Journal of Environmental Science International
25(10); 1381~1387; October 2016

pISSN: 1225-4517 eISSN: 2287-3503
http://dx.doi.org/10.5322/JESI.2016.25.10.1381

ORIGINAL ARTICLE

Appilication of a Green City Index as a Green Space Planning Index for the Low-Carbon Green City of Gangneung-si

Su-Hyun Cho, Hyun-Ju Jo[1)*]

Department of Future City, Gangneung City, Gangneung 25522, Korea
[1)]East Coast Life Sciences Institute, Gangneung-Wonju National University, Gangneung 25457, Korea

Abstract

This study aims to establish baseline data for sustainable monitoring by applying the green city index (GCI), which is set up to evaluate the city level, to the city of Gangneung-si, which was designated as a pilot city for the Low-carbon Green Growth City project by the Ministry of Land, Infrastructure, and Transportation. The GCI was applied in the framework of European systems, while considering the social and economic status of Korea. Indicators from 7 areas—CO_2, energy, building, transportation, water, waste, and quality of atmosphere were analyzed, except for qualitative indicators. Results indicate that total CO_2 emissions were 30.8 tons per capita, or 2.2 tons per one million units of real GDP. The total final energy consumption was 0.231 TOE/capita, or 0.317 TOE per one million units of real GDP. The percentage of total energy derived from renewable resources was 0.41% and energy consumption by the building was 433.5 Mwh/1,000 ㎡. The total percentage of the working population travelling to work daily by public transportation (limited to bus) was 19%. Further, the total annual water consumption was 99 ㎥/capita, and the water lost in the water distribution system was 0.057 ㎥/capita/day. The total annual waste collected was 0.0077 ton per capita, The annual mean emission were 0.014 ppm/day for NO_2, 0.005 ppm/day for SO_2, and 0.019 ppm/day for O_3. The annual mean for PM_{10} emissions was 39 ㎍/㎥/day.

Key words : Green city indicator, GCI, Low-carbon green growth city, Baseline data

1. Introduction

More than 50% of the world's population currently lives in cities. The ICLEI (international council for local environmental initiatives) has estimated that, of the total world population of 9 billion expected by 2050, two-thirds will reside in cities. Rapid urbanization has developed alongside numerous environmental and social concerns. Environmental issues include serious changes to natural ecosystems, such as biodiversity loss and climate change. In response to such concerns, international environmental organizations and national environmental policy institutions have conducted quantitative and qualitative investigations into the conditions of urban ecosystems and developed environmental evaluation indicators that can be applied to help solve these urban environmental issues (Sherbinin et al., 2013). To promote well-being and build a well-equipped, eco-friendly and sustainable society, countries have used the EPI (environmental performance index, which evaluates environmental improvement) and the ESI (environmental sustainability index, which assesses the sustainability of a country based on environmental,

Received 1 September, 2016; **Revised** 14 September, 2016;
Accepted 20 September, 2016
[*]**Corresponding author** : Hyun-Ju Jo, East Coast Life Science Institute, Gangneung-Wonju National University, Gangneung 25457, Korea
Phone : +82-33-640-2639
E-mail : hjjo1011@gmail.com

societal and financial conditions). The Climate Change Performance Index by Germanwatch compares different countries based on their efforts against climate change (Burck et al., 2008). However, the index has limitations because, with its country -level focus, it does not reflect actions at the regional level. For a comprehensive comparison of city units, A.T. Kearney's global cities index (GCI) is often used in Europe because it evaluates cities differently according to each continent's characteristics, rather than applying a blanket approach to all cities in the world (Ko and Kim, 2010). In Asia, 22 metropolitan areas, including Seoul, have implemented the Economist Intelligence Unit's Green City Index; however, small and medium-sized cities could not be included because of a lack of clear and consistent data for evaluation.

