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**Achieving Food vs. Fuel Security – Economywide Implications of India’s
“Right to Food Act 2013”**

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Abstract

There have been increasing concerns about the challenges associated with meeting the growing global needs for food, feed, fiber, and fuel in a sustainable manner over coming decades. World population is projected to reach 9 billion by 2050 and income growth in low and middle income countries is spurring demand for a more varied diet, combining to increase pressure on arable land resources around the world. This study offers insights into the potential macroeconomic impacts of India’s recent food and fuel security policies through application of a dynamic global economy-wide model. Although India has experienced impressive economic growth in recent years, the country remains home to more than 300 million people living in poverty. In addition, India has recently adopted very aggressive policies aimed at improving both food and energy security. The Government of India passed the National Food Security Act 2013, which entails providing subsidized food grains to nearly 75% of the rural population and 50% of the urban population. In addition to addressing food security, India is also strengthening its energy security with its National Policy on Biofuels, which targets 20% blending of biofuels by 2017. Assessment of the economy-wide impacts of implementing these policies can provide valuable insights into the economic impacts that may result and could inform decisions being made in other countries considering similar policies. This study reveals that India’s food security policy projected to reduce its projected economic growth, while the fuel security policy help boost the economy, but do not significantly impact crop prices, cropping patterns, land use, or land cover change.

Key Words: Food Security, Biofuels, Computable General Equilibrium, Recursive Dynamic, Global Trade Analysis Project (GTAP).

Achieving Food vs. Fuel Security – Economywide Implications of India’s “Right to Food Act 2013”

1. Introduction

Issues surrounding food versus fuel security tradeoffs have been highly debated by researchers and policy makers in recent years. A growing global population and rising incomes in low and middle income countries are driving greater demand for food and for more varied diets as well as increasing demand for energy. At the same time, concerns about energy security and regarding the environmental impacts of fossil fuels have led to interest in policies encouraging the use of bioenergy around the globe. Due to greatly expanded use of agricultural and forestry feedstocks for bioenergy production, food and energy security have become increasingly linked over time in many countries as growing global needs for food, feed, fiber, and fuel increase competition for arable land resources. *The public sector can play a vital role in helping to meet these challenges through the identification and implementation of appropriate policy actions, but food and fuel security policies have wide-ranging impacts and complex interactions. Thus, it is very important to assess the potential implications of alternative policies and carefully consider both intended and unintended consequences that may result.* This study offers insights into the potential macroeconomic impacts of efforts to address these global challenges, with a focus on India’s recent food and fuel security policies.

Research on food security issues has been focused mainly on increasing crop yields, with a recent focus on productivity improvements needed to feed the projected global population of 9 billion people by 2050. But the crux of the problem is market failure in removing food insecurity, which has not gained as much priority as food production *per se*. Although India has experienced impressive economic growth in recent years, the country remains home to more than 300 million people living in poverty. Despite recent occurrences of surplus production of food grains (exceeding the buffer stock norms) in India, achieving food security at the micro level has been a continual challenge. Prevalence of undernourishment, a key indicator food access, computed as the proportion of population suffering from chronic hunger is currently about 11% of population in the World, while it is 15% in India (FAO, 2015). In addition, India is one of the fastest growing economies in the world and meeting its growing energy needs is another challenge to address in the 21st century.

In response to these challenges, India has recently adopted very aggressive policies aimed at improving food and fuel security. The Government of India passed the National Food Security Act 2013, which entails providing subsidized food grains to nearly 75% of the rural population and 50% of the urban population. In an effort to strengthen its energy/fuel security, India has introduced its National Policy on Biofuels, which targets 20% blending of biofuels with petroleum for transportation by 2017. In this study, we examine the economy-wide implications of India's food security and biofuel policies within the context of global food versus fuel security challenges, in a recursive dynamic computable general equilibrium (CGE) modelling framework.

The rest of this section provides a description of India's current food security and biofuel policies. In the remainder of the paper, we summarize the study approach in section 2, discuss the experimental design used to implement food security and biofuel policy scenarios in section 3, present and discuss the results generated by implementing the two policy scenarios in the model in section 4, and provide conclusions and policy implications in section 5.

1.1 Food versus Fuel Security in Perspective

The World Summit of Food Security in 2009 defined food security as “*a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life*” (FAO, IFAD and WFP, 2013). Based on this definition, Food and Agricultural Organization of the United Nations (FAO) identifies four dimensions that influence food security: food availability, economic and physical accessibility to food, food utilization, and stability (vulnerability and shocks) over time.

It is the poorest section of the society that is most vulnerable to food insecurity. In the event of adverse consequences such as natural calamities, people above the poverty line could also get affected. Based on a survey of household consumer expenditure, the Planning Commission of India estimated that the number of people below the poverty line (equivalent to USD 1.25 a day at 2005 purchasing-power poverty defined by the World Bank) is about 21.9% of the population in 2011-12. This is a significant reduction from 37.2% in 2004-05, mostly attributed to high economic growth during the past decade. The rise in income has also raised the consumption capacity. The Indian economy has been growing at a rate of 6 to 8 percent annually over the past decade and it

is expected to grow at this pace over the next few decades, implying an immense need for additional food resources.

In addition to food security concerns, India also faces an energy security challenge. Being one of the fastest growing economies in the world with a population projected to become the world's largest by 2022 (United Nations, Department of Economic and Social Affairs, Population Division, 2015), meeting the growing demand for energy in a sustainable way is a daunting challenge especially when nearly two thirds of energy supply is met by imports. Over the past decade, expansion of biofuels production has been a popular strategy for improving energy security across multiple countries. India has also launched national policies that encourage increased use of biofuels in transportation fuels. It is argued that greater use of biofuels such as ethanol, biodiesel, and other liquid and gaseous fuels for transport could reduce greenhouse gases (GHGs), improve vehicle performance, protect ecosystems and soils, and enhance rural economic development by providing employment opportunities. However, currently most of the biofuels are sourced from agriculture, which leads to complex interactions with food and feed markets. Below we summarize key features of the National Food Security Act 2013 and the National Policy on Biofuels.

1.1.1 The National Food Security Act 2013

Until 2013, India followed a welfare based approach of distributing food grains to its low income group at an *issue price* which is much lower than its *market price* or *procurement price*. In September 2013, the Government of India passed the National Food Security Act 2013 (NFSA, also called the Right to Food Act due to its rights based approach). The NFSA entails providing subsidized food grains to nearly 75% of the rural population and 50% of the urban population, expanding the population eligible for subsidized food grains relative to the previously existing policy. The NFSA entitlement is 5 kg of food grains per person per month at issue prices of: 4.8¢ per kg of rice, 3.2¢ per kg of wheat, and 1.6¢ per kg of coarse grains (millets).

In addition, the NFSA entitles pregnant women, lactating mothers, and children from 6 months to 14 years to a free nutritious “take home ration” of 600 calories per day and provides \$100 per month to new mothers as a maternity benefit for the first six months after birth. This policy is regarded as the biggest experiment in the world to achieve food and nutritional security in terms of population coverage with huge fiscal expenditure (Gulati et al. 2012). The NFSA was

estimated to provide 61.2 million tons of food grains with an implementation cost of \$22 billion for 2013-14.

It is argued that though some components of the NFSA are directly targeted at women and children's nutrition, the supply of cheap rice and wheat could have detrimental effects on the commodity markets and consumers (Kotwal et al., 2013). Gulati et al. (2012) point out the adverse economy wide implications such as: (a) shifting of government resource allocation more towards subsidies rather than investments is regressive for long term agricultural growth; (b) the NFSA could reverse movement of Indian consumers towards high value crops such as pulses, fruits and vegetables, back to cheaper food grains leading to nutritional implications; (c) since NFSA focuses only on food grains, assured procurement of grains could induce a severe imbalance in production of oilseeds and pulses, leading to implications for the trade deficit; and (d) the higher cost of food subsidies may lead to rising fiscal deficits that could fuel inflationary pressures.

