

Chapter 5

Technical Roadmap of GEC Evaluation & Analysis

5.1 General Research Organization and Contents

5.1.1 Research Framework

GEC research is a whole new area; there is neither mature research model or methodology, nor existing research contents for reference. Therefore, such researches need to first summarize the related previous researches and then extend the research with more contents and innovation in methodology. GEC is a cross-discipline research involving multiple areas of environmental economics, biology, economics and sociology, which are intricately interrelated; at the same time, we need to rationally define and objectively evaluate GEC, and make innovations in methodology. In this way, we can thoroughly explore the inherent essence of GEC and reveal the laws of GEC evolution. For such a complicated research subject, it requires clear organization and correct research approach, strictly following the designed technical roadmap (See Fig. 5.1) to ensure satisfaction of research standards and quality.

In terms of contents, through substantial literature review and reference to theories about environmentology, economics and management science, the significance and necessity of GEC research is profoundly discussed from different angles; the key contents of this research is to construct the GEC theory system based on the results of previous international researches. Particularly, as a new research area, how to define the term of GEC and how to summarize the characteristics, component factors and motive power of GEC, are the focus and challenge of this study.

As to evaluation methodology, competitiveness research can't be done in separation with evaluation, which requires construction of scientific and objective evaluation model. Any evaluation model and method shows certain degree of subjectivity and orientation, and the contents reflected by such subjectivity and orientation might have certain guiding effect on the development and formation of the evaluated target. GEC evaluation model not only borrows and applies the mainstream methodology for international competitiveness study, but also shows unique features related to the

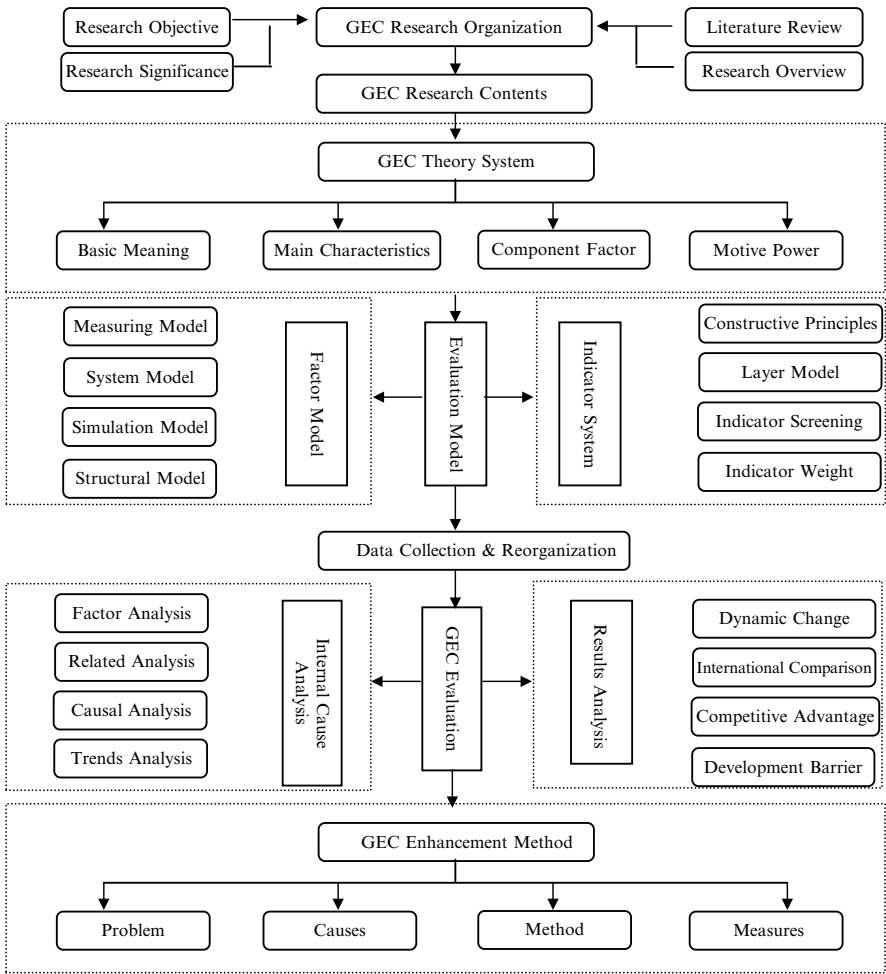


Fig. 5.1 GEC research technical roadmap

characteristics of GEC; it must be able to objectively evaluate the GEC of all countries and reflect the internal mechanism and key points of GEC; the evaluation results should also adequately reflect the philosophy behind the research, which is good to the course of global environmental protection and development of ecological economy and good to the realization of global sustainable development. The evaluation model mainly includes two parts, factor model and indicator system; the former uses quantitative analysis to conduct empirical test on the factors influencing GEC based on the connotations and characteristics of GEC, providing reference to analysis on the driving force of GEC, as the foundation of the GEC evaluation indicator system. The indicator system is the basis of competitiveness evaluation and construction of an indicator system that scientifically and objectively reflects the

connotations of GEC is a very important part of GEC research. Selection of the indicators is not random and must follow definite principles; they are screened out using hierarchical model and weighted according to certain methods after careful investigation. In terms of evaluation methodology, the most mature evaluation technology in competitiveness research is adopted to conduct comprehensive evaluation on the GEC of all countries; evaluation results are also thoroughly interpreted and analyzed, and compared horizontally and vertically. Also under analysis are the comparative advantage and history of each country, the causes for such advantage or disadvantage, and the barriers of enhancing competitiveness. These analyses are not only aiming at evaluation of history and the present, but also the intrinsic factors that influence competitiveness. Judgment and prediction of the trend of competitiveness development is likewise done.

As for application of the evaluation results, focus is put on the integration of theory and practice. Evaluation results are the objective reflections of things and therefore should be used to better guide the development of the things. Of course, evaluation itself is not the purpose, but an instrument; evaluation results are neither simply rankings nor can be more visualized scores to give a better image of GEC. On the one hand, horizontal and vertical comparison of GEC may found out the advantages and disadvantages of all countries, so as to summarize the basic features and trend of development of GEC; thus the key indicators that constrain and influence the GEC of all countries, the weak link and its root, as well as the trends of GEC can all be found out. With these findings, relevant countermeasures can be proposed to help the enhancement of GEC. On the other hand, through GEC evaluation and analysis, it will be good to raise people's awareness of the importance of environmental protection and ecological economic development; awareness of enhancing GEC will be converted into feasible actions to make new contributions to the global sustainable development.

