ENVIRONMENTAL ECONOMICS CONCEPTS AND EVIDENCE FOR SUSTAINABLE DEVELOPMENT

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Introduction

To some, the juxtapositioning of the terms environmental and economic is an oxymoron. Individuals holding strong views about ultimate ends and environmental preservation as well as those concerned with entropy and ultimate means may feel that "economics" is one of the major causes of environmental degradation. However, economics, particularly the sub-field of natural resource and environment economics, provides many useful insights for sustainable land use and agricultural growth because it includes explicit concern for defining natural resource related property rights and valuing environmental service flows. This paper briefly reviews some key environmental economic and sustainability concepts relevant to land use and agricultural growth. It also presents the results of an analysis of the factors determining the agricultural and food production growth rates in a sample of 23 developing countries. The results of this analysis are used to develop some policy implications for sustainable land use and agricultural growth.

Much of the controversy over "economics" and the environment stems from the tendency to treat the environment as a free good or God given right rather than a source of raw materials and a waste disposal "sink" with limits. In the simplest materials balance model, Freeman et al. view the environment as a large shell surrounding the economic system. It has the same relationship to the economy as does a mother to an unborn child -- it provides sustenance and carries away wastes. Raw materials flow from the environment, are processed in the production sector (that is, converted into consumer goods), and in part, pass on to the household sector. The materials returning to the environment from the household sector are wastes or residuals. They are the unwanted byproducts of the consumption activities of households. Similarly, not all of the material inputs that enter the production sector are embodied in the consumption goods flowing to the household sector. These are the wastes or residuals from production. Thus, there is a flow of residuals from both the production and consumption sectors back to the environment.

If the environment's capacity to absorb or assimilate wastes or residuals were unlimited, there would be no major environmental problems. However, the assimilative capacity of the environment is limited and in the case of some residuals like mercury it has no assimilative capacity. One of the limits of the environment's capacity to assimilate is the conflict or competition with other environmental services such as human habitat, esthetics, plant and animal biodiversity, and raw materials inputs to the economic system. This suggests the need for more comprehensive measures of the social costs and benefits of various environment services in order to facilitate sustainable agricultural development.

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Sustainability of agriculture and other natural resource based systems is a very popular concept, a bit like motherhood. It seems like a common sense idea, but the concept has many ambiguities and alternative points of view. Dixon and Fallon suggest that these viewpoints can be grouped into three distinct categories including: (1) a purely physical concept for a single resource such as a fishery where the rule is to use no more than the annual increase in the resource, i.e., maximum sustainable yield, (2) a physical concept for a group of resources or an ecosystem where a variety of system outputs involve trade-offs, i.e., individual resources may be enhanced, maintained or degraded to maintain system integrity, and (3) an environmental economic concept with emphasis on economic rationality and some minimal level of environmentally sustainable economic growth. This latter concept with emphasis on sustaining some level of agricultural growth is the conceptual starting point for this paper. A static or steady state notion of agricultural sustainability does not address the projected global increases in population and demand for food.

Historically, economic development has been based heavily on exploitation of natural resources, particularly of land resources. Soil erosion and land degradation have been serious worldwide. High population pressure on land, poorly defined property rights, and limited fossil energy supplies, result in land degradation that is generally more serious in the developing world. Empirical studies show that soil erosion and degradation of agricultural land not only decrease the land productivity but they can also result in major downstream off-farm or off-site damage (Crosson, 1985; Hauck, 1985; Clark et al., 1985; Warford, 1987b; Hitzhusen et al., 1984). Clark (1985). Furthermore, the off-site damage may be several times that of on-site damage (Crosson, 1985; Clark et al., 1985; Hitzhusen et al., 1991).

The exploitation of natural resources, particularly in developing countries continues in large part because they are not priced at their marginal social values. This underpricing in turn occurs because most centrally planned and some private market economies with imperfectly defined and enforced property rights fail to fully internalize the external costs or environmental service benefits related to the use of these natural resources. Environmental economists usually talk about at least four categories of social opportunity costs related to environmental services including: (1) direct costs to current users, (2) external costs borne by others now and in the future, (3) foregone benefits of future users from a depleted resource, and (4) existence values for the sustainable maintenance of a given resource. The following two sections utilize an environmental services flow framework to develop the foregoing and additional concepts in detail.

