

연구논문

A Sociological Approach to the Destruction of Ecosystem*

Dai-Yeun Jeong** · Shin-Ock Chang***

Prof. of Sociology at Cheju National University**

Research Fellow of Social Science Research Institute at Cheju National University***

(Manuscript received 10 May 2007; accepted 29 May 2007)

생태계 파괴에 대한 사회학적 접근*

정대연** · 장신옥***

제주대학교 사회학과 교수**, 제주대학교 사회과학연구소 특별연구원***

(2007년 5월 10일 접수, 2007년 5월 29일 승인)

Abstract

본 연구는 오늘날 범지구적 차원에서 심각한 수준에 있는 생태계 파괴에 대한 사회학적 함의를 정립하는 데 목적이 있다. 이를 위해 먼저 생태계의 개념과 구조를 살펴보고, 다음으로 인간활동으로 인한 생태계 파괴의 메커니즘을 분석하고, 마지막으로 그 메커니즘에 기초하여 생태계 파괴에 대한 사회학적 함의를 정립하였다.

생태계로서의 자연은 인간 없이 존재할 수 있지만 인간은 자연 없이는 생존할 수 없다. 따라서 생태위기는 곧 인간의 위기다. 그럼에도 불구하고 18세기 산업혁명 이후 풍요성과 편리성 추구를 위한 인간의 활동 결과 지구는 점용환경용량을 2.5배 초과되었다. 이것은 인간이 범한 모순이다.

이 모순을 해결하면서 사회발전을 추진하자는 이념으로 1987년 지속가능발전이 제창되었고, 지속가능발전은 1990년대 중반에 지속가능사회로 대체되었고, 2000년대에 와서는 지속가능사회가 생태적 근대화로 대체되었다.

18세기 산업혁명 이후 풍요성과 편리성 증대를 위한 인간의 활동으로 생태계가 파괴되기 시작한 후, 생태계를 보전하면서 사회발전을 추진하자는 생태적 근대화 이념이 출현까지의 역사적 과정은 정(正)-반(反)-합(合)의 변증법 과정으로 이론화될 수 있다. 산업혁명 이전의 농업사회 때는 인간의 활동이 점용환경용량 범위 안에서 이루어졌기 때문에 환경문제가 없었다. 이 시대는 생태적 지속가능성이 유지되었기 때문에 생태적 합(合)의 상태라고 할 수 있다. 산업혁명 이후 인간의 활동이 생태계의 점용환경용량을 초월시킨 것은 생태계에 반(反)이 작용한 것이다. 따라서 범지구적 차원에서 환경문제의 심각성을 인식하고 지속가능발전을 위한 정책이 도입되기 이전까지 생태계는 정(正)과 반(反)이 대립상태에서 공존하였다. 1990년대 이후 생태적 지속가능성을 위한 각종 지속가능발전 정책의 도입은 정(正)과 반(反)의 대립을 통해 다시 생태학적 합(合)의 상태를 지향하는 과정이라고

할 수 있다.

주요어 : mechanism of ecosystem destruction, sustainable development, sustainable society, appropriated carrying capacity, ecological modernization

I. Introduction

An ecosystem is a structural characteristic of nature, and defined as a set of living organisms and non-living substances interacting to produce an exchange of material and energy between the living and the non-living parts. Their interaction is characterized as a self-regulating system. This self-regulating system has been destructed as industrialization has advanced since the eighteenth century.

Industrialization has improved material affluence and convenience. Meanwhile, it has destructed and/or polluted the individual components of ecosystem, and has caused a crisis of nature in the Earth's self-regulating system. The crisis of the ecosystem is the crisis of human existence. This means that humans are the beneficiaries and sacrificers of industrialization. Then, it may be argued that ecosystem health and industrialization are causing a contradiction.

In order to solve the contradiction, in 1987 WCED suggested the concept of sustainable development as a worldwide ideology for present and future social development as a way of harmonizing with and preserving nature. A lot of activities have been undertaken to achieve the ideology of sustainable development. Examples include activities of international organizations such as UNEP on a worldwide basis, environmental policy by governments, environmental movements by NGOs, green management by business corporations, and academic research by scholars.

With such implications, this paper aims at theorizing the mechanism of ecosystem destruction by human activities from a sociological perspective. To achieve the objective, this paper is divided into three parts. The first defines the concept of an ecosystem and its structure. The second examines destruction of the ecosystem by human activities. The third part draws sociological implications of the destruction of the ecosystem.

II. The Concept of Ecosystem and Its Structure

1. The Concept of Ecosystem

The underlying concept of an ecosystem goes back at least to G. P. Marsh in 1864 (O'Neill, 2001). But, its basic definition was first articulated by A. Tansley in 1935. He defined the ecosystem as a biotic community or assemblage and its associated physical environment in a specific place (Pickett and Gadenasso, 2002). Tansley emphasized the links between the biotic and the abiotic components of ecosystem. He chose a term from physics, 'system' that highlighted interactions. Furthermore, he presented both abiotic and biotic components as complexes.

Pickett and Gadenasso (2002) point out that such a definition has three important characteristics. First, it is scale-independent. An ecosystem can be of any size so long as organisms, physical environment, and interaction can exist within it. Given this characteristic, an ecosystem can be as small as a patch of soil supporting plants and microbes; or as large as the entire biosphere of

the Earth.

Another important feature of the basic definition is that the ecosystem concept is free of narrow assumptions. It is not restricted to an equilibrium, a complex, or a stable system. In fact, ecosystems may be far from equilibrium, so that they are changing in composition, content, or in the processing of nutrients and energy. Similarly, an ecosystem may be autotrophic or heterotrophic.

The power of the general definition articulated is that it is applicable to any case where organisms and physical processes interact in some spatial arena. Therefore, the basic definition covers an almost unimaginably broad array of instances.

In addition, ecosystems can include humans and their artifacts. For example, many scholars (e.g. Costanza *et al*, 1993; Grimm *et al*, 2000) emphasize that ecologists should study ecosystems that incorporate humans and human-generated processes and structures. The use of the ecosystem as a core idea invites a wide variety of approaches, from biodiversity, through evolutionary, to nutrient and energy processing, from instantaneous to historical, and from microbial to biospheric (Jones and Lawton, 1995).

Considering that these factors are included in the concept of an ecosystem, we reach a conclusion that the concept of an ecosystem can be categorized into two versions - the biophysically founded and the socio-ecologically user-founded. The former is based on the biophysical community as a nature itself, whereas the latter extends the biophysical community to a socio-economically oriented concept, which is linked to natural resources and environmental impact issues. It may be maintained that the two orientations to an ecosystem can be characterized in the following way.

They represent the difference between a biophysically based ecosystem approach, and a broader user-oriented connotation of a socio-ecologically based approach with a focus on natural resource as an economic potential. In the former approach, humans are not seen as part of the ecosystem but rather as disturbing agents. In the latter case the interpretation is more of a socio-economic and ecological approach where humans are part of the natural system and depend on its resources that influence the development potential.

