AN ECONOMIC ANALYSIS OF GHANA'S SAVANNAH ACCELERATED DEVELOPMENT PROGRAM

A Dissertation

by

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ABSTRACT

This dissertation intends to review and assesses economic consequences of elements within the Savannah Accelerated Development Program in Ghana. The program has never been economically assessed in the literature. Agricultural policies are assessed at both the regional and national level. To achieve the assessment, a regional farm planning model is developed and then it is used in interaction with a computable general equilibrium model. The research attempts to determine the regional impacts of different agricultural policies and whether they will narrow the developmental gap between northern and southern Ghana. The policies assessed are input subsidy, expanded agricultural extension, guinea fowl program, and expanded irrigation. The assessment shows that the expansion in agricultural extension has the biggest effect in terms of narrowing the income gap.

DEDICATION

Dedicated to my parents and grandparents.

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NOMENCLATURE

CAADP	Comprehensive African Agriculture Development Program
CGE	Computable General Equilibrium
ECOWAS	Economic Community of West African States
ECOWAP	ECOWAS Agricultural Policy
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture Sector Development Policy
GDP	Gross Domestic Product
GHANACGE	Ghana Computable General Equilibrium Model
GIDA	Ghana Irrigation Development Authority
GLSS	Ghana Living Standards Survey
GMOF	Ghana Ministry of Finance
GOG	Government of Ghana
GSS	Ghana Statistical Service
ICOUR	Irrigation Company of Upper East Region
IMF	International Monetary Fund
ISSER	Institute of Statistical, Social and Economic Research
MOFA	Ministry of Food and Agriculture
SADA	Savannah Accelerated Development Authority
SADAFPM	SADA Farm Planning Model

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CHAPTER I

INTRODUCTION

The West African country of Ghana has experienced major economic development in recent decades, but this has not been distributed evenly throughout the country. In particular, development in the three northern savannah regions—the Upper East, Upper West and Northern Regions (Figure 1)—has lagged, with these regions exhibiting the highest poverty levels. Nine out of 10 people in the Upper East region, eight out of 10 in the Upper West, and seven out of 10 in the North are classified as poor by the International Monetary Fund (IMF) (2012). These regions also are home to the country's most food insecure and vulnerable populations. In its 2012 assessment, the World Food Program (WFP) estimated that 10 percent of the people in the Northern, 15 percent in the Upper East, and 34 percent in the Upper West regions are currently food insecure. Regional production is limited due to poor soils, limited water and labor scarcity.

To improve economic growth and sustainable development in the northern regions, (known as the SADA zone), in 2007 Ghana implemented a major agricultural initiative called the Savannah Accelerated Development Authority (SADA). The vision of SADA is stated as "creating a forested and green north by 2030, doubling the incomes of northern Ghanaians and reducing the incidence of poverty in the northern Savannah ecological belt to less than 20 percent within 20 years" (Bibir Ghana Annual Report 2013). SADA's short-term objectives are to invest in immediate, tangible development results, especially for the most vulnerable, to enhance youth employment, and to engage in measures improving adaptation to climate change (SADA 2011a).

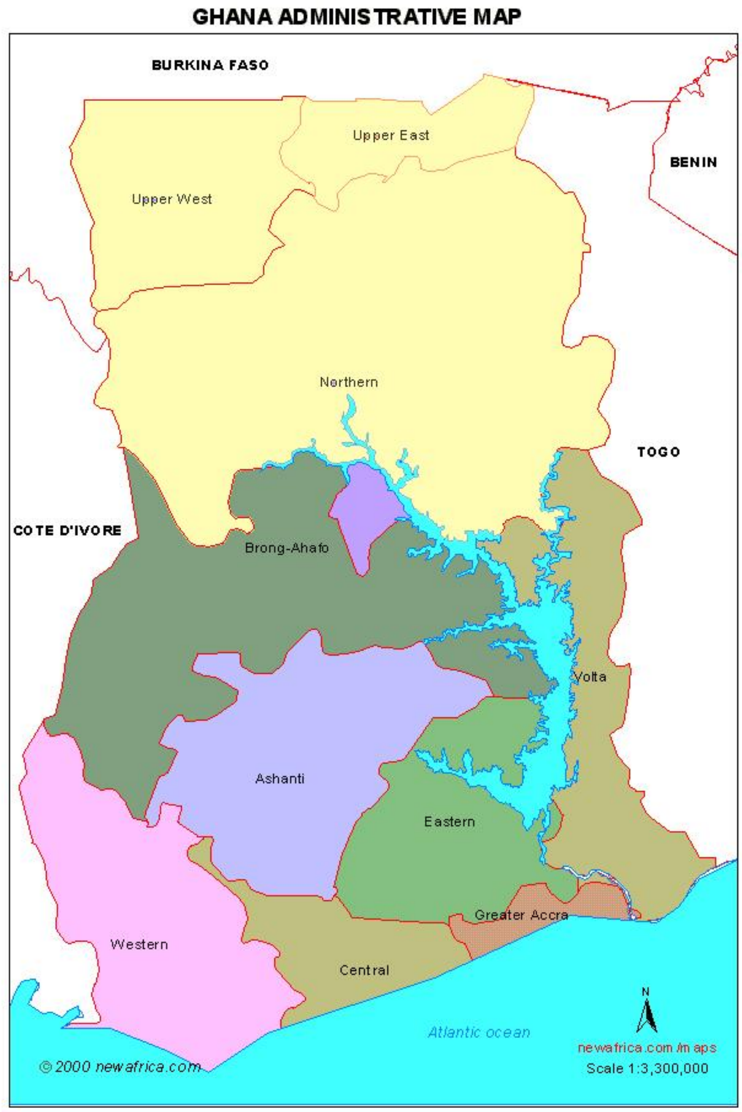

Figure 1. The Three Northern Savannah Regions of Ghana
Source: Ghana Web. http://www.ghanaweb.com/GhanaHomePage/geography/maps.php

The SADA program contains three main elements.

1. An objective of making the North a major grain-producing area capable of

supplying surplus to other regions in Ghana (Institute of Statistical, Social and Economic Research [ISSER] 2012).

2. Plans for long-term adaptation to climate change by increasing tree planting (SADA 2011b).
3. Proposals for minimizing the agricultural effects of floods and droughts (SADA 2011b). This includes capturing flood waters to allow irrigation and building food storage facilities to alleviate food shortages during the dry season. SADA also includes rice land development to alleviate regional food shortages and create a surplus for export to other regions in Ghana.

A number of SADA components still are untested, however, and may or may not achieve their objectives. To date, for example, no analysis has been conducted for the SADA region that addresses the likely success of the SADA program. The objective of this thesis is to assess the elements of the SADA program; specifically, it accomplishes the following:

1. Simulates the economic consequences of implementing selected agricultural efforts under SADA. The specific efforts to be analyzed include expansion of irrigated acreage, government subsidies for fertilizer, equipment, and improved seed, and increased crop and guinea fowl production;
2. Assesses the regional economic implications of SADA program elements, with a focus on household income, agricultural production, and price levels.

The analytical framework consists of the following:

1. A SADA region farm level model is developed that depicts agriculture in the SADA region and allows simulation of the impact of SADA program elements. The model will reflect regional farm land availability, crop calendars, crop inputs and outputs, crop mix possibilities, hired labor, yield uncertainty, rainfall distribution, subsistence nutrition requirements, irrigation, and risk aversion.
2. An existing Computable General Equilibrium (CGE) model will be used to analyze the impacts of SADA regional agriculture development on the regional and national economy.

CHAPTER II

LITERATURE REVIEW

The scholarly literature relevant to this study is reviewed in two sections, literature relevant to Ghana and the SADA program, and studies relevant to the assessment of the SADA program interventions in terms of regional and national economic implications.

Ghana's Agriculture and the Northern Regions

The 2010 census reports that Ghana had a population of 24.7 million, with an annual average growth rate of 2.5 percent (Ghana Statistical Service 2012). Population density has increased from 79 persons per square kilometer in 2000 to 103 persons per kilometer in 2010. Such growth puts considerable pressure on land and other agricultural resources. Ghana's GDP growth rate rose from 4 percent in 2009 to 14.4 percent in 2011, and dropped to 2.5 percent in 2014 (World Bank 2016a). With a stable political environment, a recent oil discovery, and a decentralized system of government, most consider Ghana to be a good example in a region of the world riddled with political strife, poverty, disease, and despair.

Ghana's current agricultural policies are heavily influenced by the Comprehensive African Agriculture Development Program (CAADP) developed under the New Partnership for Africa's Development (NEPAD), and the Agricultural Policy (ECOWAP) developed under the Economic Community of West African States (ECOWAS).

Ghana's agricultural policies are discussed in the Ghana Food and Agriculture Sector Development Policy document (FASDEP II - Ghana, Ministry of Food and Agriculture 2009). Its policy objectives are:

1. Enhance food security and emergency preparedness.
2. Improve income growth.
3. Improve competitiveness and enhance integration in domestic and international markets.
4. Pursue sustainable management of land and the environment.
5. Expand science and technology applied in food and agricultural development.
6. Improve institutional coordination (MOFA 2009).

These are to be achieved via the following: a) enhanced agricultural productivity growth of six to eight percent per year; b) crop and livestock productivity growing at a six percent rate; c) forestry, logging, and fisheries productivity each growing at five percent, and d) a robust cocoa sector that supports income and exports (MOFA 2009).

Ghana has a total land area of approximately 22.8 million hectares, of which 15.5 million is classified as agricultural (FAO 2014a). About 38.9 percent of the total agricultural land area is currently cultivated; 15 percent is used as permanent natural pasture; and 30 percent is unreserved woodland (FAO 2014b).

Ghana's agriculture can be broken down into five main subsectors: crops, livestock, cocoa, forestry/logging, and fisheries (ISSER 2012). The crops subsector is the main focus of the current study, and it can be further broken down into roots and tubers such as cassava, yam, cocoyam, and plantain; cereal crops such as maize, rice, millet, and sorghum; fruit such as pineapple and mango; vegetables such as pepper, okra, onion, and tomato; and other crops, such as cotton and coffee. Production levels of the major staple food crops in a normal rainfall year meet consumption needs, particularly for non-grain crops. There is substantial dependence on imports for some crops, however. For example, Ghana has large rice consumption and typically faces a deficit in rice production relative to consumption. In 2011, the deficit between production and demand was about 13 percent (ISSER 2012). This reliance on imports threatens food security and the achievement of national agricultural policy objectives.

Northern Ghana represents almost half of Ghana's total land mass, is home to nearly a third of its population. and produces more than 60 percent of the country's staple foods (SADA 2011a). Crop production and livestock rearing are the main means of subsistence for those in rural farm households. Cattle production is the major livestock activity, but there is also production of poultry, sheep, goats, and pigs. Major crops grown in northern Ghana are maize, rice, sorghum, groundnut, millet, cowpea, yam, and onion (MOFA 2014). Groundnut and maize account for 59 percent of total crop harvest value in the savannah zone (GSS 2008). The most widely crops cultivated in northern Ghana in terms of the value of crops harvested in 2008 are shown in Table 1.

Table 1. Estimated Values of Major Crops Produced in Northern Ghana (Thousand GH¢)

Crops	Value of production	Percentage of total country value by crop
Maize	280,974	58.0
Groundnut	115,620	90.5

Table 1 Continued

Crops	Value of production	Percentage of total country value by crop
Guinea Corn/Sorghum	61,417	100.0
Millet	61,328	100.0
Rice	55,245	86.3
Beans	37,125	89.4
Cotton	13,386	100.0
Tobacco	8,128	99.3
Cashew Nut	4,212	91.7
Shea Nut	3,800	100.0
Yam	598	100.0
Cassava	159	95.8
Okra	120	100.0
Sweet Potato	76	100.0
Pepper	26	100.0
Tomato	8	100.0

Source: GSS 2008 (The percentage is calculated by the author.)

Smallholders in northern Ghana work at compound farms, which Gyasi (1995) described as

> the land sitting around the compound which is a relatively permanent mixed cropping system. The land immediately surrounding the compound is the most intensively cultivated. The first major zone, mainly vegetables for daily consumption, is succeeded by a second, much larger but less enriched area of land dedicated mainly to millet, maize, and groundnuts. This zone and the surrounding outer unused common land serve as grazing ground. Beyond are the bush fallow farms with the staples including yam.

According to GSS (2013a), 95 percent of the farms are smaller than 15 acres, 88 percent are smaller than 10 acres, and 70 percent are smaller than five acres. The average farm size is about 5.46 acres. The smallholders mainly engage in subsistence production and consume large portions of the produce themselves. Farming is highly dependent on the weather and follows the traditional crop calendar.

Some households also engage in off-farm activities such as food processing, trading, and craftsmanship. A recent survey found that about 68.9 percent of economically active persons aged 15 years and older in rural areas are engaged in skilled agricultural, forestry, and fishery work, compared to the 50.1 percent across the entire nation (GSS 2013b).

Home consumption and cash requirements both influence household crop consumption and marketing decisions. The largest proportion of harvested crops for smallholders are used for home consumption. The remainder is for sale, given away as gifts, stored for future use, or spoils while in storage (GSS 2013a). The proportion of home consumption in the SADA region is relatively higher compared with the rest of the country. The region produces about 50 percent of the crops harvested in Ghana but sells about 26 percent off-farm (GSS 2012). Maize, millet, sorghum, and rice are largely produced for home consumption, while groundnut, cowpea, soybean, cassava, and yam are mainly sold (Wiredu et al. 2010). Maize plays an important role in poultry feed, and around 23 percent of maize production is used for this purpose (USAID 2012).

Agro-ecological conditions are generally the same across the three northern regions. The SADA region has a rainy season lasting about six months, from May to October. Average annual precipitation for the Upper East, Upper West, and Northern regions are 800 to 1,100 mm, 750 to 1,100 mm, and 750 to 1,100 mm. Recent studies of rainfall trends across the West African Sahel region show a decrease in both rainfall and the number of rainy days (Mohamed 2011). The prolonged November-to-April dry season is exceptionally dry. Average annual values for selected climate variables in the SADA region are shown in Table 2.

Table 2. Average Annual Values for Selected Climate Variables in Northern Ghana

Station Region	Navrongo Upper East	Wa Upper West	Tamale Northern	Yendi Northern	Bole Northern
Rainfall (mm/y)	987	1007	1083	1192	1069
Potential Evap. (mm/y)	1723	1770	1839	1710	1541
Avg. Temp. (°C)	28.9	27.9	28.3	27.9	27.8
Min. Temp. (°C)	19.3	19.5	18.7	19.2	16.6
Max. Temp. (°C)	39.3	37.4	38.2	37.7	36.6
Min. Rel. Humidity (%)	40.3	44.0	44.6	46.7	50.1
Max. Rel. Humidity (%)	68.8	71.8	75.9	78.0	83.9
Sun Hours (h)	7.8	7.6	7.3	7.2	7.0
Wind Speed (m/s)	0.91	1.25	1.57	1.26	0.84

Source: Ghana Meteorological Agency (2014).

Climate poses major challenges to agricultural development in northern Ghana. Heavy rains cause flooding that threatens livelihoods. Temperatures are high throughout the year, and with almost no rain during the six-month dry season each year, droughts are frequent.

Review on Modeling and Policy Analysis

This section covers farm-level agricultural impact modeling, risk modeling, and computable general equilibrium (CGE) modeling, and considers the analytical tools that have been applied to developing countries, particularly in Sub-Saharan Africa.

Agricultural impact models generally are designed to assess the effects of changes in land and water availability, government policy (such as input subsidies), climate variations, new farming methods (such as non-tillage farming), and agricultural investments (such as irrigation system development) (McCarl and Spreen 1980).

The scope and form of the models used depend on the policy objectives to be addressed, and data availability. Thoerbecke (1973) summarized different forms as multi-level planning models, microeconomic-dynamic models, simulation-systems models, and general equilibrium models. Each covers different aspects of the economy, and each requires justification in agricultural planning modeling. For example, in the United States, the agricultural sector contributes only one percent of GDP over the past five years (World Bank 2016a). Thus, most policy analyses focus on the farm-to-sector scope. In the case of Ghana, however, the agricultural share of GDP fluctuated between 23 and 32 percent from 2009 to 2014 (World Bank 2014). The agricultural share of GDP was sufficient to require the application of analytical policy tools that determine the agricultural sector's impacts on the rest of the economy. In this context, a computable general equilibrium model is used to assess economy-wide impacts of agricultural sector policies.

The following summarizes the various modeling approaches that have been presented in the literature.

Farm Level Modeling

Farm activities are the core of agricultural modeling. Mathematical farm planning models may be used to study resource allocation. For example, Danok, McCarl, and

White (1978) established a farm planning model to simulate the performance of machinery selection in an Iraqi state. Kutcher and Scandizzo (1981) found that numerous, ongoing agricultural programs had not significantly improved Brazil's economy, so they developed a farm planning model for northeast Brazil to analyze land reform alternatives and technical improvements. The study also reported simulation results for both exogenous and endogenous commodity prices, finding that that the latter provided a better fit for the real economy. Deybe and Flichman (1991) developed a farm planning model with three representative farms to assess different farming activities in a region of Argentina. Farm planning models usually focus on the production side of the economy.

Sector Modeling

National agricultural sector models cover a wider scope than farm models, which usually involve multiple farm level, spatial components. The partial equilibrium sector model was first developed by Samuelson (1952) and Takayama and Judge (1964a; 1964b; 1971), and later reviewed by McCarl and Spreen (1980). Farm activities are aggregated to some extent, while farming characteristics for single farms (such as crop budgets, historical crop mix, or livestock mix) are traceable. According to McCarl and Spreen (1980), a partial equilibrium agricultural sector model contains both production and consumption of agricultural outputs. It describes both individual behavior in agricultural resource usage and an output aggregating procedure. Agricultural sector models have been widely used for national planning purposes. Some agricultural sector models have been developed for developing countries such as Siam (2001); Chen et al. (2002), and Butt et al. (2005).

Risk Modeling

Risk is a major concern facing SADA region farmers. Erratic rainfall and fluctuations in yield and crop prices cannot be ignored when modeling SADA region farming activities. Modeling risk has a long history in the agricultural economics literature. There are two perspectives: One is static, one-shot decision-making, such as the E-V model (Markowitz 1989), the MOTAD model (Hazell 1971), and the DEMP model (Lambert and McCarl 1985), which deal with risks in the objective function coefficients. DEMP model is less restrictive in that it does not fix the forms of the utility function, especially regarding the way the risk aversion parameter behaves with respect to wealth. It also does not require assumptions on the distribution of the uncertain parameters. Other models also address risks in resource availability and the technical coefficients, including chance-constrained programming (Charnes and Cooper, 1959) and Merrill's approach (Merrill 1965).

