

# Impact of the Integrated Pest Management Program on the Indonesian Economy

Budy P. Resosudarmo

October, 2001

Comments should be sent to: Budy P. Resosudarmo, at the Graduate Program in Economics – Faculty of Economics, Gedung B, 2<sup>nd</sup> Floor, University of Indonesia, Depok, Indonesia.

E-mail: [pradnja@indo.net.id](mailto:pradnja@indo.net.id)

---

EEPSEA was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, Papua New Guinea and Sri Lanka.

EEPSEA is supported by the International Development Research Centre (IDRC); the Danish Ministry of Foreign Affairs (DANIDA); the Swedish International Development Cooperation Agency (SIDA); the Ministry of Foreign Affairs, the Netherlands; the Canadian International Development Agency (CIDA); the MacArthur Foundation; and the Norwegian Agency for Development Cooperation (NORAD).

EEPSEA publications are produced by CorpCom Sdn. Bhd. in association with the Montfort Boys Town, Malaysia. This program provides vocational training to boys from low-income families and home-based work to mothers. EEPSEA publications are also available online at <http://www.eepsea.org>.

---

**EEPSEA** is supported by a consortium of donors and administered by IDRC.  
Tanglin P.O. Box 101, Singapore 912404 • Visiting address: 7<sup>th</sup> Storey RELC  
Building, 30 Orange Grove Road • Tel: +65 235 1344 • Fax: +65 235 1849  
• E-mail: [eepsea@idrc.org.sg](mailto:eepsea@idrc.org.sg) • Website: <http://www.eepsea.org>

## **TABLE OF CONTENTS**

|                                                |           |
|------------------------------------------------|-----------|
| <b>Abstract</b>                                | <b>1</b>  |
| <b>1.0 Introduction</b>                        | <b>2</b>  |
| <b>2.0 Methodology</b>                         | <b>4</b>  |
| <b>3.0 Sources of Data</b>                     | <b>11</b> |
| <b>4.0 Simulation Scenarios</b>                | <b>13</b> |
| 4.1 Base Scenario: No More IPM                 | 15        |
| 4.2 IPM Scenario                               | 15        |
| 4.3 Double IPM Scenario                        | 16        |
| 4.4 IPM Plus Pesticide Pricing Policy          | 16        |
| <b>5.0 Results and Discussion</b>              | <b>17</b> |
| 5.1 Base Scenario                              | 17        |
| 5.2 IPM Scenario                               | 19        |
| 5.3 Sensitivity Analysis of the IPM Scenario   | 23        |
| 5.4 Double IPM Scenario                        | 24        |
| 5.5 IPM Plus Pesticide Pricing Policy Scenario | 25        |
| <b>6.0 Conclusion</b>                          | <b>28</b> |
| <b>References</b>                              | <b>30</b> |

## **LIST OF TABLES**

|          |                                                                                                                                        |    |
|----------|----------------------------------------------------------------------------------------------------------------------------------------|----|
| Table 1. | List of Production Sectors in the CGE Model                                                                                            | 11 |
| Table 2. | Results from the Base Scenario                                                                                                         | 19 |
| Table 3. | Total Changes in GDP, Household Incomes, and Health Problems and Costs Associated with Pesticide Poisoning Under the Various Scenarios | 22 |
| Table 4. | Sensitivity Analysis of the IPM Scenario                                                                                               | 24 |
| Table 5. | GDP and Household Incomes Under the IPM Plus Pesticide Pricing Policy Scenario                                                         | 26 |
| Table 6. | GDP and Household Incomes: IPM Plus Pesticide Pricing vs Pesticide Pricing-Only Scenario                                               | 27 |

## **LIST OF FIGURES**

|           |                                                                                        |    |
|-----------|----------------------------------------------------------------------------------------|----|
| Figure 1. | Link Between the Economy and Pesticides in Agriculture                                 | 5  |
| Figure 2. | Structure of the Sectoral Production Function                                          | 7  |
| Figure 3. | Base Scenario GDP Growth                                                               | 15 |
| Figure 4. | Estimated Percentage of Rice Farmers Practicing IPM Technique                          | 16 |
| Figure 5. | Base Scenario: Changes in GDP and Health Costs and Problems Associated with Pesticides | 17 |
| Figure 6. | GDP under the Base and IPM Scenarios                                                   | 20 |

# **IMPACT OF THE INTEGRATED PEST MANAGEMENT PROGRAM ON THE INDONESIAN ECONOMY**

**Budy P. Resosudarmo**

## **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, the contamination of agricultural products, the destruction of both beneficial natural parasites and pest predators, and pesticide resistance in pests. To overcome these environmental problems, the Indonesian government implemented an integrated pest management (IPM) program from 1991 to 1999. During that time, the program was able to help farmers reduce the use of pesticides by approximately 56% and increase yields by approximately 10%. 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 in food crops on the Indonesian economy and household incomes for different socioeconomic groups.

## 1.0 INTRODUCTION

The chronic food shortage during the first two decades of Indonesian independence (1945-1965) prompted 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 program (Oka, 1995). The food intensification program consisted of the widespread use of high-yielding modern seed varieties, the development of irrigation systems, the expansion of food crop producing areas, the increased use of chemical fertilizers and pesticides, the expansion of agricultural extension services, the establishment of farmer cooperatives and input subsidies, and the stabilization of national food crop prices (Oka, 1991).

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

Despite the remarkable success of the food intensification program, the excessive use of pesticides caused serious environmental problems. These include acute and chronic human pesticide poisoning, animal poisoning, the contamination of agricultural products, the destruction of beneficial natural parasites and pest predators, and pesticide resistance in pests (Achmadi, 1992; Oka, 1995; Pimentel et al., 1992; and Antle and Pingali, 1994).<sup>3</sup>

To overcome these environmental problems caused by the overuse of pesticide, the Indonesian government adopted a strategy of integrated pest management (IPM) in the early 1990s. The government's pest control policy changed from one which depended solely on pesticides to one which used a combination of control tactics, such as synchronized planting, crop rotation, the use of natural predators, and pesticides. It was reported that farmers who

---

<sup>1</sup> The average annual population growth was approximately 2.3% in the 1970s and 1980s.

<sup>2</sup> However, due to a long drought season, since the mid-1990s Indonesia has had to import rice again to fulfil the national demand for rice.

<sup>3</sup> In 1988, Achmadi found 1,267 cases of acute pesticide poisoning in 182 general hospitals throughout the islands of Java and Bali. He also observed that approximately 20-50% of the farmers who used pesticides contracted chronic pesticide-related illnesses. These illnesses included headaches, weakness, insomnia, and difficulty 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).

participated in the IPM program were able to reduce the use of pesticides by approximately 56% and increase yields by approximately 10% (Oka, 1995).<sup>4</sup>

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 see their income rise by approximately 50%. Literature on other countries' experiences is also limited. Among others are Rola and Pingali (1992), Antle and Pingali (1994), and Pingali et.al. (1994), who conducted studies on the use of pesticides, productivity and farmers' health in the Philippines. In the United States, the literature includes the works of Chamber and Lichtenberg (1994), Zilberman et.al. (1991), and Lichtenberg et.al. (1988). These studies, however, observed only the impact of the IPM program on farmers' income—they did not take into account the multiplier impact on the incomes of both farmers and other household groups. The studies also did not mention the impact of the IPM program on the national economy.

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

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

In addition to its relevance to Indonesia, this research is also valuable as a comparative study for other developing countries.

---

<sup>4</sup> The increasing yields are caused by the elimination of serious or large-scale pest outbreaks.

## 2.0 METHODOLOGY

As mentioned previously, this research uses a CGE model to analyze the impact of the IPM program on the Indonesian national economy.<sup>5</sup> 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 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 new capital.
- **Market-Clearing Block:** Equations in this block determine the market-clearing conditions for labor, goods, and services in the economy. The national balance of payments 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 explains only some of the most important features of the CGE used 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. The higher the amount of pesticides used in the 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 inputs and lower the overall productivity of all other factor inputs in agricultural production activities.<sup>6</sup>

---

<sup>5</sup> GAMS Syntax of the CGE utilized in this paper is available from the author upon request.

<sup>6</sup> This research certainly underestimates societal and environmental impact of using pesticides. However, data on the societal and environmental impact associated with the use of pesticides, such as animal poisoning, the contamination of products, groundwater and surface water, and fishery losses (Pimentel et al., 1992; Antle and Pingali, 1994; and Pingali et.al., 1994), are not yet available in Indonesia. Limiting the scope of this research to human poisoning cases appears to be a reasonable choice.



