An International Comparative Research on the Structure and Change in Sustainable Development among Islands*

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Abstract: The objective of this paper was to compare sustainable development and change among Jeju, Tasmania, and Hawaii, using a set of 33 identical ten-year time series sustainable development indicators (SDIs) from 1996 to 2005. The 33 SDIs were grouped into ten categories as composite variables. The comparison was done in terms of the structure and change in sustainable development as an integrated reality.

The structure of sustainable development was compared in terms of the explanatory power of the 33 SDIs on sustainable development as a whole reality and their relative importance as the determinants of sustainable development. The relative importance was compared in terms of both individual SDIs and their categories.

The change in sustainable development was compared by category in terms of the process of sustainable development having been determined throughout the ten years, using their change in the position of

Key words: Structure of Sustainable Development, Change in Sustainable Development, Relative Importance of Factors Determining Sustainable Development, Relative Deviation Index

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sustainability on the basis of their relative deviation index.

The explanatory power of the SDIs and their relative importance were different among the three islands. However, overall, the factors related to economic development and/or those resulted from them, *a priori* and/or *expost facto* policies, and the conservation of nature contribute to sustainable development. Interestingly, the impeding factors were different among the three islands. The sustainability level of the ten categories has changed significantly throughout the ten years in all of the three islands.

To determine the structure and change in sustainable development, assumption would have to take into account a long list of more parameters. The results cited in this paper are based on a limited number of parameters in terms of SDI and time-series as well. However, the methods for analyzing the structure and change in sustainable development has been partially developed in this paper. Further development of this model will prove useful for policy formation and management for sustainable development.

Ⅰ. Introduction

Sustainable development being defined as industrial expansion within the carrying capacity of environment has emerged as a reflection on environmental problems arisen from traditional industrialization. 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* (WCED, 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.

Even though industrialization has been advanced mostly in mainland, islands have begun to be polluted and/or destroyed by the wide range of environmental problems arisen from mainland and the advance of their own industrialization. With such a state of islands, Chapter 17 of Agenda 21 covers Small Island Developing States (SIDS) that are in low-lying coastal countries that share similar sustainable development challenges in terms of increase in their vulnerability to global development in the international arena. In 1994 the United Nations Global Conference on SIDS was held in Barbados. It adopted the Barbados Programme of Action (BPoA) that set forth specific actions and measures to be taken at the national, regional and international level in support of the sustainable development (UN, 2005). The World Summit on Sustainable Development (WSSD) in 2002 reaffirmed the special case of SIDS. The issues included rising sea levels and climate change, fragile ecosystems, market access, renewable energy, tourism, information technology, and fighting disease, among others (NGLS, 1994). The international meeting to review the implementation of the BPoA for the sustainable development of SIDS was held in Mauritus in 2005, bringing together island nations with other countries. One of the key objectives of the Mauritius meeting was to renew the political commitment of all countries to implement the BPoA.

In accordance with such international activities, a lot of academic research has been done on the sustainable development of island. The research has been done mostly on sustainable tourism (e.g. Loannides, 2001; Apostologoulos and Gayle, 2002; Gossling, 2003; Sahli et al, 2007; Tsaur and Wang, 2007). Some research has been done on environment (e.g. Beller, 1990), natural resource (e.g. Davis, 2004), ecosystem (e.g. Davies and Wismer, 2007), economy (e.g. Kakazu, 1994; Mak, 1996; Wallner et al, 1996), and population (e.g. Lea and Connell, 2002).

At least, three shortcomings are inherent in the existing researches. First; even though sustainable development is an integrated reality as a whole covering environment, economy, and society, their research is an ad hoc focusing on a specific issue of sustainable development such as on tourism, consumption, and ecosystem, etc. Second; even though the structure of sustainable development changes as time goes by, no research has been done on the change in sustainable development. Thirdly, the empirical generalization on sustainable development in island is weak because their research has been done on the basis of individual island.

With such implications, this paper aims at comparing the structure and change in sustainable development as an integrated reality among three islands — Jeju in South Korea, Hawaii in USA, and Tasmania in Australia. The three islands are a special case as a semi-independent state in each country in terms of ecosystem, socio-economic structure, and the management of own development plan and environmental impact assessment, etc. The difference is that South Korea is a developing country, and USA and Australia are developed ones.

For comparing the structure and change in sustainable development among the three islands, the paper is divided into the following five parts.

Firstly, the paper will briefly describe some aspects of the three islands in terms of their some aspects of socio-economic structure and their transformation. This is for providing readers with some background knowledge on the three islands.

Secondly, sustainable development indicators will be selected for analyzing the structure and change in sustainable development.

Thirdly, the structure of sustainable development will be analyzed. Structure is generally defined as a configuration of structural components being patterned. In this paper, the sustainable development indicators are the structural components. Their configuration being patterned will be investigated in terms of their explanatory power of sustainable development as a reality and their relative importance as the determinants of sustainable development.

Fourthly, change in sustainable development will be analyzed for ten years from 1996 to 2005. The change will be analyzed in terms of the process of sustainable development throughout the ten years.

Finally, as concluding remarks, the paper will attempt to establish an empirical generalization on the structure and change in sustainable development in island.

This paper is neither for improving the shortcomings inherent in the existing research on island, nor for testing a theoretical hypothesis which is drawn from existing theories on the sustainable development of island. As is identified from the objectives described above, the research question of the paper is for finding sustainable development being structured and changed on a comparative basis among the three islands, employing a different approach that has never been attempted in the existing research on island.

