The Economy-Wide Impact of the Integrated Food Crop Pest Management in Indonesia

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Abstract

The excessive use of pesticides in Indonesia during the 1970s and 1980s caused serious environmental problems such as acute and chronic human pesticide poisoning, animal poisoning and contaminated agricultural products, destruction of both beneficial natural parasites and pest predators, and pesticide resistance in pests. To overcome these environmental problems, since 1989 the Indonesian government has actively adopted a strategy of integrated pest management (IPM). During the first few years of the IPM program's implementation, the program has been able to help farmers reduce the use of pesticides by approximately 56 percent, and increase yields by approximately 10 percent. However, economic literature that analyzes the impact of the IPM program on household incomes and national economic performance is very limited. The general objective of this research is to analyze the impact of the IPM program on Indonesian economic growth and household incomes for different socioeconomic groups.

Introduction

The chronic food shortage during the first two decades of Indonesian independence (1945-1965) stimulated the Indonesian government to establish a comprehensive food intensification program as a national priority. Achieving and maintaining self-sufficiency in food, increasing farmers' income, and providing strong support for the rapidly expanding industrial and service sectors were the main goals of this food intensification program (Oka, 1995). The food intensification program included large-scale adoption of high-yielding modern seed varieties, development of irrigation systems, expansion of food crop producing areas, increased use of chemical fertilizers and pesticides, expansion of agricultural extension services, establishment of farmer cooperatives and input subsidies, and stabilization of national food crop prices (Oka, 1991).

During the 1970s and 1980s, this food intensification program caused food crop production to grow at an annual rate of approximately 3.74 percent (CBS, 1973-1991).[1] A major miracle occurred in rice production. Pushing the average annual growth rate of rice production to approximately 4.67 percent, the rice intensification program transformed Indonesia from the world's largest importer of rice, importing approximately two million tons per year by the end of the 1970s, to self-sufficiency in 1983 (Oka, 1991 and 1995).[2]

Despite the remarkable success of the food intensification program, the excessive use of pesticides caused serious environmental problems. The problems include acute and chronic human pesticide poisoning, animal poisoning and contaminated

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1 The average annual population growth was approximately 2.3 percent in the 1970s and 1980s.
2 However, due to a long drought season, since mid 1990s Indonesia has, again, to import rice to fulfill the national demand on rice.

agricultural products, destruction of beneficial natural parasites and pest predators, and pesticide resistance in pests (Achmadi, 1992; Oka, 1995; and Pimentel et al., 1992).[3] To overcome these environmental problems caused by the overuse of pesticide, in the beginning of 1990s, the Indonesian government adopted a strategy of integrated pest management (IPM). The program altered the predominant government policy of pest control from a unilateral method, depending solely on pesticide, to a combination of various control tactics to manage pests, including synchronized planting, crop rotation, natural predator, and pesticides. It was reported that farmers, who implemented the IPM program, had been able to reduce the use of pesticides by approximately 56 percent, and increase yields by approximately 10 percent (Oka, 1995).[4]

However, economic literature that analyzes the impact of the IPM program on household incomes and national economic performance is very limited. The Indonesian IPM National Program Monitoring and Evaluation Team in 1993 argued that IPM farmers would increase their incomes by approximately 50 percent. This study, however, only observed the partial impact of the IPM program on farmer incomes, i.e. the team did not take into account the multiplier impact of an IPM program on incomes of both farmers and other household groups. The team also did not mention the impact of the IPM program on national economic growth.

It is in the interest of the Indonesian government to determine the overall benefits of the IPM program on the national economy. If the program is proven to be significantly beneficial for the country's national economic performance, the program's implementation will be recognized as one of national priorities.

This research utilizes a Computable General Equilibrium (CGE) model to analyze the overall impact, including the multiplier impact, of the Indonesia integrated food crop pest management program on national economic growth and household incomes for various socioeconomic groups. A CGE model is a system of equations that represent all agents' behaviors and market clearing conditions in a national economy.

Besides for Indonesia, the result of this research is also valuable as a comparative study for other developing countries.

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[3] In 1988, Achmadi found 1267 cases of acute pesticide poisoning in 182 general hospitals throughout the islands of Java and Bali. He also observed that approximately 20 to 50 percent of the farmers who utilized pesticides contracted chronic pesticide-related illnesses. These illnesses included headaches, weakness, insomnia, and difficulties in concentrating (Achmadi, 1992). In the case of pesticide resistance in pests, brown planthoppers and green leafhoppers became resistant to pesticides and damaged more than 450,000 hectares of rice fields in 1976/1977. The estimated yield loss was 364,500 tons of milled rice, which could have fed three million people for an entire year. In 1980 and 1986, the same pest problem broke out again, causing damage to at least 12,000 and 75,000 hectares of rice fields, respectively (Oka, 1995).

[4] The increasing yields are caused by the elimination of serious or large-scale pest outbreaks.

Methodology

As mentioned previously, this research utilizes a Computable General Equilibrium (CGE) model of a national economy to analyze the impact of an implementation of the IPM program on the Indonesian national economy. The CGE consists of six blocks of equations. The blocks are:

- **Production Block**: Equations in this block represent the structure of production activities and producers' behavior.
- **Consumption Block**: This block consists of equations that represent the behavior of households and other institutions.
- **Export-Import Block**: This block models the country's decision to export or import goods and services.
- **Investment Block**: Equations in this block simulate the decision to invest in the economy, and the demand for goods and services used in the construction of the new capital.
- **Market Clearing Block**: Equations in this block determine the market clearing conditions for labor, goods, and services in the economy. National balance of payment is also in this block.
- **Intertemporal Block**: This block consists of dynamic equations that link economic activities in the current year to future economic conditions.

This section only explains some important features of the CGE utilized in this research. To become familiar with other features of this CGE, one should review the Indonesian CGEs developed by Lewis (1991), Thorbecke (1992), and Resosudarmo (1996). This research combines the three Indonesian CGEs just mentioned to create a new CGE model.

The important features in the new model focus on modeling the link between agricultural activities utilizing pesticides and human health problems, as shown in Figure 1. The use of pesticides in agricultural production activities causes human pesticide poisoning cases. The higher the amount of pesticides utilized in agricultural sector, the higher the number of cases of pesticide-related illnesses. These illnesses cause agricultural households to spend money on medical care. The pesticide-related illnesses also reduce the effectiveness of labor input and lower the overall productivity of all other factor inputs in agricultural production activities.[5]

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[5] This research certainly underestimates societal and environmental impact of using pesticides. However, data on societal and environmental impact associated with the use of pesticides, such as animal poisonings and contaminated products, groundwater and surface water contamination, and fishery losses (Pimentel et al., 1992), are not yet available in Indonesia. Limiting the scope of this research to human poisoning cases appears to be a reasonable choice.