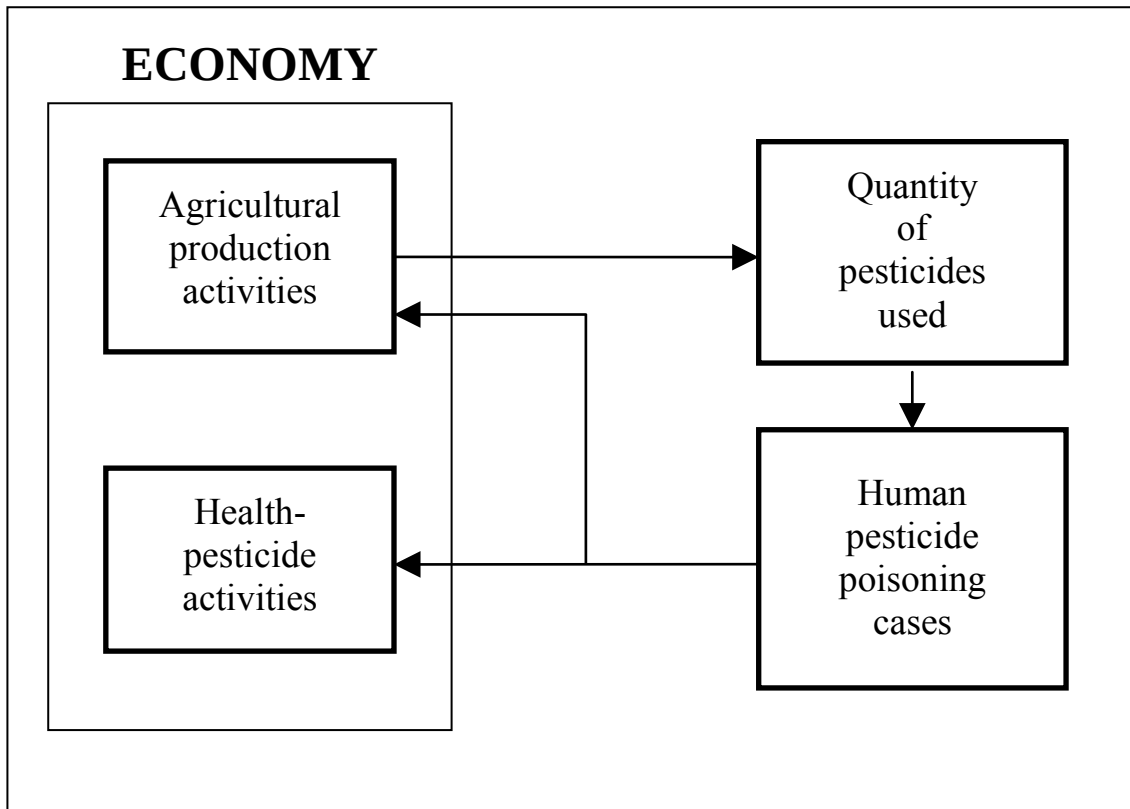


Figure 1. Link Between the Economy and Pesticides in Agriculture

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

- The government needs to spend a certain amount of money to implement the IPM program, resulting in a smaller budget for other government programs and capital investment in other sectors.
- Most of the government's 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 can a program that depends solely on pesticides.
- Since the use of pesticides can cause pesticide poisoning among farmers, the reduction in the amount of pesticides use in the food crop sector decreases the number of such 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. This in turn enables households to spend money on other goods and services, particularly food.
- The occurrence of pesticide-related illnesses negatively affects the productivity of agricultural labor inputs. 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 disaggregated the food crop production sectors. The important features of these sectoral production activities are the value-added function, the sectoral production function, and the input-output coefficient of the quantity of pesticide used in the food crop sector (see Figure 2).

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.

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

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.

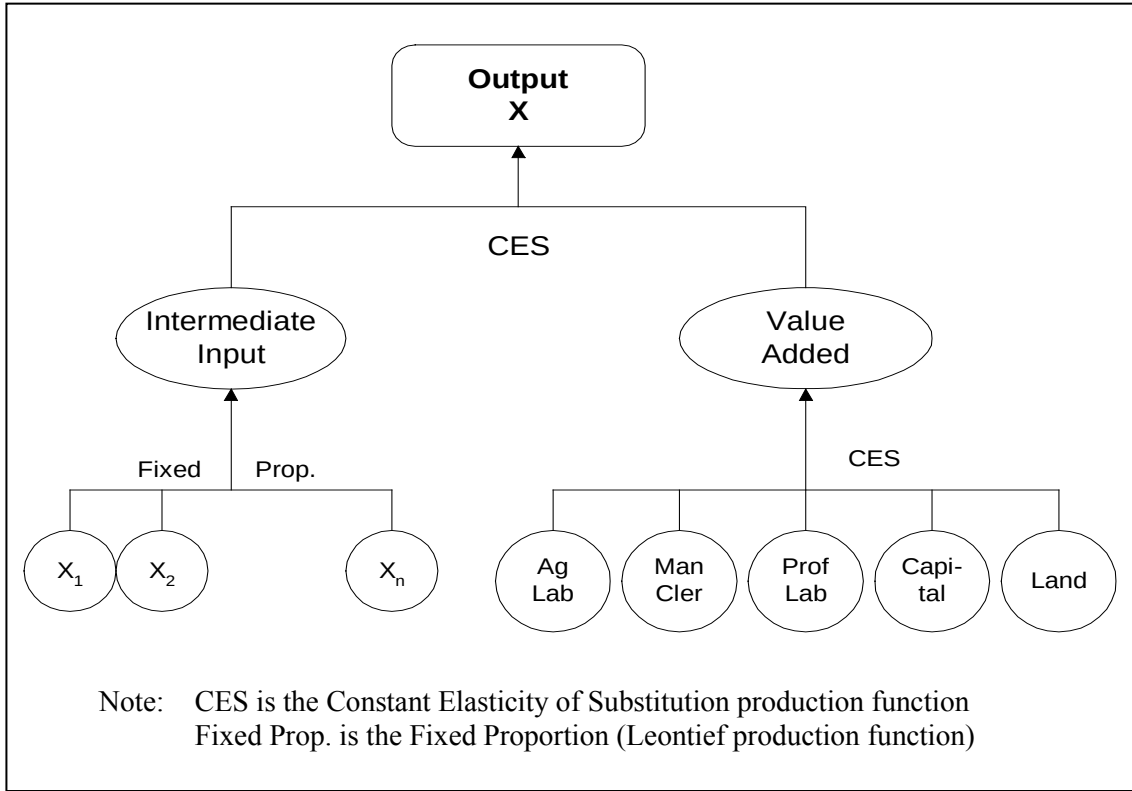


Figure 2. Structure of the Sectoral Production Function

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, the  $HE_i$  function is:

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

and

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

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 illnesses occur.

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

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

where:

$X_i$  is gross domestic sectoral outputs

$IN_i$  is composite intermediate inputs.

In the food crop sector, particularly the 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 ( $\alpha_i^x$ ) 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:

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

where:

|                              |                                                                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\gamma_{IPM}$               | equals 1.10. This is due to the fact that IPM farmers are 10% more efficient than non-IPM farmers                                                               |
| $\gamma_{NONIPM}$            | represents the fact that non-IPM farmers also receive benefits from the implementation of an IPM program, since the total population of pests in the area falls |
| $\overline{\alpha}_{RICE}^x$ | 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                                                                                                    |
| $FACDEM_{RICE,AGLAB}^t$      | 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 pesticides used in the food crop sector. Farmers who implement the IPM can reduce the amount of pesticides 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:

$$iomi_{PEST,RICE}^t = \overline{iomi}_{PEST,RICE} \cdot \left( 1 - \frac{IPMFARM^t}{FACDEM_{RICE,AGLAB}^t} \right) + \overline{iomi}_{PEST,RICE} \cdot \frac{IPMFARM^t}{FACDEM_{RICE,AGLAB}^t} \cdot 0.44 \quad (6)$$

where:

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

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

subject to:

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

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/minimum health costs to recover from pesticide-related illnesses.<sup>8</sup>

Note that this research limits its analysis to cases of pesticide-related illnesses among farmers. The health costs associated with pesticide-related illnesses ( $CDHE_h$ ) in the relationship (8) hence appear only in agricultural household groups' budget constraints; 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 that occur. The quantity of pesticide-related illnesses is a function of the quantity of pesticides used in agricultural sectors:

<sup>7</sup> 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.

<sup>8</sup>  $CDHE$  is an exogenous variable in this model.  $CDHE$  represents only the minimum health cost needed. Households can consume more health activities beyond  $CDHE$ . Household consumption on health activities to recover from pesticide-related illnesses is covered in the consumption of Public and Private Services (See Table 1).

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

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  
 $iomi_{PEST,ag} \cdot IN_{ag}$  is the amount of pesticides used in agricultural sector  $ag$   
 $R(AGLAB)$  is the ratio between agricultural labor in any simulation scenario and in the benchmark scenario.