Ⅱ. Some Aspects of Socio-Economic Structure and Transformation in the Three Islands

The three islands are all almost independent states with autonomy in launching policy and management for the development and preservation of the islands. The three islands have pristine natural environment, and particularly valued is their marine environment, the purity of air and water. These natural attractions make the three islands a domestic and international tourist destination.

Table 1 shows a trend of some aspects of socio-economic structure and their transformation in the three islands for ten years from 1996 to 2005.

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

Sector \ Year \ Island	Jeju		Hawaii		Tasmania	
	1996	2005	1996	2005	1996	2005
Area Size (Km^2)	1,845	1,845	28,311	28,311	68,401	68,401
Population	523,736	559,474	1,203,755	1,273,278	474,400	486,300
Number of Tourists	4,143,955	5,020,275	6,723,150	8,840,063	472,900	812,500
Earnings from Tourism (US million dollar)	1,071	1,720	6,954	13,056	5,385	10,887
GRDP (US million doll)	4,226	6,934	36,959	54,863	14,010	17,890
GRDP per Capita at Current Prices ($US)	8,069	12,394	30,703	43,088	29,532	36,788

GRDP: Gross Regional Domestic Product

The following are found to be significant from Table 1. Tasmania is the biggest island with about 37 times and 3 times than Jeju and Hawaii, respectively. However, Hawaii has the largest population with about 2.3 times than Jeju in 1996 and 2005, and with 2.5 and 2.6 times than Tasmania in 1996 and 2005 respectively. Jeju is most densely populated, showing population density of 284 and 303 in 1996 and 2005, respectively, and followed by Hawaii (43 in 1996 and 45 in 2005) and Tasmania (7 in both 1996 and 2005.

Hawaii gained the largest number of tourist in both 1996 and 2005, and followed by Jeju and Tasmania. The number of tourists increased by about four millions in Hawaii for ten years from 1996 to 2005, while the increase was about 900,000 and 400,000 in Jeju and Tasmania, respectively. In terms of the earnings from tourism in 1996, Hawaii earned seven and two times more than Jeju and Tasmania, respectively. Tasmania earned five times more than Jeju. In 2005, Hawaii earned eight and two times more than Jeju and Tasmania, respectively. Tasmania earned six times more than Jeju.

GRDP per capita in 1996 was $30,703 for Hawaii, $29,532 for Tasmania, and $8,069 for Jeju. In 2005, it was $43,088 for Hawaii, $36,788 for Tasmania, and $12,394 for Jeju. The ratio of earnings from tourism to GRDP in 1996 is estimated as 25.3% for Jeju, 18.8% for Hawaii, and 38.4% for Tasmania. In 2005, the ratio changed to 24.8% for Jeju, 23.8% for Hawaii, and 60.9% for Tasmania. This would mean that even though the three islands are characterized as a tourism destination, the socio-economic profile of tourism is determined relatively strongest in Tasmania, and followed by Jeju and Hawaii with a slight difference.

It is a generalized thesis that such a transformation to a higher industrial society is achieved by sacrificing the environment. Therefore, it is significant to analyze empirically whether such differences exampled in Table 1 are significant factors determining difference in the structure and change in sustainable development or not in the three islands. In particular, the significance lies in finding what different factors contribute positively or negatively to the achievement of sustainable development in the three islands.

Ⅲ. Selection of Sustainable Development Indicators

The conceptual components, which are derived from the concept of sustainable development, are theoretical, therefore, empirical ones representing their theoretical meanings should be derived for identifying the structure of sustainable development. They are then the indicators of sustainable development. There are debates on what the indicators should be (for details, see SCOPE, 1997: 13). In general, however, an indicator has the following three dimensions (Jeong, 2002: 285-286). First, it is a proxy measure of a reality. Second, it is sometimes used as a variable. Third, an indicator is used as a concrete and empirical measure representing an abstract concept.

Such indicators are constructed using information that is readily available, or can be obtained at a reasonable cost. Therefore, indicators are unavoidably biased at least in two senses (SCOPE, 1997: 13): the availability of information is much greater in industrialized countries than in developing countries, and environmental factors are under-represented in the information routinely collected and reported. We therefore need to examine the ways in which the indicators should be selected for measuring how successfully sustainable development is being achieved. The indicators are called sustainability indicators or sustainable development indicators as identified bel

ow (hereafter called sustainable development indicators: SDI).

Environmental indicators (EI) had been developed before the development of SDIs was attempted. EI expresses (change in) the amounts/levels of emissions, discharges, deposition, intervention, and so on in a predetermined region. Thus, EI can be defined as quantitative descriptors of changes in either (anthropogenic) environmental pressure or in the state of the environment. The examples of EI include the work done by WHO (1992), Adriaanse (1993), and OECD (1994).

However, SDI is conceptually different from EI (Opschoor & Reijnders, 1991). SDI is not simply an indicator of the actual state but rather an indicator of states vis-à-vis some reference, but can either be some past environmental state, or a future one that is regarded as more desirable than the present. SDI is, thus, more than a mere descriptor 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).

As is identified from a lot of literatures on the concept of sustainable development, sustainable development began to focus on the impact of economic development on the natural environment, and was extended to broader and more integrative areas including other socio-cultural factors determining the sustainability of economic development and the natural environment. There were some works on the development of SDIs in order to replenish the shortcomings inherent in environmental indicators (e.g. Bratt, 1991).

