Philippine Institute for Development Studies

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Danilo C. Israel

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For comments, suggestions or further inquiries please contact:
The Research Information Staff, Philippine Institute for Development Studies
3rd Floor, NEDA sa Makati Building, 106 Amorsolo Street, Legaspi Village, Makati City, Philippines
Tel Nos: 8924059 and 8935705; Fax No: 8939589; E-mail: publications@pidsnet.pids.gov.ph
Or visit our website at http://www.pids.gov.ph

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REVIEW OF MACROECONOMIC MODELS AND MICROECONOMIC VALUATION METHODS APPLIED IN THE NATURAL RESOURCES AND ENVIRONMENT SECTOR*

by Danilo C. Israel**

I. Introduction

1.1 Background

The growing consensus that sustainable development[1] is the preferable development path for countries to pursue has brought centerstage attention to a traditionally secondary sector in economic research, the natural resources and environment. In developed countries, empirical works attempting to measure the two major sectoral problems related to sustainable development, i.e. natural resource depletion and environmental degradation, have mushroomed (e.g. Hoagland and Stavins 1992). These studies include those using macroeconomic models and microeconomic valuation methods which incorporate natural resource and environmental variables in the analysis. In developing countries, on the other hand, interest in natural resource and environmental economic analysis has grown also, although, with the general research lag in these countries, empirical studies done have been understandably few so far.

The major factors which hinder natural resource and environmental economic research in developing countries, in general, and the application of macroeconomic models and microeconomic valuation methods, in particular, are limitations in qualified research personnel and available data. In the Philippines, for instance, few economists are working in the natural resource and environment field. In addition, available data from government and other sources fall grossly short of what are required for resource and environmental analysis, especifically where models and valuation methods are involved.

With the rising popularity of the sustainable development concept, however, research expertise is expected to improve in the future. Already, Philippine economists have started to participate in workshops and trainings in natural resource and environmental economics and policy analysis abroad. At home, the Department of Environment and Natural Resources (DENR) commenced recently an annual workshop to train personnel on microeconomic valuation methods and policy analysis. In addition, more and more economists from traditional fields of research have shown keen interest in natural resource and environmental economics. With these encouraging developments, it is foreseen that the number of competent researchers doing natural

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**Research Fellow, Philippine Institute for Development Studies.

[1]Since its inception, the term "sustainanble development" has been defined in many ways. A general acceptable definition was given by WCED (1987), which describes sustainable development as "development that meets the needs of present generations without compromising the ability of future generations to meet their own needs."

research have shown keen interest in natural resource and environmental economics. With these encouraging developments, it is foreseen that the number of competent researchers doing natural resource and environmental economics research will eventually proliferate.

It is expected that the quality and quantity of data useful for natural resource and environmental economic analysis will improve also. In recent years, a number of research activities which generate data potentially useful for macroeconomic modeling have been going on. Foremost among these research activities are the Environmental and Natural Resource Accounting Project (ENRAP) and the Industrial Efficiency and Pollution Program and Environmental Management Strategy Project. Reports from these projects containing industry level quantitative data on resource depletion and environmental degradation are now available (see Angeles, 1994; Angeles, Peskin and Bennagen 1994 and World Bank 1992). These and other similar projects, now and in the near futur, should help alleviate the problem of availability of natural resource and environmental data.

1.2 The Microeconomic Impacts of Macroeconomic Adjustment Policies (MIMAP) Project

Currently, an important research project going on in the Philippines is the MIMAP project. The main objective of this project is to evaluate the effects of macroeconomic adjustment policies on the welfare of households, with emphasis on the poor (see Lamberte et al. 1991). This project was born out of the concern that although adjustment policies are primarily aimed at attaining macroeconomic objectives, they can cause negative and significant impacts on the well-being of households. The MIMAP project hopes that an empirical analysis of these unwanted welfare impacts, which was not done before, would be useful in the search for effective safety nets and other measures that mitigate the diminution in welfare, especially among the households who suffer the most.

Among the economic sectors considered by the MIMAP project as important to the analysis of the welfare impacts of macroeconomic adjustment policies is the natural resources and environment. The sector is judged critical because the Philippine economy is highly dependent on its natural resource base and many of its industries are highly polluting. Compounding this situation, a large portion of the poor of the country also rely on its natural resources for survival and are directly exposed to the polluted environment.

1.3 The Francisco and Sajise MIMAP Paper

A conceptual framework for the evaluation of the impacts of macroeconomic adjustment policies on the natural resources and environment sector was already constructed by Francisco and Sajise (1992), under the second phase of the MIMAP project. Francisco and Sajise argued that policies affect the rate of resource depletion and environmental degradation primarily by affecting input prices and output prices faced by industries which employ resource and environmental assets in their production processes. In general, policies which lower the prices of inputs tend to promote resource and environmental deterioration as the decreasing costs of

production induced by lower input prices encourage industries to raise production and exploit the resources and environment more intensively. On the other hand, policies that lower output prices tend to slow resource and environmental exploitation since the lower revenues induced by the falling output prices force industries to produce less and also exploit the resources and environment less intensively.

Francisco and Sajise pointed out that specific macroeconomic adjustment policies happen to have clearer implications than other policies on the rate of exploitation of the natural resources and the environment sector. Export duties, for instance, will likely reduce the rate of exploitation by increasing costs of firms in the exportation of resource-based commodities. Export incentives, on the other hand, will likely increase the rate of exploitation as these will lower the costs of exportation and, thus, promote the production and export of resource-based commodities.

Some microeconomic adjustment policies, however, could have uncertain impacts of the rate of natural resource and environmental exploitation. The policy of devaluation, for example, can be viewed both as a resource and environmentally adverse and friendly policy. This is because on the one hand, a devaluation results in the cheapening of the international prices of locally produced resource-based goods which encourages exports, production and the exploitation of the natural resources and environment. On the other hand, devaluation also may make expensive the importation of capital-intensive machineries and technologies necessary for the production of resource-based goods. This will have a dampening effect on production and resource and environmental exploitation.

As regard the welfare impacts of macroeconomic adjustment policies, Francisco and Sajise stated that while sectoral policy implications can be analyzed based on the linkage between policies, input and output prices, production and resource and enviromental exploitation, measuring the effects of policies on the well-being of households may be a difficult task (Ibid pp. 64-5). Among the reasons why this is so is that predicting household response to policies will be hard to conduct given that different households have varying coping mechanisms to the effects of policies and the data needed for analyzing these coping mechanisms are presently unavailable. Another reason is that evaluating both the short and long-run welfare impacts of policies is cumbersome to do given the little available information on the behavioral and decision-making patterns of households over time.

While there are problems associated to welfare measurement, Francisco and Sajise proposed the quantification of the value of the welfare effects of macroeconomic adjustment policies to assist decision makers develop the right compensatory programs and safety nets for those disadvantaged by policies. They further suggested that to surmount the problems, data must be collected. These must include longitudinal and sector-disaggregated data useful for the measurement of the sectoral effects of policies over a period and longitudinal, resource-based and disaggregated data useful for evaluating welfare changes over time. A project designed for the collection of data was proposed by Francisco and Sajise (Ibid p. 85-8).

1.4 Objectives of the Paper

In general, the empirical measurement of both the magnitude and direction of the effects of macroeconomic adjustment policies on the welfare of households is an area of research that has not received attention in the economic literature. In contrast, the impacts of policies on the natural resources and environment sector has been investigated already. In the Philippines, the studies which evaluated the sectoral impacts of policies either depended on descriptive statistics (HKL and Associates Ltd. 1992), is still in the preliminary stage of model development (Mendoza 1994), or has already employed in a substantial way macroeconomic modeling (Cruz and Repetto 1992).

The present development of research, then, clearly indicates the need for the identification of analytical approaches with which impacts of policies can be evaluated not only at the sectoral level but right down to the household level. This is a necessary first step toward the eventual measurement of the impacts of policies in terms of resource depletion and environmental degradation as well as household welfare.

The general objective of the paper is to review the different macroeconomic models and microeconomic valuation methods applied in the analysis of the natural resource and environment sector which are potentially useful for MIMAP. The end purpose of the review is to develop approaches which can be potentially used for analyzing the sectoral and welfare impacts of policies. A corollary purpose of the paper is to pinpoint possible areas for natural resource and environmental research in the future specifically those related to the activities of the MIMAP project.

The specific objectives of the paper are to:

a) review the empirically applied macroeconomic models and microeconomic valuation methods potentially useful for measuring sectoral and welfare impacts of macroeconomic adjustment policies;

b) review the empirical works, with emphasis on those done for the Philippines, applying any of the discussed models and valuation methods;

c) identify analytical approaches which may be useful for the MIMAP project; and

d) identify areas for research in the natural resource and environment sector, specifically in relation to the MIMAP project.

The rationale for covering macroeconomic models in the review is apparent from the popularity of macroeconomic modeling as a tool for analyzing the sectoral impacts of macroeconomic policies. For the purposes of MIMAP, macroeconomic models are potentially useful in quantifying the effects of policies in terms of natural resource depletion and

environmental degradation.

Microeconomic valuation methods, on the other hand, are also reviewed in the paper because they are potentially useful for the quantification of the effects on policies on household welfare, after the sectoral impacts of policies are known from the use of macroeconomic models.

Due to the inaccessibility of some literature sources and shortness of time, the paper is not a comprehensive review of all macroeconomic models and microeconomic valuation methods employed in empirical research. Furthermore, not all the relevant empirical studies may be covered. The models and methods reviewed, however, are all potentially useful for MIMAP purposes. Moreover, the paper is a continuing effort and the future inclusion of other relevant models and methods presently not included is a welcome possibility.

1.5 Organization of the Paper

The succeeding sections of the paper are organized as follows. Section II reviews the macroeconomic models and empirical research in the Philippines using the models. Section III discusses the microeconomic valuation methods and empirical research applying the methods. Section 4 traces the potential effects of macroeconomic adjustment policies and discusses the different approaches which may be useful for empirically measuring these effects. Section V discusses the future research areas in the natural resource and environment sector, specifically in relation to the MIMAP project. Lastly, section VI provides the summary and conclusions.

II. Macroeconomic Models

In this paper, macroeconomic models are defined as models useful for analyzing the whole economy. The macroeconomic models reviewed here are input-output (I-O) models, programming models, computable general equilibrium (CGE) models, econometric models and other models. Discussions of some of these models can be found in Dervis et al. (1982), Hufschmidt et al. (1983), Hafkamp (1984), Miller and Blair (1985), and Braat and Van Lierop (1987), and Bojo et al. (1992).

For brevity, unless otherwise stated, the acronym "NRE" is used in the paper to stand for natural resources, the environment or both. The term "NRE damage" means natural resource depletion or environmental degradation or both. The term "good" also mean "service" and "sector" also imply "industry".

2.1 Input-Output Models

An I-O model is an analytical tool employed for analyzing the interdependence of the different sectors in an economy. The model was originally developed by Wassily Leontief (1936).

