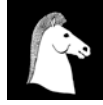




Environment & Society Portal



The White Horse Press

Full citation:

Friend, Anthony M. "Economics, Ecology and Sustainable Development: Are They Compatible?" *Environmental Values* 1, no. 2. (1992): 157-170.

<http://www.environmentandsociety.org/node/5464>.

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# Economics, Ecology and Sustainable Development: Are They Compatible?

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“Quand un économiste vous répond on ne comprend plus ce qu'on lui avait demandé.”

André Gide, Journal.

**ABSTRACT:** The prevailing economic paradigm, in which a closed circular flow of production and consumption can be described in terms of ‘natural laws’ of the equilibrium of market forces, is being challenged by our growing knowledge of complex systems, particularly ecosystems. It is increasingly apparent that neo-classical economics does not reflect social, economic and environmental realities in a world of limited resources. The best way to understand the problems implicit in the concept of ‘sustainable development’ is provided by Ecological Economics – a new synthesis in which the traditional virtue of *thrift* is justified using modern ideas from systems theory and thermodynamics.

**KEYWORDS:** Ecological economics, entropy, natural resources, sustainable development, thrift.

## INTRODUCTION

Several commentators have observed that combining the concept of Sustainability with that of Development creates an *oxymoron*. Despite the apparent contradiction, creating wealth without destroying the natural resource base is unquestionably an attractive quest, even if it turns out to be something like the *Holy Grail*.

The voracious appetite for material/energy of modern industrial economies, coupled with the Malthusian spectre of Third World population growth, support a pessimistic view, that sustainable development is actually unattainable. More optimistic observers, on the other hand, claim that human ingenuity can successfully respond to this challenge by introducing low energy and low waste production and consumption technology, efficient recycling of materials, and (man-made) substitutes for exhausted resources. Rather than join the debate over how far sustainable development can actually be achieved in practice, the present essay has a somewhat different purpose. That is firstly, to question the prevailing economic paradigm in the context of our growing knowledge of the behaviour of complex systems, and secondly, to explore the somewhat outdated idea of 'thrift' in economic thought. Its underlying objective, however, is to elucidate the compatibility of value structures implied in the precepts of sustainable development.

Classical economics, underpinned by the Newtonian world-view, has developed a conceptual framework where *economic forces* mimic *natural laws of equilibrium*. For example, consumer demand generates producer supply of just the right quantity through the great arbiter of *prices*. Karl Polanyi (1944) makes the distinction between economics in the context of, and subordinate to, societal values, and "a system of self-regulating markets" beyond the reach of social control, so seductively described in Adam Smith's metaphor of the 'invisible hand'. The Polanyi thesis suggests that dominance of market values in human intercourse is of recent origin stemming from the machine age and the globalization of markets. Thus, what appeared as natural laws might be merely an example of Whitehead's fallacy of *misplaced concreteness*. In other words they express a particular (as opposed to universal) technique for the creation of the supply and the distribution of economic goods and services. Polanyi believed that the effect, and possibly even the purpose, of the self-regulating market was to reduce all *social relationships of production* to that of a simple supply and demand model associated with *commodity trade*; including the worth-of-man to that of selling his labour. The success of this enterprise is well illustrated when our culture describes literature, theatre, art, entertainment and sports as *product*, a mere extension of the market.

Modern economies require high energy levels and complex organizational structure to maintain a given state of equilibrium. Economic theory, with its simplifying assumptions and idealized *rationality of human behaviour*, is inadequate to describe the messy world of complex systems. Economic analysis seems largely concerned with positive feedback, such as the multiplier effect of investment. Rarely examined are the effects of negative feedback, such as reduced productivity due to depleted resources and polluted environments, symptomatic of systems under stress. Introductory economic texts, for example, breathe scarcely a word about *externalities*: the social and environmental costs of production. For some reason they have suspended the laws of conservation

of matter and energy thus failing to correlate the *generation of waste residuals* with the *growth in output*. The notion of a Gross National Waste Product (GNWP) set side by side with a Gross National Product (GNP) may appear ludicrous as an economic accounting principle but it is, nonetheless, an exact description of the economic process in terms of physical transformations (Georgescu-Roegan, 1971).

