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NEOCLASSICAL ECONOMICS AND PRINCIPLES OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

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This paper reviews the principal policy-related issues for which the professions of ecology and economics provide conflicting prescriptions. Emphasis is placed on the work of the World Bank, although the issues raised are relevant to a broad range of organizations. Rather than providing definitive solutions, the paper suggests an agenda for research in the ecology–economics interface.

Present-day neoclassical economic theory and its applications to development policy seriously overlook or undervalue major ecological concerns. The economic values of environmental services, while very real, are systematically underestimated in cost–benefit analysis because of measurement and valuation difficulties. 'Intangible' environmental benefits, such as those derived from the preservation of biological diversity, are recognized even less in economic analysis. The irreversible environmental effects of projects or policies are usually treated no differently from more reversible effects. The practice of discounting economic costs and benefits strongly favors projects with short-term benefits and long-term costs, often (though not always) with highly negative environmental effects. Using Gross National Product as a measure of development progress encourages rapid overexploitation of a country's natural resource base. Extravagant natural resource consumption by industrialized countries may undermine long-term development prospects of developing countries. The emphasis of many developing countries on export crops rather than domestic food production often entails major environmental costs.

The paper outlines some of the principles of ecologically sustainable development. At the project level, safe minimum standards are an important environmental supplement to cost–benefit analysis. At the national policy level, steady-state economics can be used to reconcile economic planning with the limits to growth in natural resource consumption.

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1. INTRODUCTION

1.1 *Objectives*

This paper addresses the interface between ecology and economics [1]. In particular, it suggests areas where neoclassical economic [2] theory and applications could be modified to accommodate environmental concerns more adequately. In this paper we seek to sensitize economists to some of the problems with which ecologists are struggling. The paper does not pretend to offer solutions; instead, it suggests an agenda for research in the ecology–economics interface. Little of the material presented here is entirely new; Pigou (1912) broached these issues long before there was substantial environmental awareness. Rather, we seek to describe briefly the principal economic policy-related issues which have often been a source of contention between ecologists and environmentalists on one hand and most economists on the other. Our examples are taken primarily from the work of the World Bank, although the issues we discuss are equally relevant to a wide range of organizations, in developed as well as developing countries.

We feel that this paper is needed because current economic practice does not adequately accommodate environmental concerns in a wide variety of situations. Most orthodox literature on economic development (e.g., Little, 1982), and on cost–benefit analysis (e.g., Ray, 1984) scarcely acknowledges any of these concerns. We recognize that natural-resource policy issues involve many difficult trade-offs. With this paper, we seek to initiate a process through which the economic analysis used to evaluate these trade-offs can gradually be improved.

1.2 *Perspective*

Economics is the study of allocating the resources available to society in a way that maximizes social well-being. If something must be forgone or sacrificed in order to achieve a social goal, the economic choices are involved. Economics attempts to tell us how we can make the trade-offs among tangible, material goods in the most efficient, or 'Pareto-optimal',

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[2] As used here, 'neoclassical' refers to a spectrum of more or less conventional, market-oriented capitalist economics. Neoclassical (rather than, e.g., Marxist) economic analysis is the principal focus of this paper because of its heavy use by international development agencies, government officials, and other development planners.

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manner. A Pareto optimum is defined as a state of the economy in which all economic resources are allocated and used 'efficiently', such that it is impossible to make anyone economically better off without making someone else economically worse off.

A major advantage of efficient markets is their ability to attain Pareto-optimal resource allocation (which is no small achievement). However, a Pareto-optimal allocation can occur at an ecologically unsustainable pattern of resource use, just as it can occur at an ethically undesirable pattern of income distribution (D. Pearce, 1976b). Pareto optimality is defined independently of both income distribution and the physical scale of resource use. Public policy decision-making which relies exclusively on market criteria (and, by extension, cost–benefit analysis centered on present-value maximizations) can effectively address only short-term allocative efficiency — not many of the other important factors which determine human welfare. These factors include income distribution, intangible environmental goods, and the prospect of a safer future that can be achieved by sustainable natural resource use (Daly, 1977; Hueting, 1980a, 1984). Therefore sustainability, like equitable income distribution, cannot be properly determined with typical efficiency criteria, using techniques such as conventional economic cost–benefit analysis.

The limitations of economic-efficiency criteria in guiding economic policy decisions are now acknowledged by many institutions, including the World Bank. Neoclassical normative economics is now being modified to allow for social and income distribution effects (D. Pearce, 1980; Squire and Van der Tak, 1981); similar modifications should be added to acommodate environmental concerns. For example, sustainability criteria can be incorporated into cost–benefit analysis as a constraint on maximization (Section 3.3). Dasgupta (1982) discusses modifications to neoclassical economics to accommodate the sustainable use of renewable resources, and of extensions of the efficiency principle to the environment as a renewable resource.

1.3 *Environment at the World Bank*

The World Bank is progressing on two major fronts. First, some environmental protection components of development projects are readily justified on conventional economic grounds. For example, a Bank-assisted irrigated rice project provided funds for establishing and managing the 3200-km^2 Dumoga National Park in Sulawesi, Indonesia. The Park's dense tropical forests encompass the entire watershed catchment area for the project's irrigation works. Protecting these forests thereby also protects the irrigation works, by reducing sedimentation and resulting maintenance costs, and by helping to prevent irregularities in water supply (World Bank, 1987). The

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other significant environmental benefits of the Park (e.g., preservation of endangered species) were not encompassed by the project's economic analysis, and were not necessary to justify the component. In this case, conventional economic analysis was sufficient to justify the strong environmental measures which were taken. Many similar environmental protection components are tabulated in World Bank (1987).

Second, the World Bank implements some environmentally desirable policies and components of developments of development projects whether or not they meet conventional economic criteria. In particular, the Bank has officially committed itself to supporting a number of 'safe minimum standards' for sustainable development (discussed in Section 3.3).

This paper addresses the broad area between these achievements, i.e., those aspects of environmental management which are neither justified by conventional economic analysis, nor undertaken in spite of it. The paper outlines major issue areas within neoclassical economics that need to be supplemented with environmental principles in order to promote more sustainable development strategies. It points out that modified forms of economic analysis and alternative methods of project evaluation will be necessary in some cases. However, implementing many of the suggested changes would often require further study; such details are generally beyond the scope of this paper.

