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RESEARCH ARTICLE

Assessing the Potential Economic and Poverty Effects of the National Greening Program[1]

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Abstract: Over the years, deforestation in the Philippines resulted in significant reduction in forest cover. Between 1990 and 2013, the Philippines has lost 3.8 million hectares of its forest. This study carries out a quantitative assessment of the potential economic and poverty impacts of the NGP using a computable general equilibrium (CGE) model. In the assessment, a CGE model is specified, calibrated and used to simulate three scenarios: (i) a baseline or a business-as-usual scenario that incorporates the current forest deterioration in the Philippines; (ii) a full NGP scenario which implements a reforestation program that halts and reverses the reduction in the country's forest cover; and (iii) a partial NGP scenario where only half of the 1.5 million hectare target reforestation is achieved. The assessment indicates that the NGP will result in an improvement in the overall output of the economy. The production of agricultural crops (palay, coconut, sugar, and other agriculture) improves, as well as the processing of these crops into food. Reforestation increases the effective supply of productive land in the country. The factor markets for labor, capital, and land are affected favorably as the overall output of the economy improves. The improvement in factor efficiency decreases the cost of production, which lowers the consumer price of commodities. Food prices decline as agricultural production improves. Lower income groups benefit from declining consumer food prices as their food consumption share in their total expenditure is larger compared to households in higher income groups. Higher household incomes and lower consumer prices lead to reduced poverty. Also, those in extreme poverty benefit the most. Income distribution also improves over time as indicated by a declining GINI coefficient.

Keywords: Philippine National Greening Program (NGP), reforestation, computable general equilibrium, microsimulation, income and poverty impacts

JEL Classifications: C68, D58, Q23, Q54

Between 1990 and 2013, the Philippines has lost 3.8 million hectares of forest, which represents 36% of its 1990 forest cover. If no intervention is implemented, its forest cover will continue to deteriorate to 4.5 million hectares by 2050. This continued deforestation has negative effects on the environment, health, and agricultural productivity. The National Greening Program (NGP) which was implemented in 2011 through the Executive Order 26 was designed to increase reforestation. Through the reforestation program, the government hopes to address other related problems on poverty, food security, environmental stability and biodiversity conversation, and climate change.

The National Greening Program (NGP) can potentially result in large scale environmental changes that have economy-wide effects. However, to date most valuation methods used to analyze these changes employ partial equilibrium models, which are limited in their consideration of economic and ecological spillovers effects. For this study, a computable general equilibrium (CGE) model is used to quantitatively assess the potential economic and poverty effects of the NGP. In the assessment, a CGE model was specified, calibrated, and used to simulate two broad scenarios: (i) a baseline or a business-as-usual scenario that incorporates the current forest deterioration in the Philippines, and (ii) a NGP scenario which implements a reforestation program that reverses the continued reduction in the country's forest cover. The CGE model was calibrated to a social accounting matrix of the Philippine economy in 2012. The CGE model incorporates a land-use module which is critical in the assessment. The model also incorporates factor efficiency parameters in production to accommodate the health effects of changes in the environment on labor, and the climate change effects on the productivity of agricultural land.

The results of the CGE simulation were utilized in a poverty microsimulation model to quantify the economy-wide effects on poverty and income distribution poverty and income distribution effect of the NGP. The poverty microsimulation was calibrated to the 2012 Family Income and Expenditure Survey. Figure 1 shows how the models are used in the analysis.

The next sections of the report includes the literature review, description of the CGE model and its assumptions, and simulation results on sectoral output, land utilization, factor markets (factor prices and demand), product markets (production, consumption, and commodity prices), household income across decile, poverty, and income distribution.

Literature Review

CGE Applications in Forestry

One way of measuring the economy-wide effects of forestry policies and programs such as forest rehabilitation, reforestation, and afforestation is through the use of CGE models. CGE models are useful in simulating the effects of macroeconomic policies and external shocks because it is based on a flow matrix where different sectors in the economy interact according to a predetermined set of rules and equilibrium conditions (*United Nations Environment Programme*, 2011), including even social and environmental indicators (Bussolo & Medvedev, 2007). Several studies conducted in foreign countries have employed CGE in assessing the diverse impacts of forestry policies.

Dee (1991) studied the distributional impacts of numerous forest protection and industry policies in Indonesia using a multi-sectoral CGE model. The model accounted for both forest and non-forest sectors where the former was represented by a steady state solution to an intertemporal harvesting problem, and the latter was reflected by conventional single-period production functions. There were a total of seven policy instruments used, four of which concerned forests while the remaining three were industry related. The forest policy instruments were: (a) an increase in the minimum size of trees that can be harvested; (b) the creation of a national park; (c) an increase in the length of forest leases to concessionaires; and (d) a Pigouvian tax on forest output. On the other hand, the industry policy instruments were: (a) removal of a log export ban; (b) removal of agricultural and processing assistance; and (c) removal of assistance to all industries. Two alternative treatments of land mobility were carried out. The first scenario treated

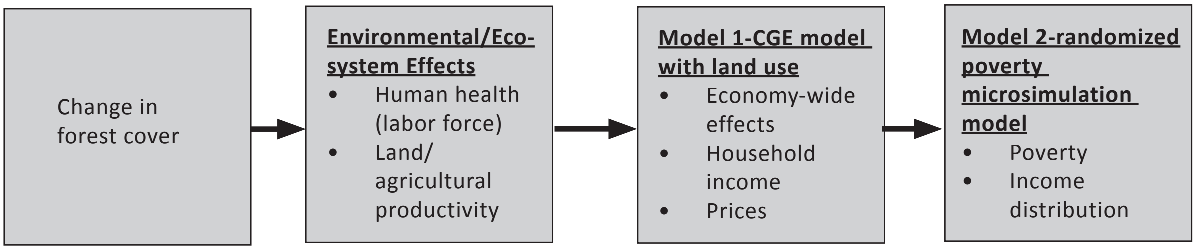

Figure 1. *Framework of analysis.*

land use in all industries as fixed. The second dealt with land as mobile between agriculture and forestry with the economy moving towards the use where there are greater discounted returns.

The results indicate that the impact of both forest protection and industry policies depend on the flexibility of land-use patterns. The simulations show that if land is mobile between agriculture and forestry, the following effects take place—first, all policies, except the Pigouvian tax, increases the amount of land converted to forestry; second, removing assistance from agriculture increases the volume of standing timber; and third*,* the burden of a decrease in real GDP caused by forest protection need not fall on the rural poor. Notwithstanding the foregoing, all forest policies were found to reduce annual forestry output and cause an increase in log prices.

Studies below reflect the general equilibrium effects of forest rehabilitation programs in the form of afforestation and reforestation.

Afforestation consists of planting trees on land previously used for other purposes. The existing literature lacks studies on the economic implications of converting agricultural land into forest land, and setting it aside as carbon graveyards. Monge (2012) addressed this gap by using a static regional CGE model in assessing the long-run impacts of a government-funded afforestation-based carbon sequestration program in the United States on the following: (a) the annual carbon removal contributions by set-asides, privately owned timberland, and harvested wood products; (b) land-use change in different major land resource areas; and (c) the production and prices of related commodities. The afforestation activities targeted were afforested set-asides and an expanding commercial forestry industry under different management intensities and a 5-year rotation age extension.

The CGE model used took into account the economic shocks affecting land allocation between agriculture and forestry, as well as the dynamic nature of forest-based carbon sequestration. Four types of nesting structure were employed—a productions nest, a land market nest, an afforestation activity nest, and a nest for carbon dioxide offsets generated by the commercial logging industry. These structures were based on constant return to scale and nested constant elasticity of substitution functions.

The results show that for a carbon offset price of $10 per metric ton carbon dioxide ($MTCO_2$), 76 million acres of agricultural land were afforested and set aside for sequestration purposes from North Dakota to Northern Texas. The commercial forestry industry also expanded in the regions adjacent to the Mississippi River and Ozark Mountains. When it comes to the production and prices of related industries, the beef cattle industry was negatively affected with a decrease in production by 4%, an increase in price by 7%, and the highest consumption reduction across all households. On the other hand, basic crops such as oilseeds and grains were not severely impacted by the afforestation program with a price increment of only 1%.

The study of Monge (2012) focused only on the primary impacts of afforestation in the economy. On the contrary, Michetti and Rosa (2012) examined both the primary and secondary costs and benefits of afforestation-reforestation and timber management (AR-TM) in European climate policy. The research looks at the changes in the carbon stabilization costs, amount of carbon sequestered given a carbon price, land use, and land and timber market prices, as well as the magnitude of leakage of afforestation-reforestation.

The Inter-temporal Computable Equilibrium System (ICES) model was used; it is a multi-country and multi-sector global CGE model. It is recursive-dynamic, developing a sequence of static equilibria, linked by an endogenous process of capital and debt accumulation. Nevertheless, in this case, only a simplified structure of the economy with only one-time jump from 2001 to 2020 was utilized. It also availed of a nested structure for its production process and final demand. It assumed that the total amount of carbon stored by forests is 34% to 40% via AR and 54% to 63% via change in TM. It is also assumed that TM does not impact land use change but only timber supply, while AR activities affect land use change.

The economy starts from a business-as-usual scenario where climate policy or the AR-TM opportunities are disregarded. Two policy scenarios were then simulated. The first is where Europe-27 (EU27) countries unilaterally commit to a 20% greenhouse gases (GHGs) emission reduction below 1990 values by 2020. The results imply a reduction in the EU27 GDP of 1% compared with the baseline. The prices of agricultural goods decreased by 0.6%, and the price of land went down by 1.6%. The leakage effect in the form of fossil fuels use increase in the regions outside the policy boundaries is +1%. Still, this leads to a positive net global CO_2 emission reduction at a reduced policy cost. The second scenario requires a 30% reduction of emission from EU27. In this context, there is a reduction in GDP by almost 2%, prices of agricultural goods by 1%, and prices of land by 2.3%. The leakage effect is +1.5%.

Michetti and Rosa (2012) were able to demonstrate the pivotal role of AR-TM activities. Although AR only comprises 20% of the EU27 emissions mitigation efforts, it allows the achievement of the 30% emission reduction target with only 0.2% GDP cost compared to a 20% emission reduction without AR. Also, the use of AR-TM decreases the following: policy costs through a savings of 28% on average for both targets, carbon price by 27% and 30% for the 20% and 30% emission reduction targets respectively, and the leakage effect by around 0.2% for both emissions reduction cases.

Yet, Monge (2012) and Michetti and Rosa (2012) centered only on the climate change effects of afforestation. Bassi (2013) looked into how reforestation will affect the entire social, economic, and environmental structure using system dynamic modeling. The direct, indirect, and induced impacts of reforestation, such as but not limited to avoided expenditure and additional benefits, to the economy were measured. These effects were projected from 2013 to 2015, and analyzed over the short, medium, and longer term. This sector specific evaluation was complemented with a macroeconomic analysis carried out using the CGE model.

Two scenarios were simulated using CGE. The first one was a business as usual (BAU) case. This presumes the continuation of historical trends and the existing policy framework. The second one was a green economy (GE) scenario. This supposes that there are investments in reforestation programs with the goal of stopping deforestation by investing in planted forests for productive purposes. The assumptions in the model include the presence of five types of forests, a deforestation rate of 0.7% to 1.5%, and carbon emissions between 1,100 and 9,133 tons CO_2. The last two are dependent on the type of forest. Furthermore, the reforestation policy starting 2014 is that the planted forest area matches the total forest area cleared from primary and secondary forests, and rainforests. The reforestation investment is 1.96 million pesos per km^2 of planted forest based on the 2011 United Nations Environmental Programme estimate.

Projections from 2020 to 2035 were made on the following: total forest area, the total amount of carbon stored in forest land, the annual CO_2 emissions from forests, forestry production, forestry value added, forestry employment, and forestry income. The values from 2020 to 2035 for both BAU and GE scenarios were decreasing. Nonetheless, the results show that the GE scenario is better because it gives a higher projection compared to the BAU scenario for all areas.

These studies show the importance of being able to comprehensively measure the contribution of forest rehabilitation programs to the economy.

Brazil has implemented a similar program, which is called the National Forests (FLONAS), with the goal of expanding the Brazilian forest by 50 million hectares (ha). The paper of Pattanayak et al. (2009) looked at the health and wealth impact of the FLONAS using a CGE model. The main idea of the paper was to understand how the changes in the ecosystem (environmental changes) affect human health and wealth. There are at least three pathways human health are affected by changes in the ecosystem: (a) direct—floods, heat waves, or drought; (b) ecosystem-mediated—altered infectious disease risk and reduced food yields (malnutrition, stunning); (c) indirect-displaced-deferred—varied health consequences of livelihood loss, population displacement (e.g, dwelling in slums), and conflict. The link between changes in the ecosystem and human health is complex, but the paper focused on pathway (b), the ecosystem-mediated, particularly the regulation of infectious diseases. In many tropical settings, changes in climate and land uses (particularly deforestation) represent a potent environmental disease risks. The paper looked at how the expansion of the Brazilian forest by 50 million hectares under the FLONAS can mitigate these environmental disease risks. The paper adopted a CGE in the analysis. In their model they incorporated several equations that represent land use. In particular, the land use representation in the model is shown in Figure 2.

