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A comparative assessment of alternative approaches to sustainable development*

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Abstract—— Environmentalists' approach to sustainable development is essentially different from economists' in that environmental sustainability is set as a condition in biophysical limits. Furthermore there exist alternative strategies for achieving environmental sustainability. This paper intends to assess and compare these alternatives in the context of environmental resource stock and economic outcomes, so that the circumstances in which a particular strategy is preferred would be suggested.

Keywords: sustainable development; alternative approaches; comparative assessment.

1 Introduction

Economists' approach to sustainable development is characterized by economic efficiency in terms of net present value maximization from resource use and intergenerational equity in terms of non-declining total capital over time. Examples include constant consumption through investment of net returns (Solow, 1986), constant real resource prices over time (Page, 1977) and constant total capital (Pearce, 1989). Comparisons of these economic indicators are found in Brown and Field (Brown, 1979) and Victor (Victor, 1991). Based on neoclassical economic theory, natural resources are either depleted (exhaustible resources), or harvested (renewable resources), or polluted (environment) optimally. The key measurement is optimal trade off between natural and reproducible capital. Resource degradation and depletion *per se* do not constitute a primary concern for sustainable development so long as they are outweighed by benefits.

However economists' interpretation of sustainability is essentially different from conservationists'. In the Green book, for instance, the term "sustainable" is defined as being "able to be exploited indefinitely without becoming depleted or causing insupportable damage to the environment" (Pope, 1990). Obviously a biophysical limit is implied. Various conservation groups consider the constancy of natural capital in physical terms a necessary condition for sustainable development. In Caring of the Earth, the new world conservation strategy (IUCN, 1991), sustainable development is defined as "improving the quality of human life while living within the carrying capacity of supporting ecosystems". In other words, the objective is to improve quality of life and the

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constraint is ecological sustainability because carrying capacity is defined as "the maximum impact that the planet or any particular ecosystem can sustain". It appears that the fundamental feature of the conservationists' approach to sustainable development is the requirement for the maintenance of ecological functions and system capacities.

Table 1 Sustainability concerns and alternatives

Ethical elements	Explicit concerns	Alternative approaches	Simplified meaning of env. sustainability	Actions for achieving env. sustainability
More anthropocentric elements	(1) Development disparities distributional inequity	(a) Capacity building	An increasing total capital stock	Economic growth & fair income distribution (e.g. WCED, 1987)
	(2) Technological asymmetries (3) multi-functionality of natural resources	(b) Carrying capacity	A resource composite, excluding reproducible capital	constant natural assets; capacity assessment and keeping within the carrying capacity (e. g. IUCN, *et al.*, 1991)
	(4) Uncertainty and irreversibility	(c) Intact natural resource base	Resource flow limit	Limit setting for individual systems and direct regulations (e. g. Commoner, 1983)
More biocentric elements	(5) Incomplete substitution (6) Respect for nature	(d) Environmentally benign structures	Low input, self-reliant production structures	Demodernisation, deindustrialisation (e. g. Friberg & Hettne, 1985)

Since economic analysis of sustainability in the context of efficiency and intergenera tional equity has been well documented in the literature (Baumol, 1988), this paper intends to investigate the environmentalists' approach to sustainable development in the context of environmental sustainability. Considering different circumstances and assumptions, however, environmental sustainability has been approached from various directions. For instance, one suggestion is to build human capacity for efficient resource use so that environmental capacity would be enlarged and would not be breached. An alternative may simply set and observe the capacity. Table 1 summarises ethical considerations, alternative approaches and conditions for achievement of environmental sustainability.

All these approaches emphasise the need to aviod depleting natural resources, but they do have distinctive implications in their requirements for conservation. For reasons of characterization, simplification an avoidance of confusion, an attempt is made to translate these broad and sophisticated requirements into the most likely explicit constraints on resource composition and stock levels. In doing so, we are aware that some interpretations may not be recognized from original discussions.

In the following sections, we first assess individual alternatives listed in Table 1 with respect to ethical justifications, ecological sustainability and indicators, and policy implications; then we compare these alternatives and suggest the circumstances in which a particular alternative could be preferred.

