An Assessment of the Impact of Higher Yields for Maize, Soybean and Cassava in Indonesia: A Multi-Market Model Approach

Bambang Sayaka, Sumaryanto, Masjidin Siregar, André Croppenstedt and Stefania DiGiuseppe

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Bambang Sayaka
Indonesian Center for Agricultural Socio Economic and Policy Studies
Ministry of Agriculture
Indonesia
e-mail: bambangsayaka@yahoo.com

Sumaryanto
Indonesian Center for Agricultural Socio Economic and Policy Studies
Ministry of Agriculture
Indonesia
e-mail: sonysumaryanto@yahoo.com

Masjidin Siregar
Indonesian Center for Agricultural Socio Economic and Policy Studies
Ministry of Agriculture
Indonesia
e-mail: caser@indosat.net.id

André Croppenstedt
Agricultural Development Economics Division
Food and Agriculture Organization
Italy
e-mail: andre.croppenstedt@fao.org

Stefania DiGiuseppe
Agricultural Development Economics Division
Food and Agriculture Organization
Italy
e-mail: stefania.digiuseppe@fao.org

Abstract

The changing structure of food demand will generate pressure to diversify away from cereals. It is therefore important that cereal productivity increases be maintained to free land as well as to meet the rising demand for animal feed. This study uses a multi-market model to assess the impact of yield increases for maize, soybean and cassava on cropping patterns, prices, incomes, and other variables of interest to policy makers. Raising maize yield reduces imports and has small but positive side-effects in terms of output and consumption of other commodities and in terms of household's welfare. Raising maize yields and then removing rice tariffs adds a large increase in soybean output and rice imports to the maize yield increase scenario. The impact on household income is modest with middle and bottom income households more affected – and more so in Java. Livestock production and consumption rise strongly and purchasing power of households is much improved. Raising maize, cassava and soybean yields stimulates production of these crops and reduces imports in particular of maize and cassava but not of soybeans. Rice imports also fall strongly. Household welfare is positively affected but by little. Combining maize, cassava and soybean yield increases with a rice tariff elimination has a particularly pronounced effect on soybean production. Livestock production and consumption grow strongly. Rice imports fall very sharply as do maize imports. Household incomes generally fall but the effect is small. Purchasing power on the other hand increases significantly.

Key Words: Indonesia, multi-market model, household welfare, maize, soybean, cassava, yields, rice tariff, crop diversification.
JEL: Q11, Q18.

1. INTRODUCTION[1]

The changing structure of food demand that is taking place over time implies increased incentives as well as pressure for greater diversification of Indonesian agriculture. Greater diversification may benefit farmers by lowering risks and raising incomes (Supadi, 2004). This is true in particular if farmers can take-up high value secondary crops such as melons, shallots, tobacco, hybrid maize, red pepper, etc. However, due to a number of constraints, such as labor availability and access to credit, farmers who diversify mostly grow low value secondary crops such as soybean, ground-nuts, and non-hybrid maize (Sumaryanto, 2006). Indeed the experience between 1996 and 2002 indicates that the trend has been to less diversification. In 1996 14 provinces out of 23 specialized in rice while in 2003 that number was 16. The trend in 19 of these provinces was for decreasing diversification (Siregar and Suryadi, 2006).

Although happening slowly, the relative composition of demand is shifting from cereals to livestock products, fruits and vegetables (San, et al., 1998). The trend towards diversification away from cereals also implies that it is important to maintain productivity growth for cereal products to free land and, in the case of some cereals, to meet the rising demand for animal feed. The most important cereal is rice which accounts for nearly half of total daily per-capita calorie intake. Rice occupies about 61% of total area planted and its cultivation provides a livelihood for about 21 million farm households. Indonesia has had considerable success with raising productivity of rice through the development and adoption of modern technology; the encouragement of active farmer participation; the provision of farm inputs at the proper time, location, quantity, quality and price, and price incentives for farmers through floor prices. Other important factors in bringing about significant increases in rice production were investment in physical infrastructure, i.e. both irrigation and roads, and institutional development. Such support meant that rice production grew at an annual average rate of 4.6 % over the 1969-1990 period. The efforts to promote domestic rice production resulted in Indonesia achieving self-sufficiency in rice in 1984 when per-capita production reached 234 kg.

The experience with rice shows that investment in research, infrastructure generally and irrigation in particular, can yield significant results. However continued productivity growth in rice is difficult to achieve as most of the land suitable for rice cultivation is already utilized. Moreover there are constraints to investment and expansion in irrigation. Indeed growth in rice production over the 2000-05 period has been slow, at 0.8%, despite considerable support given to rice farmers through tariff protection (see table A1.1, appendix 1). Moreover, given the distortions which hamper the process of agricultural transformation and the importance of rice in the consumption basket in particular of the poor but also in terms of rices' importance to the wider economy through its impact on real wages for unskilled labor, a number of authors have argued for a reduction in support to rice (see for example various BAPPENAS/Departmen Pertanian/USAID/DAI Food Policy Advisory Team publications available at www.macrofoodpolicy.com).

[1] This paper was prepared as part of the "Linking Agriculture Policies to Poverty and Food Security" module of the *Roles of Agriculture Project* [www.fao.org/es/esa/roa], funded by the Japanese Government. Content and errors are exclusively the responsibility of the authors and do not necessarily reflect the position of the Food and Agriculture Organization of the United Nations or of the Indonesian Center for Agricultural Socio Economic and Policy Studies. The multi-market model developed for this study builds on Lundberg and Rich (2002) and Stifel and Randrianarisoa (2004). We are grateful to these authors for sharing their GAMS code with us. We are grateful for comments by Keith Wiebe that helped improve the paper.

The second most important cereal crop in Indonesia, in terms of area planted, is maize. Maize is of significance not only for human consumption but also as animal-feed, providing about 51% of feed ingredients, especially for poultry and swine.[2] Soybean meal is suitable for animal feed but is mostly imported while dry cassava (*gaplek*) has a low protein content and requires additional processing.

Production has grown at a rate of 4.9% a year over the 1990-2005 period. Robust growth was mainly due to yield growth of 3.8% per year over the same period. Most maize is grown in Java but area under cultivation in Java has been declining gradually. Total area under maize increased by only 0.7% between 1990 and 2005. Despite maize yield increases from 0.96 tons/hectare to 3.4 tons/ha between 1970 and 2005 Indonesia cannot meet the rapid increase in domestic demand for maize which is estimated to having grown at a rate of about 12% between 1988-98 (various studies quote in Swastika et al., 2004b). The rapid increase in demand for maize as animal-feed is also a result of the fast growth in livestock and feed industries (Sayaka, 1995). For example, in 1970 poultry production stood at 14 thousand tons rising to 1.6 million tons by 1985 and 4.5 million tons by 2001.[3] As a consequence imports of maize have averaged about 1 million tons annually for the last 10 years (Swastika, et al., 2004a).

Focusing on increased productivity in maize may be more realistic since yields in Indonesia are still relatively low at about 3.4 tons/hectare and Indonesia is considered to have significant potential for increasing maize production through higher yields in the future (Swastika, et al., 2004b). On-farm trials with hybrid maize varieties show that yield potentials using improved crop and nutrient management ranged from a low of 7.2 tons/hectare in Central Java to 10.9 tons/hectare in East Java (Witt et al., 2006).[4] Low productivity of maize is due to, amongst other factors, low or poor soil fertility; poor infrastructure and/or remoteness of maize farms; limited access to credit, and; low adoption of improved technologies due to high hybrid seed prices (in part due to distance from seed company) as well as low levels of farmer education (Subandi (1998) cited in Swastika et al., (2004b)).