5.2 GEC Indicators Selection and Data Source

5.2.1 Selection of Indicators

Owing to the different understanding of GEC, the designed factor module may be very different, and so are the way to construct the index system and the method to select the indicators; therefore the final evaluation results would be widely divergent. Index system is the core of evaluation and the carrier of evaluation procedures and results; whether or not a complete and objectively applicable index system can be constructed is the key to successful evaluation. First, it is very important to make the process of construction always surround the connotations and definition of GEC. Design of factor module and verification of it are also necessary, because these help to define the scope for selecting indicators and are also the reference for optimization of the index system. Secondly, there must be principles followed during construction of the index system as criteria of screening; only indicators screened

via the principles can be included by the system. Finally, the system layer, factor layer and foundation layer are designed for the index system and each indicator is selected with breaking down of the layers and after several rounds of expert discussions and the final complete GEC evaluation index system is confirmed under repeated consideration. The confirmed index system is composed of 1 index, 5 Sub-index, 16 Pillars and 60 Individual indicators; each of the individual indicators is objective indicator carrying statistical data, which avoids the impact of uncertain and discrete subjective indicators on the impartiality of evaluation results.

5.2.2 Data Collection, Statistics and Calculation

Data are the basic elements of GEC evaluation; the authenticity of data directly influences the quality of evaluation results; therefore, source of data is of vital importance to evaluation results. Although the United Nations has unified the System of National Accounting (SNA) as a reference to all countries, as the countries have different state system and at different stage of development, there will be distinct differences while doing national economic accounting, especially in terms of scope of statistics, statistical range and statistical time period, which severely influences the comparability of even the same indicator in different countries.

In 1993, the United Nations formally released the System of Integrated Environment and Economic Accounting, which is featured in taking SNA as the basis to build satellite accounting covering various natural resources and environmental ecological fields and which connects the accounting of natural resources and environment with the traditional national accounting. This system added large number of estimation methods about resource consumption and reduction and environmental degradation, accompanied with enormous indicators about resources and environment. But, as the theory about resource environment accounting is not mature, practice in this area shows many problems and weaknesses; consequently, many countries failed to establish a complete accounting system, either with incomplete indicators, or inaccurate.

These problems make the selection of indicators and collection of data for this study more difficult, which actually become a bottleneck of GEC evaluation and research. In order to guarantee objectiveness and impartiality of the data source, here are the principles to be followed during selection of indicator and collection of data: (1) Better use a less number of indicators as possible, trying to select the typical indicators that can reflect the influence on GEC in certain aspect and avoiding excessive influence of the indicators on data collection; (2) Select general indicators, or the universally recognized and frequently used indicators in related researches, avoiding using obscure indicators with unclear definition or ambiguity in meaning; (3) Collect data only from international organization sources such as the UN and World Bank to guarantee the uniform scope of statistics and comparability, statistical yearbook of the countries as the alternative source of missing data. Description of the indicators and source of the data are given in [Appendix I](#). The sources listed in the appendix means the key channel of data collection, mainly the

UN, World Bank and International Energy Agency that have provided the majority of data for the countries; but many indicators lack data for certain countries, and these are obtained from the statistical yearbook or government sector official website. As these sources are in great number, details are omitted for convenience.

5.2.3 *Data Extreme Value Analysis*

Among the substantial statistical indicator data, it is inevitable to have some “noise” data (maximum or minimum value), i.e. individual datum that shows big difference from the majority of the data. Such phenomena might be the problem of the indicators due to the wide gap between themselves, or the error during the process of data collection and reorganization. Particularly under current circumstance when the resource environment statistics system is far from sound, statistical survey and method of reorganizing the data might both lead to “noise” data. The numerous indicators in GEC evaluation indicator system involve many entirely new areas, and some, including resource and environment areas, do not have well established sound statistical system; actually, some of the statistical methods are still under modification. These are all challenges for the authenticity and objectivity of the GEC indicator data. In addition, the geographical scope of evaluation covers more than 130 countries widely distributed around the globe and the national conditions in each country are varied; it is quite possible to see data error in the process of accounting. The existence of “noise” data is a negative factor for the evaluation of GEC. Especially, the evaluation adopts comprehensive weighting method, under which the comprehensive competitiveness score is obtained from the weighted score of the lower-layer indicators and the bottommost individual indicator scores are obtained from the non-dimensional value of evaluation samples by efficiency coefficient method; in other words, the score of single indicator will affect the total evaluation score through weighting layer by layer. If some indicator carries maximum or minimum value, the scores of the samples calculated according to the non-dimensional formula by efficiency coefficient method will be enormously different and the distribution of evaluation scores turn to be irrational, which all influences the evaluation result. In addition to analysis on the characteristics of each indicator and making judgment, it is also fully necessary to find possible extreme values of the indicator using appropriate quantitative approach and process the extreme values.

The judgment of extreme value is carries out according to the variance of data distribution. Indicator data shows certain distributional characteristics among the samples and the distance between each datum and their average value always follows certain laws and is related to the standard deviation of the sample data. Suppose data are in normal distribution, then 99.97 % of the data will be distributed within the range of 3 standard deviation of the average value, i.e.:

$$P(|(x - \bar{x}) / \sigma| < 3) = 0.9997$$

$$\sigma = \sqrt{\sum (x - \bar{x})^2 / (n - 1)} \quad (5.1)$$

\bar{x} is the average value of sample data and σ is the standard deviation of sample data. Of course, the actual distribution of indicators would not be strictly in normal state, but according to the Law of Large Numbers, even the indicator data is other state of distribution, such feature also exists. So, if certain sample value of the indicators goes beyond the range of 3 standard deviation of the average value, the value can be judged as the extreme value of the indicator and needs regression to within the range after treatment of re-check and revision.

5.3 GEC Indicator System Correlation Analysis

In the process of GEC evaluation, setting up the index system is a core step. In order to adequately reflect the different factors that influence environmental competitiveness, the index system becomes huge with enormous indicators and covers substantial contents. The merit of such setting is to avoid insufficiency of information because of too small number of indicator and to reflect multiple aspects of GEC. At the same time, such arrangement can prevent improper influence on the evaluation results caused by extraordinary fluctuation of individual indicator, unless the number of indicator is too small; in this way, the evaluation results will be ore stabilized and rational. But, the problem faced during construction of the comprehensive index system is that the indicators, more or less, shows correlation, or, different indicators containing same information; actually, during the process of evaluation, repetition of information is quite often. If the contents reflected by two indicators are similar or of the same nature, then the indicators contain repeated information; and if both of the indicators are included by the indicator system, the consequence is overlapping of indicator and information redundancy, or even contradiction. During evaluation, this part of information would be calculated doubly, which influences the precision of evaluation results. The indicators in the GEC evaluation index system cover multiple aspects including ecological environment, resource environment, environmental management, environmental carrying and environmental harmony, 5 Sub-index, 16 pillars and 60 individual indicators in total. There has been large amount of information commonly reflected by indicators, particularly those, that are related to economic and social activities, very often showing strong correlation in between. This is also bad for analysis on the driving power of competitiveness. Therefore, a correlation analysis on the indicators should be done first. When obvious correlation is diagnosed, relevant treatment is necessary to remove such correlation.