Current environmental input to Bank-supported development projects consists largely of modest modifications, introduced during the early planning and design stages of the project cycle. (This approach is superior to merely adding an 'environmental impact statement' to the end of a previously designed project.) This tactical process of project-specific environmental modifications is gradually improving in most sectors. It continues to occupy most of the time of the Bank's Office of Environmental and Scientific Affairs. Assuming that staffing by environmental professionals is adequate, it is reasonable to expect that this process will eventually become systematic and institutionalized within the project cycle. However, even a routine and comprehensive project advisory review process is not enough to ensure sufficient attention to environmentally sound natural resource management in Bank work. This goal can only be reached by adopting a more strategic, 'upstream' approach in the project cycle. This process includes the development and refinement of environment-related Bank policies (such as those concerning involuntary resettlement, tribal peoples, environment, wildland management, and cultural properties). It also implies more systematic attention to environmental and natural resource concerns in country-focused strategies and other economic and sector work. Furthermore, this strategic approach implies modifying the Bank's methodologies for economic analysis in certain situations. This paper focuses on this latter

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concern. It presents the case that further attention should be focused on defining specific principles of sustainable development and appropriately integrating them within neoclassical economic theory.

2. PROBLEMS OF ESTIMATING VALUES

Economic cost–benefit analysis (CBA) is a tool for aggregating, across individuals and over time, the economic value of a project's effects, measured in terms of market prices. The CBA criterion typically used in project work at the World Bank is 'net present value' (NPV), indicated by the formula:

$$\text{NPV} = \frac{B_1 - C_1}{1 + r} + \frac{B_2 - C_2}{(1 + r)^2} + \cdots + \frac{B_n - C_n}{(1 + r)^n}$$

where B_n is monetary value of benefits in year n, C_n monetary value of costs in year n, r discount rate, and where B and C relate to the monetary value of any gain (or loss) in human welfare arising from the project in question.

In the following discussion, B and C are considered together since costs can be viewed as sacrificed or foregone benefits; the term r is discussed separately in Section 2.7 on the discount rate. We emphasize that all of the environmental concerns that are relevant to NPV analysis apply equally to related cost–benefit analysis methodologies. These include internal rate of return, equal annual equivalent, and several benefit–cost ratio approaches.

NPV or similar cost–benefit analysis techniques represent a monetary measure of benefit. But benefit is difficult to measure directly, since, above a basic level, it is ultimately a psychic experience of satisfaction of wants (utility). McKenzie (1983) summarizes the literature on what economists feel is being measured when using benefit measures (consumer surplus). Since prices reflect marginal utility only as it pertains to marketed goods, there is a substantial difference between monetary valuation by means of prices and any valid measure of total satisfaction. At best, a change in monetary values attributable to a project becomes an imprecise index of change in people's level of satisfaction.

Some critics of the welfare economics upon which cost–benefit analysis is based argue that once basic human needs are satisfied, there is little or no good evidence that individuals' happiness (or utility) is positively associated with absolute income levels. These critics (e.g., Hirsch, 1976; Sagoff, 1983) claim that a person's *relative* income (i.e., relative to those individuals chosen for comparison) is a much more important factor in psychic utility than *absolute* income. Thus, a uniform, society-wide increase in income may have little actual effect on aggregate utility, if people's relative positions in society remain unchanged and if basic needs have already been satisfied.

Based on this perspective, economic efficiency does not emerge as an important goal of public policy when compared with such goals as universal satisfaction of truly basic needs, equitable income distribution, preservation of civil liberties or ecological sustainability. This paper does not seek to develop this argument further. We have mentioned it briefly here primarily to show there there is less than broad consensus in most societies that an aggregate goal of economic efficiency is especially important, except to the extent that policies which promote economic efficiency also advance other goals (e.g., meeting basic needs).

Despite the many deficiencies of CBA, it can still be useful for advancing environmental goals. Even unreasonably low or highly inaccurate estimates of environmental benefits and costs are better than none, because the alternative is to assume implicitly that these benefits and costs are zero. Rather than abandoning CBA, environmentalists should insist that it take environmental and other social costs explicitly into account. As is disussed in Section 3.3, CBA is most useful from an environmental perspective when it is 'constrained' by safe minimum standards.

2.1 *Problems of physical measurement*

Development projects have many 'tangible' environmental consequences which, while very real, cannot readily be assigned a monetary value. This is due to the difficulties inherent in both physical estimation and monetary valuation of the relevant environmental effects. In terms of physical effects, it may be difficult, as an example, to predict a priori to what extent the building of a rural road through a forested area may affect soil erosion, as well as downstream sedimentation and water quality. Similarly, it may be very difficult to predict to what extent the projected use of agricultural chemicals in an irrigation project may reduce downstream fish catches, particularly in the longer term. In practice, physical estimation of the environmental effects of a proposed project usually amounts to little more than educated guesswork. This uncertainty is due in part to the relative lack of appropriate scientific data in most developing countries, as well as the site-specific nature of many environmental effects.

Difficulties in the physical estimation of relevant environmental effects are further compounded by the fact that relatively gradual changes in resource use can sometimes produce discontinuous and catastrophic effects in multi-species ecosystems. These changes may be counter-intuitive and irreversible. For example, there have already been a number of unexpected ecological collapses in economically important ocean fisheries (WRI and IIED, 1986). There is a gradation of confidence in the physical measurement of environmental impacts, depending on what types of effects are being measured (Kneese and Sweeney, 1985).

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Even when the physical environmental effects of a proposed project can be predicted with some accuracy, monetary valuation of these effects can still prove impossible or exceedingly difficult. This is particularly evident in the case of many 'environmental services'. Environmental services are beneficial functions performed by natural ecosystems, such as maintenance of water flow patterns, protection of soil, biodegradation of pollutants, recycling of wastes, support of fisheries and other economically important living resources, and regulation of climate. Despite their actual economic value and importance to meeting human needs, environmental services are frequently ignored or underestimated in CBA because they are usually public goods, not priced in the market-place. Some environmental services, such as soil fertility on private land in areas where land tenure is secure and efficient land markets exist, can be private goods, and may therefore be reflected in market values and captured in economic analyses. However, situations such as this are the exception, rather than the rule. This is particularly the case in many developing countries, where land markets are highly distorted and land tenure is often insecure.