1.1.2 The National Policy on Biofuels

In strengthening its energy security, India approved the National Policy on Biofuels (NPB) in December 2009 which currently has an E5 ethanol mandate that is scheduled to move to an E10 requirement as soon as the ethanol production capacity is in place. The National Policy targets 20% blending of biofuels (both biodiesel and ethanol) by 2017 (Ministry of New and Renewable Energy [MNRE]/Government of India [GOI], 2009). However, the sugar-ethanol based E5 policy has been partially successful only in the years of surplus sugar production in the country. The Government of India launched the National Biodiesel Mission (NBM) in 2003 identifying *Jatropha* seed (*Jatropha curcas*) as the most suitable tree-borne non-edible oilseed for biodiesel production. The Planning Commission of India had even set an ambitious target covering 28 to 33 million acres of land under *jatropha* cultivation by the end of the Eleventh Five Year Plan (2012). However, the production of biodiesel in India has remained commercially insignificant, mainly due to much lower yields of *Jatropha* than anticipated (Singh et al., 2014). Though these biofuels policies help in stimulating rural development and employment opportunities and help in addressing global concerns on reducing GHG emissions, it is important for India to pursue sustainable biofuels production derived from non-edible feedstock which can be grown outside regular cropland, thereby avoiding any direct conflicts with food and feed demands.

Though India's biofuels targets are of small volume compared to countries such as the US, which mandates annual consumption of 36 billion gallons of total renewable fuels by 2022; 5.75% share of biofuels in transportation fuels in the EU; Brazil's mandate of minimum 18-20% ethanol blending; and China's target of 10% share of biofuels by 2020, in the global context, competition for land to grow bioenergy feedstock versus food crops is expected to become more intense. The consequences of massive expansion of biofuels on a global scale are extremely complex, with direct and indirect impacts. Biofuels sourced from agriculture could directly impact food security, international trade, and the environment. Traditionally, agriculture has been the source of food, feed, and fiber. But now, it is also a source of fuel. Historically the connection between energy and agriculture was weak and confined to the linkages through production costs comprising fertilizer, diesel, and other agro-chemicals, which are all energy intensive. This traditional linkage was a concern mainly in the developed countries. But currently, a new linkage is being established, through a demand-pull from the energy sector to agriculture. It is pulled by the massive biofuel subsidies, mandates, and also by high oil prices. It is often attributed that this new link has led to higher commodity prices with the growth in biofuels production.

The food price crisis in 2008 had fueled debate on the potential impacts of biofuels on food production. The corn price in the US spiked from USD 2.20 per bushel in September 2006 to a peak of USD 7.40 per bushel in June 2008. In the same period, soybean prices also more than tripled from USD 5.20 per bushel to USD 16.40 per bushel. Since corn and soybeans constitute major ingredients in livestock feed, their higher prices increase the cost of producing milk, meat, eggs, etc., which are eventually passed on to consumers. Following this food price crisis, a number of studies emerged on this topic attributed biofuel production being one of the key drivers. Hochman et al. (2014) did a comprehensive analysis of these studies and found that in high-income households and countries, only a small share of crop prices transmitted in the final food price mainly due to higher costs of food processing and packaging services. However, those authors found that higher crop prices contributed a larger share of food prices in low-income households and countries. In terms of annual food bill, Alexander and Hurt (2007) estimated that US consumers would pay \$22 billion more for food in 2007, two thirds of which was attributed to biofuels production. Since food grains and oilseeds form the major source of biofuel feedstock with the current widely commercialized technology, they compete directly with their use as food and feed, and indirectly for land, water, and other resources.

Since both agricultural supply and the demand for food are highly inelastic in the short-run, any surge in demand for biofuel feedstock puts upward pressure on commodity prices in global agricultural markets. Though higher commodity prices can benefit farmers, the vast majority of consumers will be worse off due to higher prices, including farmers that are net buyers of agricultural commodities. However, a policy such as NFSA in India could insulate the most vulnerable members of the population from higher food prices. Some of the direct and indirect economywide impacts of India's NFSA within the context of its biofuels policy are examined in the following sections. Study Approach

We examine the economy-wide implications of India's food security policy (NFSA) and biofuels policy (NPB) within the context of global food versus fuel security challenges, in a recursive dynamic general equilibrium framework. For this purpose, we develop a recursive dynamic computable general equilibrium (CGE) model called GDyn-E-BIO based on the Global Trade Analysis Project (GTAP) data base and a suite of GTAP based models. The key data base used in this study is the GTAP data base version 7.1 (Narayanan and Walmsley, Ed., 2008) which comprises 57 sectors and 112 regions, corresponding to the global economy in 2004. We further develop this data base by incorporating greater details on crops and biofuels, as the latter have been a key component of recent food policy debates. Since biofuels are produced from agricultural sources, their production impacts food security, international trade, and the environment. The final data base includes explicit agriculture related sectors and first and second generation biofuels. For tractability, we aggregate the data base to comprise 25 regions (Table A1) and 45 sectors (Table A2), as shown in the Appendix, focusing on food and fuel sectors most likely to be directly impacted by food security policies and expanded biofuels production.

1.1 Description of the Model

The GDyn-E-BIO model is a multi-region, multi-sector, recursive dynamic CGE model developed by adapting the GDyn-E-AEZ model (Golub et al., 2012) which was built by combining comparative static versions of the GTAP-E (Burniaux and Truong, 2002) and GTAP-BIO (Birur et al. 2008; Taheripour et al. 2010) models and the recursive dynamic GDyn (Ianchovichina and McDougall, 2001). The GDyn (dynamic GTAP) model is a recursive dynamic CGE model where the agents base their decisions on adaptive expectations, with international capital mobility and endogenous capital accumulation. Conceptually, the model assumes perfect competition in all

markets with price adjustments to ensure that all markets clear simultaneously. A regional household collects all the income in its region and spends it over three expenditure types: private household (consumer), government, and savings, over a Cobb-Douglas utility function. A representative firm maximizes profits in nested constant elasticity of substitution (CES) functions in a perfectly competitive market for each industry/sector in each region and pays income to the regional household for utilizing the endowment commodities (i.e., land, labor, capital, and natural resources). In an open economy, firms also export the tradable commodities and import the intermediate inputs from the rest of the world. The model follows Armington assumptions to account for product heterogeneity for outputs produced in different regions. The dynamics in the GDyn model comes from capital accumulation, labor productivity, and other exogenous macro variables such as real gross domestic product (GDP) and population growth.

Following the GTAP-BIO model, we further modify the nested constant elasticity of substitution (CES) production structure of firms to allow for production of seven first and three second generation biofuels by utilizing their respective feedstock crops along with other factor inputs, and complement with the petroleum products sector. We allow for substitution of all the transportation fuels in the household consumption structure with calibrated elasticity of substitution in each region. The land supply structure follows a 18 Agro-Ecological Zone (AEZ) level nested constant elasticity of transformation (CET) function where the land is first allocated across three cover types (cropland, pastureland, forestland) and in the second tier cropland is allocated across alternate crops including switchgrass. Compared to previous studies (Hertel et al. 2010; Taheripour et al. 2010), the detailed incorporation of explicit crops in this study helps in precisely identifying the change in cropping pattern and distribution.

Based on secondary data, we develop a historical (2004-2010) baseline and forward-looking (2010-2050 with five year time step) baseline that includes macro-economic variables and agriculture specific features of the economy over the projected period. The baseline trends (2004 through 2015) on exogenous macro-variables such as growth of real GDP, population, skilled labor, and unskilled labor aggregated for all 25 global regions are based on projections from Chappius and Walmsley (2011). In addition to the macro-variables, the baseline also includes projections on technological change in agricultural production based on Total Factor Productivity (TFP) growth rates as offered by Ludena et al. (2007) for the crops and livestock sectors. For example, these annual TFP growth rates for India during 2004-2010 range from 1.07 per cent for

crops, 1.65 per cent for ruminant livestock, 3.75 per cent for dairy, and 1.65 per cent for non-ruminants. We validate the model by reproducing biofuels production in key regions in 2010.

We modify the nested constant elasticity of substitution (CES) production structure of firms in the model to allow for production of seven first and three second generation biofuels by utilizing their respective feedstock crops along with other factor inputs, and complement with the petroleum products sector. We allow for substitution of all the transportation fuels in the household consumption structure with calibrated elasticity of substitution in each region. The land supply structure follows a 18 Agro-Ecological Zone (AEZ) level nested constant elasticity of transformation (CET) function where the land is first allocated across three cover types (cropland, pastureland, forestland) and in the second tier cropland is allocated across alternate crops. On the food security module, we update agricultural distortions particularly in India to reflect the production and consumption subsidies during the 2004 base year. The spatially disaggregated yet global nature of the GTAP modeling framework helps in assessing worldwide trends agricultural and energy markets as India implements its food and fuel security policies.