The second perspective on risk modeling is the dynamic sequential perspective, in which farmers plan now and receive new information on stochastic resources later, allowing them to make adaptive decisions on issues such as purchasing resources, consuming more crops, or selling more crops. The first of the models to have two stages was developed by Dantzig (1955), and more general, multi-stage models were introduced by Cocks (1968).

In the case of SADA, northern smallholders are price takers and have little control over erratic rainfall and uncertain yields. Farmers can make adaptive decisions only when yields and price levels are known to them. For example, farmers may decide to sell more if the market is moving up, and consume or stock more if the market is moving down. These are second-stage decisions depending on the state of nature after the first cropping stage. A detailed review on farm level risk and uncertainty modeling can be found in Boisvert and McCarl (1990), and Jessen (2007).

The first application of stochastic programming in agricultural economics was performed by Tintner (1955) on land and labor constraints in Iowa. Later applications include Yaron and Horowit (1972); Apland, McCarl, and Baker (1981); Garoian, Conner, and Scifres (1987); Leatham and Baker (1988); McCarl and Parandvash (1988); and Lambert and McCarl (1989).

Very few farm level applications can be found for African countries. Adesina and Sanders (1991) applied a stochastic sequential programming model to show that peasant farmers' adaptive intercropping strategy between cereal and beans to rainfall patterns was the basis for their survival under rainfall uncertainty. Maatman et al. (2002) applied a stochastic sequential programming model to describe farmers' sequential adaptive decisions under rainfall uncertainty in Burkina Faso. This model contained one cropping season with no irrigation or modern input use, such as fertilizer. The study found that farmers abandoned plots as a way to minimize rainfall restrictions.

CGE Modeling

A useful tool for economy-wide policy impact analysis is the computable general equilibrium (CGE) model, based on the Walrasian general equilibrium theory (Walras 2013). Scarf (1967) developed the first empirical CGE model, which Lofgren (2000; p.1) defined as "a class of economy-wide models used in policy analysis." The term "computable" refers to the fact that the model solution can be computed, a prerequisite when a model is used for applied purposes. Thus, the CGE model is attractive for several reasons.

First, they incorporate many sectors of the economy and trace the distributional impacts among them (Lofgren, Harris, and Robison 2002; Hosoe, Gasawa, and Hashimoto 2010). CGE models also capture the feedback effects caused by a given shock to the economy. In many Sub-Saharan countries, GDP share of the agricultural sector is very large, and consequently generates non-negligible income effects on the whole economy. CGE models are sometimes more appropriate than partial equilibrium models when assessing the economy-wide impact of certain policies, particularly since income is affected. For instance, agricultural policy influences can create spill-over effects to the industrial and service sectors outside of agriculture due to the income effects generated by the agricultural sector. CGE models are powerful tools to simulate the economy-wide impact from hypothetical policies, such as a change in government spending, tariffs, or total factor productivity (Lofgren 2000).

Second, a CGE model typically has fewer data requirements than an econometric-based model, which requires large time series or panel data that are sometimes difficult to find for Sub-Saharan African countries. CGE models, on the other hand, require less cumbersome data, usually a one-year social accounting matrix (SAM), although in this case the models can be validated only through calibration (Hosoe, Gasawa, and Hashimoto 2010).

Several CGE models have been developed for African countries. Lofgren (1995) analyzed the short-run impact of removing price-distorting subsidies for oil products sold domestically and for commodities covered by the consumer subsidy program in Egypt, by imposing alternative macro closures. He found a contractionary effect in GDP, household income, consumption, and employment. Lofgren et al. (1997) explored the effects of several developmental policies on rural development in Morocco. They found out that a combination of rapid productivity growth in rural activities, higher water tariffs and water sales, with improved penetration of export markets for fruits and vegetables, would be a favorable development strategy for this population. Grepperud, Wiig, and Aune (1999) evaluated two suggested policy measures meant to stimulate economic growth and crop production in Tanzania. They found that maize trade liberalization stimulated food crops and more land-extensive agricultural production, while fertilizer subsidies promoted cash crop production and a more land-intensive production pattern in agriculture. Konan and Maskus (2000) analyzed the inter-sectoral allocative effects of Egyptian trade liberalization policy scenarios. They found that free trade with reductions in administrative costs would provide significant welfare gains in Egypt. The output and employment expansion from trade liberalization were more significant in the service sector than in the manufacturing sector. Boccanfuso and Savard

(2007) analyzed how removing cotton subsidies in developed countries would impact poverty and inequality in a developing country. They found a significant decrease in poverty and reduced inequality in Mali. Arndt, Pauw, and Thurlow (2016) studied the impact of the farm input subsidy on Malawi's economy, and found that the CGE analysis is more comprehensive than some survey-based assessments on input subsidy. They also compared impacts under three different assumptions regarding how the subsidy was funded, and pointed out that such assumptions are important when evaluating agricultural policy.

Thurlow and van Seventer (2002) extended Lofgren's (2000) standard CGE model to a static CGE model for South Africa. Thurlow (2004) further extended the model to a dynamic recursive version. Another extension by Thurlow (2008) introduced a micro simulation module into a dynamic recursive South African CGE model to study poverty. Thurlow's work represents an evolution in CGE modeling through the combining of micro simulation modules and CGE models. Other authors who have undertaken micro simulation and CGE modelling include Savard (2003), Davies (2004), Peichl and Schaefer (2006), Colombo (2010), and Dixon and Jorgenson (2012).

Several other large-scale CGE models have been developed for South Africa, such as those by Mensbrugghe (1995), Gibson and van Seventer (1996), Coetzee et al. (1997), and van der Devarajan and van der Mensbrugghe (2000). On the empirical side, Bohlmann (2012) studied the policy impact of illegal immigration in South Africa. "Illegal immigration" was modeled as a policy-induced shock in labor supply on the economy. The study found that legal residents benefit significantly when policy-induced employment of illegal immigrants is reduced.

Several authors have studied the economy of Ghana using CGE modelling tools. Colatei and Round (2000) used a static CGE model to examine the economy-wide poverty alleviating impact of consumption transfers in Ghana. The study also explored the sensitivity of the results under alternative representations of model closures. Diao (2011) used a dynamic CGE model to analyze the impact of avian flu on the poultry sector in Ghana, where the occurrence of avian flu was modeled as a capital accumulation shock to the poultry sector, together with a down shift of marginal social benefit on the demand side. The study measured impacts on four chicken-producing regions of Ghana, and found large negative impacts on crops such as soybean and maize, which were used as chicken feed. However, due to the small size of the poultry sector in Ghana, the study found that the impacts on the overall economy was small. Dagher et al. (2010) compared different fiscal and monetary policy responses from the Ghanaian economy where oil windfalls were modeled as production shocks. By distinguishing between short-run and long-run effects, the study provided a good explanation for the incidence of the "Dutch Disease" phenomenon in Ghana. The study found that the negative "Dutch Disease" effect was small over the long term. Bhasin (2012) analyzed impacts of trade taxes on poverty and income distributions and found that eliminating import and export taxes on agricultural goods and import tariffs on industrial goods, combined with foreign capital inflows and value-added taxes, would best reduce the incidence, depth, and severity of poverty in Ghana. Arndt et al. (2015) used a static CGE model to simulate Ghana's economic performance under four climate scenarios projected by General Circulation Models. Crop yields, hydropower production, road infrastructure, and coastal arable land area were the four major shocks modeled under climate change impact. They found that climate change would negatively affect the nation's welfare, especially for the poor in the northern Savannah zone.

In addition to country-specific CGE applications, there are models using CGE modelling for various African regions. One example was by Calzadilla et al. (2009), who combined a partial equilibrium IMPACT model with a CGE model GTAP-W to explore the impact of climate change on agriculture and human well-being by simulating the production of crops and area use changes under irrigated versus rain-fed agriculture for Sub-Saharan Africa in 2050.

This sampling of CGE applications for African countries points to several themes that guide the modelling approach used in studying the SADA region of Ghana. Most studies address the distributional impacts of agricultural policy given the large share of the agricultural sector in the overall GDP and household incomes in African countries. The focus has been to determine the spill-over effects of agricultural policy change on the rest of the economy. The literature also shows that both static and dynamic CGE models have been used in policy modelling of African countries. Static models focus on medium to long-run equilibrium and are suitable for welfare analyses; whereas the dynamic models capture short-run behavioral changes within different sectors. However, since the CGE models rely heavily on the calibrated parameters, even the dynamic versions are not able to update most of the parameters over time. A third theme that emerged from the literature is the integration of auxiliary models that include microsimulation models with which to study crop yield, water usage, land availability, and other factors influencing agricultural production. The addition of these models is essential to better understand the impacts of agricultural policy shocks and to examine the short-run responses in a given sector.

CHAPTER III

SADA FARM LEVEL ANALYSIS

This chapter turns to the farm level analysis of the effects of selected agricultural modernization efforts under SADA. The specific efforts to be analyzed include government subsidies for the inputs fertilizer, equipment, and improved seed; expanded agricultural extension; expanded of irrigated acreage; and adoption of wide spread guinea fowl production.

To accomplish this analysis, a Farm Planning Model (SADAFPM) is developed that depicts agriculture in the SADA region and allows simulation of the impact of SADA program elements. SADAFPM is used to assess changes in input use, irrigated acreage, crop commodity and input prices under SADA's agricultural policies and generate data on the regional implications that will be input into the CGE based economy-wide analysis.

The SADA Farm Level Model (SADAFPM)

SADAFPM model will reflect regional farm land availability, crop calendar, crop inputs and outputs, crop mix possibilities, hired labor, yield uncertainty, rainfall distribution, subsistence nutrition requirements and risk aversion.

Features and Assumptions of SADAFPM

SADAFPM reflects a stochastic model with a resource decision-making procedure in response to stochastic rainfall conditions. The following sections discuss the features of SADAFPM.

Crop and Guinea Fowl Production Activities

A crop production activity in the model represents cultivation of a crop on one acre of land, with corresponding resource requirements by month. SADAFPM includes major crops of maize, sorghum, millet, cassava, yam, groundnut, cowpea, rice, soybean, and tomato.

Guinea fowl production is an important component of SADAFPM because it is a major economic activity in the SADA region. According to the GSS (2012), guinea fowl are only raised in northern Ghana, where 90 to 100 percent of adults own these birds. SADA's Strategic Plan has explicit guinea fowl projects designed to enhance production, create employment, and increase incomes.

Guinea fowl production interacts with crop production activities in that fowl feed comes from maize production. In Ghana, maize accounts for about 60 percent of the average poultry feed ration (Gage et al., 2012), with poultry consuming approximately 40 percent of the maize and 75 percent of the soybeans production (USAID 2012). The volume of high-quality yellow maize going into commercial poultry feed is about 200,000 metric tons, roughly 150,000 metric tons of which is produced in the Northern Region.

Soybean meal, another major ingredient in fowl feed, could be produced in northern Ghana, but at the present time is mainly imported due to a huge gap between domestic demand and supply (FAO 2014c).

Guinea fowl production activity in SADAFPM is defined as guinea fowl feeding for 50 keets with corresponding resource requirements by month.

Crop and Guinea Fowl Budgets

The models' resource use specifications are based on farm crop budgets collected from local surveys that Texas A&M University conducted in selected rural communities in the SADA region. The crop and guinea fowl budgets used are presented in Appendix 1. Crop budgets reflect the cost of inputs corresponding to production activities, which are categorized by crops and irrigation conditions. Taking maize as an example, the budget sheet describes the quantity and cost of seeds, fertilizer, labor, bagging, transportation, and other inputs required to produce one acre of maize.

The guinea fowl budget describes the feed and vaccination requirements for every 50 keets. The weekly feed quantity is drawn from Tye and Gyawu (2001). Maize is an essential ingredient in guinea fowl feed and SADAFPM assumes that part of the maize production goes to this use.

Labor

SADAFPM assumes that both family labor and hired labor are used on the farm. In 2010, the average household sizes in the Northern, Upper East and Upper West regions were 7.7, 5.8, and 6.2 people. The estimated population of rural households in these regions was 226,819, 140,684, and 94,089, respectively (GSS 2012). According to GSS (2013b), the proportion of people between 15 and 65 years old who could be counted among the labor force is about 51 percent. Based on the Ghana Living Standards Survey Round 6 (GLSS 6) (GSS 2013a), the mean time spent on farming activity in a week was about 42.6 hours. Therefore, each effective worker could contribute one man-day labor per day, which was around 8.52 hours, and 22 days per month. We also assume that farms could hire abundant outside labor to meet extra demand during the rush season.

Hired labor is used extensively in agricultural production in Ghana, accounting for 43 percent of the total crop production input expenditure (GSS 2012). These hired laborers typically are those who want a second job or who are unemployed.

Farm Livelihood

SADAFPM assumes that resources are allocated monthly. All crops except for tomato are rain-fed. Smallholders are assumed to be price takers in SADAFPM. On-farm consumption and sales can be adjusted according to the revealed yields and market prices. SADAFPM models sequential decisions that reflect this consumption and sales situation in two periods.

SADAFPM also models nutrition requirements for the family farm, guided by the Ghana nutrition requirement (FAO 2009), which specifies a minimum of 59.8 grams of protein and 2,118 calories per person, per day. SADAFPM allows smallholders to decide whether to consume more food or sell more produce depending on the revealed yield and market prices. Food nutrition supply is modeled according to the USDA national nutrient database (USDA 2016), which outlines the procedures for converting the foods a person eats into protein and calorie equivalents.

SADAFPM assumes homogeneity of smallholders in terms of input use and climate conditions across the SADA region.

Crop Calendar and Historical Crop Mix

Intercropping is an important farming practice in which two or more crops are cultivated simultaneously (Ouma and Jeruto 2010), and provides insurance against risk. The crop calendar of the Guinea Savanna zone of Ghana, which provides information about planting, growing, and harvesting periods of locally adapted crops, is shown in Table 3. SADAFPM allows farmers the flexibility to choose farming sequences according to crop calendar, and yearly crop mix activities are introduced at the same time to ensure a realistic crop mix. The theoretical underpinnings of introducing crop mix activities is discussed in McCarl (1982; 1985), and those in SADAFPM are defined in the historical observations shown in Table 4.

Table 3. Crop Calendar for Northern Ghana

Crop	Planting Onset	Planting End	Length of the Cropping Cycle	Harvesting Onset	Harvesting End
Groundnut	01/05	20/06	90-120 days	10/09	20/10
Cassava	20/06	20/07	180-210 days	10/11	10/01
Cowpea	20/04	10/07	60-70 days	10/10	20/11
Maize	20/05	20/06	90-120 days	10/09	30/09
Millet	01/06	16/09	90–120 days	01/09	30/11
Rice	10/06	31/07	110-120 days	10/11	10/12
Sorghum	10/07	31/07	100-120 days	10/11	20/12
Soybean	01/06	20/07	120-215 days	01/10	20/11
Yam	10/12	10/03	210-300 days	10/07	10/12
Tomato (Irrigated)	All year	All year	60-80 days	All year	All year

Source: FAO, 2016.

Table 4. Historical Observed Crop Mix in Northern Ghana (percent)

Crop	2006	2007	2008	2009	2010
Maize	15.74	17.42	17.61	18.91	19.57
Millet	12.15	11.01	11.57	11.33	10.69
Rice	6.93	6.68	7.69	8.97	9.96
Sorghum	19.44	14.04	17.55	16.18	15.28
Cassava	6.01	6.75	6.68	6.73	6.58
Yam	8.69	9.59	9.73	10.06	10.21
Groundnut	23.03	25.59	19.71	18.79	18.72
Beans	7.29	8.10	8.71	8.30	8.27
Tomato	0.73	0.81	0.76	0.73	0.72

Source: Author's calculation based on MoFA (2011), GSS (2008), and GSS (2013a)

Irrigation and Crop Yields

Irrigation development is a major SADA initiative. Irrigation in Ghana is regulated under the National Irrigation Policy, Strategies and Regulatory Measures (MOFA 2011). By 2010, only 0.4 percent of cultivated land was irrigated (SRID 2011). The region's major irrigation water sources are small reservoirs and dugouts (GIDA 2011). The small reservoirs capture surface runoff during the rainy season to supply during the dry season (Liebe et al., 2005). Quantifying the irrigation resource is difficult because the reservoirs were built by different agencies at different times, and records are incomplete. Information from SRID and GIDA was used to quantify irrigation use and scale in the model. The numbers of small reservoirs and dugouts available in the SADA region are shown in Table 5. Almost all irrigation is applied to vegetable growing.

Table 5. Small Reservoirs and Dugouts in Northern Ghana

Region	Number of Households	Irrigation Area (Acre)	Main Crops
Upper West	138	1759	Okra, garden eggs, tomato
Upper East	278	2211	Okra, garden eggs, tomato
Northern	529	1603	Okra, garden eggs, tomato

Source: Namara et al. 2011 (The author converted the area to acre for modeling purposes.)

The second type of irrigation system is public or communal surface irrigation. Twenty-two such schemes are managed by the Ghana Irrigation Development Authority (GIDA) and Irrigation Company of Upper East Region (ICOUR). Of these, 5 are in the north. The northern public irrigation facilities are listed in Table 6. The Fees and Charges (Amendment) Instrument (Republic of Ghana 2012) shows that the government heavily subsidizes public irrigation costs, charging a flat rate of 0.02 *cedi* per household. According to the Ghana Statistical Service (2008), only 19 out of more than 8,000 rural households pay for irrigation input.

Table 6. Public Irrigation Schemes in Northern Ghana

Region	Project Name	Irrigated Area (Acre)	Irrigation Type	Number of Households	Main Crops
Northern	Bontanga	1408	Gravity	550	Rice, maize, pepper, okra
	Golinga	49	Gravity	80	Rice, maize, pepper, okra
	Libga	40	Gravity	41	Rice, maize, pepper, okra
Upper East	Tono	6052	Gravity	3250	Rice, soybean, tomato
	Vea	1156	Gravity	2000	Rice, tomato, sorghum

Source: MOFA (2016) (The author converted the area into acre for modeling purposes.)