However, it is also true that there are some critics of such a concept of an ecosystem. For example, the ecosystem concept is not a scientific theory at all, simply a statement about physical constraints on living things (Sagoff, 1997). Concepts like stability and the ecosystem are ambiguous and defined in contradictory ways. In fact, there is no such thing as an integrated, equilibrium, homeostatic ecosystem: It is a myth (Soule and Lease, 1995). In addition, Pickett *et al* (1992) criticize that the classical paradigm in ecology, with its emphasis on the stable state, its suggestion of natural systems as closed and self-regulating, and its resonance with the non-scientific idea of balance of nature, can no longer serve as an adequate foundation for conservation. In accordance with such a perspective, some scholars (e.g. Levin, 1999) maintain that ecosystems are now seen as disequilibrium, open, hierarchical, spatially patterned, and scaled. Similarly, O'Neill (2001) argues that: The stasis implied by the ecosystem concept is self-limiting. The critical property is the ability to change state in response to a continuous spectrum of change and variability. Sustainability of an ecosystem involves two antithetical elements - (1) local and short-term stability in the sense of recovery from distur-

bance, and (2) flexibility in the sense of maintaining variability of structure in space and time because conditions will change.

Considering the ecosystem concept and its critics, perhaps the backlash should motivate a careful re-examination of the ecosystem concept rather than provoking a defensive reaction. What should be proposed is not a complete concept. Rather, it is a set of principles that might lay the foundation for such a concept.

2. The Structure of Ecosystem

As reviewed in the previous section, even though there are some debates on the ecosystem concept, there is no debate on the fact that an ecosystem consists of many components, all of which are in a mutual interaction. Such a mutual interaction among the components of a reality as a whole is defined generally as a system. In this sense, the term ecosystem being composed of 'eco' and 'system', is based on a premise that nature is characterized not as a reality with its components existing independently, but as a reality with its components existing in a mutual interaction. This means that the most fundamental concept of an ecosystem is the notion of a system as a network of interconnected and interdependent parts (Harper, 2004: 12). In ecology, the idea of a system emphasizes interdependence, balance, self-repair, and self-regulation (Dickens, 1992: 82).

In sociology, even though structure is sometimes used as the meaning of system, it is defined generally as the pattern of the interdependence among the components of a reality as a whole. In this sense, the term ecosystem itself does not tell us anything about in what way its components are structured. Thus, the structure of

an ecosystem can be defined as the pattern of the interdependence among its components as a whole. Thus, for explaining the structure of an ecosystem, the major components should be identified first, and then the pattern of their interdependence should be described.

The components of an ecosystem can be defined as the ecosystem units. As identified in the previous section, the units are both abiotic and biotic. The former includes the materials such as water, temperature, wind, air, climate, and stone, etc. The latter can be classified into, at least, three units at a very macro level - producers, consumers, decomposers.

The producers: They are the organisms that can manufacture the organic compounds they use as sources of energy and nutrients. Most producers are green plants that manufacture food through photosynthesis, without consuming other living organisms.

The consumers: They are those who get their energy and nutrients for survival by feeding directly or indirectly on producers. We can distinguish three types of consumers in terms of what they consume. They are the first consumers (herbivores), the second consumers (carnivores), and the third consumers (omnivores). The first consumers are the animals that eat plants for their energy and nutrients. Organisms that feed on the first consumers are called the second consumers. The second consumers can also consume other second consumers. The third consumers are defined as the animals that have the attributes of both the first and the second consumers in terms of obtaining their energy and nutrients. Humans belong to the third consumers. This is why an ecosystem includes humans (Costanza *et al*, 1993; Grimm *et al*, 2000; Piickett and Gadenasso, 2002).

There is relatively little difference between the second and the third consumers compared to the difference between the first and the second consumers and/or between the first and the third consumers in terms of what they consume for obtaining their energy and nutrients. In this sense, the second and the third consumers may be categorized into the same ecosystem unit.

The decomposers: Plants and animals supply organic matter to the soil system through shedding tissues and death. Consumer organisms that feed on this organic matter or detritus are called decomposers such as fungus and bacteria. The organic matter that is consumed by the decomposers is eventually converted back into inorganic nutrients in the soil. These nutrients can then be used by plants for the production of organic compounds.

The ecosystem units and their interdependence explained above may be diagrammed as Figure 1

(Jeong and Ock, 1977: 68). It is important to note that there are substructures within each ecosystem unit at many different levels.

Based on Figure 1, it may be argued that the main characteristics of the structure of ecosystem units including the abiotic and biotic ones are as follows (Jeong, 2002: 43-48).

First, the structure of an ecosystem is based on a process of energy flow and material cycle among the units. The energy begins first with the input from the sun. The solar energy is captured by the process of photosynthesis, and then is used to transform the energy to materials for the consumers and decomposers. The ecosystem units are interdependent from each other in such a process of energy flow and material cycle. The energy and materials are not destroyed or lost, so the Earth is a closed system. They are cycled endlessly between their biotic and abiotic states within the ecosystem.

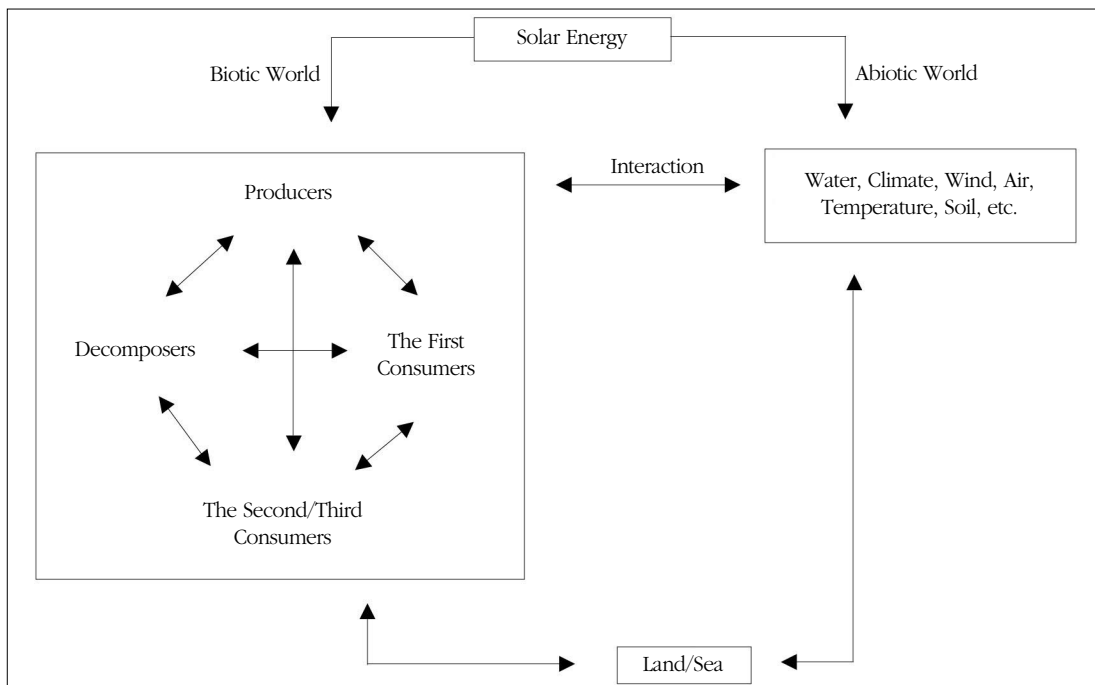


Figure 1. The Structure of Ecosystem

Second, as explained in the previous section, the structural units are working interdependently. The examples include symbiosis, competition, food-chains, invasion, succession, and functional relationship. These are called ecological processes.

