From the Ideology of Sustainable Development to Modelling a Sustainable Society: Conceptualizing Policy Change and Environmental Indicator Interactions in South Korea*

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Abstract: This six part paper analyzes developmental, environmental, and sustainability policies along with suggested indicators in South Korea. The first part reviews concepts of sustainable development. The second part outlines the process of industrialization in South Korea from the 1960s. The third part documents the change in the state of the environment in South Korea that was the result. In order to quantify the relationship of economic development expansion with the declining state of the environment, correlation coefficients were estimated between economic development variables and variables measuring environmental decline. The fourth part describes the major activities being utilized to achieve sustainable development in South Korea. The fifth part docu-

Key words: Environmental Problem, Environmental Policy, Sustainable Development, State and Change in Sustainable Development, Sustainable Society, Ecological Modernization, Environmental Indicators

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ments the change in sustainable development policies in South Korea as this continues. The sixth part concludes with a critical examination of the effectiveness of different policies for achieving sustainable development in South Korea.

In general, the paper provides an exploratory statistical method for modelling and monitoring case-specific interactions of environmental indicators for historical interactive changes. This encourages a method for testing ongoing policy soundness toward achieving a sustainable society. This paper argues the necessary of including multiple empirical indicators in real-time modeling for interactions to fine-tune conceptions of environmental policy away from a technological reductionist approach to a multi-variate structural, systemic approach.

Ⅰ. Introduction

South Korea was a polluters' paradise before the 1980s. Little attention was paid to the environment. From that decade, the South Korean government began to launch environmentally-friendly industrialization policies. From the 1990s, the government expanded these policies under the label 'sustainable development.' Nonetheless, environmental problems are still serious. In particular, South Korea exceeded appropriated carrying capacity by 9.250 times. Environmental impact also increased by 5.386 times during ten years from 1994 to 2003.[1]

Toward sustainable development in South Korea, I argue there has been a combination of beneficial and counterproductive policies that have characterized South Korea's attempted path to sustainable development. In terms of the relative higher goal of sustainability, a fluctuation of political support for environmental sustainable development policies in the past ten years from 1994 to 2003 has been seen instead of durable support for the project.

1. The concept of appropriated carrying capacity and environmental impact will be explained in Ⅵ-1.

For achieving sustainable development, it should include multiple areas of environmental policy, moving away from mostly a technological approach to a wider structural and systemic approach. Even though there is a differing of opinion whether consumers are at fault in environmental degradation or state policies (e.g. Schnaiberg, 1980; Beck, 1980), the hyperconsumption (Ritzer, 1999) demanded of consumerism threatens the environment, while the behavior invoked by environmentalism reduces people's ability to consume. Activities will be more effective when people behave in an environmentally-friendly behavior in their everyday life with a strong environmentalism rather than consumerism as a consciousness to pursue material affluence and convenience in life more than simply necessity.

Like most developing countries, South Korea experienced modernization during this century. At a very general level, modernization has been defined in various ways: the democratization of politics, the state support for large-scale private or public industrialization of the economy, the increasing urbanization of the population, and a cultural transition towards individualism.

From the middle of the 1960s, the South Korean state launched a series of five-year economic development plans meant to change the economic system from farming and small businesses to large-scale industrialized enterprises. This resulted in a great change in economic structure for twenty years from 1960 to 1980 as shown in Table 1. In accordance with the state-driven policy for industrialization, the environment began to be polluted and/or destroyed on a much larger scale. Like many countries, South Korean policymakers claimed to be in a dilemma in terms of supporting economic development combined with the preservation of the environment. In order hopefully to resolve the dilemma, South Korean government launched a policy of sustainable development since the early 1990s.

As is known, sustainable development is defined as industrial expansion within the carrying capacity of environment. It has gained popularity and legitimacy as a worldwide ideology from the 1980s, particularly due to the publication of the report of the Brundtland Commission, entitled *Our Common Future* (1987). Since then, sustainable development strategies have been argued to derive from more integrated activities in once analytically separate areas from environmental policy by public government, green management by private business corporations, environmental movement by citizen NGOs, and environmentally conscious behavior by citizens and consumers in their everyday life.

Ⅱ. The Concept of Sustainable Development

European-styles of industrialization and technology since the 18th century has brought about material and cultural affluence and many of the conveniences many now enjoy worldwide. But benefits of this developmental model have been achieved at the expense of nature and have produced environmental and health problems. Beck (1992) argues that contemporary society can be characterized as a “risk society” in terms of the worldwide external environmental problem, and how it potentially threatens the very existence of human beings more than any previous ‘internal’ human political threats or concerns of societies (For a critique of Beck’s argument, see Bronner, 1995). Furthermore, Beck argues that further technological ‘reflexive modernization’ is the solution, instead of innately proposing a contradiction between development and environmentalism. However, some eco-Marxists have proposed that there is a ‘second contradiction of capitalism’ between industrialization and preservation of the environment (e.g. Pepper, 1993: 63-67; O’Connor, 1997) making such reflexive modernization/industrialization difficult. Nevertheless, both arguments enable us to infer that we are the beneficiaries and victims of current modernist industrialization.

Globally, it took until the 1960s to recognize and popularize how serious the environmental problem was (e.g. Carson, 1962). In accordance with this newfound recognition, two main streams of thought appeared in academic circles in the 1970s. One was the pessimistic point of view on industrialization (e.g. Meadows et al., 1972), which may be one of the first environmental reports to have had a profound social impact. Meadows et al. argued that there should be a limit to economic development in terms of population, energy, food, pollution, and psychological health, for at the time he argued it seemed to be reaching levels that would soon be unsustainable. Meadows et al. (1992) maintained a pessimistic perspective on industrialization in 1992, providing 13 possible scenarios for the future to 2100 in relation to natural resources, industrial production, food, population, natural environmental pollution, and the material quality of human life. Contrary to this, Kahn et al. (1979) argued that limits could be overcome by innovation in technology and economic development on the basis of reinvestment of capital in eco-businesses – a theme soon echoed by ecological modernizationists.

In 1987 the WCED (World Commission on Environment and Development, renamed the Bruntland Commission) suggested a different model in its book *Our Common Future*, called "sustainable development." The Commission promoted the concept as a goal to evaluate 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). In accordance with this definition, the WCED (1987: 3) promoted the idea that: "It is impossible to separate economic development from environmental issues; many forms of development erode the environmental resources upon which they must be based, and environmental degradation can undermine economic development. Poverty is a major cause and effect of global environmental problems. It is therefore futile to attempt to deal with environmental problems without a broader perspective that encompasses the factors underlying world poverty and international inequality".

The WCED (1987) recognized that sustainable development 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. The WCED's concept is a much broader, integrative interpretation than that of neoclassical economics and Meadows et al. However, the WCED adds poverty alleviation as a component of sustainable development to its two other main components - economic development and the maintenance of the soundness of the natural environment.