A variety of different techniques have been used to estimate the shadow prices of environmental services (D. Pearce, 1976a, 1978; Ahmad, 1983). For example, it may be possible to estimate the cost of replacing some lost environmental services (to some specified extent) through other means (such as check dams for flood and erosion control). Alternatively, the cost of compensating victims for environmental damage (such as increased flooding or air pollution) can be estimated, to the extent that such victims can be identified. For specified situations, a variety of other valuation approaches exist (World Bank, 1987). Despite these methodologies, estimation of shadow prices [3] for tangible environmental goods and services remains incomplete and is rarely practiced on a systematic basis in project analysis.

Ahmad (1983) refers to some of the methodological problems of estimating shadow prices for environmental services:

> "In some instances, it is possible to infer a valuation from the actions of individuals in making trade-offs between market and non-market goods. Unfortunately, the results of this revealed preference approach are not always stable, consistent, or statistically valid. An alternative approach is to consider the implied values placed on similar benefits by other decisions, but in this case the analysis tends only to illustrate an inconsistency of approach, which, while useful in itself, may not help for the project under evaluation. A further approach is to study changes in the value of a marketable commodity, the price of which is likely to be influenced by the valuation placed on environmental factors... Again the analysis has its conceptual and statistical problems."

[3] 'Shadow prices' are economic values which are imputed to goods or services that have no market price (or for which the market price is considered 'distorted', such that it does not accurately reflect actual social costs and benefits).

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There is a logical analogy between the difficulties in measuring benefits from environmental protection and from the so-called 'soft' sectors (e.g., education, public health, and water supply projects). Projects in these sectors were formerly more difficult to justify on economic grounds because of the long gestation period of the investments, uncertainties about the exact nature of the links between these projects and socio-economic development, and the lack of relevant data. Now projects in the 'soft' sectors are more common (at least in multilateral development banks) because they are analyzed differently from more immediately productive projects. At the World Bank, the economic rate of return is not calculated for education projects; the social benefits are assumed to be high, especially if enrollment ratios are low. In the 1970s, primary education began to be recognized at the Bank as both a basic need and the foundation of all further education and training. Consequently, investments in this sub-sector are commonly justified on grounds of providing a necessary basis for successful long-term development and usually not by NPV or similar CBA techniques.

In recent years, increasing attention has been paid to the many non-market benefits of education. Reduced fertility, improved health and quality of child rearing, greater efficiency and rationality of educated people in the labor market and as consumers, and a better informed and more law-abiding citizenry are some of the non-market benefits of education. However, the very nature of these benefits makes their monetarization difficult. The absence of both relevant data and a suitable quantitative analytical framework still preclude using most of these benefits as quantitative investment criteria for education projects.

2.2 *Problems of valuing 'intangible' environmental benefits*

Intangible environmental values derive from the belief that many features of the natural world have a significant intrinsic value, quite apart from any 'practical' or utilitarian (i.e., economic) value which they may have. Clearly, if a need to preserve a known species is perceived and sacrifices have to be made to achieve this need, then economic choices enter. However, the need to preserve 'utilitarian' species is not yet adequately perceived; much less perceived is the need to preserve unknown species for their intrinsic value, or to avoid eliminating natural areas likely to harbor unknown or rare species. A significant and growing number of people believe that human beings should take care to avoid causing the extinction of other living species — even those species not yet known to have any practical value to humanity. Similarly, many people appreciate the mere existence of free-flowing rivers, or other undeveloped natural wonders, even when these people have no plans to visit or directly use them. Efforts to measure environmental values such as these, many of which have an ethical or spiritual basis. as an economic 'willingness to pay' have yet to become satisfactory (Hueting, 1980c; D. Pearce, 1980).

There are a number of reasons why valuing 'intangible' environmental benefits is so difficult. For example, people's preferences as self-interested, market-oriented consumers are often not consistent with their public policy opinions as socially-minded citizens (Lind, 1982; Sagoff, 1983). This does not mean that people are necessarily irrational — just that human valuation is too complex to be reduced to a simple summation of subjective individual wants. People cannot be perfectly knowledgeable, nor can all their wants be satisfied through the market place. Many ethical values are not revealed by market-place activity, nor by NPV or other forms of CBA. To the extent that ethics are important contributors to human happiness, policy makers should attempt to accommodate such ethical values, whether or not they can be measured by CBA.

2.3 *Gross national product and environmental accounting*

Gross National Product (GNP), a national account statistic that measures aggregate national generation of income, was never intended to be a complete measure of wealth or welfare, and few economists would argue that it is. Nonetheless, many institutions use GNP for exactly this purpose. As an example, many World Bank publications rank countries according to their per-capita GNP. The implicit message of such rankings is that rapid growth in per-capita GNP is an important goal of economic development. However, GNP (or the rather similar Gross Domestic Product, GDP) is seriously flawed as a measure of development success, for the following reasons:

(1) GNP does not measure income distribution or even the material well-being of the bulk of a country's population. Some countries (such as China and Sri Lanka) have managed to meet the basic needs of the great majority of their populations at very low levels of per-capita GNP. Other countries (such as Brazil or Algeria) have attained much higher GNP levels and rapid growth rates, while comparatively failing to meet the basic needs of many of their citizens.

(2) GNP measures only market transactions, not self-sufficient production. For example, households which grow their own food, without using purchased seeds, chemical fertilizers, biocides or other marketed inputs, do not have the value of their production reflected in GNP accounts. Self-sufficient production of food, clothing, and other goods still predominates in many developing countries, and may often be preferable to market-oriented production for a variety of environmental and social reasons (discussed in Section 2.6).

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(3) GNP measures the aggregate level of economic activity, but often this activity does not actually reflect social well-being. For example, more rapid obsolescence of consumer products can increase GNP. To use a hypothetical illustration, assume that person A buys five stoves, each lasting only 2 years, and person B buys one stove that lasts 10 years. Both consumers will have gotten the same level of utility, i.e., 10 years' worth of cooking service. However, in all likelihood, person A will have contributed considerably more to the GNP account than person B.