Third, the structure of an ecosystem as a whole is a self-regulating system. If a change occurs in a structural unit, other structural units change. The ecosystem is re-structured through this changing process. In this sense, the structural units are dynamic and changing, so that they are also continuously reconfiguring themselves. It has been argued that such a self-regulating system as an ecosystem has an attribute of homeostasis.

Fourth, the process of self-regulating system is a reaction to be re-structured to the change in the structure of an ecosystem. This process is termed as an adaptation that is also signified as an ecological process. The adaptation usually occurs in the best way to survive in the new structure configured by the change in a structural unit. The components of each structural unit whose adaptation is not successful are exterminated. The survival of the fittest, natural selection, and evolution are the concepts explaining the process of adaptation.

III. The Mechanism of Ecosystem Destruction

In a broad sense, as shown in Figure 1, human is a component of ecosystem units. However, if human is set up as the subject, other components are the environment of humans as the external factors to which humans respond. This has resulted in the destruction of ecosystem which connotes environmental problem.

The destruction of ecosystem as environmental

problem includes, at least, three facts which are related to human activities for the improvement of material/cultural affluences and convenience in life (Jeong, 2002: 163). They are the depletion of resources, the original state of nature being polluted, and as the result, the self-regulating system of ecosystem being destructed.

In explaining the causes of ecosystem destruction as an environmental problem at such a narrow level, two primary approaches have been offered. One is the ecological explanation, and the other is the political economy explanation. The two approaches have suggested wide ranges of causes of nature being destroyed as the ecosystem.

In terms of the ecological explanation, the traditional examples include population increase (Ehrlich, 1968), and the development of production technology such as unspoiled inorganic or synthetic material (Commoner, 1971; Commoner *et al*, 1983). Many other factors have also been suggested as the primary causes of environmental deterioration, including the West's anthropocentric and religious orientations and values drawn from Christianity (White, 1967; Toynbee, 1972), the socio-economic forces encouraging both population increase and technological development (Schnaiberg, 1980), production activity due to the increase in population beyond the optimum capacity (Borgstrom, 1969), and economic development and increase in wealth (Schumacher, 1973).

The examples of the political economy explanation include the competing functions of the environment (Catton and Dunlap, 1989), and social class issues in which the corporation and the state line up in opposition to ordinary citizens (Cable and Cable, 1995: xi). In addition, in

the narrowest sense, many environmental economists maintain that the market failure of environmental resources in capitalism is the main cause of the destruction of the ecosystem.

The above causes of ecosystem destruction are all a mono-causal explanation in that, even though the causes are interconnected, the scholars tend to point out the causes as if they are independent ones. Therefore, the explanation of the causes of ecosystem destruction should be based on a multi-causal approach. In this context, a complex set of causes are involved in the process of industrialization as the primary source of ecosystem destruction (e.g. Orr, 1979), including technological progress, economic growth, urbanization and other social processes (e.g. Kassiola, 1990; Foster, 1994). Implicit in such explanations is the recognition not only that there are multiple sources of ecosystem destruction, but that these sources are themselves interrelated in a socially and historically complex fashion as industrialization has advanced.

Some scholars have attempted to describe the dominant social paradigm of industrial society as

the main cause of environmental problems such as the destruction of the ecosystem (e.g. Dunlap and Van Liere, 1984; Milbrath, 1989; Olsen *et al*, 1992). Although the scholars differ about the details, they agree that industrialization, as the main social and historical paradigm in terms of its scale and scope, amplifies the second part of the inherent duality of human life: that humans are the unique creators of technological and socio-cultural environments that have singular power to change, manipulate, and sometimes to transcend natural environmental limits.

Industrialization since the eighteenth century has brought about material affluence and many of the conveniences we now enjoy. But such benefits have been achieved at the expense of nature. The mechanism of ecosystem destruction in the process of industrialization may be diagrammed as Figure 2 (Jeong, 2003).

As Figure 2 shows, the ecosystem as nature provides humans directly with environmental services such as water, air, soil, and landscape, etc. The resources are produced as capital and/or consumption goods and services. The goods and

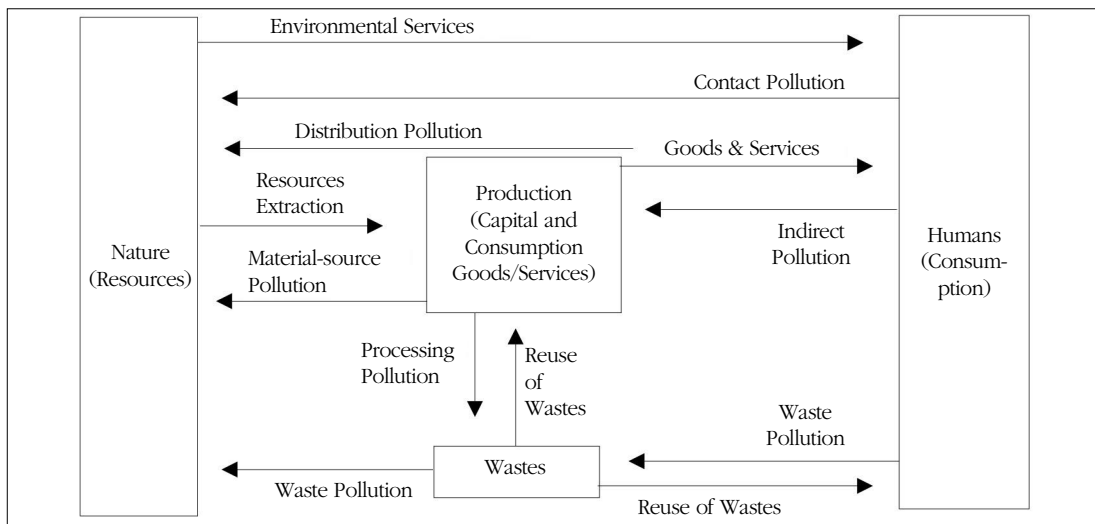


Figure 2. The Mechanism of the Destruction of Ecosystem

services are provided to humans for consumption through the process of distribution. The extraction of resources depletes natural resources.

The original quality of the ecosystem is destroyed in the process of resource extraction. This can be termed material-source pollution. Liquid, aerial, and solid wastes are discharged in the process of producing capital and/or consumption goods. These wastes are returned to the ecosystem, and as a result, the ecosystem is destroyed. This can be termed process pollution.

Even though some wastes discharged from the process of producing capital and consumption goods are re-used as resources of production, the remaining wastes return to the ecosystem. This can be termed waste pollution. Waste pollution is also generated in the process of consumption, even though some wastes discharged from the process of consuming goods are re-used.

The ecosystem is also destroyed in the process of distributing goods and services. This can be termed distribution pollution. Humans directly destruct the ecosystem in the process of their activities in everyday life such as cutting trees. This can be termed contact pollution. In capitalism, the need of consumers works as a reference for the capitalists in deciding what and how many goods and services to produce. This means that consumers generate indirectly material-source pollution and processing pollution as well. This can be termed indirect pollution.

These pollutions are made by humans in the process of industrialization for improving their material affluence and convenience, and work directly to destruct the original state of the ecosystem. These pollutions are the artifacts that do not exist in an original ecosystem.

