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## Embedding the AMPLE in a CGE model to analyze intersectoral and economy-wide policy issues

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Philippine Institute for Development Studies  
*Surian sa mga Pag-aaral Pangkaunlaran ng Pilipinas*

## Embedding the AMPLE in a CGE Model to Analyze Intersectoral and Economy-Wide Policy Issues

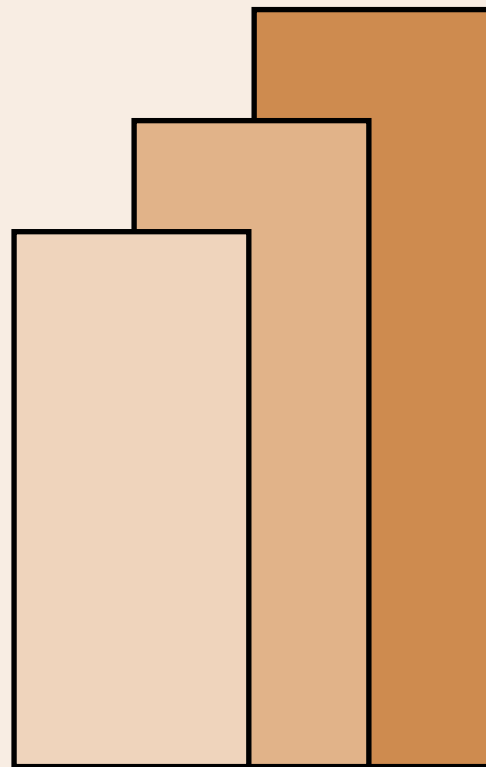
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## **DRAFT REPORT**

### **Embedding the AMPLE in a CGE Model to Analyze Intersectoral and Economywide Policy Issues**

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31 August 2016

#### **Abstract**

This study implements an updated set of projections for Philippine agriculture which addresses the following key issues:

- i) The proper modeling of land allocation to better analyze the implications of land scarcity under climate change;
- ii) The impact of climate change, agricultural productivity growth, and trade liberalization on agriculture;
- iii) The indirect impacts of climate change and agricultural productivity growth on the rest of the economy;
- iv) The impact of productivity growth in manufacturing and services on agriculture, including on agricultural wages.

To address i) and ii), the study provides a new approach towards modeling land allocation, and updated projections for agriculture to 2030 using the extended Agricultural Model for Policy Evaluation (AMPLE). The study will address iii) and iv) by extending AMPLE into a computable general equilibrium (CGE) version, called AMPLE – CGE, which is still being developed. This report documents the compilation of the AMPLE – CGE data set, namely the 2013 Social Accounting Matrix (SAM).

Keywords: Area allocation, quasi-fixed factor, partial equilibrium model, constant elasticity of transformation

## 1. Introduction

### 1.1 Challenges and opportunities for Philippine agriculture

Philippine agriculture accounts for the bulk of the country's food supply, and plays a key role in the livelihood of the poor. About 29 percent of workers in the country are in agriculture, though agriculture's share in output is just 10%, implying low levels of labor productivity relative to industry and services. Of all poor workers in the country, up to two-thirds are agricultural workers (Briones, 2016). Clearly any growth trajectory that fails to reach agriculture-dependent households cannot be inclusive.

Unfortunately, growth in agriculture slowed considerably in 2011-2015, falling to 1.7 percent, from 2.9 percent in 2001 – 2010. In stark contrast, in the 2010s, overall growth accelerated to 5.9 percent, from 4.8 percent in the 2001-10. Likewise real agricultural wages have stagnated since the 2000s, growing only 0.2 percent on average over the period 2002 – 2012 (PSA, 2016). The poor performance of agriculture is closely linked with the lackluster achievement in poverty reduction in the 2010s, which saw the country missing its Millennium Development Goal (MDG) target of reducing poverty incidence by half from 1991 to 2015.

The demands on Philippine agriculture are bound to intensify over time, as population (now at 101 million) continues to rise. Land and water however continue to impose resource constraints that limit expansion of agricultural supplies. Already prone to various risk, agriculture must furthermore contend with adverse impacts of climate change (Thomas *et al.* 2015).

Finally, import-competing sectors within agriculture – in particular rice - face intensified competition from world markets as a result of past and forthcoming initiatives for economic integration, e.g. the imminent lifting of the quota regime in rice importation by 2017. Economic integration on the other hand present promising opportunities for agriculture to leave the doldrums. Export-oriented sectors such as coconut, banana, mango, cocoa, and aquaculture, can capitalize on vast and expanding markets, as long as they can address age-old supply bottlenecks. The rapid economic growth of the economy as a whole itself offers marvelous prospects for agriculture, as long as it can adapt to changing consumer preferences, as well as integrate with dynamic industries and services. That is, agriculture must form linkages with larger value chains spanning agricultural inputs and services (e.g. transport), to agro-industries such as food processing and beverage manufactures.

The 2011 – 2016 Philippine Development Plan (PDP) subscribes to the strategy of developing forward linkage with industry. The current administration has articulated as part of its Ten-Point Socio-economic Agenda the following item: *promote rural and value chain development toward increasing agricultural and rural enterprise productivity and rural tourism*, implying continuity with the thrust of the PDP.

## 1.2 Analytical approach

How will agriculture evolve over the next few decade in the face of these and other challenges? This study aims to answer this question using the Agricultural Model for Policy Evaluation (AMPLE). The AMPLE is a numerical supply and demand model for evaluating alternative agricultural scenarios. AMPLE is comprehensive in its representation of Philippine agriculture; it is able to represent impact of the various challenges in the form of rapid population growth, resource constraints, and climate change. It had been earlier applied for assessing productivity growth from 2010 to 2020 (Briones, 2013a), food security from 2010 to 2040 (JICA, 2013), and trade liberalization scenarios from 2010 to 2020 (Briones, 2013b).

On the other hand, AMPLE has no industry, no service, and no factor (e.g. labor) market. Hence it cannot generate results for employment and wages, or incorporate forward and backward linkages to agriculture. This limits its ability to analyze scenarios of inclusive growth through transformation of agricultural value chains.

A straightforward remedy is to embed AMPLE within a computable general equilibrium (CGE) model of an economy. A CGE is a natural way to incorporate non-agricultural sectors and factor markets. A CGE extension of AMPLE, or AMPLE-CGE, will be able to generate scenarios for labor markets and agro-industries, under business-as-usual and alternative scenarios related to exogenous shocks (e.g. climate change), or changes that can be affected by policy (e.g. additional capital formation from liberalized investment policies, technological progress accelerated by public R&D, etc.).

The current study takes the first phase of extending AMPLE to a CGE version. It provides an update set of scenarios for AMPLE for the period 2013 to 2030 which incorporates productivity growth, climate change, and trade liberalization. It also outlines the design of the AMPLE-CGE; and compiles the data for developing the AMPLE – CGE, mainly in the form of a 2013 Social Accounting Matrix (SAM).

## 2. Updating AMPLE

### 2.1 Extending the area $\times$ yield formulation to model climate change

Some models of crop supply treat area and yield variables separately. This approach conveniently imposes the property of land being a quasi-fixed factor. Numerical agricultural multi-market models tend to sidestep the area  $\times$  yield formulation, or adopt an *ad hoc* formulation of land allocation or the overall land constraint. This paper proposes a parsimonious area  $\times$  yield framework based on a constant elasticity of land use transformation, derives land use from profit maximization, and imposes an additive total land constraint as a quasi-fixed factor. An application to developing country with a large agricultural sector demonstrates the feasibility and usefulness of the approach for agricultural scenario analysis.

Modeling output as a product of area and yield is formulation is a useful representation of agricultural supply as it enables a dichotomy between area (relatively fixed) and yield (variable). While much intellectual energy has been expended on projecting the yield side of agricultural supply, relatively little effort has been spent understanding the area side. Yet the two elements are integral to understanding agricultural production. Conceptually, land may be treated as a quasi-fixed factor, while other inputs to farming are treated as flexible in quantity, e.g. labor, fertilizer, and machinery. The farmer can raise yields by input intensification; however, total quantity of land is fixed in the short run.

This paper presents a modeling framework that integrates the area  $\times$  yield formulation with varying degrees of flexibility in area allocation within an overall area constraint. The framework is highly tractable, firmly rooted in optimization, requires minimal priors for calibration, and is well-suited to multiproduct modeling of agricultural supply.

### 2.2 Related literature

#### *Econometric and related approaches*

A straightforward approach to modeling area allocation is to directly posit a functional form for area shares: Bewley *et al.* (1987) estimated a multinomial logit model of crop area shares based on Theil (1969) which ensures satisfaction of non-negativity and adding-up conditions. The multinomial logit has been applied in subsequent literature, e.g. Khiem and Pingali (1995), as well as Rosegrant *et al.* (1998).

Rather than positing a function for allocating area shares, optimization attempts to derive area allocation from known priors, i.e. prices, technology, and factor constraints. Shumway *et al.* (1984) inferred allocation of area from maximization of profit subject to an aggregate land constraint. Chambers and Just (1989) showed how to recast the area-yield problem within a sequential optimization framework. Their choice model involved a two-stage decision-making procedure: in the first step the farmer selects the optimal level of inputs (and outputs) subject to an area constraint for each crop; in the second the farmer allocates the land area to the various crops.

Coyle (1993) presented an econometric approach to implementing the optimal area allocation framework, but omitted discussion of yield determination. Arnade and Kelch (2007) presented a yield and area allocation model based on duality, with land a quasi-fixed factor whether at the level of the farmer or of the industry. The sub-problem of optimizing output subject to an area constraint leads to a shadow price for land; solving for these shadow prices leads to an expression for the area elasticities. Gorddard (2013) shows that with added structure to the problem, i.e. non-jointness in production, then crop prices affect land allocation only through the shadow price of land.