Irrigation produces higher crop yields than rain-fed agriculture. Under the current irrigation system, only tomato has access to irrigation. Rice and tomato yields under different irrigation schemes are shown in Table 7, and crop yields under rain-fed conditions for the base year 2010 are shown in Table 8, as well as the yields expected to be achievable when more effective extension services and improved technologies have been adopted, according to the recently revised findings from Ghana Crop Research Institute.

Table 7. Crop Yields under Irrigation (tons/acre)

Schemes \ Crops	Rice	Tomato
Smallholder river/lake pumping	2.227	1.377-1.417
Public irrigation/gravity	1.012-1.619	1.417
Small reservoirs/dugouts	2.551	1.700
Groundwater shallow well		2.429

Source: Namara et al. 2011 (The unit is converted to acre for modeling purpose.)

Table 8. Crop Yields under Rain-fed Conditions (tons/acre)

Crop	Average Yield	Achievable Yield
Cassava	5.587	19.717
Yam	6.194	19.838
Cowpea	0.526	1.053
Maize	0.688	2.429
Rice	0.972	2.632
Sorghum	0.526	0.810
Groundnut	0.607	1.012
Soybean	0.607	0.931
Millet	0.526	0.810

Source: SRID 2011; MOFA 2013. (The unit is converted to acre for consistency.)

Risks

SADAFPM assumes that farmers in the SADA region are risk averse, facing erratic rainfall patterns, uncertain crop yields, and fluctuations in market prices. Rainfall levels are a high agricultural risk factor in northern Ghana, and are modeled extensively in SADAFPM.

Rainfall patterns in western Africa are patchy (Friesen 2002). Rainfall quantity and quality vary across the SADA regions in any particular year. The limited set of the crop budgets, however, make setting up different states of nature for different sites within the region impossible. The current study takes historical yearly average rainfall quantity from a representative site, Wa, which is located in the Upper West. The historical average rainfall recorded in Wa is listed in Table 9, from which the cumulative distribution function is shown in Figure 2. Three states of nature are considered: Low (below 75 mm), Medium (75 to 110 mm), and High (above 110 mm). The probabilities of each states are 0.2, 0.7 and 0.1.

Table 9. Historical Average Rainfall in Wa (mm)

Year	Rain	Year	Rain	Year	Rain	Year	Rain
1961	68.1	1974	87.6	1987	64.7	2000	95.1
1962	116.9	1975	82.9	1988	77.5	2001	100.6
1963	128.6	1976	83.3	1989	86.9	2002	70.6
1964	86.0	1977	102.1	1990	75.5	2003	100.0
1965	99.6	1978	79.8	1991	84.0	2004	93.8
1966	88.1	1979	109.0	1992	71.9	2005	88.4
1967	76.6	1980	98.8	1993	94.2	2006	84.2
1968	127.8	1981	63.0	1994	83.3	2007	83.1
1969	100.4	1982	85.6	1995	103.7	2008	106.1
1970	63.6	1983	56.2	1996	94.6	2009	95.2
1971	80.0	1984	78.1	1997	113.2		
1972	82.9	1985	88.3	1998	63.9		
1973	76.8	1986	43.6	1999	107.5		

Source: Ghana Meteorological Agency. http://www.meteo.gov.gh/website/

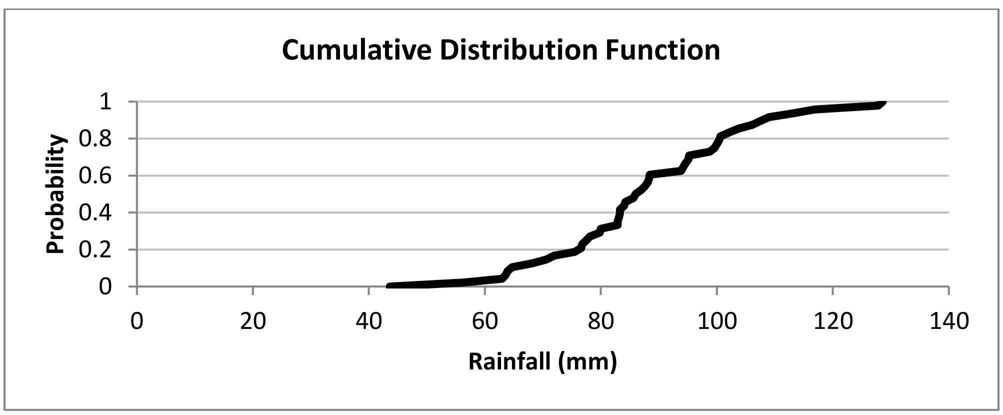

Figure 2. Cumulative Distribution Function of Historical Rainfall in Wa

Forty-nine years of historical rainfall data and observed crop yields (except for cowpea and soybean, for which no historical yield data are available) are then used to generate a probability distribution of crop yields under different rainfall patterns. Since the historical yields information is a long-term time series, a time trend is considered to filter the technology effect on yield changes. Significant positive effects of rainfall quantity on crop yields are found for cassava, rice, maize, and yam, while insignificant effects are found for groundnut, millet, sorghum, and tomato. Since tomato is an irrigated crop in SADAFPM, its yields are not influenced by rainfall. Although the biological characteristics of crops are beyond the scope of this thesis, it is worth noting that there are several potential reasons why the yields of groundnut, millet, and sorghum are not sensitive to rainfall quantity, and these likely are a complicated mixture of their planting times and mechanisms for consuming and storing water. Therefore, the yields of these three rain-fed crops do not vary according to rainfall patterns in SADAFPM. The distribution of detrended yields on rainfall for cassava, rice, maize, and yam are shown in Figure 3. Based on the statistical relationship, we are able to calculate average crop yields in the three states of rainfall patterns and use this to determine the base year in SADAFPM.

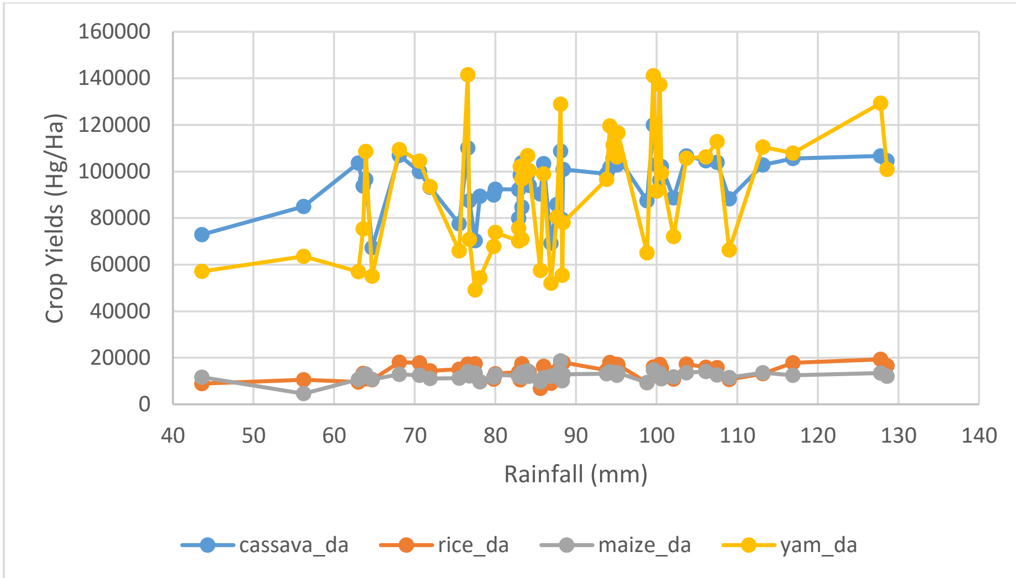

Figure 3. Distribution of Historical Crop Yields on Rainfall Quantity

A Mathematical Presentation of SADAFPM

The mathematical representation of components of SADAFPM is shown below. Equation (1) is the objective function, which is composed of two parts: an expected net income and a risk. Equation (2) contains 12 land balance constraints, one for each month. Equation (3) is a matrix consisting of 12 constraints indicating the cropping decisions on each crop, and are convex combinations of the observed historical crop mix. Equation (4) contains 11 commodity balance constraints so that each commodity (the harvested crop), should not exceed the crop grown. When a commodity is used as livestock feed, the feed amount should also count (4’). Equation (5) contains 6 nutrition requirement constraints under certain state of nature for crops and guinea fowl under each state of nature. Equation (7) contains 12 labor constraints, one for each month.

Equation (8) is an accounting one which specifies all the components of cropping activity cost. Equation (9) defines the average farm income. Equation (10) defines the household income under certain states of nature. Equation (11) defines the positive and negative deviation of farm income under certain states of nature. Equation (12) is the non-negative constraint.

All sets:

r = {1, 2, 3} rain states

c = {1, 2, …, 12} crops grown

cm = {1, 2, …, 12} crop commodities

m = {1, 2, …, 12} months in a year

mp = {1, 2, …, 12} month of planting; a duplication of set m

mo = {1, 2, …, 12} month of operation; a duplication of set m

l = {fowl} guinea fowl

lc = {50 keets} guinea fowl commodity

lt = {1, 2} land type (irrigated and non-irrigated)

li = {1, 2} guinea fowl input

cmx = {1, 2, 3, 4, 5} crop mix

n = {1, 2} nutrient (calorie and protein)

i (alli) = {1, 2, …, 19} cropping technology characteristics

op (alli) = {1, 2, …, 12} cropping operations

cc (c, mp, o, mo) = {1, 0} cropping calendar

h (cmx,c) = {historical crop mix of a crop}

All variables:

X (c,m,lt) acreage of a crop grown in a month on certain land type

XL (l) guinea fowl (50 keets as a unit) raised

SC (cm, r) self-consumption of a crop commodity under certain rain state

SCL (lc, r) self-consumption of guinea fowl under certain rain state

YCM (cmx) yearly crop mix activities

Y (r) farm income under certain rain states

AY average farm income

S (cm, r) sales of crop commodity under certain rain state

SL (lc,r) sales of guinea fowl (50 keets as a unit) under certain rain state

HL (m) hired labor in a month

R revenue from crop sale

C cropping activity cost

DEVPOS (r) positive deviation of farm income under certain rain state

DEVNEG (r) negative deviation of farm income under certain rain state

All parameters:

CY (c, cm, lt, r) crop yield with certain land type and rain state

L (m) available family labor in each month

CB (c, alli, lt) use and inputs by crops

LB (li) guinea fowl inputs

NS (cm, n) nutrient supply of a crop commodity

LC (lt) land availability of a land type

PR (cm, r) price of a crop commodity under certain rain state

LP (l, r) price of livestock under certain rain state

IP (i, c) input price for a crop

LIP (li, l) input price for livestock

SC(cm) storage cost for a crop commodity

NR(n) Ghana nutrient requirement

LL (m) labor for guinea fowl of a month

PHL price of hired labor

HS average household size

DM days of a month

WF weight of 50 fowl keets

P (r) probability of rainfall states

Φ risk aversion parameter

Objective function - maximizes probabilistically weighted profits minus a risk term

(1) $Max\ \sum_r\ P(r) * Y(r) - \phi * (\sum_r\ P(r) * (DEVPOS(r)^2 + DEVNEG(r)^2)^{0.5}$

subject to

land available by month and type where x is production in acres and lc is available land

(2) $\sum_{c} \sum_{mp} X(c, mp, lt) \leq LC(lt, m)$, for all lt and m

A crop mix constraint

(3) $\sum_{mp} \sum_{lt} X(c, mp, lt) = \sum_{cmx} HCM(cmx, c) * YCM(cmx)$, for all c and lt

Commodity balance constraint

(4) $\sum_{lt} \sum_{c} \sum_{mp} CY(c, cm, lt, r) \geq S(cm, r) + SC(cm, r) + XL(l) * LB(c, cm, l, li)$, for all cm and r where the last two terms only apply to maize

Family diet for crops

(5) $\sum_{cm} SC(cm, r) * NS(cm, n) * 1000 + SCL(l, r) * WF * NSL(l, n) \gg NR(n) * DM * HS * MY$, for all n and r

Family diet for guinea fowl

(6) $XL(l) \gg SCL(l, r) + SL(l, r)$, for all r

Family and hired labor

(7) $\sum_{c} \sum_{mp} \sum_{op} \sum_{lt} cc(c, mp, op, m) * CB(c, op, lt) * X(c, mp, lt) + LL(m) * XL(l) - HL(m) \ll LA(m)$, for all m

Production cost

(8) $C = \sum_c \sum_i \sum_{lt} \sum_m IP(i,c) * CB(c,i,lt) * X(c,m,lt) + \sum_l \sum_{li} LIP(l,li) * LB(l,li) * XL(l) + \sum_m HL(m) * PHL$

Average income

(9) $AY = \sum_r P(r) * Y(r)$

Income by state of nature

(10) $Y(r) = \sum_l SL(l,r) * LP(l,r) + \sum_c P(c,r) * S(c,r) - C$, for all r

Deviations from average income

(11) $\mathrm{Y(r) - AY - DEVPOS(r) + DEVNEG(r) = 0}$, for all r

(12) $X, XL, SC, SCL, YCM, DEVPOS, DEVNEG \geq 0$

Data Sources

This section describes the data sources used in SADAFPM. The crop and guinea fowl budgets were obtained from local surveys conducted by Texas A&M University in Gambaga, in the SADA region. Demographic information and livelihood information, such as subsistence consumption and labor supply, came from the Ghana Statistical Service (2013a). Base year commodity prices and crop yields were from MOFA (2011). Soybean prices were obtained from a study by Akramov and Malek (2012). The crop calendar, as well as historical crop yields, were drawn from FAO (2014a; 2016). The precipitation information came from the World Bank Climate Change Knowledge Portal (World Bank 2016b).

Model Validation

SADAFPM's ability to create solutions that are close to the actual observations in the real world was tested, following the steps proposed by McCarl and Spreen (2003).

The crop and guinea fowl production variables were compared. The crop mix constraints force the crop production activities to be consistent with the historical observed cropping level. Thus, the cropping activities are close by design. The historical crop mix and the base year model solution are shown in Figure 4. The historical crop mix is close to the base year solution.

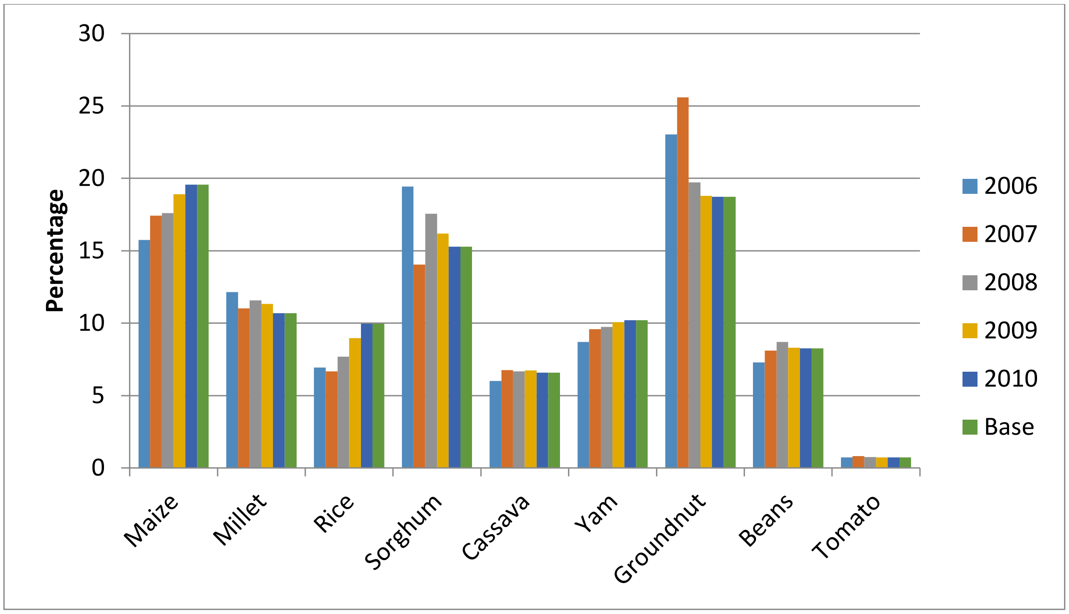

Figure 4. Comparisons among the Historical Crop Mix and the Model Base

The real-world quantities of guinea fowl in the SADA zone were found in Aning (2006) for 1996 and FAO (2014c) for 2009. An exponential projection is made to estimate the quantity in year 2010. The comparison between the real-world observation and model base are shown in Figure 5, which has more than doubled the projected year 2010 production. This was anticipated due to the fact that guinea fowl is only one of the types of poultry raised in the SADA region. The other principal category is local chicken (or local fowl). According to Aning (2006), total local fowl production in the SADA region was 2.1 million birds in 1996. According to FAO (2014c), total local chicken production in the SADA region was 2.6 million in 2009, and the projected quantity for 2010 was 2.61 million. These quantities are almost the scale of the guinea fowl production. Therefore, total guinea fowl production in SADAFPM basically equaled observed guinea fowl plus chicken production in SADAFPM. The model is judged to be a valid predictor of crop acreage plus total poultry production.

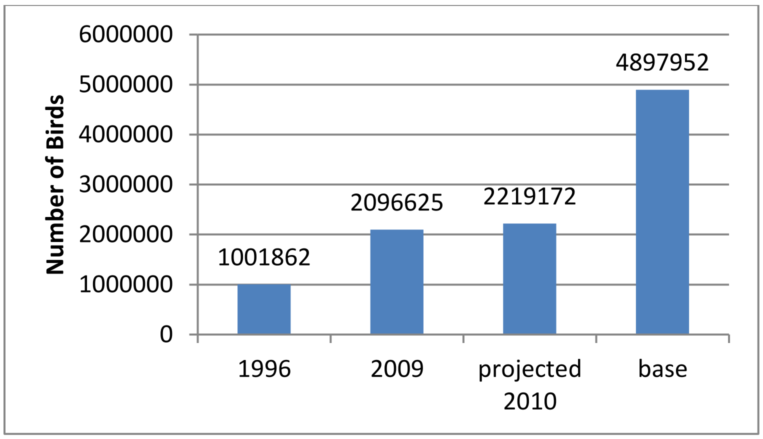

Figure 5. Historical Guinea Fowl Production and the Model Base

The base solution of hired labor expenditure is 2,991 *cedis* annually, which is around 31.07 percent of the total production cost (9,626 *cedis*). Ghana Statistical Service (2013) reported that hired labor accounted for 30.9 percent of the total crop input expenditure, which is very close to the base solution. During the dry season from January to April, no hired labor is needed in the base model. Demand peaks during the wet season, especially in the busiest planting month of July and harvesting month of September.