V. Some Sociological Implications of the Ecosystem Destruction

1. The Excess of Appropriated Carrying Capacity

As shown in Figure 1, humans are basically a component of the ecosystem. Nonetheless, humans have regarded themselves as an outsider. Even though humans are the outsiders, all of the prerequisite functions necessary for their survival are provided from the ecosystem.

At a macro level, the ecosystem as nature provides humans with, at least, four functions: production, control, space, and emotion (Oh, 1997: 4-5). The function of production is to provide humans with environmental services and resources as shown in Figure 2. The function of control includes the temperature, humidity, and climate, etc. in a suitable way for human survival. Maintaining the optimum population number through food-chains, the absorption of wastes discharged by human activities, and the sustainability of biodiversity belong to the control function. The examples of spatial function are the spatial sites such as agriculture, fishery, housing, factory, and roads. The function of emotion provides humans with such as aesthetic appreciation and the base of art and science.

The ecosystem does not have an infinite capacity to provide humans with the four functions. In particular, as shown in Figure 2, the capacity to provide resources and to absorb the wastes discharged from human activities has been conceptualized as appropriated carrying capacity (hereafter called ACC). The ACC is also called ecological footprint.

The ACC is referred to as the aggregate land area in various categories required by the people in a region to provide continuously all the

resources they presently consume, and to absorb continuously all the wastes they presently discharge. Its concept was developed and quantified by Wackernagel *et al* (1993: 10) in the early 1990s as an elaboration of the concept of carrying capacity developed in biology.

Central to the ACC concept is the notion that for every type of material or energy consumption a certain amount of land in various ecosystem categories is required to provide the consumption-related resource flows and waste sinks (Wackernagel *et al*, 1993: 19). What this means is that it is not about “How many people can the Earth support?”, but rather “How much land do people require to support themselves?” In other words, the ACC addresses not the number of heads but the size of feet. In this sense, the ACC considers the three functions of ecosystem providing humans - resources as a production function, wastes as a control function, and land size as a spatial function.

Some empirical research has been done on calculating the ACC. The examples include works done by Wackernagel *et al* (1993) on Canada, Bicknell *et al* (1998) on New Zealand, and McDonald and Patterson (2003) on New Zealand. In addition, WRI (1992), Chambers *et al* (2000), and WWF (2002) have calculated the ACC for the entire world as a unit. Typically with such empirical research, critical debate arises about its conceptual basis (e.g. Ayres, 2000; Moffatt, 2000), the validity of its calculating method and the result (e.g. van Kooten and Bulte, 2000; Vegara, 2000; DEAI, 2002). Meanwhile, some scholars (e.g. van Vuuren and Smeets, 2000) argue that despite the debates on the ACC, it is successful in providing an interesting basis for discussion on the environmental effects of consumption pat-

terns, including those outside the national borders, and on equity with regard to resource use. Recently, Wackernagel and Yount (2002) discussed the strength and weakness of ACC as an ecological accounting method.

According to the work on the ACC for the entire world as a unit (e.g. WRI, 1992; Chambers *et al*, 2000; WWF, 2002), the Earth exceeds it by 2.50 times. Meadows *et al* (1992) maintained a pessimistic perspective on the ACC of the Earth, with 13 possible scenarios for the future in relation to natural resources, industrial production, food, population, pollution, and the material quality of human life. They concluded that if humans continue enjoying the current level of affluence and convenience, the Earth is no more suitable for humans to live from the year of 2200.

Considering the functions of the ecosystem, humans can't survive without the ecosystem as nature. However, the ecosystem can exist without humans. In this sense, the crisis of the ecosystem is the crisis of human existence. Nonetheless, humans have advanced industrialization for improving material affluence and many of the conveniences we are enjoying now. But such benefits have been achieved at the enormous expense of nature and produced environmental problems. In particular, the input of human artifacts into the ecosystem through the processes shown in Figure 2 is to insert the extraneous substances that are not inherent in the original state of the ecosystem, and then resulting as a negative impact on the self-regulating system. This means that humans are both beneficiaries and sacrificers of industrialization.

2. The Emergence of Environmentalism

The main goals of industrialization are to

improve material affluence and convenience in life. The goals have created a cultural ethos termed consumerism. Consumerism is defined as a cultural imperative that demands we appropriate as many goods and services as possible and that we should do this essentially for fun and enjoyment rather than simply necessity (Miles, 1998; Sklair, 1991).

Consumerism has been conceptualized from two main sources: the sociology of development and cultural sociology. The former is most clearly enunciated by Sklair (1991), who places consumerism centrally within the development of the global system, and who maintains that consumerism is the core component of contemporary culture, enveloping all peoples in all parts of the world.

The culture-ideology of consumerism proclaims, literally, that the meaning of life is to be found in the things that we possess. To consume, therefore, is to be fully alive, and to remain fully alive we must continuously consume (Sklair, 1991: 41).

Cultural sociology's interest in consumerism is captured in theories of postmodernity (e.g. see Bauman, 1998; Bennett *et al*, 1999; Lyon, 1999; Miles, 1998), although consumerism is also linked to a wider body of scholars, including political economy (e.g. Fine and Leopold, 1993), anthropology (e.g. Howes, 1996; Miller, 1995), and mainstream sociology (Ritzer, 1999). As with the sociology of development, cultural sociology locates consumerism and consumption centrally within the global system (Lyon, 1999; Miles, 1998), but emphasizes the symbolic power of consumption: the accumulation of an increasing array of goods and services defines people socially and culturally, with a recognition that consumption is more significant for its sign-value or

symbolic qualities than for its use-value (Miles, 1998: 23).

The hyperconsumption (Ritzer, 1999) demanded of consumerism threatens the ecosystem through the processes shown in Figure 2. Fundamental changes in values, attitudes, and beliefs have occurred around the world following perceived negative impacts on the ecosystem by science and technology which are the major instruments to improve affluence and convenience (Beck, 1992; Giddens, 1991; Lash *et al*, 1996). Technological disasters such as nuclear accidents identify a society at risk, with people's growing fears about these risks leading to a questioning of the promise that science and technology will continue to bring widespread benefits.

With the perceived negative impacts of consumerism on the ecosystem, environmentalism emerged as another cultural ethos. Environmentalism is the cultural imperative that demands we act in an environmentally sustainable way and, most particularly do this by cutting back on consumption and against a backdrop of an impending apocalypse, one emanating from today's risk society.

Environmentalism has been theorized and conceptualized in another two main ways - Inglehart's work on materialist and postmaterialist values (Abramson and Inglehart, 1995) and the New Environmental Paradigm (Dunlap and Van Liere, 1978; 1984). Like risk society theorists, Inglehart and his colleagues maintain that a fundamental cultural shift has occurred in the more developed world over the last part of the twentieth century. People are now less concerned with material issues, like housing and food, because these are now readily satisfied. Instead, they focus on quality of life issues, like environmental

sustainability. Inglehart uses the term materialist values to refer to the former and postmaterialist values to refer to the latter, with the shift from the former to the latter beginning around 1950, but gaining momentum from the 1970s. This socio-cultural transformation occurred after material needs were more easily satisfied in the more developed world during the 1945-73 economic boom.