The work on the development of SDIs has been promoted since UNCSD (United Nations Committee on Sustainable Development) was established in 1992. In accordance with this, three levels of SDIs began to be developed.[1] One is for applying them to local region in a country (e.g. Sustainable Seattle, 1995; LGMBUK, 1995). Another is for applying them to a whole country (e.g. DEUK, 1996; EU, 1997; USIWGSDI, 1998; Eckersley, 1998: 299-327; EUROSTAT, 2001). The other is for applying them to the global level (e.g. UNCSD, 1996; SOEC, 1997; SCOPE, 1997; UNDPCSD, 1997; World Bank, 1997; OECD, 1998; EEA, 1999; Bell and Mores, 1999). Most SDIs are identical, but some are different by the organizations and/or scholars cited above. However, the following are found to be significant from their list of SDIs (Jeong, 2003).

(1) SDIs are selected from those representing the conceptual components of sustainable development. This means that different SDIs can be selected according to how one defines and/or emphasizes the concept of sustainable development. (2) SDIs are selected on the basis of a hierarchal framework such as conceptual dimensions of sustainable development — categories of each dimension — individual SDIs belonging to each dimension. (3) SDIs are those that can be expressed quantitatively. This is because qualitative descriptors can't provide us with the information on how successfully sustainable development is being achieved. (4)

1. This was adapted from my paper (Jeong, 2008).

SDIs should not be redundant. The problem of redundancy arises most often when indicators contain any sub-classes of other indicators, or when indicators with the same or almost the same denominators and numerators from different but actually closely related classifications are selected. (5) In particular, in case of comparative analysis, an identical set of SDIs, in which corresponding indicators have the same meaning and classification over two points in time and between areal units, should be selected. Furthermore, satisfactory SDIs should be comparable and applicable to the regions of different size and type. (6) Although there is still no consensus on how many SDIs should be constructed and what they should cover, different SDIs would be appropriate for different purposes. For example, the issues of sustainable development will vary from country to country, and so the selection of SDIs can also be expected to vary.

With such implications, an identical set of 33 SDIs was available in the three islands. Their ten-year time-series data from 1996 to 2005 were collected from Statistical Yearbooks published by the governments of the three islands (see Table 2).

Table 2. Sustainable Development Indicators Selected for Analysis

Category	Indicators
Economy in General	01. GRDP ($US) – Gross Regional Domestic Product 02. Consumer Prices Index (when fixed at 100.0 in 1996) 03. Unemployment Rate (%)
Tourism	04. Number of Tourists 05. Earning from Tourism ($US)
Environment	06. SO_2 in Air (ppm) 07. CO in Air (ppm) 08. NO_2 in Air (ppm) 09. O_3in Air (ppm) 10. Emission of CO_2 (ton/year) 11. DO in Ocean (mg/liter) 12. TN in Ocean (mg/liter) 13. TP in Ocean (mg/liter) 14. DO in Water (mg/liter)
Generation of Wastes	15. Reuse Rate of General Wastes (%) 16. Generation of Sewages (ton/day)
Land-Use	17. Factory Area among Total Area (%) 18. Residential Area among Total Area (%) 19. Forest Area among Total Area (%) 20. Park Area among Total Area (%)
Population	21. Total Number of Population 22. Population Increase (%)
Living Condition	23. Sewerage Supply Household among All Households (%) 24. Tap-Water Supply Household among All Households (%) 25. Households Having Own Housing among All Households (%)
Water Consumption	26. Water Consumption per Person (liter/day) 27. Tap-Water Leakage from the Reservoir to End-User (%)
Energy-Use	28. Supply of Fossil Energy (kilo liter/year) 29. Supply of Gas (m3/year) 30. Supply of Clean Energy (ton/year) 31. Energy Consumption per Person (TOE/year)
Transportation	32. Number of Cars Registrated 33. Road Density (length of total road is divided by total area)

It is, of course, true that those representing both its conceptual components and activities for sustainable development being done by government, business corporations, citizens' environmental behavior can be selected as SDIs. However, their data were not available in the condition of an identical ten-year time-series one in the three islands.

Additional necessary note is that the selected SDIs are in a mutual relationship in that as explained earlier, the components of sustainable development do not exist independently, rather but exist in a mechanism impacting their existence each other. For example, the higher the GRDP will be, the higher the environmental pollution will be. This means that the possibility of high correlation among some SDIs is the reality itself of sustainable development. In this sense, their possibility of high correlation is beyond the methodological problem in the analysis of the structure and change in sustainable development this paper attempts.

Ⅳ. Structure of Sustainable Development[2.]

1. Explanatory Power of Sustainable Development Indicators

Sustainable development as a reality is composed of many factors. The selected SDIs do not cover all factors, but are partial. This means that the selected SDIs can't explain a 100% of sustainable development in terms of its state being determined. Therefore, we have to measure how much the selected SDIs explain sustainable development as a whole. This is termed explanatory power.

The explanatory power can be measured by the percent total variance estimated from factor analytic technique (Jeong, 2003).

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2. The method for analyzing the structure of sustainable development was adapted from my paper (Jeong, 2008).

Principal components method was applied to the 33 SDIs. This is because the method extracts communality on the basis of an assumption that the variance of each SDI is loaded on the common factors without considering error variance and specific variance.