Indicator correlation analysis is a study of whether there is dependent relation between existing phenomena and discussion of the direction and degree of correlation in specific phenomena having dependent relationship; it is a kind of statistical method to study the correlativity between random variables. By the direction of changing in the two variables, correlativity includes positive correlation, negative correlation and

no correlation. (1) Positive Correlation: When one variable increases or decreases, the other variable is also increasing or decreasing and the directions of changing for both variables are the same, which is called positive correlation. (2) Negative Correlation: When one variable increases or decreases, the other variable is also decreasing or increasing and the directions of changing for both variables are opposite, which is called negative correlation. (3) No Correlation: Between two variables, the change in one variable is not related to the change of the other variable; such relationship is also called zero correlation. Of course, such classification is only a simple judgment of the relationship between two variables, which is not precise. A more precise statistical indicator is needed to reflect such relationship between two variables, i.e. using a statistic to reflect the correlation between two variables. According to the type of variable data, different calculation method should be used. GEC indicator system data are continuous variable using scale and dimension of definite proportion and therefore can use “product moment method” to calculate the correlation coefficient, measuring the degree of correlation. This method uses the product of the dispersion of the two variables and the respective mean value, i.e. Pearson’s formula:

$$r_{xy} = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2} \sqrt{\sum (y - \bar{y})^2}} \quad (5.2)$$

x and y are the two variables to be measured in terms of correlation coefficient. r_{xy} is the coefficient, reflecting the statistic of correlativity between x and y , also called simple correlation coefficient. The sign symbol of r_{xy} determines the positive or negative correlation between x and y and the value of r_{xy} is between -1 and 1 . The closer the absolute value is to 1 , the higher the correlation between x and y will be; vice versa, the closer the absolute value of ρ_{xy} is to 0 , the less obvious the correlation between x and y will be. There is reference standard to judge and test the correlativity, by the test statistic of:

$$t = \sqrt{\frac{r_{xy}^2 (n-2)}{1-r_{xy}^2}} \sim t_{\alpha/2} (n-2) \quad (5.3)$$

Although correlativity only reflects the relevancy between two indicators, in a comprehensive indicator system, the relationship between multiple indicators is complicated, mutually influencing and interrelated. Multiple correlation is right the study of correlativity between one variable and another set variables; it can reflect the correlation of multiple indicators. The philosophy behind this is the same as simple correlation coefficient; the larger the value, the closer relation between the variables. It is generally used in multiple regression analysis and suitable for factor analysis.

Through calculation of the correlation coefficients between each layer of indicators, the summarized results after test of significance are given in Table 5.1.

The indicator correlation statistics show that correlation between the original data of some environmental competitiveness indicators is relatively obvious and

Table 5.1 Correlation analysis on GEC indicators

	Indicator type	Number of subordinate indicator	Number of correlation coefficient	Max. value of correlation coefficient	Significance tests of correlation coefficient
Land resources	Pillar	3	3	0.407	2
Water resources	Pillar	4	6	0.858	6
Forest resources	Pillar	3	3	0.454	3
Energy resource	Pillar	4	6	0.564	3
Biodiversity	Pillar	4	6	0.761	6
Ecological safeguard	Pillar	2	1	0.341	1
Air quality	Pillar	5	10	0.879	5
Agricultural carrying	Pillar	3	3	0.419	2
Industrial carrying	Pillar	4	6	0.516	1
Energy consumption	Pillar	4	6	0.876	1
Greenhouse gas	Pillar	4	6	0.143	0
Environmental governance	Pillar	3	3	0.542	2
Environmental safety	Pillar	3	3	0.056	0
Resource utilization	Pillar	4	6	0.243	0
Population and environment	Pillar	6	15	0.960	3
Economy and environment	Pillar	4	6	0.597	2

that the correlation coefficient between the four pillar and the subordinate individual indicators is relatively larger. More number of correlation coefficient that passes the significance test indicates that many original indicators show higher correlation. But, except that the individual indicators show certain correlation, the correlation between sub-index and between pillars are not high, which means little influence on the calculation of comprehensive evaluation score and the reliability of both scores and rankings of GEC.

Appendix I: Indicators in Foundation Layer and Description

Resource Environmental Competitiveness (REC)

Land Resource

- Description:** Land resource refers to the land has been used or can be used by the human being in the foreseeable future. It is the basic means of production and labor objects, and it is the basic place to the society. It reflects the support of resources for economic production.
- Rationale:** It reflects the usage of land resource and the capacity of land resource to be exploited in economic production.

Land Area per Capita

Direction: Positive

Description: Land area per capita=Land area/total population.

Unit: square kilometers/ten thousands

Rationale: Land is the basic material of the national activities, existence and development. And it's the carrier place of the country's resources. Land area per capita reflects the relative abundance of the country's land resources.

Source: <http://data.worldbank.org/indicator>

Percentage of Arable Land to Total Land Area

Direction: Positive

Description: Percentage of arable land to total land area=Arable land area/total land area×100 %. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded.

Unit: %.

Rationale: Arable land is the core part of the land resources, and it's also the most important means of agricultural production. Arable land of the land area reflects the ownership of the land resources can be used for in agricultural production in a country.

Source: <http://data.worldbank.org/indicator>

Arable Land per Capita

Direction: Positive

Description: Arable land per capita=Arable land area/total population. Population is defined by the conventional Description. It includes all residents, except the refugees in the country of refuge. Generally, the refugees are considered part of the population of their native country.

Unit: Hectare.

Rationale: Arable land per capita reflects the situation of the country's arable land relative abundance.

Source: <http://data.worldbank.org/indicator>

Water Resource

Description: Water resource is an essential material to human being and all living. And it's the key resources to the industrial and agricultural production, economic development and environmental improvement. The storage and distribution of water resource is an important content of resources and environment competitiveness.

Rationale: The index can reflect the guarantee degree of a country's water resource on the social life and economic production.

Surface Water

Direction: Positive

Description: Surface water=Surface water produced internally+Surface water entering and bordering. Surface water is water in a river, lake, fresh water wetland, or glaciers and ice sheets.

Unit: billion cubic meters.

Rationale: Surface water is the most important water sources of human being, and it is an important part of water resources to a country. The abundant degree can reflect the competitiveness of a country's water resources.

Source: http://www.fao.org/nr/water/aquastat/water_res/index.stm

Annual Precipitation

Direction: Positive

Description: Annual precipitation=precipitation (mm/year)/1,000,000×land area of the country (1,000 ha)×10. It refers to the quantity of water deposited, in a year, that no leakage, no loss, no evaporation.

Unit: billion cubic meters.

Rationale: Precipitation is the main sources of fresh water resources of a country. It reflects the renewal and supplement of freshwater resources in the country.

Source: http://www.fao.org/nr/water/aquastat/water_res/index.stm

Groundwater

Direction: Positive

Description: Groundwater=Groundwater produced internally+Groundwater entering the country. Groundwater refers to the country's natural groundwater volume.