In this study we assess *ex-ante* the impact of improvements in maize yields on cropping patterns, producer and consumer prices, household income and calorie intake and other variables related to maize policy. We also consider scenarios that envisage yield improvements for cassava and soybean, two other important secondary crops, in addition to maize. Finally we combine the yield increase scenarios with a rice tariff elimination. An assessment of the impact of the policy changes on the desired objectives is important from the point of view of helping to shape the policy debate on the reform alternatives.

2. MODELLING AGRICULTURAL POLICY REFORM[5]

2.1 Introduction

For a number of reasons it is important to be able to provide an *ex-ante* analysis of proposed agricultural policy changes in developing countries. Many governments intervene directly in agricultural product, in particular food, markets through taxation and subsidization. Key objectives are to redistribute income, generate public revenues, correct market failures and

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[2] Swastika et al., (2004b) report a range of estimates for maize as animal-feed ranging from 69% to 21%.
[3] The layer and broiler bird population declined fairly dramatically after the onset of the financial crisis in 1997 but started to recover by 2000 (Swastika et al., 2004a).
[4] The corresponding potential yields for North Sumatra, Lampung, and South Sulawesi were 10.8, 7.6 and 7.8 tons/hectare, respectively. Swastika et al., (2004b) argue that a yield of 2.8 tons/hectare (in 2000) was low in relation to most recently released cultivars which had yield potentials ranging from 6 to 9 tons/hectare.
[5] This section is an abridged version of section 3 in Siam and Croppenstedt (2007).

provide incentives to producers (Braverman, Ahn and Hammer (1983)). An assessment of the impact of the policy changes on the desired objectives is important from the point of view of helping to shape the policy debate on the reform alternatives. In this paper we apply one tool, i.e. a multi-market model, [6] that has been used to analyze *ex ante* the impact of agricultural policy reforms.[7]

Multi-market models fall short of the complexity of Computable General Equilibrium models (CGEs) but do include direct and indirect effects in a small number of markets. In that sense they are an improvement over single market partial equilibrium analysis. They typically consist of a producer and consumer core and allow for the analysis of the impact of price and non-price policies on production, factor use, prices (for non-tradables), incomes, consumption, government revenues and expenditures and balance of trade (Sadoulet and de Janvry, 1995)). The analysis focuses on those markets which are assumed to be strongly interlinked, either on the demand or the supply side. Prices in those markets included in the analysis are endogenous. The bias in estimating welfare changes as a result of policy reforms is diminished, but remains. It follows that multi-market models will generate reliable results when the reforms being analysed affect commodities or factors for which the set of close substitutes and complements are well defined (Arulpragasam and Conway, 2003)).

Multi-market models have proven particularly popular for work on agriculture sector analysis. In the 1980s the World Bank developed multi-market models for Senegal, South Korea and Cyprus to analyse how the impact of changes in price policies would affect production, demand, income, trade and government revenues (Lundberg and Rich, 2002)). Braverman, Ahn and Hammer (1983) and Braverman and Hammer (1986) extended the single market surplus method to include income distribution and some general equilibrium considerations. Their analyses cover the agricultural sector and includes an exogenous urban sector. This is important as urban consumption may have an important impact on government revenue/deficits. Moreover staple food price changes are important for the urban poor. They note the trade-off between complete information on the consequences of policy and the need for simplicity in operational work.

More recently multi-market models have been used for agricultural sector Poverty and Social Impact Analysis (PSIA).[8] For example Murembya (1998) uses a multi-market model along the lines of Braverman and Hammer (1986) to study the impact of loosening agricultural price controls on agricultural production in the smallholder sector, the government budget deficit and on household welfare in Malawi. Dorosh et al., (1995) addresses the question of whether open market sales of yellow maize food aid is an effective means of poverty alleviation in Maputo and whether such a policy has any negative effects on the rural poor. Minot and Goletti (1998) use a spatial multi-market analysis which focuses on market liberalization of the rice sector in Vietnam.[9] Their model is innovative in the sense that it allows for differences in impacts across regions. Building on their work (and also using the Viet Nam Agricultural Spatial-Equilibrium Model) Goletti and Rich (1998a) study alternative policy options for agricultural diversification in Viet Nam and Goletti and Rich (1998b) use the Madagascar multi-market spatial-equilibrium model to analyse agricultural policy options for poverty reduction. Srinivasan and Jha (2001) analyze the effect of liberalizing food grain trade on domestic price stability using a multi-market model. In their model the direction of trade is determined endogenously.

[6] Multi-market models are sometimes referred to as "limited general equilibrium" (for example in Quizón and Binswanger (1986)) or "multi-market partial equilibrium" (as in Arulpragasam and Conway, 2003)) models.
[7] A more detailed discussion of the various tools to analyse policy change can be found in World Bank (2003).
[8] For detailed information on PSIA see the so dedicated World Bank website [www.worldbank.org/psia]. For a detailed overview of analyses on agricultural market reforms on poverty and welfare see Lundberg (2005).
[9] See also Minot and Goletti (2000).

Lundberg and Rich (2002) built a multi-market model to look at agricultural reforms in Madagascar. This was meant to be a generic model that could be adapted to policy analysis in a number of African countries. On the product side this model includes fine and coarse grains, roots and tubers, cash crops, livestock, other food products and non-agricultural production. On the input side fertilizer, feed and land were included. Labor was not included as the authors surmised that this input was more appropriately studied through the use of a CGE model. Stifel and Randrianarisoa (2004) built on Lundberg and Rich (2002) to analyze the impact of agricultural reforms, such as tariff changes, but also going beyond price changes by looking at infrastructure improvements and yield increases, in Madagascar. The model used in this paper derives from the work of Lundberg and Rich (2002) and Stifel and Randrianarisoa (2004).[10]

3. THE MODEL[11]

3.1 Product Categories

The product categories are: 1) food items, 2) maize for animal-feed, and 3) agricultural inputs. More specifically, these items include:

Rice: Indonesia is one of the world's leading rice producers, with paddy production in 2003 of more than 50 million tonnes and a cultivated area of more than 11.5 million ha. Rice occupies about 61% of the total area planted – mainly in the irrigated lowland systems. In 2003 the import tariff was 430 Rupiah/kg, equivalent to a 30% ad-valorem rate.

Maize: In Indonesia, maize is the second most important cereal crop after rice, in terms of the proportion of area planted to maize relative to the total area for all food crops. It’s grown mainly in dry-land areas (89%), with low soil fertility and erratic rainfall, and is often exposed to drought conditions.[12] Maize is grown in less developed or remote areas. It is an important staple food for the Madurese and in East Java. South and North Sulawesi people also consume a high proportion of maize. The main production areas of maize are West, Central and East Java, Lampung, Bali, Nusa Tenggara, South Sulawesi and Kalimantan. We include maize twice, once for human consumption and once for animal feed. We include maize as animal feed as our livestock variable covers poultry.

Soybean: is a major food crop consumed as sprout or more often in processed form as tofu (soybean curd), tempe (fermented soybean), kecap (soy sauce) and tauco (salty-fermented soybean). Soybeans, together with groundnuts, are an important source of protein in the traditional diet of Indonesians. The area harvested has fallen over the 1998-2002 period from 1,094 to 547 thousand hectare.

[10] We are grateful to Mattias Lundberg and David Stifel for making their GAMS code available to us. Making use of their model and adapting it to Indonesia has proven immensely helpful and time saving.

