Evaluation Index System of Urban Ecological Safety

I Preface

Urbanization is the product of human's socio-economic and cultural development and a symbol of social development trend and civilization. The process of urbanization gradually made humans separated from natural ecosystems to form a human-centered urban ecosystem. Urban ecosystem is the synthesized system of society, economy and nature. Natural and environmental elements are the basis of the survival and development of cities. Economic activities and metabolic process are the vitality and lifeline of cities. Human's social behaviors and cultural concepts are the power pump of cities' succession and evolution. The acceleration of urbanization makes natural ecosystem increasingly threatened by urban development. Deforestation, farmland occupation and environmental pollution have severely damaged natural ecosystem and gradually weakened the service function of ecosystem. Human's existence is seriously threatened, which prompts people to focus on issues of urban ecological safety.

Ecological safety refers to the state that human's life, health, happiness, basic rights, source of life security, necessary resources, social orders and abilities in adapting to environment changes are not threatened, which includes natural ecological safety, economical ecological safety and social ecological safety. These form a composite artificial ecological safety system (IASA, 1989). As an important part of the research of ecological safety, the research on urban ecological safety, is aimed to establish a sound structure of urban ecological system, promote the harmonious coexistence of the three dimensions of "society-economy-natural ecology", ease the damages to natural ecology caused by economic and social development, improve and strengthen the recovery capability of ecological system, make human beings' urban utilization methods and degrees suitable to the development process of ecological system and to realize the aim of building a well-constructed, functional and effective and ecologically safe urban operation system.

In conclusion, urban ecological system is a comprehensive and dynamic compound system. The drive of urban development is social and economic development. The excessive consumption of natural resources and ecological capacity caused by the development of society and economy is the root of urban ecological problems. In view of this, the three key components of urban ecological system are “economic-social-natural ecology”. The dynamic process of urban ecological system is “steady state of ecological system-impact and damage-improvement and repairing”. Based on the above conclusions the evaluation index system of urban ecological safety is made. This index system includes three dimensions of the health of urban ecological safety, the vulnerability of urban ecological system and the capacity of sustainable development. Each dimension is further broken down based on the three key components of “economic-social-natural ecology”. These principles can guarantee that the evaluation index system can include the key elements of urban ecological system and reflect the coupling relationships of the three dimensions of “economic-social-natural ecology” and at the same time it can reflect the relativity and development features to represent the evolution trends and development directions.

II Objectives

In order to raise the awareness of urban ecological safety of all countries in the world and to promote the construction of urban ecological safety system, UN-HABITAT and International Ecological Safety Collaborative Organization launched the program of “ecological safety ranking of cities in the world”. An important part of this program is to design an evaluation index system of urban ecological safety to evaluate urban ecological safety. Considering that the aims of urban ecological safety are the harmonious and sustainable development of the system of economic-social-natural ecology, the design of the evaluation index system of urban ecological safety tries to target international cities and reflect the urban characteristics of comprehensiveness and integration to fully cover the three dimensions of urban economic-social-natural ecology and the health and vulnerability of ecological safety. The design should also

draw on and absorb the key elements of international ecological safety researches to strive to make the system full of urban and safe characteristics and applicable for international cities. The use of the evaluation index system of urban ecological safety can not only provide standards for the horizontal comparison of ecological safety of cities in the world but also provide a scientific and objective evaluation tool for target cities to recognize their conditions of ecological safety and the evolution trends of ecological system. This evaluation index system also strives to become the academic language for target cities in internal communications and external communications and a tool of communication of professionals, government officials and the public to meet the challenge of urban ecological safety construction and formulate relevant policies.

III Principles

It is necessary to know the conditions of ecological safety for the sustainable development of cities, which is the basis for correct decisions. Objective evaluation should be guided by scientific evaluation principles. Urban ecological safety evaluation should follow the following principles:

(1) Scientific principle

The index system should be based on science to reflect the conditions of urban ecological system and the relations of each dimension and index objectively and truly and to measure the realization degree of targeted objectives.

(2) Integrated principle

Since ecological system is an organic system, the index system is to reflect the comprehensiveness of the system in the real sense. In selecting evaluation indexes, evaluation aim and indexes should be connected to form an entirety with a clear structure to guarantee the reliability of the evaluation results.

(3) Hierarchical principle

Urban ecological safety is a compound system influenced by multiple factors. In order to make a complete description of the overall system, the system should be divided

into several stages and the indexes are also designed according to these stages. The higher the stage is, the more comprehensive the index is; and the lower the stage is, the more concrete the index is.

(4) Operational principle

The selection of the evaluation indexes should take into account of the measurability, comparability, availability and popularity of the indexes. Only in this way, the indexes can be effective.

IV. Index System

The evaluation index system of urban ecological safety consists of three main dimensions of health evaluation of urban ecological safety system, toughness evaluation of urban ecological system and development capacity evaluation of urban ecological system, ten secondary dimensions and 81 indexes.