The concept of sustainable development was further popularized and strategically elaborated at the Rio Earth Summit Conference in 1992. The outcome of this Conference, *Agenda 21*, outlined the global actions that would need to be taken in order to achieve a sustainable world within the next century rather than defining what sustainable development is (UNCED, 1992). Athanasiou (1996) criticizes this conference's strategies and activities as a form of corporatization of the environmental movement, it could be counterargued that environmentalism is only now reaching its political maturity in that "The current debates on environmental problems are exacerbated, if not caused, by the planet's division into 'warring camps of rich and poor'. The bottom line is that there will be no sustainability without a large measure of justice. Without profound political and economic change, there can be no effective global environmental action, no real effort to save the planet".

Dissenting arguments about the term "sustainable development" emerged in the 1990s. Cohen (1995) argued 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 he argued like many eco-Marxists that the sacrifice of nature is an inevitable 'second contradictory' part of capitalist economic development. Environmental sociologist 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 dissenting views, there has been hot debate on whether the concept of sustainable development is useful or a mere form of 'greenwashing' ongoing unsustainability (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 arose from what was meant by development, and how broadly or specifically the term was defined. In accordance with this, concepts of weak and strong sustainability have emerged, the former relating to economy and the latter to nature (e.g. Bell and Morse, 1999; Rao, 2000; Turner 1998). Regardless of how the concept of sustainable development has been defined, its implication converges in industrial expansion within the carrying capacity of the environment.

Ⅲ. Industrialization Process

1. Changing Process of Central Development Values

The goal and direction of planning for national and regional development is strongly connected with central values and politics of any society. These goals are a reflection, not only of a country's historical and social conditions, but also of its changing character or desires for changing its character. As development goals both represent current cultural values and desires for change projected into a future, such values and plans can be reevaluated as time goes on from one historical period to another. This is clearly seen in the pattern of 20th century Korean development.

For Korea, the central development values have changed over time from building-up national strength to economic development through national independence and social integration (Lim, 1973). For example, during the latter half of the 19th century when Korea was surrounded and threatened by colonial powers such as China, Japan, and Russia the central value was the 'building-up national strength' for protecting the nation and people. In this period, the major problem perceived by the Korean people was fear of losing national independence. The threat of colonization by foreign powers made Koreans realize that only through strengthening their national power could they maintain political independence. In spite of this move, the country became a Japanese colony in 1910. Quite naturally, Koreans could not think of any higher priority or prerequisite for their country to develop than through the restoration of national independence.

With Korean independence from the Japanese Empire after World War II, the division of the country, the political and ideological conflicts between North and South Korea, the economic dependence on foreign aid, the political and military threat by the hostile communist regime of the North, and the bitterness of the Korean War, led South Koreans to believe that 'social integration' was the best development value.

During the early 1960s, the prior central development value of social integration of North and South Korea was slowly replaced by an emphasis on economic growth. This value change occurred with the gradual stabilization of the political status quo between the two Koreas.

2. Progress of Industrialization

In this changing context of the central development values, it was not until the early 1960s that the South Korean government attached a high priority to economic planning for development than simply reintegration of the two Koreas as development. National development planning employed in the 1970s concentrated on economic development by means of a series of five-year economic development plans. The major goals were to build an industrial base and to promote the modernization of the industrial structure (Choi, 1982). These goals were promoted by means of urban development, and this policy may be called 'urban-centered' or 'urban-biased'. This was perhaps inevitable in the first stage of national development planning, because only metropolitan cities had the best transportation and communication systems and a higher level of capitalist investment capacity and international trade access.

Since the mid-1970, this 'urban-centered' policy had strongly favored investment in heavy industries, particularly machinery, chemical, and manufacturing industries. In all cases, these development values were both 'urban-centered' and export-oriented (Ahn, 1986). As a result, since 1970, South Korea began to be transformed from an agricultural society into an industrializing one. Such change was seen in a number of ways; like the development of an industrial employment structure, the increasing industrial percentage of gross national product, the increase in gross national product per capita, and expanding urbanization (see Table 1).

Table 1. Some Sectoral Indicators of South Korean Industrialization, 1960-2005

Sectors \ Years	1960	1970	1980	1990	1995	2000	2005
Employment Structure							
Primary Industry[1)]	79.5%	50.5%	33.9%	18.3%	11.8%	10.6%	7.8%
Secondary Industry[2)]	5.4%	14.3%	22.6%	27.2%	23.7%	20.4%	18.0%
Tertiary Industry[3)]	15.1%	35.2%	43.3%	54.5%	64.5%	69.0%	74.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Industrial Origin of GDP							
Primary Industry	38.0%	26.8%	15.7%	8.7%	6.8%	5.7%	3.8%
Secondary Industry	12.0%	22.3%	42.5%	47.5%	47.4%	48.2%	40.6%
Tertiary Industry	50.2%	50.9%	41.8%	43.8%	45.8%	46.1%	55.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
GDP per Capita at Current Price (in US Dollars)	105	242	1,489	5,886	11,019	10,888	16,291
Urban Population (% of the total population)[4)]	28.0	41.1	57.3	81.9	85.6	87.7	90.2

Source: National Statistical Office.

1) Raw materials or natural resources before processing
2) A product from primary industry that is processed or manufactured into another product
3) A wide range of services instead of making anything
4) Population living in city with a population of 50,000 and more

As shown in Table 1, South Korea was mostly an agricultural society in 1960. However, employment in this primary industry significantly decreased from 79.5% in 1960 to 7.8% in 2005. In this period, a high-level industrialized economic structure formed. GDP per capita began to rise rapidly after 1960, increasing by about 15,415% over the period 1960 to 2005. It is also a significant fact that such industrialization promoted rapid urbanization. The urban population jumped to 90.2% of the total population in 2005 from 28.0% in 1960. This expansion was characterized by migration from rural areas rather than by natural increase during this period.

Rapid industrialization established South Korea as the world's 11th largest economy in 2003 (MEROK, 2003). South Korea's leading industries now include shipbuilding, semiconductors, electronics and auto manufacturing for the export market. However, difficulties arising from the 1997 financial crisis precipitated a bailout loan from the International Monetary Fund (IMF). As conditions for the loan, the IMF forced South Korea to adopt corporate restructuring and removal of inefficiencies in industries.

Ⅳ. Change in the State of Environment

The environment is polluted and/or ecologically destroyed in the process of industrialization in six ways; argues Jeong (2002: 172-174). First, nature is destroyed in the process of resource extraction. This can be termed material-source pollution. Second, liquid, atmospheric, and solid wastes are discharged in the process of producing capital and/or consumption goods. These wastes are returned to nature, and, as a result, nature is destroyed. This can be termed process pollution. Third, even though some wastes discharged from the process of producing capital and consumption goods are recycled 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. Fourth, nature is also destroyed in the process of distributing goods and services. This can be termed distribution pollution. Fifth, humans directly destroy the ecosystem in the process of their activities in everyday life. This can be termed contact pollution. Sixth, in capitalism, the need of consumers serves as a pressure for the capitalists in deciding what and how many goods and services to produce. This means that consumers indirectly generate material-source pollution and processing pollution as well. This can be termed indirect pollution in that product purchase is a source to generate material-source and processing pollution through leading the capitalists to produce products.

