The Future of Indonesian Food Consumption

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Abstract

This study aims to develop a model of the future of Indonesia's food consumption up to 2045, using a baseline of food consumption in 2017 and projections to 2025 as milestones, and to draw policy relevance on food and related issues for the next Medium-Term Development Planning of 2020–2024. The projected demand of Indonesian food consumption is built based on the functional relationship between income and food consumption at the baseline using three different scenarios of economic growth: baseline, moderate, and optimistic. Method of Almost Ideal Demand System (AIDS) was implemented to estimate changes of food consumption. Susenas data from 2017 is used as the baseline of food demand model. Susenas data from 1990–2016 is used to analyze selected food consumption trends and the relationship between food consumption, price trends, and income in all 33 provinces of Indonesia. The results show that future food demand in Indonesia is determined by existing demand, income, price and its composition, and various other factors that affect the behavior and trends of consumption. The policy should focus on the balance between demand-side management and supply-side or productivity improvement, as the majority of food production centers are located in Java.

Keywords: food demand; AIDS; Susenas; Indonesia
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1. Introduction

The growing demand of food consumption in Indonesia has provided serious food policy challenges for the current government and these will continue in the years to come. Existing policies to increase the production of staple foods like rice, maize and soybeans (*Upsus Pajale*) might not be adequate to meet the increasing food demand. For the existing total population of 261 million, and the growth of 1.43 percent per year, coupled with increasing income growth of 5.01 percent per year especially among middle class, fulfilling the growing demand for food in Indonesia is not an easy task. Using the standard food-demand equation of Johnston-Mellor, the growth rate of food demand in Indonesia is estimated about 4.03 percent per year (using income elasticity for food is 0.52). When food production domestically is inadequate, food imports are necessary and economically justified, however, political considerations must also be taken into consideration, given Indonesia's adoption of food sovereignty Food Law 18/2012.

The United Nations Population Division (2015) projects that Indonesia's population will grow approximately 0.7 per cent annually to reach around 312 million in 2045. The real value of food production is projected to more than double in 2050 (Hamshere et al., 2014). Indonesian policy does not seem to tolerate food import dependency, especially with regards to rice as a staple food, and the government has been under pressure to increase local food production, sometimes at a very high cost to the state budget. Large fluctuations in prices have meant large fluctuations in the purchasing power of both consumers and farmers, and it has been difficult for many to adapt to these frequent changes. The world rice market has been unstable, much more so than other world grain markets, especially after the sharp price increases after the global food crisis in 2008-2009. On the whole, food security has improved in recent years but, as a result of climate change, more frequent cases of extreme weather and environmental risks such as droughts, floods, and landslides in food-production centers in Indonesia have posed serious risks to farming practices and crop production.

In the meantime, estimates of food consumption in Indonesia are not easily verified directly in the field. For example, the level of rice consumption in Indonesia has declined significantly from nearly 140 kilograms in 2006 to only 124 kilograms per capita per year in 2015. Nevertheless, rice consumption in Indonesia is very high compared to other Asian countries, which have an average of less than 100 kilograms per capita per year. Such a high level of rice consumption could trigger more problems for the Indonesian economy, including political controversy surrounding rice imports, although problems of data accuracy have been used in the past as an excuse by various political factions. Indonesia issued Presidential Regulation 22/2009 on food diversification to reduce the pressures on rice consumption, although such a diversification movement in the last decade has been operational only on paper. This procedural movement should be combined with the development of food technology, using simple know-how that is modern in nature, which complements and is compatible with Indonesia's current food production systems.

Moreover, a growing middle class in Indonesia and a high rate of urbanization have led to changes in dietary patterns and food demand both now and in the future, from fulfilling the demand for cereals or the consumption of 2.100 kilocalories per capita, to diversifying diets towards more balanced nutrition. Obviously, food demand in Indonesia will increase in quantity and quality as population and income increases, and awareness of balanced nutrition also increases. Better income and knowledge tends to make consumers demand healthier and more diversified food. Demand for cereals may decrease while consumption of fruit, vegetables, meat, fish and dairy products is likely to increase. For example, in the period from 1990-2013, consumption of fruit and dairy products doubled, especially among middle and high income groups. In other words, changing socio-economic-demographics will transform food systems in the future. Envisioning that transformation is a pivotal part of understanding our future food systems, this study seeks to model food demand in Indonesia until 2045, as one of the prerequisites to develop better food policies.

This study aims to develop a model of the future of Indonesia's food consumption up to 2045, using a baseline of food consumption in 2017 and projections to 2025 as milestones, and to draw policy relevance on food and related issues for the next Medium-Term Development Planning (RPJM) of 2020–2024. Food commodities include rice, maize, soybeans, sugar, beef, poultry, and fruit such as orange, apple, banana, mango and snake fruit, and vegetables such as shallot, garlic, red chili, hot chili, spinach and *kangkung*.

2. Literature Review

Studies on Indonesian food demand are usually conducted in conjunction with food security issues, which normally refer to main dimensions, namely: availability, accessibility and utilization. Food availability means that, on average, sufficient food supplies should be available to meet consumption needs. Food accessibility draws attention to the fact that, even with bountiful supplies, many people still go hungry because they do not have the resources to produce or purchase the food they need. Food utilization refers to many aspects of food safety and food quality to fulfill the degree of nutritious food absorbed by the human body. Food security issues in Indonesia are quite complex, not only because the scopes are cross-boundary at individual, household, national and global levels, but also because the dimensions are quite wide and include food availability, accessibility and price stability. The poverty level in Indonesia is still very high by ASEAN standards, and the number of people under the poverty line in 2017 was over 26.6 million or 10.1 percent of the total population. This group of people is very vulnerable to food price changes and production declines due to climate change and extreme weather such as droughts, floods, and natural disasters.

Timmer (2014) suggests that food security strategies in the Asia-Pacific region are in "almost total disarray" or sometimes known as 'food policy paradox'. There has been a fundamental disconnect between "food security strategies" and the actual "food policies" pursued by most Asia and Pacific countries. The disconnect is most evident with rice policy, where high prices for rice farmers are implemented to 'reduce poverty', when in fact most of the poor and hungry in the region are net rice buyers (some regions in Vietnam and China might be exceptions) and thus suffer more hunger and poverty from high rice prices. The disconnect between politically expressed food security strategies and actual policies put in place to implement these extends well beyond rice price policies, especially as a result of low public spending for research and development on food policies and agricultural development in general. A study on the long-run dynamics of rice consumption was conducted by Timmer et al. (2010), by disaggregating rice consumption in 11 countries by income or household expenditure, by quintile and by rural and urban population. Rice consumption in China, India and Indonesia accounts for 60 percent of world consumption. Other major rice consumers in Asia are the Philippines, Bangladesh, Vietnam and Thailand, although Vietnam and Thailand are also rice exporters. Some important findings of the study can be summarized as follows:

First, rice consumption experiences sharp differences according to income class for a given country or region at one point in time, especially if that income class is quite poor. *Second*, large differences between rural and urban rice consumption are common, but the differences change substantially over time and by income class. In most important rice-consuming areas, rural rice consumption is significantly higher than urban rice consumption. These patterns have sharp implications for future levels of rice consumption, when a larger share of the population will work in urban areas.

Third, the income elasticity of demand for rice from cross-section data depends on whether the household lives in a rural or urban area. Most income elasticity for urban households are now zero or negative, which confirms the behavior of Engel curves, which are flattening out during progressive time periods; they are also falling in absolute terms. Income elasticity is more positive in rural areas, because incomes in these locations are lower on average. *Fourth*, there is a very dramatic convergence of rice consumption patterns across income classes in some Asian countries. This convergence is partly a result of flattening Engel curves across income classes as overall income levels rise, but it is also possible that tastes are changing in ways that make food consumption patterns more uniform across households, whatever their income levels and place of residence.

Declining rice consumption is quite common in most rice producing countries in Asia, although the rate of decline in Indonesia is quite small. As such, the dynamic declines of rice consumption are generally consistent with Bennett's Law, suggesting for an inherent desire for dietary diversity as incomes rise. Reardon and Timmer (2014) suggest that rural consumers in Asia fulfill about 70 percent of their daily calories from rice, as Asia is the only region in the world where a single food so dominates consumption patterns. More open trade, global communications and economic growth in most Asian countries has contributed to declining rice consumption and even to the negative income elasticity of the demand for rice. In this case, rice might eventually be associated with the food of the poor, although high income consumers in Indonesia might shift their consumption to premium or high quality rice. As a result, the stability of the price of rice remains a relevant policy issue for Indonesia and other rice producing countries in Asia.

Increases in internal food prices, including rice, during the Food Crisis from 2007–2008 also have raised poverty levels in Indonesia. The effect was significant, but not large and only temporary (Warr and Yusuf, 2014), as the weather was conducive to food production and the domestic food stock was sufficient to keep the increase in food prices manageable (Arifin, 2015). However, the percentage increase in poverty was larger in rural areas than urban areas, despite the fact that, for many of the rural poor, higher agricultural prices mean higher incomes. Their gain was outweighed by the losses incurred by a large number of the rural poor who are net buyers of food and the fact that, for these people, food represents a large share of their total budget, even larger on average than for the urban poor. Until recently, the food price has predominantly (73.4 percent) determined the poverty line in Indonesia, while the non-food price determines the remaining 26.6 percent. Among food commodities, the price of rice contributes to 24.5 percent of the poverty line in rural areas and 18.8 percent in urban areas (BPS, 2017).

Other studies of Indonesian long-term food demand projections for 2050 were also conducted by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), using the baseline of 2009 data (Hamshere et al., 2014). The study suggests that the real value of food consumption in Indonesia is projected to increase more than four times between 2009 and 2050, assuming there are no major changes in agricultural policies. The consumption increase is characterized by a move towards more diverse diets, with a higher intake of meat, dairy products, fruit and vegetables. The real value of beef consumption is projected to rise more than 14 times, dairy tenfold, and fruit and vegetables to more than triple. To support this rise in demand, imports of many agri food commodities are projected to increase up to 2050, and these imports may come from industrialized countries. The upward trend in food demand is most pronounced among urban households, whose income growth is assumed to be more than double that of rural households. A declining rural population and relatively lower incomes will result in slower growth in food consumption compared with the urban population.