2. Experimental Design

We first implement (a) the baseline scenario which includes the macro variables along with improved agricultural productivity through TFP growth rates. Starting with the base-year 2010, we explore three policy scenarios: (b) implementing NFSA by introducing food consumption subsidies in India in 2010; (c) implementing India's biofuel policy (NPB) with respect to sugar-ethanol consumption; and (d) implementing NPB along with NFSA in 2010. Comparing scenarios the three scenarios with the baseline would provide us insights on economy-wide interaction of food versus fuel security policies.

2.1 Implementing Food Security Scenario

For implementing the NFSA scenario (b), we compute the power of the *ad valorem* equivalent (ADV) subsidy (subsidies in the GTAP model are implemented as percent change in power of subsidy, where $\text{power} = 1 + \text{rate of subsidy}$) provisions for rice and wheat under NFSA. Since our model has one aggregated category of consumers/households as described in section 2.1, we compute a population-weighted average subsidy for food grains based on the share of the population below poverty line (BPL) (22%) and those above poverty line (APL) (78%). The BPL

households pay USD 0.02 per kg of rice and USD 0.06 per kg of wheat, while the APL households pay USD 0.26 and 0.16, respectively for rice and wheat. The average market prices of paddy rice and wheat in India in 2013 were USD 0.60 and USD 0.36 per kg, respectively (Singh, 2014). At this market price, the weighted average subsidy amounts to USD 0.393 per kg of paddy rice and USD 0.222 per kg of wheat (the exchange rate, INR/USD used throughout this study is 50). We compute the power of the *ad valorem* subsidy as $(TO_i) = 1 + t_i$, where t_i is the *ad valorem* subsidy rate for commodity i expressed in percentage (Hertel, 1997). The change in TO_i before and after implementing NFSA are 65.47 and 61.67, respectively, for paddy rice and wheat, which are used to shock the subsidy variable for private households. This NFSA scenario is implemented on top of the baseline scenario (a).

2.2 Implementing Biofuel Policy Scenario

We first implement the NPB policy on sugarcane ethanol in India as scenario (c), and then in scenario (d), we implement NPB along with the NFSA scenario starting from base year 2010. Though NPB policy provided an indicative target of 10% blending by 2015, the current ethanol consumption for transportation has reached only 2.9% (0.556 billion gallons). However, the target of 20% blending by 2017 still in place, which requires 1.746 billion gallons of ethanol Aradhey (2015). Keeping these current market conditions in view, we implement 2015 volume to be 0.556 billion gallons from the baseline volume of 0.129 billion gallons. Reaching 20% ethanol blending (E20) by 2020 requires a further increase in sugarcane ethanol production to 1.746 billion gallons, or about 214% greater than the quantity of sugarcane ethanol in 2015. For the period beyond 2020, since there is no stipulated volume requirements, we implement a nominal 5% increase in ethanol volume each five year time step from 2020 through 2050.

3. Results and Discussion

In this section, we present and discuss results on impact of India's food security (NFSA) and biofuel (NPB) policies on key variables such as market and world prices, trade, consumption expenditure of households, crop production, harvested area, land cover change, and real GDP.

3.1 Baseline Scenario Predictions of Food Grain Market in India

The baseline scenario provides insights on how the global macro-economic variables such as growth in population, labor productivity, real GDP along with agricultural productivity growth

contribute towards projecting the global economy forward in time. Since the initial year for our data base is 2004, we project the global economy by introducing these exogenous macro variables from 2004 to 2010 and then from 2010 through 2050 in a five year time step. Table 1 provides the baseline projections of paddy rice and wheat markets in India from 2004 through 2050. As presented in the top panel of Table 1, some of the exogenous variables (discussed in section 2) predict that India's population of 1.09 billion in 2004, increases to 1.58 billion by 2050, leading it as the largest populous country in the world. However, India's economy is also expected to grow much faster from mere USD 0.76 trillion in 2004 to USD 6.11 trillion economy by 2050 (all prices and monetary values hereafter are in 2010 USD). This nearly quadruples the annual per capita income from USD 700 per person in 2004 to USD 3868 by 2050, which strengthens the purchasing power of the population. As postulated by Engel's law, we expect that with the rising income, the proportion of income spend on food would fall. We will revisit this law in Section 4.2.

< Table 1 appears here >

The bottom panel of Table 1 show that the model predicted market price, production, and trade (endogenous variables) for paddy rice and wheat in India. The base year price of paddy rice and wheat in India are USD 235 and USD 178 per Metric ton, respectively, in 2010 prices. India produced about 125 million tons (now onwards Mt) of paddy rice in 2004, with only a small fraction (0.4 Mt) was net exported. Whereas, wheat production in India was 73 Mt with net exports of about 3.4 Mt. With the growth in the global economy, by 2050, the model predicted market price of paddy rice increased five folds and that of wheat tripled in India. On the supply side, the production of paddy rice and wheat nearly doubled by 2030 from its 2010 levels, and more than tripled by 2050. However, India's trade in paddy rice (less than 1Mt) did not change much throughout 2050, though export of wheat increased from mere 1 Mt in 2010 to 60 Mt in 2050. The net exports of wheat constituted nearly 25% of its production in 2050. These model predicted imports of wheat from India went mainly to Eastern Africa, West Asia, and South East Asia regions. Furthermore, the per capita availability of paddy rice in the baseline increased from 127 kg/annum in 2010 to 211 kg by 2030, and then to 346 kg by 2050. Whereas, the per capita availability of wheat in India less than doubled from 68 kg/annum in 2010 to 116 kg by 2050. This significant gain in availability of food grains is mainly due to rapid rise in production, which is mainly attributed to the higher growth in crop yields in the model.

3.2 Impact of Food Security Policy on Prices and Consumption

Though India introduced NFSA in September 2013, we implement the subsidy shocks for paddy rice and wheat (as discussed in section 3) starting in 2010 which is the model predicted base year. When the consumers are provided with cheaper food grains, it is expected that the consumption of these subsidized grains would rise relative to other commodities. However, the subsidies are expected to reduce the consumers' expenditure on these grains. In the GTAP model, the private household consumption structure assumes constant-difference of elasticities (CDE) functional form to accommodate non-homothetic preferences, which allows for differences in income elasticities across commodities (Hertel, 1997). This structure facilitates the consumer to shift preferences to different commodities as their income change. The share of household consumption expenditure on food versus non-food is provided in Figure 1. As India's GDP grows, the baseline trend in shifting of consumption expenditure away from food supports Engel's law. Furthermore, Figure 1 shows the change in share of Indian household consumption expenditure after introducing NFSA compared to the baseline scenario.

< Figure 1 appears here >

After implementing NFSA, the consumption expenditure on food fell by 4.5% and that of non-food increased by more than 2%. This trend continued but at a decreasing rate throughout 2050. In Figure 2, we compare the household consumption expenditure across baseline versus NFSA scenarios. In 2015 (post-NFSA), the model predicted consumer expenditure on paddy rice dropped by USD 9 billion, and that of wheat by USD 18 billion. Some of this drop in consumer expenditure on the staple food grains, is spent on oilseeds (USD 9 billion) followed by other food products. . In this scenario since we assume subsidies remain in place, this trend of shift in consumption expenditure away from staple grains towards non-food sectors, and to smaller extent towards oilseeds and other food products.. Interestingly, the total consumption expenditure slightly decrease in the NFSA case compared to baseline. This may be attributed to decline in household factor income as the subsidies induce allocative inefficiency in the economy.

< Figure 2 appears here >

This reallocation of consumption expenditure results in a small increase in import of oilseeds (USD 10 million), but larger import of other agricultural commodities such as fruits and

vegetables (USD 2.34 billion), and other processed food products (USD 1.26 billion) in 2015, and this trend continues through 2050.