#### *Multi-market and general equilibrium models*

A number of multi-market agricultural models currently in use apply the area-yield formulation for crop supply. In general however these models do not impose an aggregate land constraint for crop area. The AGLINK of FAO (Conforti and Londero 2001) models crop area as a constant elasticity function of crop revenues per ha. The IMPACT of IFPRI also uses a constant elasticity formulation, with output prices as explanatory variables; a similar formulation is used in the China Agricultural Simulation Model or CAPSIM (Huang and Li 2003).

General equilibrium models have also incorporated a special treatment for land. In the Global Trade in Agricultural Products (GTAP) model, two types of factors are distinguished, namely *mobile* and *sluggish*; the latter are characterized by an industry-specific rate of return, whereas returns per unit at the margin are identical for mobile factors (Hertel and Tsigas 1997). Land appears as a sluggish factor; this essentially derives from an earlier CGE for the United States (Hertel and Tsigas 1988). The production function is modeled directly, i.e. bypassing the area  $\times$  yield formulation.

The APSIM model (APPC 2002) of the Philippines uses a variant of this approach by expressing crop area as a share of total. This indirectly incorporates the aggregate land constraint; however to satisfy the adding up restriction one of the crop categories is treated as a residual. Instead, deriving area allocation functions from profit maximization, as done in this paper, directly incorporates the aggregate area constraint without need for *ad hoc* restrictions.

Finally, the paper of Mariano and Giesecke (2014) present a detailed analysis of land allocation within an agriculture subsystem of a CGE. Their formulation is based on Ferriera *et al.* (2001); Giesecke *et al.* (2013); and Dixon and Rimmer (2006). They posit a two-stage problem as follows: in the first stage, the model predicts adjustment of land across seven broad land types, namely: annual crops, perennial crops, animal farming, aquaculture, forestry and unused agricultural land. Of greater interest to this study is stage 2, which takes the form of a maximization problem:

$$\text{Maximize: } U_k^{(2)}(N_1^{(2)(t)} P_1^{(2)(t)}, N_2^{(2)(t)} P_2^{(2)(t)}, \dots, N_{|AGGLND(k)}^{(2)(t)} P_{|AGGLND(k)}^{(2)(t)}),$$

$$\text{subject to: } N_k^{(1)} = \sum_{g=1}^{(AGGLND(k))} N_g^{(2)} \quad (k=1, \dots, 7), \text{ where}$$

$AGGLND(k)$  defines seven sets  $k=1, \dots, 7$ , such that:

$k=1$ : Paddy;  $k=2$ : Aquaculture;  $k=3$ : Annual crops (7 types);

$k=4$ : Animal commodities (4 types);  $k=5$ : Perennial crops (7 types);  $k=6$ : Forestry;

$k=7$ : Unused; and  $|AGGLND(k)|$ : size of set  $AGGLND(k)$ ;

$N_g^{(2)(t)}$  supply of agricultural land to use  $g$ ;

$P_g^{(2)}$  rental price of agricultural land in use  $g$ ;

$U_k^{(2)}$  utility derived from agricultural land owners from allocating land across alternative uses within  $AGGLND(k)$ .

The stage 2 model involves a utility function to determine allocation of land across alternative uses within that stage. The utility function contains rental income by land type as its arguments; rental incomes are combined to obtain utility following a CES functional form. According to the authors (Mariano and Giesecke, p. 354):

As discussed in Giesecke *et al.* (forthcoming), these optimization problems follow Dixon and Rimmer (2006) in assuming that resource owners view rents earned on different uses of the resource as imperfect substitutes. The resulting land supply functions, while very similar to CET supply functions in their form, have the attractive property, not shared by CET, that total



land supply is unaffected by price-induced reallocations of land across alternative uses.’

Unfortunately the representation of the second stage problem as one of utility maximization is still an *ad hoc* device; income is in fact fungible, raising difficulties as to why different rental income sources should generate different utilities. A more intuitive approach is to directly represent imperfect substitution of land use in multi-crop production. However this approach raises the problem confounding the determination of **total** land area and the **relative allocation of land within a given area** due to differences in relative prices (mentioned in the quote). This paper proposes the more intuitive approach while maintaining a separation between total land area (sum of individual land areas) and reallocation of land across alternative uses (based on relative prices). The solution is discussed below.

### 2.3 Production with area allocation

#### *Basic model*

Under constant returns in all inputs, the production function can be expressed on average (per ha) basis. This permits representation of optimal choice in two stages: in the first stage the farmer selects on per ha basis the optimal combination of inputs to produce output; in the second stage the farmer selects the optimal allocation of area across crops.

Consider the area x yield formulation:

$$QS_i = A_i Y_i, \quad (1)$$

where  $QS_i$  denotes output of crop  $i$ ,  $A_i$  is area harvested in hectares, and  $Y_i$  is output per hectare. Let  $X_{ij}$  denote average quantity of input  $j$  applied to a hectare of land to produce crop  $i$ . The corresponding input price is  $W_j$  while  $P_i$  is the output price and  $R_i$  the revenue per hectare net of input cost. Farmers treat prices as given. The per hectare production function and net revenue expression are respectively as follows:

$$Y_i = \alpha_{0i} \prod_j X_j^{\alpha_{ij}}; \quad (2)$$

$$R_i = P_i Y_i - \sum_j W_j X_j. \quad (3)$$

Equation (2) is in constant elasticity form. Suppose production is subject to constant returns to scale, and let  $\sum_j \alpha_{ij} = \alpha_i$ ; had land been included as an input, then  $\alpha_i = 1$ ; as land

is not among the inputs, then  $\alpha_i < 1$ . Label the optimal value by an asterisk; the first-order condition for maximum profit leads to Equation (4), which calibrates  $\alpha_{ij}$ :

$$W_j X_j^* = \alpha_{ij} P_i Y_i^* \quad (4)$$

Substituting (4) in (3) and (2):

$$R_i^* = P_i Y_i^* (1 - \alpha_i); \quad (5)$$

$$Y_i^* = P_i^{1-\alpha_i} \left[ \alpha_{0i} \prod_j (\alpha_{ij} / W_j)^{\alpha_{ij}} \right]^{\frac{1}{1-\alpha_i}} \quad (6)$$

Taking natural logarithms, the following expresses own-price elasticity of yield:

$$\frac{\partial \log Y_i^*}{\partial \log P_i} = \frac{\alpha_i}{1 - \alpha_i} > 0 \quad (7)$$

Equation (7) implies cross-price elasticities of yield are all zero. Taking the logarithm of (5), the following expression on elasticity of net revenue per ha with respect to output price:

$$\frac{\partial \log R_i^*}{\partial \log P_i} = \frac{1}{1 - \alpha_i} \quad (8)$$

#### a. Area allocation

Let  $A_i$  denote area allocated to crop type  $i$ , and  $A$  denote an area composite, assumed given in one period. This is called the **composite area** model. The key assumption of this paper is that conversion of land use across crops is subject to a constant elasticity transformation function:

$$A = \left( \sum_i \beta_i A_i^\rho \right)^{\frac{1}{\rho}} \quad (9)$$

Note that the transformation function is linearly homogeneous; the producer can be treated as a representative farmer; for convenience the entire crop output is assumed to be produced by a single representative. Assuming a strictly concave transformation function, it can be shown that  $\rho > 1$ .

For convenience, let  $\phi = \sum_i \beta_i A_i^\rho$ , and let  $TR = \sum_i R_i^* A_i$  be total net revenue per ha; note that Equation (5) calibrates for  $R^*$ . The optimized net revenue per ha by crop functions as an indirect price received by the farmer from allocating land. The maximization problem is:

$$\max TR = \sum_i R_i^* A_i \quad \text{subject to (9).}$$

The Lagrangian is written as:

$$Z = \sum_i R_i^* A_i + \lambda \left[ A - \left( \sum_i \beta_i A_i^\rho \right)^{\frac{1}{\rho}} \right]$$

Let  $k$  be an alternative index for crop category. The first-order conditions of the Lagrangian obtain:

$$R_k^* A_k^* = \lambda \left( \frac{A}{\phi} \right) \beta_k A_k^{*\rho}. \quad (10)$$

Substitution and rearrangement arrive at the following expression to calibrate  $\lambda$ :

$$TR^* = \lambda A. \quad (11)$$

That is,  $\lambda$  serves as a shadow price of land. Equation (11) serves to calibrate  $\lambda$ . Re-arranging (9), with change of index, results in Equation (12), which calibrates  $\beta_i$ .

$$A_i = \left( \frac{\lambda \beta_i}{R_i^*} \right)^{\frac{1}{1-\rho}} A. \quad (12)$$

The elasticity of transformation with respect to relative net revenue per ha is given by:

$$\sigma = \frac{\partial \log(A_k/A_i)}{\partial \log(R_i^*/R_k^*)} = \frac{1}{1-\rho}. \quad (13)$$

Based on prior information on  $\sigma$ ,  $\rho$  can be calibrated based on (13). Under concavity of the transformation function,  $\rho > 1$ , hence  $\sigma < 0$ ; that is, an **increase** in the relative net revenue of  $i$  **reduces** the relative area of  $k$ , or **increases** the relative area of  $i$ . From (11), it is easily shown that the elasticity of crop area with respect to net revenue per ha is positive:

$\partial \log A_i / \partial \log R_i = -\sigma > 0$ . That is, an increase in net revenue per ha of a crop increases the area allocated to that crop.

*Total area over time*

In general  $A$  is not observable and must be inferred supposing the parameters of Equation (9) are already known. However, aside from  $\sigma$  (which can be in principle be estimated), parameters of (9) may not be known. Given known  $A_i$ 's, what is observable is total area  $atot$  defined additively, i.e.  $atot = \sum_i A_i$ . Obviously,  $atot$  will generally not equal  $A$ , a problem noted earlier in the review of literature (Section 2.2). The version based on total area is called the **additive area** model. While the original problem is a composite area model, projections for changes in exogenous area are more readily available for the additive area model. The solution proposed here is to solve an additive area model that is equivalent to a corresponding composite area model.