The percent total variance of the 33 SDIs was estimated as 59.3% in Jeju, 73.2% in Tasmania, and 63.2% in Hawaii. This means that the 33 SDIs explain 59.3% as the determinants of sustainable development in Jeju, 73.2% in Tasmania, and 63.2% in Hawaii. 40.7%, 26.8%, and 36.8% in the three islands is determined by the factors other than the 33 SDIs.

Thus, it is maintained that the sustainable development of Tasmania is determined highest by the 33 SDIs, and followed by Hawaii and Jeju.

2. The Relative Importance of Sustainable Development Indicators

The selected SDIs are the composite factors of sustainable development as a reality. However, they may have different impacts on the determination of sustainable development. The difference is termed their relative importance. The relative importance was analyzed in terms of two aspects - the 33 individual SDIs and ten categories in Table 2.

The relative importance can be measured by the value of communality estimated from factor analytic technique (Jeong, 2003). This is based on the logic that the factor with higher eigenvalue determines a reality as a whole. The positive and/or negative direction of each SDI and category in determining sustainable development also can be identified from the positive and/or negative sign of factor loading when number of factor is fixed at one. The reason for fixing number of factor as one is that this paper is not for identifying the factor structure of the 33 SDIs.

(1) The Relative Importance by Individual SDI: As the first stage, the 33 SDIs were analyzed by principal components method in order to identify their relative importance in determining sustainable development during the past ten years from 1996 to 2005. The result was classified into six categories as Table 3. The categorization was based on the value of communality and positive/negative direction of factor loading.

Table 3. Classification of Individual SDIs by Relative Importance

Factor Loading / Communality	Positively Loaded (plus sign)	Negatively Loaded (minus sign)
Higher than 0.800	Category 1	Category 4
Between 0.500 and 0.799	Category 2	Category 5
Lower than 0.499	Category 3	Category 6

Note: Like correlation coefficient, the value of communality was categorized into three levels, using an arbitrary criterion.

Categories 1 and 4 in Table 3 may be cited as the relatively important factors determining sustainable development, Categories 2 and 5 as relatively more or less important ones. However, Categories 3 and 6 may be cited as relatively not significant factors determining sustainable development. Table 4 is the list of SDIs belonging to Categories 1 and 4.

Table 4. SDIs Contributing Highly to Sustainable Development

SDI \ Island	Jeju		Tasmania		Hawaii	
Positive Contribution	01 (0.939) 04 (0.808) 05 (0.906) **15 (0.967)** 19 (0.838)	20 (0.939) 23 (0.866) 25 (0.916) 30 (0.949)	01 (0.992) 04 (0.980) 05 (0.954) **15 (0.994)** 19 (0.990)	20 (0.872) 23 (0.929) 30 (0.961)	01 (0.962) 05 (0.896) 15 (0.932) 19 (0.896) 20 (0.833)	**23 (0.965)** 25 (0.917) 30 (0.916)
Negative Contribution	**10 (0.925)** 17 (0.811) 22 (0.802)	28 (0.825) 33 (0.889)	03 (0.965) 07 (0.816) 10 (0.941)	**26 (0.981)** 31 (0.975) 33 (0.982)	03 (0.908) 06 (0.891) **10 (0.987)**	27 (0.827) 28 (0.908)

Note: The number before parenthesis is the name of SDI listed in Table 2, and the number in parenthesis is communality of each SDI.

The following are found from Table 4. For Jeju, nine SDIs are identified as the factors having determined significantly sustainable development during the past ten years from 1996 to 2005. The factor having contributed highest is Reuse Rate of General Wastes, and followed by Supply of Clean Energy, GRDP, Park Area, Households Owing Own Housing, Earning from Tourism, Sewerage Supply Household, Forest Area, and Number of Tourists. Meanwhile, five SDIs are identified as the factors having impeded significantly sustainable development. The factor having impeding highest is Emission of CO_2, and followed by Road Density, Supply of Fossil Energy, Factory Area, and Population Increase.

For Tasmania, eight SDIs are identified as the factors having determined significantly sustainable development. The factor having contributed highest is Forest Area, and followed by Reuse Rate of General Wastes, GRDP, Number of Tourists, Supply of Clean Energy, Earning from Tourism, Sewerage Supply Household, and Park Area. In contrast, six SDIs are identified as the factors having impeded significantly sustainable development. The factor having impeding highest is Road Density, and followed by Water Consumption, Energy Consumption per Person, Unemployment Rate, Emission of CO_2, and CO in Air.

For Hawaii, eight SDIs are identified as the factors having determined significantly sustainable development. The factor having contributed highest is Sewerage Supply Household, and followed by GRDP, Reuse Rate of General Wastes, Households Owing Own Housing, Supply of Clean Energy, Earning from Tourism, Forest Area, and Park Area. Meanwhile, five SDIs are identified as the factors having impeded significantly sustainable development. The factor having impeding highest is Emission of CO_2 and followed by Unemployment Rate, Supply of Fossil Energy, SO_2 in Air, and Factory Area.

In sum, the following are found as common characteristics in the three islands. Firstly, the contributing factors to sustainable development are almost the same ones. Secondly, the factors related to economic development and/or those resulted from them contribute to sustainable development. The examples include GRDP, Tourism, Sewerage Supply Household, and Households Having Own Housing. Thirdly, *a priori* and/or *expost facto* policies contribute to sustainable development. The examples include Reuse Rate of General Wastes and Supply of Clean Energy. Fourthly, the conservation of nature such as Forest Area and Park Area contributes to sustainable development.