Ecologies are the result of a long evolutionary synthesis between the biotic and abiotic environment. They can be described by equilibrium states of diurnal and seasonal cycles of natural production and wastes cycling. Economic systems can be similarly characterized in terms of an evolutionary synthesis describing socio-cultural adaptation to the changing state of the economy and the environment. However, the human capacity to control, at least in part, the natural environment adds a proactive, as opposed to merely reactive, dimension to the adaptation process. Severe disequilibrium conditions or social dysfunctions can arise out of the inability to adapt to change, referred to metaphorically as 'future shock' (Toffler, 1971). Major dysfunctional factors are organizational and technological changes in production processes, globalization of finance and production, and competition over increasing scarcities in natural resources. Again, employing the ecological analogy, these might be likened to stressors the effect of which, if mild, might be benign, but if too severe, might lead to disequilibrium states or even the collapse of the system altogether (Rapport et al. 1985).

The notion of *survival strategies* is also familiar in both ecological and economic literature. Kenneth Galbraith (1967) observed that in large corporations, where management is essentially divorced from ownership, board room strategies focus on expansion of markets and acquisition of competitors rather than on maximizing profits as assumed in the *rational economic model*. The driving force is power and control. The compulsion of the takeover syndrome of the 1980s referred to as 'casino capitalism', is but another symptom of the fall of *economic rationalism*, if it ever existed (Kierans and Stewart, 1988).

Life histories of individual business enterprises are analogous to biological growth cycles (i.e. rapid initial growth, slow down during the period of maturity, and eventual decline). Niche specialization in market analysis clearly borrows from ecological observations of species survival strategies and competition for limited resources. Biological theories of *inter* and *intra* species competition suggest that the size of the population, and even the size of individual species, is determined by the stock of available resources. The dynamics of competition may further determine the nature of the species mix (Keddy, 1989). A healthy economy, like a healthy ecology, is one characterized by *diversity* (of production) and *resilience to stress*. Again, the business strategies of widening the *product line* or *controlling supply* are found in the adaptive strategies of species. Adaptation to alternative sources of sustenance when preferred resources are unavailable or exhausted has many parallels with substitution theories in

economics. Darwinian theory of evolution, particularly in the context of survival-of-the-fittest, is echoed in justification for the brutal effects of the free enterprise system.

Sustainable economic development rests on three fundamental premises: (a) that a long-term steady state relationship exists between the *supply* and *demand* of locally available and/or globally accessible natural resources; (b) that *waste residuals* and *contaminants* generated by human activity are within the limits of the biosphere's assimilative capacity; and (c) that productivity gains are obtained by reducing *material* and *energy* inputs in production and *efficiency of use* in consumption. These conditions imply that development must be based on the concept of *parsimony*, rather than on an ever expanding consumption of materials and energy. The objectives of development must therefore shift towards a more equitable *distribution* of the accumulated stock of wealth (including access to resources), and a greater emphasis on the *qualitative* dimension of social and economic progress. This distinction was noted on John Mill's (1848) essay on "The Stationary State":

It is only in backward countries that the world of increasing production is still an important object: in those most advanced, what is economically needed is better distribution, of which one indispensable means is a stricter restraint on population. It is scarcely necessary to remark that a stationary state of capital and population implies no stationary state in human improvement. There would be as much scope as ever for all kinds of mental culture, and moral and social progress: as much room for the Art of Living, and much more likelihood of its being improved, when the mind ceases to be engrossed by the art of getting on.

## ORDER OUT OF CHAOS

Prigogine and Stengers (1984) identified critical properties of *system structure* with reference to: (a) self-organizational capacity; (b) the maintenance of stability and resilience in face of internal fluctuations and external stresses; and (c) the mechanisms of maintaining equilibrium in a world of constantly changing external environments. The questions raised in understanding the process of creating order out of chaos has many parallels to the governance of a modern state aspiring towards *social order* in face of internal fluctuations and external stresses. The agenda of governments in highly interdependent economies requires the establishment of a robust mechanism of self-organization, redundancies in system structure (in case of system failure), and an intelligent information system to provide timely indicators of system change, both in its current and anticipated future states. The capacity for self-organization is a major stabilization element in complex systems and this in turn implies wide participation in decision-making, decentralization of power and some degree of

self sufficiency in production.

Decision-makers and policy analysts seek holistic frameworks to resolve the problems of complexity and scale (often global) that characterize modern societies. For the most part, economic models are based on simplifying assumptions, often idealized, which in effect distance them from real world behaviour. For example, the Gross National Product (GNP) is described by a closed circular production/consumption cycle. While these simplified models proved successful in constructing a system of national income and production accounts based on the well known Keynesian identities they failed completely to capture externalities and the feed-back effects of degraded environments on productivity and the quality of life (Daly and Cobb, 1989).