Posit a transformation variable  $ATRAN$ , such that:  $A * ATRAN = atot$ ; hence,

$$ATRAN = atot/A. \quad (14)$$

At the base period, the value of  $ATRAN$  and  $A$  are arbitrary; for simplicity, set:

$$ATRAN = 1, A = atot. \quad (15)$$

Let total area evolve according to a growth rate  $g_{atot}$  from base period 0 to period 1, hence (with obvious notation)  $atot_1 = atot_0(1 + g_{atot})$ . Composite area  $A$  evolves at a rate  $g_A$ , where  $A_1 = A_0(1 + g_A)$ . The problem is to find  $g_A$  consistent with a given  $g_{atot}$ . Following (14), the solution is:

$$\frac{A_1}{A_0} - 1 = (1 + g_{atot}) \left( \frac{ATRAN_0}{ATRAN_1} \right) - 1 = g_{A0}. \quad (16)$$

The remaining problem now is to determine  $ATRAN$ . Consider a well-formed multi-market model consistent with equations (1) to (15); collect the equilibrium conditions into a set  $\square$ . Given the optimization problem:

$$\text{Minimize } ATRAN \text{ subject to } \square. \quad (17)$$

Suppose a solution exists and solution values are marked by an asterisk, e.g.  $ATRAN^*$ . Starting with the initial equilibrium, where markets clear and producers are maximizing profit, the solution is  $ATRAN_0^* = 1$  from Equation (15). Given a shock due to the change from  $atot_0$  to  $atot_1$ , a new equilibrium can be found by implementing (17); the solution will

implicitly define  $A_1^*$  and  $g_{A0}^*$  from (16). The process can be repeated for indefinitely many periods.

To determine if the additive model is truly equivalent to a composite area model, solve a composite model using the growth rate given in (16), and show the solution is the same as that of the original additive model. Such a test is performed in Section 2.4.

## 2.4 The AMPLE Model

The agricultural goods in AMPLE are shown in Table 1. AMPLE contains 11 crops, three livestock and poultry products, and four aquatic products, for a total of 18 commodities. Paddy rice is divided into two production systems, namely rainfed and irrigated; Freshwater fish as well as Marine fish are likewise divided into two production systems, namely capture and aquaculture. Each of the goods is converted into a final form for use on the demand side.

**Table 1: Commodities in the AMPLE**

	<b>Primary form/system</b>	<b>Final form</b>
Crops	1. Paddy rice (Rainfed, irrigated)	Milled rice
	2. White corn	White corn
	3. Yellow corn	Yellow corn
	4. Coconut	Copra
	5. Sugarcane	Raw sugar
	6. Root crops	Root crops
	7. Banana	Banana
	8. Mango	Mango
	9. Other fruits	Other fruits
	10. Vegetables	Vegetables
	11. Other crops	Other crops
Livestock and poultry	12. Swine	Pork
	13. Poultry	Poultry meat
	14. Other livestock and dairy	Other meat and dairy
Aquatic products	15. Freshwater fish (Capture, Aquaculture)	Freshwater fish
	16. Brackishwater fish	Brackishwater fish
	17. Seaweed	Processed seaweed
	18. Marine fish (Capture, Aquaculture)	Marine fish

Source: Author's model.

The sets of the model are shown in Table 1. Set  $G$  lists all the goods, including categorization by production system. The set is divided into crops, and other agricultural products (e.g. livestock products, denoted  $L\nu$ , together with aquatic products). Crops

<b>Label</b>	<b>Definition</b>	<b>Relationship</b>
$G$	Goods	
$Cr$	Crops	$Cr \subset G$
$CrS$	Crops by system	$CrS \subset Cr$
$OAg$	Other agricultural products	$OAg \subset G$

differentiated by system are collected in  $CrS$ , and similarly non-crop products by system in  $OAgS$ .

<i>OAgS</i>	Other agricultural products by system	$OAgS \subset OAg$
<i>Lv</i>	Livestock	$Lv \subset OAg$
<i>In</i>	Inputs	$In \subset GIn$
<i>GM</i>	Goods as marketed	$GM \subset G$
<i>GC</i>	Goods consumed as food	$GC \subset GM$
<i>GCN</i>	Goods consumed, non-food	$GCN \subset GM$
<i>GS</i>	Goods by system	$GS \subset G$
<i>GImp</i>	Goods imported	$GImp \subset GM$
<i>GImpN</i>	Goods not imported	$GImpN \subset GM$
<i>GExp</i>	Goods exported	$GExp \subset GM$
<i>GExpN</i>	Goods not exported	$GExpN \subset GM$
<i>H</i>	Household types	

**Table 2: Sets in AMPLE**

Source: Author's model.

Set *GM* denotes the 18 commodities or marketed goods of AMPLE; it is derived from *G* by omitting the production system categories. Elements of *GM* consumed as food are denoted *GC* (excluded elements are Yellow corn and Seaweed). Elements of *GM* that are also imported are denoted *GImp*; excluded are White corn, Coconut, Banana, Mango, Freshwater fish, and Seaweed, which are collected in *GImpN*. Elements of *GM* exported are denoted *GExp*; excluded are White corn, Swine, Other livestock, and Freshwater fish, which are collected in *GExpN*. The model accommodates multiple household types in *H* (for this application though only one household type is specified).

Variables and parameters are shown in Table 3, which are divided into blocks. These blocks are elaborated in the model equations (Table 4). The first block of equations pertain to supply. S1 converts primary output to supply. S2 is the yield function, which follows Equation (6); S2' is the case of Paddy rice which originates from two systems. S3 computes net revenue per ha, which follows Equation (4). S4 is the area function, which follows Equation (11). S4' is the case of area for Paddy rice. S5 sets the shadow price of land, which follows Equation (10). S7 computes total area. S8 is the function for primary production

supply of non-crop products. S8a and S8b respectively pertain to Freshwater fish and Marine fish (each the sum of their respective capture and aquaculture systems).

The next block pertains to demand. Household food demand is modeled as a Linear Approximate Almost Ideal Demand System (LA-AIDS): D1 is the LA-AIDS share equation; D2 and D3 compute the deflated food expenditure and the Stone deflator, respectively. D4 determines total food expenditure using the Linear Expenditure System (LES) form. D5 links expenditures on food items to the food share; D6 converts household food demand to total demand.

The last block pertains to trade, prices, and model closure. Exports and supply are modeled within a CET composite framework, while imports and demand are modeled within an Armington composite framework; both are standard in computable general equilibrium models. Note that both exports and imports take world prices as given (the small open economy assumption).

Equations T1 to T5 pertain to supply and exports. T1 computes supply price from producer price; T2 computes export price from world price. T3 relates supply revenues to revenues from exports and production for the domestic market, while T3' is the special case of goods not exported. T4 and T5 respectively determine supply to foreign and domestic destinations based on the CET composite, whereas T5' is the special case of goods not exported.

Equations T6 to T10 pertain to demand, mirroring equations T1 to T5. T6 computes the import price. T7 computes the demand revenue, where T7' is the special case of goods not imported. T8 and T9 respectively determine demand from foreign and domestic sources based on the Armington composite, whereas T9' is the special case of goods not imported.

The last set of equations close the model. T10 computes the retail price from the demand price. T11 imposes equilibrium where supply to the domestic destination equals demand from domestic destination. T12a to T12 c simply impose equality of producer price for a marketed commodity and its component production systems, applied respectively to Paddy rice, Freshwater fish, and Marine fish.



**Table 3: Variables and parameters of AMPLE**

Label	Definition	Relationship
<i>Supply Block</i>		
$QSS_i$	Primary production	$i \in G$
$QS_i$	Production in final form	$i \in GM$
$A_i$	Area harvested by crop	$i \in Cr$
$Y_i$	Yield by crop	$i \in Cr$
$NREV_i$	Net revenue by crop	$i \in CrS$
$PP_i$	Output price received by farmer	$i \in G$
$LAM$	Shadow price of land	
$ATRAN$	Proportionality factor for total area	
$conv_i$	Processed product as ratio to primary product	$i \in GM$
$byprodw_i$	Ratio of byproducts and waste to primary product	$i \in GM$
$w_i$	Factor and input prices	$i \in In$
$atot$	Total crop area	
$\alpha 0Y_i$	Constant term in yield function	$i \in CrS$
$\alpha 1Y_{ij}$	Crop yield elasticity with respect to inputs	$i \in CrS; j \in In$
$\alpha Y_i$	Term denoting $\sum_j \alpha_{ij}$	$i, j \in CrS$
$\beta_i$	Coefficient term in area function	$i \in CrS$
$\sigma A$	Elasticity term in area transformation function	
$\rho$	Constant term in area transformation function	
$\alpha OAg_i$	Constant term in supply function, non-crops	$i \in OAg$

<b>Label</b>	<b>Definition</b>	<b>Relationship</b>
$\alpha 1 OAg_i$	Own price term in non-crop supply	$i \in OAg$ ;
$\alpha 2 OAg_{ij}$	Input price term in non-crop supply	$i \in OAgS$ ; $j \in In$
<i>Demand block</i>		
$PC_i$	Retail price	$i \in GC$
$SH_{ij}$	Share of food item in food expenditure	$i \in GC$ ; $j \in H$
$STONE_i$	Stone price index	$i \in H$
$RFEX_i$	Food expenditure deflated by Stone index	$i \in H$
$FEX_i$	Food expenditure	$i \in H$
$QC_{ij}$	Quantity demanded for household consumption	$i \in GC$ ; $j \in H$
$QDC_i$	Quantity demanded for consumption	$i \in GC$
$QD_i$	Quantity demanded	$i \in GM$
$QFd_i$	Demand for feed from livestock sectors	$i \in Lv$
$QDLv_i$	Feed component of demand	$i \in GM$
$\gamma 0_{ij}$	Intercept term in AIDS	$i \in GC$
$\gamma 1_{ijk}$	Coefficient of price term in AIDS	$i \in GC$ ; $j \in GC$ ; $k \in H$
$\gamma 2_{ij}$	Coefficient of expenditure term in AIDS	$i \in GC$ ; $j \in H$
$HI_i$	Household income	$i \in H$
$\theta_i$	Marginal share of food in supernumerary income	$i \in H$
$sub_i$	Minimum expenditure	$i \in H$
$subf_i$	Subsistence expenditure	$i \in H$

