Defence and public order	-0.024	-0.027
33. Other public administration	-0.019	-0.022
34. Private non-profit institution	-0.395	-0.654
35. Amusement and recreational services	-0.172	-0.359
36. Other private services	-1.360	-1.947

Note: SIM1 *f1tax_csi*: 1% tax increase on producers.

Results for SIM2, SIM3, SIM4, and SIM5 show that industries closely related to the petroleum refinery sector (i.e., land transport, air transport, other transport services, port and airport operation services, and highway, bridge and tunnel operation services) would experience a reduction in both output and employment (Table 4.18). Land transport would experience a larger reduction in output, at -0.021% (SIM2), -0.022% (SIM3), and -0.017% (SIM4). Water transport would experience a larger reduction in employment, at -0.101% (SIM2), -0.106% (SIM3), and -0.085% (SIM4). Furthermore, increasing the tax by 1% for all fuels (SIM5) would result in land transport experiencing a total reduction in industry output of -0.060% and water transport experiencing a -0.292% decrease in employment. There would be a larger reduction in output and employment for diesel products (SIM3), followed by petrol products (SIM2) and other fuel products (SIM4) (Table 4.18).

Based on SIM2, SIM3 and SIM4 results, the waterworks industry would experience a big contraction both in output and employment. The reductions would be: -0.019% and -0.178% (SIM2), -0.020% and -0.188% (SIM3), and, -0.016% and -0.150% (SIM4). These results, however, are different from those of an earlier Indonesian study (Yusuf and Resosudarmo 2008) that found a larger contraction in output for the electricity and gas industry.

In the agriculture sector, SIM5 (all fuel products) results suggest that there would be reductions for: stone, clay and sand quarrying (-0.094% in output, -0.267% in employment); forestry and logging (-0.040% in output, -0.252% in employment); metal ore mining (-0.069% in output, -0.222% in employment); oil palm (-0.088% in output, -0.193% in employment); crude oil and natural gas (-0.001% in output, -0.094% in employment); flower plants (-0.034% in output, -0.080% in employment); and fishing (-0.013% in output, -0.054% in employment) (Table 4.18).

SIM 5 (all fuel products) results also indicate that there would be reductions in the following for the manufacturing sector: oils and fats products (-0.092% in output, -0.506% in employment); animal feeds products (-0.009% in output, -0.103% in employment); finishing of textiles products (-0.060% in output, -0.346% in employment); basic chemical products (-0.180% in output, -1.087% in employment); other chemical products (-0.084% in output, -0.858% in employment); sheet glass and glass products (-0.126% in output, -0.341% in employment);

and, cement, lime and plaster products (-0.120% in output, -0.475% in employment) (Table 4.18).

Macroeconomic variables of real GDP, exports and imports have positive signs based on SIM2, SIM3, and SIM4 results (Table 4.18). Household expenditure and government expenditure, in nominal terms, have negative signs. This is because an increase in the prices of petrol products, diesel products, and other fuel products (SIM2, SIM3 and SIM4, respectively), effected through an increase in tax, would decrease household expenditure as a result of an increase in the cost of living. Government expenditure, through fuel subsidy reductions, would fall by 0.012% (SIM2), 0.013% (SIM3) and 0.010% (SIM4) (Table 4.18); this is good in terms of having more revenue in the budget, which could be allocated for specific target groups.

An increase in fuel prices would have more impact on the expansion of employment by occupation. Based on SIM2, SIM3 and SIM4 results, all types of occupations would show an expansion in employment ranging between 0.005% and 0.012% (Table 4.18). A 1% tax increase on diesel products (SIM3) would result in a slightly larger expansion for three types of occupations: 0.012% for senior officials and managers, 0.011% for professionals, and 0.012% for service workers.

Most industries would experience a fall in output due to an increase in tax on all users (Table 4.18). This is because some producers would not be able to reduce the use of petroleum products. Price increases for petrol, diesel and other fuel products would raise the costs of production and result in contractions of output by industry. Similarly, employment by industry would also decline in most industries. The decrease in output resulting from an increase in tax on diesel users (SIM3) would be relatively larger for most industries as compared to that resulting from an increase in tax on petrol products users (SIM2). A tax increase on users of other fuel products (SIM4) would show a smaller decline in both output and employment by industry.