(4) Some of the economic activity measured by GNP is devoted to restoring, replacing, or compensating for environmental services lost through modern production systems. For example, sewage treatment plants reduce the water pollution that results from no longer recycling human waste as fertilizer; medical expenses help compensate for health damage due to asbestos or other unsafe products; and more frequent painting reduces corrosion damage from air pollution and acid rain. GNP therefore uncritically combines all market expenditures, irrespective of whether those expenditures are due to social 'goods' or 'bads'. If everyone who owns a car suddenly has an accident with it, GPN will go up; if everyone who owns a house installs a solar heater, GNP will ultimately go down!

(5) GNP measures economic 'flows', rather than the standing or 'asset' value of natural resource or other economic 'stocks'. This aspect, inherent in GNP accounting, can also short-change environmental concerns. Policy makers (who have been repeatedly told that rapid GNP growth is an important measure of successful development) may seek to 'liquidate' their natural resource base (e.g., forests or minerals) in order to convert a stock asset into a measurable economic flow.

Resource-rich countries, or those with unused renewable resources [4], can temporarily pursue such a policy of liquidation. But resource-poor countries, or those experiencing heavy population pressure on the natural resource base, may find that the undesirable effects of overexploitation (e.g., resource depletion, pollution) outweigh the benefits (Dasgupta, 1982; Mahar, 1985).

To the extent that privately held resources earn rent (e.g., a landlord's rented field), GNP accounts for resource depletion — but GNP includes such depletion as a benefit! However, national accounts statistics do not generally

[4] 'Unused renewable resources' is preferred over the somewhat environmentally deterministic concept of carrying capacity. Carrying capacity is defined as the maximum number of a given species that can be supported indefinitely by a particular habitat, allowing for seasonal and random change, without any degradation of the natural resource base that would diminish the maximum population in the future. Carrying capacity is analogous to the sustainable rate of harvest and is in turn dependent on the size of the resource stock.

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record depletion of natural resources incurred in generating income, even though this represents a loss to the country's natural resource wealth. Because many environmental services and resources are common property or public goods, their value is not reflected in the market place. Resources that are not accounted for are apt to be wasted or managed inefficiently. It is therefore important for governments to monitor their use, in order to make better-informed decisions. Modified accounting procedures would assist governments in improving resource management, including the management of consumption rates. To this end, the United Nations Environment Program (UNEP) and the World Bank have been collaborating through 'environmental accounting' workshops held in 1983, 1984 and 1985. The purpose of these workshops has been to develop methods that internalize natural resource stocks and environmental services in national accounts. The main problem is how best to operationalize this concept and incorporate it in policy. Complete correction of national accounts to reflect natural resource depletion is not yet possible due to the lack of appropriate shadow prices.

2.4 *North–South linkages*

It is frequently argued that the world's developed nations will help the developing nations by promoting their own economic growth, thereby increasing their demand for goods from the developing world (World Bank, 1984a). However, there is less than consensus on this point. Increasing affluence in the North appears more likely to increase the demand for services and high-technology goods, rather than for primary commodities from the South (Drucker, 1985). Furthermore, growth in industrialized countries consumes limited or scarce energy resources and often further encroaches upon the limited natural resource base of developing countries, thereby perhaps undermining their prospects for long-term sustainable development. For example, increased demand in the North for luxury or non-essential uses of finite resources, such as petroleum, is likely to drive up the prices that poor people in the the South must pay for them to satisfy their more basic needs. Such increased prices may, for example, compel more poor people to strip available forests for fuelwood to meet their cooking needs. Thus, the alternative hypothesis, that increased resource consumption in the North actually hurts development prospects in the South, merits closer attention.

A related question concerns the wisdom of using the industrialized countries of North America, Europe, and Japan as development models for the Third World. To the extent that present-day natural resource consumption patterns in these countries are unsustainable over the long term, it seems imprudent to attempt to generalize such patterns to the rest of the

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world. For example, Brown et al. (1984) make the case that universal private ownership of automobiles is not a desirable (or attainable) goal throughout the world, because automobiles are such extravagant consumers of natural resources. Instead, Brown et al. suggest that modern transportation systems be promoted, which can benefit most of the world's population, rather than only an affluent elite. The idea is not for people to forego the benefits of modern technology, nor to remain impoverished. Rather, it is to promote those technologies and development strategies which can provide an adequate, if not extravagant, living standard for essentially the entire population on a sustainable basis.

2.5 *Irreversibility and preservation of future options*

Many of the environmental consequences of development projects or policies are either completely irreversible, or reversible only over a very long time scale (by human standards). Examples of more or less irreversible environmental effects include species extinctions, groundwater contamination, fossil fuel depletion, loss of the traditional knowledge of indigenous tribal peoples when they are rapidly acculturated, soil erosion, human-induced climatic changes, and the removal of slowly-reproducing ecosystems such as coral reefs and certain type of forests. Many of the natural resources which are being irreversibly lost could be of major, through largely incalculable, value to future generations. For example, even if no economic or other human use is currently known for the millions of as-yet-unstudied species and the associated evolutionary processes that exist in the world's remaining natural ecosystems, past experience indicates that some of them will prove very valuable indeed (Ehrlich and Ehrlich, 1981; World Bank, 1987). This concern is particularly urgent for the developing countries of the tropics, where species diversity is greatest and scientific knowledge is poorest. As noted recently by E.O. Wilson, species extinctions or other irreversible environmental losses are the ones which future generations are least likely to forgive this generation (Wilson, 1984).

Preventing irreversible environmental losses would preserve many of the options available to future generations, so that they might more effectively meet the challenges of an uncertain future. It is prudent for the present generation to pursue courses of action which foreclose relatively fewer options for the future. Some economists have therefore suggested that relative to the benefits of preservation, there is a point in many projects where the sacrifice of short-term gain is desirable in order to preserve reversibility (i.e., prevent the permanent elimination of future options).

CBA techniques usually treat irreversible costs (if they have even been considered and quantified) no differently from more readily reversible ones.