As the South Korean government launched its industrialization policies, the environment has been polluted and/or destroyed at a high rate since the 1970s. Table 2 shows the change in the state of environment and several economic factors impacting nature in South Korea since 1990.

The following are found to be significant from Table 2 during fifteen years from 1990 to 2005. The generation quantity of general wastes increased by 103%, but that of specified wastes decreased by 54%. The discharge of industrial wastewater increased by 111%. In regards to the emission of air pollutants, sulfurous acid gas (SO2) and carbon monoxide (CO) decreased by 72% and 59%, respectively. However, the emission of carbon dioxide (CO2) increased by 101%, the most significant and long-lived 'greenhouse gas' impacting global warming. This was because number of manufacturing factories increased because South Korean Government continues to run the policy of economic development. Water pollution as measured via dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD) have decreased gradually every five years. However, the elements of marine and soil pollution — such as chemical oxygen demand (COD), total nitrogen (TN), cadmium (Cd), copper (Cu), and lead (Pb) — repeatedly increased and decreased every five years. In regard to biodiversity insecurity, the number of wild animal and plant species endangered rose from 18 in 1990 to 50 in 2005. The timber cutting area showed a trend of decrease and improvement, being 71.632 ha in 1990, 55,800 ha in 1995, 51,090 ha in 2000, and 46,800 ha in 2005.

Table 2. Changes in the State of the South Korean Environment: Some Factors Measuring Impacts on Nature, 1990-2005

Categories of Environment \ Years		1990	1995	2000	2005
Generation Quantity of Wastes (ton/day)	General[1)]	142,721	143,597	226,668	290,386
	Specified[2)]	18,721	4,445	7,614	8,634
Industrial Wastewater ($1,000m^3$/day)[3)]		4,106	8,741	7,907	8,679
Emission of Air Pollutant (1,000 tons/year)[4)]	SO_2	1,611	1,532	531	447
	CO	1,991	1,109	825	817
	CO_2	226,200	370,180	433,570	454,110
Water Pollution (mg/l)[5)]	DO	10.100	9.469	10.019	9.900
	COD	6.711	5.735	5.204	4.475
	BOD	4.263	3.654	2.735	2.550
Marine Pollution (mg/l)[5)]	COD	1.981	1.662	1.206	1.533
	TN	0.499	0.692	0.156	0.557
	TP	0.047	0.030	0.022	0.045
Soil Pollution (mg/kg)[5)]	Cd	0.161	0.149	0.199	0.078
	Cu	4.429	6.883	5.066	3.768
	Pb	5.742	7.822	5.743	6.162
Natural Ecosystem	NWAPSE	18	27	43	50
	TCA (ha/year)	71,632	55,800	51,090	46,880
Final Energy Consumption (TOE/person/year)[6)]		1.75	2.70	3.19	3.55
Expenditure on Pollution Control (USD/person/year)		90	140	177	324

Sources: Korean National Statistical Office. *Social Indicators in Korea* Ministry of Environment. *Environmental Statistical Yearbook*

Note 1: "NWAPSE", Number of wild animal and plant species endangered. "TCA", Timber cutting area.

Note 2: The abbreviations are described in the subsequent paragraph.

1) Those such as food, vegetable, paper, and wood, etc., all of which do not generate toxin materials when they are burned up and/or filled in the ground.
2) Those containing waste defective oil, waste acid, and heavy metal, etc, all of which are generated from industrial factories.
3) Wastewater generated from industrial factories.
4) Ministry of Environment measures them on the basis of total amounts of fossil energy used in a year.
5) The Ministry of Environment, South Korean Government designates sample spots on a national base, and measures the pollution concentration of each spot, then averages them.
6) "TOE", Tones of oil equivalent which is estimated based on the consumption of all kinds of energy.

Final energy consumption per person increased dramatically over the period measured was 1.75 TOE in 1990, 2.70 TOE in 1995, 3.19 TOE in 2000, and 3.55 TOE in 2005. The expenditure on pollution control per person also increased dramatically from USD90 in 1990 to USD324 in 2005.

To adjudicate and to evaluate what variables may be more to blame in South Korean environmental degradation, I correlate relationships between the measures of economic development expansion variables and trends of the declining state of the environment. Correlation coefficients were estimated from data listed in Tables 1 and 2. Only the following were found to be statistically significant (See Table 3).

Table 3. **Correlation Coefficients of the State of Environment with GDP per Capita and Expenditure on Pollution Control**

Environment / GDP & Expenditure	General Wastes	Industrial Waste-Water	CO_2 Emission	COD in Water	COD in Marine	Pb in Soil	NWAPSE	Final Energy Consumption
GDP per Capita	0.842	0.841	0.894	-0.966	-0.522	0.175	0.887	0.934
Expenditure on Pollution Control	0.942	0.641	0.799	-0.934	-0.466	-0.099	0.904	0.871

Note: NWAPSE; Number of wild animal and plant species being endangered

To summarize Table 3, for the past fifteen years from 1990 to 2005, the increase in GDP per Capita has correlated positively to the expanded generation of General Wastes and Industrial Wastewater. The increase in GDP per Capita has correlated to more emission of CO_2, more lead pollution (Pb) in soil, more final energy consumption, and increase in the number of wild animal and plant species being endangered. The argument is not that this is a required relationship: it is only a secular trend in the

South Korean case. Meanwhile, as GDP per Capita has increased, chemical oxygen demand (COD) in both fresh water and sea water has decreased possibly through the increase in the budget of expenditure on pollution control or other unmeasured factors like change of material inputs themselves. Correlations of the effectiveness of expenditures on pollution control were more highly correlated with reducing some toxins more than others.

Ⅴ. Environmental Policy for Achieving Sustainable Development

Like other countries, major activities for achieving sustainable development in South Korea converge in four policy intercessions. They are environmental policy by government, green management by business corporations, environmental movement by NGOs, and environmental behavior by citizens in their everyday life. This section only will focus on the effects of change in state environmental policy.

In South Korea, environmental policy was embodied in environmental laws and hopefully administration of these laws. Launched in 1963, the Pollution Prevention Law was the first environmental law, but it was not enforced. This was because the development values of the 1960s were to prioritize South Korean ‘urban-centered’ economic industrialization policies. It was only in the 1980s that pre-existing and additional environmental laws began to be used to manage environmental impacts. Examples of environmental laws from the 1980s-1990s included the Environment Preservation Law (1981), the Basic Environmental Policy Law (1990), the Air Environment Preservation Law (1990), the Water Environment Preservation Law (1990), the Noise and Vibration Control Law (1990), the Natural Environment Preservation Law (1991), the Environmental Impact Assessment Law (1993), the

Law on Development and Support of Environmental Technology (1994), and the Soil Environment Preservation Law (1995), etc.