Concept of Environmental Service Flows

Measuring and evaluating complex impacts involving agriculture and the environment with a concern for sustainability requires an awareness of paradigms, assumptions and inter-relationships of disciplines. Conway argues that agroecosystems may be regarded as true cybernetic systems whose goal is increased social value. This is achieved by combining different levels of productivity, stability, sustainability and equitability, and agricultural development involves making trade-offs between these properties. Marten adds the property of autonomy and calls attention to two major complications of this approach: (1) multi-dimensional character of these properties due to independent measures of agricultural production and differences in the same property at different hierarchial levels of an agroecosystem, and (2) significant limitations in generalizing from one set of environmental and social conditions to another. Clearly, some simplification and differentiation by ecoregion will be necessary to make these concepts operational.

I find it useful (Figure 1) to view agriculture as a human induced biological adaptation utilizing both ultimate and intermediate means to satisfy intermediate needs of humans for food and fiber. As such, agriculture as a sub-set of a larger socio-economic system is dependent on raw materials (e.g., water, nutrients) from the natural environment and returns some residuals (e.g., soil sediments, food wastes, chemicals) from the production and consumption of its products back to the natural environment. Some of these residuals can be fully assimilated as eco-system food, but others may interfere with one or more of the basic service flows of the environment including (1) raw material supply, (2) assimilative capacity, (3) basic human habitat, (4) amenities/aesthetics, and (5) plant and animal biodiversity (see Hitzhusen, 1984 and 1992).

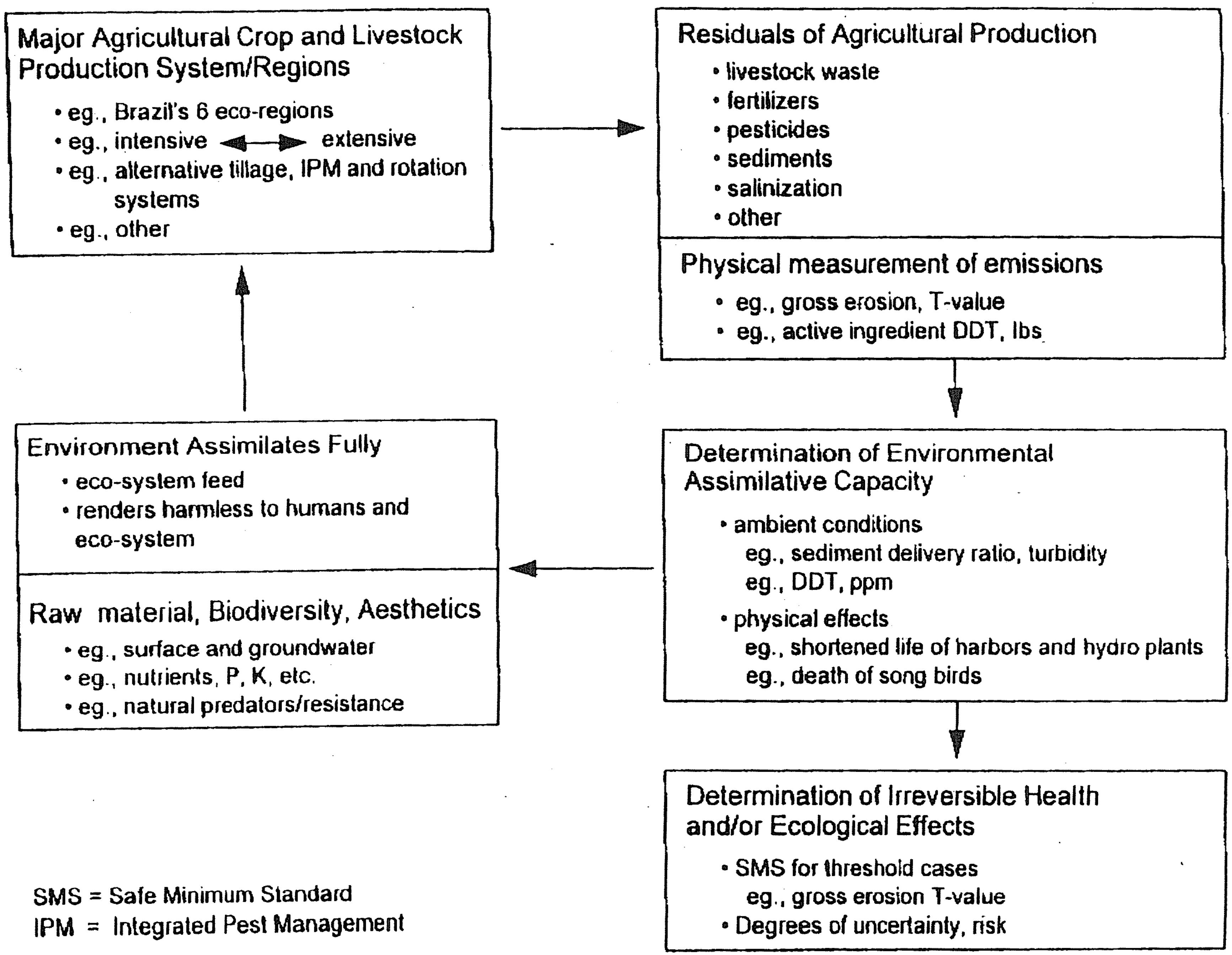
Environmental impact assessment involves measuring and understanding the magnitude and nature of these raw materials, assimilative, and other functions for each of many agriculture crop and livestock production systems and/or regions. It is particularly important to identify residual flows (e.g., DDT) that may have significant and irreversible effects, but it is equally important to identify production systems that enhance one or more of the environmental service flows. For example, higher yields on the best cropland may reduce the pressure to degrade wildlife habitat or other service flows on more marginal lands. When the physical and ambient (e.g., ppm) impacts have been identified by physical and biological science disciplines, it is possible for those practitioners of my own field (environmental economics) to apply a variety of direct and indirect means to discern full economic values or what we refer to as social (vs. private) benefits and costs. This is the focus of the next section.