2.1.1 Basic Static Input-Output Model

The basic static I-O model shows the flow of goods between the producing sectors in the economy within a period of time, usually a year. The basic I-O model is expressed mathematically as

$$X = (I - A)^{-1}D \qquad (1)$$

and

$$\Delta X = (I - A)^{-1} \Delta D \qquad (2)$$

where I is an n by n identity matrix, A is an n by n matrix of technical coefficients, X is an n by 1 vector of the total outputs of the producing sectors, Y is an n by 1 vector of the final demands for the total outputs of the producing sectors, $(I - A)^{-1}$ is the Leontief inverse matrix and Δ means change. Through equation (1), the outputs of the sectors, X, can be estimated given values of the final demand for the outputs of the sectors, D. Also, change in output due to some change in demand can be measured using equation (2).

2.1.2 Generalized Input-Output Model

The static I-O model given in equations (1) and (2) can be utilized to analyze the magnitude of NRE damage caused by producing sectors with only a few modifications. For instance, if the actual cost of damage caused by each sector is known, then we can have the following expression

$$w_{kj} = v_{kj} / X_j \qquad (3)$$

where v_{kj} is the total value of the type of damage, k, attributable to sector j and w_{kj} is the damage coefficient which measures the level of k per peso worth of output of sector j. Letting W as the matrix of these coefficients and then incorporating it to the basic I-O model gives us the generalized I-O model

$$W^* = [\ W\ (I-A)^{-1}\ ]\ D \qquad (4)$$

and

$$\Delta W^* = [\ W\ (I-A)^{-1}\ ]\ \Delta D \qquad (5)$$

where W^* is the vector of the damage levels directly and indirectly generated by the producing sectors in meeting final demand, D, and the other variables are defined as before.

To analyze the effects of macroeconomic adjustment policies on the levels of NRE damage using the generalized I-O model, policies are assumed to exogenously effect a change in the level of the final demand D. Changes in the levels of NRE damage, due to specific policies, can then be computed directly using equation (5).

Although the generalized I-O model appears straightforward to use, the main bottleneck to its application is the unavailability of data for measuring the v_{kj}s, the value of the NRE damage caused by each sector in the economy.

2.1.3 Endogenized Household Sector Model

In addition to its usefulness for evaluating the impacts of policies in term of the NRE damage caused by producing sectors, the I-O framework can be employed to analyze policy impacts in term of the NRE damage caused by households.

To trace policy-induced and household-caused NRE damage using the I-O model, it is reformulated to have an endogenized household sector. This is done by transforming the household sector from a final demand sector into producing sector n+1 in the model. With the addition of one more intermediate sector, a revised technical coefficient matrix is then computed which now include technical coefficients for the household sector.

There are strong reasons for endogenizing the household sector in the I-O model for purposes of analyzing NRE impacts of policies. Households, in general, generate substantial pollution in the form of solid and other household wastes. Therefore, households are an integral sector in the evaluation of NRE damage. Moreover, a large proportion of poor households, such as those residing in upland and coastal areas, are highly dependent on natural resources for their livelihood and survival. Hence, the activities of these households have important bearings on the NRE sector which must be explicitly considered in the analysis of sectoral policy impacts.

2.1.4 Economic-Ecologic Model

Another method of incorporating NRE variables into the I-O framework is by using an economic-ecologic model. This type of model is based on the notion that since some production processes employ as inputs or produce as outputs NRE goods, these goods must be explicitly accounted for in the analysis (see Miller and Blair 1985, p. 252).

The basic economic-ecologic I-O model is composed of four subsystems defined as follows (Figure 1):

II = is the economic sector to economic sector matrix and ii_{ij} shows the flows from economic sector i to economic sector j;

IE = is the economic sector to ecologic sector matrix and ie_{ik} shows the flows from economic sector i to ecologic sector k;

EI = is the ecologic sector to economic sector matrix and ei_{lj} shows the flows from ecologic sector l to economic sector j; and

Figure 1. Basic Structure of Economic–Ecologic Models

	Economic Sector	*Ecologic Sector*
Economic Sector	II	IE
Ecologic Sector	EI	EE

Source: Miller and Blair (1985).

EE = is the ecologic sector to ecologic sector matrix and ee_{lk} shows the flows from ecologic sector l to ecologic sector k.

The economic sectors in the model are the same as those in the basic I-O model. The ecologic sectors, on the other hand, include NRE processes which are employed as inputs or generated as outputs of the whole system.

The procedure to be followed for evaluating the NRE effects of macroeconomic policies using economic-ecologic model may follow that for the basic static I-O model. Policies may be assumed as exogenously changing the levels of final demand. The impacts of the change in final demand influences production of the different economic and ecologic sectors in the model.

An major shortcoming of the economic-ecologic model is that it allows the secondary production of ecological outputs by sectors. This violates the assumption of single-product sectors of the basic static I-O model. Another limitation is that its data requirement, specifically for submatrices IE, EI and EE, are more immense than that of the generalized I-O model.

2.1.5 Commodity-by-Sector Model

To circumvent the problem imposed by one-product sectors in the basic I-O model, a commodity-by-sector model can be employed instead. Basically, this model is composed of economic and ecologic subsystems similar to those of the economic-ecologic model (Figure 2). However, the economic and ecologic subsystems in the commodity-by-sector model are allowed to use as inputs or produce as outputs several commodities.

Following the notation by Miller and Blair (p. 255), the economic subsystem of the commodity-by-sector model is as follows:

U = the m x n economic "use" matrix for n sectors and m commodities and u_{ij} represents the amount of economic commodity i used by sector j.

V = the n x m economic "make" matrix and v_{ij} represents the amount of economic commodity i produced by sector j.

E = the m x 1 vector of economic commodity final demands and E_i is the final demand for commodity i;

Q = the m x 1 vector of economic commodity gross outputs and Q_i is the total production of commodity i;

W = the 1 x n vector of sector value-added inputs and W_j represents the total of value-added inputs to sector j; and

R = the n x 1 vector of sector total outputs and X_j represents the total output of sector j.

Figure 2. Limited Commodity–By–Industry Economic–Ecologic Model

	Economic Subsystem				Ecosystem
	Commodities	Industries	Final Demand	Total Output	Ecologic Commodities
Commodities		U	E	Q	R
Industries	V			X	S
Value Added		W	GNP		
Total Output	Q'	X'			
Ecologic Commodities	P	T			

Source: Miller and Blair (1985).

The ecologic subsystem of the commodity-by-sector model is as follows:

R = the m x l matrix of economic commodity by ecologic commodity outputs for l ecologic commodities and r_{ik} is the amount of ecologic commodity k discharged as a result of production of economic commodity i;

S = the n x l matrix of sector by ecologic commodity outputs and s_{jk} is the amount of ecologic commodity k discharged by sector j;

P = the l x m matrix of ecologic commodity by economic commodity inputs and p_{ki} is the amount of ecologic commodity k used in the production of economic commodity i; and

T = the l x n matrix of ecologic commodity by sector inputs and t_{kj} is the amount of ecologic commodity k used by sector j.

From the above, the following expressions can be derived:

$$B = U(X'')^{-1} \qquad (6)$$

and

$$C = V'(X'')^{-1} \qquad (7)$$

where X'' is an n x n diagonal matrix, V' is the transpose of V, B is an m x n matrix of economic commodity-by-sector direct requirements, b_{ij} is the amount of economic commodity i required per dollar's worth of output of sector j; C is the m x n matrix of sector output proportions and c_{ij} is the fraction of j's output that is distributed as commodity i.

With the inclusion of ecologic commodities in the model, the following can be derived also:

$$F = S'(X'')^{-1} \qquad (8)$$

and

$$G = T(X'')^{-1} \qquad (9)$$

where F is the l x n matrix of ecologic commodity output coefficients and the term $f_{kj} = s_{kj} / X$ is the amount of ecologic commodity k discharged per dollar's worth of sector j's output; S' is the transpose of S; G is the l x n matrix of ecologic commodity input coefficients and the term $g_{kj} = t_{kj} / X_j$ is the amount of ecologic commodity k used in the production of a dollar's worth of sector j's output.

The evaluation of the impacts of policies using the comodity-by-sector model may again follow the procedure for the basic and and economic-ecologic models I-O. Policies are assumed to have an exogenous influence final demand, E, which in turn determines the levels of the other variables in the system.

The provision of many economic and ecologic commodities in the commodity-by-sector model make the data requirement of the model even more immense than those of the Basic and economic-ecologic models. It follows that the model is also more difficult to apply empirically.

2.1.6 The Basic Dynamic Input-Output Model

So far, the I-O models reviewed above are static or point in time models. Being so, they are deficient because they disregard the behavior of variables over time.

The dynamic I-O model addresses the issue of time in the I-O framework. Because there are so many kinds of dynamic I-O models, only the basic model will be summarized below.

Basically, the dynamic I-O model assumes that some inputs in the production process are not used up in a single year but serves as capital stock for use in future years. Skipping mathematical derivations, the basic dynamic I-O model is a revision of the basic static I-O model given in equation (1) as follows

$$(I - A + B)\, X^t - B\, X^{t+1} = D_t \qquad (10)$$

or

$$B\, X^{t+1} = (I - A + B)\, X^t - D^t \qquad (11)$$

where B is an n by n capital stock coefficients matrix and the b_{ij}s are the amount of the output of a sector reserved as capital stock by another sector per peso worth of output of that sector and the superscript indicate years.

The basic dynamic I-O model or any of its more complicated variations, however, has not been widely applied in developing countries, primarily because the data requirements for measuring the capital stocks coefficients, B, are even more severe than those needed for setting-up the technical coefficients, A.

2.1.7 Empirical Studies Using Input-Output Models

Empirical studies using I-O models are already numerous in developed countries. A partial listing of I-O studies applied on the NRE sector can be found in Hufschmidt et al. (1983, p. 298-9). This review, however, encountered no foreign study which employs the I-O framework to analyze the sectoral and welfare impacts of macroeconomic adjustment policies.

The only local application of the I-O model in the analysis of the NRE impacts of economic policies was Mendoza (1994), a study done for phase II of the ENRAP project. The model used by the Mendoza study was a generalized static model with an endogenized household sector.

The Mendoza study used as basic source of data an 11-sector version of the 1988 I-O table, the latest available I-O table for the Philippines. This basic table was modified and extended to endogenize the household sector and cover NRE damage variables of concern. The source of data for the NRE damge variables was ENRAP.

In modifying the I-O model, the Mendoza study endogenized the household sector by making it the twelveth intermediate sector in the model, with the row containing employees compensation and the column representing household consumption expenditure, measured as a constant proportion of personal consumption expenditure. The non-marketed, resource-based household production was incorporated into the model by adjusting the columns and rows of the relevant resource sectors, agriculture and forestry. On the input side, the value of household production was inputed as labor income while on the output side, the vaue of production was taken as additions to gross outputs. As to the other NRE variables, the model considered the different NRE damages as negative adjustments and direct nature services as additions to the total outputs of relevant sectors.

The Mendoza study studied the NRE impacts of economic policies by taking the standard assumption that policies exogenously affect sectoral demand which, in turn, influence sectoral output, employment and NRE damage. Following the generalized I-O framework, multipliers for sectoral output and income were computed to quantify the output and income effects of policies. Moreover, NRE multipliers were measured to evaluate damage impacts of policies. The NRE variables considered include natural resource depreciation, environmental waste disposal services, enviromental damages and residuals or pollutants measured in specific units (see ibid p. 5).