The specification above is generally similar to the land use representation in the Philippine CGE model that will be used to analyze the poverty impacts of NGP, except for two items. The Philippine CGE: (a) includes land use for residential/commercial; and (b) disaggregates crop land into major corps using another nested CET function. Residential/commercial land use is included because the high population growth in the Philippines resulted in fast conversion of land into

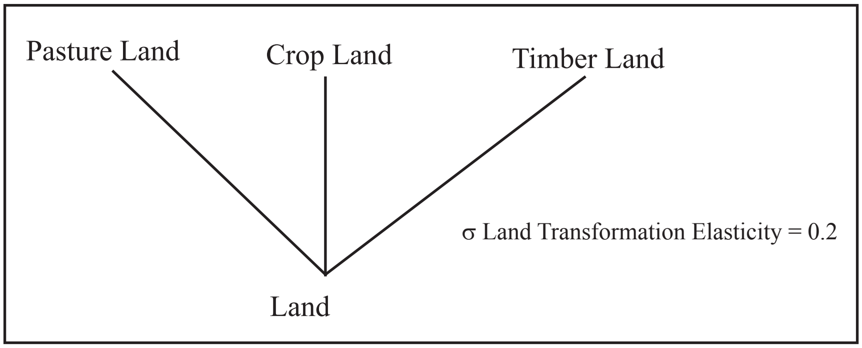

Figure 2. *Land movements and transformation in the CGE model.*

uses for dwellings. Disaggregation of land into major crops is important in understanding how agriculture is affected by the NGP and how agricultural farm households and other households in rural areas are impacted.

Another important feature of the CGE model in Pattanayak et al. (2009) is the specification of the labor supply. The labor supply function provides a link between the impact of diseases on labor supply and the rest of the economy. In the model, labor supply was specified as

$$\bar{L} = f(H_t) = \Phi(L_t + l_t), \quad where\ \Phi = f(Disease, etc)$$

$\bar{L}$ = is labor endowment (time available in a day, which is divided into labor time (L) and leisure time (l_t). The health impacts associated with diseases effectively enter as a scale factor (Φ) on the amount of labor available.

The Pattanayak et al. (2009) paper developed several scenarios, but the three important ones were: (a) a baseline scenario that incorporated the Intergovernmental Panel on Climate Change's (IPCC) moderate projection of higher temperature by 2^{o}C that would cause fluctuations in rainfall of ±15%; (b) Climate Change Plus Deforestation; and (c) the FLONAS where forest in Brazil increased by 50 million hectares. Their major findings indicated that climate change and deforestation lead to higher incidence of infectious diseases in humans and therefore decreases labor supply. The decrease in labor supply is higher in rural areas than in urban areas. Overall, welfare declined as a result. The increase in forest by 50 million hectares under the FLONAS program decreases the incidence of infectious diseases and therefore increases labor supply. Overall welfare improved as a result.

Climate Change, Land Use and Forestation/Reforestation Programs

It is difficult to quantify the effects of agriculture activities and changes in land use which includes conversion of crop lands into forest or agroforest. Forestation has been closely related to climate change through its mitigation effects. There are a few methods and models that have recently been developed to study effect of changes in land use on climate change (Turner, Lambin, & Reenberg, 2007). Models which build scenarios that involve both the impact and contribution of agriculture to climate change are among the next-generation scenarios that challenge climate change research (Moss et al., 2010). These models combine an understanding of the variability in earth's climate system, its response to human and natural influences, and the effect of changes on the populations.

The modeling framework of Wang, Kockelman, and Wang (2011) incorporates both the biophysical and socioeconomic drivers for land use into a regional climate system model. In particular, the model focuses on the impact of land use and the natural vegetation dynamics, that is, the response of natural vegetation to predicted climate changes and the resulting climate feedback.

The study of Michetti (2012) examined various models on land-use, land-use change, and forestry (LULUCF). It was pointed in the study that in order to cater to global dimensions of land-use system and a realistic representation of LULUCF, there should be a use of a spatial and global framework, which integrates the environment, economics, and biophysics. Among all methods, the integrated assessment model (IAM) represents the most advanced modeling strategy to deal with the complexity of the land-use system. It employs both geographic and economic models while including biophysical considerations, but despite this progress IAMs should render more transparency of the interactive spheres and allow for the inclusion of more feedback effects. New generation IAMs models would enhance future land demand and supply projection under baseline or under climate stabilization scenarios.

In the literature, several CGE models are linked with partial equilibrium models to better capture the climate change-agriculture and land use dynamics. The IAM is an example where a CGE model is linked with a partial equilibrium-agricultural model for land-use (Palatnik & Roson, 2009). The IAM model contains detailed representation of the different economic processes. However, one drawback of IAM is that the integration of the CGE in model is not consistent with the partial equilibrium, thus convergence of the two is not always assured. The CGE and the partial equilibrium models use different assumptions, data sources, data, and units of measurements.

Applying the necessary adjustments in the CGE parameters, Ronneberger, Berrittella, Bosello, and Tol (2009) showed that changes in emissions and crop production move in the same direction as changes in GDP and welfare. Changes in trade balance and crop prices move in the opposite direction. The simulations demonstrate that crop production adjusts according to the pattern of induced yield changes brought about by climate change. Higher yield increases crop production while lower yield decreases production. Any yield losses are compensated by increasing the area used for production which increases prices, negatively affects the balance of trade, and decreases GDP and welfare. Furthermore, the model simulation shows that climate change has a negative impact on GDP and welfare for most regions except for Central America and South Asia, and sub-Saharan Africa, Canada, and Western Europe; the former group with stronger gains and the latter group with smaller gains.

Lin and Byambadorj (2009) assessed the long-term impacts of climate change on agricultural production and trade in China using a global CGE. They found that climate change results in a 1.3% decline in GDP and a welfare loss of 1.1% by 2080. China's agricultural productivity declines, which increases the country's dependence on world agricultural markets. This effect leads to additional losses in welfare and output through unfavorable terms-of-trade effects. China's food processing sectors are negatively affected by the decline in agricultural productivity as well as the decline in global agricultural productivity as a result of climate change.

Zhai and Zhuang (2009) employed a CGE model to assess the economic effects of climate change for Southeast Asian countries through 2080. The simulation results suggest that global crop production decreases by 7.4%. There is uneven distribution of productivity losses across the different regions, with higher decline in developing countries. A reduction in global agricultural productivity has non-negligible negative impacts on Southeast Asia. With lower agricultural productivity, the dependence of Southeast Asia on crop imports increases, causing welfare losses. The negative effects are lower in Singapore and Malaysia, but higher in Indonesia, Thailand, Vietnam, and the Philippines. GDP in the last three countries contracts by 1.7% to 2.4%.

Michetti and Parrado (2012) presented a CGE model to analyze the potential role of the European forestry sector within climate mitigation. The paper has extended the traditional ICES CGE model and the new version accounts for land heterogeneity across and within regions and even land mobility. This included endogenous agent's decisions on land allocation between agriculture and forestry, and forest-sector characteristics. The model addresses one of the main conceptual challenges of modeling terrestrial mitigation options, which is simulating competition for land between different land-use activities. Results showed that the slowdown of the European economy follows to the inclusion of emission quotas, where European regions experience a GDP reduction of 2.4% and 3.9 % in 2020. It was further suggested in the study that other European regions must also take part in a climate stabilization agreement. Indeed, in terms of forest carbon mitigation, regions detaining old-growth forests would have necessarily a higher mitigation potential compared with the regions characterized by temperate forests.

Golub, et al. (2009) divide the earth into agroecological zone (AEZ) and employed a global model with land allocation mechanism to study the effects of land use change on greenhouse gas emissions. AEZ is a land resource mapping unit, defined in terms of climate, landform, and soils and has a specific range of potentials and constraints for cropping (Food and Agriculture Organization, 1996). The study demonstrates that as population and per capita income increase and consumption patterns change, the strongest growth in consumer demand is predicted in the forestry sector due to the increased demand for furniture, housing, and paper products. At the same time, unmanaged forest lands are converted to production lands in all regions except in places where no unmanaged forests are available. In Australia, New Zealand, North America, Latin America, and Western Europe, land used in forestry production declines while that for agriculture expands. Within the agricultural sector in these regions, more land is used for crops while less is used for livestock production. In the rest of the regions, including Southeast Asia and South Asia, land employed in commercial forestry expands while that for agriculture contracts as a response to increased demands for forest-based products worldwide.

Pant (2010), incorporated land use change and forestry in a dynamic CGE model. It splits the forestry activity into three parts—planting, holding, and harvesting. The framework of the study can be used in a CGE model to support implementation of the proposed reduced emissions from deforestation and forest degradation (REDD) scheme. The model can be used also to project the effects on food production and prices of an increase in bio-fuel subsidies.

In Ethiopia, climate change was assessed in terms of its effect on crop and livestock farming and how these effects extend throughout the country, in terms of economic growth and poverty reduction. Gebreegziabher, Stage, Mekonnen, and Alemu (2011) simulated the impacts of climate change induced variations in land productivity in the Ethiopian economy in the 2010-2060 period by using a dynamic CGE model with a social accounting matrix (SAM) that depicts production by sector in detail, including agriculture and manufacturing. It also employed the Ricardian model to simulate the impacts of the changes in temperature and precipitation indicated by the climate projections from the Intergovernmental Panel on Climate Change. Results demonstrate that there is a dramatic impact of climate change even in the high-growth scenarios, especially that agriculture dominates Ethiopia's economy completely and any climate-change impacts on agriculture will be considerable in the coming decades.

CGE Models and Poverty Microsimulations

Research that looks at the effects of climate change on poverty supplements the CGE model with poverty microsimulation models that use detailed household data from household surveys. The CGE model accounts for the impact of climate change on macro variables such as agricultural productivity and production, commodity demand, prices factor demand and factor returns, and household income. This set of information is used to change the distribution of household income in household surveys. There are several poverty simulation models available in the literature such as the Global Income Distribution Dynamics (GIDD) of the World Bank (de Hoyos, 2008; Estrades, 2013; Cockburn, 2001; Cororaton & Corong, 2009).

van der Mensbrugghe (2010) produced simulations of their paper with the World Bank's Environmental Impacts and Sustainability Applied General Equilibrium (ENVISAGE). ENVISAGE is a relatively standard CGE model, with a specific focus on the energy side of the global economy; it also contains a simple climate module that makes it suitable for integrated assessment analysis. The model is global, recursive dynamic CGE with 2004 base year. The distributional analysis is carried out with the World Banks's Global Income Distribution Dynamics (GIDD) model, which applies the existing CGE-microsimulation methodologies. Result shows that climate change damage increases poverty in 2030 with the poverty headcount rising by 0.2 and 1.2 percentage points at the extreme and moderate poverty lines, respectively. The adverse effects of climate change vary significantly by the main source of household earnings. Although climate-change damage is concentrated in agriculture, the agricultural households are not necessarily the most affected. The ultimate impact of climate-change damage on agricultural households depends on whether the increase in the output price is sufficient to compensate for the welfare loss due to the higher cost of feeding the family. Mitigating the negative effects of climate change is always pro-poor in Latin America, but the efficient strategy reduces the losses significantly and may even benefit the poorest households.

Buddelmeyer, Herault, Kalb, and van Zijll de Jong (2012) considered a specific approach of disaggregating output from a dynamic CGE model into impacts at the household and individual level. They linked a CGE model and an MS model in a sequential way. The approach allows the computation of the potential distributional effects of the policy changes simulated in the model. The approach is applied to assess the impacts on household income of two climate-change mitigation policies compared to a reference case without mitigation. The simulations are carried out for the period from 2005 to 2030 in Australia. Results show that these two mitigation policies are likely to have positive distributional effects despite a slightly negative effect on average real income. To a large extent, this is due to the redistribution of carbon permit revenues to households on a per capita basis through lump sum transfers.

CGE Applications in Philippine Forestry

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 the impacts on welfare, poverty, outputs, prices, international trade, consumption, employment, pollution emissions, income distribution, food security, forestry, agriculture, among others. For Philippine forestry, CGE model was employed to assess the effects of commercial logging ban on equity, efficiency, and the environment (Rodriguez, 2003). Other studies have been conducted using CGE in assessing the diverse impacts of forestry policies in the country.

Dufournaud, Jerrett, Rodriguez, Quinn, and Inocencio (2003) concentrated on quantifying the costs arising from a moratorium on commercial logging in the Philippines. The costs measured included (1) welfare losses to domestic consumers, (2) decrease in employment, and (3) foreign exchange requirements in the importation of the logs to meet domestic needs. Using a CGE model, two different scenarios were simulated under two policy regimes. The scenarios included full employment, and less than full employment. The policy regimes were a total ban on commercial logging, and a total ban on commercial logging accompanied by an across-the-board reduction of import tariffs. For both scenarios of full and less than full employment, the results showed that the reduction in welfare is greater under a ban compared to a ban with a tariff reduction. Under full employment, the decrease in welfare is PhP15.3 billion and PhP8.6 billion respectively, while with less than full employment, the reduction is PhP15.8 billion and PhP 8.9 billion, respectively. The decline in total employment was measured only for the less than full employment scenario. Total employment declines by 1.77% when there is a total ban and by 1.11% with a total ban and tariff reduction. Lastly, the impact on foreign exchange requirements was quantified only for the policy regime of total ban with tariff reduction. Here, foreign exchange requirements would increase as the value of imported forestry products is shown to increase. This, in effect, would sequentially lead to a decline in the value of the peso, cheaper exports, an increase in demand for Philippine goods, and the necessary foreign exchange needed to import more logs. These results support a total ban on commercial logging in the Philippines for at least a cycle as there are more benefits to society from halting the harvest than from allowing it to continue.

