An Empirical Analysis of Sustainable Development – A Case Study in Jeju Province, South Korea[1)]

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Abstract: This paper analyzed empirically the sustainable development of Jeju Province, South Korea in terms of environmental impact (EI), ecological footprint (EF), and the relative importance of the factors determining sustainable development. A ten-year time-series statistical data (1993 to 2002) was used for this analysis.

Jeju is sustainable in terms of EI, but unsustainable in terms of EF. The different result is drawn from different variables included in the two techniques. The leading positive factors determining sustainable development are those related to the quality of life in terms of amenity, cultural affluence, and convenience of life. Meanwhile, the leading negative factors were population, acid rain, and pollution of the natural environment. These findings may be caused by the fact that the tourism is the dominant industry of Jeju.

For achieving sustainable development efficiently in Jeju, it is required to launch an integrated environmental policy, and environmental education and movement are also required to be done for citizens in a way of increase in their pro-environmental behaviour in their everyday life.

Key words: Sustainable Development, Sustainable Development Indicator, Environmental Impact, Ecological Footprint

I. Aim of the Study

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Industrialization since the 18th century has brought about material and cultural affluence and many of the conveniences we now enjoy. But such benefits have been achieved at the expense of nature and produced environmental problems. Contemporary society is characterized as a risk society in terms of the world-wide environmental problem, as it threatens the very existence of human beings (Beck, 1992). This means that we are the beneficiaries and victims of industrialization, and that a self-contradiction lies between industrialization and the preservation of the environment.

It took until the 1960s to recognize how seriously the environmental problem was. 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 (e.g. Meadows et al, 1972), and the other was the optimistic view (e.g. Kahn et al, 1979). As is well known, the World Commission on Environment and Development (hereafter called WCED) suggested the idea of sustainable development in 1987. The idea is a compromising point of view on the relationship between industrialization and environmental conservation, defined as a social development within the capacity of environmental sustainability in terms of resource supply and the absorption of the wastes from the process of goods and service production, distribution, and consumption.

Since 1987, a lot of research has been done on sustainable development in terms of its concept, model, policy, and so on. In accordance with these aspects, ecological footprint and environmental impact as an empirical measurement of sustainable development were conceptualized in the 1990s (e.g. Wackernagel et al, 1993; Sage, 1995; Harper, 2004: 279). Some empirical research was done on ecological footprint (e.g. Wackernagel et al, 1993; Wackernagel and Rees, 1996; Bicknell et al, 1998; WWF, 2002; McDonald and Patterson, 2003) and environmental impact (e.g. Dietz and Rose, 1994; 1997). However, few empirical analyses that identify the relative importance of the factors determining sustainable development have been done.

That being the case, the objectives of this paper are to empirically analyze the sustainable development of Jeju Province, South Korea in terms of environmental impact, ecological footprint, and the relative importance of the factors determining sustainable development.

First, the paper will briefly describe aspects of Jeju Province's socio-economic structure and their transformation since 1985. This description will provide readers with some background knowledge on Jeju.

Second, in order to achieve our objectives, the paper will review the concept of sustainable development. This is to understand what sustainable development is, as well as to identify sustainable development indicators which will be used in the analysis of the factors determining sustainable development and their relative importance.

Third, the environmental impact and ecological footprint of Jeju will be calculated as a representation of the whole state of sustainable development on the Island.

Finally, the relative importance of the determinant factors of sustainable development on Jeju will be measured alongside sustainable development indicators.

II. About Jeju Province

South Korea is composed of nine provinces and six large cities. Jeju Province is an island located south of South Korea. Jeju Island has a mild oceanic climate throughout the year with the lowest annual temperature range in South Korea. The temperature for the hottest summer months averages no more than 33.5℃ and for winter it averages no less than 1.0℃.

Jeju is 73km wide and 41km long with a total area of 1,845㎢. It came into existence 700 to 1,200 thousand years ago when lava spewed from a sub-sea volcano and surfaced above the waters. Another volcanic eruption that followed formed Jeju's largest volcano, Mt. Halla.

At the center of Jeju, Mt. Halla rises to 1,950m above sea level. The rest of Jeju slopes down from its summit and is covered with dark gray volcanic rocks and volcanic ash soil. Relatively isolated from the rest of the world, Jeju's nature has been well preserved in its prehistoric state. That is why traveling to Jeju is a journey back in time.

Jeju has pristine natural environment, and particularly valued is its marine environment, the purity of air and water, and the extinct Mt. Halla that dominates the Island. These natural attractions make Jeju a domestic and international tourist destination.

Jeju was an agricultural society before the 1970s when the South Korean government launched the first five-year economic development plan, which targeted Jeju for tourism development. Since the 1970s, Jeju has been transformed into an industrial society. Table 1 shows a trend of structural transformation in Jeju since 1985.