Table 4.18. SIM2, SIM3, SIM4, and SIM5 results for macroeconomic variables, employment and industry, in percent

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Macroeconomic Variables								
Gross Domestic Products (real)	0.003		0.003		0.002		0.007	
Household expenditure	-0.001		-0.001		-0.001		-0.004	
Government expenditure	-0.012		-0.013		-0.010		-0.035	
Export	0.021		0.022		0.018		0.060	
Import	0.023		0.024		0.019		0.066	
Employment								
1. Senior officials and managers	0.011		0.012		0.009		0.032	
2. Professionals	0.010		0.011		0.008		0.029	
3. Technicians and associate professionals	0.007		0.007		0.006		0.019	
4. Clerical workers	0.010		0.010		0.008		0.028	
5. Service workers	0.011		0.012		0.009		0.032	
6. Skilled agriculture workers	0.010		0.010		0.008		0.029	
7. Craft workers	0.007		0.007		0.006		0.020	
8. Plant and machine operators	0.007		0.007		0.005		0.019	
9. Elementary workers	0.009		0.009		0.007		0.025	
Industry	***Output***	***Employment***	***Output***	***Employment***	***Output***	***Employment***	***Output***	***Employment***
Agriculture								
1. Paddy	0.007	0.013	0.007	0.014	0.006	0.011	0.020	0.038
2. Food crops	0.014	0.028	0.014	0.029	0.012	0.023	0.040	0.081

Table 4.18 continued

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Agriculture	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*
3. Vegetables	0.034	0.057	0.036	0.060	0.029	0.048	0.099	0.164
4. Fruits	0.005	0.009	0.005	0.010	0.004	0.008	0.015	0.026
5. Rubber	0.007	0.031	0.007	0.032	0.006	0.026	0.020	0.089
6. Oil palm	-0.030	-0.067	-0.032	-0.070	-0.025	-0.056	-0.088	-0.193
7. Flower plants	-0.012	-0.027	-0.012	-0.029	-0.010	-0.023	-0.034	-0.080
8. Other agriculture	0.014	0.045	0.015	0.048	0.012	0.038	0.040	0.131
9. Poultry farming	0.005	0.010	0.005	0.011	0.004	0.008	0.013	0.029
10. Other livestock	0.011	0.078	0.012	0.082	0.009	0.065	0.032	0.225
11. Forestry and logging	-0.014	-0.087	-0.015	-0.092	-0.012	-0.073	-0.040	-0.252
12. Fishing	-0.004	-0.019	-0.005	-0.020	-0.004	-0.016	-0.013	-0.054
13. Crude oil and natural gas	-0.0005	-0.032	-0.001	-0.034	-0.0004	-0.027	-0.001	-0.094
14. Metal ore mining	-0.024	-0.076	-0.025	-0.081	-0.020	-0.064	-0.069	-0.222
15. Stone clay and sand quarrying	-0.032	-0.092	-0.034	-0.097	-0.027	-0.078	-0.094	-0.267
16. Other mining and quarrying	0.002	0.011	0.002	0.012	0.002	0.010	0.006	0.033
Manufacturing								
1. Meat and meat production	0.054	0.075	0.057	0.079	0.045	0.063	0.155	0.218
2. Preservation of seafood	0.017	0.065	0.018	0.069	0.014	0.055	0.048	0.189
3. Preservation of fruits and vegetables	-0.003	-0.020	-0.004	-0.021	-0.003	-0.016	-0.010	-0.057
4. Dairy production	0.010	0.074	0.011	0.078	0.009	0.062	0.029	0.215
5. Oils and fats	-0.032	-0.175	-0.034	-0.185	-0.027	-0.147	-0.092	-0.506