Monetizing Environmental Service Flows

Social costs and benefits or gains and losses from an economic perspective refer to the aggregation of individual producer and consumer measures of full willingness to accept or pay compensation. Individual preferences count in the determination of social benefits and costs and are weighted by income or more narrowly by market power. Since most policy changes involve economic gainers and losers, economists have developed the concept of potential Pareto improvement (PPI) to add up gains and losses to get net benefits. Simply stated, the concept holds that any policy change is a PPI or an increase in economic efficiency if at least one individual is better off after all losers are compensated to their original or before the policy change income positions. The compensation need not actually occur but must be possible (Dasgupta and Pearce).

These measures of social costs and benefits are often not fully reflected in current market prices (or in government regulated prices) as in the case

Figure 1. AGRICULTURE AND THE ENVIRONMENT: An Environmental Economic Framework



of crop production in an area with high rates of soil erosion. This divergence results from several factors. First, government subsidies of inputs and/or outputs can lead to levels of input use and outputs in agriculture which are not economically efficient or environmentally sustainable, particularly in the case of agricultural chemicals. Secondly, because there are consumers willing to pay more and producers willing to sell for less than prevailing market or regulated prices, they receive what economists call consumer and producer surpluses. Thirdly, technological externalities in agricultural production exist to the extent that, external to the production and consumption of the resulting output, individuals, households or firms experience uncompensated real economic losses (or gains) from soil erosion, agricultural chemicals or other residuals. Finally, there may be willingness to pay to keep future economic options such as hydro-electric generation open (see Veloz et al.) or WTP for existence value of plant or animal species threatened by water pollution which are not reflected in the market or government regulated prices of agricultural inputs and/or outputs (see Hitzhusen, 1993).