Table 1 about here

As is shown in Table 1, Jeju has experienced remarkable structural transformation over the past 17 years from 1985 to 2002. During that period, the population increased by 19.4%, GRDP by 486.6%, and the number of tourists by 574.6%. In terms of the industrial origin of GRDP, the implementation of a highly industrialized economic structure took place from 1985 onwards, showing a remarkable increase in tertiary industry. With this, GRDP per capita also began to rise rapidly, increasing by 391.6% over the period from 1985 to 2002.

It is a generalized thesis that such a transformation to an industrial society is achieved by sacrificing the environment. Therefore, it is meaningful to analyze empirically whether the industrialization of Jeju is being achieved in a way that is environmentally sustainable or not.

III. The Concept of Sustainable Development

The first step in empirically analyzing a situation is to extract the attributes of the situation, which are defined as the conceptual components of that situation. Then, the conceptual components are the dimensions of sustainable development. For this, it is necessary to review the existing concepts of sustainable development in a comprehensive way.

The WCED was the first to use the term sustainable development formally in *Our Common Future* in 1987. However, this idea can be traced back to 19th century neoclassical economics (Noorman et al, 1998). According to Noorman et al, in ideal circumstances, relative scarcity is reflected in price; the market is considered to allocate optimally the scarce factors of production. However, the preferences for natural resources can only partly be reflected in the exchange relations of a market. Consequently, the importance of the natural environment as a contributor to increasing welfare has received only limited attention in economic decision processes.

Other proponents of the idea of sustainable development, even though they did not use this term, include the pessimistic and optimistic perspectives on industrialization that emerged in the 1970s. The example of the former is *The Limits to Growth* (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 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, 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, for example, eco-businesses. In the early 1980s, The International Union for the

Conservation of Nature and Natural Resources emphasized ecological constraints on human activities and advocated the maintenance of essential ecological processes, life-support systems, and the preservation of genetic diversity to ensure the sustainable utilization of species and ecosystems. 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). In accordance with this definition, the WCED (1987: 3) maintained 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 one than that of neoclassical economics and Meadows et al. However, the WCED adds poverty as a component of sustainable development to the two main components – economic development and the natural environment.

The concept of sustainable development was confirmed and strengthened 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).

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 nature (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 natural environment. 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 environmental sustainability. This means that economic and environmental sustainability are not possible without the sustainability of other social factors. In other words, without considering social factors, the concept of sustainable development cannot be realized in its entirety.

Thus a variety of new perspectives on the conceptual components of sustainable development emerged in the 1990s, focusing not only on the traditional components of the economy and the environment but also on 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 growth, culture, social structure, and technology.

The conceptual meaning of sustainable development implied by neoclassical economics and Meadows et al is based on the impact of economic development on the natural environment, which means that these are the main conceptual components of sustainable development. For the WCED, however, poverty, economic development, natural environment, technology, and social institutions are included as conceptual components. The WCED treats technology and social institutions as external factors determining the state of economic development and the natural environment, and poverty is implied by the economic well-being of the population. Thus, the WCED's conceptual components in summary are: population, economic development, and the natural environment. The WCED's perspective was reconfirmed and strengthened at the Rio Earth Summit Conference, without any attempts to rearrange its conceptual components.

In the 1990s, even though there were debates on whether sustainable development was a realistic or utopian goal, most scholars accept population, economic development, and the natural environment as the main conceptual components of sustainable development. Multidimensional approaches include other components such as psychological, social, historical, technological, physical, and socio-cultural. These conceptual components may be defined as the external factors determining the sustainability of the three main ones – population, economic development, and the natural environment. These multidimensional components, derived from the concept of sustainable development, should be used as composite dimensions for the empirical analysis of how successfully sustainable development is being achieved.

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' is 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, etc. (Kates et al, 2005).

The empirical measurement of sustainable development may be done through each of its multidimensional components, and there may be many possible ways to do this. However, two analytical techniques have been developed in social sciences: the calculation of environmental impact and ecological footprint. These are not simply based on individual components of sustainable development but on its state as a whole, including all multidimensional components. Therefore, the environmental impact and ecological footprint of Jeju will be analyzed in

Section IV as a whole using the multidimensional components of sustainable development.

Ⅳ. The Environmental Impact and Ecological Footprint of Jeju

1. Environmental Impact

Environmental impact is defined as the impact of a population or nation upon its environment and ecosystem (Harper, 2004: 279). Two formulae have been developed for its calculation, as below.

Formula 1 (Harper, 2004: 279) : $I = P \times A \times T$

I : Environmental Impact

P : Population

A : Affluence

T : Technology

Formula 2 (Sage, 1995) : $I = (PCP/PCUR) \times 100$

I : Environmental Impact

PCP : Percentage Change in Population

PCUR : Percentage Change in Use of Resource

Formula 1 is simple, robust, and useful as a framework for research. In particular, the relative impact of P, A, and T on I is determined by their changes over time. But the model is linear and the effects of the different terms are proportional. Therefore, the model can make it difficult to identify diminishing or increasing impacts of the terms in relation to environmental impact (Harper, 2004: 280).