The more titles of the main contents of the above environmental laws should enable us to draw the conclusion that South Korean environmental policy has been changed as summarized in Table 4 in terms of the main principle and prioritized policies (Jeong, 2002: 326). However, from the previous Table 2 (that gave data for 1990-2005) and Table 3 (that shows the limited positive correlations associated with these legal changes), many kinds of environmental pollution have expanded or only have partially been correlated with having an ameliorative environmental effect after the introduction of these laws of the 1980s-1990s.

However, in South Korea the environmental policy implementation was not successful from these mere *a priori* assumptions, as the evaluation above noted only limited successes in the wake of more pro-environmental policy changes (Table 3). Arguably, the main reason is the lack of organic relationship among the four actors or sectors – environmental policy by government, green management by business corporations, environmental movement by NGOs, and environmentally-friendly behavior by citizens. Sustainable development can be achieved more successfully through the organic relationship among the four sectors. Nonetheless, polluting corporations have perceived negatively state environmental policy as an undue regulation of their activity. For citizens, consumerism values are higher than environmentalism values (Mullins et al., 2004). NGOs have been a strong pressure in the South Korean environmental movement for the government to establish stronger environmental policies, but they have not been effectively an educator in terms of changing citizens' value to environmentalism. Forms of 'cognitive fixes' like education for changing beliefs are mostly only effective if the individual is already motivated to change. Particularly, this is empirically proved in South Korea. For example, it was found from a survey of 500 people in Jeju, South Korea in 2001 that the mean score of environmental behavior in everyday life was rated at 48.5 on the basis of 100 points maximum. However, the mean score of their willingness to change to more environmentally-sound behaviors was higher, at 80.1 (For the measurement scales and method, see Mullins, et al., 2004).

Table 4. **Changes in Principle Motivating Development Policy in South Korea, 1960s to the Present; with Related Environmental Characteristics**

The Era	Main Principle	Priority Policy	Main Instrument	Environmental Characteristics
Until the 1960s	Traditional industrial policy	National economic development	No instrument for the management of environment	Negligence or no response to environmental problems
The 1970s	Policy for modernizing national economy	Balanced economic development among regions/ industrial sectors	Regulation-Directed	Recognizing *ex post facto* response to environmental problems
The 1980s	Environmentally friendly industrial policy	Production policy harmonizing with environment	• Regulation-directed • Technology development	*Ex post facto* response to environmental problems
The early 1990s	Policy for preventing environmental problems	Preventing the arise of environmental problems	• Regulation-directed • Technology development • Financial support	*A prior* response to environmental problems
After the later 1990s	Integrated environmental policy	Environmentally friendly policy on economic system as a whole	Societal policies for the management of environment	*Ex post facto* and *a prior* response to the process of production, distribution and consumption for sustainable development

In a word, South Korean environmental policy faces a conflict between political and cultural values promoting degradative economic development and the political and cultural values promoting preservation of the environment (Sa, 1997: 146-152) and a “market failure” (Kim, 1994: 95-101). In particular, an example of market failure is that environmental policies in South Korea focus on the control of production process for preventing environmental problems, paying less attention on the policy encouraging the consumers to purchase green products in market.

Ⅵ. The State of and Change in Sustainable Development

1. The State of Sustainable Development

For evaluating the state of South Korean sustainable development, it is measured here by environmental impact, appropriated carrying capacity, and my term “the structure of sustainable development”. That will be explained momentarily.

Environmental impact is defined as the impact of a population or nation upon its environment and ecosystem (Harper, 2004: 279). Appropriated carrying capacity is defined as the aggregate land area in which both the capacity to continuously provide the required resources presently consumed, and to continuously absorb all associated wastes (Wackernagel et al., 1993: 10). The components of sustainable development in a multi-dimensional reality will be in a patterned configuration. The patterned configuration of how the particular variables interrelate and how these interrelations change over time historically instead of are static is defined as “the structure of sustainable development”.

(1) Environmental Impact: Neo-Malthusians argue human population scale is the core impact on environmental degradation.

However, many would challenge this Malthusian/populationist one-to-one correspondence construct for environmental degradation (For a summary of the literature, see Dunlap et al., 2002).

The implication of environmental impact above is rather similar to the neo-Malthusian position. Environmental impact is different from environmental degradation in that it calculates numerically the impact of human activities on environment, using a time-series data. The first year in the data is fixed to be the base year, given an environmental impact of 1.000. This paper calculated the environmental impact of South Korea during the ten years from base year 1994 to 2003 to see the pattern of change.

Two formulae have been developed for calculation of environmental impact in this way, described below (Sage, 1995; Harper, 2004: 279).

Harper's FFormula : $I = P \times A \times T$

I : Environmental Impact
P : Population
A : Affluence
T : Technology

Sage's Formula : $I = (PCP/PCUR) \times 100$

I : Environmental Impact
PCP : Percentage Change in Population
$PCUR$: Percentage Change in Use of Resource

Harper's formula is simple, robust, and useful as a framework for research. In particular, the relative impact of P, A, and T on the derived environmental impact can be used to compare changes over time. One drawback of Harper's model is it is linear and the effects of the different terms are proportional. As such, the model makes it difficult to identify discrete diminishing or increasing impacts of particular terms in this derived environmental impact. In addition, a lot of sub-variables, most of which are not available, are required for measuring A and T.

In contrast, Sage's formula for derived environmental impact includes population and the added term for resource use, which are the core-coupled impacts of human activities on nature. However, I have identified an important shortcoming in Sage's formula as well. Its view of derived environmental impact should decrease when population and use of resources decrease. However, when trends like this are inserted into Sage's formula, the result will be misleading because it will show an increase in the derived environmental impact rather than a decrease.

However, of these two formulas, Sage's formula was used for calculating the derived environmental impact in South Korea during the ten years from 1994 to 2003. The year of 1994 is the base year. Table 5 is Sage model' derived environmental impact for South Korea during the ten years from 1994 to 2003.

Table 5. **Environmental Impact (Sage's Formula)**

Year	Population (1,000)	GDP (1 billion Won)	Environmental Impact
1994	44,642	305,007.7	1.000
1995	45,092	398,837.7	3.283
1996	45,525	448,596.4	4.202
1997	45,954	491,134.8	4.816
1998	46,287	484,102.8	6.276
1999	46,617	529,499.7	6.011
2000	47,008	578,664.5	5.908
2001	47,343	622,122.6	5.819
2002	47,640	684,263.5	5.401
2003	47,925	721,354.9	5.386

Note: USD1.00 is approximately 1,000 Won (Korean monetary unit)

The following is found from Table 5 to be significant. Environmental impact has increased every year until 1998. However, in spite of continuous increase in GDP after 1999, it has begun to decrease. The reason for this is that the ratio of population increase was remarkably lower than that of resource use. One assumption of the Sage's neo-Malthusian model is that environmental impact of the economy in South Korea is somehow related to South Korean population. However, with South Korean development being export-driven and attached to population overseas instead of in South Korea, there is little cause for Sage's model to provide much internal validity on issues of environmental impact without reworking the model to include more globally interactive areas of local economy and global population.