A number of resource economists have attempted to develop appropriate methods for adequately considering irreversible effects in economic analysis (cf. Arrow and Fisher, 1974; Bishop, 1982). However, such methods have yet to be refined and properly institutionalized within the CBA procedures of most government agencies and international development organizations. The implicit value judgment inherent in CBA is therefore that irreversible consequences are no more important or serious than reversible ones. The inattention of CBA techniques to the special problems posed by irreversibility is unfortunate but not surprising, since CBA is based on the mechanistic concept of a readily reversible 'market equilibrium' (Norgaard, 1984c).

2.6 *Comparative advantage in agriculture*

The economic principle of comparative advantage is analogous to its ecological counterpart — division of labor or ecological specialization. Both can bring enormous advantage to the individuals of a community. However, comparative advantage is commonly invoked in international trade theory to justify the case for specialization among nations. As historically applied, comparative advantage has encouraged many developing nations to depend on a small number of agricultural export commodities, while attending less to domestic food production. The theory holds that it may be advantageous to sell the agricultural commodity (e.g., cocoa, palm oil) for foreign exchange and buy cheap foreign food (e.g., United States wheat). This pattern can help explain why more and more countries are importing grain, that former food exporting nations are now net importers, and that in some countries — particularly in Sub-Saharan Africa — per-capita food production has declined markedly over the past two decades. Relative emphasis on export crops rather than local food production is only one of several factors which can be blamed for the decline in food production growth, soil erosion and other environmental degradation, and inappropriate agricultural pricing policies (Mahar, 1985). Certainly, the ability to import food from climatically dissimilar areas provides a buffer to natural disasters such as droughts. This should be weighed against the local maintenance of some buffer capacity.

The extent to which countries should emphasize export crops versus domestic food production has sparked lively debate among economists and others concerned. Critics of heavy national reliance on export crop production and food imports typically point to such concerns as income distribution within the exporting country, vulnerability to commodity price fluctuations or political pressures, and poor or declining terms of trade.

While fundamental, the income distribution issue is readily overlooked if a country, rather than its people, is treated as the basic unit of analysis. To

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the extent that foreign exchange earned by the cash crop exports is spent on armaments or luxury imports for urban consumption, less of it will be available to buy food for the rural people who were encouraged to grow cash crops instead of their own food. This problem is exacerbated by the high costs and often poor reliability of transporting high-bulk, 'low value' commodities such as imported food to remote rural areas.

On a national level, a high degree of vulnerability is frequently associated with an emphasis on export crop production. Such vulnerability is largely due to significant commodity price fluctuations, over which exporting countries have little or no control. Furthermore, dependence on food imports from only a few major producers (particularly the United States) may carry significant political risks. Thus, while a hypothetical 'average' country may be better off in the aggregate by aggressively pursuing the comparative advantage strategy, this is small comfort to those countries which gamble and lose. In this light, more risk-averse policies which promote a certain measure of domestic food security over comparative advantage are not necessarily 'irrational' or 'inefficient'.

Poor or declining terms of trade for export crops also weigh against a heavy emphasis on export crop production. Most developing nations are 'price takers' on the world market, both as consumers and producers. Producers have no control over the price of their products; the price is set more by the importers, and may not even cover the real costs of production. When world commodity prices fall (such as when commodity prices fell recently to a 40-year low), or when transportation or necessary input costs climb, the 'comparative advantage' that was initially present may evaporate. Furthermore, much foreign exchange must be applied to production of the commodity (e.g., palm oil factories, biocides, transport, petroleum, machinery, and infrastructure); hence, less is available for food imports. Since the cost of the means of productions (e.g., a delivered, installed sugar mill or tractor) seems unlikely ever to decrease relative to the price of the commodity (e.g., sugar), the comparative advantage export-oriented agricultural strategy tends to keep developing countries as suppliers of agricultural commodities, while increasing their vulnerability and dependence on food imports. Export of manufactures (e.g., tires) derived from agricultural commodities (e.g., rubber), while unpopular with industrial importing countries, may be a more prudent course for many developing countries to undertake.

To this widespread questioning of export crop promotion strategies, we now seek to add an environmental perspective. Agricultural commodity projects are usually sited on prime agricultural land in order to maximize the yields needed to support the investment. This can impair indigenous food production, which is often pushed to more marginal land as a result. Indigenous food production on marginal land often threatens watersheds and slopes that are better left intact in forest or other protective cover. Overgrazing is also more difficult to avoid on marginal land. Agricultural commodity projects need modern highways, with all their environmental impacts including unplanned settlement and inappropriate land use in ecologically fragile areas. Many cash crops are often grown as large-scale monocultures, while food grown for local consumption by small farmers is more readily adapted to polyculture and agro-forestry systems. Monocultures are less desirable from an environmental standpoint because of their vulnerability to pests and diseases, their often heavy reliance on biocides and chemical fertilizers, and their suitability for using heavy machinery (which often compacts or otherwise damages the soil). From an environmental point of view, export crop promotion (unless it is unusually well-managed) appears to be a less desirable or riskier strategy than local food production. This argument is not to suggest that export crop production is never appropriate or desirable. Rather, we merely recommend that environmental concerns be adequately considered when recommendations are formulated for national agricultural policies and strategies, or when the pros and cons of export crop production are debated.

2.7 *Discount rate*

The discount rate (r) is a time preference concept. If we choose to believe that the concept of a 'socially optimum' discount rate actually exists, we must acknowledge that such a discount rate can never be precisely known because the preferences and circumstances of future generations remain unknown (Hueting, 1980a; Lind, 1982). However, we know that sound environmental management often imposes minor, short-term costs in order to gain substantial benefits over the long term. Thus, discounting of future benefits (and costs) to net present value can severely undervalue many environmental functions and services. Although many organizations rely on CBA and discounting, some economists have recognized the significance of this flaw (e.g., Mishan, 1967; D. Pearce, 1975, 1978; Daly, 1977; Page, 1977; Hueting, 1980a).