The pesticide-related illnesses are both 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.

$$FACDEM_{i,CAPITAL}^{t+1} = FACDEM_{i,CAPITAL}^t \cdot (1 - depr_i) + DK_i^t \quad (10)$$

where:

$depr_i$  is the depreciation rate  
 $DK_i^t$  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.

Macro closure specifications for this CGE can be summarized as follows. In the foreign exchange market, the current account is fixed exogenously, and the exchange rate varies. In the balance of payments equation the equilibrating mechanism is changes in the foreign reserve variable; i.e. the amount of foreign reserves in the central bank is an endogenous variable. Note that the balance of payments flows, such as foreign borrowing, interest, and amortization payments of international loans, and so on, are set exogenously.

In the investment-saving part, this CGE is a saving-driven model, meaning that aggregate investment is determined by the sum of private, government, and foreign savings. Household savings rates for all households are fixed shares of household incomes. Foreign saving is exogenously determined. Government savings is residually defined from the government revenue and consumption equation, in which government consumption is an exogenous variable.

In the market of factor inputs, land and capital are fixed. The labor markets for professional, agricultural, and manual-clerical workers are assumed to be in a full-employment condition. And, finally, the composite good price index is specified as the numeraire for the model.

### 3.0 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 the rice, bean, and corn sectors (see Table 1). Pesticide production is also 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. List of Production Sectors in the CGE Model

| Sectors |                          | Sectors |                                 |
|---------|--------------------------|---------|---------------------------------|
| 1       | Rice                     | 32      | Saw Mill Industry               |
| 2       | Bean                     | 33      | Plywood Industry                |
| 3       | Corn                     | 34      | Wood Product Industry           |
| 4       | Tuber                    | 35      | Wood Furniture Industry         |
| 5       | Fruit Vegetable          | 36      | Other Wood Industry             |
| 6       | Rubber                   | 37      | Non-plastic Anyaman Industry    |
| 7       | Sugar Cane               | 38      | Textile Leather Industry        |
| 8       | Coconut                  | 39      | Pulp Industry                   |
| 9       | Palm Oil                 | 40      | Paper Industry                  |
| 10      | Tobacco                  | 41      | Paper Product Industry          |
| 11      | Coffee                   | 42      | Printed Matter Industry         |
| 12      | Tea                      | 43      | Fertilizer Industry             |
| 13      | Clove                    | 44      | Pesticide Industry              |
| 14      | Fibrous                  | 45      | Chemical Industry               |
| 15      | Other Estate Crop        | 46      | Cement Industry                 |
| 16      | Other Crop               | 47      | Rubber Plastic Product Industry |
| 17      | Livestock                | 48      | Basic Metal Industry            |
| 18      | Wood                     | 49      | Oil Refinery                    |
| 19      | Other Forestry           | 50      | Transport Vehicle Industry      |
| 20      | Hunting                  | 51      | Electricity Gas Water           |
| 21      | Fishery                  | 52      | Construction                    |
| 22      | Metal Ore Petrol Mining  | 53      | Retail and Inventory            |
| 23      | Other Mining             | 54      | Restaurant                      |
| 24      | Food Processing Industry | 55      | Hotel                           |
| 25      | Oil Fat Industry         | 56      | Land Transportation             |
| 26      | Rice Mill Industry       | 57      | Air and Water Transportation    |
| 27      | Flour Industry           | 58      | Bank and Insurance              |
| 28      | Sugar Industry           | 59      | Real Estate                     |
| 29      | Other Food Industry      | 60      | Public Service                  |
| 30      | Drink Industry           | 61      | Pesticide-Health Services       |
| 31      | Cigarette Industry       | 62      | Private Service                 |

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 of 0.0-0.5 ha.
- *Medium Farmer*              Agricultural land owners with land of 0.5-1.0 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, large entrepreneurs, large retail store owners, large 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 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 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 3,000 cases of acute poisoning were associated with the use of pesticides in agricultural sectors. He also observed that approximately 20-50% of the farmers who used pesticides contracted chronic pesticide-related illnesses, including headaches, weakness, insomnia, and difficulty concentrating. Furthermore, Achmadi noticed that, on average, each time a farmer contracted acute pesticide poisoning, the farmer missed approximately five days of work; each time a farmer contracted



chronic pesticide poisoning, the farmer, on average, missed approximately one day of work.

This research assumes that the number of acute pesticide poisoning cases in 1993 was 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 used pesticides. Thus, the estimate of chronic pesticide-related illness cases for 1993 is approximately 12.3 million.

#### **4.0 SIMULATION SCENARIOS**

This section discusses several scenarios intended to simulate the impact of the Indonesian IPM program on income distribution and the national economy in general. To do this, this section will, first, review the implementation of the national 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 the efficiency of input use, particularly 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% of the total price in 1986 to 40-45% in 1987. Finally, in January 1989, these subsidies were completely eliminated. The government also banned 57 broad-spectrum insecticides, and allowed the use of only 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 was the supreme policy-making body, and was responsible for the success of the IPM program. Under the Board, a Steering Committee was formed to direct project activities and to ascertain the need for policy improvement. The Committee consisted of IPM experts from various government agencies, universities, and international institutions. Certain members of the committee formed a Working Group that conducted the day-to-day tasks of the committee.

The central aim of the national IPM program was 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. Between 1991 and 1999, approximately 200,000 farmers—most of them rice farmers—were trained each year. Approximately 10% of these 200,000 farmers were chosen to receive further training so that they in turn could become trainers. These farmer trainers were required to teach in surrounding IPM training programs and were encouraged to train their neighbors on a one-on-one basis. The cost of all IPM training activities is approximately Rp11.25 billion (US\$5.36 million) each year. From 1991 until 1992, most of the national costs of the IPM program were funded by a grant from the United States Agency for International Development (USAID). From 1993 until 1998, the main source of funding for the program was a loan from the World Bank (SEARCA, 1999).

Based on observations in several villages in West Java, Central Java, and Bali, the total number of rice farmers implementing the IPM program each year can be estimated as follows:

$$IPMFARM_{RICE}^t = 0.9 \cdot \frac{IPMBUDGET_{RICE}^t}{CPF_{RICE}} + 1.05 \cdot IPMFARM_{RICE}^{t-1} \quad (11)$$

where:

- $IPMFARM_{RICE}^t$  is the total numbers of rice farmers implementing the IPM program in year  $t$
- $IPMBUDGET_{RICE}^t$  is the total national (government) budget for the IPM training program in 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 Rp56,250 per farmer.

Note that although IPM practices provide an opportunity to receive a higher profit, most farmers were not aware of the program until they enrolled in an IPM training course or met other farmers who practiced the IPM technique. Some farmers either do not understand or do not trust the IPM technique, and choose to practice pest management the conventional way.

Equation (11) assumes that, each year, 90% of farmers entering the national IPM training program actually go on to implement IPM methods, while some farmers decide to adopt the IPM technique without ever joining a national IPM training course. Most learn the IPM technique from their neighbors who are IPM farmer trainers, while some learn from enrolling in an IPM local training funded by non-government organizations or by local agricultural extensions.

The scenarios developed in this paper are meant to analyze the impact of the national IPM program on the economy. The most important thing in developing the scenarios is controlling the national IPM budget. From equation

(11), it can be seen that controlling the national IPM budget affects the total number of IPM farmers each year. However, regardless of the amount of the national budget allocated to the IPM program, the total number of IPM farmers increases by at least 5% each year. The scenarios are as follows.

#### 4.1 Base Scenario: No More IPM

This research simulates the Indonesian economy up until 2020. Note that the data set is the Indonesian economy in 1993. In that year and up until 1998, using a World Bank loan as mentioned before, the Indonesian government applied the IPM program to mostly rice farmers. In 1999, the loan was terminated. Since then, no significant national IPM program has been implemented. The Base Scenario, then, is the Indonesian economy from 1993 until 2020, with no national IPM program after 1999.

Please note that from 1999 to 2020, the Indonesian government still receives loans from the World Bank and other foreign institutions, but cannot use them to finance the IPM program.

The CGE program in this paper is constructed to mimic the actual growth of Indonesian GDP in 1993-2000 and the expected growth in 2001-2020. The Indonesian GDP growth rate dropped by as much as 14% in 1998, but then slowly increased and became positive again. By 2004 and after, the estimated annual GDP growth rates are relatively steady at 6 % (see Figure 3).