Meanwhile, unlike contributing factors, impeding factors of sustainable development except Emission of CO_2 are quite different among the three islands. For Jeju, the infrastructures are the main impeding factors such as Factory Area, Supply of Fossil Energy, and Road Density. In contrast, for Tasmania, the impeding factors are dispersed Economic Area (Unemployment Rate), polluted environment (CO in Air), high consumption of resource (Water Consumption, Energy-Use), and infrastructure (Road Density). Hawaii shows a very close to Tasmania in terms of the impeding factors to sustainable development. In particular, the fact that most SDIs of environmental pollution are not significant factors impeding sustainable development in the three islands may imply that the environmental pollutions are not so much serious as impeding sustainable development.

(2) The Relative Importance by Category: As is shown in Table 2, the 33 SDIs are composed of ten categories. In order to analyze the relative importance by category, the values of the SDIs belonging to each category should be added up. However, the measure unit of each SDI is different. Therefore, the original value of each SDI was transformed to standard score, and then the standard score of each SDI was added up by category. This means that the ten categories are the composite factors determining sustainable development.

As is identified in Table 2, some SDIs were measured in the way that the higher the value of SDI, the more the SDI contribute to sustainable development, and others in the way that the lower the value of SDI, the less the SDI contribute to sustainable development. Therefore, the plus and minus value of the standard score of nine SDIs were reversed when the standard scores of composite factors were added up. This was because the SDI belonging to the same category should be measured in the same arrangement of positive or negative way. The nine SDIs were Unemployment Rate, Reuse Rate of General Wastes, Factory Area, Residential Area, Population Increase, Supply of Gas, Supply of Clean Energy, Number of Cars, and Road Density. Then, the operation will result in that the higher the value of the category, the more the category contributes to sustainable development or vis-à-vis. The former includes Economy in General, Tourism, and Living Condition, while the latter includes Environment, Generation of Wastes, Land-Use, Population, Water Consumption, Energy-Use, and Transportation.

The communality and its direction of the ten categories were identified as Table 5 when principal components method was applied.

Table 5. Contribution to Sustainable Development by Category

Category \ Island	Jeju	Tasmania	Hawaii
Economy in General	0.907	0.982	0.964
Tourism	0.935	0.965	0.925
Environment	-0.629	-0.817	-0.936
Generation of Wastes	-0.872	-0.468	-0.665
Land-Use	-0.737	-0.085	0.025
Population	0.147	-0.195	0.122
Living Condition	0.892	0.958	0.853
Water Consumption	0.023	0.332	-0.763
Energy-Use	-0.966	0.199	0.855
Transportation	-0.944	-0.946	-0.980

Firstly, the following are found to be significant from Table 5. For Jeju, Tourism contributes highest to sustainable development, and followed by Economy in General and Living Condition that might result from the development of Tourism and Economy in General. However, Energy-Use is the strongest factor impeding sustainable development, and followed by Transportation, Generation of Wastes, Land-Use, and Environment. For Tasmania, like Jeju, Tourism contributes highest to sustainable development, and followed by Economy in General and Living Condition that, like Jeju, might result from the development of Tourism and Economy in General. However, Transportation is the strongest factor impeding sustainable development, and followed by Environment and Generation of Wastes. For Hawaii, unlike Jeju and Tasmania, Economy in General contributes highest to sustainable development, and followed by Tourism, Energy-Use and Living Condition. Like Tasmania, Transportation is the strongest factor impeding sustainable development, and followed by Environment, Water Consumption and Generation of Wastes.

Secondly, the following are found from Table 5 on a comparative basis. Three categories have contributed to sustainable development during the past ten years from 1996 to 2005 in the three islands. They are Economy in General, Tourism, and Living Condition. The contribution of Economy in General and Living Condition to sustainable development is highest in Tasmania, and followed by Hawaii and Jeju. However, the contribution of Tourism is highest in Tasmania, and followed by Jeju and Hawaii.

Meanwhile, Environment, Generation of Wastes, and Transportation have impeded sustainable development in the three islands. Environment and Transportation impede Hawaii highest, and followed by Tasmania and Jeju. However, Generation of Wastes impedes Jeju highest, and followed by Hawaii and Tasmania.

Land-Use is an impeding factor of sustainable development in Jeju. However, even though Land-Use is an impeding and contributing factor in Tasmania and Hawaii, respectively, its impact on sustainable development is not significant. Population measured by total number and increase ratio is not a significant determination impacting on sustainable development in the three islands. Water Consumption is a significant factor impeding sustainable development of Hawaii, but not significant factor in Jeju and Tasmania. Energy-Use is a significant factor impacting on sustainable development of Jeju and Hawaii, for Jeju in a way of impediment and for Hawaii in environmentally friendly way. However, Energy-Use in Tasmania is not a significant factor determining sustainable development.

Ⅴ. Change in Sustainable Development[3.]

1. Analytic Method

The structure of sustainable development changes as time goes. In the 1970s, a lot of human ecologists employed two different analytic framework in their empirical analyses of ecological structure and change in the spatial patterning of human activities resulted from their interaction with environment. One was change in ecological structure, and the other was the structure of ecological change (e.g. Hunter, 1971; Latif, 1974; Janson, 1978). These two dimensions of change can be applied to the analysis of change in sustainable development over time.