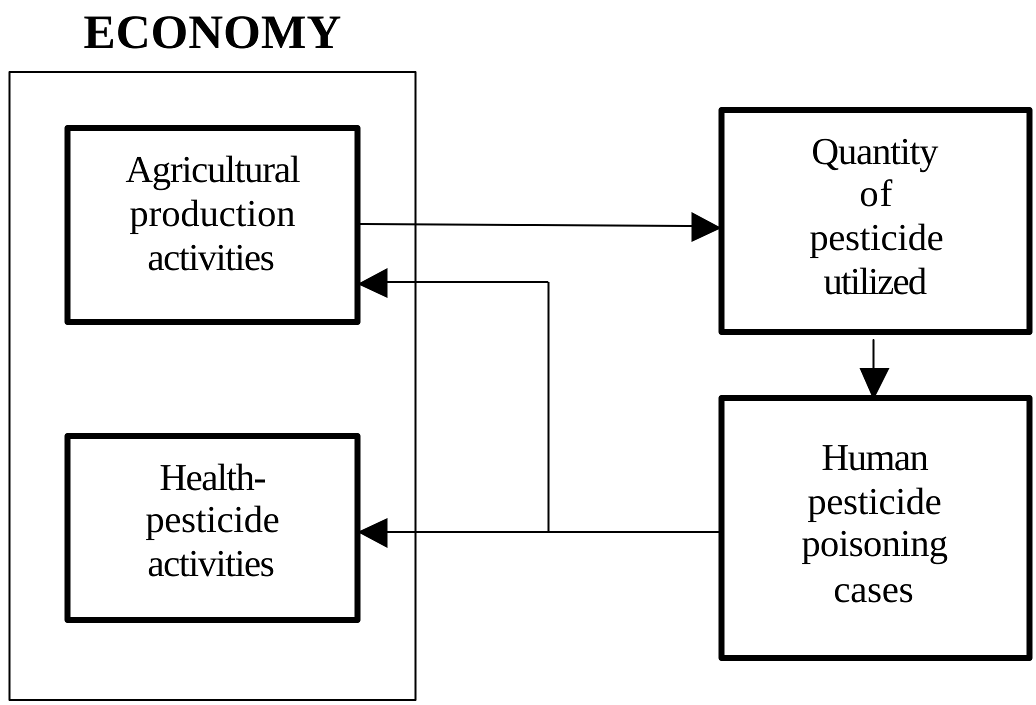


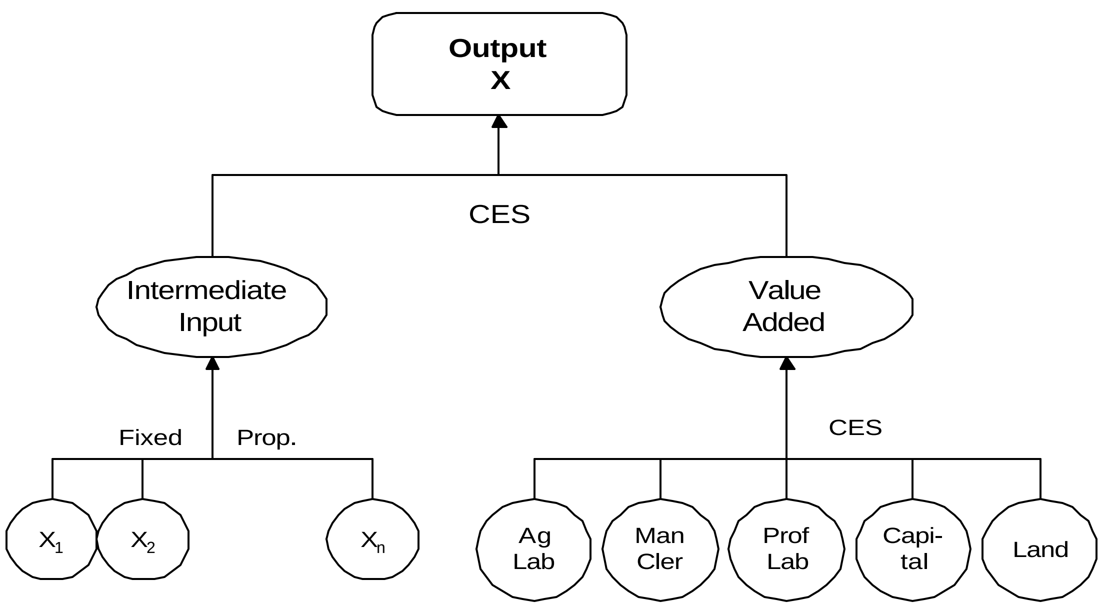
Figure 1 Link Between the Economy And Pesticide in Agriculture

The impact of an IPM program implemented in food crop sector on the economy, then, modeled as follows:

- Government needs to spend a certain amount of money to implement the IPM program. In this research, government is assumed to take this IPM budget from government savings, resulting in a smaller new government capital investment on other sectors.
- Most of the government IPM budget is allocated to the education or public service sectors, since the main activity of the IPM program is to educate farmers in IPM.
- The first direct impact of the IPM program is a reduction in the use of pesticides by farmers.
- The second direct impact of the IPM program is a more efficient food crop production sector, i.e. with a lesser amount of pesticides and the same amount of other inputs, IPM farmers are able to increase their output. This increased output is due to the fact that the IPM program can better control pest problems than a program that solely depends on pesticides.

- Since the use of pesticides causes pesticide poisoning cases among farmers, the reduction in the amount of pesticide use in food crop sector decreases the number of these pesticide poisoning cases.
- This reduction in the number of pesticide-related illnesses lowers farmer households' spending on necessary treatment to recover from pesticide-related illnesses. These lower health costs enable households to spend money on other goods and services, mostly food.
- The occurrence of pesticide-related illnesses negatively affects the productivity of agricultural labor input. This negative effect might reduce the productivity of other agricultural factor inputs, i.e. land and capital. The reduction in the number of pesticide-related illnesses among farmers hence improves the productivity of all factor inputs in the food crop production sector.

The detailed modeling of the impact of the IPM program now follows. The CGE in this research has relatively disaggregated food crop production sectors. The important features of these sectoral production activities are the value-added function, sectoral production function, and the input-output coefficient of the quantity of pesticide used in the food crop sector (see Figure 2).



Note: CES is the Constant Elasticity of Substitution production function
Fixed Prop. is the Fixed Proportion (Leontief production function)

Figure 2 Structure of the Sectoral Production Function

Let us first observe the value added function. Value added is a function of human pesticide-related illnesses and factor inputs. The factor inputs are expressed in the Constant Elasticity of Substitution (CES) function.

$$VA_i = HE_i \cdot \alpha_i \cdot \left(\sum_f \beta_{i,f}^{v} \cdot FACDEM_{i,f}^{-\rho_i^v} \right)^{-\frac{1}{\rho_i^v}} \qquad (1)$$

where:

- i is the index for production sectors
- VA_i is the value-added input for sector i
- HE_i is the impact of human pesticide-related illnesses on the value-added production activity
- $FACDEM_{i,f}$ is the demand for factor input f in sector i.

The factors represented by f are agricultural workers, manual-clerical personnel, professional laborers, land, and capital. Land and capital are fixed. The market for professional workers is assumed to be in a full-employment condition. Both the agricultural and manual-clerical labor markets experience unemployment.

