The Climate Change Adaptation Index of Korea, 2007

October 20, 2010

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The first draft of the paper was presented at the GSnJ Jeju seminar in August 2008 and at the Joint Seminar of Kyungpook National University and Kyoto University at Kyungpook National University in February 2010. The author appreciates the valuable comments from the seminar participants.

The author also thank Hwasung Jang and Huisung Ahn at Kyungpook National University and Jongyeop Kim at Seoul National University for excellent research assistance.

This work was supported by KETEP (2006-E-CC-HM-E-01-0000), which is funded by MKE (Ministry of Knowledge Economy).

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I. Introduction

In data based decisions, some quantitative performance indices are found to be very practical in socio-economic empirical assessment research. The move towards a more data-based approach allows researchers to track trends, evaluate performance, and identify the best policy practices. Researchers in climate change adaptation have also recognized the importance of identifying an appropriate set of measures and incorporating those measures in empirical assessments. The measurement of mitigation and adaptation performance to climate change, however, is still very limited; large data gaps and a lack of time-series data in climate change still hampers efforts to assess the performance of climate change adaptation. Thus, climate change policy decision making based on empirical measures may be very difficult. Recently, some quantitative performance metrics and indices have been invented in the field of climate change adaptation (see e.g. Custance (1998), German Watch (2010), Yale University & Columbia University (2010)).

Korea, one of the 10 largest CO_2 emitters in the world, showed worrisome performance and was ranked 41^{th} among 60 countries in the Climate Change Performance Index 2010 and 94^{th} among 163 countries in the 2010 Environment Performance Index. But there is until now few empirical results evaluating local Korea government efforts in climate change adaptation performance.

The focus of this study is to measure the performance of the 16 different regions of Korea on climate change adaptation. The Climate Change Adaptation Index (CCAI) is a data-driven, fact-based empirical instrument designed to measure local Korean government efforts in climate change adaptation. While there is no correct method for proper climate change adaptation measurement, this index is built on a set of 18 climate change indicators.

Data was collected based on a broad range of CO_2 emission trends, energy efficiency levels, climate change adaptation policies, and disaster/recovery policies. On the basis of the (student) t-distribution scores, the CCAI would help to evaluate and compare the adaptation performance of 16 Korean regions to demonstrate which regions are leading or lagging in each category, and to determine whether they are on a sustainable trajectory.

The paper is organized as follows. In Sections II and III, climate change adaptation indices are calculated and empirical results are analyzed and discussed. In section IV, conclusions are provided.

II. Framework

The construction of a composite index is very controversial in the field of climate change adaptation, and there is no clear consensus on how to best construct one. Various aggregation methods exist, and the choice of an appropriate method depends on the nature of the subject being evaluated.

The CCAI for this paper is one of the proxy measures of climate change adaptation performance, providing a quantitative basis for analyzing and comparing climate change mitigation and adaptation practices, identifying performance leaders and laggards, and highlighting good policy practices. It has three unequally weighted categories that add up to form a differentiable picture of the climate change adaptation of the 16 different regions of Korea.

The three categories are CO_2 Emission Trend, Energy Efficiency Level, and Climate Change Adaptation Policy. The CO_2 Emission Trend evaluates the region-specific CO_2 reduction effort and is measured in five economic subcategories: Energy Consumption, Road Transport, Industry, Agriculture and Forestry, and Waste. Each subcategory is measured individually.

The Energy Efficiency Level measures the region-specific energy usage efficiency and the absolute energy-related CO_2 emissions of a region. The Energy Efficiency Level is measured in four subcategories: CO_2 Emission per Primary Energy Unit, Primary Energy Unit per GRDP[1], Primary Energy Unit per Capita, and CO_2 Emission per Area.

The Climate Change Adaptation Policy evaluates a region's climate policy practices.

The Climate Change Adaptation Index is compiled from various indicators giving unequal weight to each under strong assumptions: CO_2 Emission Trend accounted for 60%, Energy Efficiency Level for 20%, and Climate Change Policy for 20% to a region's total CCAI.

Data

[1] GRDP: Gross Regional Domestic Products

The data used in the CCAI's 18 categories were official statistics that were measured and formally reported by Institutes related to the Korean government and the 16 different regions of Korea: Ministry of Environment, Korean Energy Economics Institute, Statistics Korea, Annual Report of 16 regions, and research data compiled by United Green Korea[2]. The United Green Korea research data are based on interviews with 16 regional government officials in charge of climate change affairs. Individual indicators included in the calculation of the CCAI are described in Table 1.

Table1. Climate Change Adaptation Index

Category		
CO_2 Emission Trend	Energy Consumption	▪ Electricity
		▪ Fossil Fuel: Oil Private
		▪ Fossil Fuel: Coal Private
		▪ Fossil Fuel: Natural Gas Private
		▪ Renewable Energy
	Road Transport	
	Industry	▪ Manufacturing in GRDP
		▪ Construction in GRDP
	Agriculture and Forestry	▪ Livestock
		▪ Fertilizer
		▪ Forestry Area
	Waste	
Energy Efficiency Level	CO_2 Emissions per Primary Energy Unit	
	Primary Energy Unit per GRDP	
	Primary Energy Unit per Capita	
	CO_2 Emissions per Area	
Climate Change Policy	Climate Change Adaptation Policy	
	Climate Disaster Restoration Policy	

Indicator Modeling[3]

[2] A Korean non-governmental organization,

[3] The indicator model is adopted from Afonso, Schknecht, and Tanzi(2003).

It is assumed that the climate change adaptation index (CCAI) is a function of individual performance sub-indicators. Let i denote a Korean regional government, j denote a certain climate change adaptation index category, and n denote the total number of indicators. The CCAI for the local government is the sum of 18 indicator values.

$$\mathrm{CCAI}_i = \sum_{j=1}^{n} w_{ij}\ \mathrm{CCAI}_{ij}$$

Where w_{ij} is the weight of j^{th} category of the CCAI of the i^{th} region and CCAI_{ij} is the score of j^{th} category of the CCAI of the i^{th} region. Thus, an improvement in the j^{th} category improves the climate change adaptation performance of the i^{th} region.

In order to facilitate the compilation, the values are first normalized and then standardized in terms of the t distribution. For those indicators where higher score numbers are less favorable (e.g. electricity, coal, and livestock), the inverse of the original t distribution values is used. The final index score for each sub-indicator is recalculated again relative to the average mean of 50 using the standardized t distribution score. The index scores of the sub-categories are finally put together in a category indicator. The total score of the CCAI is designed as the lowest score to be 0, the mean 50, and the highest score 100.

Index score = [50 + (t score) × 50/3] × weight of each sub indicator

III. Climate Change Adaptation Index

1. CO_2 Emission Trend

Effective political or economic measures that aim at reducing CO_2 emissions ultimately have a positive impact on the sectors they are targeting. Hence, the CCAI first quantifies the development of the CO_2 emission. The CO_2 Emission Trend development is measured using data of 3-year averages ending in 2006 and 2007. This is because the study is not so much interested in annual fluctuations but systematic changes in CO_2 emission reduction

performance: annual indicators reflect temporal changes, so that a 3-year average seems one of the ways to capture long term trends in CO_2 emission reduction.