Evaluation index system of urban ecological safety

No.	Dimensions	Indexes
1	Economic operation quality	The percentage of tertiary industry employment（%）
2		Industrial added value rate（%）
3		The percentage of local fiscal revenues in GDP（%）
4	Economic development environment	Urbanization rate（%）
5		Social labor productivity（yuan/ per capita）
6		Inflation rate（%）
7		The percentage of the tertiary industry in all industries（%）
8	Population and	Population density（per capita /square kilometers）

9	employment	Natural population growth rate（%）
10		Population aging rate（%）
11		Employment rate（%）
12	Social security	The percentage of population below the poverty line（%）
13		The coverage percentage of minimum living security（%）
14		The ratio of basic pension insurances and expenditures
15		The ratio of basic medical insurances and expenditures
No.	Dimensions	Indexes
16	Quality of people's lives	Urban residents' Engel coefficient（%）
17		Consumer price index（CPI）
18		Gini coefficient
19		Education index（EI）
20		The number of doctors for ten thousand people
21		Average living space per person（square meter/ per capita）
22	Natural environment	Relief Amplitude（m)
23		annual mean precipitation（mm）
24		annual mean temperature difference（℃）
25	Natural carbon sinks	Vegetation index
26		Forest coverage index
27		The percentage of green lands in parks（%）

28		The percentage of water conservation areas（%）
29	The pressure of economic system	Energy consumption per GDP（tons of standard coal/ten thousand yuan）
30		Solid waste emission for ten thousand yuan GDP
31		Waste water emission for ten thousand yuan GDP
32		Waste gas emission for ten thousand yuan GDP
33	The pressure of living service	The density of airborne respirable particulate matter(PM10)（milligram/cubic meter）
34		Daily water consumption per capita（cubic meter / per capita •day）
35		The daily electricity consumption per capita （kilowatt-hour / per capita •day）
36		The daily garbage emission per capita（ton/ per capita •day）
37		The daily sewage emission per capita（cubic meter/ per capita •day）
38		The equivalent sound level of environment noises db(A)
39	Social order and safety	rate of occurrence of criminal cases for ten thousand people （case/ ten thousand people）
40		The rate of traffic causalities per year for ten thousand people（person/ ten thousand people）
41		The rate of fire causalities per year for ten thousand people（person/ ten thousand people）
42	System guarantee	Frequency of natural disasters（frequency/day）

43		Area of land degradation（square kilometers）
44		The terrain deformation areas（square kilometers）
45	Transportation safety	Road area per capita（cubic meter/ per capita）
46		Parking spaces for ten thousand people（number）
47		Traffic monitoring per kilometer（number）
48		Population accident rate（number/one hundred thousand people）
49	Production safety	Output of industrial land per unit area（100 million/square kilometers）
50		Primary energy self-sufficiency rate（%）
51		The percentage of added value of energy saving industries in GDP（%）
No.	Dimensions	Indexes
52	Living safety	Urban density（%）
53		Living space per capita（square meters/ per capita）
54		The ratio of high-risk residential area（%）
55	Living safety	Coverage of affordable housing（%）
56		The popularizing rate of gas（%）
57	Planning results	The number of eco-industrial park（number）
58		The number of national forest park（number）
59		The number of non-material cultural heritage（number）
60	Disposal safety	The rate of comprehensive utilization of solid waste（%）
61		The compliance rate of Wastewater discharge（%）

62		The compliance rate of smoke and dust emission（%）
63	Disposal safety	The harmless treatment of garbage（%）
64		The safe disposal rate of hazardous waste, heavy metals and persistent organic pollutants（%）
65	Early warning capability	The soundness of emergency plan system
66		The soundness of emergency command decision-making institutions
67		The openness of emergency information system
68	Rescue capability	The responsiveness of emergency departments
69		The raising and configuration speed of special funds
70		The arriving speed of disaster relief and reconstruction supplies
71		The disclosure and release speed of emergency information
72	Reconstruction capability	The percentage of earmarks in GDP（%）
73		Reconstructions speed
74		The quality of engineering projects
75	Management capability	The openness of resources and environment information（%）
76		The implementation rate of planning environmental impact assessment （%）
77	ecological restoration	The percentage of environmental investment in GDP（%）

78		The total investment of environmental management（ten thousand yuan）
79		The total investment of urban environmental construction（ten thousand yuan）
80	Public participation	The popularity rate of residential environmental knowledge
81		The satisfaction degree of residents to environment.

V Index analysis

5.1 The health evaluation of urban ecological safety system

The health of urban ecological safety means: The structure of urban ecological system is reasonable and stable. The production activities within the system and the material and energy exchange of the environment form a virtuous circle. It functions efficiently and there is an efficient use of material, energy and information. Human society and natural environment are in great harmony and nature, knowledge and humanity are in fully integrated. The disposal of waste is strictly restricted within the environmental carrying capacities. The health of urban ecological safety represents the base value of urban ecological safe system, describes the existence of the city, its economic development condition, social humanity characteristics and natural resources reserves and plays a decisive role in the development trend of ecological safety and the construction mode of ecological safety. The health of urban ecological safety consists of three dimensions of the health of economic system, the stability of social structure and the health of natural system.

5.1.1 The health of economic system

Urban economic system is the driving force of urban development and also the root cause of the insecurity problems of urban ecology. The health evaluation of economic system is mainly divided into two parts. One part is the evaluation of the increase of

"quantity" of economy that is the evaluation of the increase mode and speed of products and services. The other is the evaluation of the increase of "quality" of economy that is the evaluation of the reasonability of the industrial structure, pattern of income distribution and consumption structure of the urban system. The health index system of economy contains two indexes: the quality of economic operation and economic development environment.