Once the base year is validated, a predictive experiment is conducted for year 2012 for further validation. Most crop yields and prices are updated according to MOFA (2013). Price of cowpea is obtained from West Africa Price Bulletin (Famine Early Warning Network System 2016), and soybean price is calculated according to the survey from Dogbe et al. (2013). Guinea fowl price is updated according to FAO (2014c). Hired labor price is increased from 5 to 7.2 *cedis* per man day, consistent with the minimum wage increase instituted by the Ghana Trades Union Congress (2016). All input prices are adjusted to reflect the change in the CPI between 2010 and 2012.

The simulated results have sorghum acreage of 279,681 Ha, which is higher than the real-world observation of 230,800 Ha (GSS 2013a). For the other crops, such as soybean and cowpea, precise real-world observations are not available for the SADA region. Acreages are calculated based on the information from GSS (2013b) and MOFA (2013), and are available only for millet, rice, maize, and groundnut. The comparisons are shown in Figure 6. The differences between the calculated real-word observations and the simulated quantities for year 2012 are small for millet and rice, and a little larger for maize and groundnut.

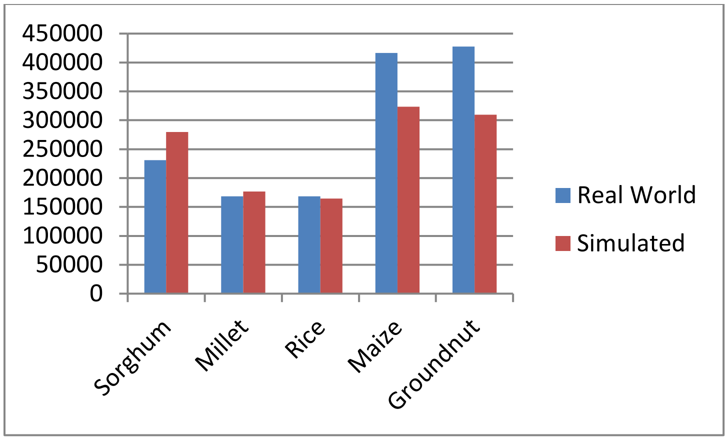

Figure 6. Simulated Cultivated Areas for Year 2012 (Ha)

An experiment on the risk aversion parameter (RAP) has been conducted following the guidelines of McCarl and Spreen (2003), with values from 0 to 2.5. As the RAP increases, the value of the objective function decreases. However, when the RAP reaches 2 to 2.5, the value of the objective function remains the same. The crop mix and guinea fowl activity do not change within the RAP ranges that were tested. However, monthly crop activities do have slight adjustments among different RAP settings. The resultant comparisons of selected variables are shown in Table 10.

Table 10. Comparison of Model Results with Alternative RAPs

RAP	0.00	0.20	0.50	0.70	1.00
Objective	13361.11	13137.13	12801.16	12465.18	12241.2
Cropmix2	21.46	21.46	21.46	21.46	21.46
Guinea Fowl Activity	11.08	11.08	11.08	11.08	11.08
RAP	1.30	1.70	2.00	2.50	
Objective	11905.23	11457.38	11123.14	11123.14	

Table 10 Continued

Cropmix2	21.46	21.46	21.46	21.46
Guinea Fowl Activity	11.08	11.08	11.08	11.08

Overall, SADAFPM depicts the real-world farming situation in the SADA region of Ghana quite well given the available data. Therefore, the model is judged valid.

Simulation Scenarios

Several simulation scenarios were generated based on the SADA Strategy and Work Plan (SADA 2011b) and the newest 2016 Ghana Budget Statement (Ghana, Ministry of Finance [GMOF] 2015). These involved input subsidies, agricultural extension, irrigation expansion, and guinea fowl enhancement.

Impact of Input Subsidy

Ghana initiated a uniform, country-wide input subsidy program in 2008 that originally focused on fertilizers in order to stabilize and the high costs of imports (Baltzer and Hansen 2011). SADA Strategy and Work Plan (SADA 2011b) recommended a subsidy plan that was implemented with allocation limits. Under the Accelerated Cereal Production Initiatives, 1,674,400 *cedis'* worth of vouchers were to be allocated to 13,000 farmers to enable them to procure fertilizers and seeds for the cultivation of maize. Under the Accelerated Legumes Production Initiative, 225,680 *cedis'* worth of vouchers were to be distributed to 5,200 farmers to enable them procure insecticides and seeds to cultivate cowpea. On average, each participating smallholder would receive 128.8 *cedis* for cereal production and 43.4 *cedis* for legume production. The subsidy distribution covered 36 districts in the three northern regions. Some survey-based assessments have shown that the early Ghana input subsidy program underperformed in terms of achievement rate (Baltzer and Hansen 2011; FAO 2015). No further program implements or assessments for recent years can be found. The subsidies potentially lower input prices for famers. Initially, Ghana government officials intended to cover approximately 50 percent of the input prices. In reality, in some cases, less than 30 percent of the input prices were covered (FAO 2015).

SADAFPM is used to simulate individual and combined input subsidy plans. We assume a range of price reduction in fertilizer, seed, and insecticide for smallholders, from 10 percent to 100 percent. For example, when the price is reduced 10 percent, farmers face fertilizer, seed and insecticide prices that are 10 percent less than those in the base scenario. When the price reduction is 100 percent (an extreme case), fertilizer, seed, and insecticide are free.

The simulation results for the change in expected regional agricultural income with subsidy on fertilizer, seed, and insecticide individually are shown in Table 11. The simulation results of the combined input subsidy on fertilizer, seed, and insecticide are shown in Table 12. The results suggest that a positive impact arises for SADA region household incomes under the input subsidy. Under the highest possible subsidy plan, where smallholders have 100 percent reduction in input prices, and receive free fertilizer, seed, and insecticide, the regional income will increase by 19.57 percent. The most expensive subsidy plan costs the government 2,528.31 *cedis* per household in a calendar year, with an increased expected income of 2,570.82 *cedis* per household.

Therefore, without other transaction costs, the regional expected agricultural profit exceeds its cost. Note that in reality, some survey-based assessments (FAO 2015) found the transaction costs of the Ghana input subsidy program to be very high. However, including transaction costs is beyond the scope of the current study.

There is a feature to these results that reveals a model shortcoming. Namely note the effect of a 70 percent subsidy is precisely 7 times that of a ten percent one. Upon investigation, the reason for this is the model did not change any of its decision variables as the subsidy was changed. The reason is there are not enough possibilities where more inputs are used to get greater production when the subsidy occurs. This could be corrected by adding say a fertilizer response function of the model or somehow adding alternative variables with different input combinations allowing input substitution.

Table 11. Simulation Results of Individual Input Subsidy

Fertilizer Price	Expected Income	Seed Price	Expected Income	Insecticide Price	Expected Income
-10%	+1.18%	-10%	+0.71%	-10%	+0.11%
-30%	+3.53%	-30%	+2.14%	-30%	+0.22%
-50%	+5.89%	-50%	+3.56%	-50%	+0.33%
-70%	+8.25%	-70%	+4.98%	-70%	+0.77%
-100%	+11.78%	-100%	+7.12%	-100%	+1.10%

Table 12. Simulation Results of Combined Input Subsidy

Input Prices	Expected Income
-10 %	+1.96 %
-30 %	+5.87 %
-50 %	+9.78 %
-70 %	+13.72 %
-100 %	+19.57 %

Impact of Agricultural Extension

Agricultural extension has been defined as application of scientific research and knowledge to agricultural practices through farmer education (Anderson and Gershon 2007). Agricultural extension services in the SADA region deliver information to farmers on how to improve their productivity through rural radio (Blench et. al 2003) and field schools (Simpson and Owens 2002). Extension officers also visit farmers at their farms to identify and assist in solving various problems. Ghana reports that there were 1,244 extension staff in 2011 (Global Forum for Rural Advisory Service 2016). In the SADA Strategy and Work Plan, an expanded extension effort is contemplated in the out-grower program, which requires marketing firms or processing companies to research and define the market for a variety of commodities and connect farmers to consumers in both domestic and external markets. These firms also are required to assist farmers by sourcing the right inputs in a timely manner, introducing new technologies, and procuring proper research and information (SADA 2011b). The public extension services for smallholders are free (Global Forum for Rural Advisory Service 2016).

MOFA has provided estimates of yield increases that resulted from effective communication by extension personnel regarding technologies, based on findings from Ghana Crop Research Institute. These are shown in Table 8, and under rain-fed conditions, vary from 54 percent to as high as 253 percent. The achievable yield is an ideal, however, and will not be achieved immediately or perhaps, ever. We use SADAFPM to simulate various attainment levels for the achievable yield ranging from 10 to 100 percent to represent a short- to medium-term perspective.

The results are shown in Table 13. All the rows but the last one show the assumed percentage increase in yield attained for a crop, and the values in the last column show the full estimated achievable yield. The last row in Table 13 shows the model generated increase in expected income.

The findings show a strong positive impact on expected regional agricultural income. If the agricultural extension services help farmers achieve 10 percent increase in crop yield, the expected regional agricultural income would increase by 27.60 percent. If all rain-fed crops achieve the maximum yields, the SADA smallholders would achieve an expected income increase of 239.25 percent higher than base level. This strong positive impact suggests huge potential returns to increased agricultural extension in the SADA region. The SADA Strategy and Work Plan (SADA 2010) has calculated costs for several extension services. For example, rice promotion would cost 29 million *cedis* per year, and the maize and legume promotion would cost 53.1 million *cedis* per year. The farmers' potential gain at base-year price levels with 10 percent achievable yields would end up at around 166 million *cedis*. Therefore, there would be around 84 million *cedis* in net gain, given no other transaction costs. The real social benefit could be much smaller than what is calculated here. Results of hired labor are shown in Table 14. No clear pattern of change emerged in comparing hired labor with full yield achievement. Relative yield varies by crop, so farmers choose crop mixes reactively, making the need for labor input fluctuate.

Table 13. Simulation Results of Agricultural Extension Impacts (ton/acre)

Crop \ Achievable Yield	10%	30%	50%	70%	100%
Cassava	7.000	9.826	12.652	15.478	19.717
Yam	7.558	10.287	13.016	15.745	19.838
Cowpea	0.579	0.684	0.790	0.895	1.053
Maize	0.862	1.210	1.559	1.907	2.429
Rice	1.138	1.470	1.802	2.134	2.632
Sorghum	0.554	0.611	0.668	0.725	0.810
Groundnut	0.648	0.729	0.810	0.891	1.012
Soybean	0.639	0.704	0.769	0.834	0.931
Millet	0.554	0.611	0.668	0.725	0.810
Expected Income	+27.60%	+62.39%	+117.30%	+168.20%	+239.25%

Table 14. Hired Labor Comparison with Agricultural Extension (Man Day)

Month	Base	Agricultural Extension	% Change
May	34.32	25.41	-25.96
June	19.67	20.23	2.84
July	120.90	132.36	9.48
August	61.27	31.58	-48.46
September	168.25	165.65	-1.54
October	73.80	100.69	36.44
November	55.27	59.44	7.54
December	61.20	62.46	2.06

Impact of the Guinea Fowl Program

SADA has been promoting guinea fowl production for years. The guinea fowl out-grower program is viewed as one approach to reduce the need for imported chicken meat in order to preserve limited foreign exchange reserves. In addition, raising guinea fowl could help diversify farm income sources and provide income opportunities for land-scarce parts of the SADA region. One of the main constraints in the guinea fowl value chain, however, is the high mortality rate of chicks (SADA 2011b). One of the services that SADA provides is to deliver grower birds and training to farmers. SADA guinea fowl out-grower farmers are given hands-on training to improve their guinea fowl production methods, and they receive eight-week-old grower birds as start-up stock for production (GMOF 2015). Providing grower birds to smallholders has been estimated to increase survival rates by 90 percent and reduce the cost of vaccination by 54 percent, according to the local guinea fowl budget (Appendix 1).

We use SADAFPM to simulate the impacts of the guinea fowl program under a range of program enrollment options. Under each scenario, the average cost reduction varies with different enrollment rates ranging from 10 to 100 percent. In an ideal case of full enrollment, the cost of vaccination and feed were assumed to be reduced by 90 percent and 54 percent, respectively.

The results are shown in Table 15. The first column lists assumed household enrollment rates, which is the percentage of SADA smallholders assumed to participate in the program. The second column lists the corresponding expected changes in regional income. The simulation results show positive impacts on regional expected income.

With 50 percent of the smallholders participating in the program, expected regional income increases by 12.56 percent. If all participate, the expected regional income would increase by 39.93 percent. The program not only bears cost of grower birds, but also involves in transaction cost as mentioned in the input subsidy scenarios. How efficiently grower birds are distributed to farmers would highly impact the effect of the guinea fowl program.

Labor requirements would be a challenge accompanied by the increase in guinea fowl production in the region. Demand for hired labor increases throughout the year. With full enrollment of the guinea fowl program, none of the monthly labor requirements could be satisfied solely by family labor, even during the dry season. The comparisons of hired labor are shown in Table 16. Neither the base nor the full program enrollment scenario shows home consumption of the guinea fowl to satisfy the nutrition requirement. Northern farmers tend to sell the fowls even though the output is more than doubled. The result is consistent with the fact that Ghana has a huge gap in domestic poultry supply, with lower-income regions such as the Savannah north having very low consumption, as showed in Table 17. The Savannah north rural (SADA farmers) consumes only 5.97 percent of the country's total.

Table 15. Simulation Results of Guinea Fowl Program

Household Participation Rate	Expected Income
10%	+2.39%
20%	+4.09%
30%	+6.55%

Table 15 Continued

Household Participation Rate	Expected Income
40%	+9.35%
50%	+12.56%
60%	+16.29%
70%	+20.66%
80%	+25.86%
90%	+32.16%
100%	+39.93%

Table 16. Hired Labor before and after Guinea Fowl Program (Man Day)

Month	Base	Full Program Enrollment	% Change
January		112.95	--
February		112.95	--
March		112.95	--
April		126.35	--
May	34.32	156.87	357.02
June	19.67	212.96	982.82
July	120.90	299.31	147.56
August	61.27	182.90	198.53
September	168.25	274.66	63.25
October	73.80	239.21	224.15
November	55.27	219.76	297.59
December	61.20	271.84	344.20

Table 17. Chicken Consumption Distribution in Ghana (Mil *Cedis*)

Region	Chicken Consumption	Percentage of Country Total
Accra	21.18	24.22
Coast urban	5.01	5.73
Forest urban	9.16	10.48
Savannah south urban	13.04	14.92
Savannah north urban	0.42	0.49
Coast rural	5.63	6.43
Forest rural	9.73	11.13
Savannah south rural	18.04	20.63
Savannah north rural	5.22	5.97

Source: Author's calculation based on Ghana social accounting matrix.

Impact of Irrigation Expansion

In this scenario, we simulate the impacts of newly available irrigated acreages for northern smallholders, which are used for the production of vegetables, particularly tomatoes. As described in the previous chapters, irrigation information, including for existing and prospective facilities in Ghana, is scarce and sometimes inconsistent. However, the general picture shows that approximately 2.2 percent of irrigation potential had been developed by 2010 (World Bank 2010). Some projections indicated that about 22 percent of the available water resources will be used by 2020 (SADA 2011b). Therefore, we assume different levels of irrigation expansion, from double the base line to ten times the base line. To reflect these changes, non-irrigated and irrigated land types in SADAFPM are adjusted accordingly. We also relax the crop mix constraint for tomato in SADAFPM. The model in turn determines new regional agricultural production and resource allocations.

The expected regional agricultural income corresponding to different levels of irrigation expansion are shown in Table 18. The first column lists the assumed irrigation expansion rates, which are 2 times to 10 times the base line irrigation level. The second column lists the corresponding expected regional income changes. The simulation results show positive impacts on the regional expected income. At 2 times the base level, we expect regional income to increase by 14.24 percent. If, as SADA (2011b) projected for 10 times expansion of the base level, the expected regional agricultural income would increase by 100.58 percent. Note that the cost of developing small dug-outs are not charged from the smallholders, therefore the social gain would be much smaller than what is calculated here.

The resultant crop and guinea fowl activities under 100 percent irrigation expansion scenario are shown in Table 19. There is large increase in the output of irrigated tomato, and all other non-irrigated crops and guinea fowl production slightly decreases, mainly due to the shift of primary inputs toward irrigated tomato production. The comparisons for hired labor use are shown in Table 20. Except for October, which is a peak month for both non-irrigated and irrigated crops, hired labor use decreases throughout the wet season. The results suggest irrigation expansion would relieve hired labor requirement. With the relaxation of the crop mix constraint on irrigated crops, expanded irrigated land is fully utilized throughout the year compared to the base, where irrigated land is not fully cultivated during the wet season. The results show that a reduction in non-irrigated crops and guinea fowl is fully compensated by revenue from irrigated tomatoes.

Table 18. Simulation Results of Irrigation Expansion

Irrigation Expansion Rate	% Change of Expected Income
2 times	14.24
3 times	28.07
4 times	37.25
5 times	47.81
6 times	58.37
7 times	68.92
8 times	79.48
9 times	86.28
10 times	100.58

Table 19. Impact of Irrigation Expansion on Crop and Guinea Fowl Activity (Production per Household)

Crop (Acre)	Month	Base	Irrigation Expansion
Cassava	July	1.45	1.32
Yam	January	0.68	0.57
	February	0.69	0.69
	March	0.69	0.62
Maize	June	3.74	3.40
Rice	June	1.43	1.30
Millet	August	2.36	
	September		2.15
Sorghum	July	3.01	2.74
Groundnut	May	5.40	4.91
	June	0.09	0.08
Cowpea	April	0.67	0.61
Soybean	June	0.14	0.12
	July	0.94	0.85
Tomato	January	0.05	0.54
	April	0.05	0.54
	July	0.03	0.54
	October	0.03	0.54
Guinea fowl (50 keets)		11.08	10.62

Table 20. Hired Labor Comparison with Full Irrigation Expansion (Man Day)

Month	Base	Irrigation Expansion	% Change
May	34.32408	28.617	-16.6271
June	19.66715	18.12023	-7.86553
July	120.9034	112.7003	-6.78485
August	61.26676	27.39231	-55.2901
September	168.2482	156.2596	-7.1255
October	73.79612	93.12123	26.18717
November	55.27345	47.51965	-14.0281
December	61.19694	56.20825	-8.15186

CHAPTER IV

ECONOMY-WIDE IMPACTS AND FEEDBACK EFFECTS

The overarching goal of SADA is to bridge the income gap between the northern and southern regions of Ghana. In this chapter, we focus on the economy-wide and income distribution effects. We utilize the results from SADAFPM to generate inputs for a CGE model and then assess the implications of several SADA agricultural actions. The following sections describe the GHANA CGE mode (hereafter referred to as GHANACGE) and the method that is used to link it with SADAFPM. The simulation results are presented at the end of the model description.