In contrast, Formula 2, even simpler than Formula 1, includes population and resource use, which are the core impacts of human activities on nature. Therefore, Formula 2 was used for calculating the environmental impact in Jeju in the research discussed here, using the year of 1993 as base year. However, there is an important shortcoming in Formula 2; that is, environmental impact should decrease when population and use of resources decrease, but when this case is applied to Formula 2, the result shows an increase rather than a decrease (Jeong, 2002: 216).

Table 2 is the environmental impact (hereafter called EI) and environmental impact index (hereafter called EII) of Jeju during the ten years from 1993 to 2002. EII is the rate of change in the value of EI when it is based on a year as a reference. In Table 2, the EIIs were calculated using 1.000 in 1993 as the base year.

Table 2 about here

The following is found from Table 2 to be significant. EI is less than 1.000 over the years from 1993 to 2002. Compared to 1993, EI increased by 1.071 times; it decreased to 60%-70% from 1995 to 1997; then, again compared to 1993, it began to increase by 1.200-1.400 times from 1998 to 2002.

Overall, EI increased by 1.115 times over 10 years from 1993 to 2002. A remarkable fact is that, compared to 1993, EI increased by about 1.400 times in 1999 and 2000. The reason for this relatively higher increase in the two years is that the ratio of population increase was remarkably higher than that of resource use.

2. Ecological Footprint

EI provides valuable information on the impact of human resource use on the natural environment in relation to population. However, it does not inform whether or not that impact is within the carrying capacity of nature. Ecological footprint (hereafter called EF) presents a complementary explanation that makes up for the shortcoming inherent in the environmental impact.

EF is referred to as the appropriated carrying capacity, and is defined 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 waste 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.

Central to the EF 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, EF addresses not the number of heads but the size of the feet.

Some empirical research has been done on calculating EF. For example, Wackernagel et al (1993) on Canada, Bicknell et al (1998) on New Zealand, Chambers et al (2000) on 52 countries as a comparative study, and McDonald and Patterson (2003) on New Zealand. In addition, WRI (1992), Chambers et al (2000), and WWF (2002) have calculated EF 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 EF, it is successful in providing an interesting basis for discussion on the environmental effects of consumption patterns, including those outside the national borders, and on equity with regard to resource use.

Several methods have been developed for calculation of EF (e.g. Wackernagel et al, 1993; Wackernagel and Rees, 1996; Folke et al, 1997; Bicknell et al, 1998; van Vuuren and Smeets, 2000; WWF, 2002; McDonald and Patterson, 2003). Although each of these methods has its own peculiarities and insights, many have their roots in the work of Wackernagel and Rees (1996). Therefore, the calculating method of EF employed for this research is that developed by Wackernagel et al (1993). Recently, Wackernagel and Yount (2002) discussed the strength and weakness of EF as an ecological accounting method.

Wackernagel et al's example of EF calculation is as follows. Let's assume the following.

- o The amount of paper being used in Jeju is 100,000 tons a year.
- o For producing 1 ton of paper, $2m^3$ of wood is required.
- o Forest land produces $100m^3$/ha of wood every 50 years.
- o Jeju's population is 500,000.

EF of the forested area for paper consumption is thus calculated as follows.

Formula 3: An Example of Calculating Ecological Footprint

(Wackernagel et al, 1993: 25)

$$\frac{100{,}000(\text{tonnes})\times 2.0(m^3/\text{ton})\times 50(\text{years})}{500{,}000(\text{population})\times 100(m^3/\text{ha})} = 0.200\text{ha/person}$$

As shown in Formula 3, EF of the forested area for paper consumption is 0.200ha per person in Jeju. As Wackernagel et al (1993: 19-20) maintain, since it is not feasible to assess land requirements for the provision, maintenance, and disposal of all goods consumed, this research was confined to major categories in the calculation of EF.

Table 3 shows EF by the categories of major consumption products, using those of Formula 3. Table 3 does not include the gigantic task of assessing the impact of several hundred thousand goods which are available for consumption on the market under the over one hundred land categories that can be distinguished.

Table 3 about here

Jeju has a population of 547,964, and is 184,710.35ha in area. Therefore, the land size of Jeju per person is 0.337ha. It is found from Table 3 that EF for Jeju is 1.0432ha. This indicates that Jeju exceed EF by 3.096 times. As shown in Table 3, however, considering the categories whose data are not available, the real excess would be more than 3.096 times.