The impact of NFSA on market prices in India as well as the world prices are presented in Table 2. A consumption subsidy reduces the market price for consumers, but for producers it raises above the market prices. As seen from Table 2, the first panel indicates the model predicted baseline market prices in India. If we compare these prices with the baseline world prices presented in third panel, the market prices in India in all of the agricultural commodities listed in table except for paddy rice, exceed the world price. This trend is observed in the sectors when there are tariffs on imports. With the implementation of NFSA, the market price of paddy rice and wheat rise respectively by 4% and 5%, relative to the baseline in 2015. Similarly, the price of all other crops rise modestly by around 1 to 2% above the baseline. Similar trend is observed in each time period through 2050.

< Table 2 appears here >

However, the model predicted relatively much smaller change in world price (0.6% in paddy rice, 1.6% in wheat, less than 1% in other commodities) due to implementation of NFSA in India. This may be attributed to trade barriers such as import tariffs which do not transmit the higher domestic prices to the international markets.

3.3 Impact of Food Security and Biofuels Policies on Crop Production

As discussed in section-3, we implement biofuel policy (NPB) scenario separately and also combined NPB scenario with NFSA scenario starting 2010. Our analyses of the two policy scenarios (NFSA and NPB) compared with baseline help in providing insights on food versus fuel security debate. With the introduction of NPB, the model predicted virtually no impact on market price of agricultural commodities (Table 2). Evidently, the model predicted biofuel policy driven impact on crop production and land use change are also insignificant. In Table 3, we present baseline crop production in Mt and percent change in production across NFSA and NPB scenarios from baseline.

< Table 3 appears here >

The top panel of Table 3 offers change in crop production due to NFSA relative to baseline scenario. When NFSA is implemented in 2010, the model predicts rise in production of paddy rice by 3.6% and that of wheat by about 7% by 2015, while the production of other crops fall only

marginally (less than 1%). However, starting 2020, production of other agriculture sector (fruits and vegetables) rise sharply by 22% and continue to do so through 2050. This rise in production of other agriculture is mainly driven by the shift in consumption expenditure towards these crops, as discussed above. Though we noticed consumer expenditure shifting slightly towards oilseeds, the model predicted small decline in domestic oilseed production, while the oilseeds production from rest of the world showed a small increase post-2020.

When NPB policy was implemented separately, the model predicted only noticeable change in sugarcane production. Though production of sugarcane ethanol requires supply of feedstock, it is interesting to note that the model predicted rise in moderate imports of other food products (sugar), most of which was imported from Brazil. Currently sugar mills in India are permitted to produce ethanol only from molasses, a by-product of sugar production (Aradhey, 2015). In principle, ethanol production in India depends on the availability of molasses, and does not directly compete with food sources. With cyclical nature of sugarcane production, the surplus molasses during the crushing season is exported to European countries for using it in cattle feed. As Ray et al. (2011) apprise, the sugarcane production in India is mainly determined by the harvested area, yield, and the proportion of sugarcane procured and crushed by the sugar factories. Those authors also report that historically there has been considerable variation in the area under sugarcane, with cyclical pattern of output mainly due to profitability of sugarcane relative to that of other crops grown in a shorter time span. It is clear from Table 3 that NFSA dominated the market impacts compared to that of NPB policy.

In terms of physical availability of food from supply point of view, we compare the per capita availability of paddy rice and wheat in India across the three scenarios in Table 4. In 2010, about 127 kg of rice and 68 kg of wheat was available per person per annum. With the greater increase in crop production as predicted in the baseline, the per capita availability of food grains significantly increased by about 11% at each time period through 2050. With the introduction of NFSA, the increase in annual food availability is around 5 kgs each of rice and wheat per person.

< Table 4 appears here >

3.4 Impact on Land Use and Land Cover

When food security and biofuel policies drive production of crops, it can lead to consequences on land use and land cover. It is important to note that the model predicted land use

and land cover change are highly sensitive to yield elasticity of elasticities of transformation in the land supply. Before we report the land use impacts, let us discuss the two key factors that influence the yield per hectare in the GDyn-E-BIO model: (i) yield elasticity with respect to price and (ii) exogenous total factor productivity (TFP) growth.

The yield elasticity in the model captures the responsiveness of crop yields to the change in the price of a given crop relative to input prices. Based on an estimate from Keeney and Hertel (2009), a value of 0.25 is used for all crops, in all regions. Those authors infer that based on the empirical estimates, the yield response is not zero in the long run. The overall change in yield is an aggregate effect of: (a) intensive margin (more crops grown in the same area due to intensification), and (b) extensive margin (shift in crops to other crops' area and/or shift in crops to other land covers such as forestry or pasture). The yield elasticity mainly drives the intensive margin yield effects by responding to changes in the price of a crop relative to the prices of its inputs. The second factor driving crop and livestock yields is the exogenous TFP growth, which is included in the baseline (discussed in section 2). As observed in the baseline results, above mentioned factors have contributed towards to greater rise in crop production.

With the NFSA and NPB policies, the rise in demand for staple food grains and sugarcane feedstock is expected to bring in more land under cultivation of these crops. This additional demand to increase the output could lead to intensification of the crops that could bring higher yields. The change in harvested area (land use change) in India across the scenarios are presented in Table 5. When NFSA is implemented, production of paddy rice and wheat expand to meet the rise in demand for staple grains. As a result, area under paddy rice and wheat expand by 1.5% and 5%, respectively, in 2015. Whereas, harvested area of all other crops such as other agriculture, followed by other cereal grains, and other oilseeds, drop moderately (around 1%). With this adjustment in cropping pattern, the model predicts that only about 0.19 million hectares (0.10%) of additional cropland is needed in India in 2015. Whereas, in 2020 the demand for additional cropland expands by 1% (2.0 Million hectares). However, the area under other agricultural sector shrinks despite of its production increase (due to growth in yields, as noted above), resulting in only a small portion of additional cropland required throughout. Given that the historical crop yields in India are much lower than the yields in developed countries, there is tremendous potential for raising crop yields in India through innovative technological adoption. This will help India sustain food security as well as produce biofuels for transportation.

< Table 5 appears here >

Interestingly, the NPB policy did not result in any significant increase in area under sugarcane as seen from the bottom panel of Table 5. This may be attributed to the fact that ethanol production in India is determined mainly by the availability of molasses, not directly demanding sugarcane as feedstock. The cost structure of Indian sugar ethanol sector in the model also reflects this pattern with sugarcane constituting only a small fraction, while the chemicals sector contributing to a larger share of the sugar ethanol industry.

The total change cropland as noted in Table 5 is allowed to come from conversion of pasture or forest covers. Table 6 presents the land cover change in India and Globe across the two policy scenarios. In 2015, after implementation of NFSA, only 0.19 million hectares of additional cropland is required in India to meet the demand for additional crops and this comes from depletion of forest (0.11 million hectares) and pasture (0.07 million hectares). This trend with similar magnitude of land conversion continues through 2050 in India. Globally the additional cropland required in 2015 is about 0.163 million hectares and interestingly the forest cover does not deplete during this period, rather the additional land comes from depletion of pasture alone (0.21 million hectares). However, starting 2020, a small portion of forest cover start converting along with the pasture cover.

Further, when NPB policy of E20 is included along with NFSA, the additional cropland required in India change only marginally (0.221 million hectares) in 2020, with NPB policy impacting requirement for only additional 0.064 million hectares of cropland. This cropland in India comes mainly from conversion of forest and a small fraction from pasture cover. However, globally the additional cropland (0.0225 million hectares) comes mainly from degradation of pasture land (0.116 million hectares), followed by forest depletion (0.109). Post-2020, pressure on requirement for additional cropland due to NFSA and NPB policies diminishes globally. Since degradation of forest and pasture lead to carbon emissions due to burning of biomass and soil carbon loss, the impact of NFSA and NPB on land cover change imply that these policies do not harm the environment from land degradation point of view.

< Table 6 appears here >

3.5 Impact of NFSA and NPB Policies on real GDP

When the NFSA was introduced in India, one of the major criticism was about its massive outlay, which could be spent in alternative ways such as investment in agriculture, employment generation, rural and urban infrastructure, etc. (Gulati et al. 2012). Currently food subsidies provided by the government in India constitute about USD 21.5 billion for the year 2014-15 (Government of India, 2015). In Table 7, we present the change in India's real GDP across the two policy scenarios in comparison with baseline. With the introduction of NFSA, the real GDP drops by 1.53% in 2015 and continue to drop around 1% throughout 2050. This drop in real GDP mainly comes from change in consumption expenditure and government spending due to introduction of food subsidies. However, the real GDP increased by a margin of 0.2% when NPB policy was introduced. This implies that while India's fuel security policy help boost its economy, the food security policy proves counterproductive to its economic growth.