The Mendoza study simulated economic policies which increase exports, investment and final demand for the energy and resource-based sectors and for the non-resource sectors manufacturing and construction. Although results of the study were preliminary (A new version of the paper is expected soon), they provided some general insights into the relationships between economic policies, sectoral output, NRE damage and households. For instance, results indicated that specific economic policies tend to promote specific sectors and, thus, the level of NRE damage induced by policies also depend to a large extent on the polluting capabilities of these sectors. Also, results suggested that households were an important sector in the evaluation of NRE damage, as endogenizing households in the I-O model highlighted the relative importance between the different forms of NRE damage, i.e. water vs. air pollution, in the analysis.

Aside from the general findings, the Mendoza study generated some sectoral results of interest. For instance, it found that the forestry and fishery sectors had the highest natural

resource depreciation multipliers and the lowest output multipliers among the sectors, implying that continuous exploitation of forestry and fishery resources will only bring about slow growth in exchange for a more rapid NRE damage. The study also found that the agriculture sector had the highest labor income multiplier, suggesting that it must be vigorously promoted if the goal of economic policy is to raise labor income and employment.

In conclusion, the Mendoza study acknowledged that its findings must be taken with caution since the inherent limitations of the static I-O model make it inappropriate for an analysis running projections for a period of time. The study suggested that to address time-related problems, a dynamic I-O model with an updated I-O table may be used in future analysis. If not, larger and more sophisticated models, such as computable general equilibrium models, may be tried.

2.1.5 Limitations of Input-Output Models

As already mentioned, a limiting factor to the utilization of I-O models is the unavailability of complete and reliable data on the levels of NRE damage caused by the different sectors of the economy. Aside from data problems, there are limitations inherent to I-O analysis. Among the more important ones is that the model assumes fixed technical coefficients which may not be appropriate in several cases. The assumption ignores the possibility of input substitution in the production process, a likely occurence when sectors expand production.

The usefulness I-O models is further hindered by another important limitation. Although developing countries, including the Philippines, have national input-output tables, these tables were based on data from years back. Employing I-O models, then, will require not only preparatory microeconomic work in the valuation of NRE damage but also the updating of the I-O tables. The alternative is to employ the old I-O tables which may reflect technologies which are already outdated.

The Mendoza study, however, demonstrated that even with the abovecited limitations, the I-O framework can be used to evaluate, albeit preliminarily, the NRE implications of economic policies. The application of the model by Mendoza can be taken as a positive exploratory step in the development of appropriate models for the analysis of NRE impacts of macroeconomic policies.

2.2 Programming Models

Programming models are another type of models which can be employed to analyze interactions between the traditional sectors of the economy and the NRE sector. There are basically three kinds of programming models already used for the purpose: linear programming (LP) models, mixed-integer linear programming models and non-linear programming models. The LP model is reviewed below. Due to the unavailability of sufficient materials, mixed-integer and non-linear programming models are not reviewed.

2.2.1 Linear Programming Model

The basic LP maximization model is of the form

Maximize: $P'X$

subject to:

$$BX \leq C \qquad (12)$$

$$X \geq 0$$

where P is an n by 1 vector of prices or weights in the objective function; X is an n by 1 vector of sectors or activities; B is an m by n matrix whose element b_{ij} gives the input requirement of the i-th resource per unit of the j-th sector and the C is an m by 1 vector of available resource inputs.

The dual of the above primal maximization problem is

Minimize: $C'W$

Subject to:

$$B'W \geq P \qquad (13)$$

$$W \geq 0$$

where the W is an m by 1 vector of shadow prices and the rest of the variables are defined as before. The primal maximizes the objective function subject to maximum limitations in resources while the dual minimizes the objective function subject to minimum limitations in output prices or weights. When applied to the same problem, the primal and the dual results to the same set of optimal solutions.

2.2.1.1 The Damage Cost Method

A way of incorporating NRE damage in the LP model is by accounting for the actual value of the damage per output and by sector and then subtracting this amount, also by sector, from the maximized objective function. Assuming that this accounting is possible, the objective function in the maximization model is transformed into

Maximize: $(P'-M')X \qquad (14)$

where M is an n by 1 vector of the monetary values of the natural resource or environmental damage per unit of output of the sectors and the rest of the equations are as shown in equation (11). For the dual minimization problem, the constraint equations will be modified into

$$B'W \geq P\text{-}M \qquad (15)$$

where the rest of the equations are the same as in equation (12).

The procedure for tracing relationships between economic policies, sectoral output and NRE damage employing the damage cost method, or any programming model, has not been discussed in the literature. A potential approach may be to assume that economic policies infuence the levels of prices in the model which in turn affect the level of sectoral production and NRE damage. Still another approach may be to assume that policies independently constrain demand in such a way that the sectoral outputs are also limited to specific levels. This implies that in the model, new constraints will be added that state these output limitations.

2.2.1.2 Damage Standards Method

If damage standards are set at some maximum level at the same time, the damage standards method may be used in combination with the damage cost method. Assuming, for instance, that the maximum total pollution level per year from a particular pollutant is set at, S^*, the following constraint equation is added to the linear maximization or minimization programming problem

$$S'X \leq S_* \qquad (16)$$

where S is an n by 1 vector of the amounts of the pollutant discharged per unit of output produced by each sector.

2.2.1.3 Alternative Abatement Method

Another LP method, which is more appropriate for application at the intra-sectoral level instead of the inter-sectoral level, is the alternative abatement method. This method can be used when a sector has a choice between available techniques for abating NRE damage in the production process.

For a simplified explanation of the alternative abatement method, we assume a single output of a sector which is also fixed at a certain level, a single and unrestricted input of the same sector, two available abatement technologies, and a single type of pollutant controlled at a maximum level. The minimization problem can then be set-up as

minimize $\quad v_1 t_1 + v_2 t_2$

subject to

$$\begin{aligned} & f_1 t_1 + f_2 t_2 \leq 1 \\ & t_1 + t_2 = q \\ & t_1 , t_2 \geq 0 \end{aligned} \qquad (17)$$

where t_1 and t_2 are the levels of output using the two available abatement technologies; v_1 and v_2 are the cost per unit of output using available abatement technologies; f_1 and f_2 are the discharge of pollutant per unit of output using the abatement technologies; q is the amount of the output that must be produced; and l is the maximum allowed emission level of pollutant.

2.2.2 Mixed Integer and Non-Linear Programming Models

A possible result of the alternative abatement method above is getting optimal solutions that requires the use of two or more abatement technologies. In reality, this can be impractical since actually only one technology may be chosen by the sector concerned. To address this problem, a mixed integer programming model, which allows optimal solutions that require the use of only a single technology may be used instead. An example of the use of this technique is Burton and Sanjour (1970) which was cited in Hufschmidt, et al 1983).

Finally, aside from the basic linear and mixed-integer models, non-linear programming models may be used to analyze economy and environment interactions. The non-linear models have nonlinear objective functions and/or constraints which allow substitution of inputs and nonlinearities in the relationship between input and output.

2.2.3 Empirical Studies Using Linear Programming Models

Programming has been quite applied in the analysis of specific concerns in the NRE sector with LP as the most accepted technique (Hufschmidt et al. 1983, p. 301). Among the foreign works with programming applications cited by Hufschmidt et al. are Russell (1973), Bower (1975), Kohn (1975) and Meister et al. (1976).

In the Philippines, programming, has not been used to analyze the sectoral impacts of macroeconomic adjustment policies. It has been utilized, however, to address issues at the subsectoral level. For the Forestry subsector, for instance, Balangue (1979) used goal programming to study different land-use management objectives and strategies given technical, economic, resource and environmental constraints. The results of Balangue suggested the usefulness of programming as an analytical tool for decision-making related to multi-objective and multi-dimensional resource allocation problems in integrated-use forestry.

2.2.4 Limitations of Linear Programming Models

The limitations of linear programming models in the analysis of interactions between the economy and the NRE sector are similar to the constraints of I-O models. Generally, linear programming models also require enormous economic and NRE data which may not be fully available yet, especially in developing countries.

Aside from the problem of data, the linear programming model has inherent weaknesses. Among these are that like the I-O model, linear programming does not tolerate substitution of inputs and economies of scale. In addition, the model requires that the number of variables in

the final solution cannot exceed the number of constraints. In some cases, this will force the inclusion of arbitrary and unnecessary constraints into a model that has many sectors.

2.3 Computable General Equilibrium Models

Other than the limitations already mentioned, I-O models and LP models are constrained because they emphasize on the producing sectors only. More sophisticated models have been developed which also emphasize on the other economic sectors as well as consider the input substituting possibilities of production and endogenous nature of product and factor prices. Among these models are the Computable General Equilibrium (CGE) models.

A review of CGE models is currently underway under the third phase of the MIMAP project (see Cororaton 1994). Thus, a discussion of the details of the CGE model will not be done here. Instead, a brief summary is presented. Theoretical discussions of the CGE model can also be found in Dervis et al. (1982).

2.3.1 The Core CGE Model

CGE models usually depend on the Social Accounting Matrix (SAM) for national income and input-output data. Also, generally, CGE models are based on competitive equilibrium assumptions where the individual consumer maximizes utility subject to some budget constraint, the individual firm maximizes profits and product and factor prices adjust to clear markets.

A core or basic CGE model covers the institutional sectors including government and households, factors of production labor and capital, producing sectors, capital accounts and foreign trade. Government spending is usually assumed as exogenously determined while household expenditures are explained by using econometrically estimated systems of demand functions. Factor payments are modeled based on the neoclassical theory of cost minimization while payments to purchases of inputs by producing sectors are based on fixed I-O data. For the capital accounts, total savings (and thus investment) are determined by applying exogenous savings rates to the earnings of each institution in the economy. Foreign trade is explained based on the relative prices of domestically produced and sold goods and goods in the world market.

CGE models have been used for different purposes and one of these is to analyze the welfare impacts, e.g. income and income distribution, of macroeconomic policies. For this purpose, the approach normally followed is to disaggregate household sectors in the model into economic groups so comparative income effects of policies between groups can be ascertained.

2.3.2 Use of CGE Models in Natural Resource and Environmental Economic Analysis

The application of full CGE models in analyses involving the NRE sector has been limited although substantial studies have been done which are built on parts of the CGE model

(Bojo et al. 1992, p. 55). For partial application, the basis of analysis is usually the producing sectors portion of the CGE model which is actually an I-O technical coefficient matrix. Assuming that the value of the NRE damage per unit of output by producing sector is known, the CGE analysis follows that of the generalized I-O model shown in equation (4).

Another approach which is used for incorporating NRE concerns into the CGE model, especially for analyzing impacts of policies, is to specifically include the different natural resource-based subsectors, i.e. forestry, fisheries, mining and energy, as producing subsectors in the model. In this approach, policies are viewed as indirectly influencing NRE damage through their impacts on sectoral production. The direction of policy influence is based on the assumption that higher production implies higher NRE damage. Assuming availability of data, the magnitude of policy influence can be computed, using damage coefficients associated to per unit of sectoral output.

2.3.3 Empirical Studies Using Computable General Equilibrium Models

In other countries, a number of studies have used CGE models in the analysis of NRE issues (see Bojo et al. 1992, p. 56). A newer application of the model on the forestry subsector is Thiele and Wiebelt (1993).