If consumers' behavior regarding food demand is projected accurately, then fulfilling the rising demand for such high income elastic foods should be straightforward. Consumers tend to behave normally, and as their income increases, they tend to demand more diversified and healthy food. This includes not only the basic carbohydrates and protein sources, as consumers also tend to buy food at higher prices. The behavioral dimensions of consumers' response to price spikes should be understood properly, especially regarding rice and other staple foods, such as during the Food Crisis from 2007–2008. The crisis has taught us some lessons that the fear or negative expectations of a food crisis could lead to panic buying by consumers, especially the panic buying of rice. The amount of rice being traded in the international market is quite small and at risk of disappearing, so panic buying behavior could lead to even higher price spikes.

Another important factor contributing to the future of food demand in Indonesia is the rapid growth of supermarkets, especially in the last decade, that have served the food needs of the urban population. The growth of supermarkets could be associated with Indonesia's economic growth of over 5 percent in the last decade, increasing household incomes, and urbanization and food systems transformation (Reardon and Timmer, 2014; Reardon et al., 2014). Over the last two decades there has been substantial growth in the number of modern food retail outlets in Indonesia, as the number of supermarkets in Indonesia increased 67 percent from 1999 to 2009, while the number of hypermarkets increased by a factor of seven, and the number of mini-markets by a factor of 18. Furthermore, Indonesian households' spending on processed or packaged food made at supermarkets and hypermarkets grew from approximately 20 to 30 percent from 1998 to 2010 (Dyck et al., 2012). Reardon et al. (2014) suggests that in 2010, urban consumers in Indonesia spent 16 percent of their food budgets on rice, 15 percent on fruit and vegetables and 22 percent on animal proteins (meat, fish, eggs and dairy). Rural consumers spent 24 percent, 17 percent and 20 percent respectively. Yet these important diversification issues have received little coverage in the policy debates.

Unfortunately, the growing number of supermarkets has been closely associated with changing diets (Reardon and Timmer, 2014), and rates of obesity are increasing across all population groups and income levels (Umberger et al., 2015). Changing diets and nutritional levels associated with the existence of supermarkets also differ by income groups and between adults and children. Children have higher potential links between the use of supermarkets and the probability of being obese, especially those coming from high income households. Child nutrition may be relatively unaffected by the use of supermarkets among lower and middle income households because they don't have the disposable income to purchase convenience food and other processed foods that are high in sugar and fat. Adult consumers who have income constraints might purchase some expensive foods in supermarkets, albeit in a small quantity. However, adult consumers from high income groups might purchase processed food products which are less healthy, but will be consumed by the children in the household. In short, the combination of high income and a large amount of food purchased at supermarkets seems to be sufficient enough to change diets and result in a higher prevalence of overweight and obese children (Umberger et al., 2015). The policy relevance of these studies is that nutrition information messages aiming to reduce the prevalence of over-nutrition should focus on children in higher income households that obtain a large share of their food from supermarkets and other modern food retailers.

Meanwhile, consumers from middle and low income groups get food products from a large number of traditional markets, including wet markets and modernized traditional dry markets. Traditional markets also refers to street vendors, peddlers or mobile vendors, small retail outlets (*warungs*) and wet and dry markets managed by companies owned by local governments. These traditional markets usually provide fresh food such as meat, chicken, eggs, fish, fruit, vegetables and grains such as rice, maize and even soybeans. Modern supermarkets and convenience stores are generally assumed to replace traditional markets, but studies by Suryadarma et al. (2010) suggest that traditional markets are able to compete against modern retailers, especially if local governments continually improve their infrastructures. Traditional markets need to improve the quality of their service, including proper hygiene, sufficient cleanliness, ample lighting and an overall comfortable environment. In the past, there might have been a very specific number of foods offered in traditional markets, while modern supermarkets and hypermarkets generally offer a variety of food products at competitive prices such as dairy, imported foods, and frozen products or products with certain quality attributes such as organic foods. They also traditionally sell foods for convenience such as packaged and ready-to-eat meals. Since the urban population of Indonesia have rapidly increased from 40 million in 1984 to 134 million in 2014 (Reardon and Timmer, 2014) or from 25 percent of the national population in the 1980s to 52 percent in 2017 (BPS, 2017), the roles of supermarkets are important in the future of food access in Indonesia.

3. Method

First, the study identifies the model for demand equation, by selecting the best model from five different models, namely: linear, polynomial, semi-logarithmic, double-logarithmic and exponential. The best model criteria chosen to represent the model used in this study is the one with the highest R-square (R^2).

Table 1: Model Specification of the Food Demand

No	Model	Specification	Income Elasticity
1	Linear	$Q = \beta_0 + \beta_1 I + \varepsilon$	$e_I = \frac{\beta_1 I}{Q}$
2	Polynomial (degree-r)	$Q = \beta_0 + \sum_{r=1}^{R} \beta_r I^r + \varepsilon$	
3	Semi-Logarithmic	$Q = \beta_0 + \beta_1 \ln(I) + \varepsilon$	$e_I = \frac{\beta_1}{Q}$
4	Double-Logarithmic	$\ln(Q) = \beta_0 + \beta_1 \ln(I) + \varepsilon$	$e_I = \beta_1$
5	Exponential	$Q = \beta_0 e^{\beta_1 I}.\varepsilon$	$e_y = \beta_0 e^{\beta_1 I}$

Note: where Q is the quantity of consumption (kg/capita/year) and I is income per capita

Second, the Almost Ideal Demand System (AIDS) is employed to present empirical evidence about food consumption behavior in Indonesia. AIDS can also answer questions about the demands of consumer preferences. The basic model of AIDS, developed by Deaton and Meulbeaur (1980), is derived from the preferences of cost function. The advantages of the AIDS model are: (i) an arbitrary first-order approximation of any system request, (ii) fulfills the axiom of choice exactly, (iii) has a form of function consistent with household expenditure, (iv) is easy to estimate because it avoids the function which is non-linear, and (v) can be used to test the restrictions of homogeneity, symmetry and adding up properties.

The AIDS function is derived from the cost minimization process to maintain a fixed utility. From the result we can obtain the Hicksian demand function – where the quantity of goods is determined by the utility and price. By entering the Hicksian demand function into the expenditure, we will find the expenditure function – determined by the utility and price. By using Lemma Shepard we can obtain a basic model of AIDS in the form of the budget share. The system used here is:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(x/p^*) + \gamma_i \log(Z) + u_i \quad (1)$$

Where w_i is the budget share of food i, p_j are food prices j, x is food expenditure, and $p*$ is a stone index defined by:

$$logp^* = \sum_k w_k logp_k \quad (2)$$

The study uses the National Survey of Social and Economics (Susenas) data collected by the Central Agency of Statistics (BPS), which are usually adequate to develop and estimate the demand function. The demand for specific foods is determined by the price of the individual foods, the total expenditure on food and other factors (for example: number of family members, education).

After specifying the model, the procedure to conduct the AIDS approach is analyzing income elasticity, own price elasticity and cross-price elasticity:

(a) Income elasticity

$$\eta_i = 1 + (\beta_i + w_i)$$

Income elasticity is calculated by applying the regression on the total expenditure of the commodity bundle against a total household income. The regression model used in this analysis is the double log model, as follows:

$$\ln x = a + b \ln Y$$

Where x is the total of food expenditure and Y is income of household. Income elasticity is then calculated using the formula:

$$\eta t = b \times \eta_i$$

(b) Own-Price Elasticity

$$\varepsilon_{ii} = \left(\frac{\gamma_{ii}}{w_i}\right) - 1$$

Own-price elasticity is a simply calculated from the coefficients of the regression demand, on how consumers respond to changes in food price.

(c) Cross-Price Elasticity

$$\varepsilon_{ij} = \left(\frac{\gamma_{ij}}{w_i}\right)$$

Cross-price elasticity is measured to examine the relationship among food commodities, whether they are complementary, substitutions, or neutral.

Third, the projection analysis is conducted by applying information income elasticity, cross-price and own price. The elasticity is also used to determine the behavior of each commodity, whether the commodity is logarithmic, exponential or quadratic. Moreover, a regression analysis using panel data from 33 provinces in recent years is also employed to verify the functional relationship between demand for selected foods and income per capita and price trends.

4. Results

This section presents five important findings of the study, namely (1) food consumption of energy and protein, (2) consumption of selected food commodities by income group, (3) consumption of selected food commodities by province, (4) income and food consumption relations, and (5) projections of food demand in 2025 and 2045. Each will be briefly explained as follows:

4.1. Food Consumption of Energy and Protein

The measurements of the energy adequacy number (AKE) and protein adequacy number (AKP) which has been used as the national reference were formulated during the National Workshop on Food and Nutrition (WNPG) in 2012. Using the minimum requirement for AKE of 2,150 kcal per capita per year and AKP is 57 grams per capita per year, the last two poorest income quintiles or the households falling into Quintile 1 and 2 cannot meet the AKE and AKP (Figure 1 and 2).

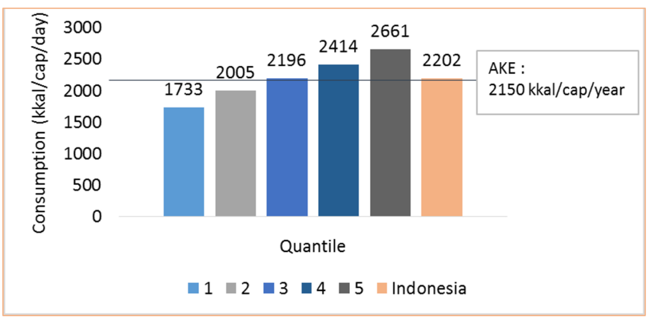

Figure 1: Average Consumption of Energy (Carbohydrates) by Income Group

In 2017, the average energy consumption of the Indonesian population was 2,202 kcal per capita per day, which exceeded the AKE set by the WNPG in 2012 by 2.5 percent. Food and nutrition economists generally use the following criteria to examine the nutrition adequacy number (AKG), namely: less than 80 percent of the AKG is considered inadequate, between 80 and 110 percent of the AKG is considered adequate, and higher than 110 percent is considered more than adequate. Figure 2 shows that the two lowest income quintiles in Indonesia fall into the category of nutrition deficiency with a figure of less than 80 percent. The energy consumption of people living in the first two highest quintiles exceeded the AKG, at 123.8 percent and 112.3 percent respectively. This finding is also consistent with the economic theory that food consumption in terms of energy adequacy increases as income increases.