Unit: billion cubic meters.

Rationale: Ground water is an important part of the available freshwater resources; the abundant degree can reflect the competitiveness of the country's water resources.

Source: http://www.fao.org/nr/water/aquastat/water_res/index.stm

Total Internal Renewable Water Resources

Direction: Positive

Description: Renewable internal freshwater resources flows refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country.

Unit: billion cubic meters.

Rationale: It reflects the country's renewable capability of freshwater resources.

Source: http://www.fao.org/nr/water/aquastat/water_res/index.stm

Forest Resource

Description: Forest can regulate the climate effectively, and conservation the soil.

It can purify the air, eliminate the noise also. It is a kind of intangible resource. It is the place for forest biological diversity. So it is an important content of resources and environment competitiveness.

Rationale: Forest resources can reflect the abundance level of a country's forest resources and biological resources, and the environmental self-purification ability.

Growing Stock in Forest and Other Wooded Land

Direction: Positive

Description: Growing stock refers to volume over bark of all living trees. Volume over bark of all living trees more than X cm in diameter at breast height (or above buttress if these are higher). Including the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches to a minimum diameter of W cm.

Unit: million cubic meters.

Rationale: It is the basic index to reflect forest resources total scale and level, and the forest ecological environment of a country.

Source: <http://www.fao.org/forestry/publications/zh>

Proportion of Land Area Covered by Forest

Direction: Positive

Description: Proportion of land area covered by forest=forest area/land area.

Forest area is land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens.

Unit: %.

Rationale: Proportion of land area covered by forest reflects the abundance level of forest resources, and the country's efforts to achieve green.

Source: <http://data.worldbank.org/indicator>

Forest Area per Capita

Direction: Positive

Description: Forest area per capita=forest area/total population.

Unit: square kilometer.

Rationale: It reflects the forest resources possession per capita. It reflects the relative abundance degree of forest resources to the country.

Source: <http://data.worldbank.org/indicator>

Energy Resource

Description: Energy is the important elements of economic production, because it can provide a large amount of energy for human being, so it is a significant element of the resource and environment competitiveness.

Rationale: Energy resources reflect the ability of the country to maintain the economic production.

Fossil Energy

Direction: Positive

Description: Fossil energy including coal, oil and Natural gas, the reserves refers volume to the proved reserves volume, and all converted into oil equivalents. The coal including Anthracite and bituminous, Sub-bituminous and lignite.

Unit: Mtoe.

Rationale: Fossil energy storage quantity reflects the ability of a country relies on its own reserves energy to maintain economic production.

Source: <http://www.bp.com/productlanding.do?categoryId=9041910&contentId=7075397>

Energy Production

Direction: Positive

Description: Energy production refers to forms of primary energy – petroleum (crude oil, natural gas liquids, and oil from nonconventional sources), natural gas, solid fuels (coal, lignite, and other derived fuels), and combustible renewables and waste – and primary electricity, all converted into oil equivalents.

Unit: thousand toe.

Rationale: It reflects the primary energy production situation, and the energy produced ability to maintain the country's economic production.

Source: <http://data.worldbank.org.cn/indicator/EG.EGY.PROD.KT.OE?display=graph>

Proportion of Combustible Renewables and Waste to Total Energy Consumption

Direction: Positive

Description: Proportion of combustible renewables and waste to total energy consumption=combustible renewables and waste volume÷ total energy consumption.

Combustible renewables and waste comprise solid biomass, liquid biomass, biogas, industrial waste, and municipal waste, measured as a percentage of total energy consumption.

Unit: %.

Rationale: It reflects the renewable capability of the country's resources, and the level of saving the primary energy.

Source: <http://data.worldbank.org.cn/indicator>

Net Energy Imports of the Energy Consumption

Direction: Negative

Description: Net energy imports of the energy consumption=Net volume energy imports/total energy consumption. Net energy imports are estimated as energy consumption less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Energy consumption refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Unit: %.

Rationale: It reflects the relationship between a country's energy consumption and reserves. The degree of net imports is high, which means the level of the country's energy consumption is higher than its energy reserves.

Source: <http://data.worldbank.org.cn/indicator/>

Ecological Environmental Competitiveness (EEC)

Biodiversity

Description: Biodiversity refers to the steady ecological complex composed of various live organism (animal, plant and microorganism) incorporated in regular pattern. It reflects the abundance of biotic resources and also the intricate relations between biotic lives as well as between environments; it even reflects the degree of human influence on ecological system. The species diversity is the key part of biological diversity.

Rationale: Biodiversity is one of the important indicators of EEC. Usually, we choose the number of species interactive in the ecological system, which can reflect the biological resource ownership and has important effects on the improvement of the ecological environment.

Increase of Threatened Fish Species

Direction: Negative

Description: Threatened species is the number of species classified by IUCN as threatened, vulnerable, rare, indeterminate, out of danger or less known species. Increase of threatened fish species = threatened fish species this year – threatened fish species last year.

Unit: species

Rationale: By making a comparison between the threatened fish species in 2 years to reflecting the change trend of fish biodiversity. It could also reflect the threatened fish species increased impacting on the EEC.

Source: Froese, R. and Pauly, D. (eds). 2008, <http://data.worldbank.org/indicator/EN.FSH.THRD.NO/countries>

Increase of Threatened Mammal Species

Direction: Negative

Description: Threatened species is the number of species classified by IUCN as threatened, vulnerable, rare, indeterminate, out of danger or less known species. Increase of threatened mammal species = threatened mammal species this year – threatened mammal species last year.

Unit: species

Rationale: By making a comparison between the threatened mammal species in 2 years to reflecting the change trend of mammal biodiversity. It could also reflect the threatened mammal species increased impacting on the EEC.

Source: <http://data.worldbank.org/indicator>

Increase of Threatened Plant Species

Direction: Negative

Description: Threatened species is the number of species classified by IUCN as threatened, vulnerable, rare, indeterminate, out of danger or less known species. Increase of threatened plant species = threatened plant species this year – threatened plant species last year.

Unit: species

Rationale: By making a comparison between the threatened plant species in 2 years to reflecting the change trend of plant biodiversity. It could also reflect the threatened plant species increased impacting on the EEC.

Source: <http://data.worldbank.org/indicator/EN.HPT.THRD.NO/countries>

GEF Benefits Index for Biodiversity

Direction: Positive

Description: GEF benefits index for biodiversity is a composite index of relative biodiversity potential for each country based on the species represented in each country, their threat status, and the diversity of habitat types in each country. It has many method to figure out the diversity index, like Simpson's diversity index, Shannon-Weiner index. The index has been normalized so that values run from 0 (no biodiversity potential) to 100 (maximum biodiversity potential).

Rationale: GEF benefits index for biodiversity can reflect the level of diversity.