2 Capacity building

Capacity building as an approach to environmental sustainability reflects the understanding of an intrinsic relationship between development and environment and is embodied in a number of reports and conferences commissioned by some UN organizations, most notably WCED (1987) and UNCED (1992). The term "capacity" here is reduced to human abilities to use and conserve natural resources, including "human resources and institutional capacities particularly in the fields of science, technology, management and professional skills" (Strong, 1991), instead of the carrying capacity of any particular ecosystem.

How does the build-up of these capacities relate to environmental sustainability? The argument is that "the accumulation of knowledge and the development of technology can enhance the carrying capacity of the resource base" (WCED, 1987). Thus the capacity building approach seeks to achieve environmental sustainability through enhancing the carrying capacity rather than by addressing environmental problems directly. Following the establishment of strong links between environment and development at the Stockholm Conference, the complexity of environmental problems is further stressed in the WCED Report: "These problems cannot be treated separately by fragmented institutions and policies, they are linked in a complex system of cause and effects" (WCED, 1987) because (1) environmental problems are linked to one another, (2) together they are linked to patterns of economic development, (3) both environmental and economic problems are linked to many social and political factors and, (4) the systemic features operate not merely within but also between nations.

Thus it becomes clear that environmental problems are only symptoms and their cure lies in successfully addressing their causes. This understanding is well reflected in the WCED definition of sustainable development as "development that meets the needs of the present without compromising the stability of future generations to meet their own needs". In particular the essential needs of the world's poor, to which overriding priority should be given; and (2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

The capacities are built through exploitation of natural resources and will substitute some natural resources. Therefore it is impossible and unnecessary to keep the natural resource base intact: "Economic growth and development obviously involve changes in the physical ecosystem. Every ecosystem everywhere cannot be preserved intact. A forest may be depleted in one part of a watershed and extended elsewhere, which is not a bad thing if the exploitation has been planned and the effects on soil erosion rates, water regimes and genetic losses have been taken into account" (WCED, 1987).

Thus the build-up of human capacities for efficient resource use and effective conservation would ensure environmental sustainability. In other words, this approach is not limits to growth; it is the "growth of limits" as MacNeil summarizes (MacNeil, 1990). Therefore total capital, man-made and natural, which reflects human capacity to meet human needs and enhance the environment, may be considered a measurement of environmental sustainability in practice.

However the emphasis on the role of economic growth in sustainable development may undermine the requirement and urgency for environmental sustainability and thus is susceptible to self-contradiction (Daly, 1990). For one thing, setting economic growth as an objective may lead resource preservation being ignored. Furthermore, when the available resource flow from natural resource stocks falls short of basic needs, it is likely that the resource will be degraded and/or depleted, even with the building of capacities.

3 Carrying capacity

In contrast to the concept of capacity as used in the capacity building approach, carrying capacity relates to ecosystem functions and productivities, often defined in terms of physical quantities. In order for development to be sustainable, efforts must be made to live within the carrying capacity of the planet Earth as a whole or of any particular ecosystem. This approach is well represented in IUCN *et al.* (1991). We refer mainly to the new conservation strategy (WCS II, IUCN, 1991), Carrying for the Earth, in this discussion.

In WCS II, nine principles have been identified for achievement of a sustainable society, of which one gives the ethical foundation, four define criteria and the remaining four prescribe the directions for change. The ethical principle requires that each individual should respect and care for the community of life, both human and non-human. These require that every species be respected "independently of its worth to people". This commitment is likely to conflict with human interests, if a species endangers human health or survival. WCS II acknowledges these conflicts and suggests as a solution that the last surviving individuals of the harmful species could be kept in internationally controlled laboratories while eradicating them else where. However these conflicts may be more complicated in some parts of the world where human subsistance depends on killing and trading wild animals. More research is urged before a satisfactory solution is given.

Among the four criteria identified in WCS II for a sustainable society, one reflects the improvement of the quality of life and the other three relate to ecological sustanability. These include (1) conserving the Earth's vitality and diversity, (2) minimising the depletion of non-renewable resources and (3) keeping within the Earth's carrying capacity. Of the three criteria for environmental sustainability, the last one is obviously dependent on, or limited by the first two criteria. Given technology and social organization, the carrying capacity would be determined by the stock of life supporting systems, biodiversity, renewable resources, and non-renewable resources. This stock is termed as natural capital or natural assets in WCS II. Keeping within the Earth's carrying capacity would require that the size of natural capital be constant over time.