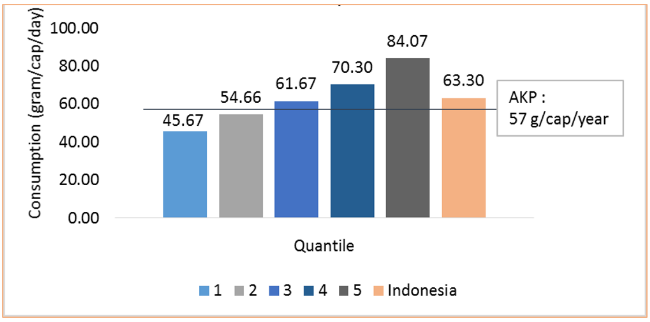

Figure 2: Average Consumption of Protein by Income Group

The average protein consumption in Indonesia in 2017 was 63.30 grams per capita per day, which exceeded the protein adequacy number (AKP) of 57 grams per capita per year or equivalent to 111 percent. By income group, the consumption patterns of protein are similar to those of carbohydrate consumption, which increases as income increases. It ranges from 45.67 gram in the lowest quintile to 84.07 grams per capita per year in the highest income group quintile. Protein consumption of the first two income group quintiles has not reached the recommended AKP or has fallen into protein deficiency as these income groups only consume protein at a figure of about 80 percent. The contrasting figures are found in the protein consumption of quintiles four and five, which fall into over consumption of 123.3 percent and 147.5 percent respectively.

4.2. Consumption of Selected Food Commodities by Income Group

The baseline consumption of selected food commodities in 2017 is presented in terms of income group and province, which have quite a strong relationship. The Bennett Law acknowledges the relationship between income groups and the quality of food consumption. Improvement of food quality increases as the household income increases. The finding shows that average rice consumption in 2017 was recorded at 97.6 kilograms per capita per year, which was significantly lower than the official rice consumption on 114 kilograms per capita. Further explanation of rice consumption could be found in the subsequent sections and chapters. In general, rice consumption in rural areas in Indonesia is a bit higher than urban areas. Under a market economy, the following explanation makes more sense.

Firstly, the income level of people living in urban areas is generally higher than that in rural areas. Secondly, food access in urban areas is relatively high compared to rural areas. Lower income groups tend to spend a greater proportion of their income on food, preferring to buy cheap but filling food, predominantly carbohydrates. Since the Asian Economic Crisis in 1998, the Government of Indonesia has provided a rice subsidy to the lowest income group of the population of about IDR20 trillion each year. This rice subsidy, known as Rice for the Poor (*Rastra*) program has been used as an instrument for price stability policy. When relatively poor people cannot have access to rice as a staple food, they look for rice in the open market, which contributes to the increase of the price of rice. This was the case when there were increasing rice prices in early 2015 and 2017, mostly due to the delay in *Rastra* distribution to poor families. The increase in the price of rice in 2017 increased the number of poor people by 6,900 and from 27.76 million people in September 2016 to 27.77 million in March 2017, although the poverty percentage of the population decreased from 10.70 to 10.764 percent in the same period.

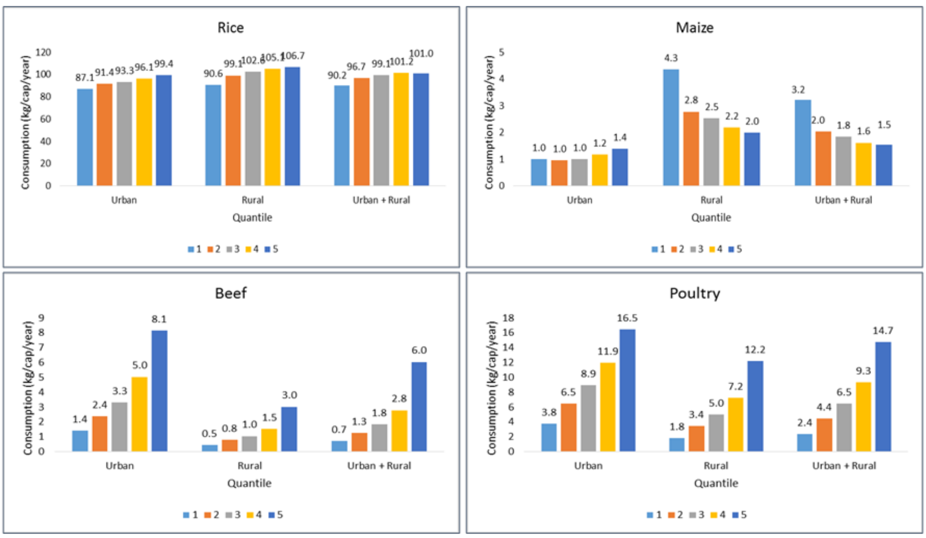

Figure 3: Consumption of Rice, Maize, Beef, and Poultry by Income Group

Average rice consumption in Indonesia has shown an interesting pattern of changes. Rice consumption has increased as income has increased, from 90.4 kilograms per capita in Quintile 1 up to 101.2 kilograms per capita in Quintile 4. However, rice consumption in the highest income group, or in Quintile 5, has decreased to 101.0 kilogram per capita. Interpreting this pattern should be conducted with caution. Low rice consumption in the low income group is mostly an access problem, which correlates with the potential for under-nutrition problems among poor families. However, a decline in rice consumption in high income groups might indicate a consumption shift from carbohydrate sources of food to higher quality foods such as proteins, fats and vitamins, which the highest income quintile consumes in much greater quantities.

These findings have confirmed the study by Timmer et al. (2010) on the dynamics of declining rice consumption in Indonesia and in Asian countries in general. There are two reasons to understand the long-run dynamics of rice consumption. First, in market-driven economies, consumer demand provides signals to producers about what they should grow, market and deliver to the retail sector. Market economies are demand-driven economies. Understanding the behavior of rice consumers is very useful to support the decision making process of rice production as efficiently as possible. Second, underlying the smooth trends of rice consumption are four key factors whose relative contributions to future demand growth are likely to change compared with past experience. These four basic forces are (1) population growth, (2) income growth and its distribution, (3) declining real prices for rice, and (4) the gradual shift of workers from rural to urban employment that accompanies a successful structural transformation (Timmer, 2010). At a macro level, investments that keep rice production rising smoothly at the rate of projected rice consumption are the surest way to provide food security in Indonesia. At a micro level, fulfilling the energy and protein intake, at least to meet the energy adequacy level (AKE) and protein adequacy level (AKP), is necessary. This should become the main priority of food policy for the central government and local governments.

Figure 3 also shows that the average consumption of beef and poultry, as protein sources, is extremely high in the highest income group. The average beef and poultry consumption in Quintile 5 is 6.0 and 14.7 kilograms per capita per year, much higher than the national average of 2.5 and 7.5 kilograms per capita per year respectively. These two protein sources are really income-elastic as the consumption of beef and poultry is much lower in the lower income group and in rural areas. The pattern of beef consumption in urban areas is skewed to the highest income group, showing a disparity of 8.1 kilograms for the highest group to 1.4 kilograms per capita per year for the lowest income group, or about a 5.8 to 1 comparison. A similar pattern is also found for beef consumption in rural areas, showing a disparity of 3.0 kilograms for the highest group to 0.5 kilograms per capita per year for the lowest income group, or about a 6 to 1 comparison. Moreover, the beef consumption disparity between urban areas and rural areas is also quite high, which may indicate that populations living in rural areas might find different sources of animal protein. High dependence on beef imports of 35 percent or more might also explain such a disparity, as urban populations might find beef more easily compared to residents in rural areas. Rural populations might be able to raise cows, buffalo and other livestock, but they usually treat these animals as investments, instead of as a farm business. Indonesia has not been successful in implementing a program of self-sufficiency for beef because farmers have different visions of the livestock business (Arifin, 2015).

Interestingly, the disparity pattern of poultry consumption is quite unique, and different from that of beef consumption. The pattern of poultry consumption in urban areas is also skewed to the highest income group, although not as sharply as beef consumption. The consumption disparity is 16.5 kilograms for the highest group and 3.8 kilograms per capita per year for the lowest income group, or about a 4.3 to 1 comparison. However, the skew of poultry consumption in urban and rural areas is very high, showing disparity of consumption between 12.2 kilograms for the highest group to 1.8 kilograms per capita per year for the lowest income group, or about a 6.8 to 1 comparison. This implies that people living in urban areas have better access to poultry compared to their peers in rural areas. The poorest people in rural areas may only have chicken in their menu once a week during the course of a year. Although poultry meat (and eggs) can be considered the cheapest source of animal protein, the income elasticity of poultry for rural people is quite high, which could shape the whole demand for such sources of protein.

A contrasting figure is found in maize consumption, as the average amount of direct maize consumption for humans in 2017 was 2 kilograms per capita per year, but declines as income increases. Maize consumption of the lowest Quintile 1 was 3.2 kilograms, but the highest Quintile 5 was 1.5 kilograms per capita per year. Although there has been a change in recent years in the use of maize from direct food to animal feed, maize represents the behavior of inferior goods. The average maize consumption of Quintile 1 in rural areas was 4.3 kilograms, but the consumption in the highest Quintile 5 was 2 kilograms per capita per year. Rural populations in Indonesia, especially in dry regions in Eastern Indonesia have traditionally consumed maize as their daily staple, or at least the second most important staple food after rice. The future consumption of maize in Indonesia might change substantially if the feed industry and poultry business change significantly. The current government of Indonesia has put much effort towards increasing maize, rice and soybean production to achieve self-sufficiency by increasing harvesting areas, stimulating intensive use of modern inputs such as fertilizer and pesticides, and managing the value chains and related trade and border policy. At the time of writing this report, BPS has not issued any estimates on maize production, as well as rice and soybean production. BPS in cooperation with the Agency for Technology Assessment and Application (BPPT) are improving the methodology of production estimates of major food crops in Indonesia.