Based on extensive review of CGE applications in forestry, the impacts of reforestation program can be assessed on a regional and national level. CGE is a useful tool for assessing possible changes in macroeconomic variables and induced impacts on the other sectors of the Philippine economy. While CGE has been used in many national and regional assessments, it will be the first application in assessing the nationwide reforestation effort of the DENR in terms of scale and components (economy, incomes through the employment/livelihood component, poverty, and the environment).

CGE Model

The CGE used in the analysis is a sequential dynamic model calibrated to a 2012 social accounting matrix (SAM) of the Philippine economy. Appendix A presents the complete specification of the model, the macro SAM used in the calibration and the elasticities in the model. The simulation results from the CGE are utilized in a poverty microsimulation model to quantify the poverty and income distribution effects of the NGP. The poverty microsimulation model is discussed in Appendix B. (Appendix A and B are available online thru this link: http://ejournals.ph/issue.php?id=840#prod)

In the CGE model, sectoral output is the sum of value added and intermediate inputs, where value added is a fixed Leontief ratio of intermediate inputs in every sector (Figure 3). The determination of the sectoral value added is in two stages. In each stage, a constant elasticity of substitution (CES) structure is used. In each sector in the first stage, skilled and unskilled labor are aggregated into total labor, and capital and land into total capital. In the second stage, labor and capital in each sector are aggregated into value added. Sectoral output is sold to the domestic market as domestic sales and to the rest of the world as exports. Product differentiation (price difference) between domestic sales and exports is formulated using a constant elasticity of transformation (CET) function. Sectoral imports and domestically produced goods sold to the domestic market determine sectoral consumption (the Armington composite good). Product differentiation (price difference) between imports and domestically produced goods is formulated using a constant of elasticity of substitution (CES) function. This Armington composite good is used as intermediate inputs, as well as final demand which is composed of household consumption, government consumption, and investment.

Figure 4 shows the structure of income and consumption of households and enterprises. Households are grouped in decile. The sources

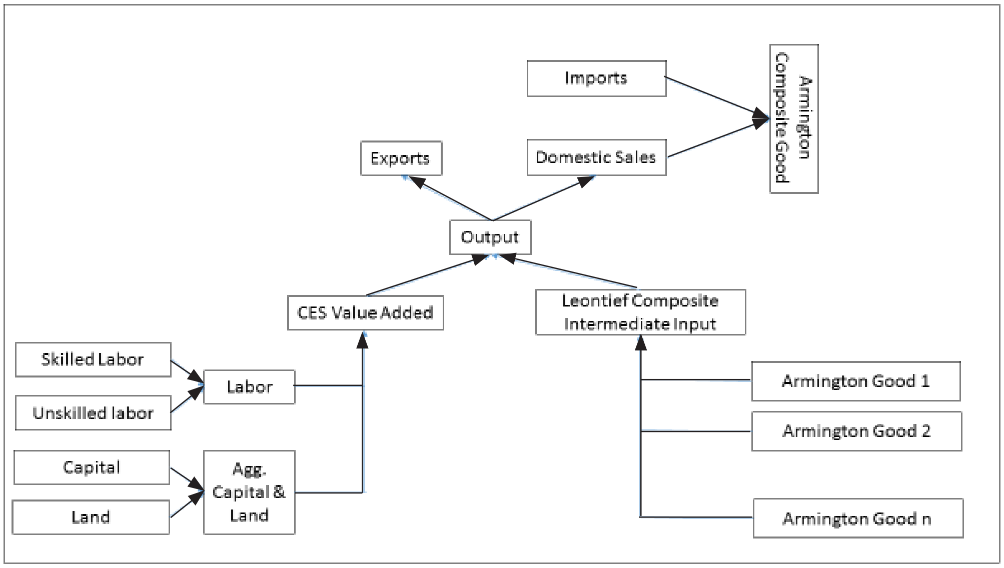

Figure 3. *CGE structure.*

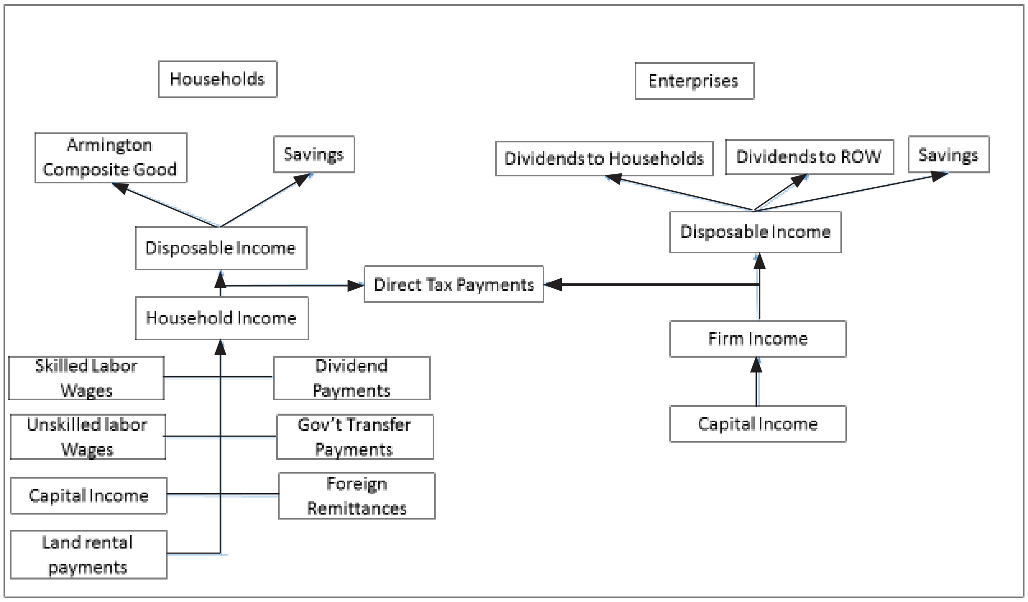

Figure 4. *Income and consumption structure of households and enterprises.*

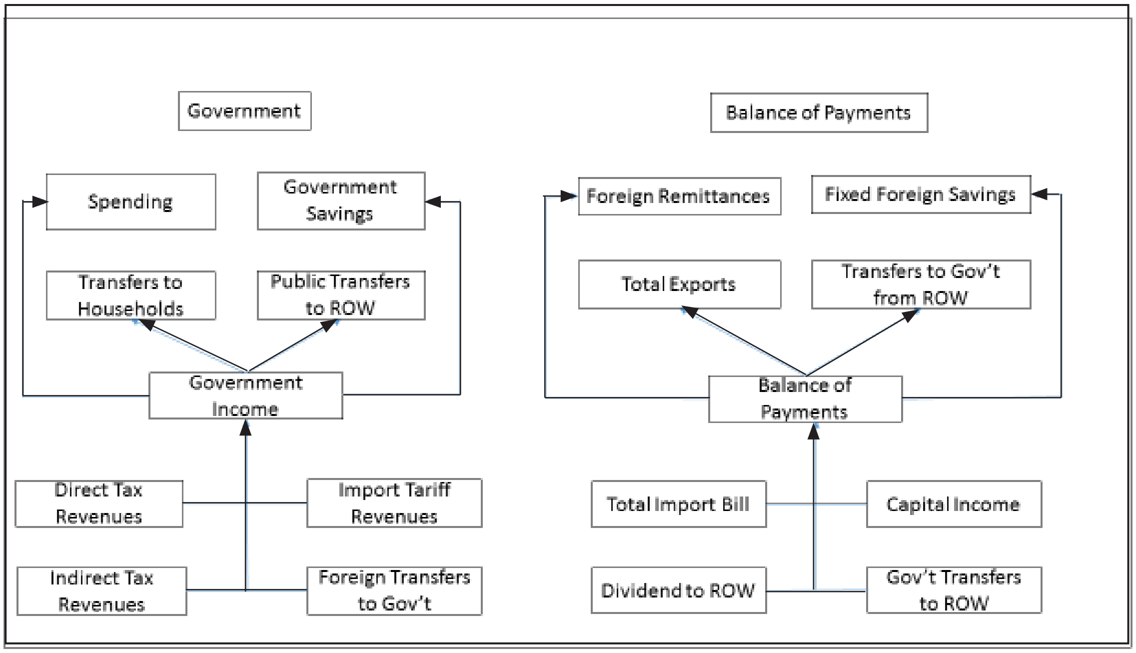

Figure 5. *Government income and expenditure and balance of payments.*

of household income are factor payments (from labor, capital, and land) and other sources which include dividend payments, government transfers, and foreign remittances. Disposable income of households, net of direct tax payments, is allocated to household consumption and savings. Household consumption/demand is specified using a linear expenditure system (LES).

The source of income of enterprises is capital. After paying direct income tax, enterprises allocated income to domestic household dividends, rest of the world dividends, and savings.

Figure 5 shows the structure of government income and expenditure, and the balance of payments. The sources of government income are direct and indirect tax revenues, import tariff revenue, and foreign transfers to the government. There are four uses of government income in the model: spending, transfers to households, public transfer to the rest of the world, and government savings.[2] In the balance of payments, the outflows include payments for imports, dividends to the rest of the world, capital income payments, and government transfers to the rest of the world. The inflows include income from foreign remittances, export receipts, rest of the world transfer to the government, and foreign savings.

To analyze the economic effects of NGP, the model needs to be modified so as to allow for a system that allocates land to various uses. The allocation of land in the model is done in two stages (Figure 6). In the first stage, using a CET function, land is allocated to four uses: crops, forest, pasture land, and dwellings (residential and commercial). The allocation of land across these uses depends on the elasticity of transformation in the first stage (σ^{CET1}) and the relative price of each of these uses. In the second stage, using another CET function, land used for crop production is allocated to key crops: rice, sugar, coconut, and all other crops. The allocation of crop land to various crops depends on the elasticity of transformation in the second stage (σ^{CET2}) and the relative price of each of the crops.

The sum of savings of households, enterprises, government and foreign savings flows back into the system as total investment. Government savings and foreign savings are fixed. The nominal exchange rate is the numeraire. The external account is cleared by changes in the real exchange rate, which is the ratio between the nominal exchange rate and endogenous prices in Philippine markets. The CGE model is marketing clearing. Prices, which include prices in factor markets (labor, capital, and land) and product markets, adjust in order to clear/equilibrate all markets in the model.

Changes in factor prices and factor demand determine factor incomes. Changes in factor incomes,

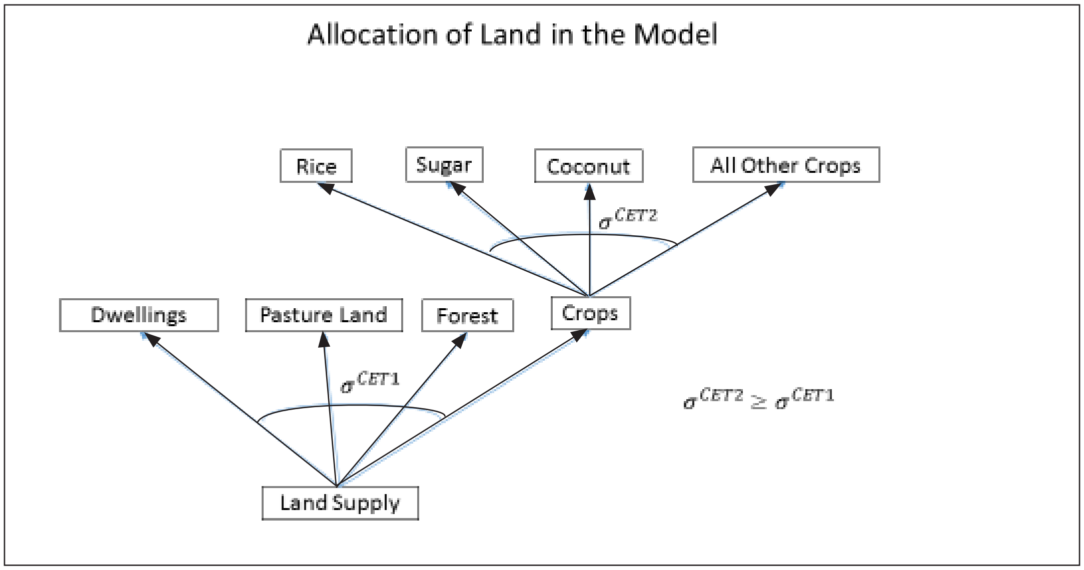

Figure 6. *Land allocation in the model.*

together with factor endowments of households, determine changes in income at the decile level. Changes in commodity prices drive the reallocation of resources across sectors. Changes in the sectoral output prices affect the consumer price of commodities, which is the composite price of the Armington good.

The model is sequential dynamic. Sectoral capital stock which is fixed in the current period is updated endogenously in the next period using a capital accumulation equation that depends on the current level of sectoral investment. Following Jung and Thorbecke (2001), sectoral investment is specified as Tobin's q. Labor is updated exogenously using the growth of population.