Description of GHANACGE

GHANACGE is an extension of the standard IFPRI CGE model documented in Lofgren, Harris, and Robison (2002). The version that are used here was developed by Robinson and Gueneau (2013). The model is designed to simulate the economy-wide impact of interventions such as policy changes and other actions, such as increased government spending, reductions in tariffs, or improvements in total factor productivity.

The model is a set of simultaneous non-linear equations based on Walrasian general equilibrium. Producers are assumed to maximize profits by choosing among primary factors under the assumption of a constant elasticity of substitution technology to form a value-added composite, and choosing among disaggregate intermediate inputs under the assumption of a Leontief technology. The value-added composite and aggregate intermediate inputs depict activity to produce final commodity with Leontief technology. Each activity produces one or more commodities using fixed yield coefficients. Consumers (households) are assumed to maximize a Stone-Gary type utility given budget constraints. Households earn income from supply of factors labor, land and capital. Government earns tax income including direct tax from domestic households and producers, export taxes, and import tariffs, and spends it on commodities, and household money transfers. Mathematically, an economic equilibrium is imposed by a series of equations. All the equations can be grouped into four blocks: the price block, the production-trade block, the institution block, and the system constraint block.

The data in the CGE include: 1) Ghana SAM, which contains commodity and sector identification, and intermediate purchases of commodities; 2) elasticities of household consumption of commodities; 3) physical factor quantities; 4) commodity value share for home consumption; and 5) tax accounts. The SAM was constructed for year 2005 by Breisinger, Thurlow, and Duncan (2007). The SAM contains both a detailed agricultural representation plus a representation of industry and households. There are 40 industrial and service sectors which are: gold mining, other mining, formal food processing, informal food processing, cocoa processing, dairy, meat processing, textiles, clothing, footwear, wood products, pulp and paper, petroleum, diesel, other fuels, fertilizer, other chemicals, metals, rubber, non-metallic mineral products, capital goods (machinery, etc.), radio and television equipment, medical equipment, motor vehicles, motor vehicle parts, other transport equipment, other manufactured products, construction, water, electricity, trade, transport, communication, banking and business, real estate, community services, public administration, education, health, and other service. In terms of households they were disaggregated by Diao (2010) into rural and urban within the four agro-ecological zones, plus the Accra area, which is the capital city.

The SAM contains 104 agricultural production sectors in the four agro-ecological zones (coastal, forest, southern Savannah, and northern Savannah) in Ghana. The coastal zone covers the Eastern and Volta regions; the Forest zone includes the Ashanti, Western, and Central regions; the South Savanna is comprised of Brong-Ahafo and part of Volta; and the North Savanna zone includes the Upper West, Upper East, and Northern regions. The North Savanna zone is the area covered by SADAFPM. The agricultural production sectors in the North Savanna zone covered by the SAM are: Maize, rice, sorghum, cassava, yam, cocoyam, cowpea, soybean, palm oil, groundnut, oil nut, fruit, vegetable, plantain, chicken, egg, beef, goat, forestry, fishery, and other crops and livestock (horticulture, etc.). The primary inputs for agricultural activities are self-employed labor, unskilled labor, agricultural capital, and land. Land in the North Savanna zone is further categorized as non-irrigated and irrigated. The intermediate inputs are agricultural commodities, fertilizers, metals, machinery, electricity, water, trade, and transport service.

Linking GHANACGE and SADAFPM

The procedure for connecting SADAFPM with GHANACGE is an iterative one adopted from Savard (2003); Davies (2004); and Peichl and Schaefer (2006). The first step is to compute total regional activity and output from SADAFPM solution for a scenario. In particular, regional resource allocation and production levels are summarized into categories of effects such as regional yield, resource endowment, and technological change, that can be modeled as shocks into GHANACGE. The changes on regional yield, resource endowment, and technology are then used to adjust the exogenous values within GHANACGE. Subsequently the equilibrium price levels that are obtained after solving GHANACGE are introduced back into SADAFPM and SADAFPM is solved to determine a revised set of regional agricultural activities. This procedure is repeated in an iterative fashion until convergent results are obtained.

Colombo (2010) conducted an experiment on comparing the performance of this iteration with a method integrating the micro-simulation directly into the CGE model. His results show that the integrating method tends to overestimate the effects of the shock on income inequality and poverty levels. The conceptual simulation framework is presented in Figure 7.

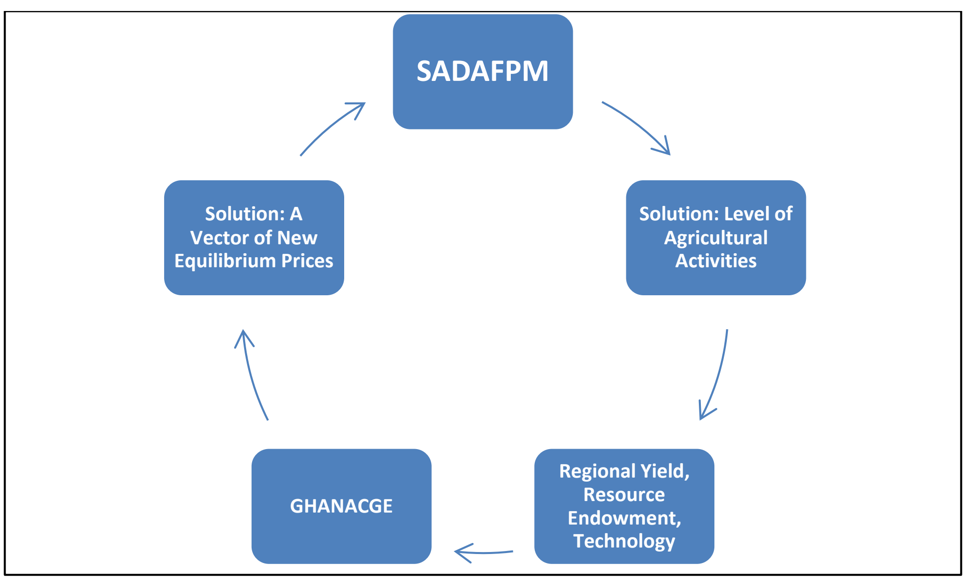

Figure 7. Conceptual Framework for Linking SADAFPM to CGE

Examining SADA Effects on Ghana Economy and the Feedback Effects

The SADA region is considered a major food production area of Ghana and modernization is expected to not only improve incomes and resource management, but also to generate spillover effects across the whole country. This chapter focuses on simulation of the effects of input subsidies, agricultural extension expansion, irrigation capacity, and the guinea fowl program using the linked SADAFPM and GHANACGE. The following sections apply the interactive method to simulate SADA impacts. Part of the simulation outcome generated by SADAFPM are drawn from the previous chapter where regional scenarios were considered.

Impacts of SADA Fertilizer Subsidy

The previous chapter has simulated input subsidy impact within the SADA region, with individual input subsidy and a combined subsidy plan. The results showed that input subsidy in SADA creates positive net regional agricultural income. In this chapter, we study the economy-wide impact of SADA fertilizer subsidy with a 50 percent reduction in fertilizer price. This assumption on cost reduction is made to be consistent with Ghana government's initial objective (FAO 2015). To reflect the policy influence in the SADA region, we disaggregate the fertilizer commodity in the SAM between the SADA region and the rest of the country based on the use of fertilizer in crop activities.

The results for the new equilibrium commodity quantity levels are shown in Table 21. Fertilizer use increases with the largest increases by intensive crops such as maize, rice, sorghum, and groundnuts. Additionally, we see a positive impact on domestic output. Rice output increases the most. Most of the crops that generally do not use fertilizer such as cassava, soybean, and cowpea show reduced quantities. Non-SADA region crops also show reduced quantities. Exported fruits and cocoa are fertilizer intensive crops which mainly grow in the south, they show negative impact in output.

The industry and service sectors show much smaller impact but mainly negative impacts. Commodity import impacts are shown in Table 22. Rice imports decrease by 2.9 percent due to large increase in domestic production. Fertilizer imports increase by 14.39 percent under the impact of the SADA fertilizer subsidy.

The income effects for each agro-ecological zone and type of household are shown in Table 23. The SADA region Savannah rural households shows a 0.85 percent gain in household income. Income changes on households in the other agro-ecological zones are all below 0.1 percent. These results suggest that rural households in the SADA region benefit the most under the fertilizer subsidy. Therefore, we observe a diminishing income gap between the SADA region and the rest of the economy.

The new equilibrium commodity and primary input price levels are shown in Table 24 and Table 25. Rice, shows 2.39 percent of drop in price due to higher output levels. Other less fertilizer use intensive crops such as maize and sorghum show slight decreases in prices. Most of the low fertilizer using crops such as cassava, cowpea, and soybean show slight increases in prices due to their reductions in output. Prices of industry and service goods do not show strong impact all showing less than a 0.05 percent change.

Self-employed labor and land prices in Savannah north increase by 1.32 and 1.35 percent. This reflects the more intensive primary input use as a result of the SADA fertilizer subsidy.

The total absorption, which is the total demand for all final marketed goods and services by all economic agents reside in an economy (Deardorff 2006), increases by 0.05 percent. The result suggests a slight gain in social welfare under the SADA fertilizer subsidy which is totally supported by government tax revenue. A discussion on social welfare and total absorption can be found in Arndt, Pauw, and Thurlow (2015).

The changes on commodity prices, together with major input prices such as labor, maize as feed, and transportation are passed on to SADAFPM proportionally to generate new regional crop and guinea fowl activities. The feedback results are shown in Table 26. Only maize and groundnut activities show monthly adjustments, and the other crop activities and guinea fowl activity remain the same as those without feedback effect. Because of the changes in crop activities, labor allocation adjusts accordingly. The monthly hired labor arrangement is shown in Table 27. Hired labor adjusts during majority of the wet months except for July. While there is no hired labor adjustment during dry season. As a result, the expected regional agricultural profit is 0.15 percent less than it was without feedback effect. The relatively small effect can be expected because fertilizer subsidy in the SADA region only accounts for a very small portion of the government sales tax revenue. However, it can be concluded that without considering feedback effect, the regional SADAFPM tends to overestimate the impact of the fertilizer subsidy.

Table 21. Economy Wide Output Impact from SADA Fertilizer Subsidy

Quantity of Aggregate Production Output	Base	After Shock	% Change
Maize	390.38	392.28	0.49
Rice	169.27	185.29	9.47
Sorghum	75.10	75.74	0.85
Cassava	716.18	715.27	-0.13
Yam	769.31	769.27	0.00
Cocoyam	192.55	192.58	0.02
Cowpea	69.33	69.13	-0.28
Soybean	13.28	13.25	-0.19
Palm Oil	125.86	125.59	-0.21
Groundnut	123.45	123.83	0.31
Tree nut	55.48	55.28	-0.36
Fruit (Domestic)	120.23	119.99	-0.20
Fruit (Export)	49.11	48.56	-1.12
Vegetable (Domestic)	649.32	649.19	-0.02
Vegetable (Export)	20.99	20.97	-0.09
Plantain	439.99	439.91	-0.02
Cocoa	1344.38	1336.14	-0.61
Other Crops	28.35	28.69	1.21
Export Industrial Crops	36.45	37.81	3.73
Fish	344.55	344.65	0.03
Cocoa Processing	192.43	191.59	-0.44
Mining	1513.15	1509.86	-0.22
Food	2610.81	2607.31	-0.13
Meat and Fish Processing	953.39	953.45	0.01
Meat and Fish Processing 2	1127.51	1126.98	-0.05
Fuel	954.29	954.77	0.05
Construction	1919.24	1918.68	-0.03
Water	107.08	107.02	-0.05
Electricity	1008.70	1008.60	-0.01
Trade and Transport Service	4062.45	4065.27	0.07
Other Service	2246.84	2244.55	-0.10
Government	2537.97	2538.39	0.02

Table 22. Commodity Imports under SADA Fertilizer Subsidy

Commodity	Base	After	% Change
Maize	70.18	69.89	-0.41
Rice	394.72	383.28	-2.90
Other grain	10.60	10.61	0.04
Other crops	12.65	12.55	-0.79
Sugar processing	64.92	65.03	0.18
Food	1282.84	1284.77	0.15
Light manufacture goods	720.67	721.32	0.09
Heavy manufacture goods	4758.63	4756.89	-0.04
Heavy manufacture goods (SADA)	36.97	37.43	1.23
Fertilizer (SADA)	19.50	22.30	14.39
Fuel	1186.58	1187.43	0.07
Other service	418.59	418.98	0.09

Table 23. Regional Income Effects from SADA Fertilizer Subsidy

Region	Base (Mil. *cedis*)	After Shock	% Change
Accra	5043.69	5044.35	0.01
Coast Urban	938.08	938.37	0.03
Forest Urban	1558.68	1559.08	0.03
Savannah South Urban	1481.19	1481.67	0.03
Savannah North Urban	293.63	293.72	0.03
Coast Rural	875.39	875.29	-0.01
Forest Rural	2767.74	2766.96	-0.03
Savannah South Rural	2516.99	2518.76	0.07
Savannah North Rural	845.90	853.10	0.85

Table 24. Equilibrium Commodity Prices with SADA Fertilizer Subsidy

Commodity	Base	After Shock	% Change
Maize	1	0.9953	-0.47
Rice	1	0.9761	-2.39
Sorghum	1	0.9942	-0.58
Cassava	1	1.0022	0.22
Yam	1	1.0017	0.17
Cocoyam	1	0.9999	-0.01
Cowpea	1	1.0065	0.65
Soybean	1	1.0043	0.43
Palm oil	1	1.0035	0.35
Groundnut	1	1.0004	0.04
Oil nut	1	1.0054	0.54
Domestic fruit	1	1.0047	0.47
Export fruit	1	1.0009	0.09
Domestic vegetable	1	1.0018	0.18
Export vegetable	1	0.9998	-0.02
Plantain	1	1.0004	0.04
Cocoa	1	0.9999	-0.01
Other domestic crop	1	0.9898	-1.02
Other export crop	1	0.9948	-0.52
Fish	1	1.0004	0.04
Cocoa processing	1	1.0002	0.02
Mining	1	0.9998	-0.02
Food	1	1.0006	0.06
Light manufacture	1	1.0000	0.00
Heavy manufacture	1	1.0000	0.00
Fuel	1	0.9999	-0.01
Construction	1	1.0001	0.01
Water	1	1.0003	0.03
Electricity	1	0.9998	-0.02
Trade and transport	1	1.0001	0.01
Other service	1	1.0001	0.01
Government	1	1.0001	0.01

Table 25. Equilibrium Primary Input Prices with SADA Fertilizer Subsidy

Primary input	Base	Level	% Change
Labor self-employed coast	1.00	1.0017	0.17
Labor self-employed forest	1.00	1.0006	0.06
Labor self-employed savannah south	1.00	1.0006	0.06
Labor self-employed savannah north	1.00	1.0132	1.32
Labor skilled	1.00	0.9999	-0.01
Labor unskilled	1.00	1.0007	0.07
Capital agriculture	0.20	0.2008	0.38
Capital non-agriculture	0.20	0.1999	-0.06
Capital service	0.20	0.1999	-0.06
Land coast	1.00	0.9991	-0.09
Land forest	1.00	0.9990	-0.10
Land savannah south	1.00	1.0001	0.01
Land savannah north	1.00	1.0135	1.35

Table 26. SADA Feedback Effect on Crop and Guinea Fowl Activities (Production per Household)

Crop (Acre)	Month	Before	Feedback
Cassava	July	1.45	1.45
Yam	January	0.68	0.68
	February	0.69	0.69
	March	0.69	0.69
Maize	May	3.74	0.49
	June	3.25	
Rice	June	0.50	0.50
	July	0.94	0.94
Millet	September	2.36	2.36
Sorghum	July	3.01	3.01
Groundnut	may	1.66	4.91
	June	3.83	0.58
Cowpea	April	0.67	0.67
Soybean	June	1.07	1.07
Tomato	January	0.05	0.05
	April	0.05	0.05
	July	0.05	0.05
	October	0.01	0.01
Guinea fowl (50 keets)		11.08	11.08

Table 27. SADA Feedback Effect on Hired Labor (man day)

Month	Before	Feedback	% Change
May	15.63	34.32	119.60
June	41.17	22.48	-45.40
July	118.38	118.38	0
August	29.27	36.75	25.55
September	128.29	165.68	29.14
October	157.00	112.14	-28.58
November	32.68	32.68	0
December	72.24	72.24	0

Impacts of SADA Agricultural Extension

SADA plans to enhance agricultural extension initiatives as a means of modernizing SADA regional agriculture. Extension personnel assist farmers in using the right inputs in a timely manner, educating on and enhancing adoption of new technologies, and otherwise improving management to increase crop yields. These firms also help improve market function for a variety of commodities, connecting farmers to consumers in both domestic and external markets. (SADA 2011b).

Previously, we simulated different levels of achievable yields and the impacts on expected regional income as well as labor arrangement. In our simulations at the farm level, we did not include considerations of extension personnel availability and balance among regions. In this chapter, we further incorporate these market elements to assess economy-wide impacts.

Agricultural extension agents are government employees. MOFA had a goal of at least one agricultural extension agent for every 100 farmers, although in reality it falls far short. Ghana reports that there were 1,244 extension staff in 2011 (Global Forum for Rural Advisory Service 2016). However, the SADA plan (SADA 2011b) does not specify any human resource or fund allocation for the expansions in the extension service in the SADA region. Based on the fact, we assume expanded extension activity in the SADA region would reallocate extension personnel from other regions in the country. Specifically, we consider the migration of extension agents as a shock in the factor augmenting technical change parameter of the CES production function of the value-added composite.