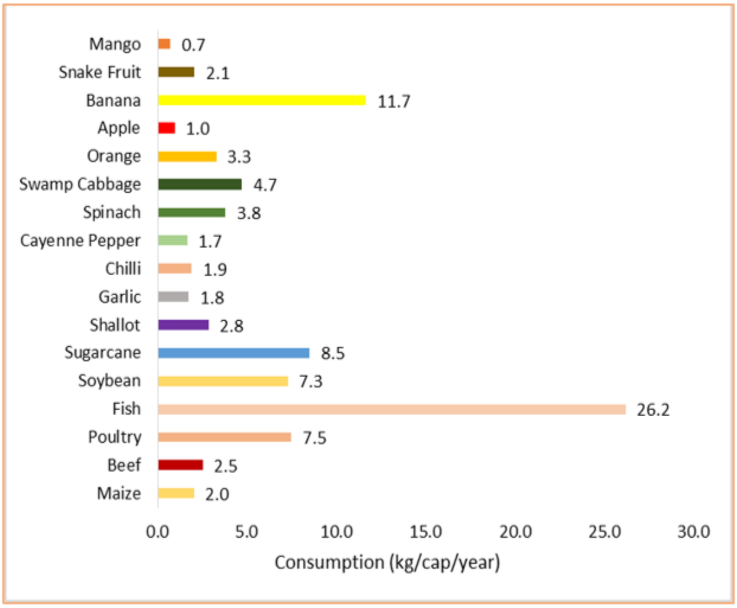

Figure 4: Average Consumption of Important Food Commodities

Consumption of other important commodities such as fish, soybeans, vegetables and fruit have a similar pattern, where the consumption increases as income also increases. The average consumption of soybeans and fruit commodities is generally higher in urban areas and in high income groups. Taking into consideration that these commodities fall into a "high quality food" category, the Bennett Law also holds, as increased income is followed by an improvement in food quality. The shifting allocation of the consumption budget from carbohydrate-based to protein and vitamin-based food generally occurs in urban areas and in high income groups. It is fair to assume that, at some point, populations in rural areas and in low income groups will eventually allocate a greater proportion of expenditure to high quality foods as their income also increases. Interestingly, the average consumption of fish and vegetables is generally higher in rural areas than urban areas. The first and foremost logical explanation for this tendency is that food access to fish and vegetables for rural people is generally better than their counterparts in urban areas. This food access could be driven by the availability of these protein and vitamin sources instead of income factors, as the rural income is generally lower than the urban income. Figure 4 represents the average consumption of some of the important commodities explained above.

4.3. Consumption of Selected Food Commodities by Province

Examining food consumption patterns by province is necessary to map out food access and availability, especially in relation to household income. One should note that rice consumption in this study includes rice, rice flour, glutinous rice, vermicelli, baby pulp and rice-based finished foods. The average rice consumption of 97.6 kilograms per capita in Indonesia tends to be evenly spread across the country, except for Bali and Papua. Rice consumption in Bali in 2017 was 117.3 kilograms per capita or the highest in country, while rice consumption in Papua was 70.5 kilogram per capita or the lowest in the country.

Two of the most logical explanations for high rice consumption in Bali are as follows: firstly, Bali is one of the main rice production centers in Indonesia and has experienced a longtime rice surplus, so rice availability in this province is relatively high compared to other provinces. Secondly, Bali is the most famous tourist destination in the country, so the number of visitors has perhaps increased the total consumption of rice. The average rice consumption might be calculated based on the total population of Bali, excluding the number of tourists. Similarly, the most logical explanation of low rice consumption in Papua could be associated with the low food availability in the province and by the fact that the local population in Papua consumes local staple foods such as sago and tubers, although rice consumption has increased in recent years. An additional explanation could be that household incomes in Papua are some of the lowest in the country, creating problems with food access for residents in the province (Figure 5).

A more careful explanation is probably needed for high levels of rice consumption, or over 100 kilograms per capita, in the provinces of Gorontalo and East Nusa Tenggara (NTT), which are some of the poorest regions in Indonesia and not rice production centers. Although Gorontalo is not as poor as NTT province, better food access in Gorontalo probably makes more sense as an explanation for these figures, compared to household income.

The pattern and behavior of maize consumption in 2017 shows that the highest consumption level of 20.3 kilograms per capita was found in the province of East Nusa Tenggara (NTT), and this was also over 10 times the national average. The lowest consumption level of 0.4 kilograms per capita per year was found in the province of North Maluku. Local populations in NTT have long been used to having maize and cassava as their staple food, in addition to rice, which historically came later. The availability of maize per capita in NTT is also one of the highest as the agro-ecosystem of this province is quite suitable for maize farming and the local population has been farming maize for years. The next largest consumption of maize is in Gorontalo with a consumption of 10 kilograms per capita, followed by East Java, Maluku and South Sulawesi, as presented in Figure 26. In short, it could be concluded that consumption of staple foods is more strongly associated with food availability and food access than household income alone.

As explained previously, the pattern of beef and poultry consumption is more

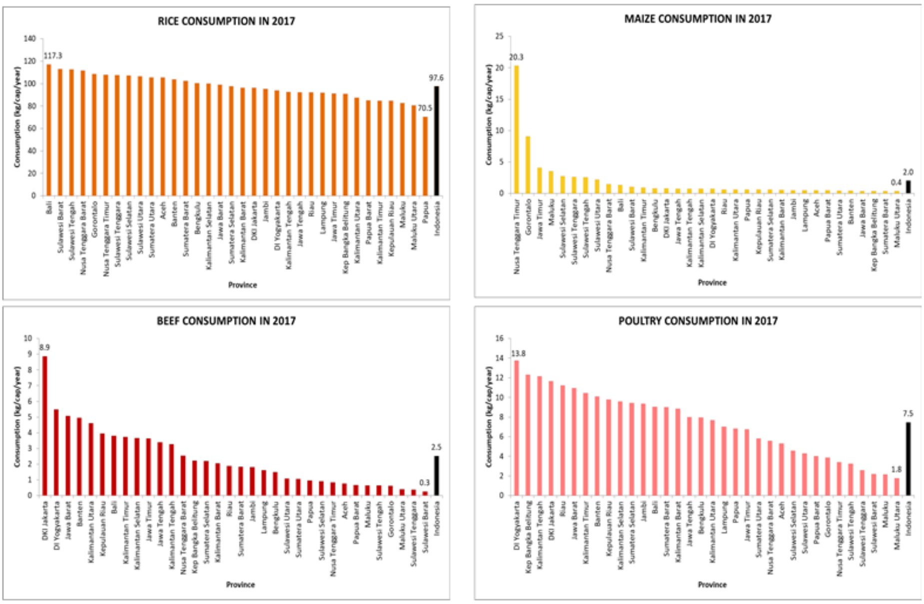

Figure 5: Consumption of Rice, Maize, Beef, and Poultry by Province

influenced by income level, as these protein sources of food have high income elasticity. The consumption of beef in 2017 in the DKI Jakarta region was the highest in the country, averaging 8.9 kilograms per capita per year. The average household income in Jakarta is far higher than that of people in other provinces, affecting access to beef. The lowest level of beef consumption was found in West Sulawesi which has a consumption rate of 0.3 kilograms per capita per year.

The highest level of poultry consumption in 2017 was recorded in the province of DI Yogyakarta, averaging 13.6 kilograms per capita per year, while the lowest level of poultry consumption was found in North Maluku, averaging of 1.8 kilogram per capita per year. The pattern of poultry consumption is similar to that of beef consumption as household income could play a part as the most dominant determinant of poultry consumption. Poultry consumption is more evenly distributed across the country, unlike beef consumption where many more provinces have a consumption level below the national average of 2.5 kilograms per capita. Poultry consumption has historically served as an affordable protein source across the country, including for the lowest quintiles of income groups.

The average consumption of fish in 2017 was recorded as 26.2 kilograms per capita per year, and fish consumption in the province of Maluku was the highest with 46.9 kilograms per capita per year. Maluku is one of the archipelagic provinces in Indonesia and therefore has the highest availability of fish. Therefore, supporting policies for fish production is really necessary in order to maintain or improve the consumption of fish in the country. Fish consumption might also improve food quality and thus boost the nutrition levels of the population.

Another important food commodity as a protein source is soybeans, and the average soybean consumption in 2017 was 7.3 kilograms per capita per year. The province of East Java has the highest soybean consumption of 12.7 kilograms per capita per year, while the province of North Maluku has the lowest level of soybean consumption, averaging 2.1 kilograms per capita. Soybeans are mostly consumed in terms of processed products such as *tempeh* and tofu, followed by soy sauce and bean consumption. The growing demand for soybeans needs to be fulfilled from soybean imports as domestic soybean production is lower than the consumption level. Total soybean production is less than one million tons per year, while the total soybean consumption in 2017 was over 2.1 million tons. Soybean consumption is expected to increase as the food industry using soybeans as the raw materials is also expected to rise.

The most consumed vegetable in 2017 was *kangkung* (swamp cabbage), and the average consumption was 4.7 kilograms per capita per year. The most consumed fruit in 2017 was bananas as the average consumption was 11.7 kilograms per capita per year. *Kangkung* and bananas are the most affordable vitamin and fiber sources of food, including among the poor or the lowest income group of the population. The pattern of vegetables and fruit consumption in Indonesia is mostly affected by the price, compared to other determinants such as income level.

4.4. Income and Food Consumption Relations

Income and food consumption relations are drawn by comparing all five models: linear, polynomial (degree-r), semi-logarithmic, double logarithmic and exponential models under certain specifications for selected commodities. One should note that the consumption of selected food commodities is direct household consumption, not including food being used for feed, seed, industrial use, and loss and waste. The model selection consists of three sets for each commodity, for all Indonesia (rural and urban consumption), for rural areas and for urban areas (see the Appendices). The breakdown is necessary as the characteristics of food consumption in rural areas and urban areas differ significantly. The findings show that semi-logarithmic and double logarithmic models seem more dominant in the model selection to describe the best relationship between food consumption and household income in Indonesia. One example of the income-consumption functional relations in cereals, protein sources and fruit is presented in the following Figure 6. For rice consumption, the best model is semi-logarithmic for all three functional relations in rural areas, urban areas, and in Indonesia as a whole. The patterns of functional relations are similar, rice consumption increases at a very steep rate at lower income levels in line with a rise in income and the trend is slower at higher income levels. The functional relations between income and rice consumption in rural areas has a much steeper increase than in urban areas.

This could imply that the Engle Law applies here, where income elasticity for rice in urban areas is much lower than in rural areas and across Indonesia as a whole.