The underlying premises of complex systems can be stated as follows:

- (i) the whole is greater than the sum of its parts, i.e. *holistic* dimension;
- (ii) everything is connected to everything else, i.e. *integrative* dimension; and
- (iii) small events can cause large-scale instability to the system, i.e. *non-linear* dimension.

Holistic, integrative, and non-linear models are the mode of science in the micro-world of quantum physics. If this approach reveals better the reality of the physical world we may well ask why this should not equally apply to the reality of the macro-world of human activities. The story slowly unfolds as we begin to discern the nature of the interactive forces of chaos and order in the universe. While we may be peering through the glass darkly, we do perceive that reality is not a well ordered world associated with the Newtonian laws of celestial mechanics, but rather a world of *probable events* where, on occasion, a small perturbation might result in large-scale change. These may be characterized as non-linear pathways or even bifurcation in evolutionary processes. Thus uncertainty looms ever larger as a variable in human calculus (Prigogine and Stengers, 1984, Gleick, 1987).

## WHAT DO ECONOMISTS HAVE TO SAY?

Economics, at least in the non-Marxist world, has been formalized in a body of theory loosely referred to as the neo-classical synthesis. The basic analytical frame is founded upon linear production functions, rational consumer behaviour personified in *homo economicus*, and the efficacy of the methods and techniques of cost-benefit analysis, preferably expressed in mathematical equations. The major variables of concern are relative prices and associated market demand, (i.e. supply/demand equilibrium) supported by the principle of the primacy of (individual) consumer choice. A key assumption is that competitive markets lead towards efficiency in production and thus, the *optimum allocation* of scarce

resources. One should hardly be surprised that this system of economic thought, with its emphasis on productive efficiency, freedom of choice, and impartiality of the market in the distribution of resources, is hugely successful with decision-makers. The capacity of the competitive market system to deliver goods and services to consumers reinforced the popular view that growth in material well-being constitutes nothing less than *economic progress*. Thus, the neoclassical synthesis established the theoretical underpinning for the social and economic policy agenda, and coincidentally provided a rationale for treating nature as a *free gift*.

A major objective of these policies is what economists refer to as *wealth creation* or growth in GNP. Until quite recently environmental resources were treated in economic analysis as a *free-gift-of-nature* and the creation of wealth, or more precisely income, was generated only at the point of extraction, harvesting or where *ownership* permitted charges of access to natural resources (e.g. shoreline properties). This peculiar decoupling of ecological and economic productivity can be attributed in part to the concept of the *closed circular flow* in the production and consumption of goods and services, and in part to the almost exclusive concern with labour, capital, and technology as the factors of production in economic growth models. Thus, the consideration of limits to growth, imposed by the biosphere's carrying capacity, was simply left out of the picture.

Classical economic theories associated with Adam Smith, Ricardo and Malthus among others considered land (i.e. a natural resource) as the original *source of wealth*, although requiring the intermediary of labour and capital to create the flow of economic commodities. Moreover, classicists believed in some kind of ultimate limit to economic growth, stemming from the finite productive capacity of the soil or what ecologists would today call *nature's carrying capacity*. The Ricardian concept of *diminishing returns* played a key role in the theory that economic growth had definite limits. In essence growing populations would force into production marginal lands. Land owners would then claim the difference of value between the most and least productive lands. It should be noted that in the classical framework the (unproductive) *rentier class* would increasingly appropriate a larger proportion of the nation's wealth. In this brutal Hobbesian world the wages for labour would inevitably fall to subsistence level, profits would fall to zero (i.e. there would be no further incentives for capital investments), and only the claimants to *finite resources* could enjoy the benefits of an overpopulated globe.

Land as the source of wealth should be understood in the context of a predominantly agricultural society which, even in the emerging industrial society of Britain in the early nineteenth century, employed about eighty per cent of the labour force. The emphasis on land disappeared in economic thought because it was considered of minor consequence in the analysis of the economic process in modern industrial states. Undoubtedly the vanishing *Malthusian*

*spectre* and its complementary *iron law of wages* was belied by the spectacular *progress* in economic wealth in the industrial countries. The Club of Rome model “Limits to Growth” has raised once again the classical scenario based this time, however, on extrapolating growth rates in the consumption of natural resources and pollution loadings in a finite world (Meadows et al. 1972). The energy crises, desertification, deforestation and projections of climate change have conjured up in our mind the image of a fragile planet floating in the vast ocean of space. Thus, our thoughts are turned once again to the limits of economic growth.