In this research the impact of human pesticide-related illnesses on production activity, i.e. HE_i, is simply a function of restricted activity days caused by pesticide-related illnesses. Furthermore, since data on the number of restricted activity days are limited to farmers only, the HE_i function is:

$$HE_i = \left(1 - \frac{RAD_i}{DA_i} \right) \qquad \forall\ i \in \text{crop sectors} \qquad (2)$$

and

$$HE_i = 1 \qquad \forall\ i \notin \text{crop sectors} \qquad (3)$$

where:

- RAD_i is the number of restricted activity days caused by pesticide-related illnesses
- DA_i is the number of man-days that should be available if no pesticide-related illness occur.

The second important point about sectoral production activities is the production of sectoral output. The form of the sectoral production function is:

$$X_i = \alpha_i^x \cdot \left(\beta_i^x \cdot IN_i^{-\rho_i^x} + (1 - \beta_i^x) \cdot VA_i^{-\rho_i^x} \right)^{-\frac{1}{\rho_i^x}} \qquad (4)$$

where:

- X_i is gross domestic sectoral outputs

IN_i is composite intermediate inputs.

In food crop sector, particularly rice sector, farmers who implement the IPM can increase their yields. To represent these increasing yields, this research defines the share parameter of the food crop production function (a_i^x) as a function of the number of farmers who adopt the IPM. The more farmers who implement the IPM, the higher this share parameter will be. For example, the share parameter of rice production is as follows:

$$\alpha_{RICE}^{x,t} = \bar{\alpha}_{RICE}^{x} \cdot \left(1 - \frac{IPMFARM^{t}}{FACDEM_{RICE,AGLAB}^{t}}\right) g_{NONIPM} + \bar{\alpha}_{RICE}^{x} \cdot \frac{IPMFARM^{t}}{FACDEM_{RICE,AGLAB}^{t}} \cdot g_{IPM} \qquad (5)$$

where:

g_{IPM} equals 1.10. This is due to the fact that IPM farmers are ten percent more efficient than non-IPM farmers

g_{NONIPM} represents the fact that non-IPM farmers also receive benefits from the implementation of an IPM program. Typically, since the total population of pests in the area reduces.

$\bar{\alpha}_{RICE}^{x}$ is the initial/benchmark shift parameter of rice sectoral production

$\alpha_{RICE}^{x,t}$ is the shift parameter of rice sectoral production in year t

$IPMFARM^t$ is the number of rice farmers implementing the IPM in year t[6]

$FACDEM^t_{RICE,AGLAB}$ is the number of total rice farmers in year t.

The third important feature of the sectoral production activities is the input-output coefficient of the amount of pesticide used in the food crop sector. Farmers who implement the IPM can reduce the amount of pesticide used. The pesticide input-output coefficient in the food crop sector is a function of the number of IPM farmers. The more farmers who adopt the IPM, the smaller this pesticide coefficient will be. For example, in the rice production sector, the input-output coefficient of the amount of pesticide used is as follows:

[6] The assumption of constant return to scale in this equation is relatively realistic. The number of additional farmers implementing the IPM program each year are relatively still small compared to the total number of rice farmers. Hence, this research is only analyzing a marginal change of farmers implementing the IPM program.

$$iomi^{t}_{PEST,RICE} = \overline{iomi}_{PEST,RICE} \cdot \left(1 - \frac{IPMFARM^{t}}{FACDEM^{t}_{RICE,AGLAB}}\right)$$

$$+\overline{iomi}_{PEST,RICE} \cdot \frac{IPMFARM^{t}}{FACDEM^{t}_{RICE,AGLAB}} \cdot 0.44 \qquad (6)$$

where:

0.44	is due to the fact that IPM farmers are able to reduce the use of pesticides by 56 percent
$\overline{iomi}_{PEST,RICE}$	is the initial/benchmark input-output coefficient of pesticide use in the rice sector
$iomi^{t}_{PEST,RICE}$	is the input-output coefficient of pesticide use in the rice sector in year t.

In the consumption block, the important feature is as follows. This research considers several different types of household groups. Each household group maximizes its utility as a Cobb-Douglas function of all goods and services, except for the necessary health treatments related to pesticide-related illnesses, subject to its budget constraint:

$$U_h = a_h \cdot \prod_{i \neq aph} \left(HCD_{i,h}\right)^{chs_{i,h}} \quad ; \quad \sum_{i \neq aph} chs_{i,h} = 1 \qquad (7)$$

subject to:

$$\sum_{i \neq aph} PQ_i \cdot HCD_{i,h} \leq YH_h - HTAX_h - HSAV_h - CDHE_h - HHTR_h \qquad (8)$$

where:

h	is the index for household groups
aph	is the index for health services consumed by households which experience pesticide-related illnesses
YH_h	is the income of household *h*
$HCD_{i,h}$	is household consumption
PQ_i	is the price of commodity *i*
$HTAX_h$	is income taxes
$HSAV_h$	is household savings
$HHTR_h$	is net household transfers
$CDHE_h$	is necessary health costs to recover from pesticide-related illnesses.[7]

Note that this research limits its analysis to the case of pesticide-related illnesses among farmers. The health costs associated with pesticide-related illnesses

[7] The utility function in equation (7) does not include any utility for better health. This utility certainly will underestimate the increase in utility due to better health. However, it is fairly difficult to estimate a utility for better health. Hence, focusing the analysis on the change in income, rather than on utility, is a more appropriate choice.

($CDHE_h$) in the relationship (8) hence only appear in agricultural household groups' budget constraint, i.e. for non-agricultural households, $CDHE_h$ always equals zero. From the relationship (8), one can see that a reduction in health costs associated with pesticide-related illnesses creates "extra income" for agricultural households to spend on goods and services. In developing countries, agricultural households mostly spend this extra income on food.

The amount of health spending by households depends on the number of pesticide-related illnesses which occur. The quantity of pesticide-related illnesses is a function of the quantity of pesticide used in agricultural sectors:

$$PESHLT_{ag,ph} = apesht_{ag,ph} \cdot iomi_{PEST,ag} \cdot IN_{ag} \cdot R(AGLAB) \qquad (9)$$

where:

ag	is the index for agricultural sectors
ph	is the index for the pesticide-related illnesses
$PESHLT_{ag,ph}$	is the number of pesticide-related illnesses
$apesht_{ag,ph}$	is the pesticide-health coefficient
$iomi_{PEST,ag} \chi IN_{ag}$	is the amount of pesticide used in agricultural sector *ag*
$R(AGLAB)$	is the ratio between agricultural labor in any simulation scenario and in the benchmark situation.

The pesticide-related illnesses are chronic and acute pesticide poisoning. Farmers who contract chronic or acute pesticide poisoning usually cannot work for at least one day.

In this CGE, the capital accumulation equation is the important dynamic equation related to the implementation of the IPM program. Capital accumulates as new capital is invested; the amount of capital next year is a function of the existing capital plus new capital, minus depreciated capital.

$$FACDEM^{t+1}_{i,CAPITAL} = FACDEM^{t}_{i,CAPITAL} \cdot \left(1 - depr_i\right) + DK^t_i \qquad (10)$$

where:

$depr_i$	is the depreciation rate
DK^t_i	is the new capital invested in year t.