A policy shock introduced into the CGE model generates general equilibrium effects on sectoral output, demand, commodity and factor prices, factor use (labor, capital, and land) and household income. These information are utilized in a poverty microsimulation model to quantify the effects on poverty and income distribution. The poverty microsimulation model was calibrated to the 2012 Family Income and Expenditure Survey (FIES) and is discussed in detailed in the appendix.

The model was calibrated using a SAM of the Philippine economy in 2012. The SAM used to calibrate the model was aggregated to 14 sectors from an original 241-sector SAM. Table 1 presents the structure on the economy based on the SAM.

Relative to the total output of the economy, the share of agricultural crops is small (X Share). Production is dominated by other service, all other manufacturing, other food, and other industry. However, in terms of value added contribution (VA/X), agriculture and service sectors have significantly larger shares than manufacturing.

Factor payments vary across sectors. For palay and coconut, the share of payments to unskilled labor (USKL) is larger than the share of payments to capital (K) and land (LND). For sugar and other agriculture, the share of payments to capital is larger than the share of payments to unskilled labor and land. The share of payments to capital is larger than the share of payments to the other factors for the rest of the sectors. Except for dwellings and public administration, the share of payments to unskilled labor is higher than the share of payments to skilled labor (SKL). Forestry, which is a key sector in the NGP analysis, has about 40% payments to land and 44% payment to capital.

The sector with the highest import-competing goods (represented by an import ratio of 43.6% under M/Q) is all other manufacturing, which include the electronics. This is followed by coconut processing (31.9%), other industry (15.5%), and forestry (14.6%). In terms of the overall country's imports (M Share), all other manufacturing accounts for the bulk of imports with 67.1% share.

Domestic production caters largely to the domestic market (E/X), except for coconut processing and to

Table 1. *Structure of the Philippine Economy Based on SAM (%)*

	X Share	VA/X	Factor Payments					Trade					
			SKL	USKL	K	LND	Total	D/Q	M/Q	M Share	D/X	E/X	E Share
Palay	1.7	67.8	1.2	52.0	34.2	12.7	100.0	99.9	0.1	0.0	100.0	0.0	0.0
Coconut	0.4	89.6	1.0	42.7	41.1	15.2	100.0	99.4	0.6	0.0	99.9	0.1	0.0
Sugar	0.3	56.4	0.8	36.0	46.1	17.1	100.0	100.0	0.0	0.0	100.0	0.0	0.0
Other agriculture	6.8	65.5	1.8	36.7	49.1	12.4	100.0	97.2	2.8	1.0	96.1	3.9	1.7
Forestry	0.1	84.4	0.4	15.9	44.3	39.3	100.0	85.4	14.6	0.1	99.6	0.4	0.0
Rice	2.2	33.0	4.0	15.0	81.0	0.0	100.0	89.2	10.8	1.5	100.0	0.0	0.0
Coconut processing	1.1	42.2	4.0	14.9	81.1	0.0	100.0	68.1	31.9	1.5	49.4	50.6	3.7
Sugar processing	0.8	35.3	9.2	34.3	56.5	0.0	100.0	90.1	9.9	0.4	80.3	19.7	1.0
Other food	10.1	26.7	5.9	21.6	72.5	0.0	100.0	90.6	9.4	5.3	88.9	11.1	7.1
All other mfg	26.0	24.8	9.1	21.9	69.0	0.0	100.0	56.4	43.6	67.1	58.9	41.1	68.0
Other industry	8.8	60.8	5.3	24.6	69.9	0.2	100.0	84.5	15.5	9.0	98.0	2.0	1.1
Dwellings	4.1	81.3	3.1	1.4	85.9	9.5	100.0	100.0	0.0	0.0	99.6	0.4	0.1
Other service	32.3	60.2	12.7	17.9	69.4	0.0	100.0	92.2	7.8	14.1	91.5	8.5	17.4
Public admin.	5.4	77.9	57.3	42.7	0.0	0.0	100.0	100.0	0.0	0.0	100.0	0.0	0.0
Total	100.0									100.0			100.0

Source: 2012 SAM

X = output
VA = value added
SKL = skilled labor (with at least high school diploma)
K = capital
USKL = unskilled labor
LND = land
M = imports
Q = Armington composite good
D = domestic sales of X
E = exports

Table 2. *Sources of Household Income (%)*

	SKL	USKL	K	LND	DIV	REM	OTHERS	Total
H1 (decile)	0.67	23.50	71.28	3.48	0.07	0.47	0.53	100.00
H2	1.30	25.73	68.02	3.32	0.03	0.94	0.66	100.00
H3	1.68	27.28	66.10	3.23	0.04	0.84	0.83	100.00
H4	2.64	28.78	62.97	3.08	0.06	1.30	1.17	100.00
H5	2.92	32.77	58.37	2.85	0.04	1.73	1.32	100.00
H6	4.40	34.23	55.11	2.69	0.05	2.37	1.15	100.00
H7	7.06	34.76	50.51	2.47	0.08	3.59	1.53	100.00
H8	12.71	32.81	45.92	2.24	0.10	4.57	1.65	100.00
H9	16.72	30.21	42.70	2.09	0.10	6.35	1.83	100.00
H10	23.28	14.39	47.97	2.34	1.49	7.43	3.10	100.00

Source: 2012 SAM

SKL = skilled labor (with at least high school diploma)
K = capital, which includes operating surplus
USKL = unskilled labor
OTHES = include rice quota rent (for H7, H8, H9, and H10) and government transfers
LND = land
DIV = dividend income
REM = foreign remittances

some extent all other manufacturing. Agricultural production, including rice, is sold practically to the local market. In terms of the overall country's exports (E Share), all other manufacturing has accounts for 68%.

Table 2 presents the sources of household income. Factor incomes (payments to labor, capital, and land) are the major sources of income across household groups. Capital, which includes operating surplus, is a key income source, followed by income from unskilled labor. Land, which is critical in the NGP analysis, has contributed significantly less to income than labor and capital but households in the lowest income bracket has a larger share from land income compared to households in the highest income bracket.

Table 3 shows the structure of consumption of households. The share of food consumption, particularly rice, is higher in lower income than in higher income groups. In contrast, the share of consumption of commodities produced in all other manufacturing sectors is higher in richer households than in poorer groups. Similar trend is observed in the consumption share of dwellings.

Definition of Scenarios

There are three sets of scenarios analyzed in the paper: (i) baseline or business-as-usual (BaU) scenario; (ii) full NGP scenario; and (iii) partial NGP scenario.

BaU scenario. There are three elements in the baseline scenario: (a) the forest cover projection of the Department of Environment and Natural Resources (DENR) without NGP; (b) the increasing incidences of infectious diseases as a result of declining forest cover which negatively affects labor supply; and (c) the declining agricultural land productivity because of climate change.

Based on DENR's projection, Table 4 shows that without NGP the total forest cover in the country will decline from 6.4 million hectares in 2010 to 4.5 million hectares in 2050. This is a major feature of the BaU scenario. The other element in this scenario is the impact of climate change on agricultural productivity. Based on Cline's (2007) climate model, the projected CO_2 atmospheric concentration will increase to 735 parts per million (ppm) in 2080 from the current level of 380 parts ppm. The global mean temperature (GMT) will increase by 3.3^{o}C. The average surface temperature of land areas, which will warm more than the oceans, are projected to rise by 5.3^{o}C, weighted by land area, and 4.4^{o}C, weighted by farm area.

Table 3. *Household Consumption Share(%)*

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	All
Palay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coconut	0.33	0.34	0.34	0.33	0.33	0.31	0.31	0.29	0.28	0.23	0.28
Sugar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other agriculture	6.06	6.44	6.30	5.92	5.64	5.06	4.67	4.14	3.52	2.46	3.94
Forestry	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	17.61	16.44	14.44	12.32	10.09	8.35	6.86	5.40	4.00	2.03	5.89
Coconut processing	0.76	0.87	0.86	0.83	0.78	0.72	0.66	0.56	0.46	0.30	0.53
Sugar processing	0.50	0.71	0.83	0.86	0.88	0.91	0.89	0.79	0.71	0.54	0.71
Other food	17.12	20.11	21.17	21.84	22.45	22.72	21.94	20.48	18.26	13.03	18.00
All other mfg	6.64	7.70	9.08	9.83	10.70	11.04	11.71	12.32	13.13	15.26	12.73
Other industry	0.67	0.93	1.15	1.41	1.84	2.24	2.54	2.72	2.72	2.60	2.36
Dwellings	4.29	4.64	5.07	5.39	6.05	6.71	7.28	7.73	7.80	9.21	7.66
Other service	46.00	41.81	40.75	41.27	41.23	41.94	43.12	45.55	49.12	54.33	47.90
Public admin.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: 2012 SAM

Table 4. *Projected Forest Cover Without NGP ('000 hectares)*

	2010	2015	2020	2025	2030	2040	2050
Forest lands - closed canopy	1,868	1,494	1,300	1,381	1,264	1,264	1,264
Forest lands - open canopy	4,291	3,847	3,849	3,044	3,002	2,856	2,828
Forestlands - mangroves	203	244	281	309	340	374	411
Total	6,362	5,585	5,430	4,734	4,606	4,494	4,503

Source: DENR

Table 5. *Projected Climate Change and Impacts on Agricultural Productivity*

Climate Variables	Land Area	Farm Area
Base levels		
Temperature (°C)	13.15	16.2
Precipitation (mm per day)	2.2	2.44
By 2080		
Temperature (°C)	18.1	20.63
Precipitation (mm per day)	2.33	2.51
Impacts on Agricultural Productivity (%)	Carbon Fertilization Effect	
	Without	With
World (output weighted)	-15.9	-3.2
Industrialized countries	-6.3	7.7
Developing countries	-21	-9.1
Africa	-27.5	-16.6
Asia	-19.3	-7.2
Philippines	-23.4	-11.9
Middle East	-21.2	-9.4
Latin America	-24.3	-12.9

Source: Cline, 2007

°C = degree Celsius; mm = millimeter

In Cline's analysis, there are two cases that examine the impact of climate change agricultural productivity: with carbon fertilization effect and without carbon fertilization effect.[3] His results indicated that when carbon fertilization effect is included, global agricultural productivity by 2080 is projected to decline by 3%; but without the said effect, the agricultural productivity is seen to drop by 16% (Table 5). The effects across regions vary significantly; those located in lower latitudes would tend to experience larger losses because they are already close to or beyond the thresholds at which further warming will reduce agricultural productivity. The results indicate that developing countries tend to have larger negative effects compared to developed countries. In particular, Philippine agricultural productivity in 2080 is projected to decline by 23.4% in the case without carbon fertilization effect and 11.9% in the case with carbon fertilization effect. In the analysis, agricultural productivity declines by 14%.

The third element in this scenario includes the human health effects of deforestation. Changes in the environment affect health in three path ways: (a) direct—floods, heat waves, or droughts; (b) ecosystem-mediated—altered infectious disease risk and reduced food yields (malnutrition, stunting); and (c) indirect-displaced-deferred—varied health consequences of livelihood loss, population displacement (e.g., dwelling in slums), and conflict. In Brazil, deforestation in the Amazon forest can reduce labor endowment/supply by 3% by 2050 base on the estimates of Pattanayak et al. (2009). Since the Amazon and the Philippines have similar tropical conditions, in the absence of a similar empirical estimate of the effects of environmental changes on human health in the Philippines, the paper adopts the same 3% decline in labor endowment by 2050 in the BaU scenario.

Full NGP scenario. The assumptions in this scenario address the three concerns in the baseline. The full implementation of NGP will increase the country's forest cover by 1.5 million hectares from 4.5 million in 2050 to 6 million. This will have favorable effects on health. There is no reduction in labor supply in this scenario as human health improves with increasing forest cover. Also, agricultural land productivity improves as a result of the reforestation activities in NGP.

Partial NGP scenario. Past experience in the Philippines indicates that attaining the desired targets of a reforestation program may be difficult to attain. This scenario assumes that the country's forest cover will improve by 750 thousand hectares only as a result of NGP, which is 50% lower than the desired target. However, this will have favorable health impact. Labor supply will decline by only 2% in 2050, a slight improvement compared to the BaU scenario. Agricultural land productivity will decline by 10%, also an improvement than the 14% decline in the BaU scenario.

Model implementation of scenarios. How are these effects implemented and simulated in the CGE model? The reforestation in the NGP which maintains the current forest cover increases effectively the forest land relative to the baseline where there is continued deforestation. In the land use framework shown in Figure 4, the increase in forest land under the NGP scenario relative to the baseline increases effectively the overall supply of productive land in the country.

The negative health effects on labor and the decline in agricultural land productivity are implemented in the model through changes in factor efficiency parameters in the production function. Consider a production with four inputs

$$Q = f(\delta_s \cdot L_s, \delta_u \cdot L_u, \delta_k \cdot k, \delta_{ld} \cdot Ld_{ld})$$

where Q is output, L_s is skilled labor L_u is unskilled labor, L_k is capital, and Ld_{ld} is land. The respective factor efficiency parameters are δ_s for skilled labor, δ_u for unskilled labor, δ_k for capital and δ_{ld} for land.[4] Table 6 presents the values of the factor efficiency parameters in the baseline. In the NGP scenario, the values of these parameters are all set to one in the simulation.