For our analysis, we simulate two scenarios. First a positive shock of 10 percent for the Savannah north with a negative shock of 3.33 percent for the other three agro-ecological regions (Scenario A1) and second a 20 percent positive shock for the Savannah north with 6.67 percent for the other regions (Scenario A2). With a medium-run perspective, we assume a 30 percent increase in the crop yields under extension service. We shock the yield parameter of the linear production function of crop activity by 30 percent for the non-irrigated crops that also appear in the GHANAFPM. The change represents productivity growth in both intermediate inputs and primary inputs in the SADA crop sectors.

Results for the new equilibrium commodity quantity levels are shown in Table 28. In both scenarios A1 and A2, the north (SADA) dominant crops rice, sorghum, groundnut, and cowpea show strong increases in total production. While the south dominant maize and vegetable show relatively smaller positive impacts.

The commodity imports are shown in Table 29. Rice imports have always been a concern of Ghana since it accounts for 58 percent of cereal imports (Osei-Asare 2010). In both scenarios, we find rice imports decrease by more than one percent. However, imports of other crops are increased by over nine percent which offsets foreign reserve savings from rice.

Fertilizer imports are also increased by more than eight percent in both scenarios. Imports of other intermediate inputs such as metal, machinery, trade and transport service also increase.

The income effects for each agro-ecological zone and type of household are shown in Table 30. The Savannah north receives more than a 11 percent increase in income in both scenarios. There are positive impacts among all other zones as well, but the impacts are much smaller than those in the Savannah north. Therefore, a diminishing gap in income between the SADA and the rest of the economy is found.

The new equilibrium commodity and primary input price levels are shown in Table 31 and Table 32. Prices of SADA crops drop most compared with other crops because of the increase in output. Wages of self-employed labor, as well as rent of non-irrigated land of the Savannah north increase due to the production expansion. The total absorption of the economy increases by 1.67 percent in both scenarios. The result suggests a weak nominal gain in social welfare.

Results were also obtained from SADAFPM. There the changes in commodity prices, together with major input prices such as labor, maize as feed, and transportation are passed on to SADAFPM. Since results from scenario A1 and A2 are very close, we only report the effects under scenario A1. The scenario results compared to the base model solution are shown in Table 33. Only maize activity show monthly adjustments while the other crop and guinea fowl activities remain the same. Because of the change in crop activities, labor allocations adjust accordingly. The monthly hired labor is shown in Table 34. Hired labor shows adjustment across the wet season except for July. As a result, the expected regional agricultural profit is 12.60 percent more than it was without feedback effect. Based on the results, we find that without considering feedback effect, the regional SADAFPM tends to underestimate the impact of agricultural extension.

Table 28. Economy Wide Output Impact from SADA Agricultural Extension

Quantity of Aggregate Production Output	Base	A1	% Change	A2	% Change
Maize	391.37	412.98	5.52	413.21	5.58
Rice	171.21	194.58	13.65	195.00	13.90
Sorghum	75.26	91.02	20.95	91.22	21.21
Cassava	718.57	738.35	2.75	737.98	2.70
Yam	771.49	808.19	4.76	808.24	4.76
Cocoyam	192.54	193.45	0.47	193.45	0.47
Cowpea	69.67	77.57	11.35	77.68	11.49
Soybean	13.32	13.73	3.12	13.74	3.18
Palm oil	126.49	124.02	-1.96	123.99	-1.97
Groundnut	125.02	150.90	20.70	151.17	20.92
Oil nut	55.84	53.88	-3.50	53.86	-3.54
Domestic fruit	120.45	119.31	-0.95	119.29	-0.96
Export fruit	49.12	46.56	-5.21	46.54	-5.26
Domestic vegetable	649.22	653.67	0.69	653.73	0.69
Export vegetable	20.99	21.38	1.83	21.38	1.84
Plantain	440.30	439.52	-0.18	439.51	-0.18
Cocoa	1350.72	1527.61	13.10	1529.15	13.21
Other crop	28.39	27.91	-1.72	27.90	-1.73
Other export crop	36.53	36.11	-1.15	36.11	-1.16
Chicken	5.17	5.28	2.05	5.28	2.06

Table 28 Continued

Quantity of Aggregate Production Output	Base	A1	% Change	A2	% Change
Egg	155.59	160.30	3.03	160.33	3.05
Beef	125.56	125.65	0.07	125.64	0.07
Goat	97.12	97.54	0.44	97.54	0.44
Other livestock	181.47	183.06	0.88	183.07	0.88
Forestry	783.36	744.86	-4.91	744.55	-4.95
Fishery	345.16	347.22	0.60	347.23	0.60
Gold mining	1425.95	1391.99	-2.38	1391.79	-2.39
Other mining	96.59	97.05	0.48	97.06	0.48
Formal food processing	151.38	157.45	4.01	157.49	4.03
Local food processing	492.47	503.89	2.32	503.89	2.32
Cocoa processing	192.48	214.83	11.61	215.00	11.70
Dairy	105.48	106.51	0.98	106.52	0.99
Meat	518.53	517.29	-0.24	517.24	-0.25
Textile	74.55	73.35	-1.61	73.34	-1.62
Clothing	145.33	145.89	0.39	145.89	0.39
Footwear	122.44	123.05	0.50	123.05	0.50
Wood	546.03	524.38	-3.96	524.20	-4.00
Paper	67.21	66.87	-0.51	66.86	-0.52
Petroleum	497.64	497.79	0.03	497.81	0.03
Diesel	443.15	442.09	-0.24	442.09	-0.24
Fuel	13.51	13.57	0.46	13.57	0.47
Chemical	264.20	263.58	-0.23	263.57	-0.24
Rubber	30.82	29.66	-3.76	29.66	-3.78
Non-metal	226.98	226.38	-0.27	226.37	-0.27
Metal	482.12	482.08	-0.01	482.09	-0.01
Non-electric machinery	13.79	13.72	-0.45	13.72	-0.45
Electric machinery	12.71	12.63	-0.68	12.63	-0.68
Television	2.66	2.66	-0.14	2.66	-0.14
Medical equipment	0.48	0.48	-0.15	0.48	-0.15
Vehicle parts	1.92	1.91	-0.68	1.91	-0.69
Transport equipment	0.47	0.48	0.52	0.48	0.53
Other manufacture goods	94.69	94.55	-0.15	94.56	-0.14
Construction	1923.08	1935.98	0.67	1936.06	0.67
Water	107.00	105.80	-1.12	105.78	-1.14
Electricity	1008.15	1006.96	-0.12	1006.93	-0.12
Trade	1998.63	1984.99	-0.68	1984.97	-0.68
Other service	1369.13	1334.77	-2.51	1334.26	-2.55
Transport Service	1703.09	1695.64	-0.44	1695.66	-0.44
Communication	360.68	360.67	0.00	360.66	-0.01

Table 28 Continued

Quantity of Aggregate Production Output	Base	A1	% Change	A2	% Change
Business	279.55	275.93	-1.30	275.88	-1.31
Real estate	616.73	619.39	0.43	619.39	0.43
Community Service	906.86	912.19	0.59	912.21	0.59
Administration	1169.78	1169.79	0.00	1169.79	0.00
Education	330.09	330.09	0.00	330.09	0.00
Health	120.21	120.55	0.28	120.55	0.28

Table 29. Commodity Imports under SADA Agricultural Extension

Crop	Base	A1	% Change	A2	% Change
Maize	69.19	68.35	-1.21	68.34	-1.22
Rice	391.65	385.45	-1.58	385.31	-1.62
Sorghum	10.60	10.74	1.34	10.75	1.35
Other crop	12.61	13.81	9.50	13.82	9.59
Chicken	106.73	107.39	0.61	107.38	0.61
Egg	35.23	35.04	-0.54	35.03	-0.55
Beef	61.50	62.36	1.41	62.36	1.41
Goat	13.41	13.65	1.82	13.66	1.84
Other livestock	39.45	39.95	1.26	39.95	1.27
Formal food processing	670.81	674.93	0.61	674.94	0.62
Sugar processing	64.84	66.23	2.15	66.25	2.17
Diary	21.90	22.18	1.30	22.18	1.30
Meat	300.90	303.38	0.82	303.38	0.83
Textile	157.96	159.83	1.19	159.84	1.19
Clothing	391.67	396.18	1.15	396.20	1.16
Footwear	113.90	115.17	1.11	115.18	1.12
Paper	50.59	50.96	0.72	50.96	0.72
Oil	726.70	726.03	-0.09	726.05	-0.09
Fuel	396.90	400.40	0.88	400.43	0.89
Fertilizer	205.16	221.92	8.17	222.12	8.27
Other Chemicals	540.44	543.45	0.56	543.47	0.56
Rubber	29.95	29.74	-0.69	29.74	-0.70
Non-metal	226.79	228.49	0.75	228.50	0.75
Metal	428.56	430.74	0.51	430.76	0.51
Machinery	713.75	716.60	0.40	716.64	0.40
Electronic machinery	582.45	583.64	0.20	583.65	0.21
Television	388.40	390.92	0.65	390.94	0.65

Table 29 Continued

Crop	Base	A1	% Change	A2	% Change
Medical equipment	157.02	157.75	0.46	157.75	0.47
Vehicle	881.69	885.70	0.45	885.72	0.46
Vehicle parts	282.92	284.61	0.60	284.62	0.60
Transport equipment	573.13	579.66	1.14	579.72	1.15
Other manufacture	151.32	155.67	2.87	155.72	2.91
Other service	415.03	419.04	0.97	419.07	0.97

Table 30. Regional Income Effects from SADA Agricultural Extension

Region	Base (Mil. *cedis*)	A1	% Change	A2	% Change
Accra	5034.92	5089.35	1.08	5089.42	1.08
Coast Urban	936.75	946.85	1.08	946.87	1.08
Forest Urban	1557.25	1575.27	1.16	1575.30	1.16
Savannah South Urban	1479.11	1496.24	1.16	1496.272	1.16
Savannah North Urban	326.57	330.51	1.21	330.52	1.21
Coast Rural	853.73	857.00	0.38	856.95	0.38
Forest Rural	2787.49	2814.36	0.96	2814.43	0.97
Savannah South Rural	2280.76	2284.58	0.17	2284.33	0.16
Savannah North Rural	1117.43	1241.64	11.12	1242.80	11.22

Table 31. Equilibrium Commodity Prices with SADA Agricultural Extension

Commodity	Base	A1	% Change	A2	% Change
Maize	1.00	0.9657	-3.43	0.9653	-3.47
Rice	1.00	0.9168	-8.32	0.9153	-8.47
Sorghum	1.00	0.8743	-12.57	0.8728	-12.72
Cassava	1.00	0.9500	-5.00	0.9508	-4.92
Yam	1.00	0.9187	-8.13	0.9188	-8.12
Cocoyam	1.00	1.0112	1.12	1.0113	1.13
Cowpea	1.00	0.8758	-12.42	0.8743	-12.57
Soybean	1.00	0.8423	-15.77	0.8411	-15.89
Palm oil	1.00	1.0491	4.91	1.0494	4.94
Groundnut	1.00	0.8487	-15.13	0.8474	-15.26
Oil nut	1.00	1.0721	7.21	1.0727	7.27
Domestic fruit	1.00	1.0629	6.29	1.0633	6.33
Export fruit	1.00	1.0160	1.60	1.0161	1.61

Table 31 Continued

Commodity	Base	A1	% Change	A2	% Change
Domestic vegetable	1.00	1.0239	2.39	1.0239	2.39
Export vegetable	1.00	1.0022	0.22	1.0022	0.22
Plantain	1.00	1.0137	1.37	1.0137	1.37
Coco	1.00	1.0083	0.83	1.0083	0.83
Other crop	1.00	1.0599	5.99	1.0604	6.04
Other export crop	1.00	1.0085	0.85	1.0085	0.85
Chicken	1.00	0.9914	-0.86	0.9912	-0.88
Egg	1.00	0.9931	-0.69	0.9930	-0.70
Beef	1.00	1.0152	1.52	1.0153	1.53
Goat	1.00	1.0155	1.55	1.0155	1.55
Other livestock	1.00	1.0109	1.09	1.0109	1.09
Forestry	1.00	1.0109	1.09	1.0109	1.09
Fish	1.00	1.0121	1.21	1.0121	1.21
Gold mining	1.00	1.0091	0.91	1.0091	0.91
Other mining	1.00	1.0092	0.92	1.0092	0.92
Formal food processing	1.00	0.9958	-0.42	0.9957	-0.43
Local food processing	1.00	0.9848	-1.52	0.9850	-1.50
Coco processing	1.00	1.0035	0.35	1.0035	0.35
Dairy	1.00	1.0104	1.04	1.0104	1.04
Meat	1.00	1.0116	1.16	1.0116	1.16
Textile	1.00	1.0176	1.76	1.0177	1.77
Clothes	1.00	1.0121	1.21	1.0121	1.21
Footwear	1.00	1.0115	1.15	1.0115	1.15
Wood	1.00	1.0136	1.36	1.0136	1.36
Paper	1.00	1.0112	1.12	1.0112	1.12
Petroleum	1.00	1.0096	0.96	1.0096	0.96
Diesel	1.00	1.0096	0.96	1.0096	0.96
Fuel	1.00	1.0095	0.95	1.0095	0.95
Chemical	1.00	1.0103	1.03	1.0103	1.03
Rubber	1.00	1.0105	1.05	1.0105	1.05
Non-metal	1.00	1.0105	1.05	1.0105	1.05
Metal	1.00	1.0100	1.00	1.0100	1.00
Non-electric machinery	1.00	1.0102	1.02	1.0103	1.03
Electric machinery	1.00	1.0103	1.03	1.0103	1.03
Television	1.00	1.0102	1.02	1.0102	1.02
Medical equipment	1.00	1.0099	0.99	1.0099	0.99
Vehicle parts	1.00	1.0108	1.08	1.0108	1.08
Transport equipment	1.00	1.0099	0.99	1.0099	0.99
Other manufacture	1.00	1.0131	1.31	1.0131	1.31
Construction	1.00	1.0110	1.10	1.0110	1.10

Table 31 Continued

Commodity	Base	A1	% Change	A2	% Change
Water	1.00	1.0101	1.01	1.0101	1.01
Electricity	1.00	1.0095	0.95	1.0095	0.95
Trade	1.00	1.0118	1.18	1.0118	1.18
Other service	1.00	1.0102	1.02	1.0102	1.02
Transport Service	1.00	1.0103	1.03	1.0103	1.03
Communication	1.00	1.0105	1.05	1.0105	1.05
Business	1.00	1.0105	1.05	1.0105	1.05
Real estate	1.00	1.0105	1.05	1.0105	1.05
Community Service	1.00	1.0121	1.21	1.0121	1.21
Administration	1.00	1.0120	1.20	1.0120	1.20
Education	1.00	1.0119	1.19	1.0120	1.20
Health	1.00	1.0121	1.21	1.0121	1.21

Table 32. Equilibrium Primary Input Prices with SADA Agricultural Extension

Primary input	Base	A1	% Change	A2	% Change
Labor self-employed coast	1.00	1.0481	4.81	1.0484	4.84
Labor self-employed forest	1.00	1.0125	1.25	1.0126	1.26
Labor self-employed savannah south	1.00	0.9914	-0.86	0.9911	-0.89
Labor self-employed savannah north	1.00	1.1881	18.81	1.1899	18.99
Labor skilled	1.00	1.0143	1.43	1.0143	1.43
Labor unskilled	1.00	1.0146	1.46	1.0147	1.47
Capital agriculture	0.20	0.2003	0.17	0.2003	0.16
Capital non-agriculture	0.20	0.2012	0.61	0.2012	0.60
Capital service	0.20	0.2007	0.34	0.2007	0.34
Land coast	1.00	0.9850	-1.50	0.9848	-1.52
Land forest	1.00	1.0132	1.32	1.0133	1.33
Land savannah south	1.00	0.9919	-0.81	0.9916	-0.84
Land savannah north non-irrigated	1.00	1.1995	19.95	1.2014	20.14
Land savannah north irrigated	1.00	1.0234	2.34	1.0234	2.34

Table 33. SADA Feedback Effect on Crop and Guinea Fowl Activities (Production per Household)

Crop (Acre)	Month	Before	Feedback
Cassava	July	1.449	1.449
Yam	January	0.680	0.680
	February	0.693	0.693
	March	0.685	0.685
Maize	May	3.739	
	June		3.739
Rice	June	0.496	0.496
	July	0.938	0.938
Millet	September	2.363	2.363
Sorghum	July	3.013	3.013
Groundnut	May	1.661	5.400
	June	3.831	0.092
Cowpea	April	0.665	0.665
Soybean	June	1.073	1.073
Tomato	January	0.054	0.054
	April	0.054	0.054
	July	0.054	0.054
	October	0.012	0.012
Guinea fowl (50 keets)		11.077	11.077

Table 34. SADA Feedback Effect on Hired Labor (man day)

Month	Before	Feedback	% Change
May	15.63	34.32	119.60
June	41.17	22.48	-45.40
July	118.38	118.38	0.00
August	29.27	36.75	25.55
September	128.29	165.68	29.14
October	157.00	112.14	-28.58
November	32.68	32.68	0.00
December	72.24	72.24	0.00

Impacts of SADA Guinea Fowl Program

This section discusses economy-wide impacts of the guinea fowl program assuming full program participation rate among fowl growers. As discussed before, the government estimates providing grower birds to smallholders can increase the survival rates and reduce the cost of vaccination and feed by 90 percent and 54 percent. The crop and guinea fowl activities before and after participation in the guinea fowl program are shown in Table 35. The focus is on the impact of total production from the region even though there are slight monthly differences in activities. The results of the simulation show that guinea fowl activity is increased by 117.88 percent.

Table 35. Impact of Guinea Fowl Program on Crop and Guinea Fowl Activity (Production per Household)

Crop activity (Acre)	Month	Base	After
Cassava	June		1.42
	July	1.41	
Yam	January		
	February		2.20
	December	2.20	
Maize	May	4.21	2.45
	June		1.77
Rice	June		1.08
	July	2.14	1.07
Millet	August	2.30	2.30
	September		
Sorghum	July	3.29	3.29
Groundnut	May	4.02	2.95
	June		1.08
Cowpea	Apr		0.69
	May		
	June	0.69	

Table 35 Continued

Crop activity (Acre)	Month	Base	After
Soybean	June		0.05
	July	1.09	1.04
Tomato	January	0.04	
	April	0.04	
	July	0.04	
	October	0.04	0.16
Guinea fowl (50 keets)		20.53	44.74

We introduce the production shock to GHANACGE, which is captured as an expansion in the poultry sector in the Savannah north agro-ecological zone. We shock the yield parameter of the linear production function of the poultry activity from 1 to 2.18 based on the results from SADAFPM. The change represents productivity growth in both intermediate inputs and primary inputs in the northern chicken sector.