Government and private savings fund new capital investments. Government savings also must provide the budget for IPM program implementation. In the absence of this program, the government would use the funds allocated for the IPM budget for new capital investment. Implementation of the IPM program, hence, reduces the amount of new capital invested, and, in the end, decreases the rate of capital accumulation.

Sources of Data

The main sources of data are the 1993 Indonesian Social Accounting Matrix (SAM) and Input-Output (I-O) Table which are available from the Indonesian Central Bureau of Statistics (CBS). This research modifies the 1993 SAM in two ways. First, it reduces the classification of factor inputs to five categories: agricultural labor, manual-clerical labor, professional labor, capital, and land. Second, using the I-O Table, the Food Crop sector is disaggregated into several sectors; among others are Rice, Bean, and Corn sectors (see Table 1). Pesticide production also is removed from the Chemical and Basic Metal sector to become a separate Pesticide sector. In addition, the health activities related to pesticide poisoning illnesses are separated from the Public Service sector to become the Pesticide-Health sector.

Table 1. Agricultural Sectors in This Research

Food Crop	**Estate Crop**	**Others**
Rice	Rubber	Livestock
Bean	Sugar Cane	Fishery
Corn	Coconut	
Tuber	Palm Oil	
Fruit and Vegetable	Tobacco	
Other Crops	Coffe	
	Tea	
	Clove	
	Fibrous	
	Other Estate Crop	

The SAM in this research uses the same categories for household classes that the CBS SAM does. The categories are as follows:

- *Agricultural Employee* : Agricultural workers who do not own land.
- *Small Farmer* : Agricultural land owners with land between 0.0 and 0.5 ha.
- *Medium Farmer* : Agricultural land owners with land between 0.5 and 1.0 ha.
- *Large Farmer* : Agricultural land owners with land larger than 1.0 ha
- *Rural Non-labor* : Non-agricultural households, consisting of non-labor force and unclassified households in rural areas.

- *Rural Low Income* : Non-agricultural households, consisting of small retail store owners, small entrepreneurs, small personal service providers, and clerical and manual workers in rural areas.
- *Rural High Income* : Non-agricultural households, consisting of managers, technicians, professionals, military officers, teachers, big entrepreneurs, big retail store owners, big personal service providers, and skilled clerical workers in rural areas.
- *Urban Non-labor* : Non-agricultural households, consisting of non-labor force and unclassified households in urban areas.
- *Urban Low Income* : Non-agricultural households, consisting of small retail store owners, small entrepreneurs, small personal service providers, and clerical and manual workers in urban areas.
- *Urban High* : Non-agricultural households, consisting of managers, technicians, professionals, military officers, teachers, big entrepreneurs, big retail store owners, big personal service providers, and skilled clerical workers in urban areas.

Information on pesticide-related illnesses relies mostly on Achmadi's work which provides the estimate for the number of acute and chronic pesticide poisoning cases. Achmadi (1991) estimated that in 1988 approximately 3000 cases of acute poisoning were associated with the use of pesticides in agricultural sectors. He also observed that approximately 20 to 50 percent of the farmers who utilized pesticides contracted chronic pesticide-related illnesses. These illnesses included headaches, weakness, insomnia, and difficulties in concentrating. Furthermore, Achmadi noticed that, on average, each time a farmer contracts acute pesticide poisoning, the farmer misses work approximately five days. Each time a farmer contracts chronic pesticide poisoning, the farmer, on average, misses work approximately one day.

This research assumes that the number of acute pesticide poisoning cases in 1993 is the same as in 1988. CBS (1995) estimated that approximately 40 million people worked in agricultural sectors in 1993 and approximately 29.5 million of them were farmers (and agricultural workers) who utilized pesticides. Thus, the estimate of chronic pesticide-related illness cases for 1993 is approximately 12.3 million.

Simulation Scenarios

This section discusses several scenarios intended to simulate the impact of the Indonesian IPM program on income distribution and national economic growth. To do this, this section will, first, review the implementation of the IPM program in Indonesia.

The implementation of the Indonesian IPM nationally started when the government launched the Presidential Decree No. 3 of 1986. This presidential decree established the IPM program as a national policy that all government agencies would support. The decree had the following objectives (Oka, 1995):

- develop manpower, both farmers and field personnel, at the grassroots level to implement the IPM
- increase efficiency of input use, in particular pesticides
- improve the quality of the environment and its influence on human health.

Along with this decree, the government decreased subsidies for pesticides from 75-80 percent of total prices for pesticides in 1986 to 40-45 percent in 1987. Finally in January 1989 these subsidies were completely eliminated. The government also banned 57 broad-spectrum insecticides, and only allowed the use of a few relatively narrow-spectrum insecticides.

To actively implement the IPM, in 1989 the National Development Planning Agency (BAPPENAS) established an Advisory Board which consisted of high-ranking officers from BAPPENAS, the Ministry of Agriculture, and the Ministry of Home Affairs. The Board is the supreme policy-making body, and responsible for the success of the IPM program. Under the Board, a Steering Committee is formed to direct the project activities, and to ascertain the need for policy improvement. The Committee consists of IPM experts from various government agencies, universities, and international institutions. Certain members of the Committee form a Working Group which conducts the day-to-day tasks of the Committee.

The central activity of this national IPM program is to educate farmers in IPM using the "learning by doing" method. The Working Group first trained extension workers and field pest observers to teach farmers. By the end of 1991, 2,000 extension workers and 1,000 field pest observers were able to train approximately 100,000 farmers. After 1991, approximately 200,000 farmers, most of them are rice farmers, are trained each year. Approximately ten percent of these 200,000 farmers become one-on-one trainers. Each of these farmer trainers is required to train one farmer twice per year, and repeat this training with a new farmer in the following year. The cost of all IPM training activities is approximately 11.25 billion rupiahs (5.36 million dollars) each year.[8] The central government provides approximately 80 percent of this total cost; the various regional governments provide the reminder.

Based on the information just mentioned, total numbers of (rice) farmers implementing the IPM program each year can be estimated as follows:

$$IPMFARM_{RICE}^{t} = \frac{IPMBUDGET_{RICE}^{t}}{CPF_{RICE}} + 1.2 \cdot IPMFARM_{RICE}^{t-1} \qquad (11)$$

where:

8 This number is actually for 1991.

$IPMFARM^{t}_{RICE}$	is the total numbers of rice farmers implementing the IPM program at year *t*.
$IPMBUDGET^{t}_{RICE}$	is the total (government) budget for the IPM training program at year t.
CPF_{RICE}	is the cost to train one rice farmer in implementing the IPM technique; it is estimated that this cost is approximately 56,250 rupiahs per farmer.

The scenarios developed in this research, then, are as follows:

1. Base Scenario

The base data set for this research is the Indonesian economy in 1993. In that year, the IPM program had been implemented. Even up until 1998, the Indonesian government still implements the IPM program. The Base Scenario is, then, that the Indonesian government spends 11.25 billion rupiahs to train approximately 200,000 rice farmers each year for five years time horizon after 1993. Figure 3 shows the estimated numbers of rice farmers implementing the IPM program each year under this scenario.