<b>Label</b>	<b>Definition</b>	<b>Relationship</b>
$pop_i$	Population	$i \in H$
$feedr_i$	Feed requirement per unit livestock output	$i \in Lv$
$feedsh_i$	Share of sector in feed requirement of livestock	$i \in GM$
<i>Trade, prices, closure</i>		
$PS_i$	Producer price after processing	$i \in GM$
$PX_i$	Export price	$i \in GExp$
$PWH_i$	Wholesale price	$i \in GM$
$QSF_i$	Export component of CET composite	$i \in GExp$
$QSL_i$	Domestic component of CET composite	$i \in GM$
$PD_i$	Product price on demand side	$i \in GM$
$PM_i$	Import price	$i \in GImp$
$QDF_i$	Import component of Armington composite	$i \in GImp$
$QDL_i$	Domestic component of Armington composite	$i \in GM$
$exr$	Exchange rate in PhP per dollar	
$pwx_i$	World price of exported good in dollars	$i \in GExp$
$pwm_i$	World price of imported good in dollars	$i \in GImp$
$tar_i$	Tariff rate in percent of world price	$i \in GM$
$marh_i$	Marketing margin, farm to wholesale	$i \in GM$
$marr_i$	Marketing margin, wholesale to consumer	$i \in GC$
$\sigma D_i$	Elasticity term in Armington composite	$i \in GImp$
$\delta DF_i$	Foreign component term, Armington composite	$i \in GImp$

Label	Definition	Relationship
$\delta DL_i$	Domestic component term, Armington composite	$i \in GImp$
$\sigma S_i$	Elasticity term in CET composite	$i \in GExp$
$\delta SF_i$	Foreign component term, CET composite	$i \in GExp$
$\delta SL_i$	Domestic component term, CET composite	$i \in GExp$

Source: Author's model.

**Table 4: Equations of AMPLE**

Label	Statement	Relationship
<i>Supply block</i>		
S1.	$QS_i = conv_i * QSS_i * (1 - byprodw_i)$	$i \in GM$
S2.	$Y_i = \left[ (PP_i^{\alpha Y_i}) * (\alpha OY_i) * \prod_j (\alpha 1Y_{ij} / w_j)^{\alpha 1Y_j} \right]^{\frac{1}{1 - \alpha Y_i}}$	$i \in CrS; j \in In$
S2'.	$Y_{Paddy\ rice} = \frac{A_{Paddy\ rainfed} Y_{Paddy\ rainfed} + A_{Paddy\ irrigated} Y_{Paddy\ irrigated}}{A_{Paddy\ rice}}$	
S3.	$NREV_i = (1 - \alpha Y_i) * PP_i * Y_i$	$i \in CrS$
S4.	$A_i = ATRAN * atot * (LAM * \beta_i / NREV_i)^{\sigma A}$	$i \in CrS$
S4'.	$A_{Paddy\ rice} = A_{Paddy\ rainfed} + A_{Paddy\ irrigated}$	
S5.	$LAM * ATRAN * atot = \sum_i NREV_i A_i$	$i \in CrS$
S6.	$QSS_i = A_i * Y_i$	$i \in CrS$
S7.	$atot = \sum_i A_i$	$i \in CrS$
S8.	$QSS_i = \alpha OAg_i \prod_j PP_i^{\alpha 1OAg} \prod_k w_k^{\alpha 2OAg_k}$	$i \in OAg; k \in In$
S8a.	$QSS_{Freshwater\ fish} = QSS_{Freshwater\ fish\ capture} + QSS_{Freshwater\ fish\ aquaculture}$	

Label	Statement	Relationship
S8b.	$QSS_{\text{Marine fish}} = QSS_{\text{Marine fish capture}} + QSS_{\text{Marine fish aquaculture}}$	
<i>Demand block</i>		
D1.	$SH_{ij} = \gamma 0_{ij} + \sum_k \gamma 1_{ik} \log PC_k + \gamma 2_{ij} RFEX_j$	$i \in GC; j \in H;$ $k \in GC$
D2.	$RFEX_i = FEX_i - STONE_i$	$i \in H$
D3.	$STONE_i = \sum_j SH_j \log PC_j$	$i \in H; j \in GC$
D4.	$FEX_i = subf_i + \theta_i (HI_i - sub_i)$	$i \in H$
D5.	$PC_i * QC_{ij} = SH_{ij} FEX_j$	$i \in GC; j \in H$
D6.	$QDC_i = \sum_j QC_{ij} * pop_j$	$i \in GC; j \in H$
D7.	$QFd_i = feedr_i * QSS_i$	$i \in Lv$
D8.	$QDLv_i = feedsh_i * \sum_j QFd_j$	$i \in GM$
<i>Trade and prices</i>		
T1	$PS_i = \left( \frac{PP_i}{conv_i} \right) \cdot (1 - byprodw_i) \cdot (1 + marh_i)$	$i \in GM$
T2	$PX_i = pwx_i \cdot exr$	$i \in GExp$
T3.	$PS_i \cdot QS_i = PX_i \cdot QSF_i + PWH_i \cdot QSL_i$	$i \in GExp$
T3'.	$PS_i = PWH_i$	$i \in GExpN$
T4	$QSF_i = QS_i \left( \frac{\delta SF_i \cdot PS_i}{PX_i} \right)^{\sigma_{S_i}}$	$i \in GExp$
T5	$QSL_i = QS_i \cdot \left( \frac{\delta SL_i \cdot PS_i}{PWH_i} \right)^{\sigma_{S_i}}$	$i \in GExp$

Label	Statement	Relationship
T5'	$QSL_i = QS_i$	$i \in GExpN$
T6	$PM = pwm_i \cdot exr \cdot (1 + tar_i)$	$i \in GImp$
T7	$PD_i \cdot QD_i = PM_i QDF_i + PWH_i \cdot QDL_i$	$i \in GImp$
T7'	$PD_i = PWH_i$	$i \in GImpN$
T8	$QDF_i = QD_i \cdot \left( \frac{\delta DF_i \cdot PD_i}{PM_i} \right)^{-\sigma_{D_i}}$	$i \in GImp$
T9	$QDL_i = QD_i \cdot \left( \frac{\delta DL_i \cdot PD_i}{PWH_i} \right)^{-\sigma_{D_i}}$	$i \in GImp$
T9'	$QDL_i = QD_i$	$i \in GImpN$
T10	$PC_i = PD_i \cdot (1 + marr_i)$	$i \in GC$
T11	$QSL_i = QDL_i$	$i \in GM$
T12a.	$PP_{\text{Paddy rice}} = PP_{\text{Paddy rainfed}} = PP_{\text{Paddy irrigated}}$	
T12b.	$PP_{\text{Freshwater fish}} = PP_{\text{Freshwater fish capture}} = PP_{\text{Freshwater fish aquaculture}}$	
T12c.	$PP_{\text{Marine fish}} = PP_{\text{Marine fish capture}} = PP_{\text{Marine fish aquaculture}}$	

Source: Author's model.

The baseline data of the model are constructed mostly from CountrySTAT data sets of the Philippine Statistical Authority – Bureau of Agricultural Statistics (PSA-BAS) (<http://countrystat.bas.gov.ph>). Baseline values are set at the average of annual data for 2012 – 2014 (centered on 2013), assumed to approximate a baseline equilibrium. Data on quantity produced, imported, consumed, exported and used for other purposes, are obtained from the supply and utilization accounts (SUA). Where no SUA are available (i.e. for freshwater, brackishwater and marine water fisheries), quantity data were computed using proportions corresponding to the SUA of representative commodities. Most value of production data are also obtained from CountrySTAT. Where value data is unavailable, values are computed as a

product of farmgate prices and output quantities. Unit values of imports and exports are derived from TradeMap ([www.trademap.org](http://www.trademap.org)).

Calibration of model parameters requires a baseline data set (constructed along the preceding lines), along with several sets of elasticities. For crops, data on cost shares calibrates the elasticities for the yield function. For non-crop supply, own-price elasticity is obtained from the cost shares (with cross price elasticities set to zero).

For the demand side, the LES minimum food expenditure was estimated using the food subsistence threshold of the NSCB. Food consumption elasticities are drawn from Lantican *et al.* (2013), with some adjustments to make cereals into inferior goods. Armington elasticities and elasticities of transformation are based on Cororaton (2000). The computable form of the model is programmed in Generalized Algebraic Modeling System (GAMS). The AMPLE data set defines agricultural area in terms of area harvested, whereas the obvious sense of the model of Section 3 is in terms of physical land area. Physical land area translates into area harvested by multiplying the area of temporary crops by cropping intensity ratio, with different types of crops subject to different intensities. Hence, the differences in adjustability of the intensity ratio can be subsumed into differences in substitution across area harvested, which highlights the advantage of the CET formulation.