GHANACGE then solves new equilibrium commodity quantity levels shown in Table 36. There are few impacts on almost all sectors except for chicken itself. All of the other commodities have less than 1 percent of change compared with the base. This is as expected because poultry accounts for a very small share of GDP in Ghana. We find that chicken imports do not decrease as Ghana's wish to save foreign exchange reserves, and the import amount slightly increased by 0.18 percent. This is because all types of households increase chicken consumption at the same time, which is shown in Table 37. Results suggest that domestic poultry production has a huge gap and the northern guinea fowl promotion may not straight reduce the country's chicken import.

The income effects for each agro-ecological zone and type of household are shown in Table 38. The income effects are large. The total absorption increases by 1.2 percent, which suggests a nominal gain in social welfare. From the above results, a small diminishing income gap is found between the SADA and the rest of the economy.

The new equilibrium commodity and primary input price levels are shown in Table 39 and Table 40. Except for chicken price reducing by 10.99 percent, impacts on other commodities are small. This result is expected due to expansion in chicken supply. Primary input prices do not change either. Among all, northern self-employed labor increased most by 0.17 percent. This is consistent with the fact that unskilled labor is extensively used in agriculture, and certainly northern fowl expansion calls for more unskilled labor.

The changes on commodity prices, together with major input prices such as labor, maize as feed, and transportation are passed on to SADAFPM proportionally to generate new regional optimum. The feedback results for crop and guinea fowl activities generated by SADAFPM are shown in Table 41. The crop activities of yam, rice, cassava, millet, groundnut, soybean and tomato show monthly adjustments while the other crop activities remain the same. Because of the change in crop activities, labor allocation needs to adjust accordingly as well. The monthly hired labor is shown in Table 42. Hired labor shows adjustment in both dry and wet seasons. As a result, the expected regional agricultural profit is 11.24 percent less than it was without feedback effect. While comparing with the base scenario, the guinea fowl program still leads to 18.28 percent of growth in the regional expected agricultural income. It can be concluded that without considering feedback effect, the regional SADAFPM tends to overestimate the impact of the guinea fowl program.

Table 36. Economy Wide Output Impact from Northern Guinea Fowl Program

Quantity of Aggregate Production Output	Base	After Shock	% Change
Maize	391.37	391.35	-0.004
Rice	171.21	171.21	0.003
Sorghum	75.26	75.26	-0.001
Cassava	718.57	718.58	0.000
Yam	771.49	771.49	0.001
Cocoyam	192.54	192.54	0.001
Cowpea	69.67	69.67	-0.001
Soybean	13.32	13.31	-0.043
Palm oil	126.49	126.49	-0.002
Groundnut	125.02	125.02	-0.003
Oil nut	55.84	55.83	-0.003
Domestic fruit	120.45	120.46	0.013
Export fruit	49.12	49.18	0.112
Domestic vegetable	649.22	649.23	0.002
Export vegetable	20.99	21.03	0.148
Plantain	440.30	440.30	-0.002
Cocoa	1350.72	1350.59	-0.009
Other crop	28.39	28.39	-0.009
Other export crop	36.53	36.52	-0.032
Chicken	5.17	5.69	9.964
Egg	155.59	155.60	0.007
Beef	125.56	125.55	-0.004
Goat	97.12	97.12	0.000
Other livestock	181.47	181.46	-0.003
Forestry	783.36	782.90	-0.058
Fishery	345.16	345.17	0.003
Gold mining	1425.95	1424.58	-0.096
Other mining	96.59	96.62	0.030
Formal food processing	151.38	151.38	-0.002
Local food processing	492.47	492.51	0.009
Cocoa processing	192.48	192.47	-0.004
Dairy	105.48	105.49	0.011

Table 36 Continued

Quantity of Aggregate Production Output	Base	After Shock	% Change
Meat	518.53	518.49	-0.009
Textile	74.55	74.54	-0.020
Clothing	145.33	145.31	-0.011
Footwear	122.44	122.43	-0.008
Wood	546.03	545.75	-0.051
Paper	67.21	67.20	-0.007
Petroleum	497.64	497.76	0.023
Diesel	443.15	443.19	0.009
Fuel	13.51	13.51	-0.010
Chemical	264.20	264.14	-0.020
Rubber	30.82	30.79	-0.104
Non-metal	226.98	227.00	0.007
Metal	482.12	482.12	-0.001
Non-electric machinery	13.79	13.79	-0.006
Electric machinery	12.71	12.71	-0.015
Television	2.66	2.66	0.008
Medical equipment	0.48	0.48	0.014
Vehicle parts	1.92	1.92	-0.022
Transport equipment	0.47	0.47	0.015
Other manufacture goods	94.69	94.67	-0.020
Construction	1923.08	1923.76	0.035
Water	107.00	107.00	0.003
Electricity	1008.15	1008.07	-0.008
Trade	1998.63	1999.43	0.040
Other service	1369.13	1371.33	0.161
Transport Service	1703.09	1703.55	0.027
Communication	360.68	360.71	0.008
Business	279.55	279.71	0.056
Real estate	616.73	616.74	0.003
Community Service	906.86	906.83	-0.004
Administration	1169.78	1169.78	0.000
Education	330.09	330.09	0.000
Health	120.21	120.21	-0.002

Table 37. Impact of Guinea Fowl Program on Household Chicken Consumption

Household Type	Base	After	%Change
Accra	21.18	21.31	0.61
Coast urban	5.01	5.04	0.64
Forest urban	9.16	9.23	0.67
Savannah south urban	13.04	13.14	0.73
Savannah north urban	0.42	0.43	0.81
Coast rural	5.63	5.67	0.84
Forest rural	9.74	9.82	0.85
Savannah south rural	18.04	18.18	0.81
Savannah north rural	5.22	5.27	0.85

Table 38. Regional Income Effects from Northern Guinea Fowl Program

Region	Base (Mil. *cedis*)	After Shock	% Change
Accra	5034.92	5035.24	0.006
Coast Urban	936.75	936.83	0.008
Forest Urban	1557.25	1557.37	0.008
Savannah South Urban	1479.11	1479.24	0.008
Savannah North Urban	326.57	326.60	0.009
Coast Rural	853.73	853.75	0.003
Forest Rural	2787.49	2787.45	-0.002
Savannah South Rural	2280.76	2280.80	0.002
Savannah North Rural	1117.43	1117.48	0.005

Table 39. Equilibrium Commodity Prices with Northern Guinea Fowl Program

Commodity	Base	After Shock	% Change
Maize	1.00	1.000034	0.00
Rice	1.00	1.000033	0.00
Sorghum	1.00	1.000051	0.01
Cassava	1.00	1.000030	0.00
Yam	1.00	1.000029	0.00
Cocoyam	1.00	1.000021	0.00
Cowpea	1.00	1.000041	0.00
Soybean	1.00	1.000056	0.01
Palm oil	1.00	1.000028	0.00
Groundnut	1.00	1.000057	0.01
Oil nut	1.00	1.000028	0.00

Table 39 Continued

Commodity	Base	After Shock	% Change
Domestic fruit	1.00	1.000020	0.00
Export fruit	1.00	1.000028	0.00
Domestic vegetable	1.00	1.000031	0.00
Export vegetable	1.00	1.000040	0.00
Plantain	1.00	1.000035	0.00
Coco	1.00	1.000024	0.00
Other crop	1.00	1.000039	0.00
Other export crop	1.00	1.000036	0.00
Chicken	1.00	0.890066	-10.99
Egg	1.00	1.000045	0.00
Beef	1.00	1.000106	0.01
Goat	1.00	1.000080	0.01
Other livestock	1.00	1.000074	0.01
Forestry	1.00	1.000034	0.00
Fish	1.00	1.000069	0.01
Gold mining	1.00	1.000020	0.00
Other mining	1.00	1.000020	0.00
Formal food processing	1.00	1.000064	0.01
Local food processing	1.00	1.000058	0.01
Coco processing	1.00	1.000049	0.00
Dairy	1.00	1.000066	0.01
Meat	1.00	1.000072	0.01
Textile	1.00	1.000069	0.01
Clothes	1.00	1.000078	0.01
Footwear	1.00	1.000070	0.01
Wood	1.00	1.000077	0.01
Paper	1.00	1.000061	0.01
Petroleum	1.00	1.000030	0.00
Diesel	1.00	1.000030	0.00
Fuel	1.00	1.000029	0.00
Chemical	1.00	1.000044	0.00
Rubber	1.00	1.000046	0.00
Non-metal	1.00	1.000046	0.00
Metal	1.00	1.000037	0.00
Non-electric machinery	1.00	1.000043	0.00
Electric machinery	1.00	1.000043	0.00
Television	1.00	1.000037	0.00
Medical equipment	1.00	1.000031	0.00
Vehicle parts	1.00	1.000055	0.01
Transport equipment	1.00	1.000038	0.00

Table 39 Continued

Commodity	Base	After Shock	% Change
Other manufacture	1.00	1.000088	0.01
Construction	1.00	1.000058	0.01
Water	1.00	1.000037	0.00
Electricity	1.00	1.000027	0.00
Trade	1.00	1.000074	0.01
Other service	1.00	0.999968	0.00
Transport Service	1.00	1.000045	0.00
Communication	1.00	1.000047	0.00
Business	1.00	1.000043	0.00
Real estate	1.00	1.000050	0.01
Community Service	1.00	1.000076	0.01
Administration	1.00	1.000074	0.01
Education	1.00	1.000063	0.01
Health	1.00	1.000068	0.01

Table 40. Equilibrium Primary Input Prices with Northern Guinea Fowl Program

Primary input	Base	Level	% Change
Labor self-employed coast	1.00	0.99908	-0.09
Labor self-employed forest	1.00	0.99956	-0.04
Labor self-employed savannah south	1.00	0.99920	-0.08
Labor self-employed savannah north	1.00	1.00166	0.17
Labor skilled	1.00	1.00010	0.01
Labor unskilled	1.00	1.00013	0.01
Capital agriculture	0.20	0.19994	-0.03
Capital non-agriculture	0.20	0.19999	0.00
Capital service	0.20	0.19999	-0.01
Land coast	1.00	1.00006	0.01
Land forest	1.00	1.00000	0.00
Land savannah south	1.00	1.00001	0.00
Land savannah north non-irrigated	1.00	1.00000	0.00
Land savannah north irrigated	1.00	1.00008	0.01

Table 41. SADA Feedback Effect on Crop and Guinea Fowl Activities (Production per Household)

Crop (Acre)		Before	Feedback Effect
Maize	May	2.45	4.22
	June	1.77	
Rice	June	1.08	1.46
	July	1.07	0.69
Sorghum	July	3.29	3.29
Millet	August	2.30	
	September		2.30
Cassava	June	1.42	
	July		1.42
Yam	February	2.20	
	December		2.20
Cowpea	April	0.69	0.69
Soybean	June	0.05	1.09
	July	1.04	
Groundnut	May	4.03	1.18
	June		2.85
Tomato	April		0.05
	July		0.05
	October	0.16	0.05
Fowl (50 keets)		44.74	44.74

Table 42. SADA Feedback Effect on Hired Labor (man day)

Month	Before	Feedback	% Change
January	112.95	112.95	0.00
February	209.75	112.95	-46.15
March	112.95	112.95	0.00
April	121.22	126.28	4.17
May	165.50	156.85	-5.23
June	203.76	180.74	-11.30
July	232.43	345.69	48.73
August	214.08	173.10	-19.14
September	286.79	254.60	-11.23
October	267.65	268.07	0.16
November	218.93	165.20	-24.54
December	176.69	313.33	77.33

Impacts of SADA Irrigation Expansion

As discussed in the literature review, the majority of irrigation facilities in the SADA region are small reservoirs and dug-outs (GIDA 2011), and smallholders literally pay nothing for irrigation water (Republic of Ghana 2012). SADAFPM does not consider the investment cost for irrigation development. In this scenario, we simulate economy-wide impact of SADA irrigation expansion by involving capital investment. Approximately 2.2 percent of irrigation potential has been developed by 2010 (World Bank 2010). Some projections indicated that about 22 percent of the available water resources will be used by 2020 (SADA 2011b). Consistent to the previous chapter, we assume irrigated land available to northern farmers to be 10 times of that in the base scenario in a medium-run perspective. In GHANACGE, land in Savannah north is divided between non-irrigated and irrigated. We adjust the endowment of irrigated land to be 10 times of the base and deduct from the non-irrigated land accordingly. To reflect capital investment in the irrigation facility, we also increase the agricultural capital factor by 5 million *cedis* based on the estimation from SADA (2011b) while reducing the same amount for non-agricultural uses. For sensitivity analysis, we include both of the results with and without agricultural capital adjustment (scenario I1 and I2).

The new equilibrium commodity quantity levels are shown in Table 43. Production of export fruit increases the most (88 percent). All of the non-irrigated crops show reduced production because of the shift of land out of dryland production to irrigated land. Rice, both irrigated and dryland crop, also has reduced total production because majority of the rice cultivation is rainfed in the country.

The income effects for each agro-ecological zone and type of household are shown in Table 44. Majority of the regions and households show negative impact in income except for the coast rural. The Savannah north rural households, although benefit most from the irrigation expansion, the contractive effects from less non-irrigated land exceeds the benefit. The total absorption of the economy decreases by around 0.18 percent both with and without agricultural capital adjustment, which suggests a nominal decrease in social welfare. From the above results, we cannot find a diminishing gap in income between the SADA and the rest of the economy.

The new equilibrium commodity and primary input price levels are shown in Table 45 and Table 46. Majority of the non-irrigated crops show slight increase in prices except for cocoyam. The rent of irrigated land in Savannah north decreases because of decrease in scarcity. On the other hand, rent for non-irrigated land increases. Wage of both self-employed labor in the Savannah north increases by 2.57 percent.

The changes of commodity prices, together with major input prices such as labor, maize as feed, and transportation service are reintroduced into SADAFPM proportionally to examine the regional feedback effect. The feedback results for crop and guinea fowl activities generated by SADAFPM are shown in Table 47. The crop activities of yam, rice, cassava, and soybean show monthly adjustments while the other crop activities remain the same. As a combination effect from feed and labor price drop, guinea fowl activity increases by 16.76 percent. Due to the change in crop activities, labor allocation needs to adjust accordingly as well. The monthly hired labor is shown in Table 48. Hired labor shows adjustment in both dry and wet seasons. With the feedback effect, the expected regional agricultural profit is 0.64 percent higher than it was without feedback effect. Therefore, without taking feedback effect taking into consideration, SADAFPM tends to slightly underestimate the impact of northern irrigation expansion.

Table 43. Economy Wide Output Impact from SADA Irrigation Expansion

Quantity of Aggregate Production Output	Base	I1	% Change	I2	% Change
Maize	391.37	389.57	-0.46	389.57	-0.46
Rice	171.21	169.28	-1.13	169.28	-1.13
Sorghum	75.26	73.99	-1.68	73.99	-1.68
Cassava	718.57	714.08	-0.63	714.06	-0.63
Yam	771.49	765.08	-0.83	765.04	-0.84
Cocoyam	192.54	192.29	-0.13	192.29	-0.13
Cowpea	69.67	68.45	-1.75	68.44	-1.76
Soybean	13.32	13.23	-0.68	13.23	-0.67
Palm oil	126.49	125.12	-1.08	125.11	-1.09
Groundnut	125.02	122.56	-1.97	122.55	-1.98
Oil nut	55.84	54.83	-1.79	54.83	-1.81
Domestic fruit	120.45	119.84	-0.51	119.85	-0.50
Export fruit	49.12	92.35	88.00	92.36	88.03
Domestic vegetable	649.22	652.14	0.45	652.11	0.45
Export vegetable	20.99	20.88	-0.55	20.92	-0.36
Plantain	440.30	439.58	-0.17	439.55	-0.17
Cocoa	1350.72	1293.17	-4.26	1293.10	-4.27
Other crop	28.39	27.60	-2.79	27.60	-2.79
Other export crop	36.53	34.20	-6.39	34.19	-6.42
Chicken	5.17	5.19	0.36	5.19	0.40
Egg	155.59	155.36	-0.15	155.36	-0.15
Beef	125.56	125.65	0.07	125.65	0.07
Goat	97.12	97.18	0.06	97.18	0.06
Other livestock	181.47	181.38	-0.05	181.38	-0.05
Forestry	783.36	778.37	-0.64	775.28	-1.03
Fishery	345.16	345.76	0.17	345.79	0.18
Gold mining	1425.95	1417.21	-0.61	1418.09	-0.55
Other mining	96.59	96.58	-0.01	96.59	0.00
Formal food processing	151.38	150.52	-0.57	150.53	-0.56
Local food processing	492.47	491.19	-0.26	491.25	-0.25