(1) The quality of economic operation

The quality of economic operation is a comprehensive evaluation of the health and stability of economic system and it is reflected in whether the national economy can have a continuous, rapid and healthy development, whether the economic benefits is increased, whether the economic structure is balanced and whether the population and employment are in harmony.

The percentage of tertiary industry employment（%）: the percentage of the quantity of tertiary industry in the total number of employment in all industries in a given area. The tertiary industry refers to the departments which offer service for production and consumption in the process of production.

Calculation formula:

$$\textit{The percentage of tertiary industry employment}(\%) = \frac{\textit{the quantity of tertiary industry}}{\textit{the total number of employment in all industries}} \times 100\%$$

Industrial added value rate (%): The percentage of industrial added value in industrial output. Industrial added value means the final results of industrial production represented in monetary items of industrial enterprise during the reporting period. It also means the value of the total results of the production activities of enterprises after the deduction of the value of material production and service consumed or transferred in the process of production.

Calculation formula:

$$Industrial\ added\ value\ rate(\%) = \frac{industrial\ added\ value}{total\ industrial\ output} \times 100\%$$

The percentage of local fiscal revenues in GDP (%): Local fiscal revenues refer to the yearly revenues of local finance including local revenues, central tax return and transfer payment.

Calculation formula:

$$The\ percentage\ of\ local\ fiscal\ revenues\ in\ GDP(\%) = \frac{Local\ fiscal\ revenues}{GDP} \times 100\%$$

(2) Economic development environment

Economic development environment is the concrete representation of thought emancipation degree of cities, market development degree and the governing capacity of governments. It decides the prospects and momentum of urban development and an important aspect in evaluating the health of urban ecological system.

Urbanization rate (%): The percentage of urban population in total population (including agricultural and non-agricultural population).

Calculation formula:

$$Urbanization\ rate(\%) = \frac{The\ percentage\ of\ urban\ population}{total\ population} \times 100\%$$

Social labor productivity (yuan/ per capita): The ratio of fruits of labor the workers created in a given period to the accordingly consumption of labor

Inflation rate (%): the ascensional range of average price level. Consumer price index is used to reflect the degrees of inflation.

Calculation formula:

$$Inflation\ rate(\%) = \frac{current\ price\ index - previous\ price\ index}{previous\ price\ index} \times 100\%$$

The percentage of the tertiary industry in all industries（%）: the percentage of the total value of the tertiary industry of the total value of all industries in a given area.

Calculation formula:

$$The\ percentage\ of\ tertiary\ industry\ in\ all\ industries(\%) = \frac{the\ percentage\ of\ the\ total\ value\ of\ the\ tertiary\ industry}{the\ total\ value\ of\ all\ industries} \times 100\%$$

5.1.2 Stability of social structure

Social structure is the structure of education levels, cultural categories, income distribution, social status, and employment of city residents. As the flow path of materials, information and energy of the system of ecological safety, city social structure's stability directly decides the structure reasonableness and the functional efficiency of the system. The stability of social structure is evaluated by the three perspectives of population and employment, social security and people's life quality.

(1) Population and employment

Demographic development is an evolution process in which social population develops toward a moderate population scale, good demographic quality, balanced population structure and reasonable population distribution. Population is closely connected to social security and stability. Employment is actually a social allocation process which uses labor force as a resource and it is a "stabilizer" of society.

Population density (people per km^2): refers to the indicator of the population density around the world, i.e., population living on a unit of land, usually taking permanent residents per km^2 as the calculating unit.

Natural population growth rate (%): indicates the extent and tendency of natural population growth and is a key indicator of the growth rate and planning of population.

Calculation formula:

$$Natural\ population\ growth\ rate(\%) = birth\ rate - human\ mortality$$

Ageing rate of population (%): refers to the proportion of the number of elderly people aged over 60 in the total population.

Calculation formula:

$$Ageing\ rate\ of\ \ population(\%) = \frac{the\ number\ of\ \ elderly\ \ people\ aged\ over\ 60}{the\ total\ \ population} \times 100\%$$

Employment rate（%）： refers to the percentage of the total labor force employed. Employed population refers to those who aged above a minimum age within a certain period and have paid jobs, whereas workforce refers to the active labor force who have labor capabilities and are willing to work, including the employed who are engaged in social labors and have paid jobs or profitable businesses, and the unemployed and laid-off who do not have jobs but are willing to.

Calculation formula:

$$Employment\ rate(\%) = \frac{the\ employed\ \ workforce}{the\ labor\ \ force\ \ population} \times 100\%$$

(2) Social security

As an important system of all countries, social security is vital to maintain the stability of urban social structures. Social security mainly includes social insurance, social relief, social welfare, special care and placement. A sound and stable social security system is an important guarantee for social stability and lasting national security. It is also a "balancer" of social equity.

Percentage of population living below the poverty line (%): Poverty line refers to the minimum cost of consumer goods and services required to sustain the basic human survival within a certain period, space and social development stage**.** A country's poverty line usually equals to 50% of the average income of all residents.

Calculation formula:

$$Percentage\ of\ \ population\ living\ below\ the\ \ poverty\ line(\%) = \frac{population\ living\ below\ the\ \ poverty\ line}{the\ total\ urban\ \ population} \times 100\%$$

Coverage of the minimum living standards system (%): refers to the percentage of the de facto population who receive minimum subsistence over all the population that is qualified for minimum subsistence. The minimum subsistence refers to a social security system in which a certain amount of cash assistances are given by the government to the households whose per capita family income is below the minimum living standard announced by the local government so as to guarantee the basic living needs of the family members.