Two checks are performed prior to the scenario analysis. First is the *calibration check*: an equilibrium solution is found for the base year and compared with the base year dataset; to pass the calibration check, the two should be approximately identical. Second is the *equivalence check*: solve for the composite area growth equivalent to predetermined shocks to total agricultural area, namely: 5 percent; 10 percent; and 50 percent; and for each shock, solve the corresponding composite area model. To pass the equivalence check, the solutions to the additive area model and the corresponding composite area model should be identical. The AMPLE passes both checks. Results of the equivalence check for crop area are shown in Table 5. In general the percentage change in composite area approximates that of assumed change in total area, except for very large changes (e.g. around 50 percent). The changes share a marked consistency, in that the crops that expand disproportionately more than the assumed change in total area are the same across shocks.

**Table 5: Percentage change in area by crop, under alternative growth rate of exogenous total area, in percent over base year**

	<b>5 percent</b>	<b>10 percent</b>	<b>50 percent</b>
Composite area	5.254	10.523	53.225
Paddy rice	5.549	11.124	56.601
Paddy rainfed	4.593	9.163	45.015
Paddy irrigated	5.997	12.044	62.031
White corn	5.275	10.560	53.161
Yellow corn	4.005	7.973	38.578
Coconut	4.264	8.847	40.833
Sugarcane	6.672	13.403	69.087
Banana	4.926	9.856	49.520
Mango	5.272	10.573	54.033
Other fruit	5.189	10.385	52.212
Rootcrops	4.866	9.706	47.511
Vegetables	4.290	8.577	42.910
Other crops	5.940	11.962	63.101

Note: approximately identical results are obtained when composite area is treated as exogenous and shocked by the amount given in the row “Composite area”.

Source: Author’s calculation.

### **3. Updating AMPLE Scenarios**

#### **3.1 Overview of the scenarios**

Projections are made over the horizon 2013 to 2030; results for each year pertain to a three-year average centered on that year. The Baseline scenario continues past trends in tracing the path of Philippine agriculture over time, while incorporating negative impacts of climate change, both on crop productivity and aggregate area harvested. Underlying productivity trends are based on Briones (2013). Alternative scenarios examine the implication of: i) reduced absolute value of the land transformation parameter; ii) accelerated productivity, and avoidance of aggregate land reduction, owing to climate-smart investments.



These are respectively labeled **Less flexible scenario** and **Optimistic scenario**. Tables 5 to 7 document the assumptions for the Baseline and Optimistic scenarios (aside from the land substitution parameter, the Less flexible scenario has identical assumptions as the Baseline). In addition, the Optimistic scenario reduces the tariff on rice from 50 to 35 percent on 2017, given the scheduled expiration that year of the waiver from tariffication given by the World Trade Organization.

**Table 6: Assumptions for annual growth rates by scenario, 2013 – 2030 (%)**

	Baseline		Optimistic	
	Growth	Interval	Growth	Interval
Total area	0.0 -1.0	2013 – 18 2019 – 30	0.0	2013 – 2030
Population	1.8 1.7	2013 – 17 2018 – 30	Same	Same
GDP growth	6.6 6.3 6.0 6.3 6.2	2013 2014 2015 2016 2017 - 30	Same	Same

Source: Author's model.

**Table 7: Assumptions for annual productivity growth of crops, Baseline and Optimistic scenarios, 2013 – 2030 (%)**

	Baseline		Optimistic	
	Growth	Interval	Growth	Interval
Paddy rainfed	0.5	2013 – 30	0.6	2013-30
Paddy irrigated	1.6 1.0	2013 – 2016 2017-2030	Same	Same
White corn	-0.4	2013 – 30	0	2013-30
Yellow corn	1.2	2013 – 30	1.2	2013-30
Sugarcane	0.9	2013 – 30	1.2	2013-30
Coconut	0.0	2013 – 16	0.0	2013-16

	1.0	2017 – 30	1.0	2017-30
Banana	0.6	2013 – 30	1.0	2013-30
Mango	0.6	2013 – 30	1.0	2013-30
Other fruit	1.6	2013 – 30	1.6	2013-30
Rootcrops	1.6	2013 – 30	1.6	2013-30
Vegetables	1.6	2013 – 30	1.6	2013-30
Other crops	1.6	2013 – 30	1.6	2013-30

Source: Author's model.

**Table 8: Assumptions for annual productivity growth of livestock and aquatic products, Baseline and Optimistic scenarios, 2013 – 2030 (%)**

	Baseline		Optimistic	
Poultry	2.0	2013 – 30	Same	Same
Swine	0.6	2013 – 30	Same	Same
Other livestock	0.6	2013 – 30	Same	Same
Freshwater fish, capture	0.0	2013 – 30	Same	Same
Freshwater fish, aquaculture	1.0	2013 – 30	Same	Same
Brackishwater fish	1.0	2013 – 30	Same	Same
Seaweed	2.0	2013 – 30	Same	Same
Marine fish, capture	0.0	2013 – 30	Same	Same
Marine fish, aquaculture	1.0	2013 – 30	Same	Same

Source: Author's model.

### 3.2 Results: Baseline scenario

To keep the discussion manageable only results for crops are presented. Table 9 displays crop area shares at the base year and in 2030. At the base year, the largest area was

devoted to Paddy rice, followed by Coconut and Corn; these three already account for 85 percent of total area harvested. The fourth largest is Banana at 3.6 percent, followed by Sugarcane.

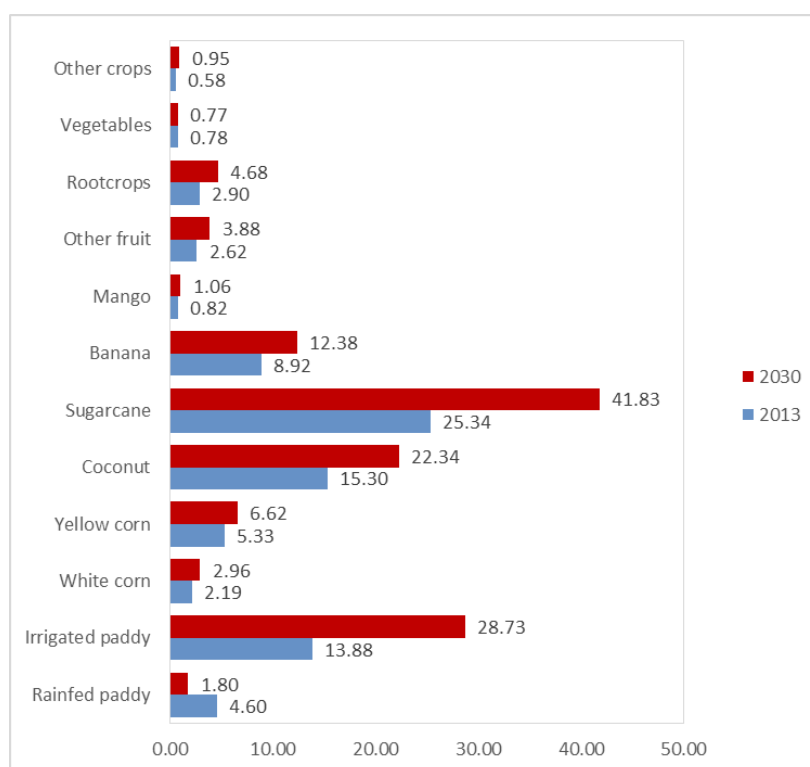
**Table 9: Area Harvested (Million ha) and Area Shares (%), 2013 and 2030 (Projected)**

	2013		2030	
	Area	Shares	Area	Shares
Paddy Rice	4.47	36.0	4.15	36.6
Corn	2.58	20.7	2.24	19.8
Coconut	3.51	28.2	3.19	28.1
Sugarcane	0.40	3.2	0.44	3.9
Banana	0.45	3.6	0.39	3.4
Mango	0.19	1.5	0.15	1.3
Other Fruit	0.08	0.6	0.07	0.6
Rootcrops	0.33	2.6	0.29	2.6
Vegetables	0.13	1.1	0.09	0.8
Other Crops	0.29	2.4	0.33	2.9
Total	12.80	100.0	11.35	100.0

Source: Author's calculation.

By 2030, aggregate agricultural area shrinks by 1.45 million ha by assumption. Shares remain similar, but not identical, across crops; Paddy rice, Corn, Banana, Mango, and Vegetables, suffer a slight decline in share, while Coconut, Sugarcane, and Rootcrops increase their respective shares in total area. Sugarcane in fact manages to increase the absolute area harvested despite the decline in aggregate area.

Figure 1 shows the projections for output. Despite the decline in overall area harvested, production manages to increase for all crops, except for a slight decline in Vegetables, and a sharp fall in Paddy rainfed. However Paddy irrigated more than doubles, such that overall output by 2030 is nearly double that of 2013. The largest relative increase in output is Paddy irrigated, followed by Sugarcane and Other crops.

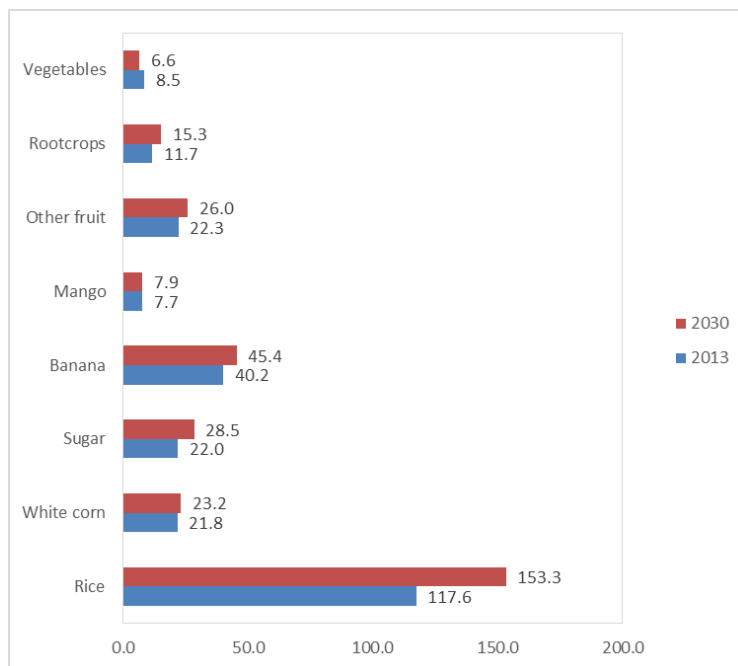
**Figure 1: Output by crop, 2013 and 2030 (projected), in million tons**

Source: PSA-BAS (2013 data); Author's calculation (2030)

Consumption projections are shown in Figure 2. Per capita consumption increases for cereals (especially Rice), Sugar, Banana, Mango, Other fruit, and Rootcrops. The increase in per capita consumption contrasts with expectations of widespread hunger given the contraction in area harvested, and is due to continued growth in productivity, even accounting for climate change. Rice consumption increases from 118 to 153 kg per capita, in apparent defiance with the global trend of declining per capita consumption of rice as per capita income rises. The one negative finding is for Vegetables, suggesting a persistent trend of low Vegetable consumption in the Philippines.