[11] When preparing the model we benefited from the active participation of Henny Reinhardt and Tanti Novianti, Department of Economics, Faculty of Economics and Management, Bogor Agricultural University; Leo Mualdy Christoffel and Yudha Hadian Nur, Ministry of Trade; Noor Avianto and Jarot Indarto, Bappenas; Erika Speelman and William Henderson, UNESCAP-CAPSA, Roosgandha, Helena J. Purba, Erna Maria Lokollo, Saktyanu K. Dermoredjo, Sri Nuryanti, Tri Bastuti Purwantini, Budiman Hutabarat, Reni Kustiari and Sri Wahyuni, ICASEPS, participants in two “Multi-Market Learning Workshop” held at the Indonesian Centre for Agriculture and Social Economic Policy Studies (ICASEPS), Bogor, between the 19-23 June, 2006 and 19-26 November 2006.

[12] Indeed Swastika et al., (2004) find that top priority should be given to maize research focusing on “the dryland agro-ecosystem of outer Java, were acid soils, weeds, and drought problems are the main constraints.”

Table 2: Proportion of overall rice, maize and soybean output by region

Region	Rice	Maize	Soybean
Sumatra	24 %	23 %	18 %
Java	54 %	56 %	61 %
Bali, East Timor and Nusa Tenggara	6 %	8 %	12 %
Kalimantan	5%	1 %	2%
Sulawesi	11 %	13 %	7 %

Source: FAO (1998)

Cassava: is the third most important crop in Indonesia which is widely eaten and used as a staple food during times of hardship. However, it is considered inferior to rice. Both maize and cassava (cassava and *gaplek* – dried cassava) are often consumed as staple food, particularly in Java (Gunawan, 1997).[13]

Banana: is one of the main horticultural commodities in Indonesia.

Wheat: Indonesia does not produce wheat. Although wheat consumption is small relative to rice and other staples produced, wheat is a substitute for rice and is an important source of calories. Total consumption in 2003 was about 3.8 million tons.

Livestock (poultry): the country has a large poultry industry. Production is mainly aimed at the domestic market, although some export can be regionally important, e.g. from Sumatra. Eighty percent of the poultry in Indonesia is produced by three large commercial companies, which are vertically integrated poultry production systems of substantial capacity. Seventy percent of total poultry production in Indonesia is carried out in Java (FAO, 2004). Our modelling of livestock supply is therefore unrealistic but, since output only depends on output price and animal feed prices, still accurate with regard to output response to price changes.

Three agricultural inputs are modelled explicitly:

Urea and **Phosphorous and Potassium**: The dominant fertilizers produced and used in Indonesia are urea, TSP (triple superphosphate), AS (ammonium sulphate) and KCl (Potassium chloride) (FAO (2005)).[14] There are six fertilizer producing companies, five of which are government owned while the sixth is a joint venture that produces for export. The supply, distribution and price of fertilizer is regulated by the government which gives priority to domestic fertilizer requirements.[15] Urea is produced from indigenous raw materials and domestic production typically exceeds consumption. Exports fluctuated between 1 and 2.3 million tons between 1998 - 2003. For a brief period between December 1st 1998 and 2001 fertilizer prices were left to the market but subsequently decrees were issued to regulate prices. Fertilizer price subsidies were phased out in 1998 because they placed a heavy burden on government finances and lead to inefficiency in fertilizer application at the farm level. The government re-introduced subsidies for 2003-05 for urea, SP-36, AS and NPK fertilizers but only for use on food crops and smallholder plantations. However control of fertilizer use

[13] Cassava, maize, soybean, as well as groundnut and sweet potato are the most important secondary crops after rice. In particular cassava, maize and sweet potatoes are consumed by rural people mostly as seasonal substitutes to rice (Gunawan, 1997).
[14] More recently TSP has been replaced by SP-36 (superphosphate).
[15] However, illegal exports are known to have occurred when export prices were particularly attractive.

proved difficult and applications to cash crops are more profitable. A further serious issue with regard to fertilizer consumption are the distributional problems.

Land: Land is included as a variable input but is not incorporated into the model as a traded commodity.

3.2 Households

Production and consumption patterns are distinguished among nine broad types of household groups: urban-rich, urban-middle, urban-bottom, Java-top, Java-middle, Java-bottom, off Java-top, off-Java-middle, off-Java-bottom. Where top, middle and bottom refer to the top 20%, the middle 50% and the bottom 30% of households on the basis of per-capita income. Only Java and off-Java households are involved in agricultural production activities.

3.3 Structure of the model

The multi-market model is an adaptation of Stifel and Randrianarisoa (2004) and consists of six blocks of equations: prices, supply input demand, consumption, income and equilibrium conditions. Unlike Stifel and Randrianarisoa (2004) we do not include seasonality nor do we include an aggregate for all other food products as well as non-food commodities in the model. Below we detail the different sets of equations, present the data used and explain which are their sources.

Prices: Consumer prices (PC) are higher than producer prices (PP) due to the domestic marketing margin (MARG) which can proxy, for example transportation costs due to infrastructure improvements:

$$PC_{c,h,r} = PP_{c,h,r} \bullet (1 + MARG_{c,r}) \qquad (1)$$

where the subscripts c, h, and r refer to commodity, household type and region, respectively.

The border price (PM) of the importable products (*im*) rice, soybean and wheat are linked to the world price by the exchange rate (*er*), import tariffs (*tm*), and the international marketing margin (RMARG).

$$PM_{im} = \overline{PW}_{im} \bullet er \bullet (1 + RMARG_{im}) \bullet (1 + tm_{im}) \qquad (2)$$

Although no exportable items are included the relevant price equations are already defined. Specifically, the border price (PX) of the exportable products (*ix*) are linked to the world price by the exchange rate (*er*), import tariffs (*tm*), and the international marketing margin (RMARG).

$$PX_{ix} = \frac{\overline{PW_{ix}} \bullet er}{(1 + RMARG_{ix}) \bullet (1 + te_{ix})} \qquad (3)$$

Consumer prices for the importable items are related to the border price by the commodity specific border-to-market marketing margin:

$$PC_{im,'urban'} = PM_{im} \bullet (1 + IMARG_{im}) \qquad (4)$$

where IMARG is the border-to-market marketing margin, specific to commodities.

Consumer prices for the exportable items are related to the border price by the commodity specific market-to-border marketing margin:

$$PC_{im,'urban'} = \frac{PX_{ix} \bullet (1 + MARG_{ix})}{(1 + IMARG_{ix}} \qquad (5)$$

where IMARG is the market-to-border marketing margin, specific to commodities.

Rural consumer prices differ from urban consumer prices by an internal marketing margin (INTMARG) that reflects transportation and marketing costs.

$$PC_{c,'urban'} = PC_{c,'rural'} \bullet (1 + INTMARG_c) \qquad (6)$$

The internal marketing margin is positive for products which are primarily exported from rural to urban areas. Products that are assumed not to move from rural to urban or vice-versa have a zero INTMARG).

This particular set-up allows one to distinguish between farm-rural market (MARG), rural market to urban market (INTMARG) and urban-border (IMARG).

We assume that households in the different income groups face the same prices in rural and urban locations. We include a price index for each household group to reflect changes in prices weighted by their shares of consumption:

$$PINDEX_h = \sum_i \left(w_{h,r,i} \bullet \left(\frac{PC^1_{h,r,i}}{PC^0_{h,r,i}} \right) \right) \qquad (7)$$

where w is the budget share for each commodity. The superscript on the PC terms refers to periods 0 and 1 and denote starting prices and end of simulation prices. Since we do not include all consumption items on which households spend money the weights in the PINDEX must be multiplied by the actual weight of the consumption commodities included in the model.[16]

Supply: Rural household's supply of rice, maize, soybean, cassava and bananas are determined by a) the total amount of land available to each household; b) the share of that land allocated to the specific crops and, c) the associated yield for the crops. The share of land (SH) allocated to a particular crop by household group h is a function of all crop prices:

$$\log(SH_{h,f}) = \alpha^s + \sum_f \beta^s \bullet \log(PP_{h,f}) \qquad (8)$$

where *f* refers to farmed commodities. The sum of the shares may or may not be restricted to sum to 1. If not restricted to 1 the assumption is that land is endogenously determined even though land is not explicitly traded. If shares add up to more than one following a simulation then extensification is practiced. The realism of this assumption will depend on the particular setting. The land substitution and expansion elasticities will reflect how easy it is to switch between crops and/or to bring new land into production.