Table 4.18 continued

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Manufacturing	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*
6. Grain mills	0.007	0.026	0.007	0.028	0.006	0.022	0.020	0.075
7. Bakery products	-0.018	-0.049	-0.019	-0.052	-0.015	-0.041	-0.053	-0.143
8. Confectionery	0.018	0.148	0.019	0.156	0.015	0.125	0.053	0.429
9. Other food processing	0.005	0.024	0.006	0.025	0.004	0.020	0.015	0.069
10. Animal feed	-0.003	-0.035	-0.003	-0.037	-0.003	-0.030	-0.009	-0.103
11. Wine and spirits	0.028	0.128	0.030	0.136	0.024	0.108	0.082	0.372
12. Soft drinks	-0.008	-0.034	-0.009	-0.036	-0.007	-0.029	-0.024	-0.099
13. Tobacco products	0.029	0.148	0.031	0.157	0.025	0.125	0.085	0.430
14. Yarn and cloth	-0.007	-0.024	-0.008	-0.026	-0.006	-0.020	-0.021	-0.070
15. Finishing of textiles	-0.021	-0.119	-0.022	-0.126	-0.017	-0.100	-0.060	-0.346
16. Other textiles	0.009	0.028	0.009	0.029	0.007	0.023	0.026	0.080
17. Wearing apparel	0.027	0.098	0.028	0.103	0.023	0.082	0.078	0.282
18. Leather industries	0.018	0.055	0.019	0.058	0.015	0.046	0.051	0.159
19. Footwear	0.044	0.122	0.047	0.129	0.037	0.103	0.129	0.353
20. Sawmilling and planning of wood	0.007	0.022	0.007	0.023	0.006	0.018	0.019	0.063
21. Veneer sheets, plywood, laminated & particle board	-0.009	-0.031	-0.009	-0.032	-0.007	-0.026	-0.026	-0.088
22. Builders' carpentry and joinery	0.016	0.029	0.017	0.031	0.014	0.025	0.046	0.085
23. Wooden and cane containers	0.022	0.041	0.022	0.041	0.019	0.037	0.062	0.119
24. Other wood products	-0.010	-0.030	-0.011	-0.031	-0.009	-0.025	-0.030	-0.086

Table 4.18 continued

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Manufacturing	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*
25. Paper and paper products and furniture	-0.009	-0.030	-0.009	-0.032	-0.007	-0.025	-0.025	-0.088
26. Publishing	0.007	0.025	0.007	0.027	0.006	0.021	0.020	0.073
27. Printing	-0.004	-0.015	-0.005	-0.016	-0.004	-0.013	-0.012	-0.045
28. Petrol products	-0.010	-0.091	-0.027	-0.254	-0.022	-0.202	-0.059	-0.547
29. Diesel products	-0.026	-0.241	-0.011	-0.104	-0.022	-0.202	-0.059	-0.547
30. Other fuel products	-0.026	-0.241	-0.027	-0.254	-0.006	-0.052	-0.059	-0.547
31. Basic chemicals	-0.062	-0.376	-0.066	-0.397	-0.052	-0.316	-0.180	-1.087
32. Fertilizers	0.003	0.010	0.003	0.011	0.002	0.009	0.008	0.029
33. Paints and varnishes	-0.001	-0.005	-0.001	-0.006	-0.001	-0.005	-0.004	-0.016
34. Pharmaceutical, chemical & botanical products	0.005	0.017	0.005	0.018	0.004	0.015	0.015	0.050
35. Soap, perfumes, cleaning and toilet preparations	0.025	0.212	0.026	0.224	0.021	0.178	0.073	0.615
36. Other chemical products	-0.029	-0.297	-0.031	-0.313	-0.024	-0.250	-0.084	-0.858
37. Tyres	-0.007	-0.016	-0.008	-0.017	-0.006	-0.014	-0.021	-0.047
38. Rubber processing	-0.005	-0.027	-0.005	-0.028	-0.004	-0.022	-0.014	-0.078
39. Rubber gloves	-0.002	-0.004	-0.002	-0.004	-0.002	-0.003	-0.007	-0.011
40. Rubber products	0.007	0.016	0.007	0.017	0.006	0.013	0.019	0.045
41. Plastic products	0.010	0.034	0.011	0.036	0.009	0.028	0.030	0.097
42. Sheet glass and glass products	-0.044	-0.118	-0.046	-0.125	-0.037	-0.099	-0.126	-0.341
43. Clay and ceramics	-0.031	-0.095	-0.032	-0.100	-0.026	-0.080	-0.089	-0.275