Despite these critiques of the Sage model's shortcomings South Korean GDP increased by 1.365 times over ten years from 1994 to 2003, but environmental impact increased by 5.386 times. This implies that environmental impact arisen from economic development was higher than economic benefits achieved during the last ten years.

(2) Appropriated Carrying Capacity: Appropriated Carrying Capacity (hereafter ACC) is another model's attempt to quantify and evaluate the state of sustainable development. It is defined as the aggregate land area in which the capacity to continuously provide the required resources presently consumed is related to the capacity to continuously metabolize and render harmless associated wastes (Wackernagel et al., 1993: 10). What this means is that it is not about the basis of the Sage's model — "How many people can the earth support?" — but rather "How much land do people need to support themselves?" ACC is derived by dividing the size of the ecological footprint(hereafter EF) into the area of suitable land that is available. Both Sage's and Wackernagel's model have the same difficulties, since they cannot integrate non-quantitative data like technological and organizational change that would change the capacities to utilize the same amount of land or alter the manner in which the same number of population can subsist independently of their model's limited variables. Arguably, all attempts to entirely force environmental impact analysis into quantitative analysis is a dead-end. However, much can be learned from comparing the numbers derived from such models toward refining our understanding of environmental degradation.

Some research employing the ACC model has been done. Examples include works by Wackernagel et al. (1993) on Canada, Bicknell et al. (1998) and McDonald and Patterson (2003) on New Zealand, and Chambers et al. (2000) on 52 countries as a comparative study. The World Resources Institute (1992), Chambers et al. (2000), and The World Wildlife Fund (2002) have estimated the ACC for the entire world as a unit.

According to the work on ACC for the entire world as a unit (e.g. World Resources Institute, 1992; Chambers et al., 2000; World Wildlife Fund 2002), which integrates the aforementioned critique of the Sage model, the earth exceeds the ACC by 2.50 times. South Korea exceeded ACC by 9.250 times in 1995 (Chambers et al., 2000: 122). In details, average EF per capita was 3.7 ha, available biocapacity per capita 0.4 ha, and ecological deficit per capita 3.3 ha. Table 6 shows the ACC of some countries.

Table 6. ACC of Some Countries (Wackernagel's Formula)

Country	ACC	Country	ACC
China	+2.333	Philippines	+1.750
India	+2.000	Singapore	+66.000
Japan	+6.000	Thailand	+1.462
Korea (South)	+9.250	Australia	−1.373
Malaysia	−1.162	Canada	−1.708
Pakistan	+2.250	USA	+1.745

Source: Chambers et al., 2000: 122-123
Note: +; exceeded, −; not exceeded

(3) The Structure of Sustainable Development: Arguably, unlike the quantitative models above, the state of sustainable development is a conceptual tool that is closer to the multi-dimensional reality determined by many factors covering environmental/biodiversity capacities to rebound, economic, technological, material, socio-cultural, distributive, political, and institutional components, etc. However, the factors are different in their contribution positively or negatively to sustainable development. This is termed the variable's "relative importance determining the state of sustainable development".

Even though the relative importance is different among the variables, they do not exist independently, but rather are in an interrelated feedback loop relationship mutually determining their existence. This is termed the mutual relationship among the variables as the determinants of sustainable development.

As such, the relative importance of the variables and their interrelated relationship in a given time may be termed "the structure of sustainable development". This paper concentrates on discussing only the relative importance, instead of detailing the many variables influencing the whole "structure of sustainable development".

Jeong et al. (2005) have analyzed this view of the structure of sustainable development in South Korea, creating a model of the interactive patterns and attempting to find the most important strategic variables for intercession in environmental amelioration and whether these variables changed over time. They used 169 indicators as the determinants of sustainable development. These 169 indicators were classed within 14 categories (agriculture, energy, marine, ecosystem, water resource, land use, waste, education, economy, institution, environment, society, transportation, and social welfare). As above, time series data in the indicators from 1994 to 2003 was used in the analysis. The reasons for this are as follows. Since it was impossible to use a set of time series data throughout the whole span of years, for example from 1950 to 2003, a set of ten-year times series data from 1994 to 2003 was used for analysis. In addition, an identical set of indicators throughout the ten years was selected. The data of the identical set of 169 indicators was available for the ten years from 1994 to 2003.

Jeong et al. (2005) analyzed the 169 indicators, using an analytic model that was initially developed by environmental sociologists in the 1970s (e.g. Hunger, 1971; Janson, 1978) when they analyzed the urban socio-ecological structure which is conceptually applicable to the structure of sustainable development.

The 169 indicators showed a percent total variance (percent of variance explained) of 65.4 among them that is related to a factor pattern when principal components analysis was used. This figure measures the variation in the original data matrix that can be reproduced by a pattern. In other words, it measures a pattern's comprehensiveness and strength. This means that the 169 indicators used in the analysis explains 65.4% as the determinants of sustainable development in South Korea, and the remaining 34.6% are determined by indicators other than the 169 indicators.

Table 7 shows the relative importance of the major determinants whose communality is higher than 0.900.

Table 7. **Relative Importance of Discovered Major Determinants in Categories Where Communality Is Higher Than 0.900**

Category	Total number of indicators used in analysis	Average communality of the indicators used in analysis	Major indicators (communality)
Agri-culture	9	0.762	• Average debt per farm household (-0.934) • % rural household annual income to urban household (-0.901) • Amount of chemical fertilizer used (-0.932)

Energy	13	0.620	• % of fossil energy among all energies used (-0.958) • % of liquefied natural gas(LNG) among all energies used (+0.982) • Final energy consumption per person (-0.915)
Marine	13	0.589	• Amount of wastes thrown into ocean (-0.991) • Quantity of fish catch (-0.906)
Eco-system	15	0.571	• Area of natural park (+0.904) • Area of deforestation (-0.929)
Water Resource	3	0.940	• Water consumption per person (-0.902) • % of tap-water leakage from reservoir to end-user (-0.971)
Land Use	12	0.624	• % of urban public purpose area to whole national area (+0.971) • % of population living in capital city to total population (-0.946)
Waste	11	0.757	• Quantity of general wastes discharged (-0.974) • % of reuse to general wastes discharged (+0.983)
Education	24	0.784	• Number of students per teacher (-0.907) • Number of students per class (-0.912) • Public expenditure on education per university student (+0.930)
Economy	6	0.464	• Private final consumption expenditure (+0.959)
Institution	5	0.726	• Number of international environmental convention signed (+0.963) • Personal computer supply (+0.935)
Environ-Ment	14	0.464	• CO_2 emission (-0.909) • Concentration of carbon monoxide in air (-0.910)
Society	24	0.640	• Ratio of female-worker wage to male-worker (+0.910) • Distribution of home ownership (+0.984) • Ratio of urbanization (-0.979)

Trans-portation	15	0.643	• Number of cars (-0.988) • Area of car parking (+0.957)
Social Welfare	5	0.813	• Number of social welfare facilities (+0.920) • Amount paid for health insurance per person (+0.945)
Total	169	0.654	32

Source: Jeong et al. (2005): pp. 138~142.