The use of any particular discount rate r in CBA calculations operationalizes a subjective judgment of the relative importance of the present and the future. It is a normative proposition expressed in mathematical terms, rather than a neutral or objective quantitative assessment. We cannot prove that r for environmental functions (with the risk of irreversible losses) has to be equal to r for investment to produce market goods. The high discount rates currently used in project analysis, commonly 10% and more, discourage investments with long-term benefits, while promoting projects with long-term costs. High discount rates also imply excessive discounting of possible future

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environmental catastrophes (such as groundwater contamination by leaking radioactive wastes). While it may be desirable to use positive discount rates for short-run private transactions, a low or zero rate may be more appropriate for long-run public investments. However, we also do not claim that r for all public projects should be equal to zero. This paper points out the need for economic research to clarify this dilemma. The dilemma is sharpened because environmentalists opposed to particular development projects may advocate using high discount rates in order to help cancel a specific project proposal. Many potentially damaging projects have been halted by showing that the discount rates used were far too low. At the same time, low (or even zero or negative) discount rates can be attractive to environmentalists in theory because they imply greater charitability towards future generations.

The conventional discount rate used in many CBA calculations is the Consumer Rate of Interest (CRI) or the Investment Rate of Interest (IRI); they are assumed to be equal. In theory, the CRI measures consumers' judgment of the relative importance of present and future consumption. For at least two reasons, however, CRI may significantly underestimate the value that people place on future benefits in general, and future environmental benefits in particular. This flaw is shared by several other types of discount rate criteria, including 'opportunity cost of capital' and 'opportunity cost of net investment'.

First, the CRI is the social interest rate on consumption. It measures the discount rate at which society (expressed as the aggregate of all consumers) is indifferent between consuming more now or foregoing further consumption, investing the money saved, and consuming still more at a later date. However, there is no good reason to assume that a discount rate used by individuals in the consumption of market goods should be the same as the discount rate applied by societies to the provision of public goods — most of which, even in theory, cannot be bought or sold by individuals. Some economists have argued that whereas individuals naturally discount the future because their own lives are finite, societies are quasi-immortal and some decisions made on behalf of society should therefore be made with a very low or zero discount rate (Pigou, 1962; I. Pearce, 1975; cf. Kay and Mirrlees, 1975 and Lind, 1982).

Second, the CRIs on which many agencies (such as the World Bank) base their discount rates are rarely derived from empirical data. Third World investment markets are often highly distorted; interest rates of 30% or more are not uncommon. This fact, of course, does not imply that the appropriate social discount rate is also 30%. Similarly, the fact that some religions forbid interest to be charged does not indicate a discount rate of zero. Interest rate, or the cost of capital, have two components. The first is the rate of time

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preference prevailing among individuals. The second is the premium added by the scarcity of capital; in equilibrium, the two must be the same [5]. How much do interest rates reflect time preferences, and how much do they reflect capital scarcity? This question is difficult, if not impossible, to answer. However, it seems certain that recent sharp fluctuations of interest rates in the United States were not triggered by sudden shifts in individuals' intertemporal preferences. In other words, interest rates do not accurately reflect our relative valuation of present and future. In practice, the discount rates commonly used are estimated on a largely ad-hoc basis. These discount rates, therefore do not reflect a measurement of the intertemporal preferences of the people affected by a project. Instead, the discount rates reflect a very imprecise guess by project planners as to what these people's intertemporal preferences should be.

The most fundamental question involving discounting concerns the extent to which today's society should sacrifice material consumption to improve the well-being of the future. Some economists see an "integenerational invisible hand". For example, Barnett and Morse (1963) claim that "By devoting itself to improving the lot of the living, therefore, each generation, whether recognizing a future oriented obligation to do so or not, transmits a more productive world to those who follow." It is therefore only fair, they argue, for the present generation to discount the future at a high rate, because future generations are almost certain to be much wealthier in material terms [6]. We may work to make this true, but historically it has not been the case for many societies and even whole countries. This optimistic assumption is thus highly uncertain and questionable. Since this assumption can be viewed as a logical consequence of any investment calculated with a positive rate of return, the latter is questioned.

For example, it has been repeatedly demonstrated that a very large proportion of today's affluence (in the wealthier portions of the globe) is the direct result of irreversible consumption and depletion of cheap petroleum. While other energy sources are available, none promise to be so cheap for at least the foreseeable future. Since the oil price shocks of 1973 and 1979, many of the world's poorer countries have struggled to make the painful

[5] I.e., in a supply–demand model where loanable funds come from refraining from consumption, and demand is for capital formation whose productivity diminishes as capital becomes more abundant. Investment continues until the rate of return equals the discount rate. Furthermore, if consumer's marginal time preference exceeds the cost of loans, they will borrow up to the point where the marginal time preference falls and the interest rate rises sufficiently to make them equal.

[6] The point of view that even if the future is materialistically richer, borrowing from the future may be equitable but not necessarily ethically justified, is not pursued here.

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structural adjustment to higher energy prices. In fact, ten oil-importing countries in sub-Saharan Africa experienced negative per-capita growth rates between 1960 and 1982 (World Bank, 1984a; Brown and Wolf, 1985). The average African's standard of living has declined by 10% since 1974; and the average Latin American's, 10% between 1980 and 1983. Therefore, it appears prudent for planners at least to entertain the possibility that because of more expensive energy alone, in the future we might (in the aggregate) live more frugally, rather than more lavishly, than at present. If this latter outcome is at least plausible (or even likely) then the equity argument for high social discount rates loses much of its validity. Since the future is inherently highly uncertain, discounting many valuable natural resources at today's opportunity cost of capital (as per Barnett and Morse's "intergenerational invisible hand") is not a very prudent or risk-averse option from the point of view of the future.

3. SOME PRINCIPLES OF SUSTAINABLE DEVELOPMENT

3.1 *Sustainable development defined*

Although 'sustainable development' has seldom been precisely defined, it has become a popular slogan among conservationists and even within elements of the mainstream development community. We therefore seek to provide in this paper a tentative definition of this important concept, as follows. Sustainable development is here defined as *a pattern of social and structural economic transformations (i.e., 'development') which optimizes the economic and other societal benefits available in the present, without jeopardizing the likely potential for similar benefits in the future*. A primary goal of sustainable development is to achieve a reasonable (however defined) and equitably distributed level of economic well-being that can be perpetuated continually for many human generations. Sustainability implies a transition away from economic growth based on depletion of non-renewable resource stocks and towards progress (i.e., improvement in the quality of life) based more on renewable resources over the long run.