Table 2 also displays the composition of CO_2 Emission Trend index in each region. As for the CO_2 emission Trend, CO_2 emission reduction is measured as a composite of the following indices – Energy Consumption, Road Transportation, Industry, Agriculture and Forestry, and Waste.

1-1. Energy Consumption

The Energy Consumption indicator contains Electricity, Oil, Coal, and Natural Gas consumption in the private sector, and Renewable Energy generation in both the private and public sectors. The Road Transportation indicator is the un-weighted aggregate sum of passenger cars, trucks, and two-wheeled motor cycles, construction vehicles, etc. The Industry indicator contains Manufacturing and Construction field measurements. The Agriculture and Forestry contain Livestock breeding, Fertilizer usage and Tree grown area. The Waste category estimates the volume of disposed waste.

The degree to which a sector is involved in the CO_2 Emission Trend assessment depends upon its relevance to climate change adaptation. The conceptual weighting scheme is of course artificial: Energy Consumption is supposed to contribute 34%, Road Transportation 5 %, Industry 9%, Agriculture and Forestry 5%, and Waste 5% to the entire CCAI score.

The detailed sub-indicators for the CO_2 Emission Trend are described in Table 2.

Table 2. CO_2 Emission Trend Index Weight

Category		Subcategory	Weight
CO_2 Emission Trend (60%)	Energy Consumption (34%)	Electricity	10%
		Fossil Fuel: Oil Private	9%
		Fossil Fuel: Coal Private	5%
		Fossil Fuel: Natural Gas Private	5%
		Renewable Energy	5%
	Road Transport (5%)	Vehicles Registered	5%
	Industry (9%)	Manufacturing in GRDP	5%
		Construction in GRDP	4%
	Agriculture and	Livestock	2%

	Forestry (6%)	Fertilizer	2%
		Forestry Area	2%
	Waste (6%)	Waste	6%

1-1-1. Electricity

The sales of electricity in each region were measured and used as a good proxy value of CO_2 emissions from electricity consumption.

All 16 Korean regions showed increasing growth trends in electricity consumption. Daegu and Incheon were the front runners in saving electricity even though their electricity consumption increased. Busan and Seoul ranked 8th and 10th, respectively. Chungcheongbuk-Do, Gyeonggi-Do and Chungcheongnam-Do showed poor performance in electricity saving. The raw data showed Chungcheongbuk-Do, Gyeonggi-Do and Chungcheongnam-Do were high electricity consumption regions such that Chungcheongnam-Do's electricity consumption had increased 40% during a period between 2002 and 2007. No particular pattern was shown between metropolitan regions and rural regions.

Table 3. Index Score of Electricity Consumption, 2007

Region	Trend	Index Score	Rank
Seoul	3.95%	5.97	4
Busan	4.92%	5.28	9
Daegu	2.77%	6.80	1
Incheon	3.30%	6.42	2
Gwangju	5.66%	4.76	11
Daejeon	4.28%	5.73	6
Ulsan	3.44%	6.32	3
Gyeonggi-Do	7.49%	3.47	15
Gangwon-Do	4.05%	5.90	5
Chungcheongbuk-Do	6.44%	4.21	14
Chungcheongnam-Do	12.91%	-0.34	16
Jeollabuk-Do	4.95%	5.26	10
Jeollanam-Do	4.47%	5.60	7

Gyeongsangbuk-Do	4.87%	5.32	8
Gyeongsangnam-Do	5.88%	4.61	13
Jeju	5.78%	4.68	12

1-1-2. Fossil Fuel: Oil for the Private Sector

Fossil fuels for the private sector measured the consumption of fuel oil, coal, and natural gas for the household and commercial sectors excluding the combustion of all fossil fuel types used for the production, transportation, and public sectors to avoid double counting these fuels.

Fossil fuel oil is the sum of gasoline, jet fuel, kerosene, diesel fuel, and B-C oil consumed for the private sector. The aggregation is performed using Toe (Ton of oil equivalent) conversion such that gasoline is equivalent to 0.74 Toe, jet fuel and kerosene 0.820, diesel fuel 0.835, and B-C oil 0.935.

All the regions, except Chungcheongnam-Do, showed lower or decreasing trend rates.

Table 4. Index Score of Oil, 2007

Region	Trend	Index Score	Rank
Seoul	-0.66%	4.78	7
Busan	-1.61%	5.21	6
Daegu	-5.02%	6.76	1
Incheon	2.82%	3.20	15
Gwangju	-2.75%	5.73	5
Daejeon	-3.91%	6.26	3
Ulsan	2.12%	3.52	13
Gyeonggi-Do	2.00%	3.57	12
Gangwon-Do	-4.24%	6.41	2
Chungcheongbuk-Do	0.89%	4.07	10
Chungcheongnam-Do	7.62%	1.01	16
Jeollabuk-Do	-2.84%	5.77	4
Jeollanam-Do	2.64%	3.28	14

Gyeongsangbuk-Do	-0.22%	4.58	8
Gyeongsangnam-Do	0.63%	4.19	9
Jeju	1.81%	3.66	11

1-1-3. Fossil Fuel: Coal for the Private Sector

Coal consumption had sharply increased while fuel oil consumption had decreased nation-wide in the 2000's. This change in energy mix may be due to substitution phenomena as the fuel oil price had increased rapidly in the 2000's.[4]

Incheon and Ulsan had never combusted coal in 2000's. Jeju's coal consumption in the private sector was 1 in 2004 and 0 thereafter, thus their consumption trend rate -100%.

Table 5. Index Score of Coal, 2007

Region	Trend	Index Score	Rank
Seoul	10.61%	2.31	8
Busan	7.19%	2.41	5
Daegu	21.07%	2.00	16
Incheon	0.00%	2.62	2
Gwangju	10.94%	2.30	9
Daejeon	17.75%	2.10	14
Ulsan	0.00%	2.62	2
Gyeonggi-Do	6.38%	2.43	4
Gangwon-Do	11.73%	2.28	10
Chungcheongbuk-Do	10.16%	2.32	7
Chungcheongnam-Do	16.25%	2.15	13
Jeollabuk-Do	7.25%	2.41	6
Jeollanam-Do	14.62%	2.19	12

[4] In 2007, Kerosene price per caloric heating value was 0.066 Won, those of coal and natural gas were 0.014 Won and 0.032 Won, respectively. In other words, coal and natural gas prices per caloric value are just 21% and 48.5% of Kerosene's value, (see Development of Integrated Model and Economic-Environmental Effect of Climate Policy, Korea Energy Economics Institute , 2008.12).