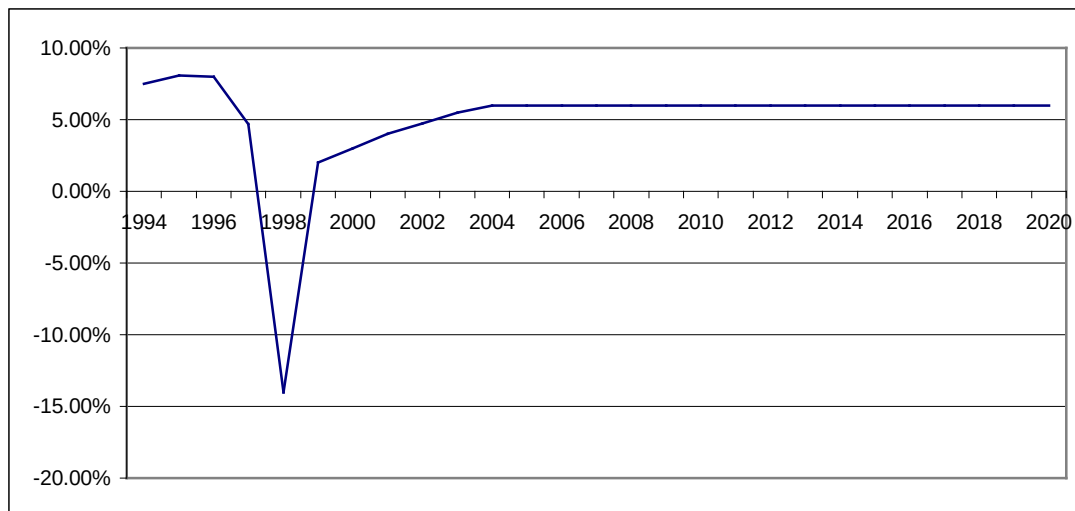


Figure 3. Base Scenario GDP Growth

#### 4.2 IPM Scenario

This scenario assumes that, from 2001 onwards, the Indonesian government is able to implement the national IPM program again. Some of the foreign loans received are actually designated for the IPM program. Note that the

total foreign loan amount is the same as it is under the Base Scenario. In this IPM Scenario, the Indonesian government spends Rp11.25 billion to train approximately 200,000 rice farmers each year from 2001 until 2020.

Comparing the results of this scenario to those of the Base Scenario gives an indication of the economic impact of implementing the IPM program in Indonesia.

### 4.3 Double IPM Scenario

This scenario is almost the same as the previous scenario, except that it assumes that, each year from 2001 onwards, the Indonesian government spends Rp22.5 billion—or double the amount spent in the previous scenario—to train 400,000 rice farmers.

Comparing the results of this scenario to those of the IPM Scenario gives some idea of what the impact would be if the Indonesian government were able to spend more money on the IPM program.

### 4.4 IPM Plus Pesticide Pricing Policy

This scenario simulates the effect of a 5% increase in the tax rate on pesticides from 2001 onwards. From 2001-2014, the government uses all of the revenue from this additional tax to fund the national IPM program. From 2015 onwards, by which time more than 80% of Indonesian rice farmers would have implemented the IPM technique, the government uses only some of the revenue for the IPM program (see Figure 4).

The main aim of this scenario is to assess the economic impact of self-financing the national IPM program, rather than depending on foreign loans or donors.

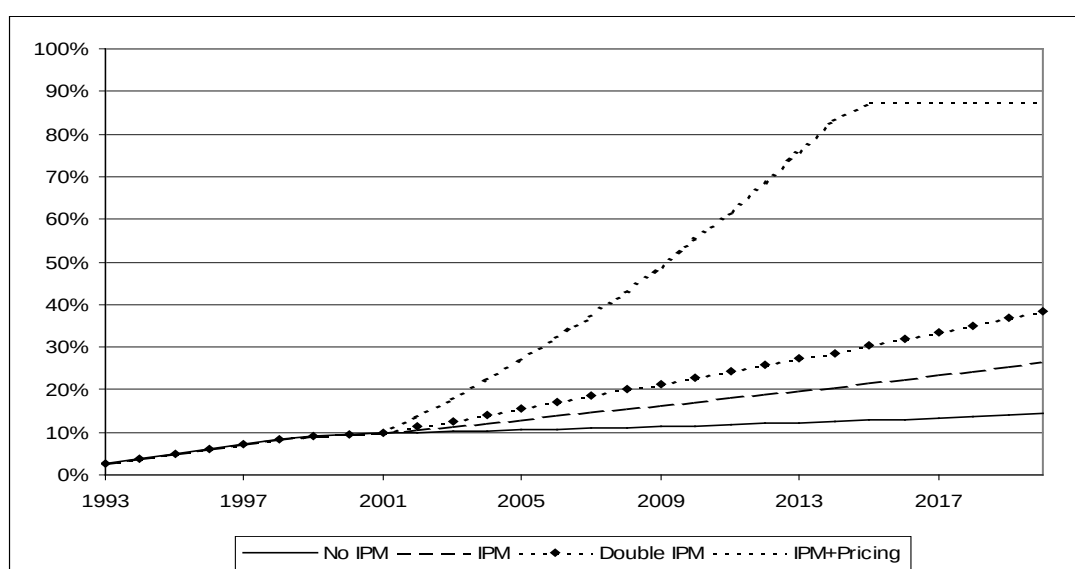


Figure 4. Estimated Percentage of Rice Farmers Practicing IPM Technique

## 5.0 RESULTS AND DISCUSSION

### 5.1 Base Scenario

Figure 5 and Table 2 present the results of the Base Scenario in terms of GDP, total household income, and the health problems and costs associated with pesticide poisoning cases.

From Figure 5 it can be seen that the Indonesian GDP in 2020 is approximately 3.5 times the GDP in 1993. However, the health problems associated with the use of pesticides are more than six times greater in 2020 than in 1993. The reason that health problems increase faster than GDP is that, besides the increase in the amount of pesticides used in the agricultural sector, the number of farmers is expected to increase at a rate of about 3% per year.

Health costs associated with the use of pesticides do not increase as fast as the number of health problems since the relative price per unit of health cost decreases each year.

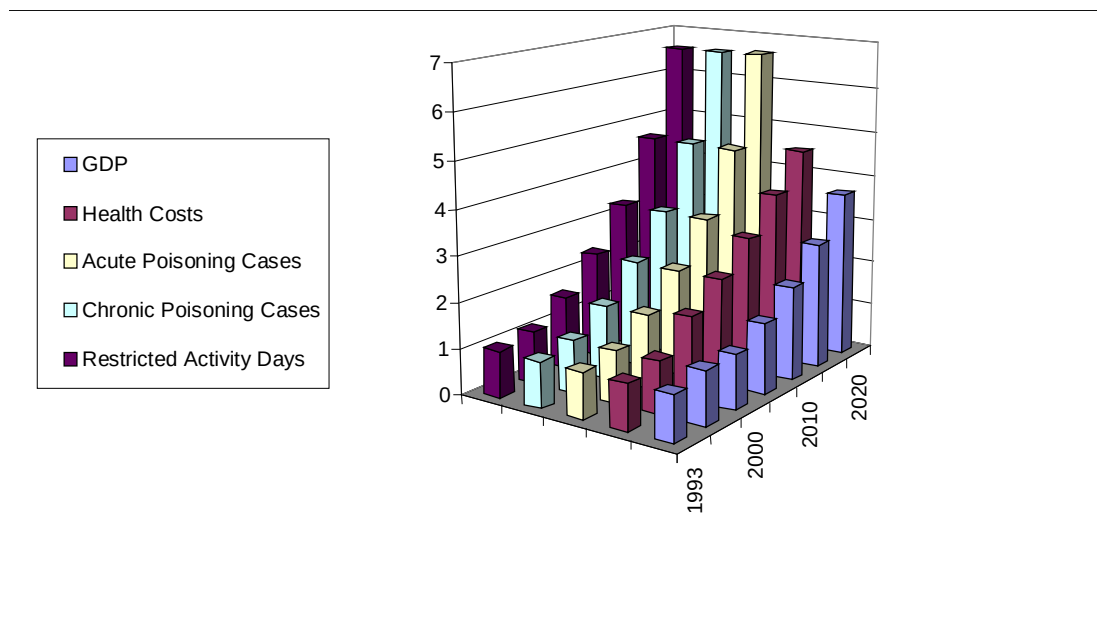


Figure 5. Base Scenario: Changes in GDP and Health Costs and Problems Associated with Pesticides

GDP, total household incomes, and health costs in Table 2 are in billions of rupiahs. Health problems associated with pesticide poisoning accidents are in the number of cases, while restricted activity days related to pesticide poisoning cases are in the number of days. The percentages in columns (2) to (6) are the ratios between the conditions in a particular year and the condition in 1993.