### OIKOS OR OECONOMY AS HOME

A common root for ecology and economy can be traced to the Greek word *oikos*, meaning *home*. The concept of household is also embodied in the meaning of *oikos*. Ecology and economy merge once again in the idea of sustainable development, where economic production is contained within the integrity of the biosphere’s ecosystem. The Oxford English Dictionary (OED) defines an early version of the concept of economics as:

The art, or practical science of managing the resources (or wealth) of the nation so as to increase its material prosperity.

This was later modified to reflect the late nineteenth century viewpoint, or neoclassical conception, as:

The laws which regulate the production, distribution, and consumption of those articles or products that have exchangeable value, and are either necessary, useful, or agreeable to man.

The earlier definition is interesting in that it recognises the link between economy and (natural) resources. The later, more hedonistic definition, divorces the production process from the source of wealth.

The old English spelling of oeconomy is associated with the *art of thrift in household management*. The discourse on oeconomy was expanded in the eighteenth century to encompass the concept of the *national household*, or what was referred to at the time as the ‘commonweal’. This became known as the science of political economy. Already in the seventeenth century pamphleteers were advocating state intervention in foreign commerce in order to augment the national treasury with a balance of payment surplus (Polanyi, 1944).

This view, known as Mercantilism, was attacked by Adam Smith as confusing the effect with the cause of wealth. What the classical economists objected to was not the augmentation of wealth through trade, but the official sanction of restrictive trade practices. Allowing for the free play of markets, unfettered by interferences by officialdom, was in their view the secret for *economic progress*.



Adam Smith argued that wealth is not created through political manipulation of trade but by entrepreneurial organization of labour and capital. However, the original source of wealth, according to Adam Smith, originated in the *soils* but could only be realized “through industry and labour which modifies, divides, connects and combines the various production of the soils so as to render them fit for human consumption”.<sup>1</sup>

Adam Smith’s doctrine was ultimately based on the paradox of the effect of an ‘invisible hand’ achieving a *common interest* through *selfinterest*. The hand is, of course, the self-regulating competitive market which allows individuals to pursue their self interest in accumulating wealth and at the same time provides the most efficient distribution of the nation’s wealth among its citizens. While this may provide a rationale for the efficacy of a competitive market system it hardly justifies the nasty and brutish impact of nascent capitalism on the lives of the new working class.

The concept of the *art of thrift* is still retained in the teaching of *home economics*. Thrift, moreover, has once again become fashionable in the guise of material and energy conservation and recycling of waste residuals. It seems hardly credible today that in the 1950s and 1960s the prevailing ethos, particularly in North America, equated the means towards social progress with the values of a consumer society. Kenneth Galbraith (1958) noted the paradox that the traditional practice of thrift could quickly nose-dive an ‘affluent society’ into deep economic depression. Production for its own sake reached the height of absurdity when it was argued that high levels of arms production was a necessary condition for a thriving economy, being in a sense an insurance against economic depression.

Figure 1 traces household economy, political economy, and ecology to their common root, *oikos*. These branch out to three distinctive contemporary analytical frameworks:

- (i) consumer behaviour and market analysis;
- (ii) macro-economic policy; and
- (iii) environmental management.

Finally the singular idea of *oikos* merges once again in the concept of sustainable development.

## ECOLOGICAL ECONOMICS, NEW AND OLD APPROACHES TO ECONOMIC THEORY

As we approach the Third Millennium we may well ask if humankind can successfully adapt in a world of diminishing natural resources. Clearly, a *sine*