Yields (YLD) for crops *f* by household groups *h* are a function of output and input prices as well as land. The log-log equations are based on an underlying translog profit function.

[16] The share of the consumption bundle included in this model in total expenditure is estimated as 40 %.

$$\log(YLD_{h,f}) = \alpha^{y} + \sum_{f} \beta^{y} \bullet \log(PP_{h,f}) + \sum_{in} \gamma^{y} \bullet \log(PC_{h,in}) \qquad (9)$$

where the coefficients represent the price elasticities.

The total household supply to the market is then determined as the product of the initial area under cultivation, the share of land devoted to the crop, and the yield. Adjustments are made for losses and use of the output for seed (*loss*), and for any related conversion factors (*conv*).

$$HSCR_{h,f} = AREA \bullet SH_{h,f} \bullet YLD_{h,f} \left(1 - loss_{f}\right) \bullet \left(1 - conv_{f}\right) \qquad (10)$$

The total supply of each of the commodities is the sum of household supply:

$$SCR_{f} = \sum_{h} HSCR_{h,f} \qquad (11)$$

Household livestock supply is modelled as a function of livestock prices and input prices of animal feed products, i.e. berseem and maize.

$$HSLVSTK_{h} = \alpha_{h}^{lvstk} + \beta^{lvstk} \bullet \log(PP_{h,lvstk}) + \gamma^{lvstk} \bullet \log(PC_{h,af}) \qquad (12)$$

where the subscript *af* refers to animal feed products. Total livestock supply is given by:

$$SL = \sum_{h} HSLVSTK_{h} \qquad (13)$$

Input Demand: Household *h*'s demand for input – maize for animal feed, urea and P&K - (HDIN) is a function of output prices (PP) and input prices (PC).

$$\log(HDIN_{h,in}) = \alpha^{in} + \sum_{f} \beta^{in} \bullet \log(PP_{h,f}) + \sum_{in} \gamma^{in} \bullet \log(PC_{h,in}) \qquad (14)$$

where the subscript *in* refers to urea, P&K and maize for animal feed. Total demand for the inputs is given by:

$$DIN_{in} = \sum_{h} HDIN_{h} \qquad (15)$$

Consumption Block: Demand for the consumption items (HC) by the household groups in urban and rural locations is modelled as:

$$\log(HC_{h,i}) = \alpha_{h,i}^{d} + \sum_{f} \beta_{h,i}^{d} \bullet \log(PC_{h,i}) + \gamma_{h,i}^{d} \log(YH_{h}) \qquad (16)$$

where the *i* refer to commodities households purchase, i.e. rice, maize, wheat, soybean, cassava and bananas. YH is household income (defined below), PC are consumer prices, P is the stone geometric price index defined as:

$$\log(P_{h,r,i}) = \sum_{i} w \bullet \log(PC_{h,i}) \qquad (17)$$

Total demand is:

$$TCON_i = \sum_h HC_{h,i} \qquad (18)$$

Income Block: Agricultural income (YHAG) for rural households is the sum of crop revenue minus input costs:

$$YHAG_h = \sum_f \left(PP_{h,f} \bullet SCR_{h,f}\right) + PP_{h,lvstk} \bullet \quad HSLVSTK_h - \left(PC_{h,in} \bullet DIN_{h,in}\right) \qquad (19)$$

And total household income (YH) is the sum of agricultural income and the exogenously determined non-agricultural income. The latter component is adjusted by a price index:

$$YH_h = YHAG_h + \overline{YHNAG}_h \bullet PINDEX_h \qquad (20)$$

and the price index is as defined in equation (7).

Equilibrium Conditions: All commodity markets clear, i.e. the sum of quantity supplied (domestic production plus net imports) is equal to the amount demanded for human and animal consumption.

$$SCR_f + M_f + STOCK\Delta_f = CONS_f + \overline{FEED}_f \qquad (21)$$

$$LVSTK + M_{livstk} = DIN_{livstk} \qquad (22)$$

$$SDIN_{in} + M_{in} = DIN_{in} \qquad (23)$$

where M equals net imports and CONS and FEED denote human and animal consumption respectively. For products not traded imports are fixed at zero. Feed for maize is endogenous but other animal feed products are treated as exogenous.

Rice, wheat and soybean are treated as importable commodities. Net imports of maize and cassava are also non-negligible but only amount to about 13 and 4% of production respectively while imports of bananas and livestock are negligible. Hence prices for maize, cassava, bananas and livestock are assumed to be determined by domestic supply and demand. Imports for bananas are restricted to fluctuate within a set range around the baseline level. For the scenarios that include the elimination of the rice tariff these closure conditions are augmented by the restriction on net imports of maize, cassava, and livestock to fluctuate around a set range, i.e. +/- 10% of the net imports as determined by the scenario without the elimination of the rice tariff but with yield increases.

3.4. Data requirements

Three types of data are needed to calibrate the model to a baseline solution. These are:

Levels: production, consumption, income, and input levels must be defined for all commodities and household groups. Aggregate levels are typically taken from *Statistik Indonesia* (for land and production) or FAOSTAT (for consumption) for 2003. Household level data are either from SUSENAS for consumption data or the 1999 PATANAS survey for production data.

Prices: consumer, producer, user, and border prices must be defined for all commodities. They also define the marketing margins. Producer and consumer prices are taken from *Indonesia Statistik* (CBS), except for bananas, wheat, poultry and cassava for which they are derived from the PATANAS data set.

Parameters: these are the demand and supply elasticities, all of which are best guesses.[17] We give a short overview of the elasticities used: Land-share elasticities – equation 8: own price elasticities are 0.3 while cross-price elasticities with respect to all crops and cassava and banana and are -0.05 while all the rest are -0.1. Crop yield elasticities – equation 9: The own-price elasticities are 0.3 for rice, maize and cassava and 0.2 for soybean and bananas. The crop yield elasticities with respect to input prices are -0.11 for all commodities and all inputs except for bananas for which the elasticity is assumed to be -0.04. Livestock output supply elasticity – equation 12: The own-price elasticity is 0.6 and the elasticity of livestock supply with regard to the price of animal feed (maize) is -0.5. Input demand elasticities – equation 14: The own-price elasticity for fertilizer (both types) is -0.1 and for animal feed it is -0.2. The price elasticity of fertilizer (nitrogen and P&K) with regard to the price of the crops to which they are applied is 0.05. The elasticity of animal feed with respect to the price of livestock is 0.5. Consumer demand elasticities – equation 16: The own price demand elasticity is -0.3 for rice, maize and soybean. For cassava, banana and wheat it is -0.15, -0.1 and -0.12, respectively. For livestock it is -0.5. The cross-price elasticities are positive and between 0.05 and 0.2 for rice and maize, rice and wheat, maize and soybean, maize and wheat. They are negative and between -0.01 and -0.12 for all other combinations of commodities. The cross-price elasticities for banana with all crops except for cassava are zero and for the latter -0.01. The elasticities of demand with respect to income are 0.2 for rice, soybean and banana; -0.1 for maize and cassava; 0.1 for wheat and 0.3 for livestock.