Calculation formula:

$$Coverage\ of\ the\ minimum\ living\ standards\ system(\%) = \frac{the\ de\ facto\ population\ receiving\ minimum\ subsistence}{all\ the\ population\ qualified\ for\ minimum\ subsistence} \times 100\%$$

Ratio of revenue as against expenditure of basic pension insurance fund: refers to the ratio of the fiscal revenue of the basic urban pension insurance fund against its fiscal expenditure. It is one of the most important indicators that reflect the level of old-age security of a city.

Ratio of revenue against expenditure of medical insurance fund revenue to expenditure: refers to the ratio of the fiscal revenue of basic urban medical insurance fund fiscal revenue as against its fiscal expenditure. It is one of the most important indicators that reflect the level of medical security of a city.

(3) People's life quality

It is a criterion which most closely reflects people's life and development, often used for a comprehensive evaluation of people's living standards.

Engel's coefficient of urban citizens (%): refers to the share of food expenditure over the total personal consumption expenditure. It's an important criterion to measure the wealth of a household.

Calculation formula:

$$Engel's\ coefficient\ of\ urban\ citizens(\%) = \frac{food\ expenditure}{the\ total\ consumption\ expenditure} \times 100\%$$

The consumer price index (CPI): CPI reflected the tendency and degree of the price change of consumer goods and services in a certain period. CPI is an important indicator for national economics accounting, macroeconomics analysis and forecasting, and the implementation of overall adjustment of price level.

Gini coefficient: refers to the percentage of the income used for uneven distribution over the total income in all incomes of residents. Gini coefficient index is the index to judge the fairness of income distribution. Internationally, it is used for a comprehensive evaluation of the income distribution differences among all residents.

Education index (EI): refers to one of the three major components of human development index (HDI) created by the United Nations Development Programme. It is measured with the combination of adult literacy rate (two-thirds weight) and enrollment rate of the primary schools, secondary schools and universities (one-third weight).

Number of doctors per 10,000 persons: refers to the percentage of the total number of doctors over the total population of a region. It is a measure of the medical level of the region.

Calculation formula:

$$Nmber\ of\ \ doctors\ \ per\, 10,000\ \ persons = \frac{the\, total\ number\ of\ \ doctors}{the\, total\ \ population\, of\ \ a\ region} \times 100\%$$

Average living space per person (km^2/persons): refers to the percentage of residential area over the residential population. It is a key indicator to measure the quality of life in a region.

Calculation formula:

$$Average\, living\ space\ \ per\ \ person\, (m^2\ /\ \ persons) = \frac{residential\ area}{the\, residential\ \ population}$$

5.1.3 Soundness of a natural system

It refers to the state of ecosystem which enables ecosystem to maintain relative security and stability only through its natural adjustments within a certain period of time and space. It is usually analyzed by the aspects of urban geography, natural environment, resources and energy conditions.

(1) Natural environment

Geographical positions and climatic conditions are essential for the formation and development of a city. Natural environment is a basic requisite for the formation and development of a city and also a deciding factor of the safe development of a city.

Topographic relief ratio (m): refers to the difference between the highest and lowest altitude in a particular region. It is a macro indicator to describe a region's topographic features.

Calculation formula:

$$Topographic\ relief\ ratio(m) = \text{the highest altitude in a particular region} - \text{lowest altitude in the particular region}$$

Average annual precipitation (㎜): refers to the average annual rainfall in a region measured in multiple observation points.

Average annual temperature difference (℃): refers to the difference between the annual maximum and minimum temperatures. It is used to measure the extent to which an area suitable for human habitation.

Calculation formula:

$$Average\ annual\ temperature\ difference(℃) = \text{the annual maximum temperature} - \text{the annual minimum temperature}$$

(2) Natural carbon sink

Natural carbon sink primarily refers to the volume and ability of urban forests to absorb and store carbon dioxide.

Vegetation index: refers to the index of the growth of vegetation. It is used to

measure the biodiversity of ecosystems, and it increases rapidly with the growth of biomass.

Forest coverage (%): refers to the percentage of forest land area over the total land area in a country or region. It is an indicator to reflect the possession of forest lands or the degree of forest richness and outcome of afforesting work of a country or region.

Calculation formula:

$$forest\ coverage(\%) = \frac{forest\ land\ area}{the\ total\ land\ area\ in\ the\ country\ or\ region} \times 100\%$$

Ratio of park green area (%): refers to the ratio of city green area to the total land area.

Park green areas are the green areas which are open to the public and have recreational facilities and services, with recreation as the main function. It can also improve local ecology and landscape, prevent and alleviate disasters and so on.

Calculation formula:

$$Ratio\ of\ \ park\ green\ area\ (\%) = \frac{the\ city\ green\ area}{the\ total\ land\ area} \times 100\%$$

Percentage of water protection area (%): refers to the ratio of urban water protections area as against the total land area of the city. Water source protection area refers to the area delineated for water protection, which consists mainly of drinking water source, scenic water bodies and important fishing water bodies, and other water bodies with special economic and cultural value.