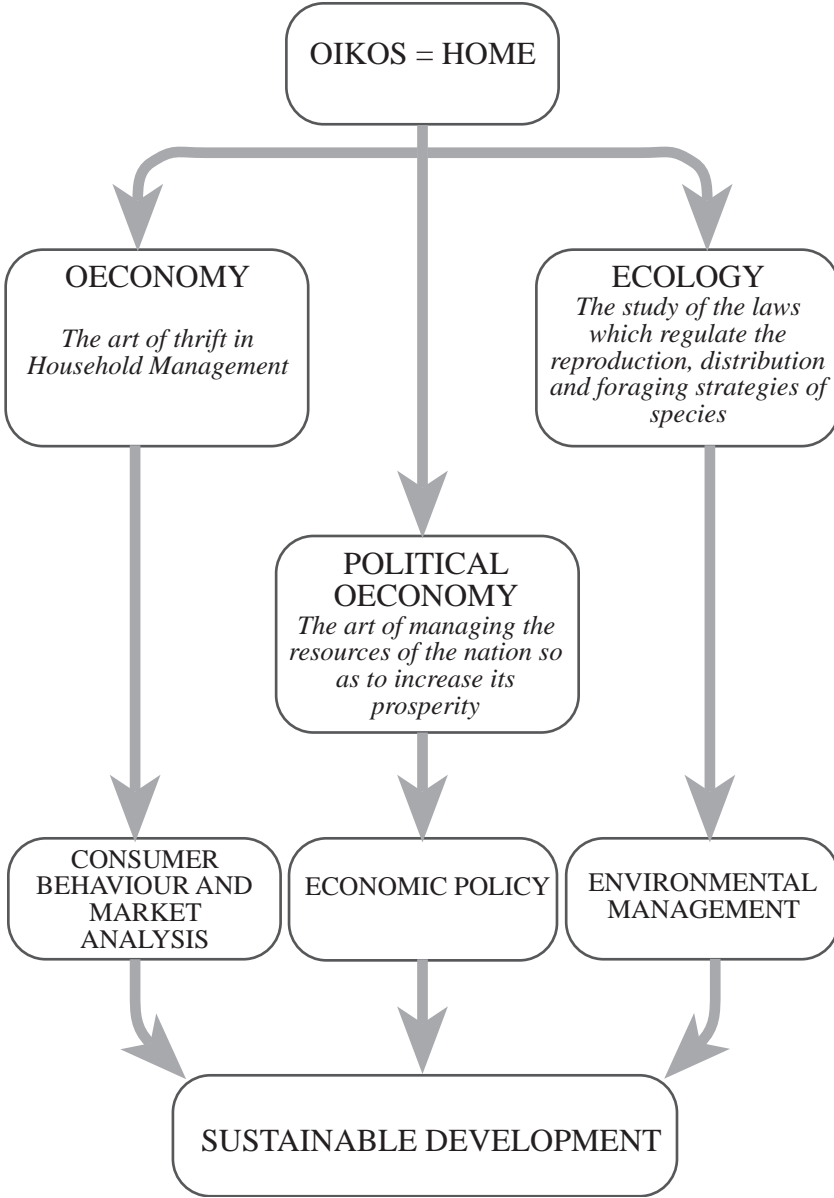


FIGURE 1.  
*Oikos, Oeconomy, Ecology and Sustainable Development*

*qua non* is the integration of environmentally sound behaviour in the day-to-day decision-making process of governments, business, and households. This implies drastic reductions in per capita consumption of material/energy in industrial societies, and the transfer of substantial resources to the Third World, in order to achieve the global management objectives for the shared 'commons' associated with reductions in greenhouse gases, protection of tropical rainforests, biodiversity conventions and so forth. Above all, perhaps, the paramourcy of environmental ethics must be established in political and economic decisions based on a world-view of man-within-the-ecosystem.

Economic theory plays an important role in the legitimization of social behaviour and values. The search for a new economic framework directed towards the socio-economic transformation to a *sustainable future* was the subject of a gathering of economists, ecologists, social historians and philosophers in Washington (May 1990). This was the first meeting of the International Society for Ecological Economics, a society dedicated to *Oikos*, or the integration of economy and ecology.<sup>2</sup>

One of the issues under scrutiny was the deceptive measure of economic performance in Gross National Product (GNP). The exclusion of the stock of ecological capital and the social cost of externalities of production/consumption processes were viewed as serious flaws. Ecological economics is concerned with the concept of *sustainable income*. Environmental degradation and resource depletions diminish the capacity to obtain future streams of income, in the same way as a business enterprise would lose its capacity to produce goods if it allowed its capital stock to run down. Similarly, gains in income are realized by the enhancement of natural production, the rehabilitation of ecosystem functions, and the efficient use of the finite resource stocks. Obviously this approach to income is based on the economist's notion of *utility*, a concept that implies usefulness and enjoyment of goods and services in contradistinction to *money incomes*. The latter might in fact increase when resources are employed to defend against or rehabilitate degraded environment. The two billion dollar bill to clean-up the Valdez spill is a notorious example of a windfall source of money income, adding substantially to Alaska's GNP in 1989.