In the Philippines, some empirical CGE modeling has been done already (see Cororaton 1994). In the NRE sector, the model was used by Cruz and Repetto (1992), to evaluate the sectoral impacts of macroeconomic adjustment policies. The Cruz and Repetto CGE model was an adaptation of the macroeconomic models used by the government and the Philippine Institute for Development Studies (PIDS). A mathematical summary of the model was provided in the paper (Ibid p. 77-8).

The Cruz and Repetto model covered four basic sectors: producing sector, households, government and external sector. the producing sector has 14 industries including those which are NRE-based: corn and root crops (erosion-prone agriculture), fisheries, forestry, mining and energy. Although NRE damage was not directly measured in the model, the inclusion of the NRE-based industries allowed the indirect analysis of damage due to the assumed chain of interaction between adjustment policies, sectoral production and NRE damage.

The production sector of the Cruz and Repetto Model was based on the 1984 I-O table. The model had three factors of production, land, labor and capital which have some degree of substitutability in production. Land was considered an input in the agriculture and forestry and was included to allow analysis of land-use effects of policies. Each of the production sectors was assumed to have a constant elasticity of substitution.

The Cruz and Repetto model subdivided households into three categories based on household income, each category of which was assumed to spent on goods under a constrained budget. The high income households obtained most of their incomes from capital and rental payments while the poor category got their earnings mostly from wages. In the model, the

government sector derives revenues from direct and indirect taxes, earnings of state corporations and transfers from abroad. The government then spends its earnings on the output of the producing sectors based on fixed expenditure proportions. For the external sector, goods are exported by the production sector while both this sector and households imported goods.

Employing simulations, Cruz and Reppeto analyzed the impacts of macroeconomic adjustment policies, i.e. trade reform, industrial promotion, energy taxation and resource rent taxation, on the NRE sector. They found that joint trade reform, in the form of tariff reduction and devaluation taken simultaneously, could result to real growth in GDP, better income distribution and improvements in the balance of payments. However, joint trade reform could have adverse and significant effects on the NRE sector, as production of NRE based industries logging, fishing, mining, energy and erosion-prone agriculture rise with its implementation.

In the case of industrial promotion, Cruz and Repetto found that the net aggregate effect such a policy would be negative as it will result to minimal increases in output and employment only and while at the same time exacerbate the distribution of income and worsen further environmental degradation. As to energy taxation, the authors found that real GDP declines while balance of payments improve with an energy price rise. The policy will also lead to an NRE improvement as the fall in production extends to sectors that are NRE based. Finally, the authors found concluded that resource rent taxation can be an attractive vehicle for improving the NRE sector and alleviate poverty as their results indicated that the policy will only reduce minimally real GDP but will improve the balance of payments and the distribution of income and reduce NRE exploitation by the NRE-based sectors.

The Cruz and Repetto study is the first Philippine study to apply modeling in the analysis of the sectoral impacts of economic policies. However, since it covers only a limited classification of households based on income, the study stopped short of analyzing the direction and magnitude of the implications of policies on the welfare of of many other types of households, such as those which are resource dependent or highly exposed to the environment.

2.3.4 Limitations of CGE Models

Since it also emphasizes on sectors other than the producing sectors, CGE models are generally bigger, and hence requires more information operationalize, than the I-O and LP models. On the other hand, perceived data problems may not be that severe anymore since it has been shown already by Cruz and Repetto that the CGE model can now be applied not only for a standard analysis of the economy but also for evaluating NRE impacts of adjustment policies.

Beyond data constraints, there are some important theoretical problems associated to CGE modeling. An issue is that CGE modeling is split into two theoretical approaches: the Walrasian approach where the market clearing variables in the model are the wage and product prices and the non-Walrasian, structuralist approach where the market clearing variables are not prices but

quantities (see e.g. Cororaton 1994). These contradicting approaches has gone down to the level of CGE models empirically applied, which individually followed one approach or the other.

The preliminary results of the review of Philippine CGE models indicated that aside from the theoretical aspects of the CGE model, there are potential computational difficulties associated to their actual application (Ibid). Thus, if a CGE model is to be employed, a problem to be addressed is the selection of the appropriate base model to be reformulated for analyzing NRE impaxts of policies, as the individual local CGE models have their own practical strengths and weaknesses.

2.4 Econometric Models

Econometric Models are algebraic models which represent an economic system by a set of stochastic relations among variables of the system (Intriligator 1978). These type of models are estimated using econometric techniques.

2.4.1 Prototype Dynamic Econometric Model

An econometric model may be linear or nonlinear and static or dynamic. Econometric models are often used both in microeconomic and macroeconomic analysis. A prototype dynamic econometric model for the economy consists of three structural equations of the form (Ibid, p. 34)

$$C_t = a_1 Y_t + b_1 + e^{Ct} \tag{18}$$

$$I_t = a_2 Y_t + b_2 Y_{t-1} + b_3 + e^{It} \tag{19}$$

$$Y_t = C_t + I_t + G_t \tag{20}$$

where a_1, a_2, b_1, b_2 and b_3 are parameters to be estimated, C_t, I_t and Y_t are year t consumption, investment and national income which are endogenous variables in the model, G_t is government spending in year t which is an exogenous variable, Y_{t-1} is the lagged and endogenous income variable and e^{Ct} and e^{It} are stochastic disturbance terms for consumption and investment. the first equation is the consumption function showing consumption as a function of income. The second equation is the investment function showing investment as a function of both current and lagged incomes. The third equation shows the equilibrium condition equalizing national income to the sum of consumption, investment and government spending.

The above econometric model is basic. In actual empirical work, econometric models are much more complicated, comprising several equations.

2.4.2 Use of Econometric Models in Natural Resource and Environmental Economic Analysis

There are not a lot of known studies which use econometric models in NRE economic analysis. An econometric model was tried in Thailand (IDRC 1992) to evaluate interactions between the economy, households and the environment. The econometric model was used as an alternative to the CGE model which was not applicable due to the currently imperfect system of NRE accounting in the country.

The model used by the Thailand study was a combination of the optimal control technique and econometric model where an objective cost function, which measures the discrepancy between actual and desired outcomes, was minimized subject to a system of equations defining economic and environmental relationships. Because of the preliminary nature of the study report and the planned expansion of the employed model, the specification of the model is presented below with minor modification and without comments.

The objective cost function of the econometric model of the Thailand study is

$$J = 1/2\ (x_n - x^*_n)'\ W_N\ (x_n - x^*_n)\ + \tag{21}$$

$$1/2 \sum_{k=1}^{n-1} (x_k - x^*_k)'\ W_k\ (x_k - x^*_k)\ +\ (u_k - u^*_k)'\ A_k\ (u_k - u^*_k)$$

and the general system equations is:

$$x_{t+1} = A_t x_t + B_t u_t + C_t z_t + c_t \tag{22}$$

where x is the state vector; u is the control vector; x^* is the desired path for state variables; u^* is the desired path for control variables; W is the penalty matrix for state variables;
A is the penalty matrix for control variables; z is the exogenous vector; and c is the constant vector.

In the analytical model, the system of equations represents four sectors, namely, the economic sector, environment sector, production sector, and constraint sector. The equations defining the economic sector are the following:

$$Y = C + I + G + X - IM \tag{23}$$

$$C = C(Y,r) \tag{24}$$

$$I = I(Y,r) \quad (25)$$

$$G = G' \quad (26)$$

$$X = X(P,Y_W) \quad (27)$$

$$IM = IM(E * P_m,Y) \quad (28)$$

where Y is the gross domestic product; C is consumption; I is investment; G is government expenditures; X is exports; IM is imports; r is interest rate; P is price level; Y_W is world gross domestic product; E is exchange rates and P_m is import prices.

The equations defining the environmental sector are the following:

$$E = E(S,Z,N) \quad (29)$$

$$S = S(S_{t-1},X) - R \quad (30)$$

$$Z = W - A \quad (31)$$

$$W = W(Y,N) \quad (32)$$

$$A = A(Z,S,V) \quad (33)$$

where E is the environmental index which measures the "state of the environment" of the country (A higher E means a better environment and vice versa); S is the existing natural resources which is expected to positively influence E; Z is the pollution level which is expected to positively influence E; N is the population size which is expected to positively influence E: X is the growth of the natural resource stock; R is the depreciation of the natural resource stock; W is the amount of pollution discharges caused by economic and human activities; A is the pollution abatement or treatment or amount of treated waste; and V is the abatement investment.

The production sector is represented by the following equations:

$$Q = Q_a + Q_i + Q_s \quad (34)$$

$$Q_a = Q_a(L_a,K_a,LD_a,FOR) \quad (35)$$

$$Q_i = Q_i(L_i,K_i,E) \quad (36)$$

$$Q_s = Q_s(L_s,K_s,E) \quad (37)$$

where Q is the total output of the economy measured by real GDP (equal to Y); Q_a is the output of the agricultural sector; Q_i is the output of the industrial sector; Q_s is the output of the service

sector; L_a is the labor in the agricultural sector; K_a is the capital accumulation in the agricultural sector; LD_a is the agricultural land; FOR is the forest stock; L_i is the labor in the industrial sector; K_i is the capital accumulation in the industrial sector; L_s is the labor in the service sector; and K_s is the capital accumulation in the industrial sector.

There are two constraints in the model, the physical constraints and policy constraints. The physical constraints limit the physical variables to some maximum values. The physical constraint equations are the following:

$$K = K_i + K_a + K_s \tag{38}$$

$$I_t \leq K_t - K_{t-1} \tag{39}$$

$$Y \leq Q \tag{40}$$

$$L = L_a + L_i + L_s \tag{41}$$

$$L \leq bN \tag{42}$$

where K is the total capital in the economy; L is the total labor force in the economy; and b is the labor participation ratio.

Finally, the policy constraint equations are the following:

$$E \geq E^* \tag{43}$$

$$FOR > FOR^* \tag{44}$$

$$W \leq W^* \tag{45}$$

$$A \geq A^* \tag{46}$$

where E^* is the desired level of the state of the environment, E;
FOR^* is the desired level of forest stock, FOR; W^* is the required standard of pollution discharges, W; and A^* is the government set abatement standard, A.

As of last report, the above model has been estimated already with air and water pollution as the environmental variables. As mentioned, the researchers working on the study planned to expand the model for other uses, i.e. consideration of solid waste as an environmental variable in the analysis. Work on further refinement of the model, and on model estimation, is going on.

2.4.3 Limitations of Econometric Models

A limitation of the dynamic econometric models for use in the evaluation of policy impacts is the unavailability of time-series data, not only for economic variables but more particularly the NRE variables. In developing countries, time-series information on NRE damage are almost non-existent as these countries are still in the early stage of developing their NRE accounting capabilities.

Assuming data availability, econometric models are attractive because of the econometric estimations of parameters in the model. It appears to have an advantage over other macro models, like the CGE model, which has some parameters, e.g. production coefficients, exogenously generated.

2.5 Other Models

2.5.1 The Francisco and Sajise Model

Another model that may be used for analyzing sectoral effects of macroeconomic adjustment policies is that discussed by Francisco and Sajise (1992). The proposed model, however, was applied only for the natural resource subsector may not be classified under the general category of macroeconomic models. Nonetheless, its is discussed below because of its potential usefulness to the MIMAP project.