Table 4.18 continued

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Manufacturing	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*
44. Cement, lime and plaster	-0.041	-0.164	-0.044	-0.173	-0.035	-0.138	-0.120	-0.475
45. Concrete and other non-metallic mineral products	-0.017	-0.046	-0.017	-0.048	-0.014	-0.039	-0.048	-0.133
46. Iron and steel products	-0.008	-0.033	-0.009	-0.034	-0.007	-0.027	-0.025	-0.095
47. Basic precious and non-ferrous metals	0.037	0.145	0.039	0.153	0.031	0.122	0.107	0.420
48. Casting of metals	0.042	0.139	0.044	0.146	0.035	0.117	0.120	0.401
49. Structural metal products	-0.004	-0.013	-0.005	-0.014	-0.004	-0.011	-0.012	-0.038
50. Other fabricated metal products	0.008	0.023	0.008	0.024	0.006	0.019	0.022	0.065
51. Industrial machinery	0.036	0.209	0.038	0.220	0.030	0.175	0.103	0.604
52. General purpose machinery	-0.013	-0.062	-0.014	-0.065	-0.011	-0.052	-0.037	-0.180
53. Special purpose machinery	0.017	0.083	0.018	0.088	0.015	0.070	0.050	0.240
54. Domestic appliances	0.053	0.232	0.056	0.245	0.044	0.195	0.152	0.672
55. Office, accounting and computing machinery	0.033	0.186	0.035	0.196	0.028	0.156	0.096	0.537
56. Electrical machinery and apparatus	0.097	0.163	0.102	0.172	0.081	0.137	0.280	0.473
57. Other electrical machinery	0.025	0.156	0.026	0.165	0.021	0.131	0.071	0.452
58. Insulated wires and cables	0.041	0.147	0.044	0.155	0.035	0.123	0.120	0.425
59. Electric lamps and lighting equipment	0.056	0.169	0.059	0.178	0.047	0.142	0.162	0.489
60. Semi-conductor devices, tubes and circuit boards	0.101	0.308	0.107	0.326	0.085	0.259	0.293	0.894

Table 4.18 continued

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Manufacturing	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*
61. TV, radio receivers and transmitters, & associated goods	0.134	0.246	0.141	0.260	0.112	0.207	0.388	0.714
62. Medical, surgical and orthopaedic appliances	0.026	0.101	0.028	0.107	0.022	0.085	0.076	0.292
63. Measuring, checking & industrial process equipment	0.109	0.207	0.115	0.219	0.092	0.174	0.316	0.600
64. Optical instruments & photographic equipment	0.032	0.128	0.033	0.135	0.027	0.108	0.092	0.371
65. Watches and clocks	0.006	0.019	0.006	0.021	0.005	0.016	0.016	0.056
66. Motor vehicles	-0.001	-0.003	-0.001	-0.003	-0.001	-0.003	-0.004	-0.009
67. Motorcycles	0.015	0.034	0.015	0.036	0.012	0.029	0.042	0.099
68. Ship and boat building, bicycles & invalid carriages	0.039	0.155	0.041	0.164	0.032	0.131	0.112	0.449
69. Other transport equipment	0.004	0.020	0.004	0.021	0.003	0.017	0.011	0.058
70. Other manufacturing	0.019	0.070	0.020	0.074	0.016	0.059	0.055	0.204
Services								
1. Recycling	-0.00003	-0.001	-0.00004	-0.001	-0.00002	-0.001	-0.0001	-0.002
2. Electricity and gas	0.021	0.239	0.022	0.252	0.018	0.201	0.060	0.689
3. Waterworks	-0.019	-0.178	-0.020	-0.188	-0.016	-0.150	-0.054	-0.516
4. Residential	-0.007	-0.011	-0.008	-0.012	-0.006	-0.010	-0.022	-0.033
5. Non-residential	-0.014	-0.022	-0.015	-0.023	-0.012	-0.019	-0.042	-0.064
6. Civil engineering	-0.017	-0.028	-0.017	-0.029	-0.014	-0.023	-0.048	-0.081