Ecological economics disputes the neoclassical assumption on the efficacy of the market system for the optimum allocation of (finite) resources. A large component of the benefits obtained from natural resources is excluded from the market and treated, in a sense, as a free gift of nature. Thus, no explicit recognition is given to the contribution of natural production (non-commercial) to the nation's wealth, particularly in the form of *environmental services*. Ecological economics would attempt to integrate nature's contribution in the general equation for the optimum allocation and utilization of the nations resources. This can be envisaged as the *ecology of the factors of production* encompassing knowledge, human resources, man-made capital, and natural capital.

A more serious flaw is the inadequacy of the market system to arbitrate between present and future. For example current consumption restraints could lead to an enhanced stream of benefits for future generations. However, the only market mechanism that allows for intergenerational transfers is based on *social discounting of current consumption for expected greater rewards in the future*. Another consideration is that *markets* essentially reflect *exchange values*. Therefore these values represent neither the *use values* (i.e. service flows) nor, for that matter, the *intrinsic social values* that play such an important role in the calculus of environmental conservation, protection and human survival.

Economists have employed a method known as social discounting to arrive at evaluating the difference between current and future consumption. The underlying premise is that a rational decision maker (*homo economicus*) will always *discount the value of future benefits*, because present consumption is assumed to be worth more than future enjoyment, and because of the need for a 'risk premium' on the uncertainty of ever receiving future rewards. Present value discounting is highly sensitive to the actual rate applied. High rates reflect rapidly diminishing future expectations, thus making restraints on current consumption hardly worthwhile. This begs the question: *whose discount rate?*

The notion of using the cost of money (interest rate) can logically be applied only to man-made capital or individual investments in 'property rights access' to natural resources. This methodology becomes increasingly dubious as one extends evaluations beyond those of income streams generated from a well identified resource stock, like timber stands. Natural assets (other than minerals and fossil fuels) provide benefits to nonhuman species and frequently environmental services (while in-place) to humans. The unpredictability of today's abundance and tomorrow's scarcities, and above all the ethics of discounting the inheritance of natural wealth of the yet-to-be-born generations are reasons enough to be cautious of employing this method in deciding which assets to save and which to consume.<sup>3</sup>

The theoretical basis for ecological economics leans heavily on ideas developed by Georgescu-Roegen (1971) on the nature of entropy and physical transformation processes of economic systems. Entropy is an abstract concept which defines the universal condition of transformation of order into disorder, or transition of structured states into dissipated states. All production processes are distinguished by *increasing organization of matter* whether human artifacts or biological reproduction and growth. In a universal context production is defined by entropy reversal or negentropy (i.e. creating order out of chaos). The no-free-lunch aspect is manifest in the acceleration of the rate of transformation of available (or free) energy to unavailable (or bound) energy. Economic activity further contributes to accelerating the entropic process by the generation of waste residual (unusable matter) loadings in the environment, by the destabilization of ecosystems, and by the steady depletion of low entropy stocks (i.e. minerals and fossil fuels).

The distinction between production and consumption is often confusing in economic analysis and ultimately leads to arbitrary definitions. For example, should household work be part of the economic product or part of consumption? This dichotomy is resolved in the Georgescu-Roegan treatise, where the *production process* is defined in terms of the transformation of matter from lower to higher levels of organization and *consumption processes* as the reverse, (dissipating processes). Housework is clearly a process of creating order, and is thus a form of production. Natural production is distinguishable from man-made production by the nature of the information input. In the case of the latter the input is human intelligence externalized in social behaviour and creative abilities of organization and technology. Nature's information is internalized in the genetic code developed over the aeons of evolutionary time. Another critical distinction is the source of energy for production processes. Nature's source is largely obtained from the continuous in-flow of solar radiation (presumably inexhaustible), while modern economic production depends largely on energy sources extractable from an exhaustible stock of low entropy, such as fossilized hydrocarbons.

Consumption is the *enjoyment of product* described not only by a stream of services obtained during its usable life but also in the context of all other products linked to its consumption. In other words it is not only the act of consumption but also the experience accompanying the consumption process.<sup>4</sup> The temporal aspect must also be considered. In the case of a *service*, such as a concert, the product is consumed (and enjoyed) the instant it is produced. In the case of a house, the consumption takes place over a discrete time, measured over its life cycle. Repair and maintenance (productive activities) are required to maintain the level of services, or to lengthen the life use, of a given stock. Therefore, consumption in ecological economics leans heavily on the concept of *use value* calculated from the stream of services obtained during *use life cycle* of commodities and rejects the notion that *exchange value* encompasses all other values. In traditional economic analysis it is assumed that in so far as people maximize their utility, within their budget constraints, there must be some correspondence between growth in national income and improvement in economic wellbeing.