The basis of the model of Francisco and Sajise (1992) was the argument, already discussed earlier in section 1.3 of this review, that macroeconomic adjustment policies affect the rate of natural resource depletion through its links to the input and output prices faced by resource-based industries. To repeat, the argument says that policies which lower output prices industries will accelerate resource damage while those which decrease the prices of the inputs of subsectors will decelerate damage. Based on this, a model of the following form can be formulated

$$D = f(S, W, I, P_o) \qquad (47)$$

where D is the rate of resource depletion, S is the resource stock, W and I are the real wage rate and interest rate which represent the prices of the production inputs labor and capital and P_o is the output price. In addition to input and output prices, the existing resource stock is an explanatory variable of resource depletion in the model. It is hypothesized that the higher the resource stock, the greater is the rate of resource damage.

Francisco and Sajise estimated equation (47) for the forestry subsector using deforestation data generated by the ENRAP project and economic data from statistical indices. A log-linear function was assumed for the model. The results of the estimation support the different hypothesizes put forward in the paper. Output price had a positive and significant effect on deforestation while the variables representing input prices, interest and real wage, had

a negative and significant influence on deforestation. The results also showed that resource stock was the most important determinant of deforestation, more than input and output prices, the economic variables affected by policies.

2.5.2 Limitations of the Francisco and Sajise Model

For the forestry subsector, Francisco and Sajise showed that their model can be estimated with existing time-series data. For the fishery and mining subsectors, on the other hand, data which can be used to accurately quantify the rate of resource depletion over time may not be available. Thus, the estimation of the model may be unlikely in the meantime. The same may hold true for the whole natural resources sector, where there exists the problem of developing an accurate index for overall resource depletion.

On the model itself, there are limitations pertaining to its usefulness to the MIMAP project. A problem which comes to mind is that although the model estimates relationships between natural resource depletion and output and input prices, it does not lead to a direct or indirect quantification of the effects of macroeconomic policies on resource depletion. In what direction and by how much policies affect depletion cannot be gleaned through the model since prices are determined by factors other than policies, such as the forces of supply and demand in the market, tastes and preferences and other factors. Segregating the pure effects of policies on prices and subsequently on resource depletion is a task that the model failed to explain.

2.6 Summary

In retrospect, three empirical works in the Philippines attempted to evaluate the impacts of macroeconomic adjustment policies on the NRE sector. These are the Mendoza study (1994) which used the generalized I-O model with an endogenized household sector, the Cruz and Repetto study (1992) which employed the CGE model and the Francisco and Sajise study (1992) which used a model specifically designed for the analysis of natural resource degradation. The results of the studies generally indicated the importance policies played as a catalyst for resource and environmental change. The studies also demonstrated the technical feasibility of empirically studying policy impacts, at least at the sectoral level.

III. Microeconomic Valuation Methods

Several microeconomic valuation methods are employed in NRE analysis. As stated earlier, the rationale for reviewing these methods is that they are potentially useful for the MIMAP project for evaluating the welfare effects of the NRE change induced by policies, once the change has been measured.

3.1 Benefit-Cost Analysis and Microeconomic Valuation Methods

The benefit-cost (B/C) criterion is a well-applied technique for judging the acceptability of a certain development project. In the context of B/C analysis, the acceptance of a proposed project whose implementation has negative and significant impacts on the NRE sector is based on the following criterion:

$$B_e / (C_e + C_n) > 1 \qquad (48)$$

where B_e is the discounted total economic benefits to be derived from the project, C_e is the discounted total economic costs and C_n is the discounted total NRE costs. C_n is measured either as the value of NRE benefits which is preserved if the proposed project is discontinued or, symmetrically, the value of NRE costs if it is pursued.

For an NRE-friendly development project, the equivalent B/C criterion is

$$(B_e + B_n) / C_e > 1 \qquad (49)$$

where B_n is the discounted NRE benefits which is measured as the value of lost NRE gain if the project is not pursued, or symmetrically, the value of the NRE benefit if the project is implemented.

The measurement of the NRE cost, C_n, and the NRE benefit, B_n, is usually done using microeconomic valuation methods. Actually, however, most B/C analysis exclude NRE costs and benefit valuation. A reason for this is that almost all NRE goods are underpriced, if not freely provided. This makes their "true" values difficult to measure.

Recently, local studies have started to include NRE costs in the B/C analysis of damaging projects and economic activities. An example of these studies is that done for ENRAP II by Cabrido and Samar (1994) which comparatively assessed the different uses of land in the Philippines. This study generated interesting findings using the B/C technique. Among others, it found that traditional upland farming was not a sustainable way of using land because it results to high total societal costs in the form of soil erosion and sedimentation.

3.2 Types of Microeconomic Valuation Methods

Microeconomic valuation methods can be classified into market-oriented and survey-oriented methods. Market-oriented methods are further disaggregated into methods using actual markets and those employing surrogate markets. There is already a large amount of available literature which reviewed these methods including Freeman (1979, Hufschmidt et al. (1983), Hohansson (1987), Folmer and Ierland (1989), Braden and Kolstad (1991), Francisco (1991) and Shin et al. (1993). So, only a brief review of the methods is done in this paper.

3.2.1 Productivity Change Method

The productivity change method measures the NRE impacts of a project by looking into its on-site and off-site effects on the on the productivity of man-made or natural production systems. Theoretically, the method assumes that NRE quality is another input in the production process. Therefore, the production function can be reformulated as

$$X = f(L, N, K, E) \qquad (50)$$

where X is the output, L, N and K are the usual inputs land, labor and capital and E stands for NRE quality. In this revised production function, it is posited that a change in E will change production costs which, in turn, either change the quantity and price of the output or the returns to the other inputs or both.

The general steps followed in quantifying productivity gains or losses from NRE changes using the productivity change method are:

a. measurement of the production response to the NRE quality change and then quantification of the gains or losses of producers in terms of increases or decreases in profits;

b. measurement of the consumption response to production changes and then quantification of the gains or losses of consumers in terms of changes in consumer surplus;

c. measurement of the gains or losses of owners of factor of production in terms of increases or decreases in factor returns; and

d. measurement of the total benefits or losses from quality changes by aggregation of the different values attained in the previous computations.

Where efficient markets exist, the valuation of productivity gains or losses from NRE quality changes in each of the above steps is based on actual market prices. On the other hand, when markets are distorted, adjustment will be made so prices used in valuation to reflect true prices.

The productivity change method is often used in valuing the productivity effects of projects affecting agriculture, such as projects which cause soil erosion, improve quality of irrigation water or abate water pollution caused by industries. A foreign study which used the productivity change method is Fleming (1981).

as fisheries and tourism. Under the second phase of the ENRAP project, Ebarvia (1994) also employed the method in estimating the off-site effects associated to changes in the environment, such as sedimentation and siltation due to soil erosion. The Ebarvia study found that off-site damage due to environmental change was substantial with damage coming in the form of productivity losses in fishery and agriculture and shortened lives and efficiency of infrastructures like reservoirs and irrigation systems.

3.2.2 Human Capital Method

The human capital method is used to assess the impacts of NRE changes on people. It is founded on the generally accepted notion that NRE damage can have negative and significant costs on human health.

The human capital method measures the human costs of NRE damage by valuing the foregone opportunities of people resulting from NRE-induced health problems. In the case of premature illness or death of an individual, the following general formula of Mishan (1972) can be used as the measure of the value of the life:

$$L_1 = \sum_{t=T}^{\infty} Y_t \, P^t{}_T (1 + r_t)^{-(t-T)} \qquad (51)$$

where L_1 is the discounted value of the labor of individual 1; Y_t is his expected gross earnings, or value added, in the t-th year outside of returns from non-human resources he owns; $P^t{}_T$ is the current (year T) likelihood that he will be alive in year t; and r_t is the social discount rate in year t. The sum of the cost of death of the individual is L_1 plus the medical costs. However, these costs can be expanded further to include the money value of the disutility related to the suffering of the family and friends of the individual.

The Human capital method is fairly applied empirically in other countries. Among the studies using the method are Ridker (1967), Cooper and Rice (1976) and Lave and Sisken (1977). In the Philippines, Ebarvia (1994) used the approach to estimate the value of morbidity and mortality associated to air and water pollution. Among others, Ebarvia found that the value of the health effects of air pollution was significantly more than the value of the health impacts of water pollution although both types of pollution affects health substantially.

3.2.3 Opportunity Cost Method

The opportunity cost method is based on the opportunity cost concept, which, for a given resource, is defined as the value of the benefit that accrues from the best alternative use of the resource. In NRE valuation, there are basically two kinds of opportunity costs: the opportunity cost of development, which is measured as the present value of the benefits from preservation, and the opportunity cost of preservation, which is estimated as the present value of the benefits from development.

Empirically, the opportunity cost method is more often used to measure the opportunity cost of preservation only. This is because the benefits from development, or the opportunity cost of preservation, can be easily quantified from existing markets. The method is seldom used to measure the opportunity cost of development, which is the value of preservation benefits, because many of the goods produced by preservation are not traded and are difficult to estimate.

An opportunity cost technique often used for assessing the cost of preservation is the computation of the net present value of value (NPV) from a project. The general form of the net present value formula is

$$NPV_0 = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+t)^n} \qquad (53)$$

where NPV_0 is the net present value in year 0, B_t and C_t are the values of the total benefits and total costs in year t, r is the discount rate and n is the number of years of project life. If the NPV of the project is small relative to some estimated value of preservation, the project is rejected.

Foreign studies using the opportunity cost method include the Commonwealth of Australia (1975), Krutilla (1969), Krutilla and Fisher (1975). The present review has not encountered a Philippine application of the opportunity cost method.

3.2.4 Cost-Effectiveness Method

The cost-effectiveness (C-E) method is a criterion useful for comparing projects that has comparable outputs. The method selects among projects the one which either minimizes costs given a fixed output or maximizes output with a fixed cost. In the case of the NRE sector, the output of concern may be some kind of NRE quality level, such as a certain pollution standard for instance.

With the nature of its objective, the empirical application of the C-E method can be done by employing mathematical optimization and programming models which generate optimal

solutions that leads to the selection of the optimal project. The method, however may use also the traditional approach of simply comparing financial estimates between competing projects.

Examples of foreign studies using optimization and programming models for C-E analysis are North and Merkhofer (1975) and Russell (1973). An application of the method in the search for the best alternative for controlling a specific disease is Rosenfield and Bower (1978). There is no application of the C-E method in the Philippines available for this review.

3.2.5 Preventive Expenditures Method

The preventive expenditures method is a valuation approach which measures the value people attach to NRE quality through the expenditures people incur to prevent quality decline.

The preventive expenditures method assumes that when faced by a decline in NRE quality, e.g. neighborhood air pollution, the individual affected has the choice of ignoring the problem, moving to another area or spending on measures which mitigate the problem. The amount spent by the individual to prevent the quality decline is taken as his personal valuation of the NRE quality before the deterioration occured. The total of the expenses of all affected individuals for preventive measures is then used as the substitute demand curve for NRE quality.