Simulation Results

The CGE model was solved annually and sequentially from 2012 to 2050. The assumptions under the BaU and the NGP scenarios were simulated separately, and the results generated under each cases are available on request from the authors for 2012, 2015, 2020, 2025, 2030, 2035, 2040, 2045, and 2050. However, the discussion in this section focuses on the effects of the NGP scenario in 2020, 2030, and 2050 as indicated by the percent difference of the NGP scenario from the baseline.

Table 7 shows that relative to the baseline, overall output of the economy under the full NGP scenario improves by 0.3% in 2020, 0.9% in 2030 and 2.3% in 2050. Agricultural crop production of palay, coconut, sugar, and other agriculture improves, as well as the processing of these crops into food. Non-manufacturing production improves also. The higher agricultural output growth is due to the improvement in agricultural land productivity and the improvement in labor efficiency under the NGP scenario relative to the baseline. Output of dwellings and other services increases, but the improvement is relatively lower than the overall output growth of the economy. The forestry sector benefits the most under the NGP scenario. Public administration (which includes public health, education, and other general government services) increases as the overall economy improves with higher government revenue and spending.[5]

The sectoral effects are lower under the partial NGP scenario. Overall output of the economy improves by only 0.7% relative to the baseline in 2050. Agriculture and food processing sectors are also favorably affected.

Table 6. *Factor Efficiency Parameters*

	Labor		Land (δ_{ld})/b/	Capital (δ_k)
	Skilled (δ_s)	Unskilled (δ_u)		
2012	1	1	1	1
…	…	…	…	…
2050 /a/	0.970	0.970	0.859	1

/a/ straight line decline, except for capital

/b/ average of Cline's projection

Table 7. *Sectoral Effects of NGP (% Change from the Baseline)*

	Full NGP Scenario			Partial NGP Scenario		
	2020	2030	2050	2020	2030	2050
Palay	0.490	1.310	3.126	0.131	0.338	0.798
Coconut	0.369	1.057	2.844	0.095	0.262	0.778
Sugar	0.483	1.289	3.221	0.128	0.330	0.889
Other agriculture	0.405	1.066	2.838	0.097	0.249	0.802
Forestry	0.750	1.978	9.533	0.286	0.730	5.650
Rice processing	0.501	1.335	3.167	0.133	0.343	0.801
Coconut processing	0.393	1.178	3.020	0.099	0.283	0.747
Sugar processing	0.485	1.293	3.231	0.128	0.330	0.893
Other food	0.449	1.219	2.980	0.121	0.319	0.794
All other manufacturing	0.414	1.183	2.883	0.121	0.341	0.820
Other industry	0.398	1.122	2.692	0.116	0.323	0.772
Dwellings	0.264	0.767	2.030	0.065	0.181	0.555
Other service	0.046	0.293	1.029	0.010	0.073	0.278
Public administration	1.064	2.237	4.441	0.326	0.689	1.347
Overall output	0.329	0.933	2.343	0.092	0.256	0.656

Source: Authors' calculation

Table 8. *Output-Land Ratio in Agriculture, % Change from Baseline*

	Full NGP Scenario			Partial NGP Scenario		
	2020	2030	2050	2020	2030	2050
Palay	3.3	7.9	15.8	1.1	2.7	4.5
Coconut	3.3	7.8	15.7	1.1	2.6	4.5
Sugar	3.3	7.8	15.8	1.1	2.6	4.6
Other agriculture	3.3	7.8	15.4	1.1	2.6	4.3

Source: Authors' calculation

Deforestation decreases the supply of forest land. This is reversed under the tree replanting activities in NGP. Reforestation increases forest land as well as the overall supply of productive land. The improvement in land productivity increases the output-land ratio in agriculture as shown in Table 8. The ratio is higher under the full NGP scenario.

The improvement in labor and land productivity increases factor incomes as shown in Table 9. Income from land registers the highest increase, followed by income from unskilled labor. The improvement in factor incomes are higher under the full NGP scenario. Moreover, because of the improvement in factor productivity under NGP, commodity prices decline.[6]

The differences in the sources of income shown in Table 2 and as well as the variations in the consumption shares presented in Table 3 translate into differences in income and consumer price effects across household groups (Table 10). Nominal household income improves while consumer prices decline. The increase in income and the decline in prices tend to accelerate over time. Also, the effects of the NGP scenario are progressive in the sense that lower income household groups tend to benefit slightly more than higher income groups.

Table 11 shows that the NGP scenario lowers poverty in the Philippines. Households who are in extreme poverty are favorably affected, as indicated by the higher decline in P2. The decline in all poverty

Table 9. *Factor Incomes and Consumer Prices (% Change from Baseline)*

	Full NGP Scenario			Partial NGP Scenario		
	2020	**2030**	**2050**	**2020**	**2030**	**2050**
Skilled labor	0.088	0.607	1.948	0.245	0.662	1.574
Unskilled labor	0.214	1.048	3.180	0.500	1.276	2.966
Capital	0.354	0.809	1.826	0.097	0.220	0.549
Land	3.369	8.618	13.233	3.090	7.420	11.341
Change in consumer prices*	-0.109	-0.219	-0.590	-0.022	-0.039	-0.174

Source: Authors' calculation

**The change in factor income is the change in factor price multiplied by the change in factor demand, while the change in consumer price is the change in sectoral Armington composite price weighted by household expenditure shares.*

Table 10. *Effects on Household Income and Consumer Prices (% Change from the Baseline)*

Household Groups (Decile)	Full NGP Scenario						Partial NGP Scenario					
	2020		**2030**		**2050**		**2020**		**2030**		**2050**	
	Income/1/	**Prices/2/**	**Income**	**Prices**	**Income**	**Prices**	**Income**	**Prices**	**Income**	**Prices**	**Income**	**Prices**
H1	0.419	-0.133	1.100	-0.262	2.430	-0.664	0.133	-0.027	0.338	-0.045	0.683	-0.182
H2	0.409	-0.126	1.092	-0.252	2.440	-0.653	0.129	-0.024	0.334	-0.040	0.683	-0.178
H3	0.404	-0.121	1.090	-0.244	2.453	-0.641	0.127	-0.023	0.332	-0.039	0.685	-0.176
H4	0.395	-0.118	1.079	-0.240	2.452	-0.632	0.124	-0.022	0.327	-0.039	0.682	-0.175
H5	0.381	-0.113	1.069	-0.231	2.472	-0.618	0.118	-0.021	0.320	-0.037	0.683	-0.173
H6	0.373	-0.109	1.065	-0.224	2.489	-0.604	0.115	-0.021	0.317	-0.036	0.685	-0.171
H7	0.361	-0.106	1.048	-0.218	2.477	-0.593	0.111	-0.020	0.310	-0.036	0.679	-0.170
H8	0.355	-0.106	1.046	-0.215	2.496	-0.585	0.108	-0.021	0.307	-0.037	0.683	-0.171
H9	0.349	-0.109	1.031	-0.217	2.465	-0.582	0.106	-0.023	0.302	-0.041	0.674	-0.174
H10	0.364	-0.105	1.007	-0.206	2.305	-0.556	0.113	-0.023	0.303	-0.041	0.642	-0.172

Source: Authors' calculations

/1/ Nominal
/2/Computed using the change in the Armington composite price, weighted by household expenditure shares in each decile group

Table 11. *Poverty and Income Distribution Effects, NGP Scenario*

	Full NGP Scenario					Partial NGP Scenario				
	Poverty Indices			% change*		Poverty Indices			% change	
	2012	2030	2050	2030	2050	2012	2030	2050	2030	2050
Philippines										
P0	24.85	24.22	23.38	-2.55	-5.93	24.85	24.69	24.44	-0.64	-1.63
P1	6.84	6.60	6.30	-3.46	-7.87	6.84	6.77	6.68	-0.97	-2.24
P2	2.68	2.57	2.43	-4.07	-9.18	2.68	2.65	2.61	-1.15	-2.64
Urban										
P0	11.57	11.25	10.80	-2.75	-6.70	11.57	11.50	11.37	-0.58	-1.70
P1	2.79	2.68	2.53	-4.11	-9.36	2.79	2.76	2.72	-1.15	-2.68
P2	0.99	0.94	0.88	-4.75	-10.69	0.99	0.98	0.96	-1.34	-3.09
Rural										
P0	35.58	34.70	33.55	-2.49	-5.72	35.58	35.35	35.01	-0.66	-1.61
P1	10.10	9.77	9.34	-3.31	-7.53	10.10	10.01	9.89	-0.93	-2.15
P2	4.04	3.89	3.69	-3.94	-8.88	4.04	4.00	3.94	-1.11	-2.55
GINI Coefficient	0.4713	0.4711	0.4709			0.4713	0.4712	0.4712		

Source: Authors' calculation

**Relative to 2012 Indices from the Family Income and Expenditure Survey*

P0 - poverty incidence; P1 - poverty gap; P2 - poverty severity

indices are slightly higher in urban areas than in rural areas. The GINI coefficient declines slightly under the full NGP scenario, which indicates favorable distributional effects of the NGP scenario.

Summary and Conclusion

Using a CGE model, this paper provides a quantitative assessment of the potential economic, poverty, and income distribution effects of NGP in the Philippines. In the analysis, three scenarios were simulated and analyzed: (a) a baseline scenario that has the following features: declining forest cover; increasing incidences of infectious diseases that negatively affects labor endowment; and declining agricultural land productivity because of climate change; (b) a full NGP scenario that reverses these trends; and (c) a partial NGP scenario where only half of the 1.5 million hectares target reforestation is achieved.

The assessment indicates that the NGP will result in the following:

1. An improvement in the overall output of the economy. The production of agricultural crops (palay, coconut, sugar, and other agriculture) improves, as well as the processing of these crops into food. The production of non-manufacturing sector improves, but the increase is lower than the improvement in agricultural output. The higher agricultural output growth is due to the improvement in agricultural land productivity and the improvement in labor efficiency under the NGP scenario relative to the baseline. Output of dwellings and other services increases, but the improvement is relatively lower than the overall output growth of the economy. The forestry sector benefits the most under the NGP scenario. Public administration (which includes public health, education, and other general government services) increases as the overall economy improves with higher government revenue and spending.
2. Reforestation increases the overall supply of productive land in the country. It increases the utilization of land as forest.

3. Factors markets for labor, capital, and land are affected favorably as the overall output of the economy improves. As a result, factor income increases. Households are therefore positively affected by higher factor incomes.
4. The improvement in factor efficiency decreases the cost of production, which lowers the consumer price of commodities. Food prices decline as agricultural production improves. Lower income groups benefit from declining consumer food prices as their food consumption share in total expenditure is larger compared to those households in the higher income groups.
5. Higher household incomes and lower consumer prices lead to lower poverty. All poverty indicators decline. Those in the extreme poverty benefit the most. Income distribution also improves over time as indicated by a declining GINI coefficient.
6. Given the relatively favorable reqults, a caveat is in order. The full NGP results assume a successful implementation of the program and 100% survival rate. The partila NGP scenario assumes a far less successful implementation with only 50% survival rate.

Notes

[1] Funded by the Philippine Institute for Development Studies

[2] Negative government savings refers to budget deficit.

[3] The rising carbon dioxide gas in the atmosphere as a result of human fossil fuel burning should in principle “fertilize” plant growth through the process of photosynthesis (this is also called the “carbon fertilization” effect”), but research evidence indicates that the effects are insignificant and short-lived. Thus, the carbon fertilization effect is unlikely to offset a significant fraction of projected increases in atmospheric CO2 concentration over the next century.

[4] These efficiency parameters appear in various equations of the model presented in Appendix A.

[5] Government budget balance is held fixed in the simulation.

[6] These price changes were computed as the weighted change in the sectoral Armington composite prices. The weights used the computation of the change consumer price are household expenditure shares.

[7] This model was used in Cororaton (2013).

[8] Skilled labor refers to those who have at least are high school diploma.

[9] The model is a sequential dynamic model. Sectoral capital, k_i, is fixed in the current period, but changes in the succeeding periods based on a capital stock accumulation equation which depends on investment in the current period. This is discussed later in the appendix

[10] Note that Error! Reference source not found. holds for all products less 1. Equilibrium in the ith product is given as:
$leon = q_{i^{th}} - \sum_h ch_{i^{th},h} - inv_{i^{th}} - intd_{i^{th}}$. The variable leon is always zero to satisfy the Walras law.

[11] (A55) is patterned after the Tobin’s q specification.

[12] The table only shows the macro SAM. However, the updated 2012 SAM is very detailed in sectoral breakdown comprising of 241 sectors, skilled and unskilled labor, and 10 household groups (decile). The list of these sectors is available upon request from the author.

[13] There are several approaches and written papers that deal with CGE microsimulation. This appendix includes only a few of these approaches.

[14] There are several approaches and written papers that deal with CGE microsimulation. This appendix includes only a few of these approaches.

[15] In reducing labor income of those who become unemployed, that is, they will move to the area where rij> u*after the change in u*. The one we adopted involves deducting the decile mean labor income from the labor income if the former is less than the latter. Otherwise, labor income is reduced to zero.

[16] Vos (2005) observed that 30 iterations are sufficient. Repeating this process additionally does not significantly alter the results.