In Table 2, one can see that, during the 27 years of simulation, total incomes of rural and agricultural households grow faster than those of urban households. It can also be observed that total incomes of agricultural households increase faster than those of rural households. Since the average income per household for agricultural households is lower than that of urban households, and total incomes of agricultural households grow faster than those of urban households, it can be inferred that a more equal income distribution will result from the IPM program.<sup>9</sup>

During the simulation years, land for food crops is relatively constant. The supply of food products cannot increase as fast as demand. This is generally not the case in the manufacturing and service sectors.<sup>10</sup> In real terms, prices of agricultural products are expected to increase, or to increase at a higher rate than those of manufacturing and service products, during each of the simulation years. Consequently, the incomes of agricultural households increase at a higher rate than those of rural and urban households.

Table 2 also shows that the health costs associated with pesticide poisoning cases paid by rice farmers increase more slowly than those paid by other types of farmers. The explanation for this is as follows. In the model, it is predicted that the increase in the number of non-rice farmers, the activities of the non-rice agricultural sector, and the amount of pesticides utilized in non-rice fields are higher than the increase in the number of rice farmers, the activities of the rice sector, and the amount of pesticides utilized in rice fields. The number of pesticide poisoning cases among rice farmers therefore increases more slowly than among non-rice farmers.

---

<sup>9</sup> It is important to note that the government's spending pattern utilized in all years of simulation is the same as that of 1993. Changing the pattern during the simulation years would therefore alter the results.

<sup>10</sup> This is assumed in the model.

Table 2. Results from the Base Scenario

| (in billions of rupiahs<br>except as mentioned)    | Base Condition<br>No IPM Program |                    |                    |                    |                    |                    |
|----------------------------------------------------|----------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                                                    | 1993<br>(1)                      | 2000<br>(2)        | 2005<br>(3)        | 2010<br>(4)        | 2015<br>(5)        | 2020<br>(6)        |
| GDP                                                | 329,776                          | 391,525<br>119%    | 505,604<br>153%    | 676,613<br>205%    | 905,460<br>275%    | 1,211,710<br>367%  |
| <b>Household Incomes</b>                           |                                  |                    |                    |                    |                    |                    |
| Ag. Employee                                       | 9,499                            | 11,363<br>120%     | 15,472<br>163%     | 22,123<br>233%     | 31,863<br>335%     | 45,770<br>482%     |
| Small Farmer                                       | 40,940                           | 51,579<br>126%     | 74,045<br>181%     | 115,612<br>282%    | 184,233<br>450%    | 291,904<br>713%    |
| Medium Farmer                                      | 11,138                           | 14,019<br>126%     | 19,969<br>179%     | 30,710<br>276%     | 47,925<br>430%     | 74,324<br>667%     |
| Large Farmer                                       | 18,083                           | 21,894<br>121%     | 29,274<br>162%     | 41,966<br>232%     | 61,009<br>337%     | 88,695<br>490%     |
| Rural Low Income                                   | 14,314                           | 16,954<br>118%     | 21,095<br>147%     | 27,860<br>195%     | 37,156<br>260%     | 49,931<br>349%     |
| Rural Non-Labor                                    | 3,915                            | 4,408<br>113%      | 5,491<br>140%      | 7,014<br>179%      | 8,952<br>229%      | 11,425<br>292%     |
| Rural High Income                                  | 45,643                           | 55,103<br>121%     | 68,008<br>149%     | 90,788<br>199%     | 123,348<br>270%    | 169,745<br>372%    |
| Urban Low Income                                   | 25,202                           | 28,959<br>115%     | 35,277<br>140%     | 44,445<br>176%     | 55,581<br>221%     | 69,194<br>275%     |
| Urban Non-Labor                                    | 6,455                            | 7,698<br>119%      | 9,964<br>154%      | 13,834<br>214%     | 19,678<br>305%     | 28,376<br>440%     |
| Urban High Income                                  | 69,360                           | 80,712<br>116%     | 93,105<br>134%     | 110,641<br>160%    | 127,146<br>183%    | 141,319<br>204%    |
| <b>Health Problems in Rice Sector</b>              |                                  |                    |                    |                    |                    |                    |
| Acute Poisoning Cases<br>(in number of cases)      | 1,125                            | 1,743<br>155%      | 2,424<br>215%      | 3,249<br>289%      | 4,348<br>386%      | 5,798<br>515%      |
| Chronic Poisoning Cases<br>(in number of cases)    | 3,864,707                        | 5,989,227<br>155%  | 8,326,160<br>215%  | 11,160,392<br>289% | 14,935,557<br>386% | 19,917,867<br>515% |
| Restricted Activity Days<br>(in number of days)    | 3,871,353                        | 5,999,527<br>155%  | 8,340,478<br>215%  | 11,179,580<br>289% | 14,961,240<br>386% | 19,952,120<br>515% |
| Health Cost                                        | 4.65                             | 8.01<br>172%       | 9.98<br>215%       | 12.29<br>264%      | 14.53<br>313%      | 16.45<br>354%      |
| <b>Health Problems in All Agricultural Sectors</b> |                                  |                    |                    |                    |                    |                    |
| Acute Poisoning Cases<br>(in number of cases)      | 3,000                            | 4,797<br>160%      | 6,953<br>232%      | 9,758<br>325%      | 13,846<br>462%     | 19,837<br>661%     |
| Chronic Poisoning Cases<br>(in number of cases)    | 10,323,532                       | 16,533,202<br>160% | 24,012,836<br>233% | 33,680,733<br>326% | 47,667,033<br>462% | 67,948,914<br>658% |
| Restricted Activity Days<br>(in number of days)    | 10,341,260                       | 16,561,550<br>160% | 24,053,950<br>233% | 33,738,420<br>326% | 47,748,860<br>462% | 68,066,050<br>658% |
| Health Cost                                        | 12.42                            | 22.12<br>178%      | 28.76<br>232%      | 37.08<br>299%      | 46.38<br>373%      | 56.14<br>452%      |

Note: The percentages show the differences between the levels of a certain variable in 2000, 2005, 2010, 2015, or 2020 compared to the level of the same variable in 1993.

## 5.2 IPM Scenario

Recall that in the IPM Scenario, the Indonesian government trains approximately 200,000 rice farmers each year from 2001 onwards to become IPM farmers, and that the conditions before 2001 are the same under the Base

and IPM Scenarios. Table 3, column (3), shows the results of the IPM Scenario compared with the results of the Base Scenario.

GDP, household incomes, and health costs are in billions of rupiahs. One can see that the estimated total GDP gain from 20 years of the IMP program (area A in Figure 6) is Rp14 trillion. This is equivalent to approximately 3.65% of GDP in 2000. Meanwhile, Table 3 column (3) shows that, in general, the incomes of rural and urban households increase at a higher rate than those of agricultural households. The more efficient rice production brought about by the implementation of the national IPM program, in a free and competitive market as assumed by the model, results in a lower price of rice, thus creating more household income for the consumption of other goods and services that are produced by rural and urban households. However, the impact of the national IPM program on household incomes is relatively small—only 1.5-4.6% over 20 years. Hence, even under the IPM Scenario, a more equal income distribution in Indonesia is likely to occur, as it does under the Base Scenario.

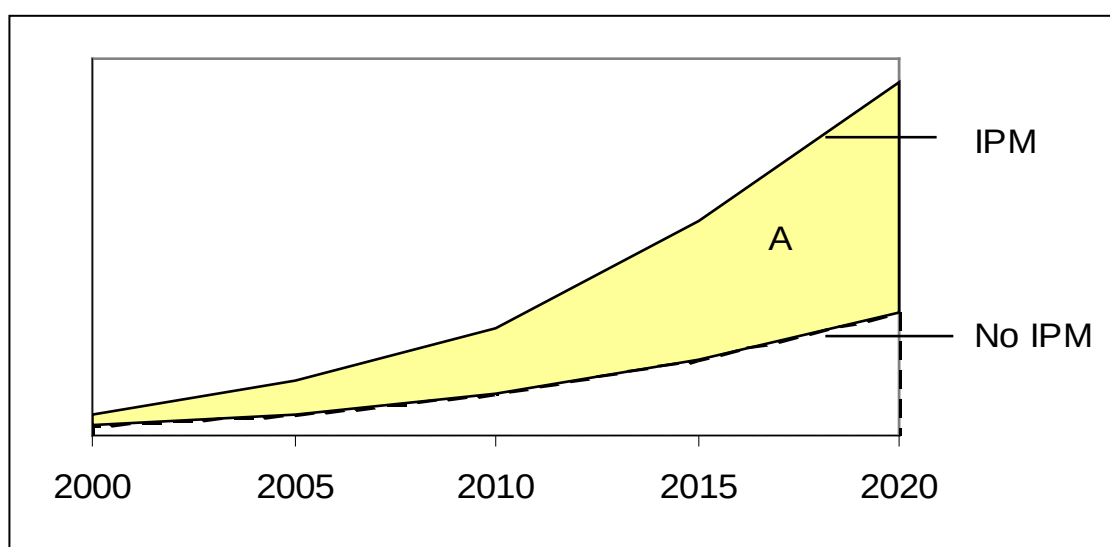


Figure 6. GDP under the Base and IPM Scenarios

The positive effects of the IPM program on GDP and household incomes are not obvious, for although the program improves the efficiency of agricultural production, it has negative effects on the economy too. First, the IPM budget lowers funds that are available for other government activities. The model allows that the funds, if not used to support the IPM program, are invested in other government activities. Second, a reduction in the amount of pesticide use lowers the output of the pesticide industry, which will reduce the incomes of workers in that industry. Third, a reduction in the health services required by rice farmers also decreases the incomes of people who work in the health sector. However, the model shows that the positive effects of the IPM program outweigh the negative effects.