The preventive expenditures method has been fairly applied internationally. Studies applying the method include those of Starkie and Johnson (1975) and Kim and Dixon (1982). The review, however, has not encountered a local application of the method.

3.2.6 Replacement Cost Method

Similar to the preventive expenditures method, the replacement cost method provides a value of NRE quality. In contrast, however, the method takes as proxy measure the cost of replacing productive assets destroyed or rendered unproductive by the deterioration in NRE quality.

The cost of replacement is usually counted in terms of market values of physical replacements (e.g. cost of fertilizer to solve soil fertility loss). Therefore, the replacement cost method is a relatively straight-forward one to implement, assuming that it is technically feasible to replace damaged systems.

A foreign application of the replacement cost method is Kim and Dixon (1982). In the Philippines, the method was employed to estimate on-site costs of soil erosion in the Magat and Pantabangan watersheds by Cruz, Francisco and Conway (1988). This study used as proxy the value of inorganic fertilizers needed to replace the natural nutrients in the soil to measure the value of losses due to soil erosion.

3.2.7 Shadow Project Method

The shadow project method is a special type of the replacement cost method which uses the cost of putting up a hypothetical shadow project which provide an alternative source of the NRE goods lost to development as the substitute estimate of the value of the NRE goods. Assuming technical feasibility of a shadow project, the method is straightforward to apply although understatement of costs will likely occur since the total value of the lost NRE good may always significantly outweigh the cost of the shadow project. A study applying the method is Commissie Oosterschelde (1974). The review has not encountered a local application of the method.

3.2.8 Relocation Cost Method

The relocation cost method is similar to the preventive expenditures method but instead of estimating expenditures on prevention, it uses the cost of relocation from the area where there is an NRE problem to an area where NRE amenity is better as a proxy measure for NRE quality. The amount the individual is willing to spend for the relocation is taken as his valuation of the benefits of an improved NRE quality in the new area or the cost of disamenity in the old location.

The review is not aware of any foreign or local studies which used the relocation cost method.

3.3 Methods Using Surrogate Markets

In contrast to valuation methods directly using actual markets reviewed above, the methods reviewed below indirectly use actual markets only. These methods are called surrogative methods because they estimate the value of unmarketed NRE goods by using the values of other marketed goods. These methods are also known as hedonic price methods and have their beginnings in the work of Rosen (1974).

3.3.1 Marketed Goods as NRE Goods Surrogates Method

This method is useful for measuring the benefits of NRE improvement in situations where a privately marketed good is a perfect substitute for an NRE good. In such a case, the value of costs or benefits from the fall or rise in the supply of the non-marketed NRE good is approximated by the value of the increase or decrease in the demand of the marketed private good.

The marketed goods as NRE goods surrogates method is easy to apply since the demand for the substitute goods that are marketed are usually easily known and, thus, measured. A constraint of the method is that isolating the change in the demand for the marketed substitute good specifically induced by the change in the supply of the unmarketed NRE good can prove difficult.

3.3.2 Property Value Method

The property value method estimates the value people attach to an NRE improvement, such as a decline in air pollution in a certain locality, by studying the actual market for real properties, such as housing, that are affected by the improvement.

Taking the housing and air pollution example, the property value method is applied by first assuming that the area analyzed is a single, well-functioning and competitive market for housing. Under these assumptions, the following relationship can be defined

$$R_i = f(P_i, A_i, N_i, E_i) \qquad (54)$$

where:

R_i = price of housing (usually measured as rent per unit of time);

P_i = physical characteristics of housing such as house size, lot size, number of rooms, age of house, type of construction materials, etc.;

A_i = accessibility characteristics such as distance to market, school, church, place of employment, etc.;

N_i = neighborhood characteristics such as average income of neighborhood residents and crime rate of neighborhood, etc.; and

E_i = air quality or pollution level in the housing location.

Computationally, the method proceeds by assuming a functional form for the relationship in equation (54). Assuming a linear function, the estimated equation is

$$R_i = a_0 + a_1 C_{1i} + a_2 C_{2i} + \ldots + a_n C_n + a_e E_i + e_i \qquad (55)$$

where a_0 is the intercept, the a_is are the coefficients, C_is are the housing characteristics, a_e is the coefficient for the air quality variable E_i and e_i is the error term.

With a linear equation, the marginal willingness-to-pay (WTP) for an additional unit of improvement in air quality is measured by the coefficient a_e. The total incremental benefits of an air pollution reduction program that improves air quality is estimated by

$$V = \sum_{i=1}^{s} a_{ni}(Q_2 - Q_1) \qquad (56)$$

where V is the total incremental benefits, Q_2-Q_1 is the improvement in air quality, and s is the number of housing in the study site.

The property value method is well applied in other countries. Among the studies using the approach are Portney (1981), Smith and Disvousges (1986) and Harrison and Rubinfeld (1978a, 1978b). A local application of the method is Jimenez (1983) which measured changes in housing quality in the slum area of Tondo, Metro Manila.

3.3.3 Wage Differential Approach

The wage differential method is similar to the property value method except that here, instead of the market for real property, the market for labor is used as the surrogate market for NRE quality.

The wage differential method starts by assuming a competitive labor market situation where the main motivation of workers for accepting jobs associated with greater exposure to NRE hazard is higher remuneration. Then, it assumes a wage equation of the form

$$W_i = f(J_i, L_i) \qquad (57)$$

where:

W_i = wage level i;

J_i = non-NRE related job attributes such as distance from residence, etc.; and

L_i = NRE-related job attributes such as exposure to air pollution, etc.

Equation (57) is estimated assuming a specific functional form. If the functional form is linear and the NRE-related factor considered is air pollution at the job site, then the estimated equation is

$$W_i = b_0 + b_1 D_{1i} + b_2 D_{2i} + \ldots + b_n D_n + b_e A_i + u_i \qquad (58)$$

where b_0 is the intercept, the b_is are the coefficients, the D_is are the job characteristics, a_e is the coefficient for the air quality at the site variable A_i and u_i is the error term. The marginal willingness-to-accept (WTA) a higher or lower wage for an unit of additional unit of decrease or increase in air quality at the site is given by the coefficient b_e. The total amount workers are willing to accept for a reduction in air pollution at the job site is estimated by

where V is the total change in wage and W_2-W_1 is the change in air quality.

$$V = \sum_{i=1}^{s} b_{ni} (W_2 - W_1) \qquad (59)$$

Applications of the wage differential method include Meyer and Leone (1977), Olson (1981) and Moore and Viscusi (1988). There is no local study applying the method was available for the review.

3.3.4 Travel Cost Method

The travel cost method is an approach used for measuring the value of public recreational services such as parks, amusement centers and similar amenities. The method was developed because directly estimating the value attached to these places by users based on subsidized admission fees will grossly underestimate true values.

For the analysis of a specific recreation site, application of the travel cost method employs the following steps:

a) zoning of surrounding areas of the recreation site (where visitors come from) based on distance from the site;

b) surveying the site users to get information on zones of origin, visitation rates, travel costs and socioeconomic characteristics;

c) estimating the following visitation rate function of each zone:

$$V_i = f\,(TC, X_1, \ldots, X_n) \qquad (60)$$

where: V_i = visitation rate computed as the number of visitors from the zone i divided by population of the zone (This is can be varied by subdividing further the zone into specific areas, e.g. districts); and

TC = is the travel cost (time and resources costs) of each visitor from the residence to the site; and

$X_1 \ldots X_n$ = socioeconomic variables associated to each visitor.

d) using the information from step c) to create a demand curve for each zone relating travel cost to total visitation;

e) computing the consumer surplus from each zone assuming an actual user admission fee; and

f) summing the consumer surpluses for all zones to arrive at total consumer surplus. This total surplus estimates the gains by all users from the use of the site.

Some foreign studies which used the travel cost method are Tussey (1967), Grandstaff and Dixon (1986) and Smith and Kaoru (1988). In the Philippines, no known study has applied the method although currently, the DENR is undertaking a study using the method and covering the Nayong Pilipino Park located in Metro Manila. Also, the ENRAP has preliminarily computed benefits from Philippine parks based on secondary data and findings of previous studies done in the Philippines and abroad using the travel cost method (Ygrubay 1994).

3.4 Contingent Valuation Methods

Contingent valuation methods (CVM) are techniques used to analyze the value people attach to NRE changes, not by using actual or surrogate markets, but hypothetical markets. The main source of data of the CVM is the survey which employ questionnaires asking preferences of respondents representing the population who are potentially going to be affected by an assumed NRE change. The name "contingent valuation" implies that the choices people reveal in the survey assuming a hypothetical market are contingent on the actual occurrence of said market (Dalvi 1988, Shin et al. 1993).

Below, the different CVM approaches are reviewed. A review of CVM is also contained in Mitchell and Carson (1989), Cummings, Brookshire and Schulze (1986) and Hufschmidt et al. (1983). The foreign studies which apply the CVM include Jones-Lee, et al (1985), Smith and Disvouges (1986a, 1987), Gerking et al. (1988), and Viscusi et al. (1991). No local study applying any of the CVM methods discussed is available for this review.

3.4.1 Bidding Game Approach

The bidding game is a CVM technique which directly asks respondents their willingness-to-pay (WTP) for a specific NRE improvement or their willingness-to-accept (WTA) compensation for NRE damage. There are basically two bidding game systems, the single-bid system and converging-bid system.

The procedure in the bidding game approach is as follows. First, the interviewer describes accurately to the respondent the specific features of the NRE improvement or damage in question, including its quantity, quality, location, and the respondent's access rights. Next, the respondent is asked about his WTP or WTA associated to the improvement or damage by using a single-bid or converging-bid system. In the single-bid system, the respondent is asked only once about the amount he is willing to pay or accept in relation to the improvement or damage. In the converging-bid system, the respondent is given a starting bid which he is asked to accept or reject. Once a starting bid is accepted, higher or lower bids are given until the

maximum WTP or the minimum WTA of the respondent for the improvement or damage is ascertained.

Once the WTP or the WTA of all the respondents are known from the survey, individual WTPs or WTAs are then summed up vertically to come up with an aggregate bid curve for the NRE improvement or damage. This bid curve serves as proxy of the income compensated demand curve in analyzing the total value attached by the affected population to the project which causes an improvement or damage.

A foreign application of the bidding game technique in found in Brookshire, Ives and Schulze (1976) also shown in Hufschmidt et al. (1983).

3.4.2 Tradeoff Game Approach

The tradeoff game is a CVM approach which gives the respondent a choice between having a lower or higher level of an NRE good at no expense made or compensation received (base option) or a higher or lower level of the good but with some level of expenses made or compensation received (alternative option).

In its simplest form, the tradeoff game gives the respondent a base option and a particular alternative option (which has a stated amount of money the respondent has to spend or receive) to choose from. If he chooses the alternative, higher or lower amounts of money the respondent has to spend or receive is set until he is indifferent between the base option and the alternative option. The final amount of money in the alternative option acceptable to the respondent is then taken as an approximation of his maximum WTP or minimum WTA for the difference in the levels of the NRE good between the base and alternative options. As in the bidding game, the individual WTP or WTA are added vertically to come up with the aggregate bid curve for the good.

An example of the use of the tradeoff game method is given in Hufschmidt et al. (1983).