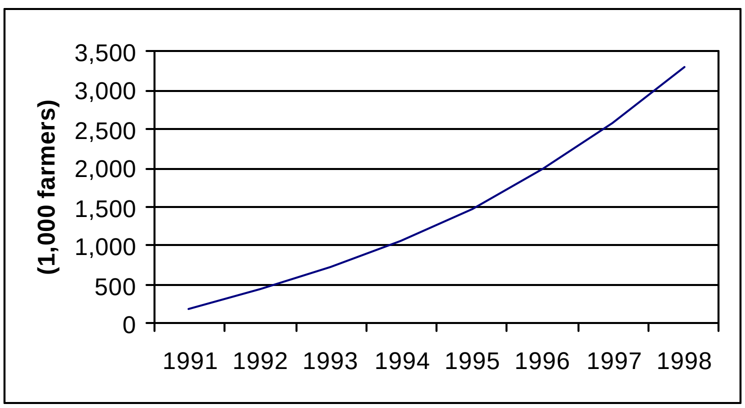


Figure 3 Estimated Numbers of IPM Rice Farmers under the Base Scenario

Important to note that, in 1993, approximately 18.5 million farmers in Indonesia were rice farmers who utilized pesticides.

2. Stop IPM Program Scenario

In this scenario, it is assumed that the Indonesian government does not implement the IPM program any more after 1993. Comparing the result of this scenario to that of the Base Scenario shows the economic impacts of implementing the IPM program in Indonesia. Table 4 presents the estimated numbers of IPM rice farmers in Indonesia.

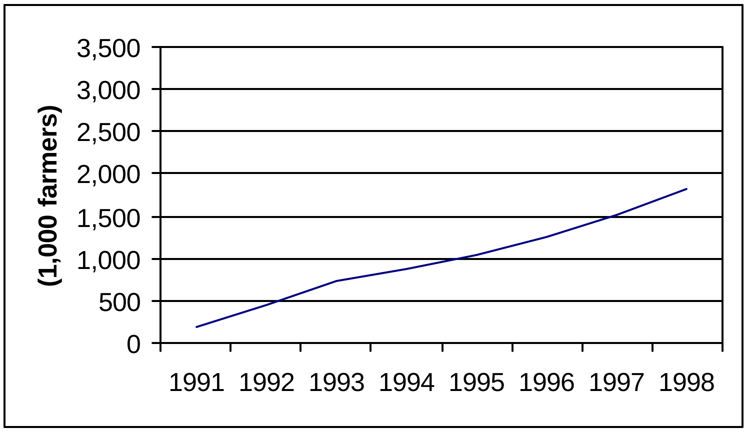


Figure 4 Estimated Numbers of IPM Rice Farmers under the Stop IPM Program Scenario

3. Double IPM Program Scenario

In this scenario, it is assumed that the Indonesian government doubles its spending on the IPM program each year after 1993; i.e. the Indonesian government spends 22.5 billion rupiahs in 1994, 45 billion rupiahs in 1995, 95 billions in 1996, etc. Comparing the result of this scenario to that of the Base Scenario gives some idea on the result if the Indonesian government would be willing to spend more money on the IPM program. Table 5 exhibits the estimated number of rice farmers who implement the IPM program.

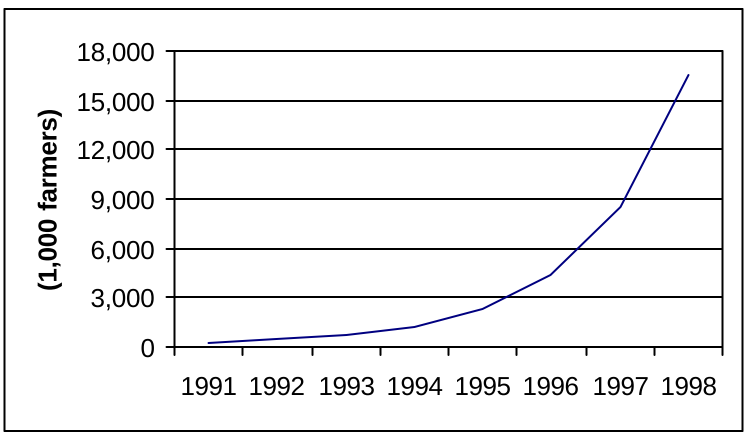


Figure 5 Estimated Numbers of IPM Rice Farmers under the Double IPM Program Scenario

Note that, under this scenario, approximately 80 percent of rice farmers are IPM rice farmers.

4. **Tax on Pesticides**

In this scenario, it is assumed that the Indonesian government increases the tax rate on pesticides by five percent each year after 1993 for five years time horizon. Revenues from this tax are utilized to fund the IPM program activities. Table 6 shows the estimated number of IPM rice farms in Indonesia until 1998. It is estimated that approximately 100 percent of rice farmers, in 1998, are farmers who implement the IPM program.

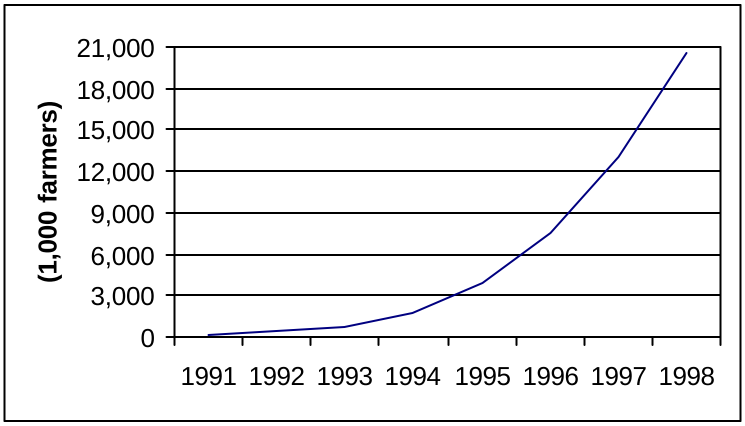


Figure 6 Estimated Numbers of IPM Rice Farmers under the Tax on Pesticides Scenario

Results

Table 2 presents the simulation results, namely the Indonesian Gross Domestic Product (GDP), total value-added from agricultural sectors, household incomes, and health costs associated with pesticide poisoning cases for the Base Scenario. All variables in Table 2 are in billions of rupiahs and in percentage difference from last years. For example, from Table 2 one can see that the Indonesia GDP in 1993 was approximately 329,776 billions of rupiahs and estimated to increase to approximately 353,679 billions of rupiahs in 1994, or the Indonesian GDP is estimated to grow by approximately 7.25 percent from 1993 to 1994.

Figure 7 shows the trends of GDP growth rates and agricultural value-added growth rates under the Base Scenario. Figure 8 exhibits the average growth rates of total household incomes during the five years time horizon simulation of the Base Scenario.