The analysis of the change may be examined in terms of two ways as human ecologists have done in the 1970s (Jeong, 2003). One is a comparison between the two structures of sustainable development after separate analyses have been undertaken at two different points in time. The other is to derive a pattern of change, using a new set of SDIs created from the value of change in each corresponding SDIs between two points in time. The former is a cross-sectional analysis and is defined as 'change in the structure of sustainable development', while the latter is a longitudinal analysis and is defined as 'the structure of change in sustainable development'.

However, this paper employed a new analytic method termed 'change in the relative position of structural components' (Jeong, 2007). It is assumed that the ten categories have been different in the level of sustainability throughout the ten years from 1996 to 2005, and their differences will be changed over time. This is termed 'change in the relative position of structural components'

3. The method for analyzing the change in sustainable development was adapted from my paper (Jeong, 2008).

when their differences in the level of sustainability is compared over time. The technique of estimating this changing process of sustainability derives from a relative deviation index (Jeong, 1997: 375-376).

Relative deviation index (hereafter called RDI) is a statistical measure defined by the changing deviation of each structural component from total values of all structural components as a base criterion. To note the historically changing process of sustainability, the RDI of each structural 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 structural component in terms of its sustainability level.

The value of RDI ranged from -1.000 to infinity. 0.000 reflects no deviation from the base criterion measured by total values of all dimensions. Thus, the category whose RDI is 0.000 is interpreted as to be in medium in sustainability level in a given year, comparing other categories. The category whose value is minus and/or plus reflects relatively lower and/or higher level of sustainability compared with other categories.

2. Change in the Relative Position of Structural Component of Sustainable Development

The 33 SDIs can be used as the structural components in the analysis of change. But this paper used the ten categories listed in Table 2 as the units of change. This is because the 33 SDIs explain the change in detail, but they are weak in catching up the outline of change in sustainable development as a whole reality. The RDIs of the ten categories were estimated as Table 6, using their standard score explained in the relative importance by category in the previous section.

The RDIs in Table 6 as the changing process of the relative degree of sustainability by component can be presented by a graph of each island, which enables us to visualize the changing processes. However, this paper omitted the graphic presentation on account of limited space.

Table 6. **The Relative Deviation Index (RDI) of Sustainable Development Categories**

Category	Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average
1	A	-0.156	-0.154	-0.448	-0.466	-0.102	0.079	0.327	0.234	0.293	0.291	-0.010
	B	-0.444	-0.393	-0.405	-0.245	-0.039	-0.046	0.183	0.286	0.381	0.374	-0.035
	C	-0.360	-0.357	-0.343	-0.200	-0.015	0.021	0.037	0.174	0.385	0.430	-0.023
2	A	-0.181	-0.187	-0.535	-0.347	0.131	0.042	0.245	0.206	0.291	0.263	-0.007
	B	-0.155	-0.198	-0.136	-0.158	-0.172	-0.136	0.202	0.220	0.175	0.191	-0.017
	C	-0.459	0.105	0.020	0.042	0.110	-0.148	-0.083	-0.060	0.119	0.262	-0.002
3	A	-0.145	-0.482	0.293	0.015	-0.945	0.125	-0.768	0.318	1.049	0.933	0.039
	B	-1.000	-0.130	0.127	-0.065	-0.498	0.195	-0.354	0.037	0.562	0.607	-0.052
	C	-1.000	-0.340	-0.354	-0.509	-0.295	0.114	0.252	0.757	0.254	0.706	-0.042
4	A	0.458	0.255	0.350	0.082	0.050	-0.104	0.242	-0.254	-0.564	-0.392	0.012
	B	0.477	0.231	-0.021	-0.024	0.048	0.153	-0.113	-0.245	-0.104	-0.177	0.023
	C	1.618	0.407	0.321	0.208	0.188	0.109	0.120	-0.553	-0.378	-0.620	0.142
5	A	-0.291	0.144	0.188	0.169	0.216	0.062	0.099	-0.053	0.029	-0.530	0.003
	B	0.308	0.038	0.507	0.114	0.056	0.002	0.056	-0.045	-0.159	-0.270	0.061
	C	0.107	0.088	0.100	0.081	0.169	-0.173	-0.230	-0.009	-0.046	-0.095	-0.001
6	C	-0.306	-0.331	-0.406	-0.094	-0.057	-0.008	0.174	0.013	0.202	0.283	-0.053
	B	0.398	0.259	0.102	0.028	0.044	-0.078	-0.146	-0.217	-0.159	-0.037	0.019
	C	0.006	-0.037	0.103	0.250	0.061	-0.081	-0.122	-0.061	-0.045	-0.031	0.004
7	A	-0.525	-0.519	-0.170	-0.008	-0.050	-0.057	0.064	-0.082	0.428	0.271	-0.065
	B	-0.664	-0.391	0.008	-0.176	0.033	-0.089	0.162	0.351	0.144	0.396	-0.023
	C	-0.398	-0.415	-0.262	-0.116	-0.189	0.093	0.141	0.245	0.388	0.296	-0.022
8	A	0.337	0.254	-0.042	-0.167	-0.134	-0.182	-0.120	-0.241	-0.002	0.088	-0.021
	B	0.171	-0.034	0.004	0.187	0.185	0.027	-0.001	-0.055	-0.170	-0.148	0.017
	C	0.431	0.021	0.066	0.148	0.032	0.096	-0.114	-0.011	-0.238	-0.278	0.015
9	A	0.598	0.653	0.270	0.445	0.502	-0.078	-0.087	-0.213	-0.631	-0.754	0.071
	B	0.182	0.092	0.022	0.121	0.171	-0.001	0.040	-0.075	-0.253	-0.143	0.016
	C	0.042	-0.140	-0.132	-0.220	-0.168	-0.071	0.052	0.154	0.162	0.228	-0.009
10	A	0.475	0.276	0.340	0.306	0.358	0.075	-0.253	-0.356	-0.427	-0.492	0.030
	B	0.736	0.535	0.229	0.226	0.181	-0.020	-0.021	-0.250	-0.411	-0.650	0.056
	C	0.640	0.402	0.278	0.187	-0.001	-0.039	-0.145	-0.245	-0.332	-0.466	0.030