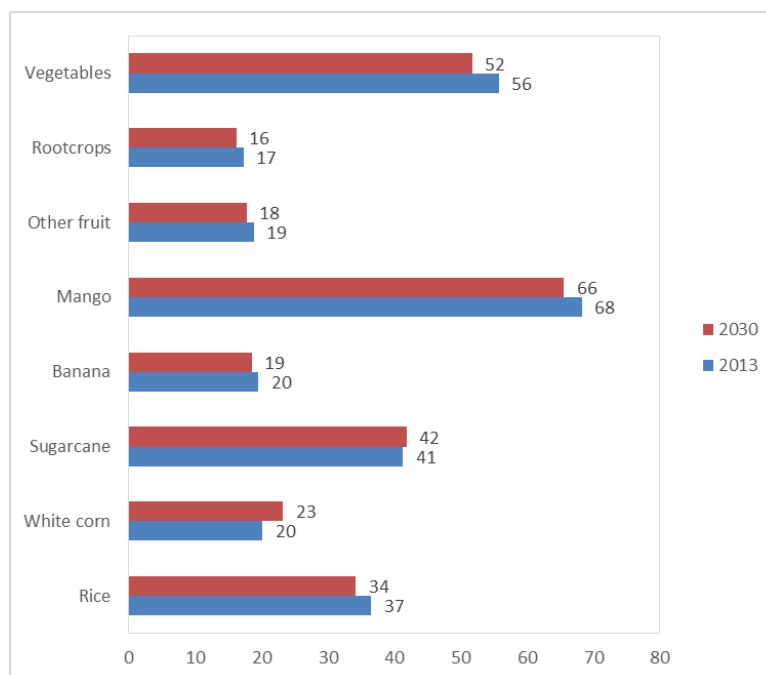
Lastly consider projections for retail price (Figure 3), which are in real terms relative to the base year. Owing to productivity growth, retail prices of most food crops decline; only White corn and Sugar become more expensive. Likewise this is consistent with the offsetting impact of productivity growth in the face of declining land availability.

**Figure 2: Per capita consumption by crop, 2013 and 2030 (projected), in kg/year**



Source: PSA-BAS (2013 data); Author's calculation (2030)

**Figure 3: Retail price by crop, 2013 and 2030 (projected), in P/kg**



Source: PSA-BAS (2013 data); Author's calculation (2030)

### 3.3 Results: alternative scenarios

Consider the alternative scenarios: differences in area changes (relative to the 2013) are shown in Table 6. Consistent with intuition, changes in area shares are smaller in absolute terms in the Less flexible scenario compared with the Baseline scenario; only Paddy rice reverses course, enlarging its area share slightly. Meanwhile the largest adjustments in area harvested are projected under the Optimistic scenario due to sharper improvements in productivity growth. The aggregate absolute change in area shares is only 1.83 percentage points for the Less flexible scenario, compared with 2.65 percentage points for the Baseline scenario and 3.44 percentage points for the Optimistic scenario.

Annual output growth projections are shown in Table 7. Directions of change in the alternative scenarios are the same as in the Baseline scenario, but the magnitudes differ. For crops that grow under the Baseline, growth rates tend to smallest for the Less flexible scenario, and largest for the Optimistic scenario. The sharpest differences between Optimistic and Baseline scenarios are for Paddy rainfed, Coconut, and Banana.

Similar patterns of change are projected for per capita consumption (Table 8). Consumption is higher under the Optimistic scenario compared with the Baseline. Reduced flexibility in re-allocation of land tends to reduce growth in per capita consumption, as seen in the results for the Less flexible scenario.

Lastly price inflation by scenario is shown in Table 9. Under the Optimistic scenario, price increases are dampened, while price reduction is more pronounced, relative to the Baseline. This is understandable given greater supply response for the former due to productivity growth and greater availability of agricultural land.

Meanwhile under the Less flexible scenario, price increases of White corn and Sugar tend to be larger than in the Baseline. On the other hand, price reduction is also larger in absolute terms for the other crops relative to the Baseline. This conforms with intuition: land shifts from uses facing greater relative abundance towards uses facing greater relative scarcity. The shift attenuates the scarcity as well as abundance (i.e. dampens price growth and price decline). Hence, suppressing the shift (due to greater rigidity in land use) likewise suppresses the dampening of price growth and price decline.

**Table 10: Changes in area shares by crop, 2030 versus 2013, by scenario, percentage points**

	Baseline	Less flexible	Optimistic
Paddy rice	-0.36	0.08	0.13
Corn	-0.45	-0.53	-1.07
Coconut	0.46	0.20	0.25
Sugar	0.48	0.37	0.83
Banana	-0.10	-0.11	-0.35
Mango	-0.12	-0.10	-0.11
Fruit	0.00	0.00	0.00
Rootcrops	0.15	0.11	0.04
Vegetables	-0.29	-0.17	-0.19
Other crops	0.23	0.16	0.47

Source: Author's calculation.

**Table 11: Projected output growth per year, 2013 - 2030, by scenario, in percent**

	Baseline	Less flexible	Optimistic
Paddy rainfed	-5.39	-2.18	-4.13
Paddy irrigated	4.38	3.98	4.35
White corn	1.79	1.72	1.67
Yellow corn	1.28	1.29	1.36
Coconut	2.25	2.21	2.76
Sugarcane	2.99	2.92	4.34
Banana	1.95	1.90	1.96
Mango	1.51	1.57	2.19
Other fruit	2.34	2.33	2.95
Rootcrops	2.87	2.81	3.10
Vegetables	-0.06	0.70	1.38
Other crops	2.92	2.85	4.11

Source: Author's calculation.

**Table 12: Projected per capita consumption growth per year, 2013 - 2030, by scenario, in percent**

	Baseline	Less flexible	Optimistic
Rice	1.57	1.49	1.66
White corn	0.36	0.28	0.24
Sugar	1.53	1.46	2.90
Banana	0.72	0.69	1.61
Mango	0.14	0.20	0.91
Other fruit	0.91	0.91	1.55
Rootcrops	1.58	1.52	1.83
Vegetables	-1.50	-0.75	-0.13

Source: Author's calculation.

**Table 13: Projected retail price growth per year, 2013 - 2030, by scenario, in percent**

	Baseline	Less flexible	Optimistic
Rice	-0.39	-0.35	-0.62
White corn	0.84	0.85	0.67
Sugar	0.08	0.14	-0.77
Banana	-0.31	-0.34	-1.66
Mango	-0.24	-0.26	-1.04
Other fruit	-0.34	-0.34	-0.97
Rootcrops	-0.36	-0.35	-1.09
Vegetables	-0.43	-0.45	-1.05

Source: Author's calculation.

To summarize: AMPLE projections are updated from 2013 to 2030. The trajectory incorporates a decline in aggregate area harvested, under a most-likely scenario of climate change impact and resource degradation project from past and present trends. Nonetheless the decline remains consistent with an increase in output, per capita consumption, and declining real prices of most food crops. The application highlights two capabilities of the modeling strategy, which is to examine the implications of changes in flexibility in the re-allocation of land, as well as changes in scope for expanding area cropped.



#### 4. Baseline data of the AMPLE - CGE

##### 4.1 Constructing accounts for the AMPLE – CGE

The goods in the AMPLE are expanded into the accounts of the AMPLE – CGE, listed in Table 14. Most of the agricultural commodities in AMPLE are carried over to AMPLE – CGE.

**Table 14: Accounts of AMPLE - CGE**

Agriculture	Industry	Services
1. Paddy rice	18. Mining	30. Transport service
2. Corn	19. Rice and corn milling	31. Storage service
3. Coconut	20. Meat production	32. Trade service
4. Sugarcane	21. Processed fish	33. Finance
5. Banana	22. Sugar	34. Other private service
6. Mango	23. Other food	35. Public service
7. Other fruit	manufacturing	
8. Rootcrop	24. Beverage manufacturing	
9. Other crop	25. Pesticide and fertilizer	
10. Vegetables	26. Other agri-based	
11. Swine	manufacturing	
12. Other livestock	27. Other manufacturing	
13. Poultry	28. Manufacture of	
14. Agricultural activities	agricultural machinery	
and services	29. Other industry	
15. Forestry		
16. Capture fishery		
17. Aquaculture		

However to maintain consistency with the 2006 I-O accounts, White corn and Yellow corn are now consolidated into Corn; Capture fishery is formed from the capture systems of Marine and Freshwater fish; and Aquaculture is formed from the aquaculture systems of Marine and Freshwater fish, together with Brackishwater fish and Seaweed. Finally two new accounts are added, namely Agricultural Activities and Services, and Forestry, for a total of 17 agricultural accounts.

Meanwhile 11 Industry accounts and 6 Services accounts are created. The main criterion for introducing an account is the relative size of the account purchase from or contribution to agricultural accounts (respectively, forward and backward linkages from agriculture).