Table 2. Result from the Base Scenario Simulation
(in billions of rupiahs)

	Base Scenario					
	1993	**1994**	**1995**	**1996**	**1997**	**1998**
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
GDP	329,776	353,679	379,489	407,142	423,730	407,153
		7.25%	7.30%	7.29%	4.07%	-3.91%
Ag. Value Added	62,078	64,997	67,900	71,049	72,552	73,188
		4.70%	4.47%	4.64%	2.12%	0.88%
Household Income						
Agricultural Employee	9,499	10,038	10,610	11,226	11,577	11,359
		5.67%	5.70%	5.81%	3.13%	-1.88%
Small Sc. Farmer	40,940	43,375	45,941	48,709	50,257	49,305
		5.95%	5.91%	6.03%	3.18%	-1.89%
Medium Sc. Farmer	11,138	11,774	12,442	13,162	13,554	13,369
		5.71%	5.67%	5.79%	2.98%	-1.37%
Large Sc. Farmer	18,083	18,947	19,853	20,827	21,349	21,160
		4.78%	4.78%	4.91%	2.50%	-0.89%
Rural Non-labor	3,915	4,167	4,441	4,734	4,915	4,719
		6.44%	6.57%	6.61%	3.82%	-3.99%
Rural Low Income	14,314	15,269	16,297	17,395	18,040	17,393
		6.67%	6.73%	6.73%	3.71%	-3.59%
Rural High Income	45,643	48,689	51,962	55,446	57,458	55,470
		6.68%	6.72%	6.71%	3.63%	-3.46%
Urban Non-labor	6,455	6,926	7,434	7,978	8,306	7,959
		7.29%	7.34%	7.32%	4.11%	-4.18%
Urban Low Income	25,202	26,975	28,900	30,956	32,208	30,830
		7.04%	7.14%	7.11%	4.05%	-4.28%
Urban High Income	69,360	74,436	79,945	85,801	89,299	85,215
		7.32%	7.40%	7.32%	4.08%	-4.57%
Health Costs related to Pesticide Poisoning Cases						
Total	12.42	14.27	16.36	18.75	19.97	18.33
		14.88%	14.66%	14.61%	6.51%	-8.25%
Among Rice Farmers	4.65	5.30	6.01	6.80	7.14	6.48
		13.93%	13.46%	13.06%	5.02%	-9.26%

Note: The numbers in percentage under each value for each variable show the percentage change of value this year compared to last year.

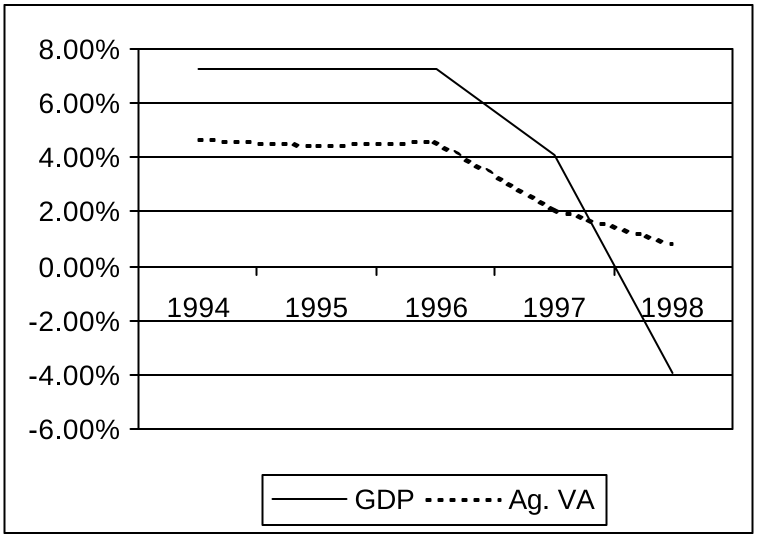


Figure 7. Estimated GDP and Agricultural Value Added Growth Rate Under the Base Scenario Simulation

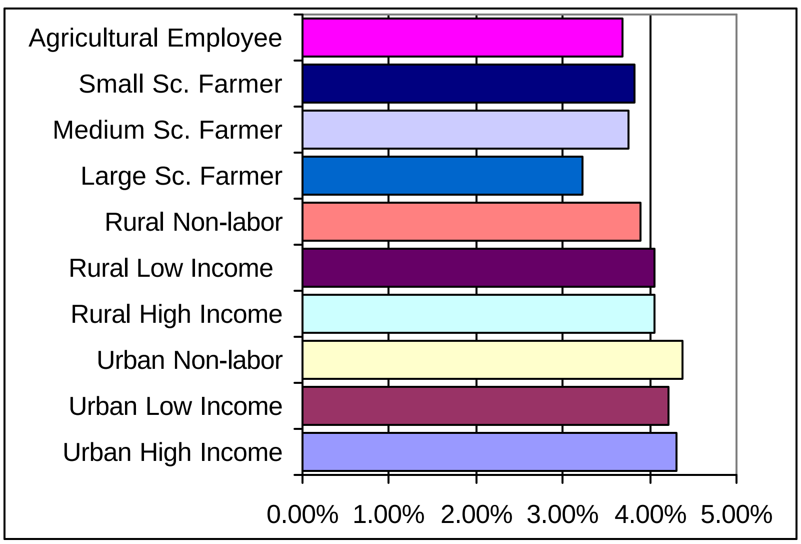


Figure 8. Estimated Average Growth Rates of Household Incomes during the Five Years Time Horizon of Base Scenario Simulation

Table 3 presents how the results from the Stop IPM, Double IPM, and Tax on Pesticides Scenarios could be different than that from the Base Scenario, both in billions of rupiahs and in percentage, for the third and fifth years of the simulation. Figures 9 and 10 show estimated changes of GDP and agricultural value-added growth rates under Stop IPM, Double, and Tax on Pesticides Scenarios compared to the situation under the Base Scenario. Figure 11 exhibits total quantities of pesticides use in agricultural sectors through the five years time horizon simulation compared to the 1993 level, under the all scenarios.

Table 3. Results from the Three Simulation Scenarios
(in billions of rupiahs and percentage difference from the Base Scenario)

	1996 (Year 3)			1998 (Year 5)		
	Stop IPM	Double IPM	Tax on Pesticides	Stop IPM	Double IPM	Tax on Pesticides
GDP	-130.80	369.90	834.10	-273.70	1,915.60	2,602.40
	-0.03%	0.09%	0.20%	-0.07%	0.47%	0.64%
Ag. Value Added	-1.10	-6.11	-43.71	-5.30	-55.86	-98.07
	-0.06%	-0.33%	-2.33%	-0.06%	-0.60%	-1.06%
Household Income						
Agricultural Employee	-1.67	4.54	4.72	-3.57	21.95	22.02
	-0.01%	0.04%	0.04%	-0.03%	0.19%	0.19%
Small Sc. Farmer	-8.85	24.77	33.47	-18.81	119.05	127.66
	-0.02%	0.05%	0.07%	-0.04%	0.24%	0.26%
Medium Sc. Farmer	-1.65	4.39	3.70	-3.54	19.37	17.17
	-0.01%	0.03%	0.03%	-0.03%	0.14%	0.13%
Large Sc. Farmer	-1.36	3.32	-1.00	-2.97	11.36	3.05
	-0.01%	0.02%	0.00%	-0.01%	0.05%	0.01%
Rural Non-labor	-1.59	4.92	9.02	-3.23	25.60	30.54
	-0.03%	0.10%	0.19%	-0.07%	0.54%	0.65%
Rural Low Income	-5.44	18.00	33.94	-10.65	88.98	101.85
	-0.03%	0.10%	0.20%	-0.06%	0.51%	0.59%
Rural High Income	-17.13	58.18	112.72	-32.93	282.03	319.59
	-0.03%	0.10%	0.20%	-0.06%	0.51%	0.58%
Urban Non-labor	-2.94	9.17	17.46	-5.94	46.92	56.32
	-0.04%	0.11%	0.22%	-0.07%	0.59%	0.71%
Urban Low Income	-11.20	35.58	68.03	-22.42	182.05	217.19
	-0.04%	0.11%	0.22%	-0.07%	0.59%	0.70%
Urban High Income	-34.56	120.55	241.64	-65.68	595.77	684.81
	-0.04%	0.14%	0.28%	-0.08%	0.70%	0.80%
Health Costs related to Pesticide Poisoning Cases						
Total	0.17	-0.56	-1.32	0.34	-2.94	-3.86
	0.92%	-2.99%	-7.05%	1.85%	-16.04%	-21.07%
Among Rice Farmers	0.16	-0.53	-1.23	0.32	-2.75	-3.56
	2.39%	-7.82%	-18.13%	4.90%	-42.51%	-55.03%