< Table 7 appears here >

4. Conclusions and Policy Implications

This study makes an attempt to provide better understanding on the consequences of India's food security policy (NFSA) on food consumption pattern, international trade, crop production, land use and land cover change, and real GDP. The detailed incorporation of explicit crops in the dynamic CGE model helps in precisely identifying the change in cropping pattern and distribution forward in time. Our study indicated that the food subsidies provided through NFSA affects growth of India's economy by about 1% per annum, while the NPB policy moderately contributes towards economic growth. However, subsidies did not indicate strong detrimental impact on cropping pattern, market prices, and land use and land cover change. Though India could grow sufficient food grains, mere availability of grains would not address the food security concern. Efficient distribution of food with minimal market distortion measures could go a long way in making the country as well as globe food secure.

Apart from this food security scenario, the biofuels scenario (NPB) helps in understanding if the increased demand for biofuel feedstock crops (sugarcane) displaces crops away from food and feed sectors in India. Our analysis revealed that there was no significant increase in demand for additional cropland due to NPB policy that would lead to degradation of pastureland and deforestation in India or elsewhere in the world. The results also provided insights on the role of

biofuels policy on change in food prices and consumption pattern over the long run in India and found that the change in domestic prices have only partially transmitted across the border to impact rest of the world.

Since food versus fuel security is a highly debated topic across the world, there are a number of interesting areas of research are opening up on this subject. A majority of the world's poor earn their living either directly or indirectly from agriculture. If the food prices are higher, they would appear to benefit from higher returns to farming. However, they also spend a large share of their income on food. Any policies on food or fuel security could directly impact the net impact on poverty and it could differ from region to region. Also, since the subsidies such as under NFSA are provided based on the poverty line, the impact of these policies different across different households and income groups. In this study we have one aggregated consumer class in the CGE model. Further work on classification of households by different income groups and implementing food security policies targeted specific to these households would give in-depth understanding of the policy impacts. Another qualification of this study is that our model does not account for water use, which is a significant constraint for sugarcane expansion in India.

Tables and Figures

Table 1. Baseline Projections of Food Grains and Fuel Markets in India.

		2004	2010	2015	2020	2025	2030	2035	2040	2045	2050
<i>Exogenous variables</i>											
Population	Billion	1.09	1.19	1.27	1.34	1.4	1.45	1.5	1.53	1.56	1.58
Real GDP	2010 USD trillion	0.76	1.25	1.75	2.17	2.42	2.83	3.49	4.28	5.16	6.11
Per capita real GDP	2010 USD/person	701.2	1052.3	1374.5	1621.8	1731.0	1949.7	2323.4	2797.2	3307.7	3867.7
<i>Endogenous variables (model predicted)</i>											
Paddy Rice											
Market Price	2010 USD/Mt	235.1	351.9	473.1	596.7	596.3	584.3	595.3	594.2	581.6	574.9
Production	Mill tonnes	124.7	150.9	178.4	213.8	258.4	306.9	357.6	412.3	474.9	546.8
Yield	tonnes/hectare	3.0	3.6	4.2	5.0	6.1	7.2	8.3	9.6	11.1	12.9
Net Trade	Mill tonnes	0.43	0.03	0.00	-0.02	-0.01	0.02	0.03	0.04	0.03	0.01
Per capita availability	Kg/annum	113.8	126.7	140.7	159.6	184.3	211.1	239.0	269.1	304.3	346.1
Wheat											
Market Price	2010 USD/Mt	177.7	235.6	284.9	329.6	315.6	300.7	294.2	284.4	270.7	259.6
Production	Mill tonnes	73.0	81.5	90.5	101.0	116.1	134.7	154.6	178.1	207.5	243.1
Yield	tonnes/hectare	2.7	3.1	3.5	4.0	4.7	5.5	6.3	7.3	8.6	10.2
Net Trade	Mill tonnes	3.41	0.98	1.07	1.37	4.11	9.78	16.41	26.39	41.50	60.11
Per capita availability	Kg/annum	63.7	67.7	70.5	74.4	79.9	85.9	92.4	99.0	106.4	115.8
<i>Fuel Market (model predicted)</i>											
Petroleum consumption	Quad Btu	2.01	2.68	3.49	4.38	4.51	4.64	5.14	5.85	6.74	7.79
Ethanol consumption	Billion gallons	0.05	0.13	0.23	0.39	0.76	1.22	1.71	2.35	3.08	3.97

Table 2. Impact of NFSA on Market Prices in India and World Prices

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Market Price in India (Baseline) (2010 USD /Mt)									
Paddy Rice	351.9	473.1	596.7	596.3	584.3	595.3	594.2	581.6	574.9
Wheat	235.6	284.9	329.6	315.6	300.7	294.2	284.4	270.7	259.6
Corn	202.2	252.1	296.7	284.9	270.9	265.4	256.0	242.6	231.9
Coarse Grains	180.6	225.4	264.1	251.4	237.3	232.4	224.7	214.3	205.8
Soybean	359.8	469.2	576.1	572.1	553.9	552.0	542.1	524.0	510.6
Rape/Mustard	600.5	780.9	959.5	956.2	927.8	923.5	905.0	871.1	846.0
Sugarcane	27.2	35.5	43.5	42.6	41.1	41.3	40.5	39.0	37.9
Other Agri	487.5	646.7	818.9	835.5	814.7	809.9	796.0	772.0	753.8
Percent Change in Market Price in India (NFSA-Baseline)									
Paddy Rice	0	3.9	3.4	3.0	2.7	2.2	1.9	1.6	1.3
Wheat	0	5.6	5.7	5.2	4.5	3.8	3.2	2.7	2.1
Corn	0	1.6	1.4	1.2	1.0	0.7	0.6	0.4	0.3
Coarse Grains	0	1.6	1.4	1.2	1.0	0.7	0.6	0.4	0.3
Soybean	0	1.5	1.3	1.1	1.0	0.7	0.5	0.4	0.2
Rape/Mustard	0	1.5	1.3	1.1	1.0	0.7	0.5	0.4	0.3
Sugarcane	0	1.7	1.4	1.2	1.1	0.7	0.6	0.4	0.2
Other Agri	0	1.5	1.3	1.1	1.0	0.7	0.5	0.4	0.2
World Price (Base) (2010 USD /Mt)									
Paddy Rice	423.4	539.8	697.0	815.0	927.9	1016.8	1058.4	1044.8	1059.5
Wheat	201.9	242.3	281.9	291.8	297.2	299.6	296.6	288.4	283.0
Corn	160.7	201.7	251.3	293.3	340.5	389.1	436.3	482.0	536.5
Coarse Grains	167.6	207.8	254.8	292.5	343.3	413.6	510.4	645.9	807.3
Soybean	297.9	365.4	433.2	460.6	477.1	485.1	486.0	480.5	478.2
Rape/Mustard	389.5	476.2	565.0	594.3	606.0	611.3	605.1	587.5	576.0
Sugarcane	28.3	36.7	46.0	50.0	53.7	58.2	62.2	65.8	70.1
Other Agri	291.3	363.8	455.6	519.1	580.9	636.3	677.8	702.4	738.0
Percent Change in World Price (NFSA-Baseline)									
Paddy Rice	0	0.6	0.7	0.5	0.4	0.2	0.1	0.1	0.0
Wheat	0	1.6	1.6	1.4	1.2	1.0	0.8	0.7	0.5
Corn	0	0.3	0.3	0.3	0.4	0.3	0.2	0.2	0.1
Coarse Grains	0	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.2
Soybean	0	0.4	0.3	0.3	0.4	0.3	0.2	-0.1	-0.3
Rape/Mustard	0	0.5	0.5	0.4	0.4	0.3	0.2	0.1	0.1
Sugarcane	0	0.9	0.7	0.6	0.6	0.4	0.3	0.1	0.0
Other Agri	0	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1