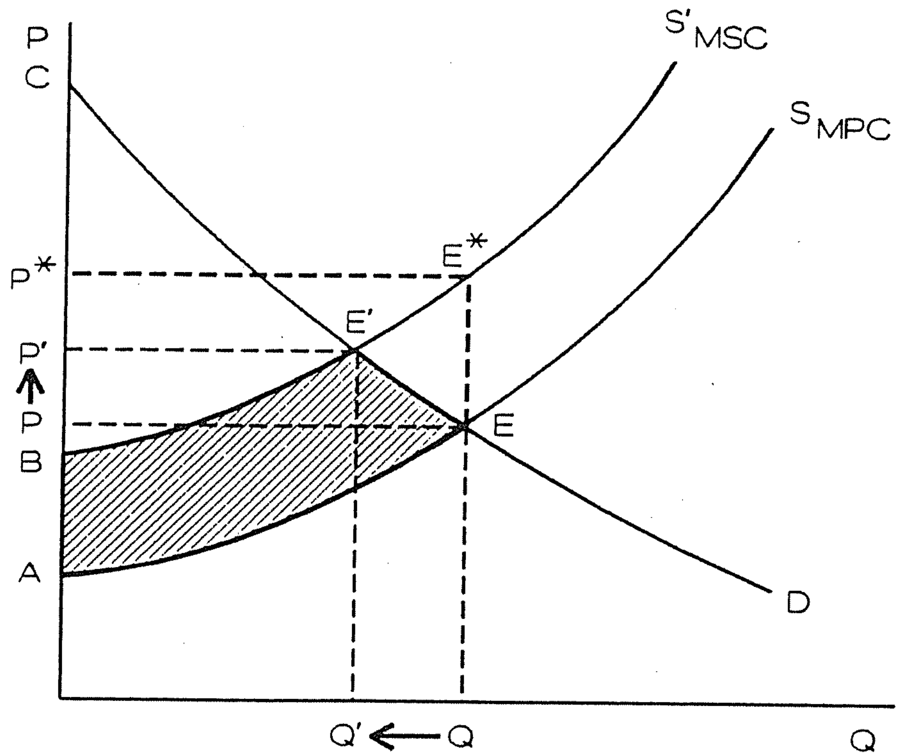
Figure 2 illustrates both the concepts of economic surplus and technological externality. For example, at market price P consumer surplus is equal to area PEC and producer surplus is equal to area PEA. One might think of P as the market price at equilibrium pt E where marginal private cost MPC of the farmer is equal to demand or marginal willingness to pay. Farm output at Q also includes the joint production of soil erosion and surplus chemicals which impose social costs on downstream watershed residents represented by P* and E*. One might also think of this as producing residuals (sediment and chemicals) that exceed environmental assimilative capacity. These external social costs are fully internalized at P′ E′ Q′. The shaded area BE′EA represents the net loss in producer and consumer surpluses from the presence of the soil and chemical externalities or alternatively the net gains from internalizing these external effects.

With the notion of conceptualizing and measuring environmental service flows established in the previous section, it is possible to develop specific values, measures, instruments and options for environmental economic assessment of these service flows and their interdependence with agricultural systems. Figure 3 summarizes this process. ***Direct current use value*** refers to agricultural use of environmental service flows such as fossil fuels and water. ***External values*** are those uncompensated costs or benefits (externalities) from agricultural production or consumption processes that are borne or received now or in the future but not reflected in current prices to producers or consumers. ***Option value*** refers to the willingness to pay to delay the use of something until some future time while ***bequest value*** refers to a willingness to preserve something for the use of future generations. This is related to the notion of foregone benefits to future users from current exhaustion of a finite resource without any close substitutes. ***Existence value*** is the willingness to pay for preservation of plant and/or animal species without regard for their use by humans (see Dixon et al., Hoehn and Walker).

Economists use a variety of measures or methods to infer or discover these foregoing values. Sometimes it is possible to directly observe values in existing prices and in other cases it is necessary to infer values from

FIGURE 2

SOIL EROSION AS AN EXTERNALITY



Technological Externality Defined (Dasgupta & Pearce 1978)

1. Necessary Condition
   Physical interdependence of production and/or utility functions
2. Sufficient Condition
   Not fully priced or compensated

S = marginal private (e.g., upstream farmer) cost function
S' = marginal social (e.g., watershed) cost function
D = demand or marginal benefit function
Q = output quantity
P = price unit of output

prices of closely related complementary goods. In the first case, reduction in commercial fish catch from agricultural pollution (externality) of a lake can be measured in lost fishing revenues. However, any reduction in sport fishing in the same lake would require assessment of any decrease in expenditures on goods and services related to boating and sport fishing activity, i.e., the development of a travel cost or proxy demand function method (see Macgregor et al.).