Note: Communality is a statistical concept of factor analysis, and is the variance of a variable (indicator) which may be considered to be shared in common with other variables in a set of variables.

Table 7 enables us to identify the following to be significant. First; 32 indicators among our subset of 169 indicators used in the analysis were the major determinants in that particular subset of sustainable development and pollution variables during the ten years from 1994 to 2003.

Second; serving as a policy evaluation tool the individual indicators can be adjudicated based on the plus and minus signs of the communality. Indicator whose sign is plus implies that the indicator has contributed positively to sustainable development during the past ten years from 1994 to 2003. Meanwhile, indicator whose sign is minus implies that the indicator has contributed negatively to sustainable development. The higher the communality of an indicator is, the more the indicator is contributable to sustainable development.

It shows that only 14 indicators have correlated positively to the sustainable development during the ten years from 1994 to 2003, and the remaining 18 indicators have correlated negatively to the sustainable development. The relative importance of the 32 indicators as the determinants of sustainable development can be identified from the value of communality. The positive determinants are liquefied natural gas (LNG) supply, area of natural park, urban public purpose area, and reuse of wastes discharged, etc. The negative determinants include a lot of debt per farm household, high gap in income between rural and urban household, excessive use of chemical fertilizer, and excessive energy use per person, etc.

Third; with the 14 categories of sustainable development being a multi-dimensional reality composed of many factors, the category of water resource indicators has been the most important determinant impacting on sustainable development during the ten years from 1994 to 2003. This is followed by social welfare, education, agriculture, discharge of waste, institution,[2] transportation, society, pattern of land use, energy use, environmental state of marine, and the state of ecosystem, etc. Unexpectedly, the state of environment is identified relatively to be the least important factor.[3]

It would be worth examining some major implications of the above findings, in particular, in relation to the environmental policies of South Korea. The plus and minus signs of communality enable us to identify whether or not each factor has been managed efficiently for achieving sustainable development during the past ten years from 1994 to 2003. For example, the fact that the

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2. Five indicators were used for measuring 'institution' inthe original data. They were Number of International Environmental Conventions Signed, Personal Computer Supply, Socio-economic Cost of Damage from Natural Disasters, Telephone Distribution, and Percent of Research and Develop ment Expenditure to GDP. All of these five indicators were selected from the category of 'institution' used by the United Nations (UNCSD, 1996).
3. Fourteen indicators of 'environment' were used in the original data. They were Amount of Carbon Dioxide Emission, Consumption of Chlorofluorocarbons, Concentration of Fine Dust in Air, Concentration of Sulfurous Acid Gas in Air, Concentration of Carbon Monoxide in Air, Concentration of Carbon Nitrogen in Air, Concentration of Ozone in Air, Concentration of Hydrogen in Water, Dissolved Oxygen in Water, Chemical Oxygen Demand in Water, Biological Oxygen Demand in Water, Suspended Solids in Water, Percentage of Environment Department Budget to Total Government Budget, Percentage of Expenditure on Pollution Abatement and Control to GDP.

indicators included in the category of agriculture are all correlated with sustainable development negatively implies that environmental policy has been paid less on the regulation for sustainable agriculture. In details, from a perspective of sustainable development, the findings of agriculture in Table 7 imply that the policies for reducing the debt of farm household, the gap of annual income between rural and urban area, and/or the use of chemical fertilizer have not been run effectively.

Following such a way of interpretation, the findings from Table 7 are corresponded to an *expost facto* effectiveness analysis of the policies launched for achieving sustainable development in terms of what policies have been successful and what policies have not been successful. Overall, the findings enable us to identify two important implications. First; the policies launched during the past ten years from 1994 to 2003 were successful (the policies on the indicators whose communality is signed plus), but others were unsuccessful (the policies on the indicators whose communality is signed minus). This would imply that South Korea has not launched an integrated policy covering its three main components – environment, economy, and society. Second; the findings imply that technological reductionistic approach to sustainable development is a limited tool without change in our lifestyle pursuing material affluence. This is evidenced from the indicators such as deforestation, water consumption, population concentration in capital city, general wastes discharged, CO_2 emission, concentration of carbon monoxide in air, and number of cars, most of which are those related to the pursuit of material affluence and/or those resulting from the pursuit. It would be expected that the states of those indicators might be switched to positive contributors to sustainable development when a social system approach, which is defined as a promotion of the ethos to decrease the current enjoyment of material affluence, is run parallel with the current technological approach.

2. The Change in Sustainable Development

Evaluating sustainable development in this fashion allows determining if certain policies are working based on measuring tangible correlations of improvement or worsening of the environment. The implications of the type of policy analysis can be conceptualized in the following three aspects.

(1) This method of analysis allows for the change in the structure of sustainable development: This is defined as differences in structural relationships between the same variables at different points in time. This allows for finding ways of determining and appreciating that the structural relationships themselves can change over time instead of assuming they are constant relations like assumptions of earlier models of Sage, Harper, and Wackernagel. Such an approach to environmental change was developed in environmental sociology with in an urban socio-ecological structure in the 1970s (e.g. Janson, 1978), and it can be revived to analyze and evaluate the historical interactions of state policy in regards to the environment–measured through important environmental indicators.

(2) This method of analysis allows for the changing implication on sustainability for each component of sustainable development: It is assumed that the process of change over time will not be in disorder, rather will be in a patterned configuration. If so, the structural components of the changing process can be extracted, using factor analysis technique. Such an approach was urban socio-ecological interactive analysis and change since the 1970s (e.g. Hunter, 1971).

(3) This method can plot the historically changing process of the sustainability of each component of sustainable development. The approach assumed that each component of sustainable development is different in the effects on sustainability at different times, and that the difference will change over time. This method allows for appreciating these three factors that were missing in earlier indicator-based models of environmental degradation or environmental amelioration.

This paper used the data above to argue how this model can explore "the changing process of the sustainability of each components of sustainable development" in South Korea during the nine years from 1994 to 2003 - something all other indicator models would be unable to do. The technique of estimating this changing process of sustainability derives from how a relative deviation index (hereafter RDI) can be applied to this data in patter recognition analysis (Jeong, 1997: 375-376).

In a set of time-series data, RDI is a statistical measure defined by the changing deviation of each component from total values of all components as a base criterion. To note the historically changing process of sustainability, the RDI of each component in a given year can be compared to that of other components. If this comparison is done throughout all years being covered in a set of time-series data, the result enables us to identify the changing process of the relative position of each component in terms of its degree of contribution toward sustainability.