#### 4.2 Mapping of I-O and AMPLE – CGE accounts

Mapping of the 2006 I-O accounts to the 35 AMPLE – CGE accounts is shown in Table 15.

**Table 15: I-O and corresponding AMPLE sectors**

No.	I-O Account	AMPLE – CGE Account
1	Palay	Palay
2	Corn	Corn
3	Coconut	Coconut
4	Sugarcane	Sugarcane
5	Banana	Banana
6	Mango	Mango
7	Pineapple	Other fruit
8	Coffee	Other crop
9	Cassava	Rootcrop
10	Rubber	Other crop
11	Sweet potato	Rootcrop
12	Citrus Fruits	Other fruit
13	Abaca	Other crop
14	Tobacco	Other crop
15	Papaya	Other fruit

16	Other fruits, n.e.c.	
17	Leafy and stem vegetable	Vegetables
18	Horticultural specialties and nursery products	Other crop
19	Cacao	
20	Other agricultural crops, nec	
21	Hog farming	Swine
22	Cattle farming (including feed lot fattening)	Other livestock
23	Livestock farming (including feed lot services)	
24	Other animal including dairy production	
25	Chicken	Poultry
26	Poultry farming (except chicken)	
27	Egg production	
28	Agricultural, Forestry and Fishing Activities and Services	Agricultural service
29	Forestry	Forestry
30	Ocean fishing (including fish corals)	Capture fishery
31	Inland and coastal fishing	
32	Prawn culture and Operation of fish farms and nurseries	Aquaculture
33	Pearl culture and pearl shell gathering	
34	Seaweeds farming	
35	Mollusks and other crustacean farm operations (except prawn farm operations) and other fishing activities, n.e.c	
36	Copper mining	Mining
37	Gold mining	
38	Chromite mining	
39	Nickel mining	
40	Other metallic mining (including silver mining)	
41	Crude oil and natural gas	
42	Stone quarrying, clay and sand pits	
43	Coal mining	
44	Other non-metallic mining (including salt mining)	
45	Slaughtering and meat packing	Meat production
46	Production, processing and preserving of meat and meat	

	products	
47	Canning/packing of fish and other marine products	Processed fish
48	Other types of processing of fish and other marine products	
49	Processing and preserving of fruits and vegetables	Other food manufacturing
50	Processing of milk and cream (including milk-based infants' and dietetic foods)	
51	Manufacture of butter and cheese	
52	Manufacture of ice cream and sherbet, ice drop, ice candy and other flavored ices	
53	Manufacture of other dairy products, nec	
54	Rice/corn milling	Rice and corn milling
55	Manufacture of bakery products	Other food manufacturing
56	Manufacture of sugar	
57	Production of crude vegetable oil, cake and meals, other than crude coconut oil, copra cake, meals and pellets	
58	Other vegetable and animal oil and fats (including refined coconut and other vegetable oil (including corn oil) and margarine, etc)	
59	Manufacture of starches and starch products	
60	Production of prepared animal feeds	Other agri-based manufacturing
61	Manufacture of grain and vegetable mill products, except rice and corn	Other food manufacturing
62	Production of crude coconut oil, copra cake, meals and pellets	
63	Manufacture of cocoa, chocolate and sugar confectionery	
64	Manufacture of macaroni, noodles, couscous and similar farinaceous products	
65	Manufacture of desiccated coconut and "nata de coco"	
66	Coffee roasting and processing	
67	Manufacture of ice, except dry ice	Beverage
68	Manufacture of flavoring extracts, food coloring,	

	mayonnaise, salad dressing, sandwich spread and similar products	manufacturing
69	Manufacture of food products, n.e.c.	
70	Alcoholic liquors and wine	
71	Malt liquors and malt	
72	Manufacture of soft drinks	
73	Manufacture of drinking water	
74	Manufacture of cigarettes	
75	Manufacture of cigars and chewing and smoking tobacco, snuff	
76	Tobacco leaf flue-curing and redrying and other tobacco manufacturing, n.e.c.	
77	Spinning, weaving and finishing of textiles	
78	Manufacture of made-up textile articles, except wearing apparel	
79	Manufacture of carpets and rugs	
80	Manufacture of cordage, rope, twine and netting	
81	Manufacture of other textiles, n.e.c.	
82	Manufacture of knitted and crocheted fabrics	
83	Manufacture of knitted or crocheted hosiery, underwear and outerwear when knitted or crocheted directly into shape	
84	Manufacture of knitted and crocheted articles, n.e.c.	
85	Manufacture of embroidered fabrics	
86	Ready-made garments manufacturing (excluding embroidered garments)	
87	Ready-made embroidered garments manufacturing	
88	Custom tailoring and dressmaking and articles of fur	
89	Manufacture of other wearing apparel n.e.c	
90	Tanning and dressing of leather	
91	Manufacture of products of leather and imitation leather	
92	Manufacture of shoes	
93	Manufacture of other footwear, n.e.c.	

94	Manufacture of veneer sheets and plywoods	
95	Sawmilling and planing of wood	
96	Manufacture of laminboard, particle board and other panels and board	
97	Manufacture of builders' carpentry and joinery; millworking	
98	Manufacture of wood carvings	
99	Manufacture of other products of wood, except furniture, n.e.c.	
100	Manufacture of products of bamboo, cane, rattan and the like, and plaiting materials except furniture	
101	Manufacture of pulp, paper and paperboard	
102	Manufacture of containers and boxes of paper and paperboard	
103	Manufacture of other articles of paper and paperboard	
104	Publishing	Other manufacturing
105	Printing and service activities related to printing	
106	Reproduction of recorded media	
107	Manufacture of refined petroleum products	
108	Manufacture of other petroleum products	Pesticide and fertilizer manufacturing
109	Manufacture of fertilizers and nitrogen compounds	
110	Manufacture of pesticides and other agro- chemical products	Other manufacturing
111	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	
112	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	
113	Manufacture of basic chemicals except fertilizers and nitrogen compounds	
114	Manufacture of plastics in primary forms and of synthetic rubber	
115	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	

116	Manufacture of other chemical products, n.e.c.	
117	Manufacture of man-made fibers	
118	Manufacture of rubber products	Other agri-based manufacturing
119	Manufacture of other rubber products	
120	Manufacture of plastic products	Other manufacturing
121	Manufacture of cement	
122	Manufacture of flat glass (including float glass)	
123	Manufacture of glass containers	
124	Manufacture of glass and glass products, n.e.c.	
125	Manufacture of non-structural, non-refractory ceramic ware	
126	Manufacture of structural, non-refractory clay and ceramic products, lime and plaster	
127	Manufacture of other non-metallic mineral products, n.e.c.	
128	Manufacture of basic iron and steel	
129	Casting/foundry of Iron and steel	
130	Manufacture of basic precious and non-ferrous metals	
131	Non-ferrous metal casting	
132	Manufacture of structural metal products	
133	Manufacture of tanks, reservoirs and containers, of metal	
134	Forging, pressing, stamping and roll-forming of metal, Treatment and coating of metals; general mechanical engineering on a fee or contract basis	
135	Manufacture of cutlery, hand tools and general hardware	
136	Manufacture of other fabricated metal products, n.e.c.	
137	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	
138	Manufacture of pumps, compressors, taps and valves	
139	Manufacture of other general purpose machinery	
140	Manufacture of agricultural and forestry machinery	Manufacture of agricultural machinery
141	Manufacture of other special purpose machinery	Other manufacturing
142	Manufacture of household appliances, n.e.c.	

143	Rebuilding or repairing of various kinds of machinery and equipment and associated parts/accessories (machine shops)	
144	Manufacture of Office, Accounting and Computing Machinery	
145	Manufacture of electric motors, generators and transformers and electric generating sets	
146	Manufacture of electricity distribution and control apparatus	
147	Manufacture of insulated wires and cables	
148	Manufacture of accumulators, primary cells and primary batteries	
149	Manufacture of lighting equipment and electric lamps and other electrical equipment , n.e.c	
150	Manufacture of semi-conductor devices and other electronic components	
151	Manufacture of electronic valves and tubes	
152	Manufacture of apparatus for line telephony and line telegraphy	
153	Manufacture of television and radio transmitters, receivers, sound or video recording or reproducing apparatus, and associated goods	
154	Manufacture of Motor Vehicles, Trailers and Semi-Trailers	
155	Building and repairing of ships and boats	
156	Manufacture of railway and tramway locomotives and rolling stock	
157	Manufacture of aircraft and spacecraft	
158	Manufacture of motorcycles, bicycles and invalid carriages	
159	Manufacture of other transport equipment, n.e.c.	
160	Manufacture and repair of wood and rattan furniture (reed, wicker, and cane)	



161	Manufacture of plastic furniture	
162	Manufacture and repair of furniture and fixtures of metal	
163	Manufacture and repair of other furniture and fixtures, n.e.c.	
164	Manufacture of medical and surgical equipment and orthopedic appliances	
165	Manufacture of professional, scientific measuring, industrial process and controlling equipment	
166	Manufacture of photographic and optical instruments	
167	Manufacture of watches and clocks	
168	Recycling	
169	Manufacture of jewelry and related articles	
170	Manufacture of musical instruments	
171	Manufacture of sports goods	
172	Manufacture of games and toys	
173	Miscellaneous manufacturing, n.e.c	
174	Construction	
175	Generation, collection and distribution of electricity	
176	Steam and hot water supply	
177	Collection, purification and distribution of water	
178	Bus line operation	Transport service
179	Jeepney and other land transport services	
180	Railway transport	
181	Public utility cars and taxicab operation	
182	Tourist buses and cars including chartered and rent-a-car	
183	Road freight transport	
184	Sea and coastal water transport	
185	Inland water transport (including renting of ship with operator) and other water transport services	
186	Air transport	
187	Supporting services to transport	
188	Storage and warehousing	Storage service