The value of an externality can also be conservatively estimated in some cases by either clean-up or avoidance costs such as harbor dredging and water treatment related to soil sediments and agricultural chemicals. In addition, the impact of an externality on private property values can frequently be estimated by hedonic pricing which is a method for statistically decomposing the sources of value or demand in a property market to allow independent estimation of an environmental amenity or disamenity (see Hitzhusen et al.). Contingent valuation refers to a survey method which estimates willingness to pay values directly from respondents for some change in an environmental service flow. This method is the most comprehensive for simultaneously estimating all of the types of economic value outlined in Figure 3, but it requires careful development to avoid strategic behavior of respondents.

In cases of environmental service flows with a critical zone or threshold, it may be necessary to establish a safe minimum standard (SMS) or maximum sustainable yield (MSY) (Barbier et al.). The objective is to avoid irreversible effects to human health or eco-systems such as in the case of nitrate-nitrogen contamination of groundwater in parts of the United States. Contamination is considered critical to human health at 10 mg/l which was established by the U.S. Environmental Protection Agency. The T-value in the Universal Soil Loss Equation (USLE) is an example of a somewhat more flexible or reversible SMS relative to long run productivity of the soil. The MSY of a water aquifer may be a withdrawal rate equal to or less than the annual recharge rate, which becomes critical in cases where the aquifer is covered by a heavy rock overburden. In these cases, excess withdrawal can result in irreversible loss in aquifer capacity.

Once some basic economic estimates have been established for environmental service flows relative to key agricultural production, processing, etc. systems, it is possible to select instruments to accomplish more efficient and/or equitable outcomes. Economists prefer instruments that provide incentives and allow a range of choices as opposed to command and control instruments. Examples include taxes, subsidies and auctioning of assimilative capacity up to some resource constraint or SMS. Well defined property rights are a recurring theme of economists and this is equally true of any changes in property or use rights related to environmental service flows.

The foregoing instruments are usually applied in the analysis of specific options regarding agriculture and the environment. Examples include crop rotation, reduced tillage and integrated pest management (IPM) with relatively more emphasis on biological vs. chemical control. For example, taxes (or even full market cost pricing) regarding nutrients or chemicals used in agriculture may provide an incentive to substitute more biological control and crop rotations. Penalties or taxes for soil loss above T would stimulate substitution of reduced tillage and rotations which might in turn result in the need for fewer purchased nutrients and chemicals. If society wants soil loss rates below T, a subsidy to the farmer would be a strategy consistent with current property rights (Hitzhusen, 1992).

The planned economy or private market imperfections at the microeconomic or watershed level in the case of soil erosion also manifest themselves as imperfections in national income accounting at the macroeconomic level. Repetto [1989] argues that by ignoring natural resources [or the broader notion of environmental services], statistics such as the gross national product (GNP) can record illusory gains in income and mask permanent losses in wealth. As a result, a nation could exhaust its minerals, erode its soils, pollute its aquifers and hunt its wildlife to extinction - all without affecting measured national income. For example, Indonesia's high 7.1 percent economic growth rate as measured by gross domestic product (GDP) from 1971-84 is only 4.0 percent when GDP is adjusted for unsustainable soil erosion, forest harvest in excess of annual growth and oil reserve depletion. One option is to reinvest economic gains from natural resource depletion in human capital development. Another is to do more comprehensive analysis of social benefits and costs of depletion.

Detailed micro or watershed level evaluations of the social opportunity costs of natural resource use are important, but difficult and costly to do. Likewise, major revisions in the national income accounts regarding pricing, depreciation, etc. of natural resources are underway in a few countries, but depend in part on better microeconomic evidence and will take considerable time to complete. As an intermediate step, it is useful to determine the role of natural resources or specifically the importance of land degradation in agricultural growth, particularly in developing countries.

Land Degradation and Ag Growth Model

A recent study by Zhao et al. (1991) focused on identifying the factors that determine the agricultural production growth rate and in testing the effects these factors have on agricultural growth in developing countries. Specifically, this study involved statistical estimation of an aggregate agricultural growth function based on cross-country data for 23 developing countries. Special attention was devoted to environmental degradation, and agricultural pricing policy and to the policy implications resulting from the effects these variables have on agricultural and food production growth.