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Appendix A: Philippine CGE and Social Accounting Matrix[7]

CGE Model Specification

Sectoral output is generated using primary factor inputs and intermediate inputs (raw materials). The sectoral primary factors generate the sectoral value added. There are three types of primary inputs in each sector: (a) two kinds of labor—skilled[8] and unskilled; (b) capital; and (c) land. The sectoral value added is a CES function of these primary inputs. In all sectors, labor is a nested CES function of skilled and unskilled labor. Capital is a nested CES function of capital and land in agriculture (including forestry) and in real estate activities and ownership of dwellings. Land is not a factor of production in the rest of the economy. Sectoral intermediate inputs are a fixed proportion (using Leontief coefficients) of sectoral output.

The cost-minimizing demand for aggregate labor is

$$\text{(A1)}\qquad l_i = \frac{pva_i va_i \theta_i^{va}}{\delta_{li}\left(\frac{w_i}{\delta_{li}}\right)^{\sigma_i^{va}}\left(\left(\frac{w_i}{\delta_{li}}\right)^{1-\sigma_i^{va}}(\theta_i^{va})^{\sigma_i^{va}}+\left(\frac{rkln_i}{\delta_{klni}}\right)^{1-\sigma_i^{va}}(1-\theta_i^{va})^{\sigma_i^{va}}\right)}$$

where pva_i is the value added price of sector i; va_i the value added; θ_i^{va} the share parameter of aggregate labor in the value added function; δ_{li} the productivity factor in aggregate labor; w_i the wage of aggregate labor; σ_i^{va} the elasticity of substitution between aggregate labor and aggregate of capital-land (in agriculture); *rkln* the returns to aggregate capital-land; and δ_{klni} the productivity factor of aggregate capital-land.

In sectors with land as one of the factor inputs, the cost-minimizing demand for aggregate capital-land is

$$\text{(A2)}\qquad kln_i = \frac{pva_i va_i (1-\theta_i^{va})}{\delta_{klni}\left(\frac{rkln_i}{\delta_{klni}}\right)^{\sigma_i^{va}}\left(\left(\frac{w_i}{\delta_{li}}\right)^{1-\sigma_i^{va}}(\theta_i^{va})^{\sigma_i^{va}}+\left(\frac{rkln_i}{\delta_{klni}}\right)^{1-\sigma_i^{va}}(1-\theta_i^{va})^{\sigma_i^{va}}\right)}$$

The unit cost function for value added is

$$\text{(A3)}\qquad pva_i = \left(\frac{1}{\alpha_i^{va}}\right)\left(\left(\frac{w_i}{\delta_{li}}\right)^{1-\sigma_i^{va}}(\theta_i^{va})^{\sigma_i^{va}}+\left(\frac{rkln_i}{\delta_{klni}}\right)^{1-\sigma_i^{va}}(1-\theta_i^{va})^{\sigma_i^{va}}\right)^{\frac{1}{(1-\sigma_i^{va})}}$$

where α_i^{va} is a scale parameter in the CES function.

Aggregate labor is a CES function of skilled and unskilled labor. The cost-minimizing demand for skilled labor is

$$\text{(A4)}\qquad skl_i = \frac{w_i l_i \theta_i^{l}}{\delta_{skli}\left(\frac{wskl}{\delta_{skli}}\right)^{\sigma_i^{l}}\left(\left(\frac{wskl}{\delta_{skli}}\right)^{1-\sigma_i^{l}}(\theta_i^{l})^{\sigma_i^{l}}+\left(\frac{wuskl}{\delta_{uskli}}\right)^{1-\sigma_i^{l}}(1-\theta_i^{l})^{\sigma_i^{l}}\right)}$$

where θ_i^l is the share parameter of skilled labor; δ_{skli} the productivity factor of skilled labor; *wskl* the wage of skilled labor; σ_i^l the elasticity of substitution in the CES function; *wuskl* the wage of unskilled labor; and δ_{uskli} the productivity factor of unskilled labor

The cost-minimizing demand for unskilled labor is

$$uskl_i = \frac{w_i l_i (1-\theta_i^l)}{\delta_{uskli}\left(\frac{wuskl}{\delta_{uskli}}\right)^{\sigma_i^l}\left(\left(\frac{wskl}{\delta_{skli}}\right)^{1-\sigma_i^l}(\theta_i^l)^{\sigma_i^l}+\left(\frac{wuskl}{\delta_{uskli}}\right)^{1-\sigma_i^l}(1-\theta_i^l)^{\sigma_i^l}\right)} \tag{A5}$$

The unit cost function of labor is

$$w_i = \left(\frac{1}{\alpha_i^l}\right)\left(\left(\frac{wskl}{\delta_{skli}}\right)^{1-\sigma_i^l}\left(\theta_i^l\right)^{\sigma_i^l} + \left(\frac{wuskl}{\delta_{uskli}}\right)^{1-\sigma_i^l}\left(1-\theta_i^l\right)^{\sigma_i^l}\right)^{\frac{1}{(1-\sigma_i^l)}} \tag{A6}$$

where α_i^l is a scale parameter in the CES function.

The cost-minimizing demand for capital in agriculture is

$$k_i = \frac{rkln_i kln_i \theta_i^{kln}}{\delta_{ki}\left(\frac{rk}{\delta_{ki}}\right)^{\sigma_i^{kln}}\left(\left(\frac{rk_i}{\delta_{ki}}\right)^{1-\sigma_i^{kln}}(\theta_i^{kln})^{\sigma_i^{kln}}+\left(\frac{rlnd}{\delta_{lndi}}\right)^{1-\sigma_i^{kln}}(1-\theta_i^{kln})^{\sigma_i^{kln}}\right)} \tag{A7}$$

where θ_i^{kln} is the share parameter of capital; δ_{ki} the productivity factor of capital; rk_i returns to capital in sector i; σ_i^{kln} the elasticity of substitution between capital and land; *rlnd* the returns to land; and δ_{lndi} the productivity factor of land. The sectoral capital k_i is fixed, thus (A7) adjusts to changes in rk_i.[9]

The cost-minimizing demand for land in sectors with land input is

$$lnd_i = \frac{rkln_i kln_i (1-\theta_i^{kln})}{\delta_{lndi}\left(\frac{rlnd}{\delta_{lndi}}\right)^{\sigma_i^{kln}}\left(\left(\frac{rk_i}{\delta_{ki}}\right)^{1-\sigma_i^{kln}}(\theta_i^{kln})^{\sigma_i^{kln}}+\left(\frac{rlnd}{\delta_{lndi}}\right)^{1-\sigma_i^{kln}}(1-\theta_i^{kln})^{\sigma_i^{kln}}\right)} \tag{A8}$$

The unit cost function of aggregate capital-labor is

$$rkln_i = \left(\frac{1}{\alpha_i^{kln}}\right)\left(\left(\frac{rk_i}{\delta_{ki}}\right)^{1-\sigma_i^{kln}}\left(\theta_i^{kln}\right)^{\sigma_i^{kln}} + \left(\frac{rlnd}{\delta_{lndi}}\right)^{1-\sigma_i^{kln}}\left(1-\theta_i^{kln}\right)^{\sigma_i^{kln}}\right)^{\frac{1}{(1-\sigma_i^{kln})}} \tag{A9}$$

where α_i^{kln} is a scale parameter in the CES function. In the sage two-stage production structure, both σ_i^{kln} and σ_i^l are greater than σ_i^{va}.

Land allocation in the model is done in two stages, where in the first stage total land is allocated to four broad uses (a) production of crops, (b) forestry, (c) dwellings, and (d) other land uses, and in second stage total crop land is allocated to the production of (i) palay, (ii), coconut, (iii) sugar, and (iv) other agriculture.

In the first stage, total land is aggregated using a constant of elasticity transformation (CET) function. The maximization of total land revenue subject to this CET constraint will generate the following land supply in each of the broad uses, $slnd_{il}$, is

(A10) $$slnd_{il} = \beta\_lnd_{il}\left(\alpha\_lnd^{(-[1+\sigma\_lnd])}\right)\left(\left[\frac{Tsplnd}{splnd_{il}}\right]^{-\sigma\_lnd}\right)Tslnd$$

where the index *il = crops, forestry, dwellings, and others;* β_lnd_{il}; and α_lnd_{il} are CET parameters; σ_lnd elasticity of transformation among the four broad land uses; *Tsplnd* is the overall unit price (return) of land; $splnd_{il}$ is the rate of return to land in *il*; and *Tslnd* is the overall supply of land. The overall unit price (return) of land is

(A11) $$Tsplnd = \left(\frac{1}{\alpha\_lnd}\right)\left(\sum\nolimits_{il}\beta\_lnd_{il}(splnd_{il})^{(1+\sigma\_lnd)}\right)^{\left(\frac{1}{(1+\sigma\_lnd)}\right)}$$

In the second stage, total crop land is aggregated using another CET function. The maximization of land crop revenue subject to this CET function will generate the following land supply in each of the crop production, $slndcrp_{ilc}$, is

(A12) $$slndcrp_{ilc} = \beta\_crp_{ilc}\left(\alpha\_crp^{(-[1+\sigma\_crp])}\right)\left(\left[\frac{splnd_{il=crops}}{splndcrp_{ilc}}\right]^{-\sigma\_crp}\right)slnd_{il=crops}$$

where the index *ilc = palay, coconut, sugar, and othersagriculture;* β_crp_{ilc} and α_crp_{ilc} are CET parameters; σ_crp elasticity of transformation among the four crop production; and $splndcrp_{ilc}$ is the rate of return to land in *ilc*. The overall unit price (return) of crop land is

(A13) $$splnd_{il=crops} = \left(\frac{1}{\alpha\_crp}\right)\left(\sum\nolimits_{ilc}\beta\_crp_{ilc}(splndcrp_{ilc})^{(1+\sigma\_crp)}\right)^{\left(\frac{1}{(1+\sigma\_crp)}\right)}$$

In the stage two-stage land allocation structure, both σ_crp is greater than σ_lnd.

Sectoral value added, va_i, is a fixed proportion of sectoral output, that is,

(A14) $$x_i = va_i\omega_i$$

where ω_i is a fixed coefficient.

Sectoral intermediate inputs, $intp_i$, are fixed proportion of sectoral output as well, that is,

(A15) $$intp_i = \varphi_i x_i$$

where φ_i is a fixed parameter. The matrix of intermediate inputs, mat_{ij}, is

(A16) $$mat_{ij} = a_{ij}intp_i$$

where α_{ij} is the input-output (IO) technical coefficients.

Sectoral output is sold in the domestic market, d_i, or exported, e_i. Using a constant elasticity of transformation (CET) function this relationship is

(A17) $$x_i = \alpha_i^e \left(\theta_i^e e_i^{\rho_i^e} + (1-\theta_i^e)\cdot d_i^{\rho_i^e}\right)^{\frac{1}{\rho_i^e}}$$

where α_i^e is a scale parameter, θ_i^e share parameter. The elasticity of transformation between d_i and e_i is $\sigma_i^e = \frac{1}{1+\rho_i^e}$.

Revenue maximization will yield the conditional supply functions of d_i and e_i, whose ratio is given as

(A18) $$e_i = d_i \left(\frac{pe_i}{pd_i}\right)\left(\frac{1-\theta_i^e}{\theta_i^e}\right)^{\sigma_i^e}$$

where pe_i is the export price in local currency and pd_i the domestic price.

The world demand for exports is specified as

(A19) $$e_i = \varepsilon_i \cdot \left(\frac{\overline{pwe_i}}{pwe_i}\right)^{\eta_i}$$

where is ε_i is a scale parameter $\overline{pwe_i}$ fixed world price of exports, pwe_i the FOB price of exports, and η_i export elasticity.

Imports, m_i, and domestic produced goods, d_i, are imperfect substitutes. They are specified using a CES function which is given as

(A20) $$q_i = \alpha_i^m \left(\theta_i^m m_i^{-\rho_i^m} + (1-\theta_i^m) d_i^{-\rho_i^m}\right)^{\frac{1}{-\rho_i^m}}$$

where q_i is the composite of m_i and d_i; α_i^m a scale parameter; θ_i^m a share parameter. The elasticity of substitution is $\sigma_i^m = \frac{1}{1+\rho_i^m}$. Cost minimization will yield the demand for m_i and d_i, whose ratio is given as

(A21) $$m_i = d_i \left(\frac{pd_i}{pm_i}\right)\left(\frac{\theta_i^m}{(1-\theta_i^m)}\right)^{\sigma_i^m}$$

where pm_i is the domestic price of imports and pd_i the domestic price of domestically produced goods which are specified as

(A22) $$pd_i = pl_i(1 + itx_i)$$

where pl_i is the local price of domestically produced goods before indirect taxes; and itx_i indirect taxes. pm_i is defined below.

Consumption of households is specified using linear expenditure system (LES) given as

(A23) $$ch_{i,h} = \frac{\left(cmin_{i,h}\cdot pq_i + \Gamma_{i,h}\cdot\left(ct_h - \sum_j cmin_{i,h}\cdot pq_j\right)\right)}{pq_i}$$

where $cmin_{i,h}$ is subsistence consumption, pq_i the price of the composite good q_i, $\Gamma_{i,h}$ is a set of parameters, and $\left(ct_h - \sum_j cmin_{i,h} \cdot pq_j\right)$ the supernumerary or residual income. The equation for ct_h is

(A24) $$ct_h = dy_h - s_h$$

where dy_h is household disposable income and s_h household savings.