In Korea, the "Low Carbon, Green Growth" act took effect in April 2010; studies on an index for Low Carbon, Green Growth cities have since been under way as a key government policy. While previous studies mostly focused on the development and application of an index related to nature conservation, transport, energy, environment, health and environ – mental disasters (Choi, 2011; Lee, 2013; Lee et al., 2011; Lim, 2011; Park and Kim, 2010; You et al., 2005), Lee and Kim have suggested improvements via laws and systems for building green cities. Song et al. (2008) addressed the need for a low-carbon, green city index that also considered quality of life.

The National Institute of Environmental Research (2013) applied the Green City Index to large municipal governments and some small and medium-sized cities to determine their rankings. Previous studies on the Low Carbon, Green Growth index, however, were still lacking research into low-carbon, green competitiveness comparisons between cities (Ko and Kim, 2010).

Adapting the international standard index to domestic conditions also created limitations for comparisons between domestic municipal governments and foreign cities. Because the index is applied to big cities, it is also especially difficult to use on cities of any size. This limitation was identified in Korea after a case study applied the GCI to small and medium-sized cities. Accordingly, it is clear there is a need to construct a standard data method and evaluate it continuously. Thus, this study aims to propose a data frame for all the items needed to apply a GCI system, with the goal of building standard data for monitoring in the future.

2. Study Site and Methods

2.1. Study site

The study site was Gangneung, chosen by the government as a low-carbon, green pilot city. Gangneung has a population of 214,560 people (2015) and a total area of 1,040 km^2. It is located in the center of the Baekdudaegan mountain range, on the eastern side. To the east, Gangneung is bordered by the East Sea of Korea; to the west are Nae-myeon, Hongcheon -gun; Jinbu-myeon; and Daegwonryoung-myeon, Pyeongchang-gun. On the city's southern border are Donghae-shi; Imgye-myeon; and Buk-myeon, Jeongseon -gun. North of Gangneung are Hyeonbuk-myeon and Hyeonnam-myeon. Gangneung is surrounded in total by five cities and the province of Gangwon-do (Fig. 1).

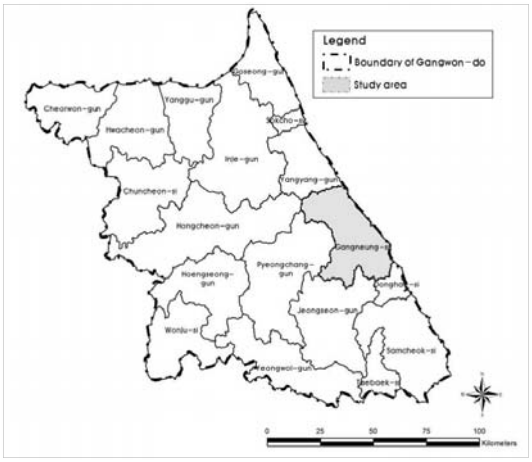

Fig. 1. The location map of the survey sites.

It was designated as the low-carbon, green growth pilot city by the Ministry of Lands, Infrastructure and Transport in 2009.

2.2. Methods

The Green City Index was developed by the Economist Intelligence Unit and is sponsored by Siemens, a multinational corporation. It was created to evaluate the environmental sustainability of cities and provide a means of comparing the performance of different cities (EIU, 2011).

Korea is located in East Asia, so it is appropriate to evaluate it according to the index used for Southeast Asia, which encompasses many developing countries. However, Korea is ranked as a developed country based on its financial and social levels of development. Accordingly, this study has used the European index system, which considers factors such as energy efficiency and reduction of carbon dioxide, and not developing-country hygiene factors such as drinking water quality and septic tank usage.