Next, the RDIs of the 14 categories (the supposed main components of successful sustainable development found by PCA analysis in my dataset) concerning South Korea were estimated as Table 8. Table 8's RDI data can be examined in two aspects. One is the comparison among the components by year, and the other is the comparison of each component by year.

Table 8. The Relative Deviation Index (RDI) of the Components of Sustainable Development for South Korea (1994-2003)

Component \ Year	1994	1995	1996	1997	1998
Agriculture	-0.408	-0.358	-0.231	-0.052	-0.086
Energy	-0.090	0.080	-0.219	-0.344	0.232
Marine	0.118	0.016	0.228	0.434	0.260
Ecosystem	1.989	0.075	0.166	0.123	0.015
Water Resource	-0.075	0.099	-0.241	-0.256	-0.160
Land Use	0.335	-0.105	0.283	-0.273	0.068
Waste	0.420	0.288	1.311	0.068	0.120
Education	-0.554	-0.469	-0.349	-0.215	-0.019
Economy	0.306	0.336	0.253	0.123	-0.750
Institution	-0.546	-0.461	-0.215	0.093	-0.242
Environment	0.085	-0.072	0.026	-0.211	0.357
Society	0.147	0.145	0.113	0.242	-0.297
Transportation	0.355	0.547	0.052	-0.017	0.116
Social Welfare	-0.997	-0.315	0.387	0.872	1.043

Source: Jeong et al. (2005); 294

Table 8. — Continued

Component \ Year	1999	2000	2001	2002	2003
Agriculture	-0.072	-0.013	0.224	0.399	0.267
Energy	0.269	0.024	-0.156	0.024	0.130
Marine	0.384	0.073	-0.101	-0.356	-0.696
Ecosystem	0.065	-0.160	-0.105	-0.154	-0.077
Water Resource	0.066	0.109	0.042	0.272	0.034
Land Use	-0.179	0.021	0.025	-0.073	-0.061
Waste	-0.110	-0.041	-0.166	-0.153	-0.192

Education	-0.015	0.050	0.237	0.437	0.504
Economy	-0.028	-0.053	-0.127	-0.001	0.054
Institution	-0.196	0.250	0.489	0.128	0.307
Environment	0.168	-0.015	-0.297	0.054	-0.036
Society	-0.094	0.076	-0.039	0.013	-0.191
Transportation	0.064	-0.158	-0.071	-0.267	-0.317
Social Welfare	-0.997	-0.483	0.139	-0.985	0.830

Source: Jeong et al. (2005); 294

The following points are found to be significant from Table 8.

First: The component of the highest sustainability has changed from 1994 to 2003.

- The component that contributed most to sustainability was Ecosystem in 1994, Transportation in 1995, Waste in 1996, Social Welfare in 1997 and 1998, Marine in 1999, Institution in 2000 and 2001, Education in 2002, and Social Welfare in 2003.
- Meanwhile, the component that contributed least to sustainability was Social Welfare in 1994, Education in 1995 and 1996, Energy in 1997, Economy in 1998, Social Welfare in 1999 and 2000, Environment in 2001, Social Welfare in 2002, and Marine in 2003.
- Overall, the difference in the degree of contribution toward sustainability among the components was great in 1994, 1996, and 1998. However, the difference was minor in the remaining years.

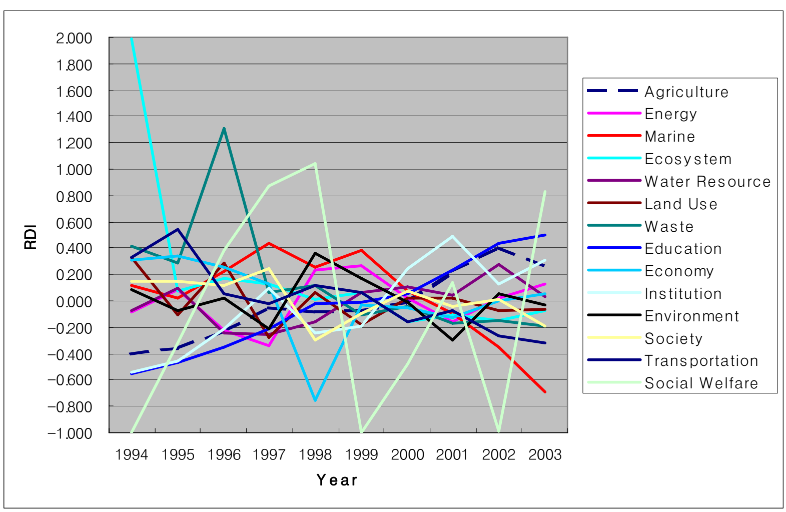
Second: The fluctuation in terms of the degree of contribution toward sustainability among the components throughout the ten years has been significantly different in each component. For example.

- Agriculture: The sustainability of Agriculture was lower from 1994 to 2000, but began to be higher from 2001.
- Energy: The sustainability of Energy has been in an extreme change, showing a change to lower and higher sustainability throughout ten years.
- Marine: Unlike other components, Marine has enjoyed a higher degree of sustainability from 1994 to 2000, but has been reduced from 2001, and was lowest in 2003.
- Ecosystem: Ecosystem was higher in the degree of sustainability from 1994 to 1999, but began to be lower from 2000.
- Water Resource: Its degree of sustainability was lower from 1994 to 1998, but began to be higher from 1999.
- Land Use: Like Energy, Land Use has been in an extreme change in the degree of sustainability throughout the ten years.
- Waste: The sustainability of Waste was higher from 1994 to 1998, but began to be lower from 1999.
- Education: The sustainability of Education was lower from 1994 to 1999, but began to be higher from 2000.
- Economy: Economy has enjoyed a lower degree of sustainability throughout ten years.
- Institution: The sustainability of Institution was lowest for six years from 1994 to 1999, jumped to the highest in 2000 and 2001, and downed to lower again in 2002 and 2003 (For the concrete indicators of Institution, see footnote 2).
- Environment: The sustainability of Environment was lower for ten years from 1994 to 2003, in particular, was lowest in 2001.
- Society: The sustainability of Society showed a trend to be lower throughout ten years.
- Transportation: The sustainability of Transportation was higher in both 1994 and 1995, but began to be lower from 1996.

- Social Welfare: The sustainability of Social Welfare fluctuated throughout these years, showing the lowest and/or the highest among the components by year.

Third: The RDIs in Table 8 as the changing process of the relative degree of sustainability by component can be presented graphically as Figure 1. The graphic presentation enables us to visualize the changing RDIs.

Figure 1. **Graphic Presentation of the Distribution of RDIs by the Component of Sustainable Development**



Ⅶ. Concluding Remarks

1. Beyond Sustainable Development to How to Evaluate the Interactions of Sustainability Policy

Like other countries, South Korea is faced with a conflict between industrialization and the preservation of environment. South Korea was a polluters' paradise before the 1980s in that little attention was paid to environment besides the mostly symbolic early 1960s Environmental Protection Law that was left unenforced. The South Korean government only began to launch environmentally-friendly industrialization policies in the 1980s, and extended this policy with term 'sustainable development' from the early 1990s. Nonetheless, environmental problems are still serious in South Korea.