3.5. Baseline Scenario[18]

The baseline solution corresponds to aggregate data for 2003. Rice (milled) output is 31.8 million tons while for maize, soybean, cassava, banana and livestock (poultry) output are 10.1, 0.5, 12,7, 3.9 and 1.2 million metric tons, respectively. 54% of rice production and 62% of maize production originates in Java. Banana and livestock production are 70% and 71% from off-Java. With regard to consumption we note that for rice this is fairly evenly distributed among Urban, Java and off-Java areas. Maize is predominantly consumed in rural areas and 3.3 million tons of maize are used for animal feed. Soybean consumption is concentrated in Urban and Java areas while about half of cassava output and 46% of the wholly-imported wheat is consumed in off-Java. Imports of rice, maize, soybean, cassava and wheat are 0.8, 1.3, 1.2, 0.8 and 3.9 million tons and the self-sufficiency ratios for rice, maize, soybean, cassava and banana are 0.98, 0.88, 0.31, 0.94 and 1, respectively. Crop diversification – a diversification index closer to 1 indicates greater specialization (see note iii

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[17] These best guesses are based on the experience and knowledge of the three first named authors, i.e. Bambang Sayaka, Sumaryanto and Masjidin Siregar. Our parameter choices were also informed by previous studies of farm supply and household demand in Indonesia. We acknowledge the considerable effort made by Wayan I. Rusastra in compiling these studies and note that the literature documents a considerable range of supply and demand side parameters. More detail is available from André Croppenstedt at andre.croppenstedt@fao.org.

[18] The baseline data set is calibrated using interlinked excel sheets that may be useful to others [even if considerable adaptation will inevitably be required] in simplifying this kind of exercise. The excel file for the Indonesia multi-market baseline is available from André Croppenstedt at andre.croppenstedt@fao.org.

at the bottom of table 3 for more detail) - in the baseline is relatively less in Java and in particular so for the middle and bottom income groups. Caloric intake is lower for top urban than for middle and bottom urban groups and is lower in urban than in rural areas. This is in line with findings for urban households reported in Skoufias (2001) also using SUSENAS. For rural households this may reflect our focus on a sub-set of commodities.

4. POLICY SIMULATION RESULTS

4.1 Scenario 1: A 10% increase in maize yields

Increasing maize yields by approximately 10% raises maize output by about that amount but has little effect on the output of other crops and livestock. Cassava output falls by 0.52% while rice and soybean production rise by 0.25%. Consumption is only little affected: 0.35% for maize; -0.14% for rice; 0.15% for cassava and 0.4% for livestock. The adjustments in supply and demand lead to a 16% drop in rice imports, a 71% drop in maize imports, equal to nearly 1 million tons, and a 10% increase in cassava imports while for other products the changes are small. Self-sufficiency in maize rises from 88 to 97%. Diversification is unaffected. Urban household incomes are unchanged. Rural farming households gain across the board but middle groups gain much more, relative to the other two groups. Purchasing power improves but by between 0.2 and 0.7%. Caloric intake is nearly unaffected.

4.1.1 Sensitivity Analysis

The results are found to be only moderately sensitive to a doubling/halving of: consumer demand side elasticities; the land share elasticities; and the livestock own price supply elasticities. The results are sensitive to a doubling of the elasticities of output supply with respect to input prices; the input demand elasticities with respect to output prices; the elasticity of livestock with respect to feed. The results are also sensitive to a halving of the crop yield own price elasticities and the own price elasticities of input demand. With regard to the scenarios that cover the rice tariff elimination we find that the results are sensitive to a doubling/halving of the supply side elasticities and the input demand elasticities as well as the elasticities of livestock supply with respect to input prices. The results are now also more sensitive to a change in the elasticities of consumer demand with respect to prices.

4.2 Scenario 2: Combining a 10% increase in maize yield with the elimination of the rice tariff[19]

Combining the maize yield increase of 10% with a rice tariff elimination leads to an output increase of 10.3% for maize, 6.8% for soybean, 0.8% for cassava and 3.5% for livestock. Rice output falls by 1.3% while banana production is virtually unchanged. On the consumption side demand increases for rice (1.4%), maize (1.4%), cassava (0.8%) and livestock (3.5%) while it falls by 1.1% for soybeans and 2.8 for wheat.

Changes in household income are generally negative, especially so for middle (-2%) and bottom (-2.3%) income groups on Java and somewhat less so for middle (-1.5%) and bottom (-1%) income groups off-Java. For urban households the effect is small and negative. For the Java top income group the income effect is +0.3%. All households see their

[19] Net imports for maize, cassava, bananas and livestock are restricted to +/- 10% of their scenario 4.1 level. In this sense the removal of the rice tariff can be seen as sequential to the yield increases. The changes are however discussed, unless otherwise indicated, with reference to the baseline.

purchasing power – in terms of the price changes implied – improve very substantially and this effect is relatively stronger for rich and poor income households.

Rice imports increase by 110% while maize imports fall to 353 thousand tons, a drop of nearly 1 million tons. Soybean and cassava imports change only marginally. Wheat imports fall 2.8%, in line with the drop in consumer demand for this commodity. Consumer prices for rice, maize, banana and livestock fall by 30, 23, 13 and 12%, respectively. Self-sufficiency for rice falls to 95%, down from 98% while for maize the ratio is 97%, up from 88%. For soybeans and cassava the self-sufficiency ratios increase marginally from 31 to 33 and from 94 to 95%, respectively. Crop diversification rises, more so in Java which was moderately less diversified in the first place.

4.3 Scenario 3: A 10% increase in maize, soybean and cassava yields

Increasing yields of maize, soybean and cassava by 10% stimulates output growth by 9.3, 10.5 and 8.2%, respectively. Consumption is only little affected: +0.6% for maize, -0.2% for soybean and +0.5% for cassava. The adjustments in supply and demand for rice lead to a drop in rice imports of 29%. Maize imports fall by 66% and cassava turns from being imported (over 800 thousand tons) to being exported (165 thousand tons). Soybean imports fall by 5%. Self-sufficiency of maize increases significantly from 88 to 96% and for cassava from 94 to 101%. Diversification is unaffected. Urban household incomes are unchanged. Rural farming households gain across the board but middle and bottom income groups gain much more, relatively speaking. Purchasing power improves for all groups but only by around 1.4% or less.

4.4 Scenario 4: Combining a 10% increase in maize, soybean and cassava yields with with the elimination of the tariff on rice imports[20]

Finally, combining the yield increases for maize, soybean and cassava with the elimination of the tariff on rice we find that output of maize and cassava is still up by about 10% (10.1% for maize and 9.1% for cassava). However soybean output is up by 17.6% while rice production declines by 1.2%. Maize, cassava and rice consumption rise 1.6, 1.2 and 1.3% respectively while soybean and wheat demand fall 1.1 and 2.8%, respectively. Livestock supply and demand increase by 4.6 and 3.4% respectively, due to the fall in the price of maize for animal feed and livestock consumer prices.

Changes in household income are generally negative but small. Middle (-1.8%) and bottom (-1.6%) income groups on Java are more affected than other rural income groups. The bottom income group in off-Java sees a fall of only 0.3% and the top income group Java is better off (by 0.4%). All households see their purchasing power – in terms of the price changes implied - improve very substantially and this effect is relatively stronger for rich and poor income households.

Rice imports increase by 100% while maize imports see a marked drop to 416 thousand tons. Soybean imports fall 11% and cassava exports reach 182 thousand tons. Wheat imports fall 2.8%, in line with the drop in consumer demand for this commodity. Consumer prices for rice, maize and livestock fall by 30, 25 and 12% respectively. Self-sufficiency of rice falls to 95%, down from 98% while for maize the ratio is 96%, up from 88%. Also for

[20] The net imports for maize, cassava, bananas and livestock are restricted to +/- 10% of their scenario 4.3 level. In this sense the removal of the rice tariff can be seen as sequential to the yield increases. The changes are however discussed, unless otherwise indicated, with reference to the baseline.

soybeans and cassava self-sufficiency increases to 37 and 101% respectively. Crop diversification is boosted, more so in Java (moderately less diversified in the first place).