In terms of the health problems associated with pesticides, Table 3 shows that the implementation of a national IPM program prevents among rice farmers the occurrence of approximately 3,500 acute poisoning cases,<sup>11</sup> 12 million chronic poisoning cases, and 12 million restricted activity days related to the use of pesticides over the next 20 years. This could reduce rice farmers' health costs by as much as Rp12 billion in 10 years.

Since the implementation of the national IPM program assumed in this paper is only in the rice sector, there is no reduction in the number of health problems associated with the use of pesticides among non-rice farmers in the IPM Scenario. Furthermore, since the extent of activities of non-rice sectors in the IPM Scenario is greater than that of the Base Scenario, there are more health problems associated with pesticide poisoning among non-rice farmers in the IPM Scenario than in the Base Scenario. Therefore, the total number of acute and chronic poisoning cases, which could be reduced under the IPM Scenario, among all types of farmers is 3,300 and 11 million, respectively. Note that the numbers are lower than if one observes rice farmers alone.

---

<sup>11</sup> Please note that, in Table 3, the minus sign associated with the number of poisoning cases means the total number of poisoning cases *prevented* from occurring, not that the number of poisoning cases occurred is negative. This also applies to health costs.

Table 3. Total Changes in GDP, Household Incomes, and Health Problems and Costs Associated with Pesticide Poisoning Under the Various Scenarios

| (in billions of rupiahs<br>except as mentioned)    | Base Condition<br>No IPM Program |                    | Total Changes Associated with Each IPM Policy<br>(and as a percentage of 2000 condition) |                   |                  |
|----------------------------------------------------|----------------------------------|--------------------|------------------------------------------------------------------------------------------|-------------------|------------------|
|                                                    | 2000<br>(1)                      | 2020<br>(2)        | IPM<br>(3)                                                                               | Double IPM<br>(4) | IPM+Price<br>(5) |
| GDP                                                | 391,525                          | 1,211,710<br>209%  | 14,283<br>3.65%                                                                          | 28,317<br>7.23%   | 86,216<br>22.02% |
| <b>Household Incomes</b>                           |                                  |                    |                                                                                          |                   |                  |
| Ag. Employee                                       | 11,363                           | 45,770<br>303%     | 255<br>2.24%                                                                             | 502<br>4.42%      | 1,464<br>12.89%  |
| Small Farmer                                       | 51,579                           | 291,904<br>466%    | 1,902<br>3.69%                                                                           | 3,757<br>7.28%    | 11,287<br>21.88% |
| Medium Farmer                                      | 14,019                           | 74,324<br>430%     | 393<br>2.80%                                                                             | 774<br>5.52%      | 2,292<br>16.35%  |
| Large Farmer                                       | 21,894                           | 88,695<br>305%     | 325<br>1.48%                                                                             | 637<br>2.91%      | 1,812<br>8.28%   |
| Rural Low Income                                   | 16,954                           | 49,931<br>195%     | 574<br>3.39%                                                                             | 1,139<br>6.72%    | 3,422<br>20.18%  |
| Rural Non-Labor                                    | 4,408                            | 11,425<br>159%     | 161<br>3.66%                                                                             | 320<br>7.26%      | 963<br>21.85%    |
| Rural High Income                                  | 55,103                           | 169,745<br>208%    | 1,869<br>3.39%                                                                           | 3,707<br>6.73%    | 11,170<br>20.27% |
| Urban Low Income                                   | 28,959                           | 69,194<br>139%     | 1,098<br>3.79%                                                                           | 2,180<br>7.53%    | 6,571<br>22.69%  |
| Urban Non-Labor                                    | 7,698                            | 28,376<br>269%     | 357<br>4.63%                                                                             | 707<br>9.19%      | 2,146<br>27.87%  |
| Urban High Income                                  | 80,712                           | 141,319<br>75%     | 2,905<br>3.60%                                                                           | 5,773<br>7.15%    | 17,419<br>21.58% |
| <b>Health Problems in Rice Sector</b>              |                                  |                    |                                                                                          |                   |                  |
| Acute Poisoning Cases<br>(in number of cases)      | 1,743                            | 5,798<br>233%      | -3,531                                                                                   | -7,066            | -22,324          |
| Chronic Poisoning Cases<br>(in number of cases)    | 5,989,227                        | 19,917,867<br>233% | -12,131,607                                                                              | -24,272,416       | -76,691,006      |
| Restricted Activity Days<br>(in number of days)    | 5,999,527                        | 19,952,120<br>233% | -12,152,484                                                                              | -24,314,156       | -76,822,890      |
| Health Cost                                        | 8.01                             | 16.45<br>105%      | -12.16                                                                                   | -24.28            | -75.89           |
| <b>Health Problems in All Agricultural Sectors</b> |                                  |                    |                                                                                          |                   |                  |
| Acute Poisoning Cases<br>(in number of cases)      | 4,797                            | 19,837<br>314%     | -3,369                                                                                   | -6,741            | -21,331          |
| Chronic Poisoning Cases<br>(in number of cases)    | 16,533,202                       | 67,948,914<br>311% | -11,566,492                                                                              | -23,146,736       | -73,246,264      |
| Restricted Activity Days<br>(in number of days)    | 16,561,550                       | 68,066,050<br>311% | -11,586,420                                                                              | -23,186,600       | -73,372,290      |
| Health Cost                                        | 22.12                            | 56.14<br>154%      | -12.81                                                                                   | -25.59            | -80.45           |

Note: Let  $x_i$  be the variable of interest in column (1). The numbers in columns (3), (4), and (5) and in row  $x_i$  are defined as the total difference between  $x_i$  under each IPM Policy Scenario and  $x_i$  under the Base Scenario from 2001 until 2020. The percentages under the numbers are the total differences between  $x_i$  under each IPM Policy Scenario and  $x_i$  under the Base Scenario from 2001 until 2020 divided by  $x_i$  under the Base Scenario in 2000. A minus sign means the amount of reduction, not the absolute level.

### 5.3 Sensitivity Analysis of the IPM Scenario

In the IPM Scenario, this paper assumes that farmers who implement the IPM technique, with no additional labor costs, will be able to reduce the use of pesticides by 56% and to increase their yields by 10%, since they are able to implement superior pest management in their fields. As these assumptions will not always be achievable, a sensitivity analysis is needed.

Let us observe the results of the IPM Scenario if: (a) IPM farmers can reduce the use of pesticides by only 45%, which is 20% less than the targeted 56%; (b) IPM farmers' yields increase by only 8%, which is also 20% less than the assumption in the model; and (c) there is an additional 20% labor cost associated with implementing the IPM technique.

Table 4 shows the results of this sensitivity analysis. From the table, one can see that the 20% reduction in the yield (Column 2) does not have a significant effect on the overall results.

The 20% decrease in the reduction of pesticides used (Column 3), however, reduces the GDP gain by about half. Therefore, when IPM farmers are only able to reduce the use of pesticides by 45%, the total GDP gain over 20 years falls from Rp14 trillion to Rp6.8 trillion. Household incomes also fall by about half. However, it is interesting to observe that the number of health problems is about the same. Why is this so? The fact that IPM farmers are able to reduce their use of pesticides by 45% instead of 56% increases production costs (intermediate input costs) by about 20%. It is this change in input costs that causes a significant reduction in the income gains of agricultural households and other households in general.

Table 4 also shows that the 20% increase in labor costs (Column 4) reduces agricultural household incomes, except in the case of small-scale farmers. Higher agricultural labor costs also lead to higher prices for agricultural products. As consumers shift their demand to non-agricultural products, the increased production in non-agricultural sectors increases GDP and the incomes of non-agricultural households.

If we assume that labor costs rise by only 5% (column 5), all household incomes increase, although for agricultural households, the rate of increase is not as high as in the case where labor costs do not rise at all.