The present study used the quantitative evaluation indicator to collect base data for Green City Index evaluations. The multiplicatively weighted application was excluded for base data construction. The seven evaluation items included CO_2, energy, building, transportation, water, waste and land utility, and atmosphere quality. Table 1 shows the calculation formula and data sources. Evaluation items for CO_2 included CO_2 emissions per capita and GDP; evaluation items for energy included energy consumption per capita and GDP, and rates of new and renewable energy. For evaluation related to building, house energy was examined. For transport, factors such as alternative forms of transportation and public traffic systems were evaluated. The evaluation of atmosphere quality was based on concentrations of nitrogen dioxide, sulfur dioxide, ozone and PM10. The EIU applied the Green City Index evaluation method taking into consideration data reliability and access, because cities did not always clearly identify their evaluation data according to the same standards used by the EIU.

For data collection, this study used the national statistics portal to access information about the green climate city registration project, as reported by the Korea Environment Corporation in the Gangneung-si statistics annual report and in statistics from the Ministry of Infrastructure and Transport.

3. Results

Based on the data sources described previously, CO_2 emissions for Gangneung were found to total 6,692,461 tons, which equates to per-capita emissions of 30.8 tons based on the population of Gangneung (216,806 people).

Energy consumption for Gangneung totaled 948,600 TOE (ton of oil equivalent), or 0.23 TOE per capita. Energy consumption per GDP was 0.231 TOE/one million won, based on the total consumption of 948,600 TOE and a GRDP of 2,990,426 million won. The ratio of new and renewable energy sources to existing energy sources was 0.41%, based on total energy consumption of 948,600 TOE and new and renewable energy supplies amounting to 3,928 TOE.

Building energy consumption was 433.5 Mwh/ 1,000 m^2, based on total electric power usage of 2,238,004 Mwh and a total building footprint of 5,162 m^2. According to data on Gangneung public bus transportation, the ratio of daily public transportation trips to trips by all other forms of transportation came to 19%.

Water consumption per capita totaled 99 m^2 based on total consumption of 21,810,277 m^2, with an average of 12,514 m^2 of water lost per day, which equates to a per capita loss of 0.057 m^2.

With a total of 1,690 tons of waste collected annual, daily waste removal came to 0.0008 ton per capita. Concentrations of NO_2 emissions for the air pollution

Table 1. Formula and data collection according to the Indicator of GCI

Indicator		Formula	Data	Source
CO_2	Total CO_2 emissions, in tons per capita	Regional CO_2 emissions (ton)/Regional number of population	The volume of CO_2 emission according to the energy resources (Region)	Enrollment Project of Green Climate City
			e-local indicator (Population)	Korean Statistical Information Service
	Total CO_2 emissions, in per unit of real GDP	Regional CO_2 emissions (ton)/Regional GRDP	The volume of CO_2 emission according to the energy resources (Region)	Enrollment Project of Green Climate City
			e-local indicator (GRDP)	Korean Statistical Information Service
Energy	Total final energy consumption, per capita	Regional consumption of energy according to the resources (TOE)/ Regional population	Consumption structure according to the energy resources	Korean Statistical Information Service
			e-local indicator (Population)	Korean Statistical Information Service
	Total final energy consumption, per unit of real GDP	Regional consumption of energy according to the resources (TOE)/ Regional GRDP	Consumption structure according to the energy resources	Korean Statistical Information Service
			e-local indicator (GRDP)	Korean Statistical Information Service
	The percentage of total energy derived from renewable resources	Amounts of regional renewable energy (TOE)/ Supply Amounts of regional energy	Supply of new and renewable energy (Regional output)	Korean Statistical Information Service
			Consumption structure according to the energy resources	Korean Statistical Information Service
Building	Energy consumption of the building	Usage of electric power (Types)(TOE)/ Gross floor area of building	Usage of electric power according to usage types	Statistics annual report
			Status of regional buildings (Gross floor area)	Statistics System of Ministry of Land, Infrastructure and Transport
Transportation	The total percentage of the working population travelling to work on public transport	-	Trip ratio according to the transportation means per day (Share ratio)	Statistics annual report
			Status of subway operation	Korean Statistical Information Service
Water	Total annual water consumption, per capita	Regional amount of water consumption (㎥)/ Regional number of population	Amount of water consumption (Metropolitan city & Province)	Korean Statistical Information Service
			e-local indicator (Population)	Korean Statistical Information Service
	Water lost in the water distribution system	Regional water lost (㎥/day)/ Regional number of population	Status of water lost (Average water lost per day)	Korean Statistical Information Service
			e-local indicator (Population)	Statistics annual report
Waste	Total annual waste collected, per capita	Regional amounts of waste (ton/day)/ Regional number of population	Environment (Removal of waste)	Korean Statistical Information Service
			e-local indicator (Population)	Statistics annual report
Quality of Atmosphere	Annual mean of NO_2 emissions	-	Environment (Air pollution-NO_2)	Statistics annual report
	Annual mean of SO_2 emissions	-	Environment (Air pollution-SO_2)	Korean Statistical Information Service
	Annual mean of O_3 emissions	-	Air pollution of O_3 according to the month and city	Statistics annual report
	Annual mean of PM_{10} emissions	-	Environment (Air pollution-PM10)	Korean Statistical Information Service