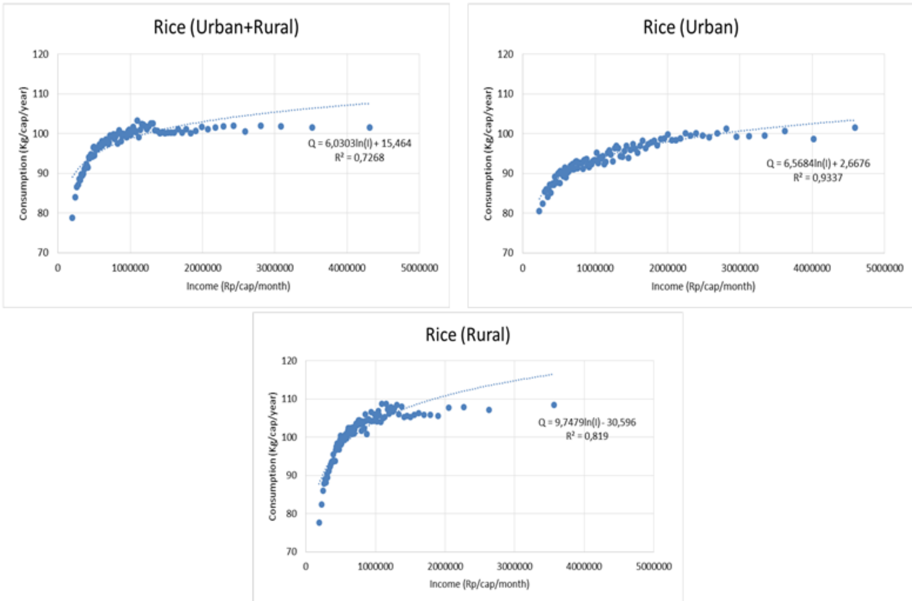

Figure 6: Income and Rice Consumption Functional Relations

For all three functional forms, the semi-log model has resulted in high values of R2 0.73, 0.82, and 0.93 respectively for income and rice consumption relations in Indonesia (rural and urban areas), rural areas and urban areas. In urban areas, increasing income does not necessarily increase rice consumption, and it actually decreases rice consumption in the highest income group. This model selection is very consistent with the previous analysis of rice consumption at the baseline of 2017 as presented at Section 7.2.

The best models for income and maize consumption relations for rural areas and for total rural and urban areas are double logarithmic, which is a negative trend and convex to the point of origin, or declining from the upper left to the lower right. Maize consumption decreases as income increases in rural areas and across Indonesia as a whole the trend is equal to the coefficient income in the logarithmic form. In this case, maize could represent an example of inferior goods, as higher income people tend not to consume more maize. The coefficients of determination R^2 of these two functional relations are 0.70 and 0.72 respectively and show that these two double-log models could best describe income and maize consumption relations. In urban areas, the best model is linear and quite flat, although the coefficient of determination R2 is 0.76. This means that as income in urban areas increases, maize consumption also increases although it is very small, as presented in Figure 29.

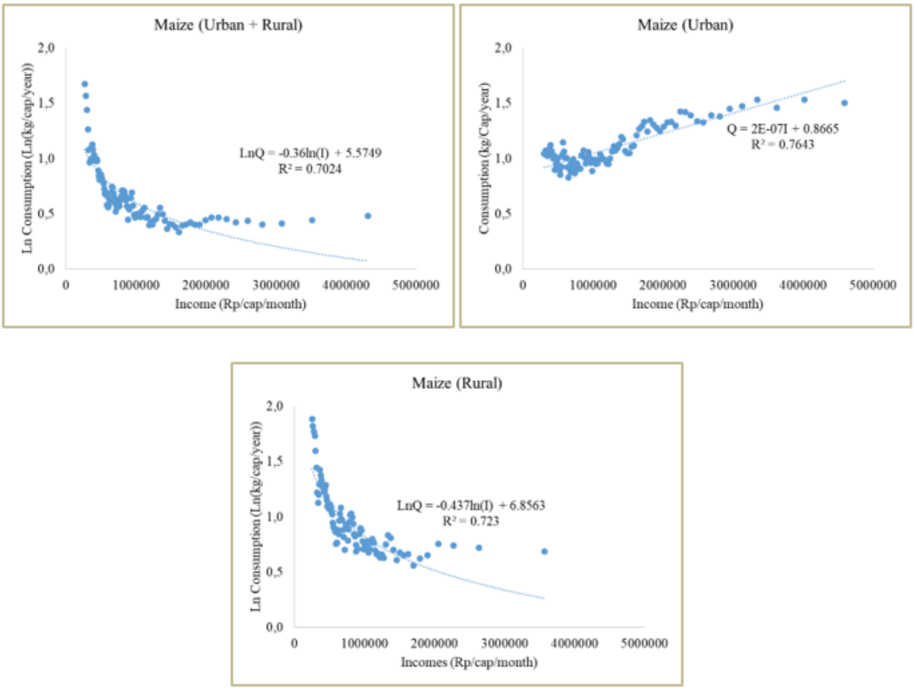

Figure 7: Income and Maize Consumption Functional Relations

People living in urban areas generally do not consume maize directly, but rather indirectly as a feed used in the poultry industry. The best functional forms between income and poultry consumption show positive relations in all three models in rural, urban and rural-urban areas across the whole country. This means that poultry consumption increases as the household income increases, in the semi-log functional forms. In contrast to the models for poultry consumption, the functional relations between income and beef consumption show all linear relations in rural areas, urban areas and rural-urban areas. The coefficient determinations R^2 of these functional relations are respectively 0.98, 0.97, and 0,98, which means that these linear models are good predictors of functional relations between income and maize consumption in Indonesia.

4.5. Projections of Food Demand in 2025 and 2045

Projections of food demand in 2025 and 2045 are made based on three different scenarios, namely: (1) Food demand for consumption (intake only), calculated based solely on the Susenas 2017 dataset, (2) Food demand 1 after considering domestic uses of food for feed, seed and non food industries according to National Food Balance Sheet (NBM), and (3) Food demand 2 after considering the food balance sheet (NBM) and additional loss and waste in line the FAO (2011).

The per capita rice consumption projection at the baseline gradually increases by 1.5 percent to 99.08 kilograms per capita per year in 2025 and increases by 2 percent to 99.55 kilograms per capita in 2045 (food demand). The projection of the demand for rice, after referring the correction factors at NBM for the domestic uses of food for non-food purposes, such as industrial use for non-food, feed, seed, food loss, also increases to 102.73 kilograms per capita per year in 2025 and 103.22 kilograms per capita per year in 2045 (food demand 1). The demand for rice is also projected to increase to 127.09 kilograms per capita in 2025 and 127.70 kilograms per capita 2045 (food demand 2), after considering food loss and waste in line with the FAO (2011). Only in the highest income group has Indonesia experienced declining rice consumption, which is somewhat different from other Asian countries, where rice consumption declines are found in medium and lower level income groups.

The poultry consumption projection shows the highest increase compared to other animal products, which is 22.1 percent in 2025 to 9.13 kilograms per capita per year and 29.3 percent in 2045 to 9.66 kilograms per capita per year (food demand). The beef consumption projection increases by 10.3 percent to 2.79 kilograms per capita per year in 2025, and 20.4 percent to 3.04 kilograms per capita per year in 2045 (food demand 1). The fish consumption projection increases by 11 percent to 29.09 kilograms per capita per year in 2025 and 14.6 percent to 30.04 kilograms per capita per year in 2045 (food demand 2). Beef is consumed by higher income groups in urban areas. Poultry is consumed by all income groups, including the lowest quintiles.

For fruit and vegetables, the highest food consumption demand projection per capita relates to apples, with an increase of 55 percent in 2025 to 1.49 kilograms per capita per year, and 73.5 percent in 2045 to 1.66 kilograms per capita per year. Consumers of apples are mostly part of the urban population in high and medium income groups. The projected demand for local fruit such as oranges, bananas, snake fruit and mangoes in 2025 and 2045 is not as high as apples, and this demand is dominated by imported apples.

The projected demand for sugar is 8.98 and 9.12 kilograms per capita in 2025 and 2045 respectively. The increase in sugar consumption is not very significant, compared to other food commodity groups. The total consumption of sugar is projected to reach 25.6 million tons in 2025 and 29.1 million tons in 2045. The estimate of sugar consumption do not include indirect consumption of sugar in the form of cakes, drinks and other food products that use refined sugar and its derivatives, so the figure may be higher.

5. Conclusion

This study has confirmed that the future food demand in Indonesia is determined by existing demand, income, price and its composition, and various other factors that affect the behavior and trends of consumption. Average rice consumption in 2017 was recorded at 97.6 kilograms per capita per year, which was lower than the official rice consumption on 114 kilograms per capita. Rice consumption in rural areas in Indonesia is slightly higher than in urban areas. Under a market economy, first, the income level of people living in urban areas is generally higher than in rural areas. Second, food access in urban areas is higher than in rural areas. Lower income groups tend to spend a larger proportion of their income on food, but these are cheap, filling foods such as carbohydrates.

The nutrition adequacy number (AKG) consists of the energy adequacy number (AKE) and protein adequacy number (AKP). The average energy consumption of the Indonesian population was 2,202 kcal per capita per day, which exceeds the AKE of 2,150 kcal per capita per day, or equivalent of 102.5 percent. However, the households falling into Quintile 1 and 2 of income groups do not meet the AKE. Carbohydrate or energy consumption of people living in the two highest quintiles exceeds the AKE by 123.8 percent and 112.3 percent respectively. This finding is consistent with the economic theory that food consumption in terms of energy adequacy increases as income increases.

The average protein consumption in Indonesia in 2017 was 63.30 grams per capita per day, which exceeds the AKP of 57 grams per capita per year, or equivalent to 111 percent. By income group, the consumption patterns of protein are similar to those of carbohydrate consumption, which increases as income increases. It ranges from 45.67 grams in the lowest quintile to 84.07 grams per capita per year in the highest income group quintile. The protein consumption of the first two income group quintiles does not reach the recommended AKP as these income groups only consume about 80 percent of the recommended protein amount. Contrasting figures are found in the protein consumption of quintiles four and five, which fall into over consumption at 123.3 percent and 147.5 percent respectively.

Average consumption of beef as a protein source is highest among the wealthiest consumers. The average beef and poultry consumption in Quintile 5 is 6 and 14.7 kilograms per capita per year, much higher than the national average of 2.5 and 7.5 kilograms per capita per year. These two protein sources are really income-elastic as the consumption of beef and poultry is much lower in the lower income group and in rural areas. The pattern of beef consumption in urban areas is really skewed to the highest income group, showing a disparity of 8.1 kilograms for the highest group to 1.4 kilograms per capita per year for the lowest income group, or about a 5.8 to 1 comparison. A similar pattern is also found for beef consumption in rural areas, showing a disparity of 3 kilograms for the highest group to 0.5 kilograms per capita per year for the lowest income group, or about a 6 to 1 comparison.