The methodology used is based on the concept of a metaproduction function hypothesized by Hayami and Ruttan (1985). Following Lau and Yotopoulos (1987), this metaproduction function can be written as:

$$(1)\ y_t = f\ (X_{1t}, \ldots, X_{mt}, t)$$

where Y_t is the quantity of output, X_{it} is the quantity of ith input, i = i..., m, and t is time. This production function can be used to represent the input-output relationship of agriculture or food production. As defined by Lau and Yotopoulos, the embedded hypothesis for this metaproduction function is that all producers (or countries) have potential access to the same set of technology options but each may choose a particular one, depending upon its natural endowment and relative prices of inputs. In the Zhao (1988)

References

Argawala, R., 1983. "Price distortion and growth in developing countries." World Bank Staff Working Paper No. 575, World Bank, Washington, D.C.

Bale, M.D. and E. Lutz, 1981. "Price distortions in agriculture and their effects: An international comparison," Am. J. Agric. Econ., 63:8-22.

Clark, II, E.H., J. Havercamp, and W. Capman, 1985. "Eroding soils: The off-farm impacts," The Conservation Foundation, Washington, D.C.

Crosson, P., 1985. "Impacts of erosion on land productivity and water quality in the United States," in: S.A. El-Swaify (editor), Soil Erosion and Conservation.

Dixon, J.A. and L. Fallon, 1989. The concept of sustainability: origins, extensions and usefulness for policy," Soc. Nat. Resour., 2: 73-84.

Dregne, H.E., 1982. "Impact of land degradation on future world food production," ERS-677, U.S. Department of Agriculture, Washington, D.C.

Hauck, F.W., 1985. "Soil erosion and its control in developing countries," in: S.A. El-Swaify (editor), Soil Erosion and Conservation. Spoil Conservation Society of America, Ankeny, IA.

Hayami, Y. and V.W. Ruttan, 1971. "Agricultural productivity differences among countries," Am. Econ. Rev., 60:895-911.

Hayami, Y. and V.W. Ruttan, 1985. Agricultural Development: An international perspective, Johns Hopkins University Press, Baltimore.

IBRD, 1980. World Development Report. Oxford University Press, New York.

IBRD, 1986. World Development Report. Oxford University Press, New York.

IIED and World Resource Institute, 1986. World Resource 1986. Basic Books, New York.

Freeman, A. Myrock, Robert Haveman and Allan Kneese. 1973. The Economics of Environmental Policy, John Wiley and Sons, Inc., New York.

Hitzhusen, Fred J., 1991. "The economics of sustainable agriculture: adding a downstream perspective," Journal of Sustainable Agriculture, Vol. 2, No. 2, p. 75-89.

Hitzhusen, Fred, Bob Macgregor and Doug Southgate, 1984. "Private and social cost-benefit perspectives and a case application on reservoir sedimentation management," Water International, Vol. 9, pp. 181-189.

Kawagoe, Toshihiko, Hayami, Y, and Ruttan, V.W., 1985. "The intercountry agricultural production function and productivity differences among countries". Journal of Development Economics Vol. 19, pp. 113-132.

Krishna, Raj, 1982. "Some aspects of agricultural growth, price policy and equality in developing countries," Food Research Institute Studies, 18 (3).

Lau, Lawrence J. and Yotopoulos, Pam M., March 1987. "The metaproduction function approach to technological change in world agriculture," Memorandum No. 270, Stanford University.

Myers, Norman, 1987. "The environmental basis of sustainable development". Annals of Regional Science. Vol. 21, No. 3.

Repetto, Robert, 1989. "Wasting Assets: The need for national resource accounting," Technology Review, January 19989, pp. 39-44.

Repetto, Robert, 1987. "Economic incentives for sustainable production," Am. Reg. Sci, 21(3):44-59.