To follow the effects of sustainable development policy through its effects on the multi-dimensional reality in South Korea, this paper has argued for popularizing a model of "the structure of sustainable development" that allows for ongoing evaluation. It argues that there have been helpful, hindering, and superfluous policy intercessions involved in the state of sustainable development over the years 1994 to 2003. Moreover, the component in terms of its degree of contribution toward sustainability has changed throughout these years instead of been constant. The fluctuation on how strongly and/or weakly contribute to sustainability in this period has been significantly different in each component as well.

It is not doubted that the attempt to achieve sustainable development since the early 1990s has been successful partially. This is evidenced in how there have been both negative and positive factors contributing to the state of sustainable development for ten years from 1994 to 2003. This conclusion of partial success is drawn from the relative importance of the indicators, associated with changing positive and negative correlations within the factor structure of the 169 indicators.

Is sustainable development really a sufficient ideological and/or practical instrument for achieving social development in a way to minimize environmental problems? This paper argues the answer to this question is 'no' because sustainable development fails to offer a means to evaluate success or failure in the more structural and systemic aspects in the "the structure of sustainable development" that this paper has analyzed. The original concept of "sustainable development" was a uni-dimensional concept based on the relationship between two main components: economic development and the preservation of the natural environment. If we only include these two abstract components, sustainable development becomes desirable only for economic survival and utility (Pezzey, 1992) or for a successful economy (Lele, 1991).

There are many other social factors determining economic and environmental sustainability. From the interactive data analysis above, it has been shown that economic and environmental sustainability variables are highly interactive and correlative with other social factors. In other words, without considering other social factors, sustainable development cannot be realized in its entirety.

Thus, for sustainable development we need to focus not only on the traditional two components of the economy and the environment. We should focus equally on social factors that have been shown to correlate highly with achievements of environmental sustainability. This has been called a more multi-dimensional approach to sustainable development. For example, Pezzey (1992) discussed physical, ecological, economic, psychological, social, and historical sustainable development. Ekins (1994) discussed the biological, economic, and social components of sustainable development. Turner (1998) discussed sustainable development in terms of nature, socio-cultural systems, and economy. Rao (2000) maintained ecological, social, and economic factors as the conceptual components of sustainable development. Harper (2004: 305-307) argued that there are seven requirements for sustainability: population, biological base, energy, economic efficiency, social forms, culture, and world order. These multi-dimensional concepts focus on interactive sustainability of society as a whole. This is what ecological modernizationists, Mol and Spargaren (2005) have described recently as an "environmental flows" analysis. Thus this perspective is toward the sustainability of society as a whole series of interactions, instead of only the policy concern being economic issues. The category of 'what to be sustained' should include nature, life support, community, people, economy, and society (Kates et al., 2005).

In this multi-dimensional analysis of how to get to a sustainable society, in the past a major stumbling block of this type of analysis was the ahistorical, static views of environmental evaluation models like Sage and Harper. They had considered their variables to be equal, static, and historically unchanging in their relations and with all having the same importance at any historical point in the analysis with each other.

Considering the fact that the crisis of human existence is caused by the destruction of nature, the sustainability of the ecosystem should be considered the most crucial value among the multidimensional conceptual components. As shown in Table 7, ecosystem as a category of sustainable development in South Korea was relatively in a low position in determining the state of sustainable development during the past ten years, comparing with other categories. However, deforestation as a component of ecosystem contributed very negatively to sustainable development. Then, the positions of other components should be in a hierarchy below, with the sustainability of the ecosystem at the top even though we set up the remaining conceptual components to be in a horizontal position.

Such a conceptual framework may contribute toward a societal-wide meaning of ecological modernization that has typically been analyzed or proposed only on the level of the individual firm before. The concept of ecological modernization involves a collection of ideas about re-structuring modern societies and economies to achieve a more sustainable relationship with the environment without compromising the quality of life delivered by industrial economies (Harper 2004: 340). However, its priority is on the sustainability of the ecosystem. Such a perspective reflects as an ecologization of societal development policies as a whole (Hills et al., 2003) and Beck's "ecological rationality". In this sense, the more tangible ideas of ecological modernization will be more useful and evaluative than ideological phraseologies like sustainable development for focusing our thought on strategies of harmonization between human needs and the sustainability of the ecosystem.

Thus, considering the fact that environmental policies in South Korea based on segmental and unintegrated individual policy, it is necessary to launch integrated ones based on the concept of sustainable society and, ecological modernization that imply a systems approach for achieving sustainable development. In addition, it is suggested that if the practice of governance is based on an interaction between the formal institutions and informal groups in formulating the decision making process of environmental policy, this will be effective in the reduction of conflict in later application of environmental policy, and this will contribute to the further achievement of sustainable development.

2. A System Approach to Sustainable Development

Environmental problems in origin can be conceived as the result of human developmental activities toward improving affluence and convenience without the consideration of the long-term ecological implications of any short-term goals. Many arguments have been suggested as a means to achieve sustainable development in a way to minimize environmental problems. Jeong (2005) has classified strategies toward sustainability into two categories — the technological approach and the system approach. Heberlein (1974) has three categories of "cognitive, technological, and structural" fixes toward environmental change. The technological approach is an attempt to reduce environmental problems without change in the enjoyment of current material affluence and convenience in life, but system approach is an attempt to change existing social system in a way that environmental problems do not arise.

In South Korea, the basic strategy of sustainable development has been a technological approach. Environmental policy focuses on the reduction of environmental pollution and/or environmental destruction, via applying a more updated technology to the same old extraction of resources, goods and services produced, distributed, consumed, and waste reused.

The strategy of only having technological solutions as a means to preserve nature continues under the terms green technology and/or clean technology (e.g. Johansson, 1992; Freeman et al., 1995; Kirkwood and Longley, 1995; OECD, 1995; Schot, 2001). This means clean technology applied to production processes, the re-use and recycling of resources, the conservation and more efficient uses of energy, and changes in general production or factory design to achieve these goals as well. Proponents maintain that the clean technology strategy will contribute to protecting nature, will reduce the necessity of scale in fresh resource use, and will save energy. As a result, they expect that the clean technology will reduce the ecological impact of human activities.

However, though technology is one possible means to preserve nature, it has been argued that technology choices or unknown 'second order effects' of technological change are also a cause of environmental problems (e.g. Commoner, 1971; Heberlein 1974). By itself, I maintain that the technological approach to the preservation of nature is not a sufficient means for environmental amelioration. The wider strategy should be an integrated system approach including though not limited to technological change.

In conclusion, I hope to have provided a different and more realistic historical modelling for "the structure of sustainable development" by providing statistical and evaluative techniques. The methods in this paper allow us to monitor, to evaluate, and to strategize what is most beneficial in real time toward achieving this sustainable society.

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