Calculation formula:

$$Percentage\ of\ \ water\ \ protection\ area\ (\%) = \frac{urban\ water\ \ protection\ area}{the\ total\ land\ area\ of\ \ the\ city} \times 100\%$$

5.2 Resilience evaluation of urban ecological security system

Resilience of urban ecological security system refers to the response capacity of a city to deal with outside pressures, setbacks or traumas and other negative interference to maintain stability under external disturbances such as natural or human activities.

5.2.1 The pressure on economic system

Economic system carries mutual contacts and interaction among production, exchange, distribution and consumption in the process of social reproduction. Energy consumption and waste disposal continuously occur in all kinds of economic behaviors with different degrees of impact on urban ecological security system.

Energy consumption per unit GDP (ton/10,000RMB): refers to the energy consumption to produce a unit GDP of a country in a certain period of time. It reflects the level of energy consumption and energy saving in the country.

Calculation formula:

$$Energy\ consumption\ per\ unit\ GDP\ (ton/10,000RMB) = \frac{energy\ consumption\ to\ produce\ a\ unit\ GDP\ of\ a\ country\ in\ a\ certain\ period\ of\ time}{GDP}$$

Emission of solid waste per 10,000 RMB of GDP: refers to the solid waste emissions to produce 10,000 RMB of gross domestic product (GDP) of a region. Solid waste refers to the solid and semisolid wastes produced in production, consumption, living and other human activities.

Emission of waste water per 10,000 RMB of GDP: refers to the total waste water emission to produce 10,000 RMB of gross domestic product (GDP) in a region. Waste water generally refers to the water discharge of human activities and rainwater runoffs. It consists of domestic and industrial sewage and the first-rain runoff in the drain pipes and other useless water.

Emission of waste gas per 10,000 RMB GDP: refers to the total waste gas emission to produce 10,000 RMB of gross domestic product (GDP) in a region. Waste gas refers to poisonous and harmful gases discharged from the living and production activities of human.

5.2.2 Life service pressure

Life service pressure refers the evaluation of the energy consumption and pollutant emission produced in daily life, study and work of urban residents.

Respirable particulates (PM10) density in air (mg/m^3): refers to the density of particulates in air with a diameter less than 10μm which can enter into human body through respiratory organs.

Daily domestic water consumption (m^3/per capita· day): refers to the daily amount of water use per person.

Calculation formula:

$$Daily\ domestic\ water\ consumption\ (m^3 / per\ capita \cdot day) = \frac{the\ daily\ amount\ of\ water\ use\ per\ person}{urban\ population\ consuming\ water \times calendar\ days}$$

Per capita daily electricity consumption (kw・h/person・day): refers to the daily average electricity consumption per person.

Calculation formula:

$$Per\ capita\ daily\ electricity\ consumption\ (kw \cdot h / person \cdot day) = \frac{the\ daily\ average\ electricity\ consumption\ per\ person}{urban\ population\ consuming\ electricity \times calendar\ days}$$

Per capita solid waste emission (ton/per capita・day): refers to the daily life waste produced per person.

Calculation formula:

$$Per\ capita\ solid\ waste\ emission\ (ton / percapita \cdot day) = \frac{the\ daily\ life\ waste\ by\ per\ person}{urban\ population\ emitting\ solid\ waste \times calendar\ days}$$

Per capita daily domestic waste water emission (m^3/per capita· day): refers to the average daily life sewage discharge per person.

Calculation formula:

$$Per\ capita\ daily\ domestic\ waste\ water\ emission\ (m^3 / per\ capita \cdot day) = \frac{the\ average\ daily\ life\ sewage\ discharge\ per\ person}{urban\ population\ discharging\ sewage \times calendar\ days}$$

Environmental noise equivalent sound level db (A): Environmental noises in urban areas include industrial, traffic and construction, social life and other noises. This indicator is set to protect human health and the environment and the data are directly measured ones.

5.2.3 Social order and security

Social order and security are key requirement of urban residents for life order and safety. The protection efforts in this aspect affect the fundamental sense of security of the residents with their living environment.

Incidence of criminal cases per 10,000 persons (cases/10,000 persons): refers to the percentage of the total number of criminal cases in a region as against the total population of the region. This indicator is to reflect the effect of the efforts made by the local police in strict control of, prevention of and clampdown on criminal cases. It is a measure of the security conditions in a region.

Calculation formula:

$$Incidence\ of\ criminal\ cases\ per\ 10,000\ persons\ (cases/10,000\ persons) = \frac{the\ total\ number\ of\ criminal\ cases\ in\ a\ region}{the\ total\ population\ of\ the\ region}$$

Annual traffic casualties per 10,000 persons (casualties/10,000 persons): refers to the percentage of the traffic casualties in a region over the total population of the region. It is a measure of the road safety situation of a region.

Calculation formula:

$$Annual\ traffic\ casualties\ per\ 10,000\ persons\ (casualties/10,000\ persons) = \frac{the\ annual\ traffic\ casualties\ in\ a\ region}{the\ annual\ total\ population\ of\ the\ region}$$

Annual fire casualties per 10,000 persons (casualties/10,000 persons): refers to the percentage of the fire casualties in a region as against the total population of the region. It is a measure of the ability of fire prevention, control and rescue in a region.