Observing columns (4), (5), and (1), one can conclude that the effect of the IPM program on the national economy and household incomes depends largely on the change in labor costs related to the program. If the increase in labor costs is relatively small, all households will benefit from the IPM program; if the increase is relatively large, most agricultural households will not receive any income benefits from the IPM program.

Table 4. Sensitivity Analysis of the IPM Scenario

| (in billions of rupiahs<br>except as mentioned) | Total Changes Associated with the IPM Scenario<br>(and as a percentage of 2000 condition) |                        |                        |                         |                        |
|-------------------------------------------------|-------------------------------------------------------------------------------------------|------------------------|------------------------|-------------------------|------------------------|
|                                                 | $\Delta$ yield = 10%                                                                      | $\Delta$ yield = 8%    | $\Delta$ yield = 10%   | $\Delta$ yield = 10%    | $\Delta$ yield = 10%   |
|                                                 | $\Delta$ ps.use = -56%                                                                    | $\Delta$ ps.use = -56% | $\Delta$ ps.use = -45% | $\Delta$ ps.use = -56%  | $\Delta$ ps.use = -56% |
|                                                 | $\Delta$ lab.cost = 0%                                                                    | $\Delta$ lab.cost = 0% | $\Delta$ lab.cost = 0% | $\Delta$ lab.cost = 20% | $\Delta$ lab.cost = 5% |
|                                                 | (1)                                                                                       | (2)                    | (3)                    | (4)                     | (5)                    |
| GDP                                             | 14,283<br>3.65%                                                                           | 14,286<br>3.65%        | 6,802<br>1.74%         | 18,984<br>4.85%         | 15,544<br>3.97%        |
| <b>Household Incomes</b>                        |                                                                                           |                        |                        |                         |                        |
| Ag. Employee                                    | 255<br>2.24%                                                                              | 250<br>2.20%           | 136<br>1.20%           | -75<br>-0.66%           | 173<br>1.52%           |
| Small Farmer                                    | 1,902<br>3.69%                                                                            | 1,888<br>3.66%         | 990<br>1.92%           | 1,210<br>2.35%          | 1,740<br>3.37%         |
| Medium Farmer                                   | 393<br>2.80%                                                                              | 387<br>2.76%           | 213<br>1.52%           | -40<br>-0.28%           | 286<br>2.04%           |
| Large Farmer                                    | 325<br>1.48%                                                                              | 314<br>1.43%           | 192<br>0.88%           | -611<br>-2.79%          | 91<br>0.41%            |
| Rural Low Income                                | 574<br>3.39%                                                                              | 572<br>3.37%           | 282<br>1.66%           | 754<br>4.45%            | 622<br>3.67%           |
| Rural Non-Labor                                 | 161<br>3.66%                                                                              | 161<br>3.65%           | 76<br>1.72%            | 261<br>5.93%            | 187<br>4.25%           |
| Rural High Income                               | 1,869<br>3.39%                                                                            | 1,862<br>3.38%         | 931<br>1.69%           | 2,406<br>4.37%          | 2,015<br>3.66%         |
| Urban Low Income                                | 1,098<br>3.79%                                                                            | 1,097<br>3.79%         | 517<br>1.79%           | 1,841<br>6.36%          | 1,291<br>4.46%         |
| Urban Non-Labor                                 | 357<br>4.63%                                                                              | 357<br>4.63%           | 171<br>2.22%           | 584<br>7.58%            | 416<br>5.40%           |
| Urban High Income                               | 2,905<br>3.60%                                                                            | 2,903<br>3.60%         | 1,386<br>1.72%         | 5,175<br>6.41%          | 3,491<br>4.32%         |
| <b>Health Problems in Rice Sector</b>           |                                                                                           |                        |                        |                         |                        |
| Acute Poisoning Cases<br>(in number of cases)   | -3,531                                                                                    | -3,547                 | -3,472                 | -4,778                  | -3,846                 |
| Chronic Poisoning Cases<br>(in number of cases) | -12,131,607                                                                               | -12,185,313            | -11,927,599            | -16,415,361             | -13,211,258            |
| Restricted Activity Days<br>(in number of days) | -12,152,484                                                                               | -12,206,253            | -11,948,109            | -16,443,595             | -13,233,981            |
| Health Cost                                     | -12.16                                                                                    | -12.22                 | -12.09                 | -15.99                  | -13.13                 |

Note that:

$\Delta$  yield = change in the amount of yield caused by better pest management

$\Delta$  ps.use = change in the amount of pesticides used

$\Delta$  lab.cost = changes in the labor cost

All are associated with the implementation of the IPM technique. See also the note under Table 3.

## 5.4 Double IPM Scenario

From Table 3, it can be seen that in the Double IPM Scenario, GDP increases at a higher rate than in the Base Scenario. The total GDP gain under the Double IPM Scenario for the next 20 years is Rp28 trillion, or 7.23% of GDP in 2000.

As in the IPM Scenario, the increase in incomes of urban households is higher than the increase in incomes of rural and agricultural households. One can conclude that urban households receive a higher benefit from the IPM program than do agricultural households. Note that the increased amount is relatively small, however. It does not significantly alter the more equal income distribution among households in Indonesia that is indicated by the Base Scenario.

Observing the GDP figures and household incomes under the IPM and Double IPM Scenarios, one might conclude that the more money the Indonesian government spends on the national IPM program, the higher the rate of increase in GDP and household incomes. However, GDP and household incomes actually increase at a decreasing rate.

It is interesting to see in Table 3 that this is not the case for the health effects of the IPM program. The reduction of acute and chronic pesticide poisoning cases under the Double IPM Scenario is more than double that of the IPM Scenario.

## **5.5 IPM Plus Pesticide Pricing Policy Scenario**

As mentioned previously, from 1991 until 1998 the main sources of funding for the national IPM program were foreign institutions. When foreign institutions stopped contributing, the program essentially came to a halt. The main goal of this scenario is to determine whether or not the Indonesian government should finance the national IPM program, by examining whether that would have a negative effect on the national economy. It does not, however, examine the issue of whether or not self-financing is better than receiving foreign loans. In this scenario, an increase in the tax on pesticides serves as the source of funding for the program.

From Table 3, it can be seen that the GDP gain in this scenario is Rp86 trillion, or 22% of total GDP in 2000. All household incomes are higher than those in the Base Scenario, and a very significant amount of health problems associated with pesticide poisoning are avoided. Therefore, one can conclude that self-financing the national IPM program, using pesticide tax revenues, has a positive impact on the Indonesian economy and farmers' health.

Although in this scenario urban households receive a higher benefit than do rural and agricultural households, Table 5 shows that a more equal income distribution is the most likely result over the next 20 years, as the incomes of agricultural households generally increase at a higher rate than those of urban and rural households.

Another result of this scenario is that, using the revenues from only a 5% increase on the tax on pesticides, the government can train more than 80% of rice farmers in IPM over the next 15 years (Figure 4).

Note, however, that when the additional government revenue from the increase in the tax on pesticides is not used for the IPM program, the results are different. Table 6, column (2), shows the results of a scenario in which the additional government revenue is used to fund new capital investments in other sectors. In this case, GDP for the next 20 years is the same as in the Base Scenario; i.e. the GDP gain is zero. Meanwhile, all household incomes are slightly lower and the health improvements are negligible. It is therefore crucial to use the tax revenue to finance the IPM program.

Table 5. GDP and Household Incomes Under the IPM Plus Pesticide Pricing Policy Scenario

| (in billions of rupiahs<br>except mentioned) | IPM plus<br>Pesticide Pricing Policy |                 |                 |                 |                 |                   |
|----------------------------------------------|--------------------------------------|-----------------|-----------------|-----------------|-----------------|-------------------|
|                                              | 1993<br>(1)                          | 2000<br>(2)     | 2005<br>(3)     | 2010<br>(4)     | 2015<br>(5)     | 2020<br>(6)       |
| GDP                                          | 329,776                              | 391,525<br>119% | 506,349<br>154% | 679,425<br>206% | 912,093<br>277% | 1,224,428<br>371% |
| <b>Household Incomes</b>                     |                                      |                 |                 |                 |                 |                   |
| Ag. Employee                                 | 9,499                                | 11,363<br>120%  | 15,473<br>163%  | 22,155<br>233%  | 31,978<br>337%  | 46,036<br>485%    |
| Small Farmer                                 | 40,940                               | 51,579<br>126%  | 74,072<br>181%  | 115,874<br>283% | 185,110<br>452% | 293,896<br>718%   |
| Medium Farmer                                | 11,138                               | 14,019<br>126%  | 19,969<br>179%  | 30,755<br>276%  | 48,104<br>432%  | 74,754<br>671%    |
| Large Farmer                                 | 18,083                               | 21,894<br>121%  | 29,264<br>162%  | 41,988<br>232%  | 61,152<br>338%  | 89,075<br>493%    |
| Rural Low Income                             | 14,314                               | 16,954<br>118%  | 21,126<br>148%  | 27,972<br>195%  | 37,418<br>261%  | 50,431<br>352%    |
| Rural Non-labor                              | 3,915                                | 4,408<br>113%   | 5,500<br>140%   | 7,047<br>180%   | 9,027<br>231%   | 11,563<br>295%    |
| Rural High Income                            | 45,643                               | 55,103<br>121%  | 68,113<br>149%  | 91,153<br>200%  | 124,201<br>272% | 171,381<br>375%   |
| Urban Low Income                             | 25,202                               | 28,959<br>115%  | 35,346<br>140%  | 44,677<br>177%  | 56,085<br>223%  | 70,108<br>278%    |
| Urban Non-labor                              | 6,455                                | 7,698<br>119%   | 9,982<br>155%   | 13,904<br>215%  | 19,842<br>307%  | 28,693<br>445%    |
| Urban High Income                            | 69,360                               | 80,712<br>116%  | 93,333<br>135%  | 111,304<br>160% | 128,467<br>185% | 143,578<br>207%   |