The New Environmental Paradigm (NEP) covers the environmental component of Inglehart's postmaterialist values thesis. Formulated in the 1970s by Dunlap and Van Liere (see also Dunlap *et al.*, 2000), it contrasts with the Dominant Social Paradigm (DSP), the belief that humans have the right to freely exploit nature.

In the West, environmentalism is most strongly held by young adults, women, the politically active, urban residents, the new middle class, professionals, the more educated, and those with higher incomes. In contrast, older people, the less educated, the welfare dependent, and churchgoers - specifically religious fundamentalists are least supportive of this cultural imperative, while working class males are more likely to hold anti-environmentalist views (Buttel, 1978; Cotgrove and Duff, 1980; Eckersley, 1989; Kanji and Nevitte, 1997; Papadakis, 1993; Scott and Willits, 1994; Skogen, 1999; Tranter, 1999). Findings similar to, but also different from these, have been recorded for Australia and Korea as a comparison between a developed and developing country (Mullins *et al.*, 2004).

3. The Paradox of Technology

It took until the 1960s to recognize how serious the environmental problem was as an indicator of ecosystem destruction. In accordance with

this recognition, two main streams of thought appeared in academic circles in the 1970s. One was the pessimistic point of view on industrialization, and the other was the optimistic view.

The pessimistic view (Meadows *et al.*, 1972) argued that there should be a limit to economic development in terms of population, energy, food, pollution, and psychological health, for at the time it seemed to be reaching levels that would soon be unsustainable. Meadows *et al.* (1992) maintained a pessimistic perspective on industrialization in 1992, with 13 possible scenarios for the future up to 2100 in relation to natural resources, industrial production, food, population, natural environmental pollution, and the material quality of human life. Contrary to this, the optimistic view (Kahn *et al.*, 1979) argued that limits could be overcome by innovation in technology and economic development on the basis of reinvestment of capital.

The argument on the development of technology as a means to preserve ecosystem continues until recently, using a new term green and/or clean technology (e.g. Johansson, 1992; Freeman *et al.* 1995; Kirkwood and Longley, 1995; OECD, 1995; Schot, 2001). Seeing the concept of clean technology in depth, different scholars cite different meanings. However, they apply the clean technology to production process, re-use and recycling of resources, conservation and efficient use of energy, and production design. They maintain that the clean technology will contribute to protect nature destroyed and/or polluted, to reduce the necessity of resource use, and to save energy. As a result, they expect that the clean technology will reduce the impact on the ecosystem. However, their arguments are summarized in terms of three connotations. They are non-pol-

luting technology, the use of renewable resources, and the use of recycling.

Firstly, in regard to non-polluting technology, there are technologies that cause pollutions. Many of these are associated with heavy manufacturing industry. However, these can be replaced with cleaner non-polluting technology which can cut down on pollution. Technical change can also deal with resource depletion problems. This brings us to the second technological change. There are technologies that use up a lot of non-renewable resources - coal, oil and gas for example. These are the resources that are gone forever once they are used up.

Secondly, the solution is to introduce new technologies exploiting renewable resources that can't be used up and depleted. This might include the use of wind, sun and wave in wind-powered, solar-powered and wave-powered machinery or the conversion of waste to liquid and gas fuels. Another set of technical solutions to resource depletion involve more efficient ways of storing and retaining heat and energy so that less energy needs to be used in the first place.

Thirdly, in regard to recycling, this involves the development of technologies that allow us to recycle goods for reuse rather than disposing of them. This cut down on resource depletion for the production of goods that can be produced using recycled waste - paper, glass, and metal products for example. It also sometimes reduces the polluting effects of extractive and manufacturing processes.

According to the above three implications, it is true that technology is a useful means to preserve the ecosystem because the implications can be applied to all the processes specified in Figure 2. In accordance with such implication on tech-

nology, the environmental policies are mostly based on a technological approach to the preservation of the ecosystem. The typical example is to install the advanced technologies in the process specified in Figure 2.

Even though technology is a possible means to preserve the ecosystem, it has been argued that technology is also a cause of environmental problems (e.g. Commoner, 1971; Commoner *et al*, 1983). Such a conflicting position of technology may be termed the paradox of technology. In this sense, it may be maintained that the technological approach to the preservation of the ecosystem is not a sufficient means, and can be defined as an attempt to get rid of tumors on our body. The fundamental strategy should be an integrated system approach attempting to change the physical constitution of our body to a new one forming no tumors.

4. From Sustainable Development to Ecological Modernization

Nowadays, sustainable development is a worldwide ideology for present and future social development. It was in 1987 that the WCED promoted the concept of sustainable development as a yardstick for long-term environmental policies, describing it in broad terms as: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987: 43). The emergence of sustainable development is a self-reflection on the crisis of human existence caused by the destruction of the ecosystem as a by-product having resulted from the improvement of material affluence and conveniences in life.

Sustainable development is not a cure-all as the WCED (1987) recognized that it does imply limits - not absolute limits, but limitations

imposed by the impact of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. In accordance with this, negative arguments on sustainable development emerged in the 1990s. For example, Cohen (1995) argues that notions like sustainable development or carrying capacity are important but are not concepts with any objective and scientific utility. He continues by stating that a question like, "How many people can the Earth support?" is inherently normative and value-laden. Lele (1991) argues that sustainable development is merely a concept implying different forms of industrialized economic development - promoted since the industrial revolution began, since the sacrifice of nature is an inevitable part of the process of economic development. Catton (1997) argues that there is no such thing as sustainable development, which is a rhetorical and ideological term for those who wish to continue destructive growth and feel good about it.

With such negative implications, there has been hot debate on whether the concept of sustainable development is useful or not (e.g. Beckerman, 1994; 1995; Daly, 1995; Jacobs, 1995). Regardless of such arguments, definitions of sustainable development abound (van den Bergh and van der Straaten, 1994). It is generally agreed that ecological sustainability has more clarity as a concept than sustainable development. The confusion usually arises from what is meant by development, and how broadly or specifically the term is defined. In accordance with this, concepts of weak and strong sustainability have emerged, the former relating to economy and the latter to the ecosystem (e.g. Bell and Morse, 1999; Rao, 2000; Turner 1998).

Such negative or positive arguments might arise from the fact that sustainable development, as it emerged in the 1990s, is based on the relationship between two main components: economic development and the preservation of the ecosystem. If we only include these two components, sustainable development only becomes desirable for economic survival and utility (Pezzey, 1992) or for a successful economy (Lele, 1991). There are, however, many other social factors determining economic and ecological sustainability. This means that economic and ecological sustainability are not possible without the sustainability of other social factors. In other words, without considering other social factors, the ideology of sustainable development can't be realized in its entirety.

Thus a variety of new perspectives on its conceptual components emerged in the 1990s, focusing not only on the traditional components of the economy and ecosystem but also on other social factors that determine their sustainability. These may be termed multidimensional approaches. For example, Pezzey (1992) discusses physical, ecological, economic, psychological, social, and historical sustainable development. Ekins (1994) discusses the biological, economic, and social components of sustainable development. Turner (1998) discusses sustainable development in terms of nature, socio-cultural systems, and economy. Rao (2000) maintains ecological, social, and economic factors as the conceptual components of sustainable development. Harper (2004: 305-307) argues that there are seven requirements for sustainability; these are population, biological base, energy, economic efficiency, social forms, culture, and world order.