However, WCS II does not specify what should be the desirable level of natural capital for individual ecosystems. The buildup of reproducible capital at the expense of natural capital would not be considered appropriate for sustabinability. Keeping within the Earth's carrying capacity may be equivalent to the maintenance of a constant resource composite, as defined in Pearce (Pearce, 1987). Substitution between resources, especially between renewable and non-renewable resources, can take precedence if the resource composite, or in other words the carrying capacity, as a whole is not reduced. This would suggest that in practice an overall resource limit be derived and imposed upon exploitation of an ecosystem. Spatial and temporal variations of resource use may be allowed, but at an aggregate level and in the long run the resource limit is met.

4 The maintenance of an intact natural resource base

This approach is closely related to, and partly based on, ecological understandings. Commoner (Commoner, 1983) summarizes ecological functions and relations as ecological laws. His first law reflects the existence of the elaborate network of the interconnections in the ecosphere. An ecosystem is stabilised by its dynamic self-compensating properties. The complexities of the ecological network and its intrinsic rate of turnover determine how much it can be stressed and for how long without collapsing. Applying the first basic law of physics that matter is indestructible, he defines the second law of ecology as "everything must go somewhere". This implies that harmful industrial wastes would not disappear but accumulate in places where in nature they do not belong.

Such accumulation would damage the elaborate ecological relations. The third law believes that "nature knows best". It rejects any improvement on nature by technological progress. In other words, "any major man-made change in a natural system is likely to be detrimental to that system". The last law applies an economic principle to ecological system: "There is no such thing as a free lunch". Because the global ecosystem is a connected whole and is not subject to overall improvement, anything extracted from it by human effort must be replaced. According to these laws, keeping natural resource base intact would be an essential condition for ecological sustainability.

It appears that an intact resource base may conveniently be interpreted as a limit in forms of an amount of resource flow, emission rate or the size of a critical ecological zone in practical decision making. As a criterion for ecological sustainability, this limit may be assessed for different systems individually rather than collectively. This would suggest that resource substitution for a particular resource may not be permitted. Also this limit level is likely to be lower than the carrying capacity level.

However, it is obvious that "intact resource" does not mean no exploitation. Rather a natural resource can be used up to the specified limit. In the case of pollution, for instance, this limit may be given as a uniform standard for all discharge sources regardless of spatial and seasonal variations and / or differences in control costs. Individual polluters can retain production levels and methods if they do not discharge more than the uniform limit.

5 Environmentally benign structures

The above approaches to sustainability may not require a fundamental change of the system concerned. Even under the intact resource base criterion, there is no explicit requirement to discontinue existing ways of consumption or production. It is often argued that it is the structure of production and consumption in addition to institutional problems that are inconsistent with sustainability. Therefore structural changes are essential for environmental sustainability. The ideological foundation here is often called "green thinking", defined as "a heterogeneous variety of political, philosophical and socio-economic ideologies broadly informed by an "ecological perspective". It is peculiar in that it questions" the development of the industrialized world and the systems which run it, whether capitalist or socialist (Pope, 1990). This thinking does not only imply an ethical commitment to respect and care for all life on the planet, but calls for a fundamental change of modern life as the action required. Paliticians, economicsts and conservationists may have contributed to and accepted such thinking, but the main strength comes from people who actually practice or search for non-modern ways of life, including: (a) the traditionalists, who resist modernization because they have access to a non-modern way of life which they want to defend, (b) marginalised people, who cannot find a place within the modern sector, and (3) the post-materialists, who question the modern project as they are searching for their own true nature and they also have the resources and opportunities to pursue their own projects (Friberg, 1985).

It appears that what the green ideologists and paractioners demand is a radical change of the current system structure which, in their view, is not consistent with environmental sustainability. A constant resource composite or a uniform standard as a resource limit would be likely to be insufficient to lead to an environmentally benign structure. However, few if any of the structural changes which occur with modernisation are in accord with environmental sustainability. The following are some examples: (1) energy consumption: from low (largely dependent on biomass) to high (highly dependent on fossil fuels) energy consumption; (2) transport: from a mass (public) transport system to extensive use of private fossil consuming transport; and (3) agricultural: from traditional low input to modern high input systems.