Table 4.18 continued

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Services	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*
7. Special trade works	0.012	0.021	0.013	0.022	0.010	0.017	0.035	0.060
8. Wholesale and retail trade	0.011	0.031	0.011	0.033	0.009	0.026	0.031	0.089
9. Accommodation	-0.003	-0.009	-0.004	-0.010	-0.003	-0.008	-0.010	-0.027
10. Restaurants	-0.028	-0.042	-0.030	-0.045	-0.024	-0.036	-0.082	-0.123
11. Land transport	-0.021	-0.040	-0.022	-0.042	-0.017	-0.033	-0.060	-0.115
12. Water transport	-0.015	-0.101	-0.015	-0.106	-0.012	-0.085	-0.042	-0.292
13. Air transport	-0.009	-0.013	-0.009	-0.014	-0.007	-0.011	-0.025	-0.038
14. Other transport services	-0.014	-0.056	-0.015	-0.059	-0.012	-0.047	-0.042	-0.161
15. Port and airport operation services	-0.015	-0.040	-0.016	-0.043	-0.013	-0.034	-0.043	-0.117
16. Highway, bridge and tunnel operation services	-0.014	-0.056	-0.015	-0.059	-0.012	-0.047	-0.042	-0.163
17. Communication	-0.005	-0.031	-0.006	-0.033	-0.005	-0.026	-0.016	-0.091
18. Banks	-0.008	-0.028	-0.008	-0.030	-0.007	-0.024	-0.022	-0.081
19. Financial institutions	-0.011	-0.064	-0.011	-0.068	-0.009	-0.054	-0.031	-0.186
20. Insurance	0.009	0.046	0.009	0.049	0.008	0.039	0.026	0.134
21. Other financial institutions	-0.005	-0.028	-0.005	-0.029	-0.004	-0.023	-0.015	-0.080
22. Real estate	-0.015	-0.166	-0.016	-0.176	-0.013	-0.140	-0.043	-0.482
23. Ownership of dwellings	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24. Rental and leasing	-0.008	-0.013	-0.008	-0.014	-0.007	-0.011	-0.023	-0.038
25. Computer services	-0.008	-0.011	-0.008	-0.012	-0.007	-0.009	-0.023	-0.033

Table 4.18 continued

Scenario	**SIM 2**		**SIM 3**		**SIM 4**		**SIM 5**	
Services	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*	*Output*	*Employment*
26. Research and development	-0.003	-0.003	-0.003	-0.004	-0.002	-0.003	-0.008	-0.010
27. Professional	-0.014	-0.020	-0.015	-0.021	-0.012	-0.017	-0.042	-0.057
28. Business services	0.000	0.0004	0.0002	0.0004	0.0002	0.0003	0.001	0.001
29. Public administration	-0.013	-0.015	-0.013	-0.016	-0.011	-0.012	-0.036	-0.043
30. Education	0.004	0.005	0.004	0.006	0.003	0.005	0.011	0.016
31. Health	-0.004	-0.007	-0.004	-0.008	-0.003	-0.006	-0.010	-0.021
32. Defence and public order	-0.0002	-0.0003	-0.0002	-0.0003	-0.0002	-0.0002	-0.001	-0.001
33. Other public administration	0.001	0.001	0.001	0.001	0.0004	0.001	0.001	0.002
34. Private non-profit institution	-0.009	-0.014	-0.009	-0.015	-0.007	-0.012	-0.025	-0.041
35. Amusement and recreational services	-0.020	-0.042	-0.022	-0.045	-0.017	-0.036	-0.059	-0.123
36. Other private services	-0.053	-0.077	-0.056	-0.081	-0.045	-0.064	-0.155	-0.222

Note: All simulations on SIM 2 f0tax_s("C44aPetrol"); SIM 3 f0tax_s("C44bDiesel"); SIM 4 f0tax_s("C44cOthFuel"); and SIM 5 f0tax_s("all fuels") contained a price increase of 1%.

The detailed results of the disaggregation of the 44th industry into petrol, diesel and other fuel products show a reduction in both output and employment when a tax increase of 1% on petrol products, diesel products and other fuels was simulated (SIM2, SIM3 and SIM4, respectively) (Table 4.18). Results indicate that petrol products would experience a -0.010% output decrease and -0.091% employment reduction (SIM2). Diesel products would decline by 0.011% in output and 0.104% for employment (SIM3) while other fuel products would decrease output by 0.006% and employment by 0.052% (SIM4). The reductions in output and employment would be larger for diesel products, followed by petrol products, and other fuel products (Table 4.18).

SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

Many countries, including Malaysia, subsidize fuel consumption. Malaysia is not a major oil producing country nor a member of OPEC, yet its oil prices are among the lowest in the world. In addition to providing subsidies, the Malaysian government has exempted diesel and petrol from sales tax. With this combination of subsidies and tax exemptions, Malaysians can enjoy more affordable public and private transport.

However, Malaysia's economy is in danger of becoming unsustainable as the fuel subsidies constitute a huge portion of the government's annual budget. In 2008, the total fuel subsidy borne by the government was MYR 15 billion (USD 5 billion). In addition to putting pressure on the public budget, fuel subsidies also create distortions by disregarding the real economic value of fuel, creating excess consumption, and discouraging energy substitution. They are also regarded as one of the major causes of environmental problems, not only because of the pollution created by excessive fossil fuel combustion by industries and vehicles, but also due to traffic congestion.

In light of all these factors, from July 2010, Malaysia started to implement gradual reform to reduce its fuel subsidies, specifically petrol, diesel, and liquefied petroleum gas (LPG). However, fuel subsidy remains a politically sensitive issue in Malaysia.

Support for the subsidy rationalization program is founded on several concerns. For one thing, the existing subsidy program typically benefits the wrong target groups, with much of the benefits going to wealthier Malaysians, foreigners, and corporate businesses. Secondly, the savings from the subsidy rationalization program could reduce the budget deficit, and the saved money could then be invested into social services, infrastructure, and community development, which will provide long-term benefits for future generations and support sustainable economic growth. Thirdly, the subsidies encourage illegal smuggling of the cheap fuel commodities, resulting in a depletion of domestic fuel resources.

On the other hand, the opponents of fuel price hikes assert that because Malaysia is a net fuel exporter, rising fuel prices would only profit PETRONAS, the state-run energy company, while burdening the majority of Malaysians who are earning relatively low incomes.

This study aimed to inform the Malaysian government as well as the public on the likely economic and equity consequences of reductions in fuel subsidies. Using a CGE model of the Malaysian economy with detailed information on fuel commodities, various simulations of reducing fuel subsidies were conducted and their impact on selected macroeconomic indicators as well as on output and employment were analyzed. With this information, the government will be able to anticipate and devise appropriate policy responses to avoid any adverse impacts of a fuel subsidy reform.

In this study, fuel commodities were disaggregated into petrol, diesel, and other fuel products. This study had the advantage of being able to examine the impact of price increases for these fuel commodities on macroeconomic variables, employment by occupation, and output and employment by industry in the Malaysian economy. The analysis of this study focused on two categories: (1) SIM1, to observe the impact of a fuel price increase on producers and (2) SIM2, SIM3 and SIM4, to investigate the impact of a price increase for petrol, diesel and other fuels (separately) on all users, and SIM5, to examine the impact of a price increase for all fuel commodities (altogether) on all users.

Firstly, the results show that a fuel price increase on producers (SIM1) would result in a contraction in employment ranging between 3.177% and 3.547% for all types of occupations. Results also show that a fuel price increase for petrol, diesel and other fuels (SIM2, SIM3, and SIM4, respectively) would result in an expansion of employment for all types of occupations ranging from 0.005%–0.012%. An increase in diesel price (SIM3) would have more impact on the expansion of employment by occupation compared to an increase in petrol price (SIM2) and other fuel product prices (SIM4). The greater expansion of employment by occupation for SIM3 reflects that the industrial sector/producers would be the most affected in terms of employment generation.

Secondly, this study found that an increase in fuel tax on producers (SIM1) would bring about a varying negative impact on macroeconomic variables, a contraction of employment by occupation, and diminishing output and employment by industry in Malaysia. The transport industry (i.e., land transport, water transport, air transport and other transport services), which is closely related to fuel commodities, would experience a large contraction in output and employment.