189	Tour and travel agencies and tour operators; tourist assistance activities, n.e.c.	Transport service
190	Activities of other transport agencies (including custom brokerage, n.e.c)	
191	Postal and courier activities	Other service
192	Telephone service includes telegraphs	
193	Wireless telecommunications	
194	Telecommunication services, n.e.c	
195	Wholesale and retail trade	Trade service
196	Repairs of motor vehicles, motorcycles, personal and household goods	Other service
197	Banking Institutions	Finance
198	Investment, financing and other non-banking services except pawnshops	
199	Pawnshops	
200	Life insurance	
201	Non-life and other insurance activities	
202	Activities auxilliary to financial intermediation	
203	Real Estate Activities	
204	Renting of Machinery and Equipment Without Operator ; Personal and Household Goods	Other private service
205	Hardware consultancy	
206	Software consultancy and supply	
207	Maintenance and repair of office accounting and computing machinery	
208	Other computer and related activities	
209	Research and Development	
210	Call center activities	
211	Legal activities	
212	Accounting, bookeeping and auditing activities; tax consultancy	
213	Market research and public opinion polling	
214	Business and management consultancy activities	

215	Architectural, engineering and other technical activities	
216	Advertising	
217	Labor recruitment and provision of personnel	
218	Investigation and security activities	
219	Miscellaneous business activities, n.e.c	
220	Ownership of Dwellings	
221	Public Administration and Defense	Public service
222	Public Education Services	
223	Private education services	
224	Public medical, dental and other health activities	
225	Private medical, dental and other health activities	Other private service
226	Other hospital activities and medical and dental practices including veterinary services, n.e.c.	
227	Social Work Activities	
228	Hotels and motels	
229	Other accommodation services	
230	Restaurants, bars, canteens and other eating and drinking places	
231	Motion picture and video production and distribution	
232	Motion picture audio and video projection	
233	Radio and television activities	
234	Other Recreational, Cultural and Sporting Activities	
235	Sewage and Refuse Disposal Sanitation and Similar Activities	
236	Washing and (dry-) cleaning of clothing and textile	
237	Funeral and related activities	
238	Beauty treatment and personal grooming activities	
239	Sauna, steam bath, slendering, and body building activities	
240	Other service activities, nec	

### 4.3 Re-aggregation of the 2006 I-O into the AMPLE – CGE accounts

The 240-sector 2006 I-O is then re-aggregated based on the matching provided above. A GAMS program was used to facilitate the re-aggregation. The resulting balanced I-O is provided in a separate Excel file attached to this Report.

### 4.4 Compiling a 2006 SAM for the Philippines

The data of the 2006 I-O is then used as basis for constructing the 2006 SAM in the AMPLE – CGE accounts. The SAM accounts are as follows:

Activities	Commodities	Others
A-Palay	C-Palay	Compensation of employees
A-Corn	C-Corn	Consumption of fixed capital
A-Coconut	C-Coconut	Operating Surplus
A-Sugarcane	C-Sugarcane	Households
A-Banana	C-Banana	Government
A-Mango	C-Mango	SI-Construction
A-Other fruit	C-Other fruit	SI-Durable equipment
A-Other crop	C-Other crop	SI-Breeding stocks and orchards
A-Root crop	C-Root crop	SI-Intellectual property
A-Vegetables	C-Vegetables	SI-Change inventory
A-Hog	C-Hog	Income tax
A-Other livestock	C-Other livestock	Indirect taxes less subsidies
A-Poultry	C-Poultry	Tariff
A-Agricultural Services	C-Agricultural Services	ROW
A-Forestry	C-Forestry	
A-Capture Fisheries	C-Capture Fisheries	
A-Aquaculture	C-Aquaculture	
A-Mining	C-Mining	
A-Rice	C-Rice	
A-Meat	C-Meat	
A-Processed fish	C-Processed fish	
A-Sugar	C-Sugar	
A-Other Food manufacturing	C-Other Food manufacturing	
A-Beverage manufacturing	C-Beverage manufacturing	
A-Pesticides and fertilizers	C-Pesticides and fertilizers	
A-Other agri based manufacturing	C-Other agri based manufacturing	
A-Other manufacturing	C-Other manufacturing	
A-Manufacture of agricultural machinery	C-Manufacture of agricultural machinery	
A-Other industry	C-Other industry	
A-Transport services	C-Transport services	
A-Storage services	C-Storage services	
A-Wholesale and retail trade	C-Wholesale and retail trade	
A-Finance	C-Finance	
A-Other private services	C-Other private services	
A-Public services	C-Public services	

Consumption of fixed capital is depreciation; SI denotes Savings – Investment; and ROW denotes Rest of the World. Additional information is obtained from the PSA Consolidated National Accounts (CAN) for 2006, namely:

- Indirect taxes (domestic and foreign, i.e. customs duties), net of subsidies
- Direct taxes (income taxes)
- Household and ROW net transfers

Additional information for disaggregating the Tariff account is obtained from Corong (2007). Inevitably, imbalances arise, which are addressed by adjusting residual accounts such as savings-investments, transfers, and so forth, until the SAM is balanced. The completed 2006 SAM is provided in a separate Excel File.

#### 4.5 Compiling a 2013 SAM for the Philippines

The 2006 SAM is then updated for 2013, the base year data set of the AMPLE.

Several adjustments are required to perform this updating:

1. The 2006 SAM accounts are matched to corresponding categories of the 2013 CA, as follows:

2006 SAM	2013 CA
Palay	Palay
Corn	Corn
Coconut	Coconut including copra
Sugarcane	Sugarcane
Banana	Banana
Mango	Mango
Other fruit	Pineapple, other crops
Other crop	Rubber
Root crop	Cassava
Vegetables	Other crops
Hog	Livestock
Other livestock	Livestock
Poultry	Poultry
Agricultural Services	Agricultural activities and services
Forestry	Forestry
Capture Fisheries	Fishing
Aquaculture	Fishing
Mining	Mining
Rice	Food manufactures
Meat	Food manufactures
Processed fish	Food manufactures
Sugar	Food manufactures
Other Food manufacturing	Food manufactures
Beverage manufacturing	Beverage industries
Pesticides and fertilizers	Other manufactures

2006 SAM	2013 CA
Other agri based manufacturing	Other manufactures
Other manufacturing	Petroleum to miscellaneous manufactures
Manufacture of agricultural machinery	Machinery and equipment except electrical
Other industry	Electricity, steam, water
Transport services	Land, water, air
Storage services	Storage and services
Wholesale and retail trade	Wholesale and retail trade
Finance	Banking institutions, non-bank financial intermediation
Other private services	Real estate and other services
Public services	Real estate and other services

2. Growth rates of GVA of the CA categories (in current prices) from 2006 to 2013 are applied to their corresponding activity accounts in the SAM based on the above matching. Intermediate inputs are assumed to also adjust by the same proportion as the account GVA.
3. Final demands are likewise adjusted by the growth rates of GVA of the CA categories.
4. The resulting imbalanced SAM is then subjected to adjustment of individual cell entries aiming to achieve balance between row and column sums. The criterion for adjustment is minimum sum of squared deviation between row and column sums. Adjustment is obtained by applying a GAMS program for SAM balancing.
5. Final discrepancies are eliminated by appropriate adjustment in the SI-Change inventory account.

The completed 2013 SAM is shown in a separate Excel file.

## 5. Next steps

The next steps for developing AMPLE – CGE are as follows:

**Refining the 2013 SAM data to fit the AMPLE – CGE:** while the 2013 SAM is already balanced, further refinements will be made by rechecking the data, reconfirming the balance, and introducing some additional information (such as a distinction between agricultural and non-agricultural labor markets).

**Combining the 2013 SAM data with the existing database in AMPLE 2013:** The existing AMPLE database is developed for an agricultural sector model and is yet to be combined with the database of a CGE model. This step will integrate existing AMPLE data on prices, quantities, area harvested, exports, imports, and food demand, other demand, etc.

**Generating the equations of the AMPLE – CGE.** The model equations for the CGE version of AMPLE will need to be developed. The AMPLE-CGE will carry over the algebraic structure of the AMPLE for the agricultural supply, demand, and trade, as well as some key assumptions, such as the small open economy assumption. To be incorporated are the following:

- Supply, demand, and trade, for industry and services, together with intermediate demands - that is, the rest of the goods markets;
- Factor markets and intermediate demands;
- Government and ROW as additional institutions in the model
- Model closure.

**Developing the GAMS code for implementing the AMPLE – CGE.** Once the model structure has been specified a GAMS code will be developed as the computable version of the AMPLE – CGE. The code will need to incorporate the AMPLE – CGE dataset, and calibrate equation parameters.

**Solving for base year equilibrium and checking replication of base year data.** As a check for consistency of the model equations with the dataset, as well as integrity of the calibration, the GAMS version will be asked to solve for baseline equilibrium under the assigned closure rules. The equilibrium solution must equal the baseline data set to pass the check.

**Performing simple experiments to ensure economic consistency of the AMPLE – CGE.** The AMPLE – CGE will be subjected to simple shocks, such as: increases in area harvested; increases in capital endowment; increases in labor endowment; productivity growth in a sector; tariff rate adjustment; tax rate adjustment; etc., to ensure the model is well-behaved.

**Developing the GAMS code for implementing projections for AMPLE – CGE.** The model will then be expanded to generate annual projections, based on a recursive set-up for deriving the next period equilibrium. Updates for the following period will be obtained from: projections on population growth; net accumulation of capital stock (from current period savings and depreciation); technological change; and projected changes in world price.

**Generating and analyzing economywide projections for the AMPLE – CGE (up to at least 2022).** The code for projections will then be applied to generate economywide

projections from AMPLE – CGE. The projections will be refined and the finalized form will then be analyzed in terms of the original aims and scope of this study.

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