Gyeongsangbuk-Do	14.53%	2.20	11
Gyeongsangnam-Do	18.06%	2.09	15
Jeju	-100.00%	5.55	1

1-1-4. Fossil Fuel: Natural Gas for the Private Sector

Metropolitan regions showed lower trend rates while rural regions had higher rates of natural gas consumption. The rapidly increasing trends of gas combustion in rural regions may be due to the fact that city gas supply networks were recently constructed in rural regions. Jeju, for example, began city gas supply in 2005 and showed a very high increase trend.[5]

Table 6. Index Score of Natural Gas, 2007

Region	Trend	Index Score	Rank
Seoul	-1.06%	3.42	1
Busan	4.73%	2.67	8
Daegu	3.90%	2.77	5
Incheon	-0.50%	3.34	2
Gwangju	5.74%	2.54	9
Daejeon	1.95%	3.03	3
Ulsan	8.60%	2.17	14
Gyeonggi-Do	2.08%	3.01	4
Gangwon-Do	6.69%	2.41	13
Chungcheongbuk-Do	6.47%	2.44	12
Chungcheongnam-Do	6.02%	2.50	10
Jeollabuk-Do	4.39%	2.71	6
Jeollanam-Do	4.39%	2.71	6
Gyeongsangbuk-Do	8.68%	2.16	15
Gyeongsangnam-Do	6.44%	2.45	11

[5] Jeju began city gas supply in 2005. 3-year trends in average gas consumption are unavailable, thus the trends in Jeju had to be estimated on the yearly basis.

Jeju	27.73%	-0.31	16

1-1-5. Renewable Energy

Renewable energies are solar, bio-fuels, wind, hydraulic, geothermal energy and energy generated from waste. Renewable energy generation is very desirable for the mitigation of greenhouse gases and is unambiguously positive for climate change adaptation. A higher renewable energy index score means comparatively better performance in CO_2 mitigation.

There are sharp differences in the index scores among regions: Regions concerned in renewable energy showed a huge increase trend even though renewable energy facilities requires a huge financial investment. Daegu, Incheon, and Gyeongsangbuk-Do showed 64%, 44%, and 37% trend increase, respectively.

Table 7. Index Score of Renewable Energy, 2007

Region	Trend	Index Score	Rank
Seoul	22.89%	2.90	4
Busan	7.40%	2.27	7
Daegu	64.28%	4.59	1
Incheon	43.89%	3.76	2
Gwangju	-8.08%	1.64	16
Daejeon	-3.30%	1.84	13
Ulsan	5.75%	2.21	8
Gyeonggi-Do	-5.54%	1.74	15
Gangwon-Do	3.97%	2.13	9
Chungcheongbuk-Do	3.81%	2.13	10
Chungcheongnam-Do	15.25%	2.59	6
Jeollabuk-Do	22.59%	2.89	5
Jeollanam-Do	3.20%	2.10	11
Gyeongsangbuk-Do	36.98%	3.48	3
Gyeongsangnam-Do	-1.71%	1.90	12

Jeju	-3.77%	1.82	14

Index Score of Energy Consumption

The Energy Consumption category is comprised of 5 sub-categories. Daegu ranked highest with a score of 22.93 with the facts that it consumed the least electricity, fuel and consumed less natural gas and generated the most renewable energy, even though it most consumed coal.

The poorest performer in energy consumption was Chungcheongnam-Do with a score of 7.91, one third of that of the top performer: it consumed the most electricity and fuel and and showed the largest consumption of coal and gas. The next above were Gyeonggi-Do with 14.23, Chungcheongbuk-Do with 15.18, and Gyeongsangnam-Do with 15.24.

These facts may imply that the resulting performances, except for performances in the Renewable Energy, in the Energy consumption of 16 regions may not have performed to the local governments' calculated and systematic solid planning for climate change adaptation, but rather the result may have been unrelated to local government environment policy but the outcome of regional economic development: Chungcheongnam-Do showed the highest GRDP growth rate of 40% while Daegu showed 20 % during 2003 – 2007.

Table 8-1. Index Score of Energy Consumption, 2007

Energy Consumption Trend Index Score						
Region	Electricity Consumption		Oil		Coal	
	Score	Rank	Score	Rank	Score	Rank
Seoul	5.97	4	4.78	7	2.31	8
Busan	5.28	9	5.21	6	2.41	5
Daegu	6.80	1	6.76	1	2.00	16
Incheon	6.42	2	3.20	15	2.62	2
Gwangju	4.76	11	5.73	5	2.30	9
Daejeon	5.73	6	6.26	3	2.10	14
Ulsan	6.32	3	3.52	13	2.62	2

Gyeonggi-Do	3.47	15	3.57	12	2.43	4
Gangwon-Do	5.90	5	6.41	2	2.28	10
Chungcheongbuk-Do	4.21	14	4.07	10	2.32	7
Chungcheongnam-Do	-0.34	16	1.01	16	2.15	13
Jeollabuk-Do	5.26	10	5.77	4	2.41	6
Jeollanam-Do	5.60	7	3.28	14	2.19	12
Gyeongsangbuk-Do	5.32	8	4.58	8	2.20	11
Gyeongsangnam-Do	4.61	13	4.19	9	2.09	15
Jeju	4.68	12	3.66	11	5.55	1

Table 8-2 Index Score of Energy Consumption, 2007

Energy Trend Index Score, 2007						
Region	Gas		Renewable		**Total Score**	**Energy Rank**
	Score	Rank	Score	Rank		
Seoul	3.42	1	2.90	4	19.38	2
Busan	2.67	8	2.27	7	17.85	7
Daegu	2.77	5	4.59	1	22.93	1
Incheon	3.34	2	3.76	2	19.35	3
Gwangju	2.54	9	1.64	16	16.97	9
Daejeon	3.03	3	1.84	13	18.96	6
Ulsan	2.17	14	2.21	8	16.83	10
Gyeonggi-Do	3.01	4	1.74	15	14.23	15
Gangwon-Do	2.41	13	2.13	9	19.13	4
Chungcheongbuk-Do	2.44	12	2.13	10	15.18	14
Chungcheongnam-Do	2.50	10	2.59	6	7.91	16
Jeollabuk-Do	2.71	6	2.89	5	19.05	5
Jeollanam-Do	2.71	6	2.10	11	15.88	11
Gyeongsangbuk-Do	2.16	15	3.48	3	17.73	8
Gyeongsangnam-Do	2.45	11	1.90	12	15.24	13
Jeju	-0.31	16	1.82	14	15.40	12

1-2. Road Transport

The Road Transport indicator used by the CCAI is the un-weighted sum of all registered vehicles such as passenger cars, trucks, two-wheeled motor cycles, and construction vehicles, etc, in each region.[6] The Road Transport indicator was assumed to contribute 5% to the overall CCAI score.