Thirdly, an increase in tax for fuel users would reduce household consumption and government expenditure, expand employment by occupation, and reduce output and employment in some industries of the Malaysian economy.

Fourthly, most industries of the agriculture, manufacturing and services sectors would show a large contraction in employment. The results of all simulations show that the reductions in employment by industry would be larger than output reductions. A tax increase on producers (SIM1) would have a larger impact on employment due to reductions in labor input as producers would try to compensate for the increase in firm costs. This implies that firms would likely utilize labor more efficiently in order to deal with the increased costs of production.

Fiftly, contraction in output by industry would be larger among industries in the manufacturing sector compared to the agriculture and services sectors. A larger contraction in output would be seen for oils and fats; basic chemicals; other chemical products; sheet glass and glass products; cement, lime and plaster; finishing of textiles; and clay and ceramic products. The manufacturing sector would suffer the most output reduction from the increase in diesel costs. This is not surprising because more than 50% of government expenditure on subsidies goes to diesel while the subsidies on petrol and other fuel products are less than 40% and 20%, respectively.

In general, it can be concluded that a tax imposed on fuel commodities, particularly diesel, would result in significant contractions in industry output, employment by industry, and the macroeconomic performance of Malaysia. However, a tax imposed on all users by type of fuel commodity would offset government expenditure and would have a positive impact on GDP, exports, imports and employment by occupation.

The simulations show that for every 1% reduction in subsidies for all fuel commodities, there would be a reduction in GDP of 0.08% compared to the baseline scenario where the subsidy remains the same. However, when the revenue from the subsidy reduction is compensated by a reduction in general sales tax, thus leaving the government budget balance unchanged, the GDP change would become a positive 0.01%. An increase in fuel prices initiated by a reduction in the subsidies would reduce activities of selected sectors in the economy, but a reduction in the general sales tax would have an expansionary impact on broader segments of the economy. This expansionary impact would more than compensate for the contractionary effect, leaving a positive net gain for the overall economy.

The distributional impact of the reduction in fuel subsidies across different types of labor varied, but to a much lesser extent than output. This result, therefore, refutes the claim that the effect of a reduction in subsidies would be felt much more by unskilled labor, such as plant and machine operators or elementary workers, compared to skilled labor.

The rather uniform impact across workers implies that the distributional impact of the reform would be more or less neutral.

Reducing fuel subsidies can have immediate negative impacts on macroeconomic indicators like GDP through an increase in the cost of economic activities, an increase in consumer price index and reductions in employment. However, when government revenue from the reduction in the subsidies is given back to the economy through reductions in general sales tax, the net macroeconomic impact is positive. This indicates that the the pre-reform fuel pricing policy has distorted resource allocation and, therefore, a departure from such a policy would be the right move towards a more efficient economy.

In general, the results of this study suggest that rationalizing fuel price subsidies in Malaysia will lead to a positive benefit for the Malaysian economy. Negative impacts such as the increase in production costs due to the higher fuel prices would be more than compensated by the positive impacts of government revenue reallocation. In addition, the neutral effect of the subsidy reduction across different types of labor suggests that concerns over the adverse distributional consequences of the reform are overrated. Therefore, this study encourages the speeding-up of fuel pricing reform in Malaysia and further recommends a subsidy reduction based on income level. Last but not least, there is a strong necessity for Malaysia to find renewable energy sources in order to reduce its dependency on fossil fuel and fuel subsides so as to achieve sustainable development.

LITERATED CITED

Abimanyu, A. 2000. Impact of agriculture trade and subsidy policy on the macroeconomy, distribution and environment in Indonesia: A strategy for future industrial development. Developing Economies. 38(4):547-571.

Allaire, M. and S. Brown. 2009. Eliminating subsidies for fossil fuel production: Implications for U.S. oil and natural gas markets. Resources for the future. Issue Brief 9-10.

Adriamihaja, N. and G. Vecchi. 2007. Madagascar: An evaluation of the welfare impact of higher energy prices in Madagascar. Africa Region Working Paper, Series No. 106. The World Bank. Washington D.C., USA.

Baig, T.; A. Mati; D. Coady; and J. Ntamatungiro. 2007. Domestic petroleum product prices and subsidies: Recent developments and reform strategies. IMF Working Paper 07/71. International Monetary Fund. Washington D.C., USA.