These multidimensional concepts can be seen

as focusing on the sustainability of society as a whole. This is because a multidimensional perspective enables us to extract as many sustainability components as there are components of a society, such as economy, ecosystem, population increase, culture, social structure, and technology. In this sense, the multidimensional approach can be termed 'sustainable society' as a whole.

Research on sustainable development has seen some advances in the 2000s. However, there is a trend to focus on what to be sustained rather than on conceptualizing its concept from another perspective. The categories of what to be sustained are based on those multidimensional components of sustainable development explained above. For example, the category of what to be sustained includes nature, life support, community, people, economy, and society (Kates *et al*, 2005).

The ideology of sustainable society also has a limitation in that its multidimensional conceptual components are considered to be in a horizontal position with the same importance. Considering the fact that the crisis of human existence is caused by the destruction of nature, the sustainability of the ecosystem should be on the top as the most crucial value among the multidimensional conceptual components. Then, the positions of the conceptual components will be in a hierarchy with the sustainability of the ecosystem at the place on top, even though we set up the remaining conceptual components to be in a horizontal position. Such a conceptual framework may reflect a conceptual meaning of ecological modernization.

The concept of ecological modernization was used first by Huber (1985) before the emergence of sustainable development in 1987. Since that time, the concept of ecological modernization has

been defined in a wide range. However, its concept involves a collection of ideas about re-structuring modern societies and economies to achieve a more sustainable relationship with the environment and ecosystem without compromising the quality of life delivered by industrial economies (Harper 2004: 340), with a priority on the sustainability of the ecosystem. Such a perspective reflects as an ecologization of society as a whole (Hills *et al*, 2003). In this sense, ecological modernization will be more desirable than sustainable development focusing on the harmonization between human need and the sustainability of the ecosystem.

VI. Concluding Remarks

The ecosystem is defined in many ways according to which attributes to emphasize. However, a consensus is that an ecosystem is an assemblage of the biotic and abiotic components. The biotic components can be classified into producers, consumers, and decomposers at a macro level. The consumers are classified into the first, the second, and the third consumers. Humans belong to the third consumers. Each of the biotic and abiotic components is also composed of their own sub-components that are termed 'sub-ecosystem'.

The components of an ecosystem are in a mutual interaction in a way of their existence mode to be determined. The mutual interaction can be explained in terms of, at least, three dimensions. One is ecological process such as competition, symbiosis, and invasion. Another is the attribute of a self-regulating system towards homeostasis through continuously reconfiguring itself. The other is a process of energy flow and

material cycle. Such a mutual interaction is usually called the natural law.

Basically, humans are a component of ecosystem as diagrammed in Figure 2. However, humans have behaved as if they are outsiders from the ecosystem. Such an anthropocentric perspective have polluted and/or destructed the ecosystem by improving material affluence and convenience in life since the eighteenth century when industrialization was embarked upon.

For survival, humans have to *get all* materials and services from nature as an ecosystem. This means that humans can't survive without nature, but nature can exist without humans. Even from an anthropocentric point of view, the most important reason why the ecosystem should not be destructed is that the crisis of the ecosystem is the crisis of human existence.

Nonetheless, human activities have already exceeded the appropriated carrying capacity of the Earth by 2.5 times. The excess has resulted from the process of industrialization to achieve the improvement of material affluence and convenience in life at the expense of the ecosystem. This means that humans are not only beneficiaries but also sacrificers of industrialization. This is definitely a contradiction humans have entered into.

Sustainable development emerged in 1987 as an ideology for solving the contradiction. The ideology expanded to sustainable society from the middle of the 1990s. The most important limitation inherent in the two is that they are basically based on a technological approach to the preservation of the ecosystem, still with an anthropocentric perspective. The ideology of ecological modernization is much more efficient for preserving the ecosystem than the ideology of

sustainable development or of a sustainable society in that it purses to structuralize the whole social system as a structure of 'environmentally sound and humanly desirable' with a priority on the preservation of ecosystem. In this sense, unlike sustainable development or sustainable society, ecological modernization is a system approach.

In order for the system approach to be more successful, there must be an explicit consideration of ecological implications of the existing social and economic decision (Costanze and Farber, 2002). Such signals provide feedback to facilitate the management of human activities, and there is therefore a need to value these implications. Value can be defined in terms of both the ecosystem and human socio-cultural systems. In relation to the ecosystem, 'value' is the contribution of something to a condition or state of a self-regulating system, then the structures and functions of the ecosystem. For example, the value of a tree to a forest is its role in perpetuating forest conditions, including nutrient and hydrologic cycling functions. So we can say a relative value of those species without reference to human perceptions or preferences. Meanwhile, in relation to human socio-cultural system, value is a contribution to a goal, which is purposeful condition. Ecosystems have value insofar as they contribute to that goal. A major goal of human interaction with the ecosystem has been to improve material affluence and convenience in life. This goal is the criteria against which human activity and the conditions of the ecosystem are often measured. Then, value will be the most important feedback signal that can guide the management of human activities in the ecosystem.

The two values from both the ecosystem and

human socio-cultural system suggest that the valuation of an ecosystem is ingredient in practicing policy. The human socio-cultural perspective is obvious, since human goals are based in part upon the flow of goods and services. Ecological perspective is similarly obvious, since valuation reflects the role and importance of natural structures and processes to the health of ecosystem and to the maintenance of ecosystem services.

In addition, one more consideration is required for the system approach to be successful. That is change of the existing socio-cultural system structured as 'human domination over human' The deep ecologists (e.g. Berry, 1995; Naess, 1995) argue that we have to realize the norm of biocentric equality, because human domination over nature is one of the causes of ecosystem destruction. However, some scholars (e.g. Bookchin, 1980; 1988) argue that the fundamental cause of ecosystem destruction is not the human domination over nature, but human domination over human. The conception of human domination over nature is derived from the unequal socio-cultural system characterized as human domination over human such as capitalist against labourer. For example, capitalists should exploit continuously nature in order to enjoy their current position of dominating labourers.

Such a conflicting relationship between human activity and the ecosystem may be termed a dialectic process through historical stages. The dialectic process has resulted in an ecological synthesis in agricultural society, economic synthesis before the 1960s when the seriousness of ecosystem destruction was recognized, and ecological synthesis again since the 1970s. The ecological synthesis in an agricultural society is defined as a society having no serious destruc-

tion of the ecosystem because human activities (thesis) were within the carrying capacity of the ecosystem (anti-thesis). The economic synthesis in the early industrial society from the eighteenth century to the 1960s is defined as a society whose goal was to improve material affluence and convenience in life. In this historical stage, human activities (thesis) were characterized as human domination over nature, as a result the ecosystem exceeded carrying capacities (anti-thesis), which has made humans recognize that the crisis of ecosystem is the crisis of human existence. In accordance with this recognition since the 1970s, even though human activities (thesis) are still continuing to exploit the ecosystem (anti-thesis) for improving material affluence and convenience in life (thesis), many institutional efforts have been launched to reduce the destruction of ecosystem (ecological synthesis). Examples are environmental policy by governments, international environmental conventions by international organizations, green management by business corporations, environmental movements by NGOs, and environmentally friendly behaviour by general citizens in everyday life. In academic areas, a lot of green social theories have also emerged such as risk society theory, deep ecology, social ecology, new environmental paradigm, and environmentalism.