Source: <http://data.worldbank.org.cn/indicator/ER.BDV.TOTL.XQ/countries>

Ecological Safeguard

Description: Ecological safeguard reflects the effects of ecological recovery and reconstruction in a region, usually we use the area of the nature preserve to reflect it; it has big impact on ecological environmental competitiveness.

Rationale: By using the protected areas, it can reflect the influence degree of ecological protection policy initiatives on EEC.

Terrestrial Protected Areas

Direction: Positive

Description: Establishing nature reserves is the most important, economical and effective measures to protect the ecological environment, biological diversity and natural resources. Reserved by law or other effective means of land and related plants and historical and cultural characteristics in order to protect part or all of the enclosed environment. Terrestrial protected areas (% of total territorial area)=Terrestrial protected areas/total area of the territory.

Unit: %

Rationale: It not only reflect the ecosystem service value of preventive use, but also reflect the guarantee ability for sustainable utilization of vulnerable species and long-term stable development. It plays an important role in improving EEC.

Source: http://unstats.un.org/unsd/ENVIRONMENT/marine_and_terrestrial.htm

Marine Protected Areas

Direction: Positive

Description: Marine protected areas are areas of intertidal or subtidal terrain – and overlying water and associated flora and fauna and historical and cultural features – that have been reserved by law or other effective means to protect part or all of the enclosed environment. Marine protected areas (% of territorial waters)=Marine protected areas/territorial waters areas

Unit: %

Rationale: It reflects a country or region to protect the marine environment and natural resources, in accordance with the law to a certain area including the protection of objects, the coast, estuary, wetland, islands or waters with special protection and management area. It plays an important role in improving the EEC.

Source: UN-Environment Statistics Database; <http://data.worldbank.org/indicator/ER.PTD.TOTL.ZS>

Air Quality

Description: Air quality reflects the extent of air pollution, which is based on the concentration of pollutants in the air to determine the level of air quality. The main sources of air pollutants including dust, total suspended particles, Inhalable particles (PM10), particulate matter (PM2.5), nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone and volatile organic compounds.

Rationale: Air pollution is a complex phenomenon, in a specific time and place, the air pollutant concentration is affected by many factors, including vehicle, ship, aircraft exhaust, industrial production emissions, residents living and heating, waste incineration, development density, city land topography and weather. with this index, it can affect the degree of air pollution on the ECC.

Inhalable Particles Matter (PM10)

Direction: Negative

Description: Inhalable particles matter (PM10) can stay in ambient air for a long time which has great influence on human health and atmospheric visibility. Estimated value represents the annual average exposure level of outdoor particles by common urban residents. It can use the LD-5 laser to test the PM10.

Unit: ug/M³

Rationale: It can reflect the influence of inhalable particulate matter on human disease, air visibility and health and growth of the plant. It is an important index to measure the air quality, which can reflect the degree of influence on the ECC.

Source: <http://data.worldbank.org/indicator>

Particulate Matter (PM2.5)

Direction: Negative

Description: Particulate matter (PM2.5) refers to the diameter of particles in the atmosphere is less than or equal to 2.5 ug. It mainly comes from the residues of daily power, industrial production process, car emissions after combustion and emissions, mostly contain heavy metals and other toxic substances. It can use the LD-5 laser to test the PM2.5.

Unit: 10 ug/m³

Rationale: PM2.5 has an important influence on air quality and visibility, it contains large amounts of toxic, harmful substances, therefore, it has great influence on human health and atmosphere quality. It is an important cause of air pollution, so it can be used to reflect the particles impact on the ecological environment competitiveness.

Source: NASA Goddard Data and Applications Center; NASA Socioeconomic Data and Applications Center hosted by CIESIN at Columbia University

Index of Indoor Air Pollution

Direction: Negative

Description: Indoor air pollution is harmful chemical factor, physical factor and (or) biological factor entering into the indoor air and has reached directly or indirectly, short-term or long-term to the body and mind health. Index of indoor air pollution is a form which it changed several indoor air pollutions into one. The higher of the index, the more serious in pollution, the more obvious effects on human health.

Unit: %

Rationale: People usually spend more than 80 % of the time in indoors. It reflects all kinds of harmful substances such as formaldehyde, benzene, ammonia, radon and radioactive impact on human health, this index can reflect the extent of its influence on a country or a region's EEC.

Source: WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation

Nitrogen Oxides Emission

Direction: Negative

Description: Common nitrogen oxides include nitrogen monoxide (NO, colorless), nitrogen dioxide (NO₂, reddish brown), laughing gas (N₂O) and dinitrogen pentoxide (N₂O₅). Nitrogen oxides discharged due to human activities mostly come from the combustion process of fossil fuel, such as the combustion process in car, airplane, internal combustion engine and commercial-size kiln, and particularly from production and the process of using nitric acid, such as nitrogen fertilizer factory, organic intermediate factory, and nonferrous and ferrous metal smelters.

Unit: Tons of carbon dioxide equivalent.

Rationale: Nitrogen oxides influence human health by respiratory tract invasion. It is not only one of the main factors in the air quality, but also one of the air pollutants which can be used to reflect the nitrogen oxide content effects on the ECC.

Source: <http://unstats.un.org/>

Sulfur Dioxide Emission

Direction: Negative

Description: As coal and petroleum normally contain sulfur compounds, they produce sulfur dioxide while burning, mainly the sulfur dioxide produced during industrial process. We usually use the Material balance method to count it.

Unit: kg

Rationale: Sulfur dioxide will produce industrial smoke, which can stimulate the human respiratory system, Therefore, it can reflect the degree of influence on the ECC.

Source: <http://unstats.un.org/>

Smith et al. 2001; World Development Indicators; CIA Factbook

Environmental Carrying Competitiveness (ECC)

Agricultural Carrying

Description: Agriculture is the basic source of food and other subsistence. It inevitably involves the exploitation and protection of land resources, water source. Agricultural carrying is an important part of the environmental bearing capacity and has a direct influence on it.

Rationale: It reflects the influence of agricultural production on the vegetation, soil and water and so on, and also reflects the influence on the environmental carrying competitiveness.

Cereal Yield per Unit of Arable Land

Direction: Positive

Description: Cereal yield per unit of arable land=Cereal yield/arable land area. Cereal yield includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Production data on cereals relate to crops harvested for dry grain only. Cereal crops harvested for hay or harvested green for food, feed, or silage and those used for grazing are excluded.

Unit: kg/hectare.

Rationale: This indicator reflects the circumstances to maintain the soil fertility, and the influence of farming on the ecological environment.

Source: <http://data.worldbank.org/indicator>

Fertilizer Consumption per Unit of Arable Land

Direction: Negative

Description: Fertilizer consumption per unit of arable land=Fertilizer consumption/arable land area. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). Traditional nutrients-animal and plant manures-are not included.

Unit: kg/hectare.