A contrasting figure is found in maize consumption, where the average maize consumption in 2017 was 2 kilograms per capita per year, but this declines as income increases. The maize consumption of the lowest Quintile 1 was 3.2 kilograms, but the highest Quintile 5 was 1.5 kilograms per capita per year. Although there has been a change in recent years in the use of maize from direct food to animal feed, maize still represents the behavior of inferior goods. The average maize consumption of Quintile 1 in rural areas was 4.3 kilograms, but the consumption in the highest Quintile 5 was 2 kilograms per capita per year. Rural populations, especially in dry regions in Eastern Indonesia consume maize as their daily staple as the second most important staple food after rice.

The model used to project the future demand for food in 2025 and 2045 is based on income and food consumption functional relations in rural, urban, and rural-urban areas. For example, the model for rice shows that increasing income does not necessarily increase rice consumption. On the contrary, it decreases rice consumption for the highest income group. Maize consumption decreases as income increases in rural areas and across Indonesia as a whole and the trend is equal to the coefficient income in the logarithmic form. In this case, maize represents an example of inferior goods, as higher income people tend not to consume more maize.

As rice remains a staple food, even in 2045, the policy relevance is that elements of food consumption could determine the level of food accessibility, and therefore food security in the country. Ensuring access to rice, especially for low and middle income groups, is as important as the stability of the retail price of rice. The policy of food assistance targeting the poorest group of rice consumers remains relevant to maintain food and nutrition adequacy. As the government is planning to transform in-kind food assistance to non-cash subsidies, the program implementation could be adjusted in line with latest development of infrastructure, data technology and preparedness of stakeholders in the food system.

The policy relevance on beef, chicken and fish consumption is based on infrastructure improvements of the marketplace, including both modern retail markets and traditional markets which could shape the performance of value chains of these sources of animal protein. The value chain policies not only directly affect food accessibility among all income groups, but also affect many value chain players, such as retailers, processors, wholesalers, and collector traders that directly connect rural areas to farmers or producers of protein sources. These players could also help convey the messages of urban consumers to farmers and other actors along the value chains, including product specifications, food safety, health and hygienic requirements, and halal and other quality standards that have shaped the characteristics of the value chains of these protein sources.

Economic actors in fruit and vegetable value chains need access to cold-storage facilities, including medium scale controlled atmosphere systems (CAS) which could improve the efficiency of horticulture products. The policy should also focus on the balance between demand-side management and supply-side or productivity improvement, as the majority of horticulture production centers are located in Java. The policy relevance is that there is a need to support farmers who could meet rising quality and safety standards set by retail markets, or by consumers, through modern retail markets and supermarkets.

References

[1] Arifin, B. (2015). *The economics of agricultural development (2nd Edition) [Ekonomi pembangunan pertanian (Edisi Kedua)]*. Bogor: IPB Press.

[2] BPS. (2017). *Statistik Indonesia 2017*. Jakarta: Badan Pusat Statistik.

[3] Deaton, A., & Muellbauer, J. (1980). An almost ideal demand system. *The American Economic Review, 70*(3), 312-326.

[4] Dyck, J., Woolverton, A., & Rangkuti, F. (2012). Indonesia's modern retail food sector: Interaction with changing food consumption and trade patterns. *USDA-ERS Economic Information Bulletin*, (97). United States Department of Agriculture-Economic Research Service. https://www.ers.usda.gov/webdocs/publications/44684/28836_eib97_1_.pdf?v=41304.

[5] FAO. (2011). *Global food losses and food waste: extent, causes and prevention*. Rome: Food and Agriculture Organization. http://www.fao.org/3/mb060e/mb060e00.htm.

[6] Hamshere, P., Sheng, Y., Moir, B., Gunning-Trant, C., & Mobsby, D. (2014). What India wants: analysis of India's food demand to 2050. *ABARES Research Report No. 14.16*. Australian Bureau of Agricultural and Resource Economics and Sciences. http://www.agriculture.gov.au/SiteCollectionDocuments/abares/publications/AnalysisIndiaFoodDemandTo2050_v.1.0.0.pdf.

[7] Reardon, T., & Timmer, C. P. (2014). Five inter-linked transformations in the Asian agrifood economy: Food security implications. *Global Food Security, 3*(2), 108-117. doi: https://doi.org/10.1016/j.gfs.2014.02.001.

[8] Reardon, T., Tschirley, D., Dolislager, M., Snyder, J., Hu, C., & White, S. (2014). *Urbanization, diet change, and transformation of food supply chains in Asia*. Michigan: Michigan State University-Global Center for Food Systems Innovation. http://www.fao.org/fileadmin/templates/ags/docs/MUFN/DOCUMENTS/MUS_Reardon_2014.pdf.

[9] Suryadarma, D., Poesoro, A., Budiyati, S., Rosfadhila, M., & Suryahadi, A. (2010). Traditional food traders in developing countries and competition from supermarkets: Evidence from Indonesia. *Food Policy, 35*(1), 79-86. doi: https://doi.org/10.1016/j.foodpol.2009.11.002.

[10] Timmer, C. P. (2010). Reflections on food crises past. *Food Policy, 35*(1), 1-11. doi: https://doi.org/10.1016/j.foodpol.2009.09.002.

[11] Timmer, C. P. (2014). Food Security in Asia and the Pacific: The Rapidly Changing Role of Rice. *Asia & the Pacific Policy Studies, 1*(1), 73-90. doi: https://doi.org/10.1002/app5.6.

[12] Timmer, C. P., Block, S., & Dawe, D. (2010). Long-run dynamics of rice consumption, 1960–2050. In Pandey, S., Byerlee, D. R., Dawe, D., Dobermann, A., Mohanty, S., Rozelle, S., & Hardy, B. (Eds.), *Rice in the global economy: strategic research and policy issues for food security* (pp. 139–174). Los Banos: International Rice Research Institute (IRRI).

[13] Umberger, W. J., He, X., Minot, N., & Toiba, H. (2015). Examining the Relationship between the Use of Supermarkets and Over-nutrition in Indonesia. *American Journal of Agricultural Economics, 97*(2), 510-525. doi: https://doi.org/10.1093/ajae/aau111.

[14] United Nations Population Division. (2015). *World Urbanization Prospects: The 2014 Revision*. United Nations, New York. https://population.un.org/wup/.

[15] Warr, P., & Yusuf, A. (2014). World Food Prices and Poverty in Indonesia. *The Australian Journal of Agricultural and Resource Economics, 58*(1), 1-21. doi: https://doi.org/10.1111/1467-8489.12015.

Appendices

Table 2: Best Model of Income and Food Consumption Relations in Indonesia

Food Groups	Food Commodity	Best Model	Specification*
Cereals	Rice	Semi-log	Q = 6.03 Ln(I) + 15.46
	Maize	Double log	Ln(Q)= - 0.36 Ln(I) + 5.58
Animal Products	Beef	Linear	Q = 3E-06 I - 0.36
	Poultry	Semi-log	Q = 6.91 Ln(I) - 86.619
	Fish	Semi-log	Q = 12.09 Ln(I) - 138.51
Beans and Nuts	Soybean	Semi-log	Q = 2.26 Ln(I) - 23.48
Vegetables	Shallots	Semi-log	Q = 0.99 Ln(I) - 10.71
	Garlic	Semi-log	Q = 0.68 Ln(I) - 7.46
	Red Chili	Semi-log	Q = 0.92 Ln(I) - 10.63
	Hot Chili	Semi-log	Q = 0.50 Ln(I) - 5.21
	Spinach	Semi-log	Q = 1.16 Ln(I) - 11.93
	Kangkung	Semi-log	Q = 0.91 Ln(I) - 7.71
Fruits	Orange	Semi-log	Q = 3.34 Ln(I) - 42.24
	Apple	Linear	Q = 2E-06 I - 0.61
	Banana	Double log	Q = 0.33 Ln(I) - 2.03
	Snake Fruit	Semi-log	Q = 1.10 l Ln(I) - 12.92
	Mango	Double log	Ln(Q) = 1.05 Ln(I) - 14.88
Others	Cane Sugar	Semi-log	Q = 1.85 Ln(I) - 16.72

Q: amount of consumption (kg/capita/year)
I: household income (capita/year)

Table 3: Best Model of Income and Food Consumption Relations in Rural Area

Food Groups	Food Commodity	Best Model	Specification
Cereals	Rice	Semi-log	Q = 9.75 Ln(I) - 30.60
	Maize	Double log	Ln(Q) = -0.44 Ln (I) + 6.86
Animal Products	Beef	Linear	Q = 2E-06 I - 0.19
	Poultry	Semi-log	Q = 6.46 Ln(I) - 81.10
	Fish	Semi-log	Q = 15.38 Ln(I) - 180.63
Beans and Nuts	Soybean	Semi-log	Q = 2.70 Ln(I) - 30.05
Vegetables	Shallots	Semi-log	Q = 1.40 Ln(I) - 15.93
	Garlic	Semi-log	Q = 0.82 Ln(I) - 9.44
	Red Chili	Semi-log	Q = 1.11 Ln(I) - 13.20
	Hot Chili	Semi-log	Q = 0.86 Ln(I) - 9.74
	Spinach	Semi-log	Q = 1.66 Ln(I) - 18.60
	Kangkung	Double log	Ln(Q) = 0.31 Ln(I) - 2.68
Fruits	Orange	Semi-log	Q = 3.17 Ln(I) - 40.06
	Apple	Linear	Q = 1E-06 I - 0.47
	Banana	Double log	Q = 0.37 Ln(I) - 2.49
	Snake Fruit	Semi-log	Q = 1.63 Ln(I) - 20.02
	Mango	Linear	Q = 7E-07 I + 0.01
Others	Cane Sugar	Semi-log	Q = 3.44 Ln(I) - 37.13

Q: amount of consumption (kg/capita/year)
I: household income (capita/year)
*Complete figure of these relations are presented in Appendix 6