Note 1: 1; Economy in General 5; Land-Use 9; Energy-Use
2; Tourism 6; Population 10; Transportation
3; Environment 7; Living Condition
4; Generation of Wastes 8; Water Consumption

Note 2: A; Jeju, B; Tasmania, C: Hawaii

Table 6's RDI data can be examined in two aspects. One is the comparison among the ten categories as the structural components of sustainable development by year, and the other is the comparison of each category by year.

(1) Jeju: Firstly, the category that was ranked as the relative highest sustainability has changed from 1996 to 2005. For example, in 1996 the highest level of sustainability was environmentally friendly Energy-Use, and followed by Generation of Wastes, Transportation and Water Consumption. The lowest level of sustainability was Living Condition, and followed by Population, Land-Use, Tourism, Economy in General, and Environment. Their relative positions changed throughout the following years.

Secondly, the change in the relative position of each category by year explores that Economy in General and Tourism were in a lower sustainability until 2000, and turned to a high sustainability from 2001. Reviewing the comparison of each category in this way, the following are found to be significant trends. Clean Environment was a leading category for Jeju being sustainable since 2003. Generation of Wastes was treated to be environmentally friendly until 2000, but was not so since 2001 except 2002. Land-Use was in higher sustainability until 2002, but was not so since 2003. Population was in lower sustainability until 2001 in terms of total number and increase ratio, but turned to be higher sustainable since 2002. Living Condition enjoyed a higher sustainability in 2004 and 2005. Water Consumption was in a higher sustainable in 1996, 1997, and 2005. Energy-Use enjoyed a higher sustainable until 2002. Transportation was in a higher sustainability until 2001.

Thirdly, based on the average score of each category throughout the ten year that enables us to catch up the whole outline of the change in the relative position, it is found that Clean Environment has been the most contributing factor to sustainable development, and followed by environmentally friendly Energy-Use, Transportation, Generation of Wastes, and Land-Use. Meanwhile, Living Condition has been the most impeding factor of sustainable development, and followed by non-optimal Population and Water Consumption, and development of Economy in General and Tourism.

(2) Tasmania: Firstly, like Jeju, the category that was ranked as the relative highest sustainability has changed from 1996 to 2005. For example, in 1996 the highest level of sustainability was environmentally friendly Transportation, and followed by environmentally friendly Generation of Wastes, optimal Population in terms of total number and increase ratio, environmentally friendly Land-Use, Energy-Use, and Water Consumption. The lowest level of sustainability was polluted Environment, and followed by Living Condition, Economy in General, and Tourism. Their relative positions changed throughout the following years.

Secondly, the change in the relative position of each category by year explores that Economy in General and Tourism were in a lower sustainability until 2001, and turned to a high sustainability from 2002. Clean Environment was a leading category for Tasmania being sustainable since 2001 except 2002. Generation of Wastes was treated to be environmentally friendly in 1996, 1997, 2000, and 2001, but was not so in the remaining years. Land-Use was in higher sustainability until 2002, but was not so since 2003. Population was in lower sustainability until 2000 in terms of total number and increase ratio, but turned to be higher unsustainable since 2001. Living Condition enjoyed a higher sustainability since 2002. Water Consumption was in a higher sustainable until 2001 except in 1997, and to be unsustainable since 2002. Energy-Use and Transportation enjoyed a higher sustainable until 2000.

Thirdly, based on the average score, it is found that environmentally friendly Land-Use has been the most contributing factor to sustainable development, and followed by environmentally friendly Transportation and Generation of Wastes, optimal Population in terms of total number and increase ratio, Water Consumption, environmentally friendly Energy-Use. Meanwhile, polluted Environment has been the most impeding factor of sustainable development, and followed by development of Economy in General, Living Condition, and development of Tourism.

(3) Hawaii: Firstly, like Jeju and Tasmania, the category that was ranked as the relative highest sustainability has changed from 1996 to 2005. For example, in 1996 the highest level of sustainability was environmentally friendly Generation of Wastes, and followed by environmentally friendly Transportation, Water Consumption, Land-Use, Energy-Use, and optimal Population in terms of total number and increase ratio. The lowest level of sustainability was the polluted Environment, and followed by development of Tourism, Living Condition, and development of Economy in General.

Secondly, the change in the relative position of each category by year explores that Economy in General, Environment, and Energy-Use showed a trend to be in a lower sustainability until 2001, and turned to a high sustainability from 2001. Tourism was in a higher sustainability throughout the ten years except 1996, 2001, and 2003. Generation of Wastes, Population in terms of total number and increase ratio, and Water Consumption showed a trend to be in a higher sustainability until 2002, and turned to a lower sustainability from 2003. Land-Use was in a higher sustainability until 2000, and turned to a lower sustainability from 2001. Living Condition was unsustainable until 2000, and turned to be sustainable from 2001. Transportation was in a higher sustainability until 1999, but turned to a lower sustainability from 2000.