3.4.3 Costless Choice Approach

The costless choice is a CVM technique which provides the respondent an option to decide between quantities of goods which are desirable to him and at the same time provided free of charge (thus, costless). In the two-alternative case, the respondent is usually given a choice between an NRE good and an economic good. If the NRE good is chosen, the value of the economic good is taken as a measure of the minimum value the respondent attaches to the NRE good because by choosing the NRE, the respondent must have valued it at least as much as the economic good. If, on the other hand, the economic good is chosen, its quantity will be reduced until the respondent will choose the NRE good over it. Once this happens, the value of the final quantity of the economic good again serves as the minimum approximation of the value of the NRE good. The vertical sum of this minimum values across respondents serves as an estimate of the aggregate demand curve for the NRE good.

The main difference of the costless choice approach from the other CVM approaches is that in making choices, the respondent will have his choice free of charge, that is, he will not have to pay anything for the NRE good if he chooses it or he will not have to lose any existing NRE good if he chooses the economic good instead.

A simplified example of the costless choice approach is found in Hufschmidt et al. (1983).

3.4.4 Priority Evaluator Technique

The priority evaluator technique is similar to the costless choice technique in that respondents are also made to choose between goods, among which is an NRE good. The technique, however, is unique for three reasons. First, the technique allows adjustment of prices of the goods from their initially set levels, to encourage convergence to a set of equilibrium values. Second, the technique considers only goods which meet conditions that simulate a perfectly competitive market, that is, the goods must be independent in production, they must be continuously variable in production and consumption and their consumption utilities must be independent of any other consumption. Third, the technique allows respondents to make choices between goods given constrained income.

The specific steps followed in the application of the priority evaluator technique are relatively more complicated and lengthy than those of the other CVM techniques and therefore will no longer be outlined here. An explanation of the steps are done with example in Hufschmidt et al. (1983).

3.4.5 Delphi Techniques

Delphi techniques are different from other CVM methods in that instead of interviewing representatives of the affected population, they generate opinion of experts on the NRE good in question.

The Delphi technique usually involves experts residing in different areas. These experts who are independently asked through written communication about their valuation of an NRE good. The initial values gathered from the experts are tabulated and sent back to them for further examination. Continuous re-evaluation by the experts is conducted until the valuation organizers believe a satisfactory average value of the NRE good has been derived.

The Delphi technique is highly useful for checking results of valuation studies using the other CVM techniques. No empirical literature using the Delphi Technique, however, is available for this review.

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been used. In particular methods applied were the productivity change method (Hodgson and Dixon 1988, Ebarvia 1994), the human capital method (Ebarvia 1994), and the replacement cost method (Cruz, Francisco and Conway 1988).

The methods using surrogate markets or hedonic methods were minimally used in the Philippines. Studies the property value method (Jimenez 1983) and Ygrubay (1994). On the other hand, a local study has yet to use the CVM in NRE valuation.

Outside of the country, microeconomic valuation methods have been widely applied. The methodologies associated to the methods are well established and provided in the literature. Therefore, a new local application of any of the methods should be relatively straightforward to conduct.

IV. Proposed Approaches for Analyzing Natural Resource and Environmental Impacts of Macroeconomic Adjustment Policies Under the MIMAP Project

Now that the review of macroeconomic models and microeconomic valuation methods is completed, the succeeding task of the paper is to develop general analytical approaches through which evaluation of the impacts of macroeconomic adjustment policies on the NRE sector and household welfare can be done. This section discusses the interactions between policies, NRE sector and households as well as the possible analytical approaches for measuring these interactions are discussed.

4.1 Relationships Between Policies, the Natural Resources and Environment Sector and Households

To facilitate the discussion of the impacts of macroeconomic adjustment policies on the NRE sector and household welfare, a flow diagram (Figure 3) was constructed tracing the likely interactions between policies, NRE sector and the households. The flow diagram identifies the following six potential sectoral and welfare impacts of policies:

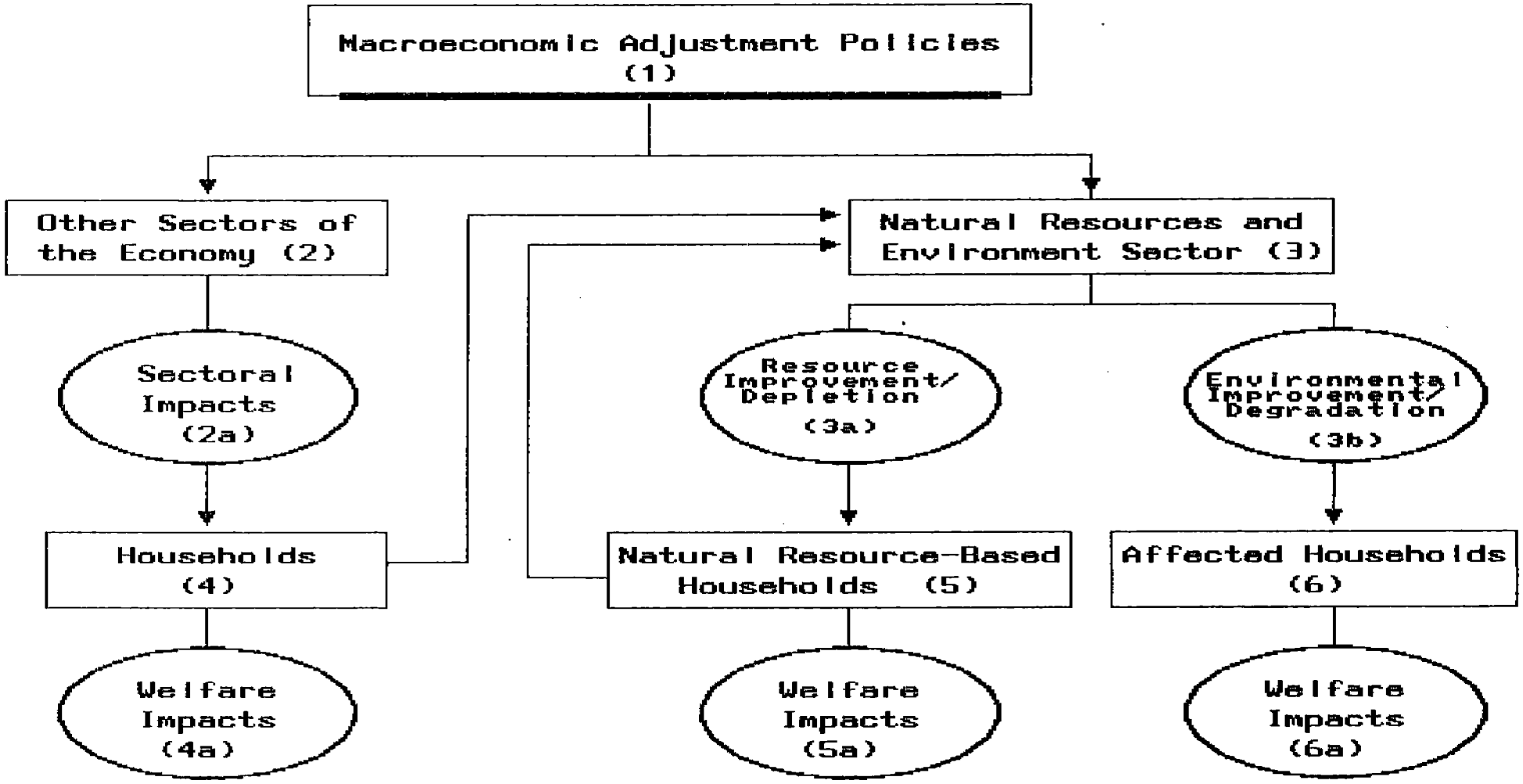
a) the effects of policies (1) on the NRE sector (3) in term of damage, i.e. natural resource improvement or depletion (3a) and environmental improvement or degradation (3b);

b) the effects of natural resource improvement or depletion (3a) induced by policies on natural resource-based households (5), in term of household welfare (5a);

c) the effects of environmental improvement or degradation (3b) induced by policies on affected households, in term of household welfare (6a);

d) the reverse effects of the change in welfare of resource-based households (5) due to changes in the stock of resources induced by policies, on the NRE sector (3), in term of resource improvement or depletion (3a);

Figure 3. Flow of Interactions Between Macroeconomic Adjustment Policies, The Natural Resources and Environment Sector and Households*



* Blocks represent policies, sectors and households. Circles represent policy effects.

e) the reverse effects of the change in welfare of affected households (6) due to canges in the environment induced by policies, on the NRE sector (3), in term of environmental improvement or degradation (3b); and

f) the reverse effects of the change in welfare of households from other sectors of the economy (4) induced by policies, on the NRE sector (3), in terms of resource improvement of depletion (3a) and environmental improvement or degradation (3b).

For each policy effect mentioned, the corresponding hypothesis on the direction of effect are as follows:

a) The expected impacts of specific macroeconomic adjustment policies on NRE change are as laid out by Francisco and Sajise (1992) and summarized in Section 1.3. Policies which lower the prices of outputs of NRE subsectors will reduce NRE damage because exploitation is discouraged by higher returns of NRE-based industries. On the other hand, policies that lower input prices will increase damage as exploitation is encouraged by lower costs of production of NRE-based industries;

b) Natural resource degradation induced by policies will reduce welfare of resource-based households because it will reduce the stock of resources households can exploit and generate income from;

c) A deteriorating environment will reduce the welfare of affected households as economic and other costs among households for mitigating its ill-effects will rise;

d) Decreasing welfare among resource-dependent households due to resource depletion induced by policies will in turn exacerbate resource depletion as households need to exploit more resources just to remain at their present economic state;

e) Decreasing welfare among households affected by the deteriorating environment induced by policies promotes further environmental degradation since poorer households are likely to pollute more; and

f) Decreasing welfare among households in the other sectors of the economy will exacerbate resource depletion as more people flock to the resource-based uplands and coastal areas for survival. It will also lead to a worsening environment because, in general, poorer households are likely to pollute more.

4.2 Analytical Approaches for the MIMAP Project

For empirically testing the different hypotheses above, the direction and magnitude of effects of macroeconomic adjustment policies on the NRE sector and the welfare of households will be estimated. The potential analytical approaches for doing so under the MIMAP project are discussed below.

For the choice of an overall model for analyzing the effects of macroeconomic adjustment policies on the NRE sector, as well as on the other sectors of the economy, the CGE model appears to have the advantage over other models reviewed in the paper. Among the advantages in using the CGE model for the MIMAP project are that it has already been empirically used in the Philippines and some MIMAP researchers are familiar with it; it emphasizes not only production sectors but also other economic sectors; it is not hampered by many of the constraints inherent in I-O and LP models; and it can be used for generating some household welfare indicators, i.e. by manipulating the household component of the model.

For measuring the NRE impacts of policies, the CGE model of the type used by Cruz and Repetto (1992) is convenient as the model was applied already for an NRE analysis with Philippine data.