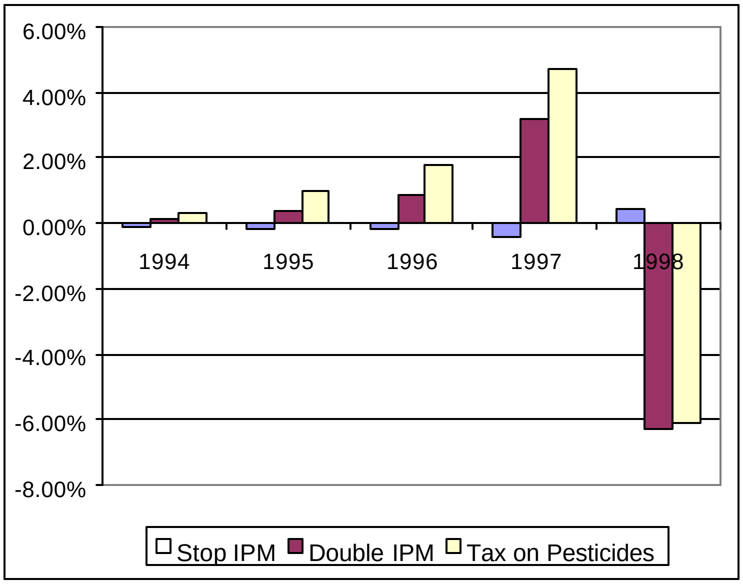


Figure 9 Estimated Changes of GDP Growth Rates under Stop IPM, Double IPM, and Tax on Pesticides Scenarios compared to the Base Scenario

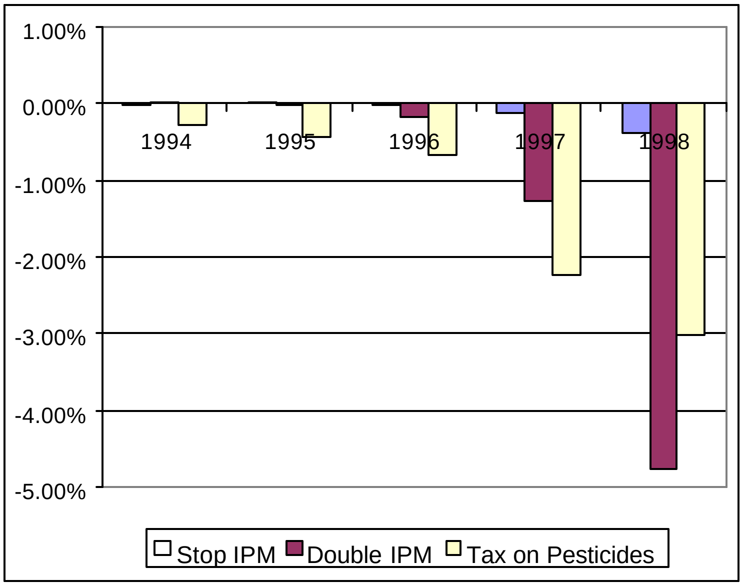


Figure 10 Estimated Changes of Agricultural Value-Added Growth Rates under Stop IPM, Double IPM, and Tax on Pesticides Scenarios compared to the Base Scenario

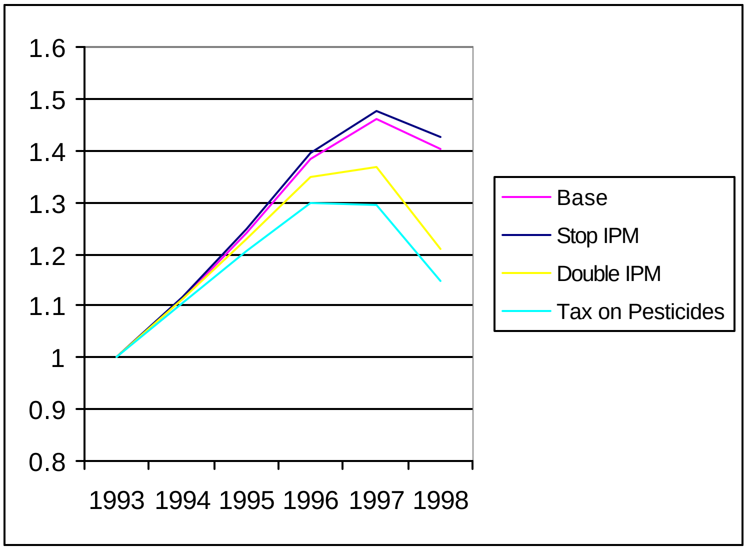


Figure 11 Estimated Total Quantities of Pesticides Use

Discussion

Discussion in this paper is focused on understanding the impact of IPM program under different implementation scenarios on GDP growth rates, household incomes, and health costs related to pesticide poisoning cases.

Base Scenario

Table 2 and Figure 7 show that, under the Base Scenario, GDP growth rates are stable at approximately 7.25 – 7.30 percent for the first three years of simulation, and drop to –3.91 percent in the last two years of the simulation period. Agricultural value-added grows above 4 percent during the first three years of simulation, and then slowing down to 0.88 percent at the end of the simulation period.

In Table 2, one can see that, until the fourth years of simulation, the total incomes of urban households grow faster that those of rural and agricultural households. Until the fourth years of simulation, it can also be observed that the total incomes of rural households increase faster than those of agricultural households. During the first four years of simulation, manufacturing and service sectors grow faster than the agricultural sectors. Manufacturing and service sectors are the main sources of incomes for urban and rural households, while agricultural sectors are the main sources of incomes for the agricultural households. Hence it is reasonable that the incomes of urban and rural households grow higher compared to those of agricultural households.

Figure 8 presents the average growth rate of household incomes during the five years time horizon. The total incomes of urban households grow faster than those of rural households, and the total incomes of rural households increase faster compared to those of agricultural households. Since the average income per household for agricultural households is lower than the average income per household of urban households, the fact that the total incomes of urban household grow faster than those of agricultural household may induce a more unequal income distribution in Indonesia.