Calculation formula:

$$Annual\ \ fire\ casualties\ \ per\ 10,000\ \ persons\ (casualties\ /\ 10,000\ persons) = \frac{the\ \ fire\ casualties\ in\ a\ region}{the\ total\ \ population\ of\ \ the\ region}$$

5.2.4 Pressure on natural system

Natural system pressure refers to the sensitiveness of natural system when facing external disturbances and changes in the external environment due to the instability of natural system itself, usually in the form of damage of normal functions, environmental degradation (desertification, salinization, ground subsidence, etc), lower biodiversity, and frequent occurrences of disasters and so on.

Natural disasters frequency (times/day): it not only reflects the occurrences of natural disasters, but also the safety of the natural environment in an area. It is an important indicator to measure the vulnerability of the natural ecosystems in a region.

Calculation formula:

$$Natural\ disasters\ \ frequency\ (times\ /\ day) = \frac{times\ of\ \ natural\ disasters\ in\ a\ given\ \ period}{reporting\ \ days}$$

Degradation of land area (km^2): refers to the evolution process of the downward degradation of land environment, progressive reduction or loss of the original production potential of the land due to the changes of the internal structure, chemical properties of land caused by man-made or natural factors or man-made or natural disturbances and destruction. Negative consequences of land degradation include the declining productivity, population migration, food insecurity, destruction of basic resources and ecosystems, as well as the loss of biological diversity caused by the habitat changes of species and genes. The indicator can directly reflect the conditions of land security and the data are directly measured ones.

Land deformation area (km^2): refers to geological disaster area (km^2) caused by the vertical deformational damages or ground elevation changes. The ground deformation in the urban area often threatens the ground and underground construction and the urban transport system. The data are directly measured ones.

5.3 Evaluation of the development capacity of urban ecological security system

Urban ecological security system capacity is the capacity of a city to maintain the structure and pattern of its ecological security system, i.e., the ability of urban ecological security system to maintain the system's stability or restore health after internal turbulence and external shocks. Urban ecological security system can be divided into security building, disaster management and institutional guarantee.

5.3.1 Security construction

Construction of urban safety includes efforts to regulate and optimize urban lifestyles and production modes, urban planning and construction and the disposal of pollutant emissions, to reduce the impact and damage of urban development to natural ecosystem and to improve the resiliency of ecological safety system. Construction of city security can be broken down into production safety, traffic safety, living safety, planning achievements and disposal safety.

(1) Traffic safety

Traffic safety is a key indicator to measure the capacity and security of urban traffic and the basic description of the traffic conditions. It reflects the carrying capacity and safety level of urban transport systems. It is a key component of the assessment of urban ecological security system.

Road space per capita (m^2/person): refers to the average road space owned by each urban resident. It includes the total area of road ground area and the area of squares, bridges, tunnels, pavements area with connections to the roads.

Calculation formula:

$$Road\ space\ per\ capita\ (m^2\ /\ person) = \frac{the\ road\ space}{the\ number\ of\ \ permanent\ urban\ residents}$$

Parking lots per 10,000 persons (PCs): refers to the number of parking lots per 10,000 permanent urban residents (PCs).

Calculation formula:

$$Parking\ lots\ per\ 10,000\ persons\ (PCs) = \frac{the\ total\ number\ of\ \ parking\ lots}{annual\ number\ of\ \ permanent\ urban\ residents}$$

Traffic monitors per km (PCs): refers to the number of traffic monitors per kilometer of the urban roads (PCs).

Calculation formula:

$$Traffic\ monitors\ per\ km\ (PCs) = \frac{the\ number\ of\ traffic\ monitors}{the\ total\ length\ of\ urban\ roads}$$

Accident rate (times/100,000 persons): refers to the number of accidents per 100,000 persons within the urban area in a year.

Calculation formula:

$$Accident\ rate\ (times/100,000\ persons) = \frac{the\ number\ of\ accidents\ within\ the\ urban\ area\ in\ a\ year}{the\ number\ of\ permanent\ urban\ residents}$$

(2) Production safety

Production safety refers to the pressure made by urban industries on eco-environment protection. It is an important indicator to measure the impact of urban production on the environment.

Output value of industrial land per unit area (100mns RMB/km^2): refers to the output value of industrial land per unit area. It reflects the economic benefits of urban industries in land use and is one of the indicators to measure land use.

Calculation formula:

$$Output\ value\ of\ industrial\ land\ per\ unit\ area\ (100 mns\ RMB/km^2) = \frac{the\ output\ value\ of\ industrial\ land}{the\ total\ area\ of\ industrial\ land}$$

Primary energy self-sufficiency rate (%): refers to the ratio of primary energy production (10,000 tons) to primary energy consumption (10,000 tons) of an area.

Calculation formula:

$$Primary\ energy\ self-sufficiency\ rate\ (\%) = \frac{primary\ energy\ production}{primary\ energy\ consumption\ of\ an\ area} \times 100\%$$

Share of added value of energy saving and environmental protection industries in GDP (%): refers to the percentage of added value of energy saving and environmental protection industries over local GDP.

Calculation formula:

$$Share\ of\ added\ value\ of\ energy\ saving\ and\ environmental\ protection\ industries\ in\ GDP\ (\%) = \frac{added\ value\ of\ energy\ saving\ and\ environmental\ protection\ industries}{GDP} \times 100\%$$

(3) Living safety

Living security is an important description of the living environment of urban residents. It reflects the quality and the security of the living environment of urban residents. It is a key component of the assessment of urban safety construction.

Urban density (%): refers to the percentage of urban construction area (km^2) over the total land area of the city (km^2).