5. CONCLUSIONS

In this study we use a multi-market model to assess the impact of yield increases for maize, soybean and cassava on cropping patterns, producer and consumer prices, household income, caloric intake and other variables of interest to policy makers. Such a model can generate substantial detail with regard to supply and demand changes in the markets for these commodities as well as those for other, closely related commodities. It is not able to capture wider impacts, say of wage and labor changes, as would be the case with a CGE model. Information on welfare changes based on household income and expenditure should therefore be treated as data specific to the model and valid for comparisons across scenarios but not valid for comparisons outside the model.

Raising maize yields reduces imports and has generally small but positive side-effects in terms of output, consumption, income and purchasing power. Raising maize yields and then removing rice tariffs adds a large increase in soybean output and rice imports to the maize yield increase only scenario. The impact on household income is modest with middle and bottom income households more affected – and more so in Java. Livestock production and consumption rise robustly and purchasing power of households is strongly affected. Raising maize, cassava and soybean yields together stimulates production of these crops and reduces imports in particular of maize and cassava but not of soybeans. Also rice imports fall strongly. Household welfare is generally positively affected but by little. Combining maize, cassava and soybean yield increases with a rice tariff elimination has a particularly pronounced effect on soybean production. Livestock production and consumption grow strongly. Rice imports fall very sharply as do maize imports. Household incomes generally fall but the effect is small. On the other hand purchasing power of households increases significantly.

Our study shows the benefits and limits to investments in raising yields of maize, cassava and soybeans. We include the removal of rice tariffs to show the positive interaction between these crops and because rice is of such fundamental importance in the Indonesian economy. Admittedly removing rice support is politically risky and therefore unlikely. Nevertheless we hope that our study adds insight and therefore helps inform the debate.

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Appendix 1

Table A1.1: Production of Some Key Staple Food Commodities, 1990-2003 – 1000 Tonnes

Year	Rice	Maize	Cassava	Soybean	Banana
1990	30,134	6,734	15,830	1,487	2,411
1991	29,807	6,256	15,955	1,556	2,472
1992	32,176	7,996	16,516	1,870	2,651
1993	32,137	6,460	17,285	1,709	2,644
1994	31,110	6,869	15,729	1,565	3,087
1995	33,179	8,246	15,442	1,680	3,805
1996	34,085	9,307	17,003	1,517	3,024
1997	32,935	8,771	15,134	1,357	3,057
1998	32,841	10,170	14,696	1,306	3,177
1999	33,928	9,204	16,438	1,383	3,376
2000	34,616	9,677	16,089	1,018	3,747
2001	33,657	9,347	17,055	827	4,300
2002	34,344	9,654	16,913	673	4,384
2003	34,776	10,886	18,524	672	4,177
2004	36,077	11,225	19,425	724	4,874
2005	36,008	12,014	19,459	797	4,503

Source: FAOSTAT

Table A1.2: Area Harvested for Some Key Staple Foods, 1990-2003, 1000 Hectare

Year	Rice	Maize	Cassava	Soybean	Banana
1990	10,502	3,158	1,312	1,334	133
1991	10,282	2,909	1,319	1,368	135
1992	11,103	3,629	1,351	1,665	165
1993	11,013	2,940	1,402	1,470	195
1994	10,734	3,109	1,357	1,407	265
1995	11,439	3,652	1,324	1,477	280
1996	11,570	3,744	1,415	1,273	246
1997	11,141	3,355	1,243	1,119	264
1998	11,730	3,834	1,205	1,095	258
1999	11,963	3,456	1,350	1,151	270
2000	11,793	3,500	1,284	825	265
2001	11,500	3,286	1,318	679	277
2002	11,521	3,127	1,277	545	269
2003	11,477	3,359	1,245	527	278
2004	11,923	3,357	1,256	565	315
2005	11,801	3,504	1,224	611	315

Source: FAOSTAT

Table A1.3: Yields for Some Key Staple Food Commodities, 1990-2003 – Tonnes/Hectare

Year	Rice	Maize	Cassava	Soybean	Banana
1990	4.3	2.13	12.07	1.11	18.2
1991	4.35	2.15	12.09	1.14	18.3
1992	4.34	2.2	12.22	1.12	16.07
1993	4.38	2.2	12.33	1.16	13.56
1994	4.35	2.21	11.59	1.11	11.64
1995	4.35	2.26	11.66	1.14	13.58
1996	4.42	2.49	12.02	1.19	12.3
1997	4.43	2.61	12.17	1.21	11.59
1998	4.2	2.65	12.19	1.19	12.29
1999	4.25	2.66	12.18	1.2	12.51
2000	4.4	2.76	12.53	1.23	14.14
2001	4.39	2.84	12.94	1.22	15.52
2002	4.47	3.09	13.25	1.24	16.3
2003	4.54	3.24	14.88	1.28	15.03
2004	4.54	3.34	15.47	1.28	15.49
2005	4.57	3.43	15.90	1.31	14.30

Source: FAOSTAT

Table A1.4: Per-capita Production of Some Key Staple Food Commodities, 1990-2003 – Kg/Capita

Year	Population (1000)	Rice	Maize	Cassava	Soybean	Banana
1990	181,414	166	37	87	8	13
1991	184,338	162	34	87	8	13
1992	187,222	172	43	88	10	14
1993	190,067	169	34	91	9	14
1994	192,875	161	36	82	8	16
1995	195,649	170	42	79	9	19
1996	198,388	172	47	86	8	15
1997	201,094	164	44	75	7	15
1998	203,783	161	50	72	6	16
1999	206,472	164	45	80	7	16
2000	209,174	165	46	77	5	18
2001	211,893	159	44	80	4	20
2002	214,624	160	45	79	3	20
2003	217,354	160	50	85	3	19
2004	220,077	164	51	88	3	22
2005	222,781	162	54	87	4	20

Source: FAOSTAT

Table A1.5: Net Imports of Some Key Selected Staple Foods, 1990-2003 - 1000 Tonnes

Year	Rice	Maize	Cassava	Soybean	Banana
1990	204	-78	-2,728	353	-13
1991	377	361	-1,750	526	-29
1992	995	-35	-1,537	522	-40
1993	-421	512	-2,351	484	-79
1994	626	1,174	-1,130	607	-58
1995	2,693	1,053	-645	532	-84
1996	3,289	715	-803	751	-140
1997	641	1,237	-42	629	-85
1998	3,819	-173	-338	463	-106
1999	7,548	829	-401	1,266	-122
2000	2,428	1,481	691	1,267	-50
2001	1,203	1,166	65	1,120	-32
2002	2,745	1,342	39	1,355	-58
2003	2,305	1,459	725	1,181	-55
2004	414	1,142	-764	1,134	-59
2005	805	282	-843	1,298	-51

Source: FAOSTAT

Table A1.6: Imports as a Proportion of Domestic Production for Some Key Staple Foods, 1990-2003 (%)

Year	Rice	Maize	Cassava	Soybean	Banana
1990	0.01	0.01	0.01	0.35	0.00
1991	0.01	0.06	0.01	0.41	0.00
1992	0.03	0.02	0.03	0.35	0.00
1993	0.00	0.09	0.00	0.40	0.00
1994	0.03	0.18	0.03	0.48	0.00
1995	0.08	0.14	0.04	0.35	0.00
1996	0.10	0.08	0.01	0.50	0.00
1997	0.03	0.15	0.04	0.58	0.00
1998	0.12	0.05	0.03	0.36	0.00
1999	0.23	0.11	0.03	0.93	0.00
2000	0.08	0.16	0.07	1.26	0.00
2001	0.05	0.14	0.03	1.38	0.00
2002	0.09	0.15	0.02	2.04	0.00
2003	0.07	0.14	0.04	1.78	0.00
2004	0.02	0.11	0.02	1.60	0.00
2005	0.03	0.03	0.03	1.65	0.00

Calculations based on FAOSTAT data.