Table 3. Change in Crop Production in India across in NFSA and NPB Scenarios

Scenarios	2010	2015	2020	2025	2030	2035	2040	2045	2050
Baseline (Million tons)									
Paddy Rice	150.9	178.4	213.8	258.4	306.9	357.6	412.3	474.9	546.8
Wheat	81.5	90.5	101.0	116.1	134.7	154.6	178.1	207.5	243.1
Corn Grain	18.3	20.0	21.8	24.3	27.3	30.5	34.0	38.0	42.6
Other Cereal Grains	21.0	22.7	24.7	27.5	30.9	34.3	38.1	42.7	48.2
Soybean	8.0	9.1	10.6	12.8	15.2	17.5	20.0	23.1	27.0
Rapeseed-Mustard	7.2	8.3	9.6	11.7	13.8	15.9	18.1	20.8	24.0
Other Oilseeds	21.2	24.4	28.4	34.3	40.6	46.6	53.3	61.3	70.9
Sugarcane	280.4	325.0	380.6	451.6	533.7	622.2	717.0	825.3	952.3
Sugarbeet	1.1	1.3	1.4	1.7	2.0	2.3	2.7	3.1	3.7
Other Agri	324.7	388.2	388.2	475.0	590.8	701.6	805.3	928.4	1083.0
Total	914.4	1067.8	1180.2	1413.3	1695.9	1983.1	2279.0	2625.2	3041.4
Percent Change in Production (NFSA- Baseline)									
Paddy Rice	0	3.65	3.21	2.81	2.52	2.30	2.10	1.88	4.58
Wheat	0	6.91	6.52	5.64	4.66	4.02	3.41	2.86	4.45
Corn Grain	0	-0.28	-0.26	-0.25	-0.24	-0.20	-0.18	-0.15	1.01
Other Cereal Grains	0	-0.24	-0.21	-0.21	-0.20	-0.17	-0.15	-0.12	3.04
Soybean	0	-0.46	-0.41	-0.43	-0.38	-0.32	-0.27	-0.22	-0.44
Rapeseed-Mustard	0	-0.46	-0.41	-0.42	-0.38	-0.32	-0.27	-0.21	-0.57
Other Oilseeds	0	-0.45	-0.41	-0.42	-0.38	-0.32	-0.27	-0.22	-0.33
Sugarcane	0	-0.21	-0.23	-0.23	-0.22	-0.21	-0.20	-0.23	2.49
Sugarbeet	0	-0.86	-0.77	-0.68	-0.57	-0.41	-0.33	-0.21	2.83
Other Agri	0	-0.45	21.86	23.87	18.35	14.44	14.97	16.39	19.27
All Agri	0	0.94	8.23	8.90	7.12	5.75	5.86	6.28	8.87
Percent Change in Production (NPB- Baseline)									
Paddy Rice	0	0.04	0.14	0.10	0.07	0.04	0.00	-0.16	2.10
Wheat	0	0.01	-0.01	-0.01	0.00	0.08	0.10	0.18	-0.76
Corn Grain	0	0.01	-0.01	-0.01	0.01	0.04	0.05	0.06	0.32
Other Cereal Grains	0	0.01	-0.01	-0.01	0.01	0.04	0.06	0.09	-0.52
Soybean	0	-0.01	-0.01	0.00	0.03	0.08	0.09	0.11	0.63
Rapeseed-Mustard	0	-0.01	0.00	0.00	0.03	0.08	0.09	0.12	0.19
Other Oilseeds	0	-0.01	-0.01	0.00	0.03	0.08	0.08	0.10	0.61
Sugarcane	0	0.14	0.49	0.33	0.19	0.09	0.10	0.06	0.05
Sugarbeet	0	0.11	0.08	0.07	0.05	0.13	0.11	0.15	-0.26
Other Agri	0	-0.01	22.36	24.37	18.81	14.86	15.36	16.76	17.76
All Agri	0	0.05	7.54	8.31	6.63	5.30	5.47	5.94	6.67

Table 4. Impact of NFSA on Per Capita availability of Paddy Rice and Wheat in India

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Paddy Rice (<i>Kg per person per annum</i>)									
Base	126.7	140.7	159.6	184.3	211.1	239.0	269.1	304.3	346.1
NFSA	126.7	145.8	164.8	189.5	216.4	244.5	274.7	310.0	362.0
<i>Change (NFSA-Base)</i>	0.0	5.1	5.1	5.2	5.3	5.5	5.7	5.7	15.9
Wheat (<i>Kg per person per annum</i>)									
Base	67.7	70.5	74.4	79.9	85.9	92.4	99.0	106.4	115.8
NFSA	67.7	75.6	79.6	85.4	91.7	98.5	105.5	113.2	118.1
<i>Change (NFSA-Base)</i>	0.0	5.2	5.2	5.5	5.8	6.2	6.5	6.8	2.3

Table 5. Change in Harvested Area in India across Scenarios

Scenarios	2010	2015	2020	2025	2030	2035	2040	2045	2050
Baseline (Million hectares)									
Paddy Rice	42.5	42.7	42.9	42.7	42.7	43.0	43.1	42.9	42.4
Wheat	26.5	26.0	25.4	24.8	24.6	24.4	24.2	24.1	23.7
Corn Grain	7.7	7.4	7.0	6.7	6.5	6.4	6.2	6.0	5.8
Other Cereal Grains	21.0	20.0	19.0	18.1	17.5	17.1	16.6	16.2	15.8
Soybean	7.4	7.3	7.2	7.2	7.2	7.2	7.1	7.1	7.0
Rapeseed-Mustard	5.3	5.3	5.3	5.3	5.3	5.2	5.2	5.1	5.1
Other Oilseeds	14.5	14.5	14.4	14.5	14.5	14.4	14.3	14.1	13.9
Sugarcane	4.0	4.0	4.0	3.9	3.9	3.9	3.9	3.8	3.7
Sugarbeet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Agri	59.2	60.8	60.8	62.6	64.1	64.2	63.7	63.5	63.4
Total	188.1	188.1	186.1	185.8	186.3	185.7	184.4	182.8	180.7
Percent Change in Harvested Area (NFSA- Baseline)									
Paddy Rice	0	1.45	1.24	1.13	1.05	0.97	0.91	0.82	5.16
Wheat	0	4.92	4.47	3.79	3.10	2.68	2.27	1.92	3.96
Corn Grain	0	-1.32	-1.17	-1.00	-0.86	-0.76	-0.66	-0.56	1.24
Other Cereal Grains	0	-1.28	-1.12	-0.94	-0.81	-0.71	-0.62	-0.52	2.74
Soybean	0	-1.58	-1.36	-1.16	-0.98	-0.85	-0.73	-0.62	-0.70
Rapeseed-Mustard	0	-1.69	-1.48	-1.26	-1.06	-0.92	-0.79	-0.66	-1.28
Other Oilseeds	0	-1.23	-1.07	-0.93	-0.81	-0.71	-0.62	-0.52	0.80
Sugarcane	0	-1.42	-1.26	-1.05	-0.90	-0.81	-0.72	-0.66	2.52
Sugarbeet	0	-1.84	-1.63	-1.35	-1.10	-0.89	-0.74	-0.57	-2.06
Other Agri	0	-1.52	1.69	1.14	-0.82	-1.53	-1.08	-0.81	1.16
All Agri	0	0.10	1.08	0.85	0.11	-0.18	-0.05	0.00	2.47
Percent Change in Harvested Area (NPB- Baseline)									
Paddy Rice	0	0.02	0.07	0.05	0.01	-0.02	-0.04	-0.14	1.28
Wheat	0	0.01	-0.03	-0.02	-0.03	0.02	0.05	0.12	-0.60
Corn Grain	0	0.00	-0.03	-0.02	-0.02	-0.01	0.00	0.02	0.26
Other Cereal Grains	0	0.00	-0.03	-0.02	-0.02	-0.01	0.00	0.03	-0.35
Soybean	0	-0.01	-0.03	-0.02	-0.01	0.00	0.01	0.04	0.49
Rapeseed-Mustard	0	-0.01	-0.03	-0.02	-0.01	0.01	0.01	0.04	0.25
Other Oilseeds	0	-0.01	-0.03	-0.02	-0.01	0.02	0.03	0.05	0.35
Sugarcane	0	0.11	0.35	0.23	0.11	0.15	0.20	0.11	0.32
Sugarbeet	0	0.08	0.05	0.04	0.01	0.05	0.05	0.10	0.64
Other Agri	0	-0.02	3.02	2.26	0.12	-0.70	-0.34	-0.14	-0.43
All Agri	0	0.00	1.00	0.77	0.04	-0.24	-0.11	-0.05	0.11