Table 9. Index Score of Road Transport, 2007

Region	Trend	Index Score	Rank
Seoul	1.75%	3.66	2
Busan	1.39%	3.96	1
Daegu	1.86%	3.57	3
Incheon	2.85%	2.76	6
Gwangju	2.94%	2.69	7
Daejeon	2.80%	2.80	5
Ulsan	3.23%	2.45	9
Gyeonggi-Do	3.97%	1.85	14
Gangwon-Do	2.55%	3.01	4
Chungcheongbuk-Do	3.88%	1.92	13
Chungcheongnam-Do	4.66%	1.28	15
Jeollabuk-Do	3.10%	2.56	8
Jeollanam-Do	3.74%	2.03	12
Gyeongsangbuk-Do	3.34%	2.36	10
Gyeongsangnam-Do	5.22%	0.82	16
Jeju	3.44%	2.28	11

1-3. Industry

In the industry category, only the Manufacturing and Construction industries were measured. Electricity, gas, automobile, agriculture, and fishery industries were excluded to

[6] The total number of all registered vehicles is 16.8 million, and among them 6.7 million vehicles are registered in Seoul and Gyeonggi-Do.

avoid redundant calculation. Education, arts, sports, and leisure, which emit little greenhouse gas, are also excluded. Manufacturing and Construction indicators are measured in terms of gross regional domestic products (GRDP). The weight for Manufacturing is 5% and the weight for Construction is 4% to the CCAI score.

1-3-1. Manufacturing

Chungcheongnam-Do, the poorest performer in Manufacturing, showed a high trend rate of 12.18% and the next worst performer is Gwangju with the trend rate of 11.17%. Gyeongsangbuk-Do, the best adaptation performer in climate change, showed a sluggish growth rate of 0.15% in the manufacturing industry.

Table 10. Index Score of Manufacturing, 2007

Region	Trend	Index Score	Rank
Seoul	1.44%	3.39	4
Busan	8.49%	1.83	13
Daegu	4.47%	2.72	7
Incheon	5.55%	2.48	10
Gwangju	11.17%	1.24	15
Daejeon	0.98%	3.49	2
Ulsan	4.52%	2.71	8
Gyeonggi-Do	3.20%	3.00	5
Gangwon-Do	3.66%	2.90	6
Chungcheongbuk-Do	4.63%	2.68	9
Chungcheongnam-Do	12.18%	1.02	16
Jeollabuk-Do	7.46%	2.06	12
Jeollanam-Do	7.36%	2.08	11
Gyeongsangbuk-Do	0.15%	3.67	1
Gyeongsangnam-Do	10.72%	1.34	14
Jeju	1.39%	3.40	3

1-3-2. Construction

Ulsan experienced a rapid trend rate of 28.43% which was twice more than Chungcheongbuk-Do's trend rate. Daejeon, Seoul, Jeju, and Busan showed negative trend rates

Table 11. Index Score of Construction, 2007

Region	Trend	Index Score	Rank
Seoul	-2.26%	2.76	2
Busan	-0.20%	2.59	4
Daegu	12.24%	1.54	13
Incheon	12.81%	1.49	14
Gwangju	7.68%	1.92	10
Daejeon	-3.82%	2.89	1
Ulsan	28.43%	0.17	16
Gyeonggi-Do	4.79%	2.17	6
Gangwon-Do	5.21%	2.13	7
Chungcheongbuk-Do	13.63%	1.42	15
Chungcheongnam-Do	6.36%	2.03	9
Jeollabuk-Do	8.43%	1.86	11
Jeollanam-Do	9.36%	1.78	12
Gyeongsangbuk-Do	0.10%	2.56	5
Gyeongsangnam-Do	5.99%	2.07	8
Jeju	-0.35%	2.60	3

Index Score of Industry

The sets of concepts, growth in the Industry and climate change adaptation efforts, are never compatible: growth is reversely related with adaptation performance. The best performer of climate change adaptation in the Industry was Daejeon, which showed a poorer growth trend rate in Manufacturing and Construction industry.

Table 12. Index Score of Industry, 2007

Index Score of Industry						
Region	Manufacturing		Construction		**Industry**	
	Score	Rank	Score	Rank	**Score**	**Rank**

Seoul	3.39	4	2.76	2	6.15	3
Busan	1.83	13	2.59	4	4.42	7
Daegu	2.72	7	1.54	13	4.26	8
Incheon	2.48	10	1.49	14	3.97	10
Gwangju	1.24	15	1.92	10	3.16	14
Daejeon	3.49	2	2.89	1	6.38	1
Ulsan	2.71	8	0.17	16	2.88	16
Gyeonggi-Do	3.00	5	2.17	6	5.17	5
Gangwon-Do	2.90	6	2.13	7	5.03	6
Chungcheongbuk-Do	2.68	9	1.42	15	4.11	9
Chungcheongnam-Do	1.02	16	2.03	9	3.05	15
Jeollabuk-Do	2.06	12	1.86	11	3.92	11
Jeollanam-Do	2.08	11	1.78	12	3.86	12
Gyeongsangbuk-Do	3.67	1	2.56	5	6.23	2
Gyeongsangnam-Do	1.34	14	2.07	8	3.41	13
Jeju	3.40	3	2.60	3	6.00	4

1-4. Agriculture and Forestry

The Agriculture and Forestry category consists of three subcategories: Livestock, Fertilizer, and Forestry. Livestock breeding and fertilizing are significant sources of greenhouse gas emissions. The indicator presented herein for Livestock measures the sum of heads of cattle and hogs. The Fertilizer indicator estimates the un-weighted sum of nitrogen, phosphoric acid, and potassium chloride fertilizer supplied in each region.

In the real world, agriculture and forestry sectors share 2.5% of the total CO_2 emissions. But in our CCAI model, the Agriculture and Forestry category carries 6% within the overall CCAI, and Livestock, Fertilizer, and Forestry Area are respectively weighed to be 2% of the overall CCAI score.

1-4-1. Livestock

The Livestock is the sum of heads of cattle and hogs. Good performance implies the reduction of livestock. All the metropolitan regions showed diminishing trend rates.

Table 13. Index Score of Livestock, 2007

Region	Trend	Index Score	Rank
Seoul	0.36%	1.10	8
Busan	-1.61%	1.30	4
Daegu	-0.67%	1.20	7
Incheon	-1.67%	1.30	3
Gwangju	-3.93%	1.53	1
Daejeon	-1.36%	1.27	5
Ulsan	-2.19%	1.35	2
Gyeonggi-Do	0.93%	1.04	9
Gangwon-Do	6.30%	0.51	16
Chungcheongbuk-Do	5.59%	0.58	14
Chungcheongnam-Do	6.05%	0.53	15
JeollabuYear k-Do	1.82%	0.95	10
Jeollanam-Do	4.34%	0.70	11
Gyeongsangbuk-Do	-0.98%	1.23	6
Gyeongsangnam-Do	4.43%	0.70	12
Jeju	4.44%	0.69	13

1-4-2. Fertilizer

The quantities of fertilizer consumed in all 16 regions had rapidly decreased. This may be due to a decrease in agriculture-wide production and an increase in organic products. Seoul had not had agriculture production for decades, thus Seoul's consumption rate of fertilizer is zero. Seoul becomes the worst performer in fertilizer consumption ironically, while Daejeon, Jeollabuk-Do, and Busan were the best performers.