Table 2. Integration of results according to the application of GCI to Gangneung

Indicator	Data	Gangneung-si		
		Value of data	Unit	Calculated value
Total CO_2 emissions, in tonnes per capita	The volume of CO_2 emission according to the energy resources (Region)	6,692,461	ton	30.8 ton/capita
	e-local indicator (Population)	216,806	person	
Total CO_2 emissions, in per unit of real GDP	The volume of CO_2 emission according to the energy resources (Region)	6,692,461	ton	2.2 ton/one million won
	e-local indicator (GRDP)	2,990,426	One million won	
Total final energy consumption, per capita	Consumption structure according to the energy resources	948,600	TOE	0.231 TOE/capita
	e-local indicator (Population)	219,274	person	
Total final energy consumption, per unit of real GDP	Consumption structure according to the energy resources	948,600	TOE	0.317 TOE/one million won
	e-local indicator(GRDP)	2,990,426	One million won	
The percentage of total energy derived from renewable resources	Supply of new and renewable energy (Regional output)	3,928	TOE	0.41%
	Consumption structure according to the energy resources	948,600	TOE	
energy consumption of the building	Usage of electric power according to usage types	2,238,004	MWh	433.5 Mwh/1,000 ㎡
	Status of regional buildings (Gross floor area)	5,162	1,000 ㎡	
The total percentage of the working population travelling to work on public transport	Trip ratio according to the transportation means per day (Share ratio)	19	%	19%
	Status of subway operation	-	-	-
Total annual water consumption, per capita	Amount of water consumption (Metropolitan city & Province)	21,819,277	㎥	99 ㎥/person
	e-local indicator(Population)	219,274	person	
Water lost in the water distribution system	Status of water lost (Average water lost per day)	12,514	㎥/day	0.057 ㎥/day/capita
	e-local indicator(Population)	219,274	person	
Total annual waste collected, per capita	Environment (Removal of waste)	1,690	ton/day	0.0077 ton/day/capita
	e-local indicator(Population)	219,274	person	
Annual mean of NO_2 emissions	Environment(Air pollution-NO_2)	0.014	ppm/year	0.014 ppm/year
Annual mean of SO_2 emissions	Environment (Air pollution-SO_2)	0.005	ppm/year	0.005 ppm/year
Annual mean of O_3 emissions	Air pollution of O_3 according to the month and city	0.019	ppm/year	0.019 ppm/year
Annual mean of PM_{10} emissions	Environment (Air pollution-PM_{10})	39	㎍/㎥/year	39 ㎍/㎥/year

index totaled 0.014 ppm/year, while SO_2 concentrations were 0.005 ppm/year, O_3 concentrations were 0.019 ppm/year and concentrations of PM_{10} dust particles were 39 μg/m^2/year.