This definition has major implications for economic development theory and practice, including the following five points:

(1) Human well-being depends upon at least three categories of value: (a) economic efficiency (i.e., Pareto optimality), (b) equitable distribution of economic resources, and (c) 'non-economic' values (e.g., religious and spiritual concerns, human dignity and pride, aesthetics, and civil liberties). It therefore makes sense for development plans to seek to optimize among these values, rather than to maximize any one (e.g., economic efficiency or growth in production), since some trade-offs are inevitable. Van Praag and

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Spit (1982) use the welfare economic theory to make the case for more equitable income distribution.

(2) Although it is impossible to predict with much precision the likely interests of future generations, it is prudent to assume that their need for natural resources (soil, air, water, forests, fisheries, plant and animal species, energy, and minerals) will not be markedly less than ours. Therefore, sustainable development implies using renewable natural resources in a manner which does not eliminate or degrade them, or otherwise diminish their usefulness for future generations. Sustainable development therefore implies usually harvesting renewable resources on a sustained-yield basis, rather than 'mining' them to near-extinction. Whales, tropical rain forests, and coral reefs are examples of renewables that are often mined rather than harvested sustainably. This policy need not be absolute, if the flow of natural products or environmental services to be lost can be readily replaced in a sustainable manner (e.g., by maintaining genetic stocks). However, exceptions to this rule need to be justified more carefully than has often been the case.

(3) Sustainable development further implies using non-renewable (exhaustible) mineral resources in a manner which does not unnecessarily preclude easy access to them by future generations. For example, it will surely be easier in the future to make use of today's scrap metal if it is recycled, than if it is dumped as waste in a dispersed manner.

(4) Sustainable development also implies depleting non-renewable energy resources at a slow enough rate so as to ensure the high probability of an orderly societal transition to renewable energy sources (including solar, wood and other biomass, wind, hydroelectric and other water-based sources) when non-renewable energy becomes substantially more costly. Sustainability implies using long-term planning (rather than merely short-term market forces) to guide the transition to renewable energy sources. The price of petroleum, arguably the world's most important non-renewable resource, has actually dropped sharply in the last five years in the United States, for example, tending to encourage more rapid depletion by consumers. In cases such as these, the market does not adequately reflect future scarcity.

(5) In the context of agricultural or other biologically-based projects sustainability implies the permanent maintenance of biological productivity on the site, with the costs of imported inputs such as energy (e.g., diesel, biocides) and nutrients (e.g., fertilizer) not exceeding the commercial value of the site's production. Even when the crop pays for its inputs, production is not sustainable if the biological productivity of the site is impaired (e.g., by soil compaction or decrease in organic matter). In a wider context, the long-term availability of energy, fertilizers, and other exhaustible agricultural inputs must be addressed.

Like most principles of equity or justice [7], these principles of sustainability are not absolute. To some extent, and under some conditions, there will be trade-offs. Although it may be possible to justify some of the principles of sustainability through conventional neoclassical criteria, this is almost never done. We suggest that research is needed to devise means to accord more weight to these principles in economic analysis. If neoclassical economic criteria (such as discounting in CBA) were modified to reflect sustainability concerns, many of the conflicts between economic and environmental criteria would diminish.

Today's applications of neoclassical economic theory to development planning often do not promote sustainable development. Primary resource flows are allowed to expand exponentially and then suddenly collapse. Natural resources which should be harvested renewably are often exploited unsustainably. The 'optimum' neoclassical management plan for renewable natural resources that reproduce slowly (e.g. whales, tropical hardwoods) may be to liquidate the easily harvestable resource completely, and then invest the profits elsewhere in a more lucrative enterprise (Clark, 1973a, b, 1976; Lecomber, 1979). Clearly, such an approach destroys many environmental services and values, and accelerates the extinction of species. Often the minimum breeding population is not known; and depletion does not always fall short of extinguishing the species: 'overshoot' (Catton, 1982) is probably common in such cases. When natural capital is liquidated, the revenues are typically invested in man-made capital stock, which is frequently oriented towards supplying the luxury demands of the present generation. This man-made capital stock is not as likely to be able to satisfy the basic needs of the future as the soils, forests, or fisheries which have been depleted, often irreversibly. Similarly, simple market price increases resulting from fossil fuel depletion may not be sufficient to ensure an orderly (or peaceful) transition to more expensive renewable energy sources. Limiting primary resource flows though non-market, conservation-oriented policies would vastly ameliorate environmental degradation and expedite the transition to sustainability.

3.2 *Steady state economics and limits to growth*

Conventional economic theory typically assumes that there are no limits to growth in the physical scale of production and consumption, or that these

[7] The terms equity and justice are closely related: as used here, the formers refers to principles of fairness in the division of available resources; the latter focuses on principles for resolving conflicting interests between people (see Rawls, 1972; Berry, 1977; and Page, 1977).

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limits are so distant as to be irrelevant. Over the past decade, a great deal of evidence has surfaced which indicates that this is no longer the case. For example, recent data indicate that the productivity of forests, fisheries, croplands, and grasslands — the fundamental renewable resource systems — is on the decline worldwide in many countries (Brown, 1981; WRI and IIED, 1986). The marginal cost of discovering and exploiting new mineral and fossil fuel deposits is increasing exponentially. Despite such evidence as this, even the theoretical possibility of limits to growth (not just their imminence) is flatly denied by many neoclassical economists. In this context, an interesting contrast appears to emerge between neoclassical microeconomic and macroeconomic theory. In microeconomics, growth in production (or consumption) is possible or is considered desirable only to the point where the marginal benefit (e.g., revenue) equals the marginal cost. In macroeconomic theory, there is usually no concept of the optimum size of an economy over the long term; rather, bigger is always better. This approach neglects the often severe environmental and other social costs associated with high and growing rates of per-capita natural resource consumption. Once these costs are taken into account, the limits to growth become visible.