According to Chambers et al's work (2000: 122) on a comparison among 52 countries, the average per capita EF necessary for socio-economic activity in South Korea was 37,000m^2 in 1995. Average land size per capita was estimated as 4,000m^2 in 1995, dividing total land size by population. This means that the whole of South Korea exceeded EF by 9.250 times in 1995, dividing

37,000m^2 by 4,000m^2. This indicates that Jeju is in relatively better shape in terms of sustainable development than the whole of South Korea.

Comparing the portions of total EF among the categories of consumption-related products, service products occupy most, followed by food, transportation, consumer goods, and housing. Of the individual products (except other services in the service category), vegetable food account for the largest EF portion, followed by private transportation, animal products for food, public transportation, and clothing.

Ⅴ. The Relative Importance of the Factors Determining Sustainable Development

1. Selection of Sustainable Development Indicators

In the analysis of the relative importance of the factors determining sustainable development, the factors are regarded as sustainable development indicators (hereafter called SDIs). SDIs should be selected from the conceptual components of sustainable development. It is impossible here to review all of the relevant literature on SDIs. However, we need to define what indicators there are, even though there are debates on what the indicators should be (for details, see SCOPE, 1997).

In general, an indicator has the following three dimensions (Jeong, 1997: 704-705). First, it is a proxy measure of a given situation. For example, the suicide rate is an indicator of social pathology. Second, it is sometimes used as a variable. An example is that per capita income is an indicator measuring economic growth. Third, an indicator is used as a concrete and empirical measure representing an abstract concept, as when IQ is used as an empirical measure of intelligence.

When applied to sustainable development, SDIs can be seen as concrete and empirical proxy measures representing the conceptual components of sustainable development, as reviewed earlier. Such indicators are constructed using information that is readily available, or can be obtained at a reasonable cost. Therefore, the empirical SDIs selected are unavoidably biased.

Environmental indicators had been developed before the development of SDIs, but the two are conceptually different (Opschoor & Reijnders, 1991). Environmental indicators express (change in) the amounts/levels of emissions, discharges, depositions, interventions, and so on in a predetermined region. They can be defined as quantitative descriptors of changes in either (anthropogenic) environmental pressure or in the state of the environment. Thus, they indicate pressure. SDIs, however, are not simply indicators of an actual state but rather indicators of states vis-a-vis some reference; they can either be some past environmental state or a future one that is regarded as more desirable than the present. SDIs are, thus, more than mere descriptors of a state, but a normative measure of the distance between the current state and the reference situation. With such an implication, SDIs focus on the links between environmental impact and socio-economic activity (DEUK, 1996).

Examples of environmental indicators include work done in Japan (Jeong, 2002: 290-291), the Netherlands (Adriaanse, 1993), and OECD (1991; 1994) etc., focusing on environmental issues and paying little attention to other socio-cultural factors other than economic ones. Such a framework is not sufficient for measuring empirically the achievement of sustainable development, which consists of broader conceptual components as has been discussed.

SDIs were initially developed in order to overcome the shortcomings inherent in environmental indicators. For example, Braat (1991) defined SDIs as indicators that provide information, directly or indirectly, about the future sustainability of specified levels of social objectives such as material welfare, environmental quality, and natural amenity. Three levels of SDIs have been developed. One applies to a local region in a country (e.g. Sustainable Seattle, 1995; LGMBUK, 1995), another applies to a whole country (e.g. DEUK, 1996; USIWGSDI, 1998; Eckersley, 1998: 299-327), and the third applies to a global situation (e.g. UNCSD, 1996; SOEC, 1997; SCOPE, 1997; UNDPCSD, 1997; World Bank, 1997; OECD, 1998; EEA, 1999; or by academic scholars, e.g. Bell & Mores, 1999).

The most important point is that they attempted to develop SDIs in a broad and integrative way, including the natural environment, the economy, socio-cultural factors, and even institutional factors (e.g. SOEC, 1997; UNCSD, 1996; SCOPE, 1997; World Bank, 1997; UNDPCSD, 1997), using a causal chain such as a framework of Driving Force-State-Response among SDIs.

Then, as identified, SDIs should be selected on the basis of the conceptual components of sustainable development noted earlier, the theoretical definition of SDIs, and the empirical limitations in selecting them. With the consideration of these three determiners, 68 factors were selected for this study as the SDIs of sustainable development and categorized into three dimensions -

socio-economic environment, living environment, and natural environment (See Tables 4-1, 4-2, and 4-3).

Table 4-1 about here

Table 4-2 about here

Table 4-3 about here

2. Analysis of the Relative Importance of the Factors

In order to analyze the relative importance of the factors determining sustainability, the 68 SDIs were factorially analyzed by the principal-factor method. On factor was extracted[2]. The communalities of the 68 SDIs estimated by this technique enable us to identify their relative importance and their percent total variances as factors determining sustainable development of Jeju. In particular, their percent total variances represent their explanatory power as SDIs. However, the factor structure extracted from this technique will be disregarded, because the examination of the structural pattern of the 68 SDIs is beyond the scope of this research.