Table 14. Index Score of Fertilizer, 2007

Region	Trend	Index Score	Rank
Seoul	0%	0.49	16
Busan	-13.06%	1.18	3
Daegu	-7.27%	0.87	13
Incheon	-8.14%	0.92	9
Gwangju	-0.91%	0.54	15

Daejeon	-23.47%	1.74	1
Ulsan	-7.38%	0.88	12
Gyeonggi-Do	-8.53%	0.94	8
Gangwon-Do	-8.03%	0.92	10
Chungcheongbuk-Do	-8.61%	0.95	7
Chungcheongnam-Do	-5.24%	0.77	14
Jeollabuk-Do	-22.63%	1.69	2
Jeollanam-Do	-7.85%	0.91	11
Gyeongsangbuk-Do	-10.50%	1.05	5
Gyeongsangnam-Do	-10.03%	1.02	6
Jeju	-12.30%	1.14	4

1-4-3. Forestry Area

Forests definitely mitigate CO_2. Measuring the area of tree growth is a good proxy for the measurement of the Forestry Area. Forestry area is measured in metric units. All 16 regions showed decreases in the tree grown area due to land development, but the rates of decrease were very low.

Table 15. Index Score of Forestry Area, 2007

Region	Trend	Index Score	Rank
Seoul	-0.01%	1.37	1
Busan	-0.35%	0.78	11
Daegu	-0.23%	0.99	10
Incheon	-0.03%	1.34	2
Gwangju	-0.41%	0.67	14
Daejeon	-0.07%	1.27	5
Ulsan	-0.13%	1.16	8
Gyeonggi-Do	-0.50%	0.52	15
Gangwon-Do	-0.05%	1.30	4
Chungcheongbuk-Do	-0.36%	0.76	12
Chungcheongnam-Do	-0.39%	0.71	13
Jeollabuk-Do	-0.03%	1.34	2
Jeollanam-Do	-0.18%	1.08	9

Gyeongsangbuk-Do	-0.12%	1.18	7
Gyeongsangnam-Do	-0.10%	1.22	6
Jeju	-0.62%	0.30	16

Index Score of Agriculture and Forestry

Total Performance in the Agriculture and Forestry did so for very different reasons: There were not performance consistencies in the sub categories of the Agriculture and Forestry as in the Energy Consumption.

Table 16-1. Index Score of Agriculture and Forestry, 2007

CO_2 Emission Trend of Agriculture and Forestry						
Region	Livestock		Fertilizer		Forestry Area	
	Score	Rank	Score	Rank	Score	Rank
Seoul	1.10	8	0.49	16	1.37	1
Busan	1.30	4	1.18	3	0.78	11
Daegu	1.20	7	0.87	13	0.99	10
Incheon	1.30	3	0.92	9	1.34	2
Gwangju	1.53	1	0.54	15	0.67	14
Daejeon	1.27	5	1.74	1	1.27	5
Ulsan	1.35	2	0.88	12	1.16	8
Gyeonggi-Do	1.04	9	0.94	8	0.52	15
Gangwon-Do	0.51	16	0.92	10	1.30	4
Chungcheongbuk-Do	0.58	14	0.95	7	0.76	12
Chungcheongnam-Do	0.53	15	0.77	14	0.71	13
Jeollabuk-Do	0.95	10	1.69	2	1.34	2
Jeollanam-Do	0.70	11	0.91	11	1.08	9
Gyeongsangbuk-Do	1.23	6	1.05	5	1.18	7
Gyeongsangnam-Do	0.70	12	1.02	6	1.22	6
Jeju	0.69	13	1.14	4	0.30	16

Table 16-2. Index Score of Agriculture and Forestry, 2007

CO_2 Emission Trend of Agriculture and Forestry

Region	**Total Score**	**Agriculture and Forestry Rank**
Seoul	2.96	8
Busan	3.26	6
Daegu	3.07	7
Incheon	3.56	3
Gwangju	2.74	10
Daejeon	4.28	1
Ulsan	3.40	5
Gyeonggi-Do	2.50	13
Gangwon-Do	2.73	11
Chungcheongbuk-Do	2.29	14
Chungcheongnam-Do	2.01	16
Jeollabuk-Do	3.99	2
Jeollanam-Do	2.69	12
Gyeongsangbuk-Do	3.46	4
Gyeongsangnam-Do	2.93	9
Jeju	2.14	15

1-5. Waste

The materials designated as waste by the Ministry of Environments include acid waste, alkali waste, oil waste, solvent waste, high molecular compound waste, and infectious waste, etc. Daegu, Gyeongsangbuk-Do, and Jeju all performed very well in Waste reduction. While, Chungcheongnam-Do, Chungcheongbuk-Do, Gangwon-Do, and Ulsan increased waste dumping thus influenced higher stresses to the regions' index scores

Table17. Index Score of Waste, 2007

Region	Trend	Index Score	Rank
Seoul	5.81%	3.03	8
Busan	2.85%	3.31	6
Daegu	-12.15%	4.72	1
Incheon	1.70%	3.42	4
Gwangju	10.95%	2.55	12
Daejeon	2.02%	3.39	5

Ulsan	14.27%	2.24	13
Gyeonggi-Do	6.08%	3.01	9
Gangwon-Do	15.04%	2.16	14
Chungcheongbuk-Do	17.59%	1.92	15
Chungcheongnam-Do	30.45%	0.71	16
Jeollabuk-Do	7.38%	2.88	10
Jeollanam-Do	3.66%	3.24	7
Gyeongsangbuk-Do	-8.56%	4.39	2
Gyeongsangnam-Do	8.93%	2.74	11
Jeju	-7.49%	4.29	3

1-6. CO_2 Emission Trend Rank

The CO_2 Emission Trend evaluates the region-specific CO_2 reduction effort over time. Developed regions with high GRDP and high energy consumption exhibited low and stable energy consumption trend. Daegu, Daejeon, Seoul, Incheon, and Busan showed moderate to high performances in the subcategories of the CO_2 Emission Trend.

To match the high GRDP and living standards of metropolitan regions, the rural area developed with a higher growth rate and with less efficient energy facilities under less restrictive environmental regulation had higher CO_2 emission and exhibited poor performance to the adaptation.

But, the performances may not totally dependupon a region's determined effort to climate change but may be just results of regional development. The poorest performer, Chungcheongnam-Do, showed the highest GRDP growth rate of 40% while the best performer, Daegu , showed 20 % during 2003 – 2007.