Table 4: Best Model of Income and Food Consumption Relations in Urban Area

Food Groups	Selected Commodity	Best Model	Specification*
Cereals	Rice	Semi-log	Q = 6.57 Ln(I) + 2.67
	Maize	Linear	Q = 2E-07 I +0.87
Animal Products	Beef	Linear	Q = 3E-06 I + 0.45
	Poultry	Semi-log	Q = 6.81 Ln(I) - 84.636
	Fish	Semi-log	Q = 11.28 Ln(I) - 130.55
Beans and Nuts	Soybean	Semi-log	Q = 1.16 Ln(I) - 7.38
Vegetables	Shallots	Semi-log	Q = 0.73 Ln(I) - 7.16
	Garlic	Semi-log	Q = 0.53 Ln(I) - 5.43
	Red Chili	Semi-log	Q = 0.72 Ln(I) - 7.78
	Hot Chili	Semi-log	Q = 0.39 Ln(I) - 3.98
	Spinach	Semi-log	Q = 0.84 Ln(I) - 7.81
	Kangkung	Double log	Ln(Q) = 0.12 Ln(I) - 0.10
Fruits	Orange	Semi-log	Q = 3.39 Ln(I) - 42.65
	Apple	Linear	Q = 2E-06 I - 0.54
	Banana	Double log	Ln(Q) = 0.41 Ln(I) - 3.31
	Snake Fruit	Semi-log	Q = 0.64 Ln(I) - 6.61
	Mango	Linear	Q = 7E-07 I + 0.01
Others	Cane Sugar	Semi-log	Q = 1.2 Ln(I) - 9.47

Q: amount of consumption (kg/capita/year)
I: household income (capita/year)
*Complete figure of these relations are presented in Appendix 6

Table 5: Projected Total Food Intake in 2017, 2025, and 2045

Commodity	Year	Food Intake (Thousand tons/Year)								
		Urban			Rural			Urban + Rural		
		Baseline	Moderate	Optimist	Baseline	Moderate	Optimist	Baseline	Moderate	Optimist
Rice	2017	12917.7	12917.7	12917.7	12467.2	12467.2	12467.2	25569.5	25569.5	25569.5
	2025	15653.1	15704.6	15764.4	12352.8	12408.7	12473.5	28219.9	28301.8	28396.7
	2045	19587.8	19812.4	20072.7	11773.0	11958.0	12172.5	31723.6	32044.3	32415.9
Maize	2017	152.2	152.2	152.2	342.0	342.0	342.0	536.0	536.0	536
	2025	185.1	187.2	189.7	289.8	283.8	277.1	510.4	501.7	491.9
	2045	234.6	245.0	259.4	265.0	246.4	226.4	555.3	522.9	487.8
Beef	2017	560.0	560.0	560.0	169.3	169.3	169.3	662.2	662.2	662.2
	2025	711.3	742.3	780.3	186.6	196.9	209.3	794.2	838.1	891.6
	2045	949.4	1104.9	1320.8	192.6	231.5	285.4	970.0	1167.2	1441.1
Poultry	2017	1315.2	1315.2	1315.2	732.3	732.3	732.3	1957.6	1957.6	1957.6
	2025	1843.7	1897.2	1959.1	867.1	904.1	947.1	2599.3	2693.0	2801.7
	2045	2403.5	2636.4	2906.3	877.6	1000.1	1142.2	3079.5	3446.7	3872.3
Fish	2017	3516.5	3516.5	3516.5	3312.4	3312.4	3312.4	6862.7	6862.7	6862.7
	2025	4646.0	4734.6	4837.2	3588.3	3676.5	3778.7	8287.1	8451.2	8641.5
	2045	5962.8	6348.6	6795.9	3531.0	3823.2	4161.8	9572.0	10214.7	10959.8
Soybean	2017	1187.4	1187.4	1187.4	780.9	780.9	780.9	1911.5	1911.5	1911.5
	2025	1461.3	1470.4	1480.9	824.5	840.0	857.9	2232.6	2263.3	2298.9
	2045	1837.3	1876.8	1922.6	803.9	855.2	914.6	2554.1	2674.2	2813.4
Cane Sugar	2017	1062.5	1062.5	1062.5	1134.8	1134.8	1134.8	2234.5	2234.5	2234.5
	2025	1316.0	1325.7	1337.0	1185.1	1204.8	1227.6	2556.4	2581.6	2610.8
	2045	1657.8	1700.2	1749.4	1151.6	1216.8	1292.4	2906.3	3004.8	3119.0
Shallot	2017	398.4	398.4	398.4	348.1	348.1	348.1	744.8	744.8	744.8
	2025	504.1	509.8	516.5	371.8	379.8	389.0	877.6	891.2	906.8
	2045	639.1	663.9	692.7	364.1	390.4	421.0	1006.6	1059.5	1120.8
Garlic	2017	261.1	261.1	261.1	204.1	204.1	204.1	459.2	459.2	459.2
	2025	332.4	336.5	341.3	218.2	222.9	228.4	545.5	554.7	565.3
	2045	422.1	440.2	461.2	213.7	229.3	247.4	627.1	663.1	704.7

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Commodity	Year	Food Intake (Thousand tons/Year)								
		Urban			Rural			Urban + Rural		
		Baseline	Moderate	Optimist	Baseline	Moderate	Optimist	Baseline	Moderate	Optimist
Red Chili	2017	293.6	293.6	293.6	218.5	218.5	218.5	503.1	503.1	503.1
	2025	378.7	384.3	390.9	239.1	245.5	252.9	609.8	622.3	636.8
	2045	482.8	507.3	535.7	236.1	257.2	281.6	705.2	754.1	810.9
Hot Chili	2017	201.3	201.3	201.3	224.7	224.7	224.7	434.9	434.9	434.9
	2025	255.7	258.8	262.4	238.8	243.7	249.4	506.8	513.7	521.6
	2045	324.6	338.0	353.6	233.5	249.8	268.7	579.6	606.4	637.4
Spinach	2017	526.3	526.3	526.3	472.3	472.3	472.3	998.9	998.9	998.9
	2025	661.1	667.7	675.3	499.3	508.8	519.9	1165.0	1180.7	1198.9
	2045	836.2	865.0	898.3	487.1	518.7	555.3	1332.2	1393.6	1464.8
Kangkung	2017	632.2	632.2	632.2	595.6	595.6	595.6	1233.9	1233.9	1233.9
	2025	771.5	775.8	780.8	604.2	613.3	624.1	1400.5	1412.8	1427.2
	2045	969.0	988.1	1010.7	585.8	617.3	655.9	1589.5	1638.0	1694.1
Orange	2017	568.6	568.6	568.6	330.3	330.3	330.3	862.8	862.8	862.8
	2025	814.9	841.5	872.2	397.7	415.8	436.9	1166.2	1211.5	1264.1
	2045	1068.3	1183.9	1318.0	404.3	464.5	534.3	1387.7	1565.3	1771.3
Apple	2017	204.9	204.9	204.9	68.7	68.7	68.7	250.3	250.3	250.3
	2025	335.0	355.8	381.0	48.4	53.5	59.8	424.0	453.2	488.9
	2045	459.8	563.4	707.4	53.8	73.3	100.3	528.6	660.1	842.7
Banana	2017	1487.5	1487.5	1487.5	1528.1	1528.1	1528.1	3056.3	3056.3	3056.3
	2025	1888.6	1925.8	1969.8	1561.5	1589.3	1622.1	3516.1	3571.4	3636.7
	2045	2426.8	2598.2	2812	1520.5	1617.2	1737.1	4035.6	4262.3	4541.0
Snake Fruit	2017	303.7	303.7	303.7	243.1	243.1	243.1	541.0	541.0	541.0
	2025	387.6	392.6	398.4	275.5	284.9	295.7	655.4	670.3	687.6
	2045	492.6	514.4	539.6	275.1	306.1	342.0	760.5	818.9	886.6
Mango	2017	119.5	119.5	119.5	74.6	74.6	74.6	187.6	187.6	187.6
	2025	150.4	157.6	166.5	74.3	77.8	82.2	208.7	219.4	232.5
	2045	202.1	238.4	288.8	75.9	89.5	108.4	253.4	302.0	370.0

Table 6: Projected Total Food Demand 1 in 2017, 2025, and 2045

Commodity	Year	Food Demand 1 (Thousand tons/Year)								
		Urban			Rural			Urban + Rural		
		Baseline	Moderate	Optimist	Baseline	Moderate	Optimist	Baseline	Moderate	Optimist
Rice	2017	13394.5	13394.5	13394.5	12927.3	12927.3	12927.3	26513.2	26513.2	26513.2
	2025	16230.8	16284.2	16346.2	12808.7	12866.6	12933.8	29261.4	29346.3	29444.7
	2045	20310.8	20543.6	20813.6	12207.5	12399.4	12621.8	32894.4	33226.9	33612.3
Maize	2017	152.4	152.4	152.4	342.4	342.4	342.4	536.5	536.5	536.5
	2025	185.3	187.4	189.9	290.1	284.2	277.4	511.0	502.3	492.4
	2045	234.9	245.3	259.7	265.3	246.7	226.7	555.9	523.5	488.3
Beef	2017	571.0	571.0	571.0	172.6	172.6	172.6	675.2	675.2	675.2
	2025	725.2	756.8	795.5	190.3	200.7	213.4	809.7	854.4	909.0
	2045	968.0	1126.5	1346.7	196.4	236.0	291.0	988.9	1190.0	1469.3
Poultry	2017	1317.2	1317.2	1317.2	733.4	733.4	733.4	1960.6	1960.6	1960.6
	2025	1846.5	1900.0	1962.1	868.4	905.5	948.5	2603.2	2697.1	2805.9
	2045	2407.1	2640.3	2910.7	878.9	1001.6	1143.9	3084.2	3451.9	3878.1
Fish	2017	3540.8	3540.8	3540.8	3335.3	3335.3	3335.3	6910.1	6910.1	6910.1
	2025	4678.1	4767.2	4870.6	3613.0	3701.8	3804.8	8344.3	8509.5	8701.1
	2045	6004.0	6392.4	6842.8	3555.4	3849.5	4190.5	9638.0	10285.2	11035.4
Soybean	2017	1188.0	1188.0	1188.0	781.3	781.3	781.3	1912.4	1912.4	1912.4
	2025	1462.1	1471.1	1481.6	824.9	840.4	858.3	2233.8	2264.5	2300.0
	2045	1838.2	1877.8	1923.6	804.3	855.6	915.0	2555.3	2675.5	2814.8
Cane Sugar	2017	1062.5	1062.5	1062.5	1134.8	1134.8	1134.8	2234.6	2234.6	2234.6
	2025	1316.0	1325.8	1337.1	1185.1	1204.8	1227.7	2556.5	2581.7	2610.9
	2045	1657.8	1700.3	1749.5	1151.6	1216.9	1292.5	2906.4	3004.9	3119.1
Shallot	2017	400.6	400.6	400.6	350.0	350.0	350.0	748.8	748.8	748.8
	2025	506.8	512.6	519.2	373.8	381.8	391.1	882.3	895.9	911.7
	2045	642.5	667.5	696.4	366.0	392.5	423.3	1012.0	1065.2	1126.9
Garlic	2017	261.1	261.1	261.1	204.1	204.1	204.1	459.3	459.3	459.3
	2025	332.5	336.6	341.4	218.3	223.0	228.4	545.6	554.8	565.5
	2045	422.2	440.3	461.3	213.8	229.4	247.5	627.3	663.2	704.9