Ten year time-series data on the 68 SDIs from 1993 to 2002 was collected from the *Jeju Statistical Yearbook* published by the

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[2] See R. J. Rummel (1970) for the advantages of principal-factor method. The reason for extracting one factor is that this research is not to identify the factor structure the SDIs as the dimensions of sustainable development, but to identify the positive and/or negative direction of each SDI on the basis of their factor loading.

Jeju Provincial Government. The result of the analysis is shown in Table 5.

Table 5 about here

The percent total variance is 50.5%. This means that the 68 SDIs explain 50.5% of sustainable development in Jeju as the determinants. 49.5% is determined by indicators other than the 68 SDIs.

Based on the plus and minus signs of the factor loadings, 32 SDIs have contributed to the sustainable development of Jeju in a positive way during the 10 years from 1993 to 2002, and the remaining 28 SDIs in a negative way. The relative importance of the 68 SDIs as the determinants of sustainable development can be identified from the magnitude of communality which ranges from 0.003 (COD in marine) to 0.990 (population). Applying an arbitrary criterion to the magnitude of communality for categorizing the 68 SDIs can conveniently classify them into high level (0.900 and over), medium level (from 0.700 to 0.899), and low level (0.699 and less).

Combining the positive and negative impact of the 68 SDIs with their level of communality, the following six categories are extracted.

- o Category 1 : Positively high contribution to sustainable development
- o Category 2 : Positively medium contribution to sustainable development
- o Category 3 : Positively low contribution to sustainable development

- o Category 4 : Negatively high contribution to sustainable development.
- o Category 5: Negatively medium contribution to sustainable development
- o Category 6 : Negatively low contribution to sustainable development

Categories 1 and 4 may be cited as the relatively important factors determining sustainable development; Categories 3 and 6 as relatively less important ones; and, Categories 2 and 5 as relatively more or less important ones. Based on such an operational definition, positively important factors include 11 SDIs. They are Home Ownership, Supply of Running Water, Supply of Electricity, Supply of Gas, Supply of Clean Energy, Area of Car Parking, Number of General Restaurants, Number of Recreation Facilities, Parks, Waste Landfills, and Supply of Water. Meanwhile, the negatively important factors include Population, Acid Rain, and As in Soil.

In terms of more or less important factors, 8 SDIs belonged to the positive category, and 9 SDIs to the negative category. The 8 positive SDIs are Environment Budget, Length of Road, Number of Physicians, Number of Sanitary Industries, Number of Social Welfare Facilities, GRDP, Tourism Receipt, and Urban Planning in Residential Area. The 9 negative SDIs are Use of Chemical Fertilizer, Number of Entertainment Restaurants, Number of Crimes Committed, Supply of Water, Discharged Livestock Wastewater, SO_2 in Air, pH in Soil, Hg in Soil, and Pb in Soil.

Finally, the remaining 37 SDIs are identified as relatively less important factors. Among the 37 SDIs are, in particular, 22 whose communality is lower than 0.200 and so these may not be significant as determinants of sustainable development, regardless of whether they are positive or negative. This means that, even though the 22 SDIs have contributed to the determination of sustainable development either positively or negatively in Jeju, their impact is so minor as to be disregarded. The 22 SDIs are Rate of Sewer System Distribution, Number of Running Air Flights and Passenger Ships, Number of Physicians, Number of Social Security Recipients, pH in Marine, COD in Marine, and Cd in Soil, etc.

Ⅵ. Summary and Discussion

Even though there has been a lot of debate on whether sustainable development is a reality or an ideology, the consensus is that as a concept it advocates the advance of industrialization with the preservation of the natural environment. The main reason for this is that the goal of industrialization is to improve material affluence and convenience in life through the consumption of goods and services, and that goal can not be achieved without nature supplying the resources necessary for producing goods and services and absorbing the wastes discharged in the process of goods and services being produced, distributed, and consumed.

As such, the concepts of environmental impact and ecological footprint were established along with techniques for analyzing them empirically. Environmental impact focuses on resources use, while ecological footprint focuses on both resources use and waste absorption. Some empirical analyses have already been done using these concepts in relation to a country, a comparison among countries, and the earth as a whole.

This study aimed at analyzing empirically the sustainable development of Jeju Province, South Korea in terms of environmental impact (EI) and ecological footprint (EF). In addition, unlike existing research, it analyzed the relative importance of the factors determining sustainable development.

In order to achieve the objectives of this study, the concept of sustainable development and its conceptual components were reviewed for extracting the factors determining sustainable development. Statistical time-series data (from 1993 to 2002) were collected from the *Statistical Yearbooks* published by the Jeju Provincial Government. The results of the analysis are summarized as follows.