Table18-1. CO_2 Emission Trend Rank, 2007

CO_2 Emission Trend Score						
Region	Energy		Vehicles		Industry	
	Score	Rank	Score	Rank	Score	Rank
Seoul	19.38	2	3.66	2	6.15	3
Busan	17.85	7	3.96	1	4.42	7
Daegu	22.93	1	3.57	3	4.26	8

Incheon	19.35	3	2.76	6	3.97	10
Gwangju	16.97	9	2.69	7	3.16	14
Daejeon	18.96	6	2.80	5	6.38	1
Ulsan	16.83	10	2.45	9	2.88	16
Gyeonggi-Do	14.23	15	1.85	14	5.17	5
Gangwon-Do	19.13	4	3.01	4	5.03	6
Chungcheongbuk-Do	15.18	14	1.92	13	4.11	9
Chungcheongnam-Do	7.91	16	1.28	15	3.05	15
Jeollabuk-Do	19.05	5	2.56	8	3.92	11
Jeollanam-Do	15.88	11	2.03	12	3.86	12
Gyeongsangbuk-Do	17.73	8	2.36	10	6.23	2
Gyeongsangnam-Do	15.24	13	0.82	16	3.41	13
Jeju	15.40	12	2.28	11	6.00	4

Table18-2. CO_2 Emission Trend Rank, 2007

CO_2 Emission Trend Score						
Region	Agriculture		Waste		**Total Score**	**Trend Rank**
	Score	Rank	Score	Rank		
Seoul	2.96	8	3.03	8	35.18	3
Busan	3.26	6	3.31	6	32.79	6
Daegu	3.07	7	4.72	1	38.55	1
Incheon	3.56	3	3.42	4	33.06	5
Gwangju	2.74	10	2.55	12	28.11	10
Daejeon	4.28	1	3.39	5	35.81	2
Ulsan	3.40	5	2.24	13	27.80	11
Gyeonggi-Do	2.50	13	3.01	9	26.75	13
Gangwon-Do	2.73	11	2.16	14	32.06	8
Chungcheongbuk-Do	2.29	14	1.92	15	25.41	14
Chungcheongnam-Do	2.01	16	0.71	16	14.97	16
Jeollabuk-Do	3.99	2	2.88	10	32.39	7
Jeollanam-Do	2.69	12	3.24	7	27.70	12
Gyeongsangbuk-Do	3.46	4	4.39	2	34.17	4
Gyeongsangnam-Do	2.93	9	2.74	11	25.14	15
Jeju	2.14	15	4.29	3	30.10	9

2. Energy Efficiency Level

The Energy Efficiency Level provides a way of evaluating the primary energy efficiency and the CO_2 mitigation performance for the private sector, excluding the primary energy used for the manufacturing and transportation industries, and public sectors to avoid the redundant counting of these fuels.

The energy efficiency the CO_2 mitigation performance of a region is assessed in four ways – Primary Energy Unit per GRDP, Primary Energy Unit per Capita, CO_2 Emissions per Primary Energy Unit, and CO_2 Emissions per Area. All indices are measured in terms of three-years ending in 2007.

The primary energies are fuel oil, coal, and liquefied natural gas, hydraulic and atomic energy as defined in the Yearbook of Regional Energy Statistics[7].

The CO_2 emission quantities in this category were the sums of CO_2 from primary energies. Thus, CO_2 emission quantities from manufacturing, agriculture, waste, and CO_2 mitigation by forests were removed from statistical calculation. The CO_2 emission calculation is performed with TOE (Ton of oil equivalent) conversion.

Table 19. Energy Efficiency Level Index Weight

Index	Subcategory	Weight
Energy efficiency Level (20%)	Primary Energy Unit per GRDP	5%
	Primary Energy Unit per Capita	5%
	CO_2 Emissions per Primary Energy Unit	5%
	CO_2 Emissions per Area	5%

2-1. Primary Energy Unit per GRDP

The Primary Energy per GRDP is a way of measuring energy efficiency. Seoul, Gwangju , Daejeon, and Daegu appeared to be high energy efficient, while Ulsan, Gyeongsangbuk-Do, Chungcheongnam-Do, and Jeollanam-Do, in descending order, appeared to be low efficient in terms of regional income. There were no particular regional patterns in energy efficiency.

[7] Yearbook of Regional Energy Statistics, 2003~2008, Korea Energy Economics Institute.

Table 20. Index Score of Primary Energy Unit per GRDP, 2007

Region	Level Value	Index Score	Rank
Seoul	0.000062	3.26	1
Busan	0.000273	2.61	10
Daegu	0.000114	3.10	4
Incheon	0.000401	2.21	12
Gwangju	0.000081	3.20	2
Daejeon	0.000096	3.15	3
Ulsan	0.000516	1.86	13
Gyeonggi-Do	0.000120	3.08	5
Gangwon-Do	0.000249	2.68	9
Chungcheongbuk-Do	0.000167	2.93	8
Chungcheongnam-Do	0.000658	1.42	15
Jeollabuk-Do	0.000144	3.00	6
Jeollanam-Do	0.001063	0.17	16
Gyeongsangbuk-Do	0.000525	1.83	14
Gyeongsangnam-Do	0.000302	2.52	11
Jeju	0.000152	2.98	7

2-2. Primary Energy Unit per Capita

Primary Energy per Capita is another way of measuring energy efficiency. Gwangju ranked first, then Seoul and Daegu. Low populated rural regions appeared to be inefficient in energy consumption per person. Chungcheongnam-Do, Ulsan, and Jeollanam-Do appeared to be inefficient in energy consumption per person.

The energy efficient regions in the Primary Energy Unit per GRDP also appeared to be efficient in the Primary Energy Unit per Capita

Table 21. Index Score of Primary Energy Unit per Capita, 2007

Region	Level Value	Index Score	Rank
Seoul	0.0012	3.11	2
Busan	0.0037	2.83	9
Daegu	0.0013	3.10	3
Incheon	0.0062	2.54	12
Gwangju	0.0011	3.13	1

Daejeon	0.0013	3.10	3
Ulsan	0.0202	0.93	15
Gyeonggi-Do	0.0019	3.03	5
Gangwon-Do	0.0039	2.80	10
Chungcheongbuk-Do	0.0030	2.91	8
Chungcheongnam-Do	0.0170	1.30	14
Jeollabuk-Do	0.0020	3.02	6
Jeollanam-Do	0.0228	0.63	16
Gyeongsangbuk-Do	0.0114	1.94	13
Gyeongsangnam-Do	0.0055	2.62	11
Jeju	0.0021	3.01	7

2-3. CO_2 Emissions per Primary Energy Unit

The CO_2 Emissions per Primary Energy Unit is to estimate CO_2 emission mitigation efficiency performance in energy mix whether a region uses fewer CO_2 emission primary energy sources.

The result of CO_2 efficiency per primary energy was quite the reverse of the primary energy efficiency per GRDP and per capita. The best performers in CO_2 mitigation efficiency, Jeollanam-Do , Chungcheongnam-Do , and Ulsan were the worst performers in primary energy efficiency. The worst performers in CO_2 efficiency, Daegu, Daejeon, and Gwangju were the best performers in primary energy efficiency.

Table 22. Index Score of CO_2 Emissions per Primary Energy Unit, 2007

Region	Level Value	Index Score	Rank
Seoul	3,362	1.85	10
Busan	1,465	3.04	6
Daegu	3,790	1.58	14
Incheon	1,515	3.01	7
Gwangju	3,880	1.52	16
Daejeon	3,828	1.56	15
Ulsan	810	3.46	3
Gyeonggi-Do	3,400	1.83	11

Gangwon-Do	1,875	2.79	8
Chungcheongbuk-Do	2,809	2.20	9
Chungcheongnam-Do	647	3.56	2
Jeollabuk-Do	3,736	1.61	13
Jeollanam-Do	436	3.69	1
Gyeongsangbuk-Do	883	3.41	4
Gyeongsangnam-Do	1,271	3.17	5
Jeju	3,555	1.73	12

2-4. CO_2 Emissions per Region Area

All the metropolitan regions failed to reduce CO_2 emission per region's area. Metropolitan regions with high population, a concentrated business area and production activities have to emit much CO_2 emission. The CO_2 emission performance ranking among metropolitan regions was reversely correlated to the region's population and GRDP ranking. The poorest CO_2 emission performer per area is Seoul, then next above that is Busan, then Incheon, and then Daegu.