Thirdly, based on the average score, it is found that environmentally friendly Generation of Wastes has been the most contributing factor to sustainable development, and followed by environmentally friendly Transportation and Water Consumption, and optimal Population in terms of total number and increase ratio. Meanwhile, polluted Environment has been the most impeding factor of sustainable development, and followed by development of Economy in General, Living Condition, Energy-Use, development of Tourism, and non-environmentally friendly Land-Use.

(4) Overall Comparison among the Three Islands: Table 6 enables us to compare the three islands in terms of many aspects. However, when the comparison is done in terms of the average score which outlines the overall outlook resulted from the change in the relative position of each category throughout the ten years, the following are found to be significant.

Firstly, the development of Economy in General, the development of Tourism, and Living Condition have impeded sustainability in the three islands. The impeding impact of the development of Economy in General was highest in Tasmania, and followed by Hawaii and Jeju. The impeding impact of the development of Tourism was highest in Tasmania, and followed by Jeju and Hawaii. The impeding impact of Living Condition was highest in Jeju, and followed by Tasmania and Hawaii.

Secondly, the common categories contributing to sustainability in the three islands are environmentally friendly Generation of Wastes and Transportation. The other common categories contributing sustainability are Environmentally friendly Land-Use and Energy-Use in Jeju and Tasmania, and environmentally friendly Water Consumption and optimal Population in terms of total number and increase ratio in Tasmania and Hawaii.

Thirdly, the common categories impeding sustainability in the three islands are the development of Economy in General, the development of Tourism, and Living Condition. The other common categories impeding sustainability are polluted Environment in Tasmania and Hawaii.

Ⅵ. Concluding Remarks

The objective of this paper was to compare sustainable development and change among Jeju, Tasmania, and Hawaii, using a set of 33 identical ten-year time series SDIs from 1996 to 2005. The 33 SDIs were grouped into ten categories as composite variables. The comparison was done in terms of the structure and change in sustainable development as an integrated reality.

The structure of sustainable development was compared in terms of the explanatory power of the 33 SDIs on sustainable development as a whole reality and their relative importance as the determinants of sustainable development. The relative importance was compared in terms of both individual SDIs and their categories.

The change in sustainable development was compared by category in terms of the process sustainable development throughout the ten years, using their change in the position of sustainability on the basis of their relative deviation index.

The explanatory power of the 33 SDIs was highest in Tasmania (73.2%), and followed by Hawaii (63.2%), and Jeju (59.3%). The relative importance of individual SDIs and their categories as the determinants of sustainable development was different among the three islands. However, overall, it was found that the factors related to economic development and/or those resulted from them, *a priori* and/or *expost facto* policies, and the conservation of nature contribute to sustainable development. Meanwhile, emission of CO_2 was the strongest factor impeding sustainable development in the three islands. However, unlike the factors contributing to sustainable development, the other impeding factors were different among the three islands.

The sustainability level of the ten categories has changed significantly throughout the ten years from 1996 to 2005 in the three islands. However, the following were found as similar characteristics in the three islands. The development of Economy in General and Tourism has impeded sustainability. Environmentally friendly Generation of Wastes and Transportation have contributed to sustainability. The other categories were different in contributing to and/or impeding sustainability in the three islands.

In conclusion, firstly; it was found that there are both similar and different structural profiles and changing processes in sustainable development among the three islands. These findings arise another research questions on what factors arise such similarities and differences. They may be the similar and/or different activities in the three islands such as the developmental and environmental policies launched by state government, the level of green management by business corporations, active and/or passive environmental movement by NGOs, and the level of environmentally friendly behavior by citizens in their everyday life. Thus, the investigation on the factors arising the similarities and differences among the three islands is another further research area.

Secondly; the ten-year time series data used in this research represents the experience of the three islands over that time. Therefore, if the experience was different, the result is to likely differ, which will lead to different findings. To determine the structure and change in sustainable development, assumption would have to take into account a long list of more parameters. The results cited in this paper are based on a limited number of parameters in terms of SDI and time-series as well.

Thirdly; the methods for analyzing the structure and change in sustainable development has been partially developed in this paper. Further development of this model will prove useful for policy formation and management for sustainable development. However, the methods in this paper allow us to monitor, to evaluate, and to strategize what is most beneficial in real time toward achieving sustainable development. It is of course true that if different methods are applied, different results are drawn.

Fourthly; the reasons why the three islands are similar and/or different in the structure and change in sustainable development should be another further research topic. The reasons may be investigated in terms of a wide range of factors such as local government policy of sustainable development, environmental movement, environmental education, and citizens' environmental behavior in everyday life, etc. In particular, considering the reality that island is in an intensive interaction with main land, the difference in the interaction should be also a significant factor (e.g. Wallner et al, 1996).

Fifthly; then, the structure and change in sustainable development in island may be generalized in dialectic logic as following. Even though human activities (thesis) are still contininuing to exploit nature (anti-thesis) for improving material affluence and convenience (thesis), many institutional efforts have been launched to reduce this destruction of ecosystem (ecolgocial synthesis). In academic areas, a lot of green social theories that advocate a dialectic logic have also emerged such as risk society theory, deep ecology, social ecology, new environmental paradigm, and environmentalism.

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