Rationale: In the process of agricultural production, fertilizer use will be a great impact on arable soil, thereby affecting the ecological environment. This indicator, which measures the fertilizer usage per unit of arable land, reflects the influence of fertilizer usage on soil quality and the environmental bearing capacity.

Source: <http://data.worldbank.org/indicator>; <http://www.nationmaster.com>

Annual Freshwater Withdrawals for Agriculture per Unit of Arable Land

Direction: Negative

Description: Annual freshwater withdrawals for agriculture per unit of arable land=Annual freshwater withdrawals for agriculture/arable land area. Annual freshwater withdrawals refer to total water withdrawals, not counting evaporation losses from storage basins. Withdrawals also include water from desalination plants in countries where they are a significant source. Withdrawals for agriculture are total withdrawals for irrigation and livestock production.

Unit: cubic meters/hectare.

Rationale: In the agricultural production process, the use of fresh water will directly affect the quality of the environment. This indicator, which measures the freshwater withdrawals per unit of arable land, reflects the utilization of freshwater resources in the agricultural production process and also reflects the impact on the environment.

Source: <http://data.worldbank.org/indicator>

Industrial Carrying

Description: Industrial production is the most important human activity and the main source of consuming resource and environment. Industrial bearer is an important part of the environmental carrying capacity and has a great influence on it.

Rationale: It reflects the resource consumption of industrial production and its impact on air quality and environmental carrying competitiveness.

Exports as a Percentage of GDP

Direction: Negative

Description: Exports as a percentage of GDP = $\text{export of goods} / \text{GDP} \times 100 \%$.

Unit: %.

Rationale: The industrial products are the main export goods and consume large amount of energy and resource. This indicator reflects the resources consumption of the industrial production and the impact on the environmental bearing capacity.

Source: UN-Commodity Trade Statistics Database; <http://www.fmprc.gov.cn>

Electric Power Consumption per Unit of Value Added of Industry

Direction: Negative

Description: Electric power consumption per unit of value added of industry = $\text{Electric power consumption} / \text{value added of industry}$. Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants.

Unit: kWh/U.S. dollar.

Rationale: The industrial production consumes a lot of electric power, in essence, that it consumes a lot of energy and will have a great impact on the environment. This indicator reflects the utilizing efficiency of electric power in the industrial production process and the impact on the natural environment.

Source: <http://data.worldbank.org/indicator>

SO₂ Emissions per Unit of Value Added of Industry

Direction: Negative

Description: SO₂ emissions per unit of value added of industry = $\text{SO}_2 \text{ emissions} / \text{value added of industry}$

Unit: kg/U.S. dollar.

Rationale: In the industrial production process, it is inevitable to emit some pollutant gases. And the sulfur dioxide is an important pollution gas, causing great harm to the environment. This indicator reflects the emissions intensity of SO₂ in the industrial production process, and further reflects the influence of industrial industry on the environment.

Source: <http://unstats.un.org/>; CIA Factbook

Annual Freshwater Withdrawals for Industry per Value Added of Industry

Direction: Negative

Description: Annual freshwater withdrawals for industry per value added of industry=Annual freshwater withdrawals for industry/value added of industry. Freshwater withdrawals for industry are total withdrawals for direct industrial use (including withdrawals for cooling thermoelectric plants).

Unit: cubic meters/U.S. dollar.

Rationale: The industrial production will consume a large amount of freshwater resources, and thus have a great impact on the natural environment. This indicator reflects the utilization of freshwater resources in the industrial production process, and also reflects the impact on the environment.

Source: <http://data.worldbank.org/indicator>

Energy Consumption

Description: Currently, the countries need to consume large amounts of energy, mainly fossil energy. It causes great pressure on the environment and has an important influence on the environmental bearing capacity.

Rationale: It reflects the influence of human production and life on the energy and environment, and further reflects the impact on the environmental bearing competitiveness.

Energy Consumption per Unit of Land Area

Direction: Negative

Description: Energy consumption per unit of land area=Energy consumption/land area. Energy consumption refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Unit: Mtoe/square km.

Rationale: This indicator reflects the country's bearing capacity on the energy consumption. It also reflects the influence of energy consumption on the environmental bearing competitiveness.

Source: IEA: <2012 Key World Energy Statistics> <http://data.worldbank.org/indicator>

Ratio of Clean Energy Consumption

Direction: Positive

Description: Ratio of clean energy consumption=clean energy consumption/energy consumption×100 %. Clean energy refers to the non-carbohydrate energy sources which do not produce carbon dioxide in the generation process, including hydro, nuclear, geothermal and solar energy.

Unit: %.

Rationale: Different types of energy have different effects on the environment. The clean energy is clean and will not produce pressures on the ecological environment. This indicator measures the country's energy consumption structure, and reflects the impact on the environmental bearing capacity.

Source: IEA: <2012 Key World Energy Statistics> <http://www.tititudorancea.com>

Elasticity of Energy Consumption

Direction: Negative

Description: Elasticity of energy consumption = growth rate of energy consumption / growth rate of GDP.

Rationale: The countries have different energy consumption demands because of the different economic developments. This indicator reflects each country's demand for energy consumption and its impact on environmental bearing capacity.

Source: IEA: <2012 Key World Energy Statistics> <http://data.worldbank.org/indicator>

Elasticity of Electric Power Consumption

Direction: Negative

Description: Elasticity of electric power consumption = growth rate of electric power consumption / growth rate of GDP.

Rationale: The countries have different electric power consumption demands because of the different economic developments. This indicator reflects each country's demand for electric power consumption and its impact on environmental bearing capacity.

Source: <http://data.worldbank.org/indicator>

Greenhouse Gases

Description: Greenhouse Gases has an important impact on human activities and may even lead to ecological disaster. Its impact on the environment bearing capacity can not be ignored.

Rationale: The climate change reflects the impact of human activities on the natural environment and the environmental bearing competitiveness.

Growth Rate of CO₂ Emissions**Direction:** Negative**Description:** Growth rate of CO₂ emissions = $\frac{\text{CO}_2 \text{ emissions} - \text{CO}_2 \text{ emissions}_{(-1)}}{\text{CO}_2 \text{ emissions}_{(-1)}} \times 100 \%$. Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.**Unit:** %.**Rationale:** Carbon dioxide is the most important greenhouse gas. The change of carbon dioxide emissions directly reflects the influence of human activities on climate change. This indicator reflects the change of the bearing capacity on the carbon dioxide emissions.**Source:** IEA: <2012 Key World Energy Statistics>

Growth Rate of Methane Emissions

Direction: Negative**Description:** Growth rate of Methane emissions = $\frac{\text{Methane emissions} - \text{Methane emissions}_{(-1)}}{\text{Methane emissions}_{(-1)}} \times 100 \%$. Methane emissions are those stemming from human activities such as agriculture and from industrial methane production.**Unit:** %.**Rationale:** Methane is an important greenhouse gas. The change of Methane emissions also reflects the influence of human activities on climate change. This indicator reflects the change of the bearing capacity on the methane emissions.**Source:** UN-Greenhouse Gas Inventory DataCO₂ Emissions per Unit of Land Area**Direction:** Negative**Description:** CO₂ emissions per unit of land area = $\frac{\text{CO}_2 \text{ emissions}}{\text{land area}}$.**Unit:** Million tons/square km**Rationale:** This indicator reflects the country's bearing capacity on the carbon dioxide emissions. It also reflects the influence of carbon dioxide emissions on the environmental bearing competitiveness.**Source:** IEA: <2012 Key World Energy Statistics>CO₂ Emissions per Unit of Energy Consumption**Direction:** Negative**Description:** CO₂ emissions per unit of energy consumption = $\frac{\text{CO}_2 \text{ emissions}}{\text{energy consumption}}$.**Unit:** Million tons/Mtoe

Rationale: The carbon dioxide emissions mainly come from the energy consumption. This indicator measures the carbon dioxide emission intensity of the energy consumption and reflects the influence of energy consumption on climate change.