Appendix 2

Table A2.1 Baseline and Simulation Results for yield improvements for maize, soybean and cassava margin: Alone, combined and in conjunction with the elimination of rice tariffs†

Variable	Baseline	Maize Yield up 10%	Maize Yield up 10% and Rice Tariff = 0%	Maize, Cassava and Soybean Yields up 10%	Maize, Cassava and Soybean Yields up 10% and Rice Tariff = 0%
Domestic Production (tons)					
Rice					
Java	17,164,849	17,207,449	16,936,225	17,242,290	16,963,296
Off-Java	14,604,366	14,640,611	14,409,846	14,670,255	14,432,878
Total	31,769,216	31,848,060	31,346,072	31,912,545	31,396,174
Maize					
Java	6,303,024	6,909,528	6,953,408	6,889,601	6,936,835
Off-Java	3,816,679	4,183,936	4,210,507	4,171,870	4,200,471
Total	10,119,702	11,093,464	11,163,915	11,061,471	11,137,306
Soybean					
Java	386,391	387,350	412,464	426,947	454,436
Off-Java	145,209	145,570	155,008	160,451	170,781
Total	531,600	532,919	567,472	587,398	625,217
Cassava					
Java	6,713,139	6,678,411	6,764,487	7,262,686	7,322,323
Off-Java	6,026,671	5,995,494	6,072,768	6,520,022	6,573,561
Total	12,739,810	12,673,904	12,837,255	13,782,708	13,895,883
Banana					
Java	1,163,735	1,164,130	1,162,684	1,164,517	1,163,070
Off-Java	2,716,985	2,717,907	2,714,529	2,718,809	2,715,432
Total	3,880,720	3,882,037	3,877,213	3,883,325	3,878,502
Livestock					
Java	352,354	353,722	364,735	357,352	368,466
Off-Java	850,926	854,228	880,824	862,996	889,836
Total	1,203,281	1,207,950	1,245,558	1,220,349	1,258,302

			Consumption (tons)		
Rice					
Urban	11,629,867	11,610,546	11,798,487	11,593,778	11,785,771
Java	9,587,526	9,575,544	9,713,048	9,563,710	9,704,883
Off-Java	9,803,837	9,790,360	9,942,342	9,778,865	9,934,248
Total	31,021,230	30,976,449	31,453,877	30,936,353	31,424,902
Maize					
Urban	839,105	842,162	850,413	844,471	852,399
Java	4,201,447	4,215,950	4,261,564	4,226,942	4,270,868
Off-Java	3,115,688	3,126,678	3,158,279	3,134,735	3,165,128
Total	8,156,240	8,184,789	8,270,256	8,206,147	8,288,395
Soybean					
Urban	807,443	806,597	799,352	805,839	798,688
Java	715,149	714,689	707,022	714,168	706,602
Off-Java	199,988	199,834	197,908	199,697	197,793
Total	1,722,580	1,721,120	1,704,281	1,719,704	1,703,084
Cassava					
Urban	3,733,294	3,739,336	3,760,713	3,750,845	3,776,546
Java	2,967,900	2,972,071	2,992,410	2,980,861	3,004,593
Off-Java	6,487,416	6,496,749	6,536,132	6,515,817	6,562,744
Total	13,188,610	13,208,155	13,289,255	13,247,522	13,343,883
Banana					
Urban	1,635,409	1,635,586	1,634,558	1,635,882	1,634,855
Java	497,021	497,295	495,896	497,490	496,109
Off-Java	1,748,514	1,749,356	1,746,939	1,750,153	1,747,719
Total	3,880,944	3,882,237	3,877,393	3,883,525	3,878,682
Wheat					
Urban	1,096,497	1,096,644	1,066,358	1,096,123	1,065,836
Java	969,043	969,408	941,668	969,023	941,296
Off-Java	1,734,350	1,734,905	1,686,316	1,734,302	1,685,694
Total	3,799,890	3,800,956	3,694,342	3,799,448	3,692,827
Livestock					
Urban	423,827	425,225	438,846	425,192	438,484
Java	302,202	303,399	312,248	303,457	312,089
Off-Java	474,171	476,012	490,764	476,149	490,529
Total	1,200,200	1,204,636	1,241,858	1,204,799	1,241,102

			Input Demand (tons)		
Maize – Animal Feed					
Java	1,030,376	1,029,299	1,013,721	1,034,420	1,019,420
Off-Java	2,269,624	2,267,252	2,232,938	2,278,533	2,245,491
Total	3,300,000	3,296,551	3,246,659	3,312,953	3,264,912
Urea					
Java	2,640,810	2,640,810	2,640,810	2,640,810	2,640,810
Off-Java	1,374,190	1,374,190	1,374,190	1,374,190	1,374,190
Total	4,015,000	4,015,000	4,015,000	4,015,000	4,015,000
P&K					
Java	659,140	659,140	659,140	659,140	659,140
Off-Java	359,860	359,860	359,860	359,860	359,860
Total	1,019,000	1,019,000	1,019,000	1,019,000	1,019,000

Net Imports (tons)					
Rice	781,814	658,189	1,637,605	553,608	1,558,528
Maize	1,336,538	387,876	353,000	457,629	416,000
Soybean	1,190,980	1,188,200	1,136,809	1,132,306	1,077,866
Cassava	818,800	904,251	822,000	-165,186	-182,000
Banana	224	200	180	200	180
Wheat	3,896,350	3,897,416	3,790,802	3,895,908	3,789,286
Livestock	-3,081	-3,314	-3,700	-15,550	-17,200
Maize - Animal Feed	0	0	0	0	0
Fertilizer - Urea	0	0	0	0	0
Fertilizer - P&K	0	0	0	0	0

Urban Consumer Prices (Rupiah/ton)					
Rice	3,174,480	3,174,480	2,441,908	3,174,480	2,441,908
Maize	2,295,150	2,250,326	1,864,086	2,213,789	1,839,498
Soybean	5,308,270	5,308,270	5,308,270	5,308,270	5,308,270
Cassava	1,028,764	1,011,131	1,055,229	973,297	1,000,194
Banana	2,983,948	2,975,573	2,637,938	2,969,572	2,634,667
Wheat	3,248,982	3,248,982	3,248,982	3,248,982	3,248,982
Livestock	13,661,010	13,525,342	12,167,189	13,571,114	12,239,200

Rural Consumer Prices Java (Rupiah/ton)					
Rice	2,769,569	2,769,569	2,130,438	2,769,569	2,130,438
Maize	2,002,399	1,963,292	1,626,318	1,931,416	1,604,867
Soybean	4,631,190	4,631,190	4,631,190	4,631,190	4,631,190
Cassava	897,543	882,159	920,632	849,151	872,617
Banana	2,603,340	2,596,033	2,301,464	2,590,797	2,298,610
Wheat	3,035,297	3,035,297	3,035,297	3,035,297	3,035,297
Livestock	13,153,293	13,022,667	11,714,990	13,066,738	11,784,325

Rural Consumer Prices Off-Java (Rupiah/ton)					
Rice	2,940,422	2,940,422	2,261,863	2,940,422	2,261,863
Maize	2,125,926	2,084,407	1,726,645	2,050,564	1,703,870
Soybean	4,915,065	4,915,065	4,915,065	4,915,065	4,915,065
Cassava	952,912	936,579	977,426	901,535	926,449
Banana	2,763,939	2,756,181	2,443,440	2,750,623	2,440,410
Wheat	3,188,402	3,188,402	3,188,402	3,188,402	3,188,402
Livestock	13,260,542	13,128,851	11,810,511	13,173,281	11,880,411