Table 6. Change in Land Cover in India & Globe across NFSA and NPB Scenarios

	2010	2015	2020	2025	2030	2035	2040	2045	2050
India (Million hectares)									
Baseline									
Forest	17.8	17.3	17.0	16.9	16.9	17.0	17.1	17.3	17.9
Cropland	171.2	171.2	171.0	170.3	169.4	168.4	167.2	165.8	163.7
Pasture	10.8	11.2	11.6	12.1	12.9	13.8	14.8	15.8	17.0
Change (NFSA - Baseline)									
Forest	0	-0.114	-0.092	-0.079	-0.071	-0.068	-0.064	-0.060	NA
Cropland	0	0.187	0.157	0.140	0.132	0.130	0.127	0.129	NA
Pasture	0	-0.073	-0.065	-0.061	-0.061	-0.062	-0.063	-0.068	NA
Change (NFSA+NPB - Baseline)									
Forest	0	0.043	-0.098	-0.222	-0.327	-0.367	-0.718	-1.459	NA
Cropland	0	0.163	0.221	0.219	0.222	0.235	0.246	0.237	NA
Pasture	0	-0.206	-0.123	0.003	0.104	0.131	0.471	1.221	NA
Global (Million hectares)									
Baseline									
Forest	1639	1595	1564	1545	1527	1503	1467	1424	1385
Cropland	1561	1569	1569	1564	1556	1544	1526	1499	1461
Pasture	2769	2805	2835	2859	2886	2921	2975	3045	3122
Change (NFSA - Baseline)									
Forest	0	0.043	-0.098	-0.222	-0.327	-0.367	-0.718	-1.459	NA
Cropland	0	0.163	0.221	0.219	0.222	0.235	0.246	0.237	NA
Pasture	0	-0.206	-0.123	0.003	0.104	0.131	0.471	1.221	NA
Change (NFSA+NPB - Baseline)									
Forest	0	0.040	-0.109	-0.230	-0.332	-0.373	-0.719	-1.455	NA
Cropland	0	0.165	0.225	0.221	0.224	0.237	0.248	0.239	NA
Pasture	0	-0.205	-0.116	0.008	0.108	0.136	0.471	1.216	NA

Table 7: Change in real GDP across different Scenarios.

	(2010 USD trillion)								
	2010	2015	2020	2025	2030	2035	2040	2045	2050
Baseline	1.252	1.746	2.173	2.423	2.827	3.485	4.280	5.160	6.111
NFSA	1.252	1.719	2.141	2.393	2.798	3.452	4.246	5.127	6.077
NPB	1.252	1.748	2.178	2.429	2.836	3.493	4.289	5.169	6.119
NFSA+NPB	1.252	1.719	2.141	2.393	2.797	3.451	4.245	5.127	6.074
NFSA - Base (% change)	0%	-1.53%	-1.47%	-1.25%	-1.04%	-0.96%	-0.80%	-0.64%	-0.56%
NPB – Base (% change)	0%	0.15%	0.23%	0.24%	0.32%	0.22%	0.21%	0.17%	0.13%
(NFSA+NPB)- Base (% change)	0%	-1.53%	-1.49%	-1.27%	-1.05%	-0.97%	-0.81%	-0.65%	-0.60%

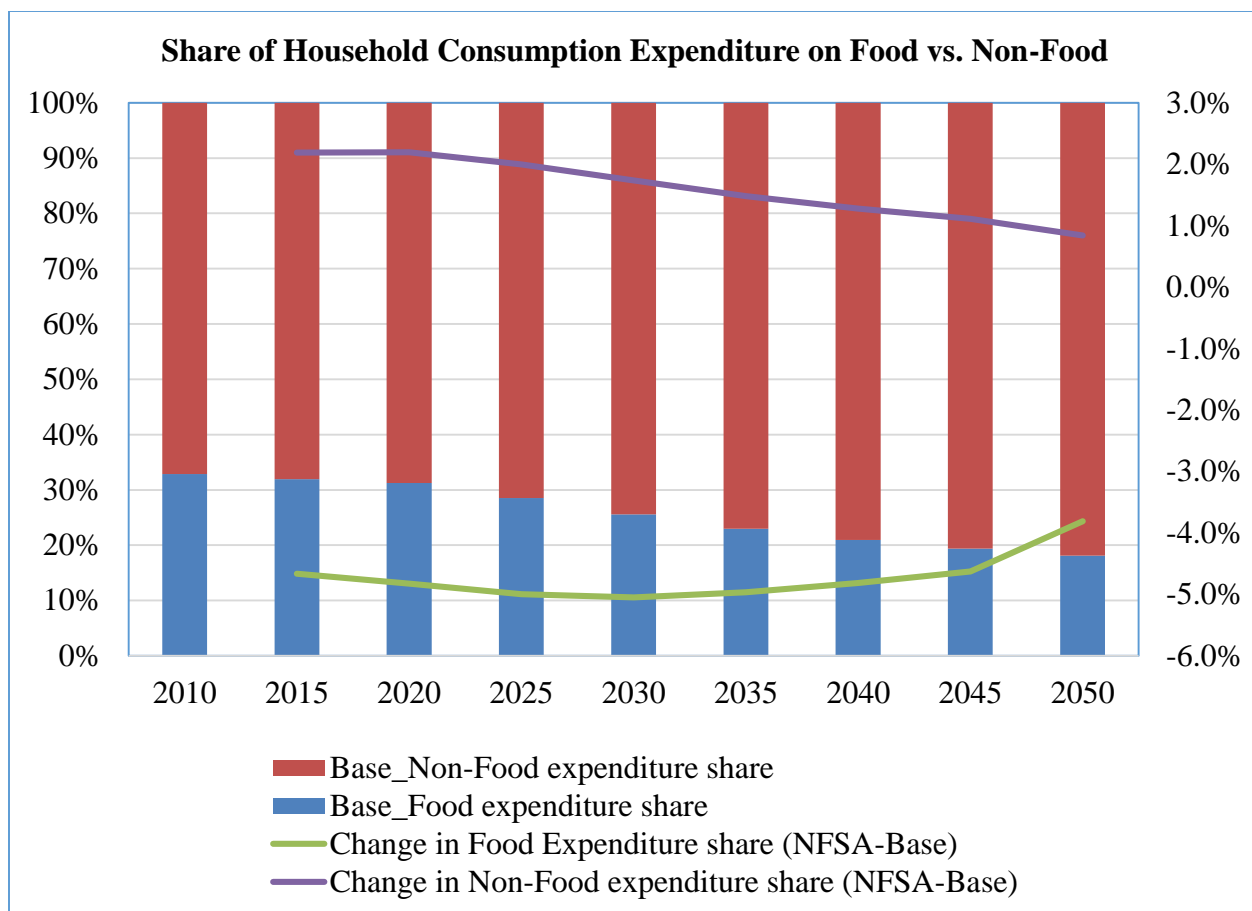


Figure 1. Share of Household Consumption Expenditure on Food vs. Non-Food in India