Source: IEA: <2012 Key World Energy Statistics>

Environmental Management Competitiveness (EMC)

Environmental Governance

Description: Environmental governance refers to the human activities, in order to achieve the desired environmental objectives, of governing the natural environment through the institution, control, supervision and so on. The effective environmental governance can reduce the negative impact of human activities on the environment, and improve the environmental conditions making the environmental systems working well.

Rationale: This indicator measures the country's governance and supervision level on the natural environment. It reflects the country's positive influence on the natural environment and the efforts to protect and improve the environment.

Agricultural Chemicals Regulation

Direction: Positive

Description: It refers to the regulation implement and supervision on the use of agricultural chemicals.

Rationale: The better or the worse of pesticide regulation in agricultural production can directly reflect the impact of pesticide in water, atmosphere, soil, vegetation and related biological ecological environment.

Source: UNEP-Chemicals; <http://chartsbin.com/view/1473>

Percentage of the Rural Population with Access to an Improved Water Source to Rural Population

Direction: Positive

Description: Percentage of the rural population with access to an improved water source to rural population = rural population with access to an improved water source / rural population $\times 100$ %. Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs.

Unit: %.

Rationale: The governance of rural water is an important part of environmental management and protection. This indicator reflects the basic situation of rural water sources, and also shows the protection and improvement of water quality of rural water source.

Source: <http://data.worldbank.org/indicator>

Percentage of the Urban Population with Access to an Improved Water Source to Urban Population

Direction: Positive

Description: Percentage of the urban population with access to an improved water source to rural population = urban population with access to an improved water source / urban population $\times 100$ %.

Unit: %.

Rationale: The governance of urban water is an important part of environmental management and protection. This indicator reflects the basic situation of urban water sources, and also shows the protection and improvement of water quality of urban water source.

Source: <http://data.worldbank.org/indicator>

Ecological Protection

Description: Ecological protection reflects the effects of ecological recovery and reconstruction in a region; it has big impact on ecological environmental competitiveness.

Rationale: It can reflect the influence degree of ecological protection policy initiatives on EEC through the efforts to protect and improve the ecological environment.

Biome Protect

Direction: Positive

Description: Biological communities mean all kinds of creatures which live in certain natural areas have direct or indirect relation between them. Biome protect = Biome protect species / Biome species.

Unit: %.

Rationale: It not only reflects the community species diversity, community growth form, the number of different species of dominant species, the relative proportion of features, but also reflects the degree of influence on the EEC.

Source: UNEP World Conservation Monitoring Centre; World Wildlife Fund USA

Area of Plantation and Afforestation

Direction: Positive

Description: Planted forests are composed of trees established through planting and/or through deliberate seeding of native or introduced species.

Rationale: This indicator of planted forest can show the effort to fix a large amount of carbon dioxide and other greenhouse gases, to slow global warming, to improve the environment.

Source: <http://www.fao.org/forestry/fra/fra2010/en/>

Overfishing of Fishing Resources

Direction: Negative

Description: Catching and fishing from offshore fishery resources influence the normal reproduction of fish stock and cause decrease of species and reduction in quantity.

Rationale: If the management of overfishing on fishery resources is not enough, it will destroy the marine ecological environment, thus it will seriously affect the sustainable development of marine fishery resources.

Source: Sea Around Us Project, Fisheries Centre, University of British Columbia

Resource Utilization Resources

Description: Resource utilization refers to the exploitation, allocation and use of natural resources by humans. It is an important part of environmental management to rationally and effectively optimize the allocation of resources and improve the utilization efficiency of resource, and it produces an important impact on environmental management competitiveness.

Rationale: Modern economy must consume the natural resources. And it is inevitable to face the over-exploitation of resources, environmental pollution and damage. This indicator reflects the country's utilization states of various resources and the influence of resource utilization on resources and environment.

Utilization Rate of Water

Direction: Negative

Description: It refers to the ratio of water consumption to the total water resources in the drainage basin or region.

Unit: %.

Rationale: The indicator is to test the country's use of water resources, reflecting the degree of exploitation and utilization of water resources. The international community generally believes that the exploitation and utilization of a river can not exceed 40 % of its water resources.

Source: <http://unstats.un.org/>

Percentage of Total Internal Renewable Water Resources to Total Water Resources

Direction: Positive

Description: Percentage of total internal renewable water resources to total water resources = $\frac{\text{total internal renewable water resources}}{\text{total water resources}} \times 100 \%$.

Unit: %.

Rationale: This indicator reflects the renewable capability of freshwater resources in the process of using water resource, and also reflects the effect of wastewater treatment and water recycling.

Source: <http://data.worldbank.org/indicator>; http://www.fao.org/nr/water/aquastat/water_res/index.stm

Percentage of Agricultural Land to Total Land Area

Direction: Positive

Description: Percentage of agricultural land to total land area = $\frac{\text{agricultural land area}}{\text{total land area}} \times 100 \%$. Agricultural land refers to the land that is arable, under permanent crops, and under permanent pastures.

Unit: %.

Rationale: It can not achieve the good protection and management of ecological environment without the exploitation and protection of land resources, especially agricultural land. Compared to the non-agricultural land, the agricultural land is relatively more conducive to the protection of the ecological environment. This indicator reflects the influence of the exploitation and utilization of agricultural land on the environment.

Source: <http://data.worldbank.org/indicator>

Percentage of Fossil Fuel Energy Consumption to Total Energy Consumption

Direction: Negative

Description: Percentage of fossil fuel energy consumption to total energy consumption = $\frac{\text{fossil fuel energy consumption}}{\text{total energy consumption}} \times 100 \%$. Fossil fuel comprises coal, oil, petroleum, and natural gas products.

Unit: %.

Rationale: Fossil fuel is the primary energy. It supports the country's economic and social development, but it causes a great impact on the environment. This indicator reflects the utilization state of fossil fuel energy and its impact on the environment.