Rural Producer Prices Java (Rupiah/ton)					
Rice	1,408,876	1,408,876	1,083,751	1,408,876	1,083,751
Maize	1,319,799	1,294,024	1,071,921	1,273,014	1,057,782
Soybean	3,049,042	3,049,042	3,049,042	3,049,042	3,049,042
Cassava	551,486	542,033	565,673	521,752	536,170
Banana	2,429,168	2,422,351	2,147,489	2,417,465	2,144,826
Wheat	..	..	..	..	..
Livestock	12,579,660	12,454,732	11,204,084	12,496,881	11,270,395
Maize - Animal Feed	1,319,799	1,294,024	1,071,921	1,273,014	1,057,782
Fertilizer - Urea	649,351	642,076	482,583	636,199	479,092
Fertilizer - P&K	931,818	921,378	692,506	912,946	687,497

Rural Producer Prices Off-Java (Rupiah/ton)					
Rice	1,495,789	1,495,789	1,150,607	1,495,789	1,150,607
Maize	1,401,217	1,373,851	1,138,047	1,351,545	1,123,036
Soybean	3,235,937	3,235,937	3,235,937	3,235,937	3,235,937
Cassava	585,507	575,471	600,569	553,939	569,246
Banana	2,579,023	2,571,784	2,279,967	2,566,597	2,277,139
Wheat	..	..	..	..	..
Livestock	12,682,232	12,556,285	11,295,439	12,598,777	11,362,291
Maize - Animal Feed	1,401,217	1,373,851	1,138,047	1,351,545	1,123,036
Fertilizer - Urea	837,872	828,485	622,687	820,902	618,183
Fertilizer - P&K	1,242,839	1,228,914	923,649	1,217,667	916,969

CPI					
Urban Top	100.0	99.9	93.6	99.9	93.5
Urban Middle	100.0	99.9	94.3	99.8	94.1
Urban Bottom	100.0	99.9	93.1	99.8	92.9
Java Top	100.0	99.9	93.6	99.8	93.5
Java Middle	100.0	99.8	93.9	99.7	93.7
Java Bottom	100.0	99.7	93.4	99.5	93.1
Off-Java Top	100.0	99.9	93.4	99.8	93.3
Off-Java Middle	100.0	99.8	95.0	99.6	94.6
Off-Java Bottom	100.0	99.7	93.5	99.5	93.2

Self-Sufficiency Ratio (%)[i]					
Rice	98	98	95	98	95
Maize	88	97	96	96	96
Soybean	31	31	33	34	37
Cassava	94	93	94	101	101
Banana	100	100	100	100	100

Crop Diversification Index (%)[iii]					
Java Top	42	42	39	42	39
Java Middle	48	48	43	48	44
Java Bottom	54	54	49	55	49
Off-Java Top	42	42	39	42	39
Off-Java Middle	37	37	34	37	34
Off-Java Bottom	46	47	42	47	43
Change in Household Income (%)					
Urban Top	0.0	0.0	-0.4	0.0	-0.4
Urban Middle	0.0	0.0	-0.4	0.0	-0.4
Urban Bottom	0.0	0.0	-0.4	0.0	-0.3
Java Top	0.0	0.2	0.2	0.3	0.4
Java Middle	0.0	0.7	-2.0	0.8	-1.8
Java Bottom	0.0	0.4	-2.3	1.0	-1.6
Off-Java Top	0.0	0.1	-0.8	0.3	-0.7
Off-Java Middle	0.0	0.6	-1.5	0.9	-1.0
Off-Java Bottom	0.0	0.2	-1.0	0.8	-0.3
Caloric Intake (Kcal/capita)					
Urban Top	1,308	1,307	1,322	1,306	1,322
Urban Middle	1,564	1,563	1,581	1,563	1,581
Urban Bottom	1,367	1,366	1,382	1,365	1,382
Java Top	1,746	1,746	1,767	1,745	1,767
Java Middle	2,078	2,078	2,099	2,079	2,100
Java Bottom	2,453	2,455	2,481	2,457	2,483
Off-Java Top	1,900	1,899	1,921	1,898	1,921
Off-Java Middle	2,688	2,689	2,715	2,690	2,717
Off-Java Bottom	2,557	2,558	2,587	2,560	2,589
Change in value of original consumption bundle when valued at new versus old prices (%)[ii]					
Urban Top	0.0	-0.2	-16.9	-0.4	-17.0
Urban Middle	0.0	-0.3	-15.3	-0.6	-15.7
Urban Bottom	0.0	-0.3	-18.1	-0.5	-18.5
Java Top	0.0	-0.3	-17.0	-0.5	-17.2
Java Middle	0.0	-0.5	-16.3	-0.9	-16.7
Java Bottom	0.0	-0.7	-17.3	-1.4	-18.0
Off-Java Top	0.0	-0.3	-17.4	-0.5	-17.7
Off-Java Middle	0.0	-0.5	-13.7	-1.1	-14.4
Off-Java Bottom	0.0	-0.7	-17.1	-1.4	-17.8

Land Shares (%)					
Rice					
Java	0.3251	0.3261	0.3083	0.3273	0.3096
Off-Java	0.3548	0.3558	0.3365	0.3572	0.3379
Total	0.6799	0.6819	0.6448	0.6845	0.6475
Maize					
Java	0.1113	0.1107	0.1078	0.1104	0.1077
Off-Java	0.0875	0.0870	0.0848	0.0868	0.0847
Total	0.1988	0.1977	0.1926	0.1972	0.1924
Soybean					
Java	0.0221	0.0221	0.0233	0.0223	0.0233
Off-Java	0.0091	0.0091	0.0095	0.0092	0.0096
Total	0.0312	0.0312	0.0328	0.0315	0.0329
Cassava					
Java	0.0237	0.0236	0.0246	0.0233	0.0243
Off-Java	0.0499	0.0498	0.0519	0.0492	0.0511
Total	0.0736	0.0734	0.0765	0.0725	0.0754
Banana					
Java	0.0079	0.0079	0.0079	0.0081	0.0079
Off-Java	0.0084	0.0084	0.0084	0.0085	0.0084
Total	0.0163	0.0163	0.0163	0.0166	0.0163

†See Sayaka et al., (2007) for simulations for alternative rice tariff scenarios (tm=0, tm=15% and tm = 50% versus the baseline of tm = 30%).

[i] Refers to domestic production out of total availability, i.e. domestic production plus net imports.

[ii] Calculated as: (value of original bundle at new prices minus value of original bundle at original prices)/value of original bundle at original prices. The bundle includes the food commodities covered in the model, i.e. rice, maize, soybean, what, livestock, cassava and bananas.

[iii] Various methods are available to calculate the diversification index. Here we used the Herphindal Index, defined as: $H = \sum_{i=1}^{n} p_i^2$ where p_i is the proportion of area under crop i. So $p_i = \frac{A_i \rightarrow \textbf{ area under crop } i}{\sum_{i=1}^{n} A \rightarrow \textbf{ total area}}$

The H index takes value from 0 to one, we have one in case of perfect specialization and zero in case of perfect diversification.

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Agricultural Development Economics Division (ESA)
The Food and Agriculture Organization
Viale delle Terme di Caracalla
00153 Rome
Italy

Contact:
Office of the Director
Telephone: +39 06 57054358
Facsimile: + 39 06 57055522
Website: www.fao.org/es/esa
e-mail: ESA@fao.org