Calculation formula:

$$Urban\ density\ (\%) = \frac{urban\ construction\ area}{the\ total\ land\ area\ of\ the\ city} \times 100\%$$

Per capita residential space (m^2/persons): refers to the percentage of the total residential area (per 10,000 km^2) over urban population (10,000 persons).

Calculation formula:

$$Per\ capita\ residential\ space\ (m^2\ /\ persons) = \frac{the\ total\ residential\ area}{over\ urban\ population} \times 100\%$$

High-risk areas housing ratio (%): refers to the ratio of residential area in areas prone to volcanoes, coastal floods, mudslides, and tornadoes and other high risk zones (10,000square meters) over the total residential area of the city (10,000 m^2).

Calculation formula:

$$High-risk\ areas\ housing\ ratio(\%) = \frac{residential\ area\ in\ high\ risk\ zones}{the\ total\ residential\ area\ of\ the\ city} \times 100\%$$

Affordable housing coverage (%): refers to the percentage of the affordable house units (sets) of houses over all house units include the affordable houses and the commercial houses (sets).

Calculation formula:

$$Affordable\ housing\ coverage\ (\%) = \frac{the\ affordable\ house\ units\ of\ houses}{the\ affordable\ houses + the\ commercial\ houses} \times 100\%$$

Gas using rate (%): the percentage of urban population using gas over the total population includes both permanent and temporary urban population.

Calculation formula:

$$Gas\ using\ rate(\%) = \frac{urban\ population\ using\ gas}{permantent\ urban\ populution + temporary\ urban\ population} \times 100\%$$

(4) Outcome of planning

It is an indicator to measure the quality and quantity of the ecological safety planning of a city's space. It is also an important manifestation of the degree of security in city construction. The quality of urban space planning and the quantity of ecological safety plans of urban space can reflect the attitude of the government on ecological safety in city construction.

Number of eco-industrial parks (PCs): refers to the total number of eco-industrial parks in a city (**PCs**).

National Forest Parks (PCs): refers to the total number of national forest parks in a city (**PCs**).

Number of non-material cultural heritage (PCs): refers to the total number of non-material cultural heritages in a city (**PCs**).

(5) Disposal security

It is an important indicator to measure the ability of a city to dispose urban pollutants and also a key factor to measure the quality of urban construction and development.

The comprehensive utilization rate of solid waste (%): refers to the percentage of the total annual amount of the solid waste that are comprehensively utilized over the total annual amount of the solid waste that includes the whole production of solid waste that year as well as the storage of the past.

Calculation formula:

$$\textit{The comprehensive utilization rate of solid waste}\,(\%) = \frac{\textit{the total annual amount of the solid waste comprehensively utilized}}{\textit{the whole production of solid waste comprehensively utilized that year} + \textit{the storage of the past comprehensively utilized}} \times 100\%$$

Wastewater discharge compliance rate (%): refers to the ratio of the waste water discharge up to the compliance standards over the total waste water emission.

Calculation formula:

$$\textit{Wastewater discharge compliance rate}\,(\%) = \frac{\textit{the wastewater discharge up to the compliance standards}}{\textit{the total wastewater emission}} \times 100\%$$

Soot and dust emission compliance rate (%): refers to the smoke and dust discharge emission up to the compliance standards over the total soot and dust emission.

Calculation formula:

$$Soot\ and\ dust\ emission\ compliance\ rate\ (\%) = \frac{the\ smoke\ and\ dust\ discharge\ emission\ up\ to\ the\ compliance\ standards}{the\ total\ soot\ and\ dust\ \ emission} \times 100\%$$

Decontamination rate of refuse (%): refers to the percentage of decontamination treated volume of waste over the total refuse disposal.

Calculation formula:

$$Decontamination\ rate\ of\ \ refuse(\%) = \frac{the\ decontamination\ treated\ \ volume\ of\ \ waste}{the\ total\ refuse\ disposal} \times 100\%$$

Safe disposal rate of hazardous waste, heavy metals and persistent organic pollutants (%): refers to the percentage of volume of the safely disposed hazardous waste, heavy metals and persistent organic pollutants over the total disposed volume of hazardous waste, heavy metals and persistent organic pollutants.

Calculation formula:

$$Safe\ disposal\ rate\ of\ \ hazardous\ waste, heavy\ metals\ and\ persistent\ organic\ \ pollutants\ (\%) = \frac{the\ safe\ disposed\ \ volume}{the\ total\ disposed\ \ volume} \times 100\%$$

5.3.**2 Disaster management**

Disaster management is an important function of the government. It includes improving the response ability of government departments to disaster emergency, relief and post-disaster reconstruction to minimize the impact of disasters on urban ecological security system and maintain the normal order of production and life of a city. Disaster management can be divided into the capacities of early warning, rescue and reconstruction.

(1) Early-warning capacity

Early-warning capacity refers to the ability of government to minimize the harm caused by the hazards before disaster or calamity and others hazards occur.

Soundness of the emergency response system:

Soundness of emergency response system refers to the completeness of the urban emergency response system. It relates to the emergencies handling ability of a city and is an important indicator to measure the early warning capacities of the city. Contingency plans refer to plans for contingency control, command and rescue when facing emergencies such as natural disasters, major accidents, environmental hazards and human destructions.