Source: <http://data.worldbank.org/indicator>

Environmental Harmony Competitiveness (EHC)

Population and Environment

Description: There is interdependence between population and environment influence each other close relationships.

Rationale: This index can reflect the degree of coordinated development of population and the environment.

Improved Sanitation Facilities (% of Population with Access)

Direction: Positive

Description: Improved sanitation facilities (% of population with access)=the population access to improved sanitation facilities/mid-year population. Access to improved sanitation facilities refers to the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection.

Unit: %.

Rationale: Improved sanitation facility is one of the important contents to protect basic survival and development of members of society. It is not only able to protect human health, but also to protect the ecological environment. Improved sanitation facilities (% of population with access) reflect the coordinated development degree between population and the environment.

Source: World Health Organization and UNICEF Joint Monitoring Programme (JMP) (<http://www.wssinfo.org/>)

Motor Vehicles (per 1,000 People)

Direction: Negative

Description: Motor vehicles (per 1,000 people)=Motor vehicles/mid-year population. Motor vehicles include cars, buses, and freight vehicles but do not include two-wheelers. Population refers to midyear population in the year for which data are available.

Unit: vehicles per 1,000 people.

Rationale: Automobile exhaust emissions are important sources of carbon emissions, causing serious air pollution, endangering human health and environmental effects. With population expansion and the increase in car ownership, car and environment, energy and other related contradictions have become increasingly prominent. Motor vehicles (per 1,000 people) can be a reflection of the population impact on the environment.

Source: <http://data.worldbank.org/indicator>

Renewable Internal Freshwater Resources per Capita

Direction: Positive

Description: Renewable internal freshwater resources per capita = Renewable internal freshwater resources / mid-year population. Average renewable internal freshwater resources calculated by mid-year population. Renewable internal freshwater resources flows refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country.

Unit: cubic meters per capita

Rationale: Fresh water as a renewable resource, mainly recharged by atmospheric precipitation. With the increase in population and economic development, freshwater resources are becoming scarce. Economical use of freshwater resources, reduce pollution and improve renewable freshwater resources per capita ownership for achieving the coordinated development of population and the environment has important significance.

Source: FAO, Agriculture and Water Information System (AQUASTAT)

SO₂ Emissions (metric tons per capita)

Direction: Negative

Description: SO₂ emissions (metric tons per capita) = SO₂ emissions / mid-year population. Average SO₂ emissions calculated by mid-year population. Sulfur dioxide emissions are mainly industrial enterprises in the fuel combustion and production processes in the atmosphere of total sulfur dioxide.

Unit: metric tons per capita

Rationale: Sulfur dioxide is one of the main pollutants in the atmosphere. It is an important indicator to measure whether there has been an atmospheric pollution. Sulfur dioxide emissions not only damage to human health, but also to the ecosystems and agriculture, forestry, aquatic resources. Sulfur dioxide emissions per capita reflect the harmful levels to human and ecological environment.

Source: <http://unstats.un.org/>; CIAFactbook

CO₂ Emissions (metric tons per capita)

Direction: Negative

Description: CO₂ emissions (metric tons per capita) = CO₂ emissions / mid-year population. Average carbon dioxide emissions calculated by mid-year population. Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.

Unit: metric tons per capita

Rationale: Carbon dioxide accounted for 50 % of the effect of global warming. The total population has an incremental effect on carbon dioxide emissions, the more the population, the more energy and resource consumption, carbon dioxide emissions will be greater. CO₂ emissions per capita reflect the impact of human activities on climate level. It has an important role for promoting the development of low-carbon economy.

Source: IEA: <2012 Key World Energy Statistics>

Energy Consumption per Capita

Direction: Negative

Description: Energy consumption (kg of oil equivalent per capita)=Energy consumption/mid-year population. Average energy consumption calculated by mid-year population. Energy consumption refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Unit: kg of oil equivalent per capita

Rationale: The total consumption of energy is strictly related to the volume of population of one country or area, and due to the difference of population in different countries, the indicator of total consumption of energy cannot reveal the difference of level of consumption, so the indicator of energy consumption per GDP can more accurately express the level of consumption of energy and its variation trend.

Source: IEA: <2012 Key World Energy Statistics>

Economy and Environment

Description: Economy and the environment is a system of two factors. The two have the dialectic relationship of the unity of opposites.

Rationale: Reflect the degree of coordinated development of economy and environment.

Land Resource Utilization Efficiency

Direction: Positive

Description: Land resource utilization efficiency=GDP/Land area. Land area per unit of GDP (PPP) is gross domestic product converted to international dollars using purchasing power parity rates.

Unit: USD/sq km

Rationale: The land resource utilization efficiency can not only tell the economic discrepancy of different countries and areas, but also the degree of industrialization

and pollution of one country or area, so as to reveal the coordinated development of economy and environment in different countries and areas.

Source: <http://data.worldbank.org/indicator>

Sulfur Dioxide Emissions per Unit of GDP

Direction: Negative

Description: Sulfur dioxide emissions per unit of GDP = Sulfur dioxide emissions / GDP. Calculated per unit of GDP by sulfur dioxide emissions. PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates.

Unit: metric tons per \$1,000 GDP

Rationale: The emission of sulfur dioxide per GDP is an important indicator of the quality of economic development. By using such indicator as intensity of the emission of sulfur dioxide per GDP, we can have the idea of happiness and well-being and economic transformation and the development of human living areas of one country.

Source: <http://unstats.un.org/>; CIA Factbook

Carbon Dioxide Emissions per Unit of GDP

Direction: Negative

Description: Carbon dioxide emissions per unit of GDP = Carbon dioxide emissions / GDP. Calculated per unit of GDP by carbon dioxide emissions. PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates.

Unit: metric tons per \$1,000 GDP

Rationale: The emission of sulfur dioxide per GDP is an important indicator of the achievement of controlling of the emission of carbon dioxide and slowing down the climate change. The data reveal that emission of carbon dioxide increases in proportion to the GDP per capita. By using the emission of carbon dioxide per GDP, we can guide the different countries and areas to emit less carbon dioxide while achieving the economic growth, so as to promote the sustainable development of economy, society and environment.

Source: IEA: <2012 Key World Energy Statistics>

Energy Consumption per Unit of GDP

Direction: Negative

Description: Energy consumption per unit of GDP = Energy consumption / GDP. GDP per unit of energy consumption is the PPP GDP per kilogram of oil equivalent of energy consumption. PPP GDP is gross domestic product converted to

current international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as a U.S. dollar has in the United States.

Unit: kg of oil equivalent per \$1,000 GDP

Rationale: Energy consumption per unit of GDP is a main indicator that reveal the level of energy consumption and energy saving, which can also reveal energy consumption efficiency and dependence. It expresses the use of energy of one country or area, and the change of economic structure and energy using structure, which could guide one country or government to make appropriate policies to save energy.

Source: IEA: <2012 Key World Energy Statistics>

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