EI for Jeju was less than 1.000 each year from 1993 to 2002. This may have been caused by the fact that the dominant industry of Jeju is a tertiary one, requiring less extraction and use of natural resources. However, in comparison with 1993, EI increased by 1.115 times in 2002. These findings indicate that Jeju is still sustainable in terms of EI, but is becoming unsustainable.

EF per capita for Jeju was 1.0432ha in 2002, exceeding the total land size of Jeju 3.096 times. Comparing the excess of 9.250 times for all of South Korea in 1995, Jeju is relatively sustainable. In Jeju, service consumption-related products account for the largest portion of total EF, followed by food, transportation, consumer goods, and housing. A major reason for these is the fact that the dominant industry in Jeju is tourism.

EF per capita measures the amount of land appropriated by a person in supporting their consumption. The smaller this amount of land, the more sustainable the pattern of consumption is deemed to be because it requires less appropriated natural capital. In regard to the degree of overshoot, it is argued that to be sustainable a population must utilize less embodied land than the amount of useful land available. That is, the population must live within its carrying capacity or biocapacity. If the population overshoots its carrying capacity by using too much land, then, it is argued, this amount of land cannot sustain the population.

The leading positive factors determining sustainable development in Jeju are those related to the quality of life in terms of amenity, cultural affluence, and convenience such as Home Ownership, Supply of Running Water, Supply of Clean Energy, Parks, Green Zones in Urban Planning, Recreation Facilities, Reuse of Wastes, and Car Parking Areas, etc. Meanwhile, leading negative factors are population, acid rain, and the pollution of air and soil, etc. Discharged Domestic Wastes, Discharged Sewage, and Manufacturing Industry, etc. though negative determinants impact on sustainable development at a low level.

The research results of this paper lead us to at least two debatable issues. First, one important thing found is that Jeju is sustainable in terms of EI, but unsustainable in terms of EF. Why do we get such a contrary result? The reason for this is the difference in the variables included in the two analytical techniques. Even though the two analytic techniques have their own limitations and shortcomings, EI considers only two variables – population and resource use – while EF considers three – population, resource use, and land size.

Thus, inconsistent results lead us to doubt whether we can feasibly examine sustainable development with any accuracy. The doubt makes us reconsider the debates on whether sustainable development is an empirical reality or an ideology. Furthermore, it may also be questionable whether the earth actually exceeds a sustainable EF (Meadows et al, 1992; WRI, 1992; Chambers et al, 2000; Dunlap and Catton, 2002; WWF, 2002).

Another issue is whether or not the relative importance of the determinants of sustainable development can be generalized or not. The answer is definitely 'no'. Because the relative importance of the determinants are drawn from data related to the process of industrialization, and each region is different in terms of the pattern and current level of industrialization. Repeated research on the regions whose process and/or level of industrialization is similar may be a key approach to establishing the generalization.

Given these issues, it is worth considering the arguments on whether or not sustainable development can be empirical assessed, the concept of EF is scientific, and the calculating method of EI and EF is scientific.

In particular, the measures of both EI per capita and overshoot are controversial and not without methodological problems. Firstly, EF per capita requires the adding up of land of different quality or productivity. The addition of land areas of varying qualities assumes that all land is equally valuable or productive when measured on a per hectare basis. Wackernagel and Rees (1996) propose a series of productivity factors that can be used to allow for land productivity (quality) differences. It was, however, problematic to use their land productivity factors in this study largely because they are crudely constructed across four land use types and these did not have the degree of refinement required desired. Secondly, the degree of overshoot measure is also problematic as it assumes a hypothetical closed system where a population is purported to be supporting itself without any external inputs or outputs of embodied land. Modern economies are, on the other hand, open systems among countries and/or among regions in a country. Thirdly, it is also questionable whether land is the only or the most important limiting factor as assumed by the overshoot argument.

Overall, there may be no doubt that the three concepts – sustainable development, EI, and EF – are useful as indicators of sustainability performance, but their utilization requires conceptually rigorous computation rules compatible with empirical approximations.

In relation to the findings from this research, it is worth considering some policy tools that could be used for pursuing sustainable development in Jeju. From a world-wide perspective, the activities for achieving sustainable development have been organized into environmental conventions by international organizations, environmental policy by governments, green management by business corporations, environmental movement by civic organizations, environmental education by schools and civic organizations, and pro-environmental behaviour by the general population in everyday life.

For the case of Jeju, effective policy tools are needed to facilitate environmental policy and pro-environmental behaviour. Green management can be regulated by environmental policy; environmental education can lead citizens to practice pro-environmental behavior.