Note

This is the revised paper presented at the International Conference on Ecosystem Health held in The University of Newcastle, Australia from April 14 to 16, 2003.

References

- Abramson, P. and Inglehart, R., 1995, *Value Change in Global Perspective*, Ann Arbor, University of Michigan Press.
- Ayres, R. U., 2000, Commentary on the Utility of the Ecological Footprint Concept, *Economics*, 32(2), 347-350.
- Bauman, Z., 1998, *Work, Consumerism, and the New Poor*, Buckingham, Open University Press.
- Beck, U., 1992, *Risk Society: Towards a New Modernity*, London, Sage Publications.
- Beckerman, W., 1994, Sustainable Development: Is It a Useful Concept?, *Environmental Values*, 3, 191-209.
- , 1995, How Would You Like Your Sustainability, Sir? Weak or Strong?: A Reply to My Critics, *Environmental Values*, 4, 169-179.
- Bell, S. and Morse, S., 1999, *Sustainability Indicators: Measuring the Immeasurable?*, London, Earthscan Publications Ltd.
- Bennett, T., Emmison, M., and Frow, J., 1999, *Accounting for Taste*, Cambridge, Cambridge University Press.
- Berry, T., 1995, Viable Human, Pp. 8-18 in *Deep Ecology for the 21st Century*, Edited by G. Sessions, Boston, Shambhala Publications, Inc.
- Bicknell, K. B. *et al.*, 1998, An Indicator of Our Pressure on the Land: New Zealand's Ecological Footprint, *New Zealand Geographer*, 54(2), 4-11.
- Bookchin, M., 1980, *Toward an Ecological Society*, Montreal: Black Rose Books.
- , 1988, Social Ecology versus Deep Ecology, *Socialist Review*, 19(3), 11-29.
- Borgstrom, G., 1969, *Two Many - A Study of the Earth's Biological Limitations*, New York, Macmillan.
- Buttel, F., 1978, Economic Growth and the Welfare State: Implications for the Future of Environmentalism, *Social Science Quarterly*, 58, 692-699.
- Cable, S. and Cable, C., 1995, *Environmental Problems Grassroots Solution: The Politics of Grassroots Environmental Conflicts*, New York, St. Martin's Press.
- Catton Jr, W. R., 1997, Redundancy Anxiety, *Human Ecology Review*, 3(2), 175-178.
- Catton Jr., W. R. and Dunlap, R. E., 1989, Competing Functions of the Environment: Living Space, Supply Depot and Waste Repository, Paper presented at the annual meeting of the Rural Sociological Society, Salt Lake City, Utah.
- Chambers, N. *et al.*, 2000, *Sharing Nature's Interest: Ecological Footprints As an Indicator of Sustainability*, London: Earthscan Publications Ltd.
- Cohen, J. E., 1995, *How Many People Can the Earth Support?*, New York: W. W. Norton.
- Commoner, B., 1971, *The Closing Circle Confronting*, New York: Knof.
- Costanza, R. and Farber, S., 2002, Introduction to the Special Issue on the Dynamics and Value of Ecosystem Services: Integrating Economic and Ecological Perspectives, *Ecological Economics*, 41, 367-373.
- Costanza, R., Wainger, L., and Maler, K-G., 1993, Modeling Complex Economic Systems: Towards an Evolutionary, Dynamic Understanding of People and Nature, *BioScience*, 43, 545-555.

- Cotgrove, S. and Duff, A., 1980, Environmentalism, Middle-class Radicalism, and Politics, *Sociological Review*, 28, 333-351.
- Daly, H. E., 1995, On Wilfred Beckermans Critique of Sustainable Development, *Environmental Values*, 4, 49-55.
- Dickens, P., 1992, *Society and Nature: Towards a Green Social Theory*, London, Harvester Wheatsheaf.
- Dunlap, R. and Van Liere, K., 1978, The New Environmental Paradigm: A Proposed Measuring Instrument and Preliminary Results, *Journal of Environmental Education*, 9, 10-19.
- _____, 1984, Commitment to the Dominant Social Paradigm and Concerns for Environmental Quality: An Empirical Examination, *Social Science Quarterly*, 65, 1013-1028.
- Dunlap, R., Van Liere, K., Mertig, A., and Jones, R., 2000, Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale, *Journal of Social Issues*, 56(3), 425-442.
- Eckersley, R., 1989, Green Politics and the New Class, *Political Studies*, 37, 205-223.
- Ehrlich, P., 1968, *The Population Bomb*, New York, Ballantine.
- Ekins, P., 1994, The Environmental Sustainability of Economic Processes: A Framework for Analysis, Pp. 25-55 in *Toward Sustainable Development: Concepts, Methods, and Policy*. Edited by J. C. J. M. van den Bergh and J. van der Straaten, Washington, D. C., Island Press.
- Fine, B. and Leopold, E., 1993, *The World of Consumption*, London, Routledge.
- Foster, J. B., 1994, *The Vulnerable Planet - A Short Economic History of the Environment*, New York, Monthly Review.
- Freeman, H. M., Puskas, Z., and Olbina, R., 1995, *Cleaner Technologies and Cleaner Products for Sustainable Development*, New York, Springer.
- Giddens, A., 1991, *Modernity and Self-Identify*, Cambridge, Polity.
- Goldblatt, D., 1996, *Social Theory and the Environment*, Oxford, Polity Press.
- Grimm, N. B., Grove, J. M., Pickett, S. T. A., and Redman, C. L., 2000, Integrated Approaches to Long-Term Studies of Urban Ecological Systems, *BioScience*, 50, 571-584.
- Harper, C. L., 2004, *Environment and Society: Human Perspectives on Environmental Issues* (3rd ed.), New Jersey, Upper Saddle River.
- Hills, P. Welford, R., and Robers, P., 2003, Ecological Modernization, Environmental Reform and the Transformation of Production and Consumption, *International Journal of Environment and Sustainable Development*, 2(3), 231-236.
- Howes, D. (ed.), 1996, *Cross-Cultural Consumption*, London, Routledge.
- Huber, J., 1985, *The Rainbow Society: Ecology and Social Politics*, Fisher Verlag: Frankfurt am Main.
- Jacobs, M., 1995, Sustainable Development, Capital Substitution and Economic Humility: A Response to Beckerman, *Environmental Values*, 4, 57-68.
- Jeong, D. Y., 2002, *Environmental Sociology*, Seoul, Acanet.
- _____, 2003, A Sociological Approach to