Birol, F.; A.V. Aleagha; and R. Ferroukhi. 1995. The economic impact of subsidy phase out in oil exporting developing countries: A case study of Algeria, Iran and Nigeria. Energy Policy. 23(3):209-215.

Breisinger, C.; W. Engelke; and O. Ecker. 2011. Petroleum subsidies in Yemen. Leveraging reform for development. Policy Research Working Paper 5577. World Bank. Washington D.C., USA.

Coady, D.; M. El-Said; R. Gillingham; K. Kpodar; P. Medas; and D. Newhouse. 2006. The magnitude and distribution of fuel subsidies: Evidence from Bolivia, Ghana, Jordan, Mali, and Sri Lanka. IMF Working Paper WP/06/247. International Monetary Fund. Washington D.C., USA.

Department of Statistics. 2000. Malaysian Industrial Standard Classification. Department of Statistics. Putrajaya, Malaysia.

Department of Statistics. 2010. Input-Output Tables Malaysia 2005. Putrajaya, Malaysia.

El-Said, M. and D. Leigh. 2006. Fuel price subsidies in Gabon: Fiscal cost and distributional impact. IMF Working Paper WP/06/243. International Monetary Fund. Washington D.C., USA.

EPU (Economic Planning Unit). 2005. Socio-economic indicators 2005. Prime Minister's Department. Putrajaya, Malaysia.

EPU. 2008. Socio-economic indicators 2008. Prime Minister's Department. Putrajaya, Malaysia.

EPU. 2004-2010. Socio-economic indicators 2004-2010. Prime Minister's Department. Putrajaya, Malaysia.

EPU. 2010. Tenth Malaysia Plan 2011-2015. Prime Minister's Department. Putrajaya, Malaysia.

Granado, J.A.; D. Coady; and R. Gillingham. 2010. The unequal benefits of fuel subsidies: A review of evidence for developing countries. IMF Working Paper, WP/10/202. International Monetary Fund. Washington D.C., USA.

Harrison, W.J. and K.R. Pearson. 1994. Computing solutions for large general equilibrium models using GEMPACK. IMPACT Preliminary Working Paper No. IP-64. June, pp 55. Monash University. Clayton, Australia.

Hartono, D. and B.P. Resosudarmo. 2006. The economy-wide impact of fuel oil, gas and electricity pricing and subsidy policies as well as their consumption improvement efficiency in Indonesia. Working Paper in Economics and Development Studies. No. 200611. Department of Economics, Padjajaran University. Bandung, Indonesia.

Khalid, A.H.; A.R. Zakariah; and H.H. Mohd. Khairul. 2010. Effects of higher oil prices to consumer food products in Malaysia. Working Paper at Ministry of Science, Technology and Innovation. Malaysia.

Ministry of Energy, Water and Communications. 2006. National Energy Balance 2005. Putrajaya, Malaysia.

Ministry of Energy, Green Technology and Water. 2009. National Energy Balance 2008. Putrajaya, Malaysia.

Ministry of Energy, Green Technology and Water. 2011. National Energy Balance 2010. Putrajaya, Malaysia.

Ministry of Finance. 2001-2011. Malaysia, Economic Reports 2000-2010. Ministry of Finance, Malaysia. Putrajaya, Malaysia.

Ministry of Human Resources. 2009. National Employment Returns 2008. Putrajaya, Malaysia.

Motlagh, S.P. and M.M. Farsiabi. 2007. An environmental and economic analysis for reducing energy subsidies. International Journal Environment. 1(2):150-162.

Oktaviani, R.; D.B. Hakim; S. Siregar; and H. Sahara. 2007. Impact of a lower subsidy on Indonesian macroeconomic performance, agricultural sector and poverty incidences: A recursive dynamic computable general equilibrium analysis. MPIA Working Paper 2007-2008. Poverty and Economic Policy Research Network. Manila, Philippines.

Yusuf, A.A. and B.P. Resosudarmo. 2008. Mitigating distributional impact of fuel pricing reform: The Indonesian experience. ASEAN Economic Bulletin. 25(1):32-47.

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