Note: The percentages show the differences between the levels of a certain variable in 2000, 2005, 2010, 2015, or 2020 and the level of the same variable in 1993.

Table 6. GDP and Household Incomes: IPM Plus Pesticide Pricing vs Pesticide Pricing-Only Scenario

| (in billions of rupiahs<br>except mentioned)    | IPM+Price        | Price Only     |
|-------------------------------------------------|------------------|----------------|
|                                                 | (1)              | (2)            |
| GDP                                             | 86,216<br>22.02% | 10<br>0.00%    |
| <b>Household Incomes</b>                        |                  |                |
| Ag. Employee                                    | 1,464<br>12.89%  | -33<br>-0.29%  |
| Small Farmer                                    | 11,287<br>21.88% | -8<br>-0.02%   |
| Medium Farmer                                   | 2,292<br>16.35%  | -13<br>-0.09%  |
| Large Farmer                                    | 1,812<br>8.28%   | -42<br>-0.19%  |
| Rural Low Income                                | 3,422<br>20.18%  | -41<br>-0.24%  |
| Rural Non-Labor                                 | 963<br>21.85%    | -16<br>-0.37%  |
| Rural High Income                               | 11,170<br>20.27% | -91<br>-0.17%  |
| Urban Low Income                                | 6,571<br>22.69%  | -99<br>-0.34%  |
| Urban Non-Labor                                 | 2,146<br>27.87%  | -14<br>-0.19%  |
| Urban High Income                               | 17,419<br>21.58% | -258<br>-0.32% |
| <b>Health Problems in Rice Sector</b>           |                  |                |
| Acute Poisoning Cases<br>(in number of cases)   | -22,324          | -16            |
| Chronic Poisoning Cases<br>(in number of cases) | -76,691,006      | -56,171        |
| Restricted Activity Days<br>(in number of days) | -76,822,890      | -56,268        |
| Health Cost                                     | -75.89           | -0.09          |

Please see the note under Table 3.

## 6.0 CONCLUSION

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

The major conclusions of this paper are as follows:

***The Indonesian government should resume its national IPM program soon.***

The IPM Scenario shows that implementing the national IPM program in 2001-20 increases GDP and all household incomes in Indonesia. The total GDP gain is equivalent to 3.65% of Indonesia's GDP in 2000, while the increase in household incomes is 1.5-4.8%. Among rice farmers, 3,600 and 12 million cases of pesticide-related acute and chronic health problems, respectively, can be avoided.

***The Indonesian government should increase the national IPM budget.***

The Double IPM Scenario indicates that doubling the budget for the national IPM program could produce higher economic and health benefits than under the standard IPM program. It is important to note that health benefits tend to increase at a greater rate as the IPM budget rises, while there is evidence that the economic benefits, as measured by GDP and household income, increase at a decreasing rate.

***If external funding to support the national IPM program is not available, the Indonesian government should self-finance the national IPM program.***

Under the IPM plus Pesticide Pricing Policy Scenario, it can be seen that self-financing the national IPM program using revenues from additional pesticide taxes results in higher GDP and household incomes than not having the program at all. Furthermore, the revenue from only a 5% increase in the tax on pesticides is enough to train more than 80% of rice farmers in the IPM technique over the next 20 years. The impact of more than 80% of rice farmers practicing the IPM technique over that time period are: (1) the avoidance of 23,000 and 79 million cases of acute and chronic pesticide poisoning, respectively, among rice farmers; (2) a total GDP gain equivalent to 22% of Indonesia's GDP in 2000; (3) household income gains of 8-28%.



***In implementing the national IPM program, it is important that farmers: (1) incur the same or only slightly higher labor costs; (2) decrease their use of pesticides by more than 50%.***

The sensitivity analysis of this research shows that, if labor costs rise by 5% or less, the implementation of IPM will benefit all households, including agricultural households. If labor costs increase by more than 5%, it is not clear whether agricultural households will benefit from the program in monetary terms. If labor costs increase by 20% or more, agricultural household incomes will not benefit from the program—in fact, their incomes under the IPM Scenario will be lower than under the No-IPM Scenario or the Base Scenario. Similarly, it is important for IPM farmers to reduce their pesticide use by more than 50%. A reduction of less than 50% will significantly cut the benefits that farmers, and others, would receive.

## REFERENCES

- Achmadi, U.F. "Agricultural Injuries in Indonesia: Estimates and Surveys." Department of Public Health Working Paper, University of Indonesia, Jakarta, 1991.
- Antle, J.M. and P.L. Pingali. "Pesticides, Productivity, and Farmer Health: A Philippine Case Study." *American Journal of Agricultural Economics*, 76 (August 1994): 418-430.
- Central Bureau of Statistics. Statistical Yearbook of Indonesia 1993 Jakarta: Central Bureau of Statistics, 1994.
- Chambers, R.G. and E. Lichtenberg. "Simple Econometrics of Pesticide Productivity." *American Journal of Agricultural Economics*, 76 (August 1994): 407-417.
- IPM National Program Monitoring and Evaluation Team. The Impact of IPM Training on Farmers' Behavior: A Summary of Results from the Second Field School Cycle. Jakarta: BAPPENAS, 1993.
- Lewis, J.D. "A Computable General Equilibrium (CGE) Model of Indonesia." Development Discussion Papers, Harvard Institute for International Development, Cambridge, 1991.
- Lichtenberg, E. and D. Zilberman. "The Econometrics of Damage Control: Why Specification Matters." *American Journal of Agricultural Economics*, 70 (May 1986): 261-273.
- Lichtenberg, E., D. Parker, and D. Zilberman. "Marginal Analysis of Welfare Costs of Environmental Policies: The Case of Pesticide Regulation." *American Journal of Agricultural Economics*, 70 (November 1988): 866-874.
- Oka, I.N. "Success and Challenges of the Indonesian National Integrated Pest Management Program in the Rice-based Cropping System." *Crop Protection*, 10 (3 1991): 163-65.
- . "Integrated Crop Pest Management With Farmer Participation in Indonesia." Working Papers, Food Crop Research Center, Bogor, 1995.
- Pimentel, D., H. Acquay, M. Biltonen, P. Rice, M. Silva, J. Nelson, V. Lipner, S. Giordano, A. Horowitz, and M. D'AMore. "Environmental and Economic Costs of Pesticide Use." *BioScience*, 42 (November 1992): 750-60.

- Pingali, P.L., C.B. Marquez, and F.G. Palis. "Pesticides and Philippine Rice Farmer Health: A Medical and Economic Analysis." *American Journal of Agricultural Economics*, 76 (August 1994); 587-592.
- Resosudarmo, B.P. "The Impact of Environmental Policies on a Developing Economy: An Application to Indonesia." Unpublished Dissertation, Cornell University, 1996.
- Rola, A.C. and P.L. Pingali. *Pesticides and Rice Productivity: An Economic Assessment for the Philippines*. Los Banos-Laguna: IRRI Publication, 1992.
- SEARCA. *Integrated Pest Management Program Training Project: Impact Evaluation Study*. Internal Report for Indonesian Ministry of Agriculture and the World Bank, 1999.
- Thorbecke, E. "A Computable General Equilibrium Model Integrating Real and Financial Transactions." *Adjustment and Equity in Indonesia*. E. Thorbecke et al., pp. 85-102. Paris: OECD Publications, 1992.
- Zilberman, D., A. Schmitz, G. Casterline, E. Lichtenberg, and J.B Siebert. "The Economics of Pesticide Use and Regulation." *Science*, 263 (August 1991): 518-522.