The environmental policy of Jeju is characterized by a focus on the regulation of each component of nature threatened by pollution and/or destruction, and the control of wastes discharged from the process of goods and services being produced, distributed, and consumed. Considering the fact that nature and human socio-economic activities are an interrelated system and determined through mutual impact, an integrated environmental policy is necessary for achieving sustainable development in a more efficient way. In addition, it is necessary to include an order-of-priority in this integrated policy which gives a priority to the negative factors affecting the state of sustainable development. The six categories drawn from Table 5 in the section above, 'analysis of the relative importance of the factors', may be a good starting point for identifying priorities in enacting the integrated environmental policy.

Pro-environmental behaviour refers to actions taken to protect environment and thus is a way of achieving sustainable development (Mullins et al, 2004). Without the pro-environmental behaviour of citizens, sustainable development can not be expected to be efficiently achieved even with the launch of an integrated environmental policy. The ultimate goal of environmental education is to achieve sustainable development by leading citizens to practice environmental friendly behaviour in everyday life. In this sense, environmental education should focus on increasing pro-environmental behavior rather than a knowledge and understanding of the environment. Thus, an empirical analysis of the effectiveness of existing environmental education is necessary in order to examine to what extent it contributes to pro-environmental behaviour. The result of analysis may enable us to modify environmental education in a way that more efficiently produces pro-environmental behavior.

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Table 1. Some Aspects of Socio-Economic Structure and Their Transformation

Year / Sectors	1985	1990	2000	2002
Population	462,755	514,608	543,323	552,310
Tourists	669,369	2,992,096	4,110,934	4,515,515

Gross Regional Domestic Production at Current Prices (US Million Dollars)		892.7	2,416.1	4,849.2	5,237.0
Industry Origin of GRDP	Primary Industry	40.7%	34.0%	16.1%	16.4%
	Secondary Industry	17.6%	20.5%	16.8%	16.2%
	Tertiary Industry	41.7%	45.5%	67.1%	67.4%
	Total	100.0%	100.0%	100.0%	100.0%
GRDP per capita at current prices (US Dollar)		1,929	4,695	8,925	9,482

Data Sources: *Jeju Statistical Yearbook* published by the Jeju Provincial Government.

Table 2. Environmental Impact and Its Index

Year	Population	GRDP (1 billion Won)	Environmental Impact	Environmental Impact Index
1993	511,019	2663.3	0.071	1.000
1994	517,449	3225.0	0.076	1.071
1995	519,394	3741.9	0.043	0.606

1996	523,736	4014.5	0.049	0.691
1997	528,360	4466.3	0.051	0.719
1998	534,715	4152.0	0.085	1.198
1999	539,493	4221.1	0.099	1.395
2000	543,323	4398.0	0.098	1.381
2001	547,964	4858.8	0.089	1.254
2002	552,310	5374.1	0.082	1.155

Data Sources: *Jeju Statistical Yearbook* published by the Jeju Provincial Government.

Note: 1. The environmental impact in 1993 was calculated by the percentage of change in population and resources between 1992 and 1993.

2. 1 US dollar is about 1,050 Won (Korean monetary unit).

Table 3. Ecological Footprint

Ha/Person	Energy	Built-up Land	Arable Land	Pasture	Forest	Others	Total
A. Food	0.1870		0.0992	0.0326			0.3188
1. Vegetables	0.1270		0.0992				0.2262
2. Animal Products	0.0600			0.0326			0.0926
B. Housing	0.0003	0.0084					0.0087
1. Construction							

2. Heating/ Electricity	0.0003	0.0084					0.0087
C. Transportation	0.1900	0.0128					0.2028
1. Private	0.1250						0.1250
2. Public	0.0560	0.0128					0.0688
3. Others	0.0090						0.0090
D. Consumer Goods	0.1740	0.0005					0.1745
1. Packing	0.0390						0.0390
2. Clothing	0.0480						0.0480
3. Furniture	0.0270						0.0270
4. Tabaco/Alcohol	0.0110						0.0110
5. Personal Care	0.0160						0.0130
6. Recreation	0.0310						0.0310
7. Other Goods	0.0020	0.0005					0.0025
E. Service	0.1544	0.0103			0.1681	0.0056	0.3384
1. Government	0.0040						0.0040
2. Education	0.0300	0.0010					0.0310
3. Health Care	0.0150						0.0150
4. Social Care	0.0001	0.0075					0.0076
5. Tourism	0.0003	0.0002					0.0005
6. Bank/Insurances	0.0020						0.0020
7. Other Services	0.1030	0.0016			0.1681	0.0056	0.2783
Total	0.7057	0.0320	0.0992	0.0326	0.1681	0.0056	1.0432

Data sources: *Jeju 2003 Statistical Yearbook* published by the Jeju Provincial Government.

Note: The blank cells are 'unavailable data' or 'irrelevant category'.