The total available investment is distributed across sectors using a set of fixed shares

(A25) $$inv_i = \frac{\kappa_i \cdot tinv}{pq_i}$$

where κ_i is a share parameter and *tinv* total investment defined as

(A26) $$tinv = pinv \cdot rtinv$$

where *pinv* is the price of investment and *rtinv* total investment in real terms.

Intermediate demand is specified as

(A27) $$intd_i = \sum_j mat_{i,j}$$

Government consumption is given as

(A28) $$g = px_{ntrd} x_{ntrd}$$

where px_{ntrd} is the price of output of the government service sector (*ntrd*) and x_{ntrd} is the output of the government service sector.

Income from skilled labor is

(A29) $$yskl = \sum_i \delta_{skli} skl_i\, wskl$$

Income from skilled labor is

(A30) $$yuskl = \sum_i \delta_{uskli} uskl_i wuskl$$

Income from capital is

(A31) $$yk = \sum_i \delta_{ki} k_i\, rk_i$$

Income from land is

(A32) $$ylnd = \sum_i \delta_{lndi} lnd_i rlnd$$

Household income is

$$(A33)\quad y_h = \delta_{h,sk} yskl + \delta_{h,unsk} yuskl + yk(1 - \lambda_f - \lambda_{row})\delta_{h,unsk} + \delta_{h,lnd} ylnd + ydiv_h pindex + ygtrf_h pindex + yrow_h er$$

where $\delta_{h,f}$ is household income share parameter; λ_f capital income share of firm; λ_{row} capital income share of foreign capital; $ydiv_h$ dividend income of households; $ygtrf_h$ government transfers to households; $yrow_h$ foreign remittances to households; *pindex* general price index; and *er* nominal exchange rate.

The disposal income of households in equation is

$$(A34)\quad dy_h = y_h(1 - dtx_h)$$

where dtx_h is the rate of direct income tax on households.

Firm income is specified as

$$(A35)\quad yf = yk_{cap}\lambda_f$$

Firm income net of taxes is

$$(A36)\quad dyf = yf(1 - dtxf)$$

where *dtxf* is the rate of corporate tax on firm

The revenue from direct taxation is

$$(A37)\quad dtxrev = \textstyle\sum_h dtx_h\, y_h + yf \cdot dtxf$$

The revenue from import tariff is

$$(A38)\quad tmrev = \textstyle\sum_i er \cdot pwm_i \cdot m_i \cdot tm_i$$

where tm_i tariff rate and pwm_i the CIF price of imports.

The revenue from indirect taxes is

$$(A39)\quad itxrev = \textstyle\sum_i \left((pl_i \cdot d_i + er \cdot pwm_i \cdot m_i \cdot (1 + tm_i)) \cdot itx_i \right)$$

The total revenue of the government is

$$(A40)\quad yg = dtxrev + tmrev + itxrev + er \cdot rowtrfg$$

where *rowtrfg* is foreign transfers to the government.

Household savings is given as

(A41) $s_h = aps_h dy_h$

where *aps*$_h$ is the average propensity to save of households.

Firm savings is specified as

(A42) $sf = dyf - pindex \sum_h ydiv_h - divrow$

where is *divrow* dividend payments of firm to the rest of the world.

Savings of the government is

(A43) $sg = yg - g - pindex \sum_h ygtrf_h - er \cdot gvtrow$

where *gvtrow* is payments of the government to the rest of the world.

The general price index is

(A44) $pindex = \sum_i \mu_{va,i} pva_i$

where $\mu_{va,i}$ is share parameter.

The price of investment is specified as

(A45) $pinv = \sum_i \mu_{inv,i} pq_i$

where $\mu_{inv,i}$ is share parameter.

The sectoral output price is

(A46) $px_i = \frac{pl_i \cdot d_i + pe_i \cdot e_i}{x_i}$

Total investment is the sum of all savings

(A47) $tinv = \sum_h s_h + savf + savg \cdot pindex + er \cdot cab$

where *cab* the current account balance which is

(A48) $cab = \sum_i pwm_i \cdot m_i + \frac{\lambda_{row} yk}{er} + divrow + gvtrow - \sum_i pwe_i \cdot e_i -$
$\sum_h yrow_h - rowtrfg$

The zero-profit condition is given as

(A49) $px_i x_i = pva_i va_i + \sum_j mat_{j,i} pq_i$

Equilibrium in the product market is[10]

(A50) $q_i = \sum_h ch_{i,h} + inv_i + intd_i$

Equilibrium in the skilled labor is

(A51) $spskl = \sum_i skl_i$

where *spskl* is the supply of skilled labor

Equilibrium in the unskilled labor is

(A52) $spuskl = \sum_i uskl_i$

where *spuskl* is the supply of unskilled labor.

Equilibrium in the land is

(A53) $splnd = \sum_i lnd_i$

where *splnd* is the supply of land

The model is sequential dynamic, with the index *t* representing year/period. Capital stock in the next period is

(A54) $k_{i,t+1} = (1 - dep_i)k_{i,t} + indd_{i,t}$

where dep_i is sectoral depreciation rate, $indd_{i,t}$ sectoral investment demand in *t* which, following Jung and Thorbecke (2001), is defined as[11]

(A55) $\frac{indd_{i,t}}{k_{i,t}} = \Psi_i \left(\frac{rk_{i,t}}{u_{i,t}}\right)^2$

where Ψ_i is a constant; $rk_{i,t}$ the sectoral returns to capital in period *t*; and $u_{i,t}$ is the user cost of investment in period *t* which is given as

(A56) $u_{i,t} = pinv_t\left(ir_t + dep_{i,t}\right)$

where $pinv_t$ is the price of investment in period *t*; and ir_t real interest rate.

The supply of skilled labor in the next period *t*+1 is

(A57) $spskl_{t+1} = spskl_t(1 + grspskl)$

where *grspkl* is the growth of skilled labor. The supply of unskilled labor in the next period has similar form

(A58) $spuskl_{t+1} = spuskl_t(1 + gruspkl)$

where *grspkl* is the growth of skilled labor. Both the growth in skilled and unskilled labor is represented by the growth in population.

Following Annabi, Khondler, Raihan, Cockburn, and Decaluwe (2006), all inter-agent transfers in the model increase at the same growth in population. The model is formulated as a static model that is solved recursively from 2012 to 2050. The model is homogenous in prices and the nominal exchange rate is the numéraire in each period.

2012 Social Accounting Matrix

The 240 sectors of the 2006 IO table were updated to 2012 levels using the 2012 Gross Domestic Product (GDP) in the input-output (IO) relationship, $x = (I - A)^{-1} \cdot d$ where x is the column matrix of sectoral output, I identity matrix, and A matrix of 2006 IO table technical coefficients, and d column matrix of final demand, which is the 2012 GDP. This updated 2012 IO provides a major source of information to construct the 2012 SAM. The other sources of information are the savings of households, firm, and the government, which were taken from the 2012 Flow of Funds account of the Bangko Sentral ng Pilipinas (BSP). Information on the 2012 government accounts were taken from the Bureau of Treasury (BoC). The external accounts were taken from the balance of payments (BOP) accounts of the BSP. The 2012 FIES was use to update the structure of consumption across households and across commodities. The 2012 Labor force Survey (LFS) was used to update structure of labor inputs across sectors, including the breakdown of labor into skilled and unskilled, where unskilled labor is defined as labor without high school diploma.

This set of information is combined using a SAM framework. Because data come from various sources, initially the resulting SAM is not a balanced. Adjustments are needed to balance the SAM. There are several methods available in the literature to balance a SAM. In the present case, the SAM adjustments were made using an entropy method (Fofana, Lemelin, & Cockburn, 2005). Table 12 shows the resulting macro SAM.[12] In 2012, GDP of the Philippine economy was PhP 10,613.1 billion. The government-deficit-to-GDP was -2.29%.

Table 12. *2012 Macro SAM of the Philippines, PhP Billion*

	Activities				Commodities				Factors			Institutions			Invest-ment	Rest of World	Total
	Agr_a	Ind_a	Ser_a	Ntrad_a	Agr_c	Ind_c	Ser_c	Ntrad_c	Labor	Land	Capital	Hhld	Firm	Gov't			
Agr_a	-	-	-	-	1,805.3	-	-	-	-	-	-	-	-	-	-	54.0	1,859.3
Ind_a	-	-	-	-	-	7,372.4	-	-	-	-	-	-	-	-	-	2,583.7	9,956.2
Ser_a	-	-	-	-	-	-	6,817.5	-	-	-	-	-	-	-	-	558.5	7,376.0
Ntrad_a	-	-	-	-	-	-	-	1,096.8	-	-	-	-	-	-	-	-	1,096.8
Agr_c	190.0	1,047.3	73.0	1.9	-	-	-	-	-	-	-	325.0	-	-	261.3	-	1,898.4
Ind_c	294.1	4,474.9	1,040.3	66.4	-	-	-	-	-	-	-	3,155.3	-	-	1,715.4	-	10,746.4
Ser_c	132.2	1,188.5	1,649.8	174.4	-	-	-	-	-	-	-	4,355.9	-	-	94.5	-	7,595.3
Ntrad_c	-	-	-	-	-	-	-	-	-	-	-	-	-	1,096.8	-	-	1,096.8
Labor	513.1	952.6	1,234.9	854.1	-	-	-	-	-	-	-	-	-	-	-	-	3,554.8
Land	160.3	2.0	64.5	-	-	-	-	-	-	-	-	-	-	-	-	-	226.8
Capital	569.6	2,290.9	3,313.5	-	-	-	-	-	-	-	-	-	-	-	-	-	6,173.9
Hhld	-	-	-	-	-	-	-	-	3,554.8	226.8	4,640.4	-	52.6	183.5	-	447.6	9,105.6
Firm	-	-	-	-	-	-	-	-	-	-	1,392.7	-	-	-	-	-	1,392.7
Govt	-	-	-	-	53.1	333.5	271.0	-	-	-	-	435.8	210.3	-	-	4.5	1,308.2
Accummulation	-	-	-	-	-	-	-	-	-	-	-	833.6	1,092.7	(242.8)	-	387.7	2,071.1
Rest of World	-	-	-	-	40.1	3,040.5	506.8	-	-	-	140.8	-	37.2	270.7	-	-	4,036.0
Total	1,859.3	9,956.2	7,376.0	1,096.8	1,898.4	10,746.4	7,595.3	1,096.8	3,554.8	226.8	6,173.9	9,105.6	1,392.7	1,308.2	2,071.1	4,036.0	

Source of basic data: 2006 Input-Output Table; 2012 National Income Accounts, 2012 Family Income Expenditure Survey; 2012 Bangko Sentral ng Pilipinas (BSP) Flow of Funds; 2012 Bureau of Treasury;2012 Balance of Payments Account; and 2012 Labor Force Survey.

Memo items:

	Consump-tion	Invest-ment	Govern-ment	Exports	Imports	GDP	Value added	Indirect Taxes	GDP
GDP:	7,836.2	2,071.1	1,096.8	3,196.2	3,587.3	10,613.1	9,955.5	657.6	10,613.1
Gov't deficit/GDP ratio,%:			(2.29)						

where *Agr*: agriculture; *Ind*: industry; *Ser*: service; *Ntrad*: government services; *Hhld*: households; *Govt*: government; *_a*: activities; and *_c*: commodities.

Elasticities

Table 13 shows the various elasticity parameters used in the model.

Table 13. *Elasticity Parameters*

	sigVa1	sigVa2	sigE	sigM
Palay	0.2412	0.2436	-0.3000	0.6000
Coconut	0.2412	0.2436	-0.3000	0.6000
Sugar	0.2412	0.2436	-0.3000	0.6000
Other agriculture	0.2412	0.2436	-0.3000	0.6000
Forestry	0.2412	0.2436	-0.3000	0.6000
Rice milling	0.3216	0.3248	-0.5500	0.8000
Coconut processing	0.3216	0.3248	-0.5500	0.8000
Sugar processing	0.3216	0.3248	-0.5500	0.8000
Other food	0.3216	0.3248	-0.5500	0.8000
All other manufacturing	0.3216	0.3248	-0.5500	0.8000
Other industry	0.3216	0.3248	-0.5500	0.8000
Dwellings	0.2412	0.2414	-0.5500	0.8000
Other service sector	0.3216	0.3248	-0.5500	0.8000
Public administration	0.3216	0.3248	-0.5500	0.8000
sig_lnd	-1.2000			
sig_crps	-1.5000			

sigVa1 = elasticity of substitution in stage 1, between aggregate labor and aggregate capital
sigVa2 = elasticity of substitution in stage 2, between skilled and unskilled labor, and capital and land
sigE = elasticity of transformation between exports and domestic sales
sigM = elasticity of substitution between imports and domestically produced goods
sig_lnd =elasticity of transformation among broad uses of land: crops, forestry, dwellings and others
sig_crps =elasticity of transformation among crops: palay, coconut, sugar, other agriculture

Appendix B: Philippine Poverty and Income Distribution Simulation Model

There are several approaches to linking CGE models with data in the household survey to analyze poverty issues.[13] One approach is a top-down method where the results of CGE models with representative households are applied recursively to data in the household survey with no further feedback effects. Within the top-down method there are wide variations. A popular one is to assume a lognormal distribution of income within household category where the variance is estimated from data in the survey (De Janvry, Sadoulet, & Fargeix, 1991). In this method, the change in income of the representative household generated in the CGE model is used to estimate the change in the average income for each household category, while the variance of this income is assumed fixed. Decaluwé, Patry, Savard, and Thorbecke (2000) argued that a beta distribution is preferable to other distributions such as the lognormal because it can be skewed left or right and thus may better represent the types of intra-category income distributions commonly observed. Instead of using an assumed distribution, Cockburn (2001) apply the actual incomes from a household survey and use the change in income of the representative household generated in the CGE model to each individual household in that category.