The 'limits to growth' debate can be clarified by distinguishing between growth in natural resource consumption (or 'throughput') and in economic output per se (as measured by GNP or a related index) (Daly, 1984a). Notwithstanding any conceivable technological advances, growth in natural resource consumption (whether due to an increase in population, per-capita consumption, or both) is ultimately constrained by the physical laws of thermodynamics and by the finite size of the planet. However, growth in economic output may not be similarly constrained, since innovation may continue to find ways to squeeze more 'value added' from a natural resource bundle. Thus, governments concerned with long-term sustainability need not seek to limit growth in economic output, so long as they seek to stabilize aggregate natural resource consumption.

Steady-state economics (Daly, 1977), one attempt to define a theory of economics that admits limits to growth in throughput, has not been well received by mainstream neoclassical economists. Such efforts as these deserve more attention than they have received to date if our society is to approach sustainable patterns of development. Current development strategies, which follow conventional economic prescriptions, often result in environmental degradation and reduced ecosystem stability. If policy makers wish to ensure that their chosen development strategies are sustainable, they need to ensure that natural resource throughput is limited to sustainable levels.

3.3 *Safe minimum standards*

'Safe minimum standard' (SMS) analysis (Ciriacy-Wantrup, 1963; Bishop, 1982; Bishop and Anderson, 1985) is one decision methodology which can be used to address those ecological concerns which are given little or no attention in economic CBA. An SMS is any non-economic criterion which a project must meet to be approved. SMS analysis is a time-tested, standard operating procedure that is widespread throughout engineering design, health planning, industrial worker safety, and other sectors. For example, a bridge is commonly designed with a safety factor of three or more to accomodate the unexpected and the unknown.

When used in the appraisal of development projects, SMSs constrain the economic CBA by specifying environmental, social, or other criteria which the project must meet in all cases. If a project is modified to meet SMS criteria, any extra costs of such modification are automatically added to other project costs in the CBA. If a proposed project cannot be modified to meet SMS criteria, it is abandoned in favor of more environmentally or socially prudent investments. CBA which incorporates SMSs is therefore a type of constrained economic optimization.

Ecological concerns in development projects are more completely addressed through constrained CBA (with SMSs) than through unconstrained CBA. This is because the SMSs can be established to deal with specific ecological concerns, which may be neglected or undervalued in conventional CBA because of the above-mentioned problems of measurements and valuation, discounting, and irreversibility.

Some economists advocate minimizing or totally avoiding use of the SMS approach because the SMS criteria are established 'subjectively' and 'arbitrarily', without reference to what is economically 'efficient' or 'optimal' (Fisher, 1981). In response to such claims, it is important to remember that reliance on the market-place as the basic yardstick by which to measure social well-being (as is done in CBA) is no less 'arbitrary', and no more 'objective' or 'optimal', than SMS analysis. Like other disciplines, economics arises from value-laden theories. Policy analysis invariably involves highly subjective value judgements, on which different people will disagree. No amount of mathematization (such as is used in CBA) can change this basic fact.

In recent years, the World Bank has advanced considerably in the use of environmental and social SMSs in the appraisal of proposed development projects. Comprehensive and routine implementation of these relatively new policies would help significantly to rectify many of the above-mentioned conflicts between economics and ecology. The Bank's experience to date has shown that the costs of modifying projects so that they meet the SMSs are

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usually a very small fraction of total project costs (World Bank, 1984b, 1986, 1987; Baum and Tolbert, 1985). The main exception to this rule is some cases of involuntary human resettlement, when large numbers of people need to be moved to accomodate a hydroelectric or other project. This constraint on conventional economic optimization in project analysis, however, is social, rather than strictly environmental, in nature.

Up to this time, the World Bank has publically committed itself to the following SMSs in the projects it supports:

(1) Projects depending on the harvest of renewable natural resources (such as forests, fisheries, and grazing lands) shall adhere to sustained-yield principles, to minimize the risk of overexploitation and degradation (through overcutting, overfishing, or overgrazing) (World Bank, 1984b).

(2) Projects shall not clear, inundate, or otherwise convert ecologically important wildland ecosystems, including (but not limited to) officially designated protected areas, without adequate compensatory measures (World Bank, 1984b, 1986).

(3) Projects shall avoid knowingly causing the extinction or endangerment of plant or animal species, unless adequate mitigatory measures are provided (World Bank, 1984b, 1986).

(4) Any project based in one country shall not affect the environment or natural resource base of any neighboring countries without their full consent (World Bank, 1984b). Judgment is necessary in determining the cut-off point, particularly where data are inadequate (such as with acid rain).

(5) Projects shall not contravene any international environmental agreement to which the borrowing country is party (World Bank, 1984b).

(6) Any groups seriously disadvantaged by Bank-supported projects (such as vulnerable ethnic minorities or communities undergoing involuntary resettlement) shall be appropriately compensated to a degree that makes them no worse off (and may make them better off) than without the project. This is to be done even if the compensatory project components do not contribute to the stream of economic benefits (World Bank, 1982, 1984b).

(7) Projects shall not compromise public health and safety to any degree which would be widely regarded as unacceptable by the affected people or by experienced, impartial third parties (World Bank, 1982, 1984b).

Ecological SMSs can be set at levels that policy makers can more or less agree upon as 'reasonable', given the particular circumstances of a proposed development project or policy. SMSs are often applied in ways that are 'tailored' for specific projects, countries, or regions (Baum and Tolbert, 1985). Such tailoring is often appropriate because of the great variation in the natural resource base, environmental absorptive capacities, population pressure, and economic and social conditions of different areas. There is a

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major need for ecologists to help specify appropriate SMSs for different areas, in a form useful to economists and other development planners.

4. CONCLUSION

While the 'tactical', project-specific methods to improved management of the environment and natural resources should be more widely adopted, this paper presents a necessary strategic supplement. The case is made that the economics–environment interface needs more attention to the extent sustainability of economic development is sought. This paper can be used to develop a research agenda for such attention, which must come more from the economics profession supported by environmentalists, rather than vice versa. In this paper, we have sought to raise questions, rather than provide definitive answers. If we have stimulated the quest to find improved answers to these pressing issues, then we have succeeded.

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