To measure the impacts of moacroeconomic adjustment policies on the NRE sector in terms of resource depletion and environmental degradation, an approach that may be feasible is to first compute for the changes in sectoral output, induced by specific policies, through the CGE model. Once these are known, resource depletion and environmental degradation levels associated to output changes can be computed by using depletion and degradation coefficients similar to those for the generalized I-0 model. This approach of measuring resource and environmental damage was already tried by Mendoza (1992). Also, although the data needed for computing depletion or degradation coefficients may still be unavailable for several sectors at present, it is expected that data gathering efforts by ENRAP and similar projects will eventually pave the way for the generation of coefficients for most, if not all, sectors in the future.

As to the measurement of the effects of resource appreciation or depreciation caused by macroeconomic adjustment policies on the welfare of resource-based households, there are two possible approaches that can be tried. The first is to disaggregate the household sectors in the CGE model to include resource-based households such as upland households and coastal households. The inclusion of resource-based households will allow the measurement of the effects of policies on some welfare indicators for these households, e.g. as well as for the rest of the households in the economy.

If disaggregation and inclusion of resource-based households into the CGE model is not possible because of data constraints, the second possible approach in by analyzing the welfare effects of the natural resource stock change induced by policies through the use of microeconomic valuation methods. Some of the methods which are reviewed above can be used

to measure in monetary term how resource change has affected household welfare, individually and as a group. Among the methods which can be potentially employed for the purpose are the methods employing actual markets, such as the productivity change method, and any of the CVM techniques.

Application of the microeconomic valuation methods will mean the collection of primary data and information from households in study areas where the resource base has dramatically changed over the years, the actual sites of which will be selected by the MIMAP project. The data to be gathered will center on household costs or benefits associated to the resource change. The data per household data will used for computing the indicators of welfare change, on average, per unit of change. This, when multiplied by the number of resource-based households affected by the change will provide an indicator of the total welfare change per unit of resource change. This indicator, in turn, when multiplied by the estimated total resource change induced by particular policies as computed from the use of results of the CGE model and the damage coefficients, will give an indicator of the total change in welfare associated to the particular policies.

It is also possible that primary data collection, which can be a costly process to undertake, can be sidestepped and may no longer necessary. What may be done instead is to review all the relevant empirical studies in the past, foreign or local, to see if reliable data can be had that are useful for estimating costs and benefits associated to resource changes. These data, if available, may then be used in the manner already described above to derive indicators of the evaluate of policies on the well-being of resource-based households.

For the effects of the change in the environment, induced to policies, on the well-being of affected households, the approaches that can be used are similar to those just discussed. Households in the CGE model can be disaggregated to include the urban poor who are the most likely to suffer or benefit from environment change induced by policies. If this is not possible, a study of the urban poor households in selected sites can be done using microeconomic valuation methods. Candidate methods for this study include the actual market methods, such as the human capital method, surrogate market methods, such as the property value method and any of the CVM techniques dpepending on the type of environmental damage of interest. If doing this study is too costly, a review of previous works can be done to see if secondary data, e.g. on environmental damage response functions, can be had for computing the costs and benefits associated to environmental changes. Figures generated can then be matched with the levels of environmental changes, computed by using results of the CGE model and damage coefficients, to derive an indicator of the impacts of policies on the welfare of households affected by the environmental changes.

The reverse effects of the change in the welfare of resource-based households on the NRE sector lookss tougher to estimate given present state of knowledge. Measurement may have to go beyond the use of macroeconomic models or microeconomic valuation methods. An approach that comes to mind is to conduct a partial equilibrium regression analysis estimating a resource or environmental damage function where one of the explanatory variables of damage

is an indicator of the welfare of resource-based households, such as income for instance. The income coefficient of this function can be used to estimate the income elasticity of damage. This elasticity measure, when multiplied by the change in income of resource-based households induced by policies, as determined by computations from the CGE model or the application of microeconomic valuation methods, will approximate the change in the damage associated to the income change induced by policies.

The above approach, on the other hand, will certainly encounter data problems since time-series secondary data for resource and environmental changes are not yet available. Therefore, the regression analysis outlined above may not be the practical way of estimating the reverse effect of welfare on NRE utilization among resource-based households unless a long-term, and abviously costly, effort to get the relevant data will be conducted. Thus, an alternative approach is to directly study resource-based households in selected sites. Data on their NRE use practices over a reasonable period of time can give insights into how they exploit NRE assets in response to changing welfare, measured by some indicator such as income. The change in NRE use by households due to change in welfare can then be inferred by using the welfare-damage ratios of these households. These ratios and the change in welfare levels induced by policies computed in the earlier stages will then be used to quantify the total change in NRE damage caused by welfare change induced by policies.

The reverse effects of the change in the welfare of households affected by environmental changes on the NRE sector can be measured in a similar manner to that just discussed. An NRE damage function with the income of households affected by the environmental change as an explanatory variable can be computed. Otherwise, welfare-damage ratios can be computed based on primary data gathered over a reasonable period of time from households affected by the environmental changes.

Finally, for the reverse effects of the change in the welfare of households from other sectors of the economy on the NRE sector, a possible approach that can be used is to look into the migration pattern of the urban and lowland interior populations to the upland and coastal areas. Based on results of previous studies or those of a new study to be done by the MIMAP project, the relationship between the welfare of households in the economic sectors and the migration of households to the resource-based sectors can be established, e.g. through correlation analysis or other methods. This relationship and the estimated household welfare change in the economic sectors induced by policies, as derived from previous measurement, can be used to estimate the number of households migrating to resource-based sectors as a reaction to policies. The NRE change associated to this migration is then measured as the product of the number of households migrating and the NRE change induced per households, a parameter which is quantified from earlier measurement.

V. Areas for Future Research

5.1 Microeconomic Research

As repeatedly stated in this review, an important problem in the employment of macroeconomic models for the MIMAP project is the inadequacy of NRE data not only at the sectoral level but also at the household level. To address infromation problems of data at the sectoral level, projects like ENRAP must continually be given priority and support. ENRAP, in particular, may not be just a point in time effort in NRE data gathering but can be extended as a regular activity for monitoring and generating longitudinal and sector disaggregated data. The success of these projects will pave the way for a much improved evaluation of sectoral issues, by macro projects like MIMAP. ENRAP, in particular, must not be just a point in time effort in NRE data collection. It can be extended

As to the problem of NRE data at the household level, which is a contraint to welfare analysis, a potential approach is to have the gathering of household NRE data be incorporated into the activities of numerous on-going projects which have been gathering data at the household level. Another way of addressing the problem is to undertake the project proposed by Francisco and Sajise (1992, pp. 85-88). For the purposes of MIMAP, in particular, primary data gathering in selected NRE is necessary.

Finally, beyond the problem of data, there is the need to review all the empirical foreign works on the NRE sector to see if there are studies done in other third world countries similarly situated as the Philippines which can be useful for the MIMAP project, specially for the measurement of damage coefficients, damage response functions and other variables. This review could have been made part of this paper if not for time limitations.

5.2 Macroeconomic Research

At the macroeconomic level, the application of models which explicitly consider NRE concerns in the analysis of the economy must be promoted, especially in light of the growing acceptance of the sustainable development concept. In the case of the MIMAP

project, the final macroeconomic model to be selected must have NRE as an integral sector in the analysis. The NRE sector is important to MIMAP not only because many of the poor households, which are the target group of project, depend much on the sector for survival but more importantly because the fate of the sector is inextricably linked to the fate of the highly resource-dependent macroeconomy.

VI. Summary and Conclusion

To summarize, the paper reviews the macroeconomic models and microeconomic valuation methods applied in NRE analysis which are potentially useful for the MIMAP project. The objective of the paper is to identify analytical approaches which can be employed to analyze the impacts of macroeconomic adjustment policies on the NRE sector and on the welfare of

households, with emphasis on the less economically fortunate.

The different macroeconomic models reviewed in the paper are the I-O models, LP models, CGE models, econometric models and other models. The microeconomic valuation methods discussed were the market-based methods, including those using actual and surrogate markets, and the CVM or survey-based methods. In addition to reviewing the models and valuation methods, the paper discussed areas for microeconomic and macroeconomic research, specifically in relation to the MIMAP endeavor.

The paper identifies six possible effects that policies bear upon the NRE sector and households. These are (a) the effects of policies on the NRE sector in terms of natural resource improvement or depletion and environmental improvement or degradation; (b) the effects of natural resource improvement or depletion induced by policies on the welfare of natural resource-based households; (c) the effects of environmental improvement or degradation induced by policies on the welfare of affected households; (d), the reverse effects of the change in welfare of resource-based households due to resource stock change induced by policies, on the NRE sector; (e) the reverse effects of the change in welfare of affected households due to environmental change induced by policies on the NRE sector; and (f) the reverse effects of the change in welfare of households from other sectors of the economy induced by policies, on the NRE sector.

For an overall framework, the paper suggests that a CGE model be considered for the MIMAP project. Among others, the model has been empirically used in the Philippines and some MIMAP researchers are familiar with it. Also, the CGE model can be used to generate welfare indicators by disaggregating its households component into specific groups of interest to the MIMAP project.

For estimating the effects of adjustment policies on the NRE sector in terms NRE damage, the paper suggests the generalized I-O approach of first computing changes in sectoral output induced by policies through the CGE model and afterward deriving the changes in damage levels associated to changes in output by multiplying output changes by computed depletion or degradation coefficients.

As to the measurement of the effects of natural resource improvement or depletion induced by policies on the welfare of natural resource-based households, the paper suggests two possible approaches. The first approach is to disaggregate the household component of the CGE model to include resource-based sectors. The second approach is to apply the microeconomic valuation methods, either by using results of previous studies or conducting studies in selected MIMAP sites.

For evaluating the effects of environmental improvement or degradation induced by policies on the well-being of the affected households, similar approaches are suggested. Households in the CGE model can be disaggregated to include the urban poor, the group likely to suffer or benefit directly from environmental change. If not, microeconomic valuation may

be used, either by using results of previous studies or studying the urban poor households in some selected MIMAP sites.

The reverse effects of the change in welfare of resource-based households due to resource stock change induced by policies, on the NRE sector as well as the reverse effects of the change in welfare of affected households due to environmental change induced by policies on the NRE sector may be difficult to estimate and, hence, may be measured beyond models and valuation methods. A possible approach is to estimate resource and environmental damage functions with welfare, measured by some indicator such as income, as a dependent variable through regression analysis. Still another approach is to estimate damage-welfare ratios. These damage-welfare ratios can be employed to approximate the reverse effects of policies, together with parameters derived from the computation of other potential effects.

Lastly, for the reverse effects of the change in welfare of households from other sectors of the economy induced by policies, on the NRE sector, the paper suggests the approach of studying the migration pattern of the urban and lowland interior populations to the upland and coastal areas based on results of previous studies or those of a new study to be done by MIMAP. Computation of the effects will use migration parameters as well as parameters derived from the computation of the other effects of policies.

The paper concludes that the final choice of approaches to be employed by the MIMAP project in the evaluation of the effects of macroeconomic adjustment policies on the NRE sector and household welfare will depend not only on technical considerations but on practical factors as well. Among the practical factors are the availability of secondary data and information, expertise of MIMAP

researchers and the general availability of MIMAP resources for research. These considerations will form an important part of the set of criteria by which particular approaches will be chosen over others. At this point, the criteria must be clearly set-up so that the choice of particular approaches to be used for MIMAP can be decided.

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