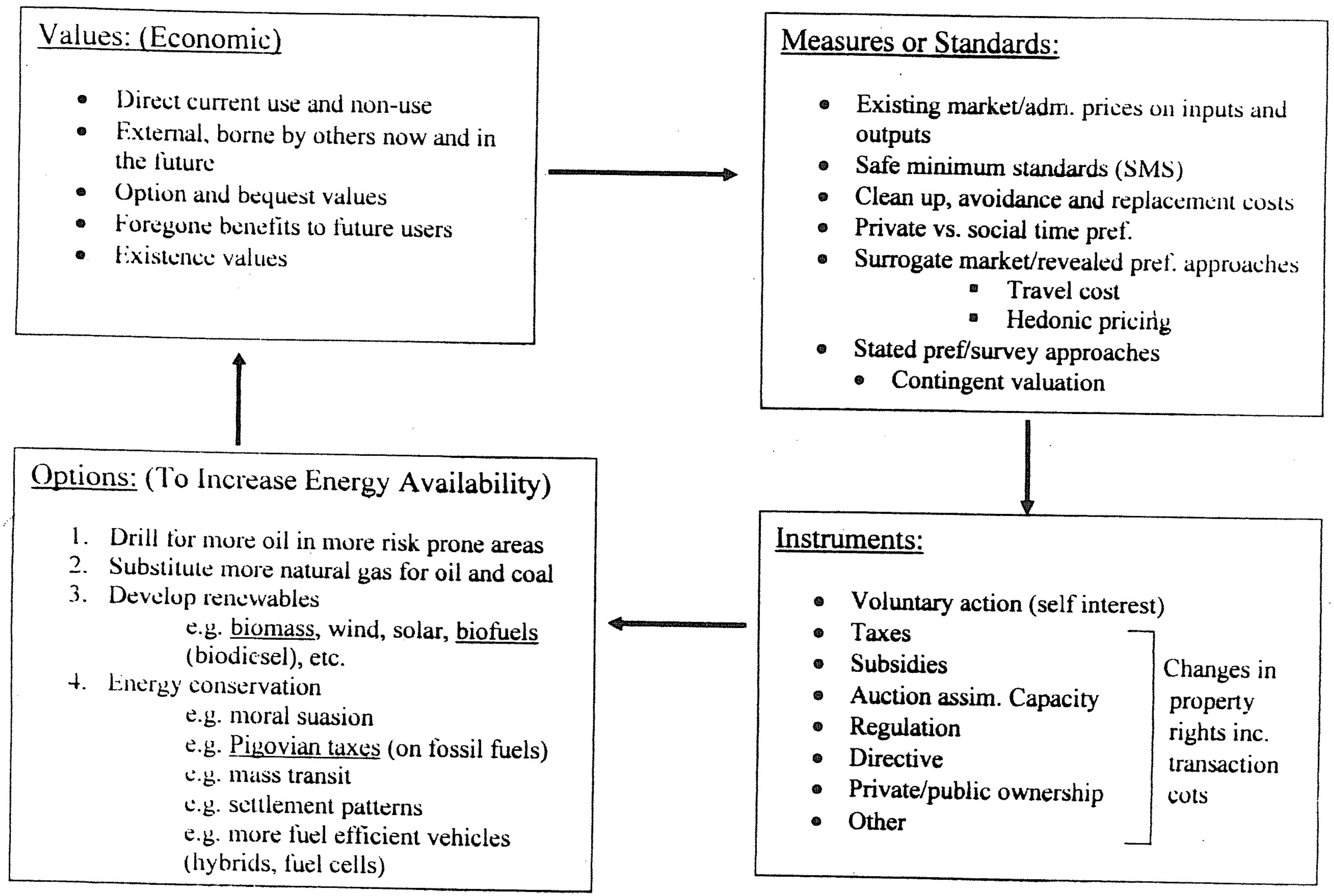
Schultz, T. W. (Editor), 1978. Distortions of Agricultural Incentives. Indiana University Press, Bloomington.

Timmer, C. Peter, and Falcon, Walter P., 1975. "The political economy of rice production and trade in Asia", in L.G. Reynolds (Editor), Agriculture in Development Theory. pp. 373-408. New Haven: Yale University Press.

Warford, Jeremy J., 1987b. "Natural resources and economic policy in developing countries." Annals of Regional Science. Vol. 21, No.3.

Zhao, Fengkun., 1988. "Some new evidence on factors related to agricultural growth in the Third World." A thesis for M.S. degree, Department of Agricultural Economics and Rural Sociology, The Ohio State University, (unpublished).

Zhao, Fenkum, Fred Hitzhusen and Wen Chern, 1991. "Impact and implications of price policy and land degradation on agricultural growth in developing countries," Agricultural Economics, Vol. 5, p. 311-324.



MSY = Maximum Sustainable Yield

Figure 2. Monetizing energy related environmental service and residual flows and implementing change/reform.