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Commodity	Year	Food Demand 1 (Thousand tons/Year)								
		Urban			Rural			Urban + Rural		
		Baseline	Moderate	Optimist	Baseline	Moderate	Optimist	Baseline	Moderate	Optimist
Red Chili	2017	293.7	293.7	293.7	218.5	218.5	218.5	503.3	503.3	503.3
	2025	378.8	384.5	391.0	239.2	245.6	253.0	610.0	622.5	637.0
	2045	483.0	507.5	535.9	236.2	257.2	281.7	705.4	754.4	811.2
Hot Chili	2017	201.3	201.3	201.3	224.7	224.7	224.7	435.1	435.1	435.1
	2025	255.8	258.9	262.5	238.9	243.8	249.5	507.0	513.8	521.8
	2045	324.7	338.1	353.7	233.6	249.9	268.8	579.7	606.6	637.7
Spinach	2017	526.4	526.4	526.4	472.4	472.4	472.4	999.1	999.1	999.1
	2025	661.2	667.8	675.5	499.4	509.0	520.0	1165.3	1181.0	1199.2
	2045	836.4	865.2	898.5	487.2	518.8	555.4	1332.5	1394.0	1465.2
Kangkung	2017	632.6	632.6	632.6	595.9	595.9	595.9	1234.5	1234.5	1234.5
	2025	771.9	776.2	781.2	604.6	613.7	624.4	1401.3	1413.6	1428.0
	2045	969.6	988.6	1011.3	586.1	617.6	656.2	1590.4	1638.9	1695.0
Orange	2017	568.8	568.8	568.8	330.4	330.4	330.4	863.1	863.1	863.1
	2025	815.2	841.8	872.6	397.8	416.0	437.1	1166.6	1212.0	1264.6
	2045	1068.7	1184.4	1318.5	404.4	464.7	534.5	1388.2	1565.9	1772.0
Apple	2017	205.0	205.0	205.0	68.7	68.7	68.7	250.5	250.5	250.5
	2025	335.3	356.0	381.3	48.5	53.6	59.8	424.3	453.5	489.2
	2045	460.1	563.8	707.9	53.9	73.3	100.3	529.0	660.6	843.3
Banana	2017	1489.0	1489.0	1489.0	1529.6	1529.6	1529.6	3059.3	3059.3	3059.3
	2025	1890.5	1927.7	1971.8	1563.1	1590.9	1623.7	3519.6	3575.0	3640.3
	2045	2429.2	2600.8	2814.9	1522.0	1618.8	1738.9	4039.6	4266.5	4545.5
Snake Fruit	2017	303.8	303.8	303.8	243.2	243.2	243.2	541.3	541.3	541.3
	2025	387.8	392.8	398.6	275.7	285.1	295.9	655.8	670.7	688.0
	2045	492.9	514.7	540.0	275.3	306.3	342.2	761.0	819.4	887.1
Mango	2017	119.6	119.6	119.6	74.6	74.6	74.6	187.7	187.7	187.7
	2025	150.4	157.7	166.5	74.3	77.9	82.2	208.8	219.5	232.6
	2045	202.2	238.5	288.9	75.9	89.5	108.4	253.5	302.1	370.1

Table 7: Projected Total Food Demand 2 in 2017, 2025, and 2045

Commodity	Year	Food Demand 2 (Thousand tons/Year)								
		Urban			Rural			Urban + Rural		
		Baseline	Moderate	Optimist	Baseline	Moderate	Optimist	Baseline	Moderate	Optimist
Rice	2017	16570.6	16570.6	16570.6	15992.7	15992.7	15992.7	32800.0	32800.0	32800.0
	2025	20079.4	20145.5	20222.2	15845.9	15917.6	16000.7	36199.8	36304.9	36426.6
	2045	25126.8	25414.9	25748.8	15102.1	15339.5	15614.6	40694.3	41105.7	41582.4
Maize	2017	195.0	195.0	195.0	438.0	438.0	438.0	686.3	686.3	686.3
	2025	237.0	239.7	242.9	371.1	363.5	354.8	653.6	642.5	629.9
	2045	300.5	313.8	332.2	339.4	315.5	289.9	711.1	669.7	624.6
Beef	2017	666.5	666.5	666.5	201.5	201.5	201.5	788.0	788.0	788.0
	2025	846.4	883.4	928.5	222.1	234.3	249.1	945.1	997.3	1061.0
	2045	1129.8	1314.9	1571.8	229.2	275.4	339.7	1154.3	1389.0	1714.9
Poultry	2017	1565.1	1565.1	1565.1	871.5	871.5	871.5	2329.6	2329.6	2329.6
	2025	2194.0	2257.6	2331.4	1031.9	1075.9	1127.0	3093.1	3204.7	3334.1
	2045	2860.2	3137.3	3458.5	1044.3	1190.2	1359.2	3664.7	4101.6	4608.1
Fish	2017	4360.5	4360.5	4360.5	4107.4	4107.4	4107.4	8509.8	8509.8	8509.8
	2025	5761.0	5870.9	5998.2	4449.4	4558.8	4685.6	10276.0	10479.5	10715.4
	2045	7393.9	7872.3	8426.9	4378.5	4740.7	5160.6	11869.2	12666.2	13590.1
Soybean	2017	1306.2	1306.2	1306.2	859.0	859.0	859.0	2102.6	2102.6	2102.6
	2025	1607.5	1617.4	1629.0	907.0	924.0	943.7	2455.9	2489.7	2528.8
	2045	2021.0	2064.5	2114.9	884.3	940.7	1006.0	2809.5	2941.6	3094.7
Cane Sugar	2017	1062.5	1062.5	1062.5	1134.8	1134.8	1134.8	2234.5	2234.5	2234.5
	2025	1316.0	1325.7	1337.0	1185.1	1204.8	1227.6	2556.4	2581.6	2610.8
	2045	1657.8	1700.2	1749.4	1151.6	1216.8	1292.4	2906.3	3004.8	3119.0
Shallot	2017	565.8	565.8	565.8	494.3	494.3	494.3	1057.7	1057.7	1057.7
	2025	715.9	724.0	733.4	527.9	539.3	552.4	1246.3	1265.4	1287.7
	2045	907.5	942.8	983.7	517.0	554.4	597.9	1429.4	1504.5	1591.6
Garlic	2017	370.7	370.7	370.7	289.8	289.8	289.8	652.1	652.1	652.1
	2025	472.0	477.9	484.7	309.9	316.6	324.3	774.6	787.7	802.8
	2045	599.5	625.2	654.9	303.5	325.7	351.4	890.5	941.6	1000.7

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Commodity	Year	Food Demand 2 (Thousand tons/Year)								
		Urban			Rural			Urban + Rural		
		Baseline	Moderate	Optimist	Baseline	Moderate	Optimist	Baseline	Moderate	Optimist
Red Chili	2017	416.9	416.9	416.9	310.2	310.2	310.2	714.4	714.4	714.4
	2025	537.8	545.8	555.1	339.6	348.6	359.1	866.0	883.8	904.3
	2045	685.6	720.4	760.7	335.2	365.2	399.9	1001.4	1070.9	1151.5
Hot Chili	2017	285.8	285.8	285.8	319.0	319.0	319.0	617.7	617.7	617.7
	2025	363.2	367.6	372.6	339.2	346.1	354.2	719.7	729.4	740.7
	2045	460.9	480.0	502.2	331.7	354.8	381.6	823.0	861.1	905.2
Spinach	2017	747.3	747.3	747.3	670.6	670.6	670.6	1418.4	1418.4	1418.4
	2025	938.7	948.1	959.0	709.0	722.5	738.2	1654.3	1676.6	1702.4
	2045	1187.5	1228.3	1275.6	691.7	736.5	788.5	1891.7	1978.9	2080.1
Kangkung	2017	897.9	897.9	897.9	845.9	845.9	845.9	1752.4	1752.4	1752.4
	2025	1095.7	1101.8	1109.0	858.2	871.1	886.3	1989.1	2006.6	2027.0
	2045	1376.3	1403.4	1435.5	832.0	876.7	931.5	2257.6	2326.4	2406.1
Orange	2017	807.4	807.4	807.4	469.0	469.0	469.0	1225.2	1225.2	1225.2
	2025	1157.2	1194.9	1238.6	564.7	590.5	620.4	1656.0	1720.4	1795.1
	2045	1516.9	1681.2	1871.6	574.1	659.6	758.7	1970.5	2222.8	2515.2
Apple	2017	290.9	290.9	290.9	97.5	97.5	97.5	355.5	355.5	355.5
	2025	475.8	505.2	541.1	68.8	76.0	84.9	602.0	643.6	694.2
	2045	652.9	800.1	1004.5	76.5	104.0	142.4	750.6	937.3	1196.6
Banana	2017	2112.3	2112.3	2112.3	2169.9	2169.9	2169.9	4339.9	4339.9	4339.9
	2025	2681.8	2734.6	2797.2	2217.3	2256.8	2303.4	4992.9	5071.4	5164.0
	2045	3446.0	3689.4	3993.1	2159.0	2296.4	2466.7	5730.6	6052.4	6448.2
Snake Fruit	2017	431.2	431.2	431.2	345.2	345.2	345.2	768.2	768.2	768.2
	2025	550.4	557.5	565.7	391.2	404.5	419.9	930.7	951.8	976.4
	2045	699.5	730.4	766.3	390.7	434.7	485.7	1080.0	1162.8	1258.9
Mango	2017	169.7	169.7	169.7	106.0	106.0	106.0	266.4	266.4	266.4
	2025	213.5	223.8	236.4	105.4	110.5	116.7	296.3	311.6	330.2
	2045	287.0	338.6	410.1	107.7	127.0	153.9	359.8	428.8	525.4