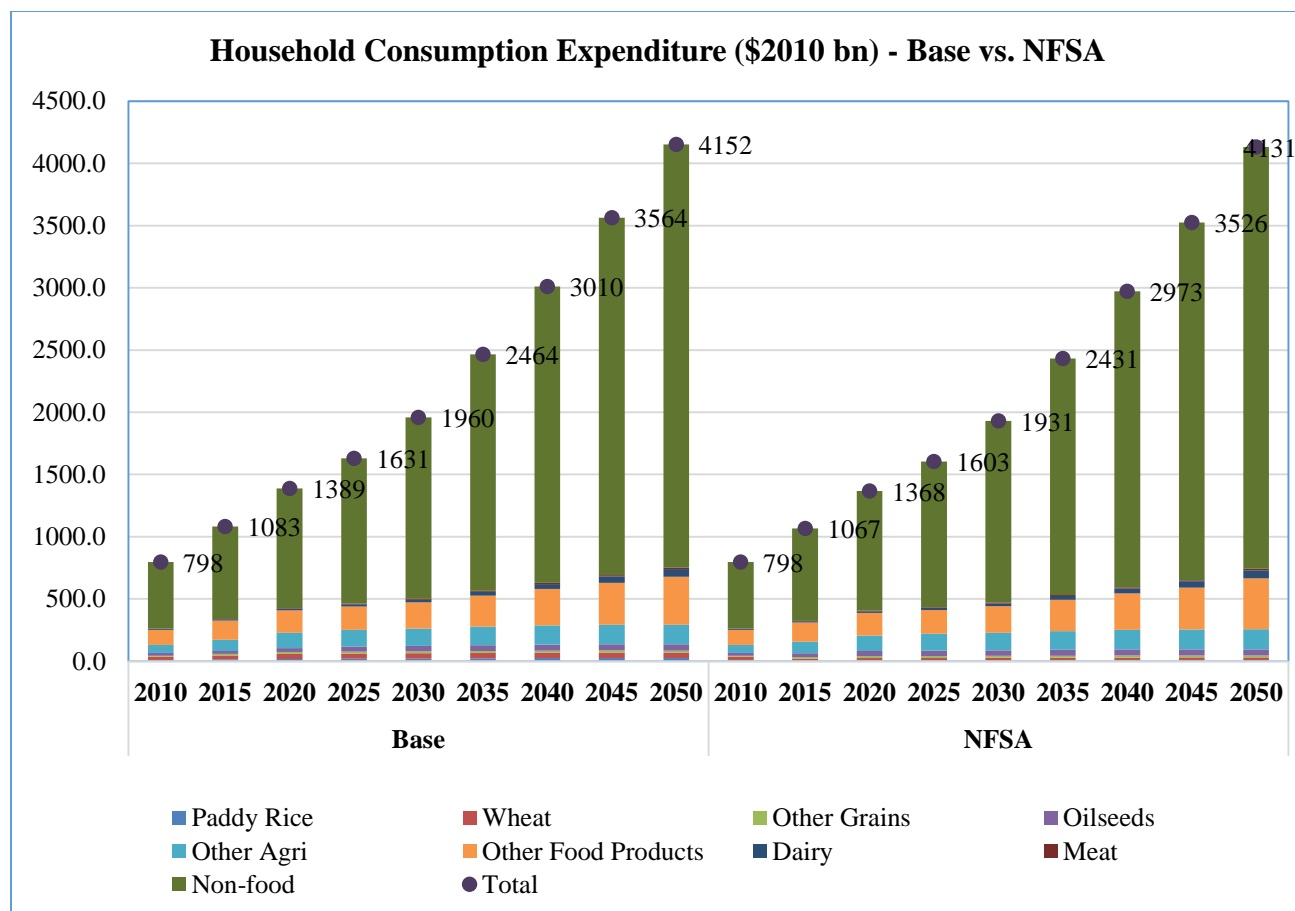


Figure 2. Household Consumption Expenditure in India –Base versus NFSA Scenarios

Appendix

Table A1. Aggregation of Regions in the Model.

<i>No.</i>	<i>Region-Code</i>	<i>Region Description</i>	<i>Comprising GTAP regions</i>
1	USA	United States	United States of America.
2	EU27	European Union 27	Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Bulgaria; Romania.
3	Brazil	Brazil	Brazil
4	Canada	Canada	Canada
5	Mexico	Mexico	Mexico
6	Japan	Japan	Japan
7	China	China, Hong Kong	China; Hong Kong.
8	India	India	India
9	Russia	Russia	Russia
10	SAfrica	South Africa	South Africa
11	Argentina	Argentina	Argentina
12	Korea	Korea	Korea
13	Indonesia	Indonesia	Indonesia
14	Thailand	Thailand	Thailand
15	Malaysia	Malaysia	Malaysia
16	LAEEEX	Latin American Energy Exporters	Bolivia; Colombia; Ecuador; Paraguay; Venezuela.
17	OthLACA	Rest of LatinAmerica & Caribbean	Rest of North America; Chile; Peru; Uruguay; Rest of South America; Costa Rica; Guatemala; Nicaragua; Panama; Rest of Central America; Caribbean.
18	RoWestEU	Rest of Western Europe	Switzerland; Norway; Rest of EFTA; Ukraine.
19	EastEU	Rest of Eastern Europe	Rest of Europe, Rest of Eastern Europe; Albania; Belarus; Croatia.
20	WestAsia	Western Asia	Rest of Western Asia; Kazakhstan; Kyrgyzstan; Rest of Former Soviet Union; Armenia; Georgia; Iran; Turkey.
21	RoSEAsia	Rest of South and S.East Asia	Taiwan; Phillipines; Singapore; Vietnam; bangladesh; Rest of Oceania; Rest of East Asia; Cambodia; Lao People's Democratic Republic; Rest of South East Asia; pakistan; Sri Lanka; Rest of South Asia.
22	NAfrica	Northern Africa	Rest of North Africa; Egypt; Morocco; Tunisia.
23	WCAfrica	Western and Central Africa	Nigeria; Rest of Western Africa; Senegal; Central Africa; South-Central Africa.
24	ESAfrica	Rest of East Africa and SACU	Ethiopia; Madagascar; Malawi; Mauritius; Mozambique; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Rest of South African Customs Union.
25	Oceania	Oceania	Australia; New Zealand.

Table A2. Aggregation of Sectors in the Model

No.	Sector-code	Description	Comprising sectors
1	PaddyRice	Paddy rice	pdr
2	Wheat	Wheat	wht
3	CornGr	Corn Grain	Corn grain
4	rCrGrains	rest of Cereal Grains	gron
5	Soybean	Soybean	soyb
6	RapeMustd	Rape-Mustard	rapm
7	Palm	Palm-Kernel	plmk
8	rOilseeds	rest of Oilseeds	osdn
9	Sugarcane	Sugarcane	scane
10	Sugarbeet	Sugarbeet	sbeet
11	OthAgri	All other Crops	ocr, pfb, v_f
12	Ruminant	Ruminants	ctl, wol
13	NonRumnt	Non-Ruminants	oap
14	RawMilk	Dairy Industry	rmk
15	Forestry	Forestry	frs
16	OthPrimSect	OtherPrimary:Fishery & Mining	fsh, omn
17	ProcRumt	Processed Ruminant Meat: cattle,sheep,goats,horse	cmt
18	ProcNRumt	Processed NonRuminant Meat products nec	omt
19	FoodPdt	Food Products nec	ofdn
20	OthFoodPdts	Sugar; Beverages & tobacco pdts, Proc Rice, Dairy Pdts.	sgr, b_t, pcr, mil
21	Chemicals	rest of Chemical,rubber,plastic prods	crpn
22	En_Int_Ind	Energy intensive Industries	i_s, nfm
23	Oth_Ind_Se	Other industry and services	tex, wap, lea, lum, ppp, nmm, fmp, mvh, otn, ele, ome, omf, wtr, cns, trd, cmn, ofi, isr, obs, ros, osg, dwe, wtp, atp
24	RoadTrans	Transport nec	otp
25	Coal	Coal	coa
26	CrudeOil	Crude Oil	oil
27	Electricity	Electricity and heat	ely
28	Gas	Natural gas	gas, gdt
29	Oil_pcts	Petroleum, coal products	p_c
30	Wht_Eth1	Wheat Ethanol	weth1
31	Scn_Eth2	Sugarcane Ethanol	sceth2
32	Sbt_Eth2	Sugarbeet Ethanol	sbeth2
33	Soy_biod	Soy Biodiesel	sbiod
34	Rape_biod	Rape-Mustard Biodiesel	rbiod
35	Palm_biod	Palm-Kernel Biodiesel	pbiod
36	Corn_Eth1	Corn Ethanol	ceth (Tcet)
37	DDGS	DDGS	ddgs (Tcet)
38	VegOil	Vegetable Oils	rvol (vol)
39	Oilmeal	Veg Oil-meal	omel (vol)
40	SwthGrass	Switchgrass	swgrs
41	Miscanthus	Miscanthus	mscts
42	CornResi	Corn Residue	cornresi
43	CellEth_CR	Corn Residue based cellulosic ethanol (Enzymatic)	celleth_cr
44	CellEth_SG	Switchgrass based cellulosic ethanol (Thermochemical)	celleth_sg
45	CellBiod_MC	Miscanthus based cellulosic biodiesel (Fischer-Tropsch)	cellbiod_mc

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