The good performers in the CO_2 Emission per Region were all rural areas. The less populated region Gangwon-Do was the best performer,. Then the next below was Gyeongsangbuk-Do and then . Jeollanam-Do..

Table 23. CO_2 Emissions per Region Area, 2007

Region	Level Value	Index Score	Rank
Seoul	66,949	-0.21	16
Busan	25,430	1.84	15
Daegu	13,725	2.42	12
Incheon	25,242	1.85	14
Gwangju	11,977	2.51	10
Daejeon	13,267	2.45	11
Ulsan	16,959	2.26	13
Gyeonggi-Do	6,979	2.76	9
Gangwon-Do	656	3.07	1
Chungcheongbuk-Do	1,719	3.02	4
Chungcheongnam-Do	2,525	2.98	8
Jeollabuk-Do	1,760	3.01	5
Jeollanam-Do	1,605	3.02	3

Gyeongsangbuk-Do	1,417	3.03	2
Gyeongsangnam-Do	2,129	3.00	6
Jeju	2,274	2.99	7

2-5. Energy Efficiency Level Rank

The Energy Efficiency Level score was the sum of four subcategory scores.

Top performers in the Primary Energy Unit per GRDP and per Capita were poor performers in the CO_2 Emission per Primary Energy Unit. This fact implies that the primary energy efficiency in the private sector increases as the volume and production of a region increases. But the energy source mix for mitigating CO_2 becomes worse as a region may seek relatively cheaper energy sources. There were no particular patterns among regions due to different efficiency results being mixed up.

Table 24-1. Energy Efficiency Level Rank, 2007

Energy Efficiency Level Total Rank						
Region	Primary Energy Unit per GRDP		Primary Energy Unit per Capita		CO_2 Emissions per Primary Energy Unit	
	Score	Rank	Score	Rank	Score	Rank
Seoul	3.26	1	3.11	2	1.85	10
Busan	2.61	10	2.83	9	3.04	6
Daegu	3.10	4	3.10	3	1.58	14
Incheon	2.21	12	2.54	12	3.01	7
Gwangju	3.20	2	3.13	1	1.52	16
Daejeon	3.15	3	3.10	3	1.56	15
Ulsan	1.86	13	0.93	15	3.46	3
Gyeonggi-Do	3.08	5	3.03	5	1.83	11
Gangwon-Do	2.68	9	2.80	10	2.79	8
Chungcheongbuk-Do	2.93	8	2.91	8	2.20	9
Chungcheongnam-Do	1.42	15	1.30	14	3.56	2
Jeollabuk-Do	3.00	6	3.02	6	1.61	13
Jeollanam-Do	0.17	16	0.63	16	3.69	1
Gyeongsangbuk-Do	1.83	14	1.94	13	3.41	4
Gyeongsangnam-Do	2.52	11	2.62	11	3.17	5

Jeju	2.98	7	3.01	7	1.73	12

Table 24-1. Energy Efficiency Level Rank, 2007

Energy Efficiency Level Score				
Region	CO_2 Emissions per Region Area		**Total Score**	**Efficiency Rank**
	Score	Rank		
Seoul	-0.21	16	9.86	11
Busan	1.84	15	10.25	7
Daegu	2.42	12	10.27	6
Incheon	1.85	14	9.96	10
Gwangju	2.51	10	11.79	1
Daejeon	2.45	11	10.63	5
Ulsan	2.26	13	8.04	16
Gyeonggi-Do	2.76	9	11.33	2
Gangwon-Do	3.07	1	9.56	12
Chungcheongbuk-Do	3.02	4	8.9	14
Chungcheongnam-Do	2.98	8	9.54	13
Jeollabuk-Do	3.01	5	10.08	9
Jeollanam-Do	3.02	3	10.74	4
Gyeongsangbuk-Do	3.03	2	10.2	8
Gyeongsangnam-Do	3.00	6	10.79	3
Jeju	2.99	7	8.09	15

3. Climate Change Policy

The Climate Change Policy consists of the Climate Change Adaptation Policy and the Climate Disaster Restoration Policy sub-category. The Climate Change Adaptation Policy, weighted at 15 % to the CCAI score , measures a regional government's policy preparedness for the adaptation. The Climate Disaster Restoration Policy, weighted at 5 % to the CCAI score, measures a regional government's activity readiness for disaster recovery.

The data for Climate Change Adaptation Policy is based on the 2007 specific measurement

research by a non-governmental organization, Green Korea United[8]. The institute interviewed 16 regional government officials in charge of climate change affairs through a questionnaire.

The Climate Disaster Restoration Policy Index is based on a 3-year average ratio of regional government restoration expenses to economic losses caused by weather events – storms and floods, as well as temperature extremes.

Table 25. Climate Change Policy Index Weight

Index	Subcategory	Weight
Climate Change Policy (20%)	Climate Change Adaptation Policy	15%
	Climate Disaster Restoration Policy	5%

3-1. Climate Change Adaptation Policy

This rating is crucial for a region's ranking in the CCAI because only an active climate policy today enables the realization of a lower level of CO_2 emissions in the future and thereby creates a positive trend.

Metropolitan regions - Seoul, Gangwon-Do, and Daegu appeared to have well prepared policy regarding climate change adaptation, while Incheon, Chungcheongnam-Do, and Chungcheongbuk-Do appeared not to have proper climate change adaptation policies.

Table 26. Index Score of Climate Change Adaptation Policy, 2007

Region	Climate Change Adaptation Policy	
	Index Score	Rank
Seoul	11.65	1
Busan	8.87	5
Daegu	9.70	3
Incheon	5.54	14
Gwangju	9.70	3
Daejeon	6.65	11
Ulsan	6.93	10
Gyeonggi-Do	6.37	12
Gangwon-Do	10.81	2

[8] Local CO_2 Diet (2008)

Chungcheongbuk-Do	1.10	16
Chungcheongnam-Do	5.54	14
Jeollabuk-Do	7.48	8
Jeollanam-Do	8.32	6
Gyeongsangbuk-Do	6.09	13
Gyeongsangnam-Do	7.21	9
Jeju	8.04	7

3-2. Climate Disaster Restoration Policy

The Climate Disaster Restoration Policy Index is also based on the 3-year average ratio of local government restoration expenses to economic losses caused by weather events – storms and floods, as well as temperature extremes. It did not matter whether the restoration expenditure was funded by a central government subsidy or by a local region.