Low input, organic and regenerative agriculture, collectively termed as alternative agriculture by Crosson and Ostrov (Crosson, 1988), has fundamentally different structures from conventional agriculture, especially in terms of crop rotations and use of agrichemicals. Unlike conventional agriculture, the alternative may use cultivation and crop rotations to control weeds and insects, usually provides crop nutrients with animal manure, other organic matter and legumes. In its strictest form, all synthetic inputs, including chemical pesticides, inorganic fertilizers in crop production and growth regulators and other chemicals in animal production, have to be excluded. The use of other inputs from off the farm has also to be minimized. Like a traditional farm system, an alternative agricultural system should be basically self-sufficient.

Alternative agriculture may be more intensive than permaculture, or permanent agriculture, an ecologically designed bio-production system. Mollison (Mollison, 1985) designed and managed on the basis of ecological interactions between plant species and animals useful to man. More species including perennial are involved than is a conventional system; and like a natural ecological system, it holds the property of stability, diversity and efficient use of the environment.

Nevertheless it is a labour intensive system, "unsuited to a large commercial enterprise or inapplicable to conventional farming". This may constitute the major obstacle to such transition from modern production system to low input system, given available technology and institutional structures. In addition, promoting a benign system change itself does not recommend any instruments for a smooth transformation into the desired structure.

6 A comparative assessment

By now we have examined and assessed four representative alternative interpretations of sustainable development, all being highly abstract and simplified. They specify different sustainability requirements and consequently produce different sets of environmental and economic outcomes. Although it is not intended to rank these alternatives, a comparison may be able to show the circumstances in which one would be preferred.

First we look at changes in resource stock over time. In Fig. 1, $\underline{S}$ depicts the ecological threshold stock level at which the resource base in question would be irreversibly degraded or destroyed, while $\overline{S}$ is the stock level with little human interference. $\hat{S}$ is the resource composite level representing nature's capacity for being sustainably exploited. Assume that all the sustainability requriements are complied most efficiently, then given any initial resource stock level S_0, e. g. $\underline{S} < S_0 < \hat{S}$, the carrying capacity alternative would approach $\hat{S}$ at time T and remain thereafter (Fig. 1, curve b). The intact resource base approach would result in a quick increase in $S(t)$ and at T the resource stock level is slightly higher than $\hat{S}$ (curve c). A structural change (green strategy) in production system may give the highest stock level at T. As shown by curve d in Fig. 1, it is possible that the resource stock reaches its maximum if human interference is completely withdrawn. By contrast, the capacity building approach (total capital maximization strategy) would reduce the stock level initially and reach an equilibrium level somewhere between zero and S_0, lower than $\hat{S}$ at T (curve a). Green strategy leaves the natural resources stock to wildness to a certain extent and thus the natural environment is best preserved. Both strategies of maintaining a constant resource composite and an intact resource base arrive at fixed end states of natural resource stock, but the latter presents a more certain outcome before T.