There are several approaches to linking CGE models with data in the household survey to analyze poverty issues.[14] One approach is a top-down method where the results of CGE models with representative households are applied recursively to data in the household survey with no further feedback effects. Within the top-down method there are wide variations. A popular one is to assume a lognormal distribution of income within household category where the variance is estimated from data in the survey (De Janvry et al., 1991). In this method, the change in income of the representative household generated in the CGE model is used to estimate the change in the average income for each household category, while the variance of this income is assumed fixed. Decaluwé et al. (2000) argued that a beta distribution is preferable to other distributions such as the lognormal because it can be skewed left or right and thus may better represent the types of intra-category income distributions commonly observed. Instead of using an assumed distribution, Cockburn (2001) applied the actual incomes from a household survey and use the change in income of the representative household generated in the CGE model to each individual household in that category.

There are recent more sophisticated microsimulation methods that link CGE models with household data to analyze poverty issues through the labor market transmission channel. Ganuza, Barros, and Vos (2002) introduced a randomized process to simulate the effects of changes in the labor market structure. Random numbers are used to determine key parameters in the labor market such as: (i) which persons at working age change their labor force status; (ii) who will change occupational category; (iii) which employed persons obtain a different level of education; and (iv) how are new mean labor incomes assigned to individuals in the sample. The random process is repeated a number of time in a Monte Carlo fashion to construct 95% confidence intervals for the indices of poverty. The CGE model is used to quantify the effects of a macroeconomic shock on key labor market variables such as wages, employment, and so forth, and apply them to the microsimulation process. The advantage of this method is that it works through the labor market channel.

The top-down method usually uses CGE models with representative households. One criticism of this approach is that it does not account for the heterogeneity of income sources and consumption patterns of households within each category. Intra-category income variances could be significant part of the total income variance. That is, there is increasing evidence that households within a given category may be affected quite differently according to their asset profiles, location, household composition, education, and so forth. To address this issue an integrated CGE microsimulation allows full integration of all households in the survey in the CGE model. As demonstrated by Cockburn (2001) and Cororaton and Cockburn (2007), this poses no particular technical difficulties because it involves constructing a standard CGE model with as many household categories as there are households in the household survey providing the base data.

In this paper we apply a simpler version of the Ganuza et al. (2002) method. The idea is to allow a change in employment status after a policy change. Thus, if a household does not earn labor income initially because of unemployment, it will have a chance to gain employment after the policy shock. Similarly, if it earns labor income initially, it will have a chance of getting zero labor income after the policy change. Thus, household labor income is affected by changes in wages as well as the chance of getting unemployed after the policy shock. Similar to the Ganuza et al. (2002) method, we introduce a randomized process to simulate the effects of changes in sectoral employment. This approach has been applied in Cororaton and Corong (2009).

The poverty microsimulation model adopted in the project will translate the CGE simulation results on changes in factor prices, employment, and commodity prices to changes in household income and poverty threshold in order to determine the poverty and income distribution impacts of the NPG. Below is a discussion of the procedure used in the poverty microsimulation model.

The FIES provides information on household income. Household income is composed of labor income (total wages and salaries, which is further divided into wages and salaries from agriculture and non-agriculture) and all other income (which includes net share of crops, income from entrepreneurial activities, remittances, etc.). Let the total household income be

$$Y_h = w \cdot L + r \cdot OY$$

where Y_h is total household income, w wage rate, L labor, rate of return or payment to other income, OY. w and r are factor prices while L and OY are factor endowments of households, which include income from land ownership. In the poverty microsimulation model, the results from the CGE simulation are used to change w, L, and r to determine the change in Y_h.

The poverty threshold can be specified as

$$Pov^* = P \cdot MBN$$

where Pov^* is value of the poverty threshold, P commodity prices, and *MBN* the minimum basic needs. The value of the poverty thresholds changes with changes in commodity prices. Changes in commodity prices are taken from the CGE simulation results. *MBN* is held fixed.

Consider a situation where a certain household is initially below poverty, that is, $Y_h<Pov^*$. Changes in w, r, L, and P as a result of the implementation of the NGP could lead to a situation where the household could either remain in poverty (i.e. $Y_h<Pov^*$) or move up the poverty threshold ($Y_h>Pov^*$). This is poverty analysis is conducted in the project. In addition, since Y_h changes across households, the distribution of income also changes. This is also analyzed in the project. These effects across households are analyzed using the poverty microsimulation model that utilizes data from the FIES. The FIES provides several household information including job/business indicator for the household heads, occupation, as well as employment status (employed/unemployed).

Based on the FIES, households can be grouped into those whose household heads are unemployed and those with employment. This is illustrated in Figure 7 below as the employment bar divided into two parts by a line. Those above the line are employed, while those below are unemployed. Employed household heads earn labor income, while those who are unemployed do not.

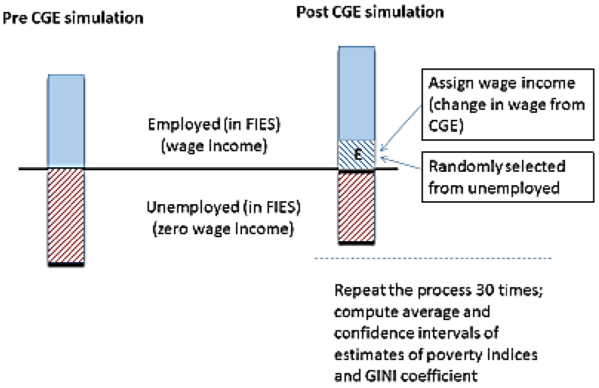

Figure 7 Poverty microsimulation.

A CGE policy simulation generates changes in sectoral employment, factor prices (wages, returns to capital, and returns to land), and commodity prices. These results are used to change the employment bar in Figure 9. To illustrate, assume the employment bar represents employment in agriculture. Assume a CGE policy shock generates a relative sectoral price ratio that favors agriculture. Since agriculture is profitable relative to industry and services, assuming fixed supply of resources (labor, capital, and land), some of the resources used in industry and services will move to agriculture, thereby increasing the output of the agricultural sector. The demand for labor in agriculture will increase, as well as the demand for other factor inputs.

Higher employment in agriculture will move the employment bar in agriculture up as shown in the figure in the post CGE simulation. The number of unemployed in agriculture will decline (those below the horizontal line), while the number of employed will expand (those above the line). The change in agricultural employment from the CGE simulation will determine how far the employment bar is shifted upwards.

There is an area in the employment bar (Area E) which represents those who were originally unemployed during the pre-CGE simulation but have gained employment in the post-CGE simulation. The question then is: how does one select who among the unemployed household heads during the pre-CGE simulation will gain employment in the post-CGE simulation? In the poverty microsimulation model, the previously unemployed household heads in Area E are randomly selected from a pool of unemployed household heads in the pre-CGE simulation. Once they are selected and included in Area E, they are assigned a wage, *w*, which is determined from the CGE simulation. As a result, these household heads will start generating labor income which will increase their total household income.

The random selection of unemployed household heads is repeated 30 times. In each repeated random selection of household heads, the composition of households in Area E is different. In each repeated random selection, poverty indices and income distribution coefficient are calculated. This repeated random selection will allow one to establish confidence interval of the estimates of the poverty indices and the income distribution coefficient.

Conversely, the same process is applied to household heads who belong to the contracting sectors, industry, and services. Unemployment in these sectors will increase and some of the employed household heads will get unemployed and will lose labor income. The random selection of the employed household heads is also done 30 times to establish confidence intervals for the estimates of the poverty indices and income distribution coefficient.

In the project, the Foster, Greer, and Thorbecke (1984) or FGT poverty indices (see below for the formula) are computed using data in the FIES data. The income distribution coefficient that will be used is the GINI coefficient. The FGT indices and the GINI coefficient are computed separately during the pre-CGE simulation and in the post-CGE simulation. The results are then compared to determine whether the NGP generates favorable poverty and distributional impacts or not.

FGT poverty indices. The simplest measurement of poverty, for a given poverty line, is to assess how many households or individuals fall below that line. Expressed as a proportion of the whole population this constitutes the poverty headcount ratio (P_0). However, this measure overlooks how intense household's poverty is, and for instance does not differentiate between a household living just below the poverty line and another far below. A common measure to account for the intensity of poverty is the poverty gap (P_1), which measures the average distance of poor households from the poverty line. Finally, a third measure is used to capture poverty severity index (P_2) which captures the degree of inequality amongst the poor. All three measures are specific measures of the generalized FGT poverty metric, where alpha equals 0, 1, and 2 respectively.

$$\text{(B1)} \quad P_\alpha = \frac{1}{N}\sum_{i=1}^{H}\left(\frac{z-y_i}{z}\right)^\alpha$$

There are several ways of measuring inequality. The most common is through the GINI ratio, which measures the area between the 45^0 perfect equality line and the Lorenz Curve. The value of the coefficient ranges between 0 (perfect equality) and 1 (complete inequality). This measurement of inequality is used in the project. The formula of the GINI coefficient is given by

$$\text{(B2)} \qquad GINI = \frac{1}{2n^2\bar{y}}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|y_i - y_j\right|$$

where *n* is the number of individuals, y_i and y_j are income of the individuals, and is the mean income.

The step-by-step procedure given below adopts some features of the process in Vos (2005).

1. The household head represents the entire family. In the first phase of this procedure, household heads are distinguished by: (a) skill level; and (b) sector of employment. Sector of employment is differentiated into agriculture and non-agriculture whereas skill level is classified into unskilled (no education to non-high school graduates) and skilled (high school graduates and higher). There are four labor income sources/sectoral employment groups: unskilled agriculture, skilled agriculture, unskilled non-agriculture, and skilled non-agriculture.
2. Generate a dummy variable called *employed* where 1 = households with wage income and zero otherwise. Compute the total employment rate $u*$ for each of the four groups defined in step 5. The total employment rate for each group, $u*$ is the weighted mean of the dummy variable *employed* and weights in the household survey. Note that the dummy variable is only a subset of the survey as it only covers those with wage income (dummy variable =1) and those with zero wage income but unemployed (dummy variable = 0).
3. Update the total sectoral employment $u*$ in the household survey by using the variation in sectoral employment from the CGE model.
4. Assign a random number from a normal distribution to those identified as employed. This is called *random*. The variables *random* and *employed* are then sorted by descending order.
5. Compute the accumulated weight of *employed* in each group (by sector and by skill level as defined in 5).
6. Compute the over-all weight of each group. This is simply the sum of accumulated weight by sector and by skill level as defined in 5.
7. Take the ratio of accumulated weight and the overall weight of each group. This ratio is called r_{ij}.
8. Compare r_{ij} and $u*$. If $r_{ij} \leq u*$, then that household head is employed, and unemployed otherwise ($r_{ij} > u*$).
9. Arrange each group in decile. The decile grouping is based on the sum of labor income and capital income, where capital income is the sum of "total income from entrepreneurial activities" and "net share of crops" in the household survey. Other incomes such as dividends, interest income and others are not used in grouping households into decile.
10. Assign the decile mean labor income to those who become newly employed (after a change in $u*$), and reduce labor income of those who become unemployed[15] (after a change in $u*$,). For those who become newly employed, and if they belong to the first decile for example, the mean labor income in the first decile will be assigned to them. Those with labor income, but not picked by the random process will retain their labor income. On the other hand, those with zero labor income but not picked by the random process will continue to have no labor income earnings.
11. Define total income. It is composed of three major items: labor income, capital income, and other income. Capital income is income derived from the various production sectors other than labor income, while other income includes income from dividends, government transfers, and remittances. Note that similar income sources are found in the CGE model and in the household survey.
12. Derive the change in capital and other income of each household in the survey using the average change in capital and other income per household category from the CGE model.
13. Derive the change in labor income in a two-step procedure: (a) use the change in labor income of each household in the survey from the average change in labor income per household category from the CGE model; (b) update the final labor income using the result of the random process carried in step 8.
14. Compute for the total household income by taking the sum of labor income, capital income, and other income.
15. Update the nominal value of the poverty line of each household in the survey by applying the variation in household specific consumer price index from the CGE model.

16. Calculate the GINI coefficient using the new column of income, as well as the FGT poverty indices using the income and new nominal poverty line.
17. The FGT poverty indices are calculated according to the demographic characteristics of the household head: (1) gender; (2) skill level; and (3) location, urban-rural. In total, the final FGT indices are derived for households both in decile and socio-economic categories. The micro-simulation process is repeated 30 times.[16] Thus, there will be 30 estimates of GINI coefficient and FGT indices in each simulation. Confidence intervals of estimates from the 30 simulations/runs are derived.