This index measures a local government's policy readiness and restoration performance to climate disaster. Gyeonggi-Do, Gyeongsangnam-Do, and Chungcheongbuk-Do performed well in climate disaster restoration, but Daejeon had a trend rate of -11% implying that its disaster restoration financial resources were not sufficient and the financial resources had decreased in an absolute amount.

Table 27. Index Score of Disaster Damage/ Disaster Restoration, 2007

Region	Disaster Damage against Disaster Restoration Price Rate Score and Rank		
	Trend	Index Score	Rank
Seoul	12%	1.52	15
Busan	39%	2.03	11
Daegu	32%	1.90	12
Incheon	63%	2.48	7
Gwangju	29%	1.84	13
Daejeon	-11%	1.09	16
Ulsan	53%	2.30	10
Gyeonggi-Do	157%	4.26	1
Gangwon-Do	79%	2.79	6
Chungcheongbuk-Do	111%	3.39	3
Chungcheongnam-Do	25%	1.77	14

Jeollabuk-Do	61%	2.45	8
Jeollanam-Do	58%	2.39	9
Gyeongsangbuk-Do	88%	2.96	5
Gyeongsangnam-Do	116%	3.48	2
Jeju	109%	3.35	4

3-3. Climate Change Policy Rank

The Climate Change Policy Index, the weighted sum of the Climate Change Adaptation Policy Index Score and the Climate Disaster Restoration Policy Index Score, shows a local region's determination to climate change adaptation policy planning. The total score of the Climate Change Policy was heavily dependent upon the index score of the Climate Change Adaptation Policy because the score differences in the Climate Disaster Restoration Policy is much less than that of the Climate Change Adaptation Policy among regions.

Gangwon-Do, which had suffered from harsh climate activities, was positioned as the top performer in policy readiness to climate change adaptation.

Table 28. Climate Change Policy Rank, 2007

Region	Climate Change Adaptation Policy		Climate Disaster Restoration Policy		**Sub-Total Score**	**Policy Rank**
	Score	Rank	Score	Rank		
Seoul	11.65	1	1.52	15	13.17	2
Busan	8.87	5	2.03	11	10.90	6
Daegu	9.70	3	1.90	12	11.60	3
Incheon	5.54	14	2.48	7	8.02	13
Gwangju	9.70	3	1.84	13	11.55	4
Daejeon	6.65	11	1.09	16	7.74	14
Ulsan	6.93	10	2.30	10	9.22	11
Gyeonggi-Do	6.37	12	4.26	1	10.63	9
Gangwon-Do	10.81	2	2.79	6	13.60	1
Chungcheongbuk-Do	1.10	16	3.39	3	4.49	16
Chungcheongnam-Do	5.54	14	1.77	14	7.31	15
Jeollabuk-Do	7.48	8	2.45	8	9.93	10
Jeollanam-Do	8.32	6	2.39	9	10.71	7
Gyeongsangbuk-Do	6.09	13	2.96	5	9.05	12

Gyeongsangnam-Do	7.21	9	3.48	2	10.69	8
Jeju	8.04	7	3.35	4	11.39	5

4. Climate Change Adaptation Rank, Year 2007

The CCAI is a proxy metric to climate change adaptation performance, and is comprised of 3 indicators and 18 sub-indicators with design that the mean of the CCAI score is 50 and the maximum is 100 score.

The empirical results showed that the index scores were much lower. The top performer's score was just 60.36. The results also showed that there are small differences in scores: Scores were close to each other and very continuous except for a big gap between the 15th and 16th ranked regions.

The top performer was Daegu followed by Gangwon-Do with a score of 56.99, then Seoul with 56.37, and then Busan with54.01. The comparatively well-developed metropolitan regions with significant financial and human resources for immediate needs to adaptation, except Incheon, Gwangju, and Ulsan generally constituted the top performers.

Exceptions do also exist in rural regions, Gangwon-Do which suffered from harsh weather and geographical conditions, outperformed other regions.

The worst performing regions were Chungcheongbuk-Do with a score of 40.96 then Chungcheongnam-Do with 31.53. Regions that scored poor in CCAI may do so for very different reasons; Ulsan has the distinct disadvantage in adaptation performance due to the existence of heavy and chemical industries in the city, but some regions exhibited worrisome performance in the CCAI. These regions may still neglect the importance of climate change issues and have still not established any initiative.

Table 29. The Climate Change Adaption Rank, Year 2007

The Climate Change Adaption Index of Korea					
Region	CO_2 Emission Trend	Energy Efficiency Level	Climate Change Policy	Final Score	Final Rank
Seoul	35.18	8.01	13.17	56.37	3
Busan	32.79	10.32	10.90	54.01	4

Daegu	38.55	10.20	11.60	60.36	1
Incheon	33.06	9.62	8.02	50.70	9
Gwangju	28.11	10.36	11.55	50.01	10
Daejeon	35.81	10.26	7.74	53.80	5
Ulsan	27.80	8.51	9.22	45.53	14
Gyeonggi-Do	26.75	10.69	10.63	48.08	11
Gangwon-Do	32.06	11.34	13.60	56.99	2
Chungcheongbuk-Do	25.41	11.05	4.49	40.96	15
Chungcheongnam-Do	14.97	9.25	7.31	31.53	16
Jeollabuk-Do	32.39	10.65	9.93	52.98	7
Jeollanam-Do	27.70	7.52	10.71	45.92	13
Gyeongsangbuk-Do	34.17	10.21	9.05	53.44	6
Gyeongsangnam-Do	25.14	11.30	10.69	47.13	12
Jeju	30.10	10.71	11.39	52.20	8

IV. Conclusion

This paper developed a metric index for Climate Change Adaptation. For this purpose, a number of indicators were used as proxies for evaluating energy reduction trend performance, energy efficiency, and concerted policy efforts to climate change adaptation.

The Climate Change Adaptation index measurement will help identify the climate change adaptation performance of 7 metropolitan and 9 rural regions in Korea.

The results show that the top five local regions ranked according to their efforts in the CCAI were Daegu, Gangwon-Do, Seoul, Busan, and Daejeon. The comparatively developed regions that had high GRDP and significant financial and human resources for the environment were the top performers. But there is no room for the front-runners to be relaxed since the CCAI scores of the regions were very low.

The bottom five regions ranked in the descending order of the performance effort were Gyeongsangnam-Do, Jeollanam-Do, Ulsan, Chungcheongbuk-Do, and Chungcheongnam-Do, all of which have a long way to go to catch up the top performers.

The empirical results also showed that the scores were generally low: the highest score was 60.36 and the lowest one was only half of the highest. The empirical results also showed that some local regions exhibited worrisome performances in all three categories – CO_2 Emission

Trend, Energy Efficiency Level, and Climate Change Policy.

These facts may imply that the resulted adaptation performances by 16 regions may not have been performed by the local governments' calculated and systematic solid planning for climate change adaptation, but rather have been the result of randomness unrelated to local government environment policy but the result of regional economic development.

The data for the empirical study, however, showed that there are strong nation-wide tendencies for CO_2 Emission Reduction Trend and Energy Efficiency Level improvement as well as implemention of climate change adaptation policies among regions.

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