Table 43 Continued

Quantity of Aggregate Production Output	Base	I1	% Change	I2	% Change
Cocoa processing	192.48	185.62	-3.56	185.63	-3.56
Dairy	105.48	105.55	0.07	105.56	0.08
Meat	518.53	518.50	-0.01	518.64	0.02
Textile	74.55	73.21	-1.80	73.21	-1.79
Clothing	145.33	145.11	-0.15	145.14	-0.13
Footwear	122.44	122.33	-0.09	122.35	-0.08
Wood	546.03	543.24	-0.51	541.77	-0.78
Paper	67.21	67.25	0.06	67.27	0.09
Petroleum	497.64	499.47	0.37	499.56	0.38
Diesel	443.15	443.98	0.19	443.99	0.19
Fuel	13.51	13.50	-0.03	13.51	0.00
Chemical	264.20	264.01	-0.07	264.09	-0.04
Rubber	30.82	30.63	-0.62	30.67	-0.49
Non-metal	226.98	226.91	-0.03	226.99	0.00
Metal	482.12	480.96	-0.24	480.88	-0.26
Non-electric machinery	13.79	13.75	-0.27	13.75	-0.23
Electric machinery	12.71	12.69	-0.16	12.70	-0.13
Television	2.66	2.66	0.02	2.66	0.02
Medical equipment	0.48	0.48	0.10	0.48	0.09
Vehicle parts	1.92	1.92	-0.13	1.92	-0.07
Transport equipment	0.47	0.47	-0.01	0.47	0.04
Other manufacture goods	94.69	93.94	-0.79	93.95	-0.79
Construction	1923.08	1922.74	-0.02	1922.85	-0.01
Water	107.00	107.06	0.06	107.03	0.03
Electricity	1008.15	1007.23	-0.09	1007.18	-0.10
Trade	1998.63	2014.18	0.78	2014.99	0.82
Other service	1369.13	1407.38	2.79	1410.28	3.01
Transport Service	1703.09	1711.06	0.47	1711.47	0.49
Communication	360.68	361.22	0.15	361.21	0.15
Business	279.55	282.56	1.08	282.75	1.15
Real estate	616.73	617.07	0.06	617.06	0.05
Community Service	906.86	906.60	-0.03	906.59	-0.03
Administration	1169.78	1169.78	0.00	1169.78	0.00
Education	330.09	330.09	0.00	330.09	0.00
Health	120.21	120.22	0.01	120.22	0.00

Table 44. Regional Income Effects from SADA Irrigation Expansion

Region	Base (Mil. *cedis*)	I1	% Change	I2	% Change
Accra	5034.92	5025.96	-0.18	5025.58	-0.19
Coast Urban	936.75	935.45	-0.14	935.33	-0.15
Forest Urban	1557.25	1554.66	-0.17	1554.47	-0.18
Savannah South Urban	1479.11	1476.85	-0.15	1476.65	-0.17
Savannah North Urban	326.57	326.05	-0.16	326.00	-0.17
Coast Rural	853.73	855.58	0.22	855.56	0.21
Forest Rural	2787.49	2781.27	-0.22	2781.26	-0.22
Savannah South Rural	2280.76	2278.58	-0.10	2278.40	-0.10
Savannah North Rural	1117.43	1112.72	-0.42	1112.67	-0.43

Table 45. Equilibrium Commodity Prices with SADA Irrigation Expansion

Commodity	Base	I1	%Change	I2	%Change
Maize	1.00	1.0044	0.44	1.0044	0.44
Rice	1.00	1.0073	0.73	1.0073	0.73
Sorghum	1.00	1.0160	1.60	1.0160	1.60
Cassava	1.00	1.0083	0.83	1.0084	0.84
Yam	1.00	1.0121	1.21	1.0121	1.21
Cocoyam	1.00	0.9997	-0.03	0.9998	-0.02
Cowpea	1.00	1.0262	2.62	1.0263	2.63
Soybean	1.00	1.0162	1.62	1.0162	1.62
Palm oil	1.00	1.0137	1.37	1.0138	1.38
Groundnut	1.00	1.0194	1.94	1.0194	1.94
Oil nut	1.00	1.0211	2.11	1.0212	2.12
Domestic fruit	1.00	1.0193	1.93	1.0194	1.94
Export fruit	1.00	0.9482	-5.18	0.9483	-5.17
Domestic vegetable	1.00	0.9928	-0.72	0.9928	-0.72
Export vegetable	1.00	1.0035	0.35	1.0035	0.35
Plantain	1.00	1.0009	0.09	1.0009	0.09
Coco	1.00	0.9983	-0.17	0.9983	-0.17
Other crop	1.00	1.0177	1.77	1.0177	1.77
Other export crop	1.00	1.0043	0.43	1.0044	0.44
Chicken	1.00	1.0008	0.08	1.0009	0.09
Egg	1.00	1.0007	0.07	1.0008	0.08
Beef	1.00	0.9980	-0.20	0.9981	-0.19

Table 45 Continued

Commodity	Base	I1	%Change	I2	%Change
Goat	1.00	0.9983	-0.17	0.9983	-0.17
Other livestock	1.00	0.9987	-0.13	0.9988	-0.12
Forestry	1.00	0.9980	-0.20	0.9983	-0.17
Fish	1.00	0.9981	-0.19	0.9981	-0.19
Gold mining	1.00	0.9978	-0.22	0.9979	-0.21
Other mining	1.00	0.9978	-0.22	0.9978	-0.22
Formal food processing	1.00	1.0008	0.08	1.0008	0.08
Local food processing	1.00	1.0039	0.39	1.0039	0.39
Coco processing	1.00	1.0005	0.05	1.0005	0.05
Dairy	1.00	0.9985	-0.15	0.9985	-0.15
Meat	1.00	0.9983	-0.17	0.9983	-0.17
Textile	1.00	1.0040	0.40	1.0039	0.39
Clothes	1.00	0.9985	-0.15	0.9984	-0.16
Footwear	1.00	0.9982	-0.18	0.9981	-0.19
Wood	1.00	0.9984	-0.16	0.9987	-0.13
Paper	1.00	0.9981	-0.19	0.9980	-0.20
Petroleum	1.00	0.9979	-0.21	0.9979	-0.21
Diesel	1.00	0.9979	-0.21	0.9979	-0.21
Fuel	1.00	0.9979	-0.21	0.9979	-0.21
Chemical	1.00	0.9980	-0.20	0.9979	-0.21
Rubber	1.00	0.9980	-0.20	0.9979	-0.21
Non-metal	1.00	0.9980	-0.20	0.9979	-0.21
Metal	1.00	0.9980	-0.20	0.9979	-0.21
Non-electric machinery	1.00	0.9980	-0.20	0.9979	-0.21
Electric machinery	1.00	0.9980	-0.20	0.9979	-0.21
Television	1.00	0.9978	-0.22	0.9978	-0.22
Medical equipment	1.00	0.9977	-0.23	0.9977	-0.23
Vehicle parts	1.00	0.9981	-0.19	0.9980	-0.20
Transport equipment	1.00	0.9980	-0.20	0.9980	-0.20
Other manufacture	1.00	0.9985	-0.15	0.9985	-0.15
Construction	1.00	0.9981	-0.19	0.9980	-0.20
Water	1.00	0.9979	-0.21	0.9979	-0.21
Electricity	1.00	0.9979	-0.21	0.9979	-0.21
Trade	1.00	0.9983	-0.17	0.9982	-0.18
Other service	1.00	0.9970	-0.30	0.9969	-0.31
Transport Service	1.00	0.9980	-0.20	0.9980	-0.20
Communication	1.00	0.9980	-0.20	0.9979	-0.21
Business	1.00	0.9978	-0.22	0.9978	-0.22
Real estate	1.00	0.9981	-0.19	0.9980	-0.20
Community Service	1.00	0.9981	-0.19	0.9980	-0.20

Table 45 Continued

Commodity	Base	I1	%Change	I2	%Change
Administration	1.00	0.9981	-0.19	0.9980	-0.20
Education	1.00	0.9977	-0.23	0.9977	-0.23
Health	1.00	0.9977	-0.23	0.9977	-0.23

Table 46. Equilibrium Primary Input Prices with SADA Irrigation Expansion

Primary Input	Base	I1	%Change	I2	%Change
Labor self-employed coast	1.00	1.0212	2.12	1.0214	2.14
Labor self-employed forest	1.00	1.0052	0.52	1.0053	0.53
Labor self-employed savannah south	1.00	1.0030	0.30	1.0030	0.30
Labor self-employed savannah north	1.00	0.9743	-2.57	0.9743	-2.57
Labor skilled	1.00	0.9975	-0.25	0.9975	-0.25
Labor unskilled	1.00	0.9988	-0.12	0.9985	-0.15
Capital agriculture	0.20	0.1992	-0.38	0.1997	-0.14
Capital non-agriculture	0.20	0.1995	-0.26	0.1995	-0.24
Capital service	0.20	0.1994	-0.29	0.1994	-0.30
Land coast	1.00	1.0138	1.38	1.0139	1.39
Land forest	1.00	0.9970	-0.30	0.9971	-0.29
Land savannah south	1.00	0.9991	-0.09	0.9991	-0.09
Land savannah north non-irrigated	1.00	1.0627	6.27	1.0627	6.27
Land savannah north irrigated	1.00	0.4532	-54.68	0.4533	-54.67

Table 47. SADA Feedback Effect on Crop and Guinea Fowl Activities (Production per Household)

Crop (Acre)	Month	Before	Feedback Effect
Maize	June	3.40	3.40
Rice	June	1.30	0.45
	July		0.85
Sorghum	July	2.74	2.74
Millet	September	2.15	2.15
Cassava	June	1.32	
	July		1.32
Yam	January	0.68	0.41
	February	0.69	0.53
	March	0.69	0.45
			0.49
Cowpea	April	0.61	0.61
Soybean	June	0.12	0.98
	July	0.85	
Groundnut	May	4.91	4.91
	June	0.08	0.08
Tomato	January	0.54	0.54
	April	0.54	0.54
	July	0.54	0.54
	October	0.54	0.54
Fowl (50 keets)		10.62	12.40

Table 48. SADA Feedback Effect on Hired Labor (man day)

Month	Before	Feedback	% Change
May	28.62	35.74	24.88
June	18.12	27.48	51.64
July	112.70	132.47	17.54
August	27.39	37.60	37.27
September	156.26	151.37	-3.13
October	93.12	108.72	16.75
November	47.52	28.98	-39.02
December	56.21	94.93	68.89

CHAPTER V

CONCLUSIONS AND POLICY IMPLICATIONS

This thesis assesses the effects of implementation of select SADA policies in Ghana. An interactive farm and economy-wide framework was used to do the assessment. In particular, during the work the farm model (SADAFPM) was developed and then used to simulate the regional production outcomes and then those results were passed as the regional shocks into a country-wide computable general equilibrium model.

We assess four SADA agricultural policies: input subsidy, agricultural extension, irrigation expansion, and guinea fowl program. Without smallholders bearing program costs, all policy scenarios show positive regional impact on expected agricultural income. The economy-wide impacts vary greatly due to assumptions about capital and extension labor allocations across the country. Irrigation expansion shows no diminishing income gap between the SADA region and the rest of Ghana. The input subsidy and guinea fowl programs show a slight effect on diminishing income gap. Agricultural extension has biggest impact on narrowing the income gap. The simulation results suggest that SADAFPM is a useful tool to examine regional production activities under SADA agricultural policies, while interacting SADAFPM with GHANACGE are more proper to assess economy-wide impact and feedback effect.

The interaction between SADAFPM and GHANACGE also provides a flexible framework for analyzing agricultural policy impacts from expanded agricultural production in northern Ghana. SADAFPM can be extended as needed to assess future SADA strategies. One direction is to include more crop and livestock commodities produced by northern Ghana, such as fruit and livestock, especially cattle and traditional chicken. Another possible extension is to consider heterogeneity among producers, especially commercial versus substance farms. Modelling heterogeneity likely will improve the model performance and simulation outcomes given crop budget data availability. The results from this study may also be improved by relaxing some underlying assumptions. SADAFPM assumes smallholders' cropping activities are not adjustable in response to stochastic rainfall conditions in the northern regions. This assumption can be relaxed when more off-farm activities or financial instruments are available to the smallholders.

There also are some limitations. The farm model revealed itself during the input subsidy analysis to not enough possibilities where more inputs are used to get greater production when the subsidy occurs. This could be corrected by adding say a fertilizer response function of the model or somehow adding alternative variables with different input combinations allowing input substitution. Additionally the quantity and price information transferred between SADAFPM and GHANACGE is treated in as detailed and consistent a manner as possible, given the model structures and assumptions. Due to the model closure assumption, however, not all quantity and price changes can be captured. For example, in the medium-run perspective, imported inputs such as fertilizer, weedicide, and bag twine would most fluctuate. Such information is exogenous in both SADAFPM and GHANACGE which cannot be captured when world environment is changing. As with all CGE models, some typical limitations remain. The model did not contain information on the social cost and transactions cost of adopting these new technologies that could be added which would result in smaller results for social benefit. The income elasticities and many parameters such as production technology are exogenously determined and therefore the results from the CGE application do not reflect structural changes in the economy such as natural disaster, political turmoil, or technological change. These limitations suggest that the numbers generated by the study are best used as indicative of agricultural potential in the SADA region.

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APPENDIX 1

Crop Budget for One Acre Sorghum (Local Variety)

Input/Activity	Unit	Quantity	Unit Cost (¢)	Total Cost (¢)
Seed	Kg	3.5		10.00
Ploughing	Acre	1	35.00	35.00
Seed Dressing (Apron Plus)	Gm	3.5	5.00	18.00
Planting	Man day	5	5.00	25.00
Fertilizer- NPK	50 bag	2	51.00	102.00
- S/A	50kg bag	1	44.00	44.00
Fertilizer Application	Man day	10	5.00	50.00
Weeding	Man day	10	5.00	50.00
Harvesting	Man day	5	5.00	25.00
Threshing	Man day	5	5.00	25.00
Winnowing/Bagging	Man day	5	5.00	25.00
Bags/Twines	Piece	10	3.00	30. 00
Transportation		10	2.00	20. 00
Total				459.00

Crop Budget for One Acre Millet (Local Variety)

Input/Activity	Unit	Quantity	Unit Cost (¢)	Total Cost (¢)
Seed	Kg	3.5		10.00
Ploughing	Acre	1	35.00	35.00
Seed Dressing (Apron Plus)	Gm	3.5	5.00	18.00
Planting	Man day	5	5.00	25.00
Fertilizer- NPK	50kg bag	2	51.00	102.00
- S/A	50kg bag	1	44.00	44.00
Fertilizer Application	Man day	10	5.00	50.00
Weeding	Man day	10	5.00	50.00
Harvesting	Man day	5	5.00	25.00
Threshing	Man day	5	5.00	25.00
Winnowing/Bagging	Man day	5	5.00	25.00
Bags/Twines	Piece	10	3.00	30.00
Transportation		10	2.00	20.00
Total				459.00

Crop Budget for One Acre Maize (Improved Variety)

Input/Activity	**Unit**	**Quantity**	**Unit Cost (¢)**	**Total Cost (¢)**
Seed	Kg	9	1.75	15.75
Ploughing	Acre	1	35.00	35.00
Planting	Man day	5	5.00	25.00
Fertilizer- NPK	50kg bag	2	51.00	102.00
- S/A	50kg bag	1	44.00	44.00
Fertilizer Application	Man day	10	5.00	50.00
Weeding	Man day	10	5.00	50.00
Harvesting	Man day	5	5.00	25.00
Shelling	Man day			40.00
Bags/Twines	Man day	10	3.00	30.00
Transportation		10	2.00	20.00
Total				436.75

Crop Budget for One Acre Rice (Improved Variety)

Input/Activity	**Unit**	**Quantity**	**Unit Cost (¢)**	**Total Cost (¢)**
Seed	Kg	30		20.00
Ploughing	Acre	1	35.00	35.00
Planting	Man day			10.00
Fertilizer- NPK	50 bag	2	51.00	102.00
- UREA		1	50.00	50.00
Fertilizer Application	Man day	10	5.00	50.00
Weedicides	Man day	2	10.00	20.00
Weedicide Application	Man day	1	10.00	10.00
Harvesting	Man day			30.00
Shelling	Man day	1	30.00	30.00
Bags/Twines	Man day	12	3.00	36.00
Transportation		12	2.00	24.00
Total				417.00

Crop Budget for One Acre Groundnut (Improved Variety)

Input/Activity	Unit	Quantity	Unit Cost (¢)	Total Cost (¢)
Seed	Kg	30		20.00
Ploughing	Acre	1	35.00	35.00
Planting	Man day			25.00
Weedicides	Man day	2	10.00	20.00
Weedicide Application	Man day	1	10.00	10.00
Harvesting	Man day			30.00
Shelling	Man day	1	30.00	30.00
Bags/Twines	Man day	12	3.00	36.00
Transportation		12	2.00	24.00
Total				230.00

Crop Budget for One Acre Soybean (Improved Variety)

Input/Activity	Unit	Quantity	Unit Cost (¢)	Total Cost (¢)
Seed	Kg	10		10.00
Ploughing	Acre	1	35.00	35.00
Planting	Man day	5	5.00	25.00
Weeding	Man day	2	25.00	50.00
Insecticides		2	10.00	20.00
Insecticide Application	Man day	2	10.00	20.00
Harvesting	Man day			30.00
Threshing	Man day	1	30.00	30.00
Bags/Twines	Man day	12	3.00	36.00
Transportation		12	2.00	24.00
Total				280.00

Crop Budget for One Acre Cowpea (Improved Variety)

Input/Activity	**Unit**	**Quantity**	**Unit Cost (¢)**	**Total Cost (¢)**
Seed	Kg	10		15.00
Ploughing	Acre	1	35.00	35.00
Planting	Man day	5	5.00	25.00
Weeding	Man day	2	25.00	50.00
Insecticides		3	10.00	30.00
Insecticide Application	Man day	3	10.00	30.00
Harvesting	Man day			30.00
Threshing	Man day	1	30.00	30.00
Bags/Twines	Man day	12	3.00	36.00
Transportation		12	2.00	24.00
Total				305.00

Budget for Guinea Fowl Production for 50 Keets

1. Housing

Input/Activity	**Unit**	**Quantity**	**Unit Cost (¢)**	**Total Cost (¢)**
Wawa Board (Wood)	Pieces	45	20.00	900.00
2 by 4 Inches Wood	Pieces	25	14.00	350.00
Roofing Sheets	Packet	1	180.00	180.00
Nails (3 Inches)	Packet	1	30.00	30.00
Nails (4 Inches)	Packet	0.25	10.00	10.00
Roofing Nails	Packet	1	15.00	15.00
Labor or Workmanship				150.00
Total				1635.00

2. FEEDING

Age of Birds	**Number of Birds**	**Quantity of Feed (Kg) /Day**
1 Week	50	0.2
3 Weeks	50	0.4

Note: A Bag of 50Kg Feed is GH¢ 60.00.

3. Vaccinations

Age of Birds	Vaccines	Cost (¢)
1 Week	Glucose	9.00
1 Week	Antibiotics	9.00
1 Week	Vitamins	9.00
3 TO 4 Weeks	Antibiotics	9.00
3 TO 4 Weeks	Vitamins	9.00
5 Weeks	Dewormer	9.00
7 Weeks	Antibiotics	9.00
7 Weeks	Vitamins	9.00
8 Weeks	Dewormer	9.00
14 Weeks	Dewormer	9.00
Total		900.00