Table 4-1. Sustainable Development Indicators Selected - Socio-economic Environment

1. Population	18. Number of Pharmacies
2. Home Ownership (%)	19. Number of General Restaurants
3. Supply of Running Water (%)	20. Number of Entertainment Restaurants
4. Rate of Sewer System	21. Number of Sanitary Industries

Distribution (%)	22. Number of Crimes Committed
5. Number of Running Domestic	23. Number of Social Welfare Facilities
Air Flights	24. Number of Social Security Recipients
6. Number of Running International	25. Number of Students per Teacher
Air Flights	26. Number of Recreation Facilities
7. Number of Running	27. GRDP (1 billion Won)
Passenger Ships	28. Number of Manufacturing Industries
8. Supply of Electricity (MWh)	29. Number of Tourists
9. Supply of Fossil Oil (kl)	30. Tourism Receipt (1 billion Won)
10. Supply of Gas (m^3)	31. Number of Tourist Establishments
11. Use of Chemical Fertilizer (MT)	32. Number of Hotel Rooms
12. Supply of Clean Energy (ton)	33. Number of Banks
13. Environment Budget (1 billion Won)	34. Number of Retails and Wholesales
14. Length of Road (km)	35. Unemployed (%)
15. Number of Cars	36. Number of Public Servants
16. Area of Car Parking (m^2)	37. Number of Car Accidents
17. Number of Physicians	

Table 4-2. Sustainable Development Indicators Selected - Living Environment

38. Park (km^2)	45. Area of Forest (ha)
39. Discharged Domestic	46. Noise of Airplane (WCPNL)
Wastes (ton/day)	47. Urban Planning in Residential

40. Discharged Sewage (m^3/day)
41. Landfill of Wastes (m^2)
42. Reuse of Wastes (%)
43. Supply of Water (m^3)
44. Green Zone in Urban Planning (km^2)

Area (km^2)
48. Number of Toxic Industries
49. Number of Noise Industries
50. Discharged Livestock Wastewater (ton/day)

Table 4-3. Sustainable Development Indicators Selected - Natural Environment

51. SO_2 in Air (ppm)
52. CO in Air (ppm)
53. NO_2 in Air (ppm)
54 O_3 in Air (ppm)
55. TSP in Air ($\mu g/m^3$)
56. DO in Marine (mg/l)
57. pH in Marine (pH)
58. COD in Marine (mg/l)
59. T-N in Marine (mg/l)
60. T-P in Marine (mg/l)
61. SS in Marine (mg/l)
62. Acid Aain (pH)
63. pH in Soil(mg/kg)
64. Cd in Soil (mg/kg)
65. Cu in Soil (mg/kg)
66. As in Soil (mg/kg)
67. Hg in Soil (mg/kg)
68. Pb in Soil (mg/kg)

Table 5. Communalities and Percent Total Variance of SDIs

SDI	Factor Loading	Communality	SDI	Factor Loading	Communality	SDI	Factor Loading	Communality
1	−0.995	0.990	24	+0.412	0.170	47	+0.914	0.835
2	+0.990	0.980	25	+0.672	0.452	48	−0.688	0.473

3	+0.993	0.986	26	+0.974	0.949	49	−0.556	0.309
4	+0.366	0.134	27	+0.902	0.815	50	−0.916	0.839
5	+0.379	0.144	28	−0.434	0.188	51	−0.870	0.757
6	+0.276	0.076	29	+0.491	0.241	52	−0.588	0.346
7	+0.336	0.113	30	+0.885	0.783	53	−0.619	0.383
8	+0.976	0.953	31	+0.779	0.607	54	−0.558	0.311
9	+0.385	0.148	32	+0.373	0.139	55	−0.639	0.408
10	+0.975	0.951	33	+0.141	0.020	56	−0.245	0.060
11	−0.910	0.828	34	+0.599	0.359	57	−0.055	0.003
12	+0.988	0.976	35	−0.706	0.498	58	−0.173	0.030
13	+0.905	0.819	36	+0.179	0.032	59	−0.045	0.002
14	+0.882	0.778	37	−0.045	0.002	60	−0.126	0.016
15	+0.785	0.616	38	+0.979	0.958	61	−0.360	0.130
16	+0.993	0.986	39	−0.366	0.134	62	−0.973	0.947
17	+0.848	0.719	40	−0.490	0.240	63	−0.947	0.897
18	+0.126	0.016	41	+0.420	0.176	64	−0.315	0.099
19	+0.955	0.912	42	+0.983	0.966	65	−0.836	0.699
20	−0.839	0.704	43	−0.915	0.837	66	−0.990	0.980
21	+0.866	0.750	44	+0.954	0.910	67	−0.879	0.773
22	−0.902	0.814	45	+0.830	0.689	68	−0.871	0.759
23	+0.869	0.755	46	−0.241	0.058			
Total		14.049	Total		10.223	Total		10.056
Communality in total : 34.328								
Percent total variance : 34.328/68(number of SDIs)×100=50.5%								

Note: The numbers in SDIs are identical with those in Tables 4-1, 4-2, and 4-3.