Growth of physical capital and infrastructure development is a process of accumulating a *stock of low entropy*. It is useful to further distinguish the capital stock required to produce other products, the so called *means of production*, from accumulated stock of durable consumption goods like houses, cars, and public buildings. The durable products of nature, sometimes referred to as *ecological capital*, can similarly be divided between the means of production, like soils, nutrients, fossil fuels, and solar energy, and natural assets whereby humankind obtains a stream of *environmental services*, like forests, lakes and pure air.

The crux of the matter for sustainable development is to find the means to minimize the material-energy flow required to accumulate, and to maintain, a desired level of economic stocks. Kenneth Boulding drew a similar conclusion,

long before the phrase sustainable development had been invented, in his discussion of the purpose of economic activity (Boulding, 1949). In his view income is derived from the flow of *services* obtained from the stock of wealth rather than the act of production, i.e. *rewards for work*. This makes sense when income is a measure of the access to, and enjoyment (or utility) obtained from, a given economic product (i.e. use value). The current national accounting measure of income, based as it is on a concept of rewards for work and entrepreneurship, confuses the *ends* for the *means*. The objective of economic policy should be to maximize the *service flow* from the *stock of wealth* and, *ipso facto*, to minimize the work required to maintain it. By extension we can apply similar principles to the service flows obtained from the environmental and natural resource stocks.

## CONCLUSIONS

That we should even have to ask the question whether economics, ecology and sustainable development are compatible suggests that we may have taken the wrong turn in economic development. What we cannot deny is the need for policies aimed at achieving a harmonious balance of economic production, ecosystem integrity and the maintenance of natural resource stock for the use of future generations. In this essay I have attempted to demonstrate that a major obstacle in restructuring the conceptual framework for sustainable development is the strongly embedded neoclassical paradigm in social decision-making. Despite its success, this body of thought paradoxically bears the seeds of its own destruction. The approach employed is reductionist. The questions addressed are hermetic within the discipline, and there is a weak linkage between micro-economic theory (decision-making rules) and macro-economic theory (how the real world works).

In the tradition of the political oeconomy the micro/macro world was better integrated because, in part, there was a recognition of the limits to economic growth imposed by land, or what today would be referred to as the biosphere's carrying capacity. Moreover, economics emphasized the *efficiency of thrift*, and the futility of pursuing economic growth as an end in itself. There is no doubt that the classical framework provides some of the basic theoretical constructs for a holistic and integrated approach to economic theory. In ecological economics this has been further extended along two basic lines. Firstly, by the integration of natural and man-made production processes with respect to the laws of entropy. Secondly, by emphasizing the generation of income and wealth from stock as opposed to flows. The adaptation of the concept of income in national accounting as a stream of services obtained from the stock of wealth is clearly more compatible with sustainable development objectives.

To sum up, I may conclude that the incompatibility of economics, ecology

and sustainable development is, in the main, a problem of a neoclassical framework out of phase with social, economic and environmental realities. A new paradigm is required to fit the needs of the decision-makers in a world of resource scarcities and growing environmental deterioration. These questions are now being addressed at all levels of political discourse and have become the subject matter of the new science of *ecological economics*.

## NOTES

<sup>1</sup> From *Inquiry into the Nature and Causes of the Wealth of Nations*, first published in 1776.

<sup>2</sup> The Ecological Economics of Sustainability: Making Local and Short-Term Goals Consistent with Global and Long-Term Goals. An international and interdisciplinary conference of the International Society for Ecological Economics, held at the World Bank, Washington D.C., 21-23 May 1990.

<sup>3</sup> It is perhaps a sobering thought that if discounting methodology was applied to (rational) political decisions no nation would ever go to war, since this would imply a (totally irrational) higher value placed on future as opposed to current consumption (the resources being the nation's youth), in effect a negative discount rate applied to intergenerational distributions.

<sup>4</sup> In the traditional economic model, the *experience* of consumption is irrelevant. To take the example of driving a car, being stuck in a traffic jam is treated the same as motoring along a quiet country lane.

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