- Sustainable Development, *Journal of Environmental Impact Assessment*, 12(1), 55-72.
- Jeong, Y. and Ock, C. S., 1997, *Humans and Environment*, Seoul, Jigumunhwasa.
- Johansson, A., 1992, *Clean Technology*, Boca Raton, Lewis.
- Jones, C. G. and Lawton, J. H. (eds.), 1995, *Linking Species and Ecosystems*, New York, Chapman and Hall.
- Kahn, H. *et al.*, 1979, *World Economy Development, 1979 and Beyond*, Boulder, West View Press.
- Kanji, M. and Nevitte, N., 1997, Environmental Support, Concern and Action, *International Journal of Public Opinion Research*, 9(1), 66-76.
- Kassiola, J. J., 1990, *The Death of Industrial Civilization*, Albany, State University of New York Press.
- Kates, R. W., Parris, T. M., and Leiserowitz, A. A., 2005, What is Sustainable Development, *Environment*, 47(3), 8-21.
- Kirkwood, R. C. and Longley, A. J. (eds.), 1995, *Clean Technology and the Environment*, London, Blackie Academic & Professional.
- Lash, S., Szerszynski, B., and Wynne, B. (eds.), 1996, *Risk, Environment, and Modernity*, London Sage.
- Lele, S. M., 1991, Sustainable Development: A Critical Review, *World Development*, 19(6), 607-621.
- Levin, S. A., 1999, *Fragile Dominion*, Massachusetts, Perseus Books, Readings.
- Lyon, D., 1999, *Postmodernity*, Buckingham, Open University Press.
- Martell, L., 1994, *Ecology and Society: An Introduction*, Cambridge, Polity Press.
- McDonald, G. and Patterson, M., 2003, *Ecological Footprints of New Zealand and Its Regions, 1997/98*, Ministry for the Environment, New Zealand Government.
- Meadows, D. H. *et al.*, Limit to Growth, New York, Universe Books.
- _____, 1992, *Beyond the Limits: Global Collapse or a Sustainable Future*, London, Earthscan Publications Limited.
- Milbrath, L., 1989, *Envisioning a Sustainable Society: Learning Our Way Out*, Albany, NY, State University of New York Press.
- Miles, S., 1998, *Consumerism as a Way of Life*, London, Sage Publications.
- Miller, D. (ed.), 1995, *Acknowledging Consumption*, London, Routledge.
- Moffatt, I., 2000, Ecological Footprints and Sustainable Development, *Ecological Economics*, 32(3), 359-362.
- Mullins, P., Jeong, D. Y., Western, J. S., Lowe, I., and Simpson, R., 2004, Consumerism and Sustainable Development, *Korean Social Science Journal*, 31(1), 1-38.
- Naess, A., 1995, Self-Realization: An Ecological Approach to Being in the World, Pp. 225-239 in *Deep Ecology for the 21st Century*, Edited by G. Sessions, Boston, Shambhala Publications, Inc.
- OECD (Organization for Economic Cooperation and Development), 1995, *Technologies for Cleaner Production and Products: Towards Technological Transformation for Sustainable Development*, Paris, Andre-Pascal.
- Oh, H. S., 1997, *Environmental Economics*, Seoul, Beummun Publication Co.

- Olsen, M. E. *et al.*, 1992, *Viewing the World Ecologically*, Boulder, CO, Westview Press.
- O'Neill, R. V., 2001, Is It Time to Bury the Ecosystem Concept? (With Full Military Honors, of Course!), *Ecology*, 82(12), 3275-3284.
- Orr, D. W., 1979, Modernization and the Ecological Perspective, Pp. 75-79 in *The Global Predicament*, Edited by D. W. Orr and M. S. Soroos, Chapel Hill, University of North Carolina Press.
- Papadakis, E., 1993, *Politics and the Environment: The Australian Experience*, Sydney, Allen and Unwin.
- Pezzey, J., 1992, Sustainability: An Interdisciplinary Guide, *Environmental Values*, 1, 321-362.
- Pickett, S. T. A. and Gadenasso, M. L., 2002, The Ecosystem as a Multidimensional Concept: Meaning, Model, and Metaphor, *Ecosystems*, 5, 1-10.
- Pickett, S. T. A., Parker, V. T., and Fiedler, P. L., 1992, The New Paradigm in Ecology: Implications for Conservation Above the Species Level, Pp. 65-88 in *Conservation Biology: The Theory and Practice of Nature Conservation, Preservation and Management*, Edited by P. L. Fiedler and Jain, New York, Chapman and Hall.
- Rao, P. K., 2000, *Sustainable Development: Economics and Policy*, London, Blackwell.
- Ritzer, G., 1999, *Enchanting a Disenchanted World: Revolutionizing the Means of Consumption*, Thousand Oaks, Pine Forge Press.
- Sagoff, M., 1997, Muddle or Muddle Through?, *College of William and Mary Law Review*, 38, 825-993.
- Schnaiberg, A., 1980, *The Environment: From Surplus to Scarcity*, New York, Oxford University Press.
- Schumacher, E. F., 1973, *Small is Beautiful: Economics as If People Really Mattered*, London, Abacus.
- Schot, J., 2001, Towards New Forms of Participatory Technology Development, *Technology Analysis and Strategic Management*, 13(1), 39-52.
- Scott, D. and Willits, F., 1994, Environmental Attitudes and Behavior, *Environment and Behavior*, 26, 239-260.
- Sklair, L., 1991, *Sociology of the Global System*, New York, Harvester Wheatsheaf.
- Skogen, K., 1999, Another Look at Culture and Nature, *Acta Sociologica*, 42, 223-239.
- Soule, M. and Lease, G., 1995, *Reinventing Nature?*, Washington, D.C, Island Press.
- Toynbee, A., 1972, The Religion Background of the Present Environmental Crisis, *International Journal of Environmental Crisis*, 3, 141-146.
- Tranter, B., 1999, Environmentalism in Australia: Elites and the Public, *Journal of Sociology*, 35, 321-350.
- Turner, R. K., 1998, Household Metabolism and Sustainability: Some Introductory Remarks, Pp. 1-6 in *Green Households: Domestic Consumers, Environment and Sustainability*, Edited by K. J. Noorman and T. S. Uiterkamp, London, Earthscan Publications Ltd.
- van den Bergh, J. C. J. M. and van der Straaten, J., 1994, Historical and Future Model of Economic Development and Natural Environment, Pp. 209-234 in

- Toward Sustainable Development: Concepts, Methods, and Policy*, Edited by J. C. J. M. van den Bergh and J. van der Straaten, Washington, D. C., Island Press.
- van Kooten, G. C. and Bulte, E. H., 2000, The Ecological Footprint: Useful Science or Politics?, *Ecological Economics*, 32(3), 385-389.
- van Vuuren, D. P. and Smeets, E. M. W., 2000, Ecological footprints of Benin, Bhutan, Costa Rica and the Netherlands, *Ecological Economics*, 34(1), 115-130.
- Vegara, J. M., 2000, Footprint Computation: Three Common Errors, presented at World Meeting on Man and City: Towards a Human and Sustainable Development held in Italy in September, 2000.
- Wackernagel, M. *et al.*, 1993, *How Big is Our Ecological Footprint?: A Handbook for Estimating a Community's Appropriated Carrying Capacity* (Discussion Draft) for the task Force on Planning Health and Sustainable Communities, Vancouver, Canada.
- Wackernagel, M. and Yount, J. D., 2002, Footprints for Sustainability: The Next Step, *Environment, Development and Sustainability*, 2, 21-42.
- WCED (World Commission on Environment and Development), 1987, *Our Common Future*, Oxford, Oxford University Press.
- White Jr., L., 1967, The Historical Roots of Our Ecological Crisis, *Science*, 155, 1203-1207.
- WRI (World Resources Institute), 1992, *World Resources 1992-1993: A Guide to the Global Environment*, New York, Oxford University Press.
- WWF (World Wildlife Fund), 2002, *Living Planet Report*. WWF.