Using the Green City Index and data from the National Institute of Environmental Research (2013), the results for Gangneung were compared to other small and medium-sized cities with populations of 200,000 to 400,000 people, including Iksan, Mokpo and Jinju. Out of all of these cities, Gangneung had the highest rates of CO_2 emissions per capita and per GDP, energy consumption per GDP, building energy consumption, waste per capita and annual average SO_2 concentrations. The city ranked second, after Mokpo, in terms of water lost per capita and per day. In water consumption, Gangneung ranked third, after Gumi and Jinju.

Gangneug's air pollution index, with the exception of SO_2, compared favorably to that of other cities, as did energy consumption per capita. Even taking error into consideration, CO_2 emissions per capita were high, comparable to those for Seoul, which has emissions of 3.7 tons per capita (EIU, 2011). Based on an analysis of energy consumption rates by source, using data from the city's energy maintenance corporation, Gangneung has a higher rate of CO_2 emissions from coal than other cities.

Accordingly, Gangneung may in the future need to improve its CO_2 maintenance policies for coal utilities; it should also consider general improvements for energy, water and waste.

4. Conclusion

The present study collected formula and data of Gangneung where was designated low carbon green city in 2009, using GCI system. The study aimed to reflect GCI system which was designed for low carbon green growth city construction and actively applied in Europe, and to propose data frame according to items for the construction of reliable and systemic baseline data construction. Total 14 items of 7 division were analyzed based on the basic data frame, and baseline data for Gangneung green city indicator was constructed. Based on the formula proposed by this study, it would be able for baseline data construction of each city. Also there is a critical meaning that it would be able to compare the green growth among cities for some period.

As for the limitation of this study, some errors remained in the comparison between previous data of small and midium cities and present formula of Gangneung. Accordingly further studies would be needed related on baseline data construction using GCI, and weighted value application, and ranking formula. Therefore, could secure competitiveness through construction of low carbon green growth city among foreign and domestic cities.

REFERENCES

Burck, J., Christoph, B., Simone, A., 2008, The climate change performance index results 2009, Germanwatch Inc., Berlin.

Choi, S. Y., 2011, A study on the development of the model and indicators for green growth city, Ph. D. Dissertation, Dongguk University, Gyeongju.

EIU, 2009, European green city index, Simens, Munich, 51.

EIU, 2011, Asian green city index, Simens, Munich, 63.

Ko, J. K., Kim, H. S., 2010, A study on the development of low carbon green competitiveness indicators of local government - Centering of Gyeonggi-do, J. Local Govern. Stud., 22(3), 175-200.

Lim, D. I., 2011, Analysis of the change of urban structure in Gangneung-city by urban development, J. Korean Reg. Dev., 10(2), 113-147.

Lee, J. H., 2013, Development and application of quantitative assessment indicators for low-carbon green city, Ph. D. Dissertation, Dongguk University, Gyeongju.

Lee, J. J., Lee, W. H., Kim, D. Y., 2011, A study on the

local autonomous entity's establishment of direction for low-carbon green-city policy, Geogr. J. Korea, 45(2), 295-308.

Lee, M. H., Kim, R. H., 2011, A suggestion on the laws and institutions for the green city, Environ. Law Assoc., 33(2), 276-296.

National Institute of Environmental Research, 2013, A study on development and application of green city index for urban environmental management in Korea, National Institute of Environmental Research, Incheon.

Park, J. C., Kim, J. Y., 2010, Urban planning measure -ments in pursuit of a low-carbon green city - Case analyses of basic planning elements and spatial urban structures in Korea and Japan-, J. Korean Reg. Dev. Assoc., 22(1), 17-52.

Song, K. S., Kim, Y. O., Kwen, Y. H., 2008, A study on construction and application of evaluation indicators in quality of life, Korean J. Local Govern. Stud., 12(4), 225-247.

You, J. H., Park, K. H., Jung, S. G., 2005, A study on importance of assessment factors and indicators of natural ecosystem for environmentally friendly land conservation, J. Environ. Impact Assess., 14(4), 165-177.