Soundness of emergency commanding and decision-making organs:

It is a key indicator to measure the after-disaster early warning and response capacities of a region. An effective emergency commanding and decision-making center and timely and effective disaster relief are important guarantees for the disaster-stricken people to get help.

Disclosure of emergency information system:

Emergency information system composes infrastructure, information resource, information application service system, information technology standards system and information security system. The disclosure of emergency information system helps ensure the publicity of information so as to effective meet the needs of public participation.

(2) Rescue capacity

Rescue capability refers to the disaster response capacity and mobility of government departments or other organizations in time of disaster or other hazards. It is a key indicator to measure the safety development of urban ecosystem.

Response capability of emergency departments:

Timely and effective disaster relief and post-disaster recovery and reconstruction require emergency departments to have strong response ability to respond to disasters so as to guarantee to first-time reaction and prompt measures. The responding capacity of emergency services departments demonstrates the ability of execution and response to emergencies of a city.

Speed of financing and allocation of special fund:

Response to emergencies and disasters requires a huge amount of financial support. Improving the relief emergency fund allocation mechanism for disaster-stricken people, ensuring the capital source of disaster relief and the fund allocation are important guarantees for the success of disaster relief.

Arrival speed of disaster relief and rehabilitation supplies:

Planning appropriate routes for provisions and ensuring a timely response after the disaster so as to efficiently distribute the supplies for the reconstruction.

Speed of disclosure and release of emergency information:

Emergency information disclosure is an important guarantee of the public right to information and supervision. The more information is disclosed, the stronger the public's right to information. Timely and effective information release would help the public to understand the situation in real time, ensuring that rescue operation as soon as possible.

(3) Rehabilitation capacity

Rehabilitation capacity reflects the ability of the government or other organizations to completely or partly re-construct, clear up and renovate the disaster-stricken places in the wake of disasters or calamities and other dangers. Reconstruction is an important guarantee for the recovery of the normal lives of people and the city.

Share of special fund in GDP (%): refers to the share of the special fund earmarked by government of relevant departments for the reconstruction over the GDP that year.

Reconstruction speed: It is a key indicator to measure the overall disaster response capacity of the region.

Project quality: The condition of safety, utility, durability, cost and appearances of the construction should meet the needs of the people in the disaster areas and can support the post-disaster recovery and development of the life and production in the disaster-stricken region.

5.3.3 System guarantee

Urban ecological security construction should be on the legal track. Efforts should be made to strengthen the legislation of environmental protection and pollution prevention and control, improve the local environmental regulatory system and strengthen law enforcement and supervision, establish effective information disclosure platform, develop relevant policies and regulations defining information disclosure system, maintain the public's environmental right, right to discuss official business and to supervision and improve the public's satisfaction on environment. Institutional guarantee is divided into management capacity, ecological restoration, and public participation.

(1) Management capacity

Management capability is the ability of government departments in managing ecological environment and resource and it is a basic indicator to measure the ability of government departments to safeguard ecological security for sustainable development.

Disclosure rate of resource and environmental information (%): refers to the ratio of the number of the news on environment disclosed by the municipal government as against the total number of news on environment sorted out and cataloged by the municipal government.

Calculation formula:

$$\textit{Disclosure rate of resource and environmental information}\,(\%) = \frac{\textit{the number of the news on environment voluntarily disclosed by the municipal goverment}}{\textit{the total number of news on environment sorted out and cataloged by the municipal goverment}} \times 100\%$$

Implementation rate of PEIA (%): It is the abbreviation of the implementation rate of the planning environmental impact assessment and refers to the ratio of the de facto number of developments and constructions that have implemented PEIA as against the number of all the developments and constructions that should implement PEIA.

Calculation formula:

$$\text{Im}\ plementation\ rate\ of\ \ PEIA\,(\%) = \frac{the\ de\ \ facto\ number\ of\ \ developments\ and\ constructions\ that\ have\ implemented\ \ PEIA}{the\ number\ of\ \ all\ the\ developments\ and\ constructions\ that\ should\ implemented\ \ PEIA} \times 100\%$$

(2) Ecological restoration

Ecological restoration refers to the fiscal spending by government departments to enhance the urban ecological recovery and improve the ecological security level.

It is one of the important indicators to measure sustainable development of urban ecological security.

Share of green investment in GDP (%): refers to the ratio of the capital investment in pollution treatment, ecological protection and construction, urban environmental infrastructure construction and environmental management capacity building to GDP.

Calculation formula:

$$Share\ of\ \ green\ investment\ in\ GDP\,(\%) = \frac{the\ capital\ investment\ in\ environmental\ \ protection}{GDP\ of\ \ that\ \ year} \times 100\%$$

Total investment in environmental governance (10,000RMB): It is one of the important indicators to measure environmental governance and the total urban investment in environmental governance (10,000RMB).

Urban environment construction investment (10,000RMB): It is a key indicator for environmental input (10,000RMB) and the total investment in the construction of urban environment projects (10,000 RMB).

(3) Public participation

Public participation refers to the responsiveness of residents to urban ecological security. It is an important foundation that affects city residents' environmental awareness and capacity in coping with ecological safety problems and a key indicator to measure the development of urban ecological security.

Residents' environmental literacy: refers to the degree of urban residents' environmental awareness and knowledge acquisition.

Residents' satisfaction of the environment: refers to urban residents' satisfaction with the state of the urban environment.