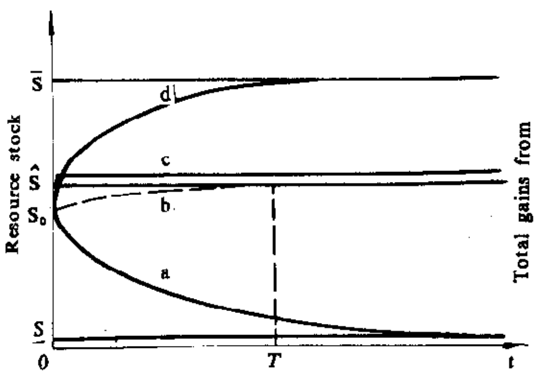

Fig. 1 Comparisons of changes in natural resources stock over time

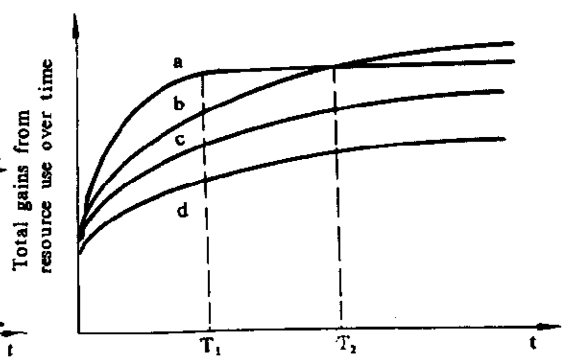

Fig. 2 Total capital gains under various strategies

If we compare the total level of capital resulting from various alternatives, the preference ranking may be different (Fig. 2). At T_1, total capital maximization generates the highest gain (curve a) due to high rates of resource flow and discounting, but this trend may not be sustained infinitely when it is out-performed by the strategy of a constant resource composite at time T_2 (curve b). Because of strict biophysical limits, strategies of keeping an intact resource base and green structure are likely to be inferior to the constant resource composite strategy in terms of net present value maximization, with the green strategy the least attractive financially (curves c and d).

However the preference order can be complex even when efficiency is the only criterion. First the period of planning affects the result. In the initial stages, the total capital maximization strategy is advantageous to the others, but this advantage is eroded away as the planning period extends further into the future. Second the benefits are valued under the assumption that the same price level is applied to similar products from various strategies. If the products from the green strategy are marketed at a premium price in comparison with those from other strategies, the net present value from this strategy may be greatly increased.

7 Discussion and conclusions

The relationship between resource stock level and production is illustrated in Fig. 3. Assume that the maximum current output potential is 1.0 when no constraint of any kind is imposed on the natural resource stock. With a requirement of maintaining a higher level of natural resource stock, the current output ratio is assumed to be lower than 1.0. Further increases in requried stock levels will further reduce such production potential. Thus it is possible to construct a current production frontier in accordance with resource stock changes, as depicted in Fig. 3. If economic incentives are incorporated, we may assume that all the strategies are located on the frontier. The capacity building (total capital) approach apparently presents the highest output since it does not prescribe any specific level of natural resource stock (point a). The carrying capacity (composite resource base) and intact resource base (points b and c) approach are around the sustainability levels as required but the current output potentials are lower than that of the capacity building approach. As a result of an allowance for adjustment freedom, the carrying capacity (resource composite) approach gives a higher current output than the intact resource base strategy. The green strategy is likely to represent the other extreme: high natural resource stock but low current output potential (point d). If economic incentives are included in strategy implementation, it is possible that resource stock levels may be well kept compatible with sustainability requirement, but output is lower than the corresponding point on the efficiency frontier. Points A, B, and C are depicted as examples.

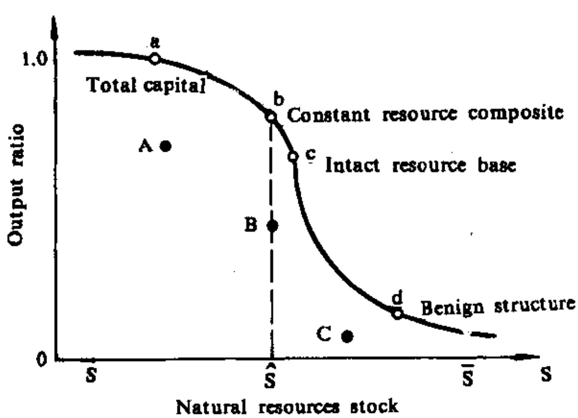

Fig. 3 Output potential and resource stock levels

Apart from emphasis on ethical commitments and ideological prejudice, all these alternatives are relevant to and could be applicable to practical resource management. Considering the complexity of the environment and development and differences of various ecosystems in economic development and ecological sustainability, it is not likely that any single alternative, as simplified and specified in this discussion, would provide a panacea to environmental problems.

What we have learnt from this comparison is that one indicator of strategy performances does not present the whole picture and can be misleading. It implies that, when choosing a specific strategy, a decision maker needs to understand the circumstances and to examine a set of indicators instead of a single one. For a specific area or context, one may need to choose only one strategy and reject all the others if he understands the specific circumstances. But in general as policy initiatives for resource management, it is their combination, instead of one particular strategy that should be applied.

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