Total health costs associated with pesticide poisoning cases in Indonesia is estimated to increase from 12.42 billions of rupiahs in 1993 to 18.33 billions of rupiahs in 1998. Approximately 4.65 billions of rupiahs from the 12.42 billions of rupiahs in 1993 are the health costs that occurred among rice farmers. Meanwhile, it is predicted that from the 18.33 billions of rupiahs health costs related to pesticides in 1998, 6.48 billions of rupiahs was shouldered by rice farmers.

Stop IPM Scenario

Table 3 shows that, under the Stop IPM Scenario, the Indonesian GDP in the fifth year of simulation is 0.07 percent lower than that under the Base Scenario. This fact implies that the implementation of the IPM program benefits Indonesian economy so that the GDP can be 0.07 percent higher than if the Indonesian government were to stop the IPM program in 1993.

From Table 3, one can see that in the fifth year of the time horizon, 1998, total incomes of urban households, under the Stop IPM Scenario, are estimated to be between 0.07 to 0.08 percent lower compared to their incomes under the Base Scenario. Total incomes of rural households are likely to be between 0.06 to 0.07 percent lower than their incomes under the Base Scenario. Meanwhile, total incomes of agricultural households are expected to be only 0.01-0.04 percent lower. This fact implies that the implementation of the IPM program from 1993 to 1998 very likely benefited the urban households the most.

Table 3 indicates that the implementation of the IPM program from 1993 to 1998 lower the total health costs associated with pesticide poisoning cases as much as approximately 1.85 percent, meanwhile, total health costs related to rice farmer pesticide poisoning cases are to reduce by approximately 4.90 percent.

Double IPM Program

From Table 3, it can be seen that the Double IPM Scenario consistently increases the GDP higher than the situation under the Base Scenario. The GDP under the Double IPM Scenario, in 1996, is estimated to be 0.09 percent higher compared to the situation under the Base Scenario. For the 1998, the GDP under the Double IPM Scenario is predicted to be 0.47 percent higher than that under the Base Scenario. Interesting to observe is Figure 9. From this figure, one can observe that, while the economic growth positively, the Double IPM Scenario induces a higher GDP growth than that under the Base Scenario. However, with negative economic growth, the Double IPM Scenario causes the GDP growth rate even lower compared to a situation under the Base Scenario. This indicates that when the economy in general grow negatively, it might be wise to slow down the implementation of the IPM program.

Table 3 shows that urban households benefit the most under the Double IPM Scenario, since they receive the highest increasing in incomes compared to the increase in income received by other households. This indicates that the Double IPM program result in a more unequal income distribution.

Double IPM program improves efficiency in producing rice. However, an increase in rice production, as it turns out, lowers the price of rice, so that at the end reduce the value-added from agricultural sectors (Figure 10) and benefits received by agricultural households. Meanwhile, the lower price of rice enables society to spend on other goods and services, that are rural and urban related activities, in which their prices are relatively stable. Value-addeds from these other goods and services are then growing higher than the value-added from rice production. Hence, rural and urban households receive higher benefits from the Double IPM program than do agricultural households.

The health costs related to pesticides among rice farmers are reduced in a relatively proportional manner with the total reduction in pesticides use under the Double IPM program.

Tax on Pesticides Scenario

Note that an increase in 5 percent tax on pesticides each year for the five years of simulation provides an opportunity to educate up to approximately 100 percent of rice farmers with the IPM technique. Under this condition, i.e. tax on pesticide to fund the IPM program, the Indonesian GDP, in the fifth year of the simulation, is estimated to be approximately 0.64 percent higher than that under the Base Scenario.

Figure 9 shows that, under the Tax on Pesticides Scenario, GDP grows higher than that under the Base and Double IPM program, during the first four years of simulation. In the fifth year of simulation, when the Indonesian economy grows negatively, the impact on GDP growth rate under the Tax on Pesticides Scenario is not as bad as the impact under the Double IPM Scenario.

From Figure 10, one can see that while the economy grow positively, from 1994 to 1997, the agricultural value-added grow slower under the Tax on Pesticides Scenario than that under the Base and Double IPM Scenarios. However, when the economy grows negatively, in 1998, the agricultural value-added under the Tax on Pesticides Scenario is higher compared to that of Double IPM Program.

A major difference between the Double IPM and Tax on Pesticides Scenarios is that in the Tax on Pesticides Scenario, only pesticide industries has to shoulder the burden of funding the IPM program, while under the Double IPM Scenario, all sectors contribute in funding the IPM program. Hence, one can conclude that an appropriate targeted tax system, compared to a uniform tax system, may induce a higher growth rate of GDP when the GDP growth rate is positive, and may slow down the reduction of GDP growth rate when the GDP growth rate is negative.

As for the Double IPM Scenario, urban households benefit the most from the Tax on Pesticides Scenario. The increase in their incomes, under the Tax on Pesticides Scenario, is the highest compared to the increase in other household incomes.

Health costs associated with pesticides poisoning cases are reduced proportionally with the reduction in quantity of pesticide use. However, in the Tax on Pesticides Scenario, there are two reasons for the decline in the quantity of pesticide use: (1) more farmers implementing the IPM program, and (2) higher prices of pesticides. Meanwhile in the Double IPM Scenario, there is only one major reason for the decline in the quantity of pesticide use: more farmers implementing the IPM program.

Conclusion

Before stating the conclusions of the results, it is important to note that the results need to be qualified. Since data are limited, the CGE in this paper cannot capture perfectly all relationships with the economy, within the environment, and between the economy and the environment. The underlying assumptions for the CGE and the simulation scenarios also should be carefully examined.

From the results of the simulations conducted, there are five major conclusions, which are as follows:

First, the IPM program reduces the use of pesticides among farmers, which in turn decreases the quantity of pesticide-related illnesses. Increased number of farmers implementing the IPM program means further reduction in the quantity of pesticide poisoning cases.

Second, the IPM program improves efficiency in producing agricultural products, hence enable farmers to produce more products at a lower price. Lower prices of agricultural products enable society to spend on non-agricultural products. The more efficient agricultural sectors, then, are able to stimulate higher outputs of non-agricultural sectors in which their prices are relatively stable. Value-addeds from non-agricultural sectors then grow higher that those from agricultural sectors. Therefore, although the incomes of agricultural sectors increase, the increase is lower that the increase in incomes of rural and urban households.

Third, since the implementation of the IPM program could stimulates most sectors to produce more, the implementation of the IPM program will most likely induce a higher growth of GDP compared to the growth without IPM. The more farmers adopt the IPM program, the country’s economy will grow higher.

Fourth, when the overall growth rate of the country is negative, investment in the IPM program becomes too "expensive," lowering the growth rate of the country even further.

Fifth, a targeted tax system on pesticide products to fund the IPM program seems to work better that a uniform tax system to fund the IPM program. When compared to a uniform tax system, a scheme with a targeted tax system not only reduced the number of pesticide poisoning cases more, but also produced a higher economic growth rate.

Finally, the general conclusion is that it would be wise for the Indonesian government to combine the implementation of the IPM program with a tax on pesticide products program. Both programs may effectively lower human health problems associated with pesticides and induce a higher growth of GDP. However, when the overall economy has a tendency to grow negatively, it is suggested that the government to slow down the IPM program.

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