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THE CHINESE ECOLOGICAL RESEARCH NETWORK

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ABSTRACT: The Chinese Ecological Research Network (CERN), proposed by the Chinese Academy of Sciences (CAS) in 1987 and authorized by Chinese Government in 1991, is a comprehensive research network system of linking established ecological and environmental observation and experiment stations located at different natural zones across China. The characteristics of CERN are as follows: 1) CERN is an interdisciplinary and comprehensive research network; 2) CERN will focus on the studies on the trends of changes in structures and functions of ecosystems under the strong actions of human activities; 3) CERN will predict macro–ecological environmental problems caused by human activities. CERN includes three levels, i.e. ecological research stations subcenters and synthetic centers, and four support systems, i.e. research system and management system. The ecological research stations are the basic units of CERN to make the long–term monitoring for ecological and environmental elements, and also the bodies to conduct comprehensive studies on structures and functions of ecosystems. At present, CERN has 52 research stations, among which 26 are agricultural ecological stations, 13 forest ecological stations, 5 grassland ecological stations, and 8 lake and sea stations. The subcenters are nodes of CERN. Four subcenters are planned at the present stage. They are Hydrological subcenter, Soil subcenter, Atmospheric subcenter and Biological subcenter. The Synthetic Center plays the role of the pivot of the network.

KEY WORDS: ecosystem, ecological station, ecological research network

I. INTRODUCTION

With the rapid development of science and technology, the impact of human economic activities on the natural environment has grown on a global scale. The deterioration of the ecological environment is one of the major global problems facing contemporary human society. In China, due to population explosion, rapid economic development, accelerated consumption of resources and increased generation and discharge of wastes, the development of our control measures can hardly catch up with the speed of deterioration. Deterioration of the ecological environment has already been a menace to people's livelihood. The Chinese government has paid great attention to environmental protection and has made it a basic national policy to protect and improve the human living environment.

In order to understand the mutual relationship between ecosystem and its impact on the environment and to make a long-term observation of their status and characteristics so as to study the trends of their development, the Chinese Academy of Sciences (CAS) decided in 1987 to establish a Chinese Ecological Research Network (CERN) by linking its established ecological and environmental observation and experiment stations located at different natural zones across the country. CERN will also be established to contribute to global change programs such as International Geosphere-Biosphere Programme (IGBP) and the global observation network of ecosystems and environments.

II. FOUNDATIONS AND PROGRESS

Since the founding of CERN, CAS has established 52 research and experiment stations covering major types of ecosystems throughout the country (Fig.1 and Appendix 1 to 4), including 26 agricultural ecological stations, 13 forest ecological stations (natural and artificial), 5 grassland ecological stations, and 7 aquatic ecological stations (fresh water lakes and seawater). These stations have become the important bases for biological and geo-scientific studies in CAS. About 1,500 scientists and engineers, nearly 1/ 3 of whom are senior, have long been devoting themselves to observations, experiments and studies in these stations under difficult field conditions, and have made contributions to finding out the natural laws, accumulating abundant data, and also providing scientific basis and typical demonstrations for regional development, rational utilization of natural resources, and comprehensive tackling of environment. With the specific regional representatives and high level research teams, they have become the important bases of our country either for ecological training or for international cooperative research.

In 1987, a Network Leading Group was organized by CAS, headed by its vice president, Professor Sun Honglie, with participation of many research and administration experts in concerned fields. An extensive investigation concerning how to accomplish CERN was then carried out. The main contents of the network research were defined as:

1) Demonstrational research on structures, functions of main types of ecosystems in

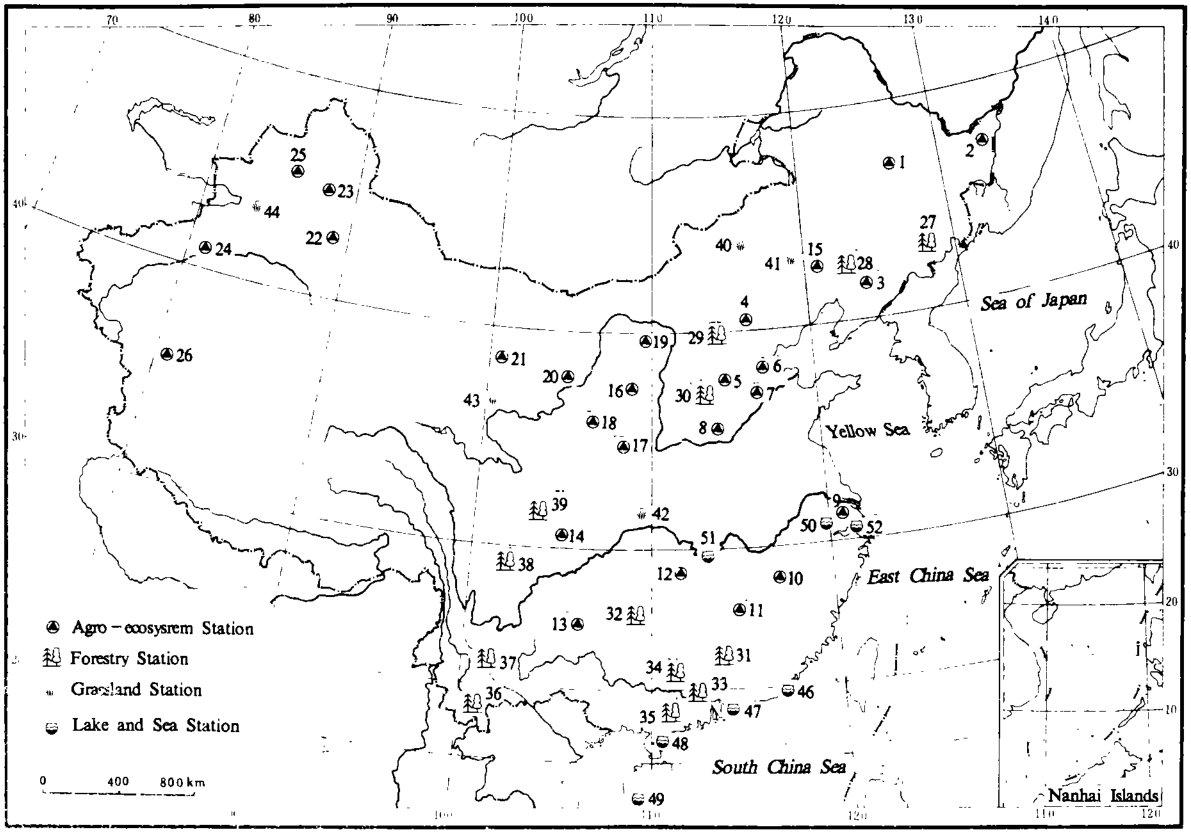

Fig.1 Distribution of CAS stations

China and the development of stable ecosystems with high productivity.

2) Experimental study on the critical processes and the long-term impact of human activities on ecosystems.

3) Long-term observation and monitoring on ecosystem evolution and environmental changes.

Based on these main research items, eight observation-experiment subnetworks of selected field stations with better conditions were formed in 1989 as follows:

1) Demonstration of optimized model of ecosystems (in 17 stations);

2) Crop water demand and consumption (in 7 stations);

3) Decomposition, accumulation and equilibrium of organic matters in soils (in 5 stations);

4) Release of soil potential nutrients and their dynamics (in 3 stations);

5) Methane emission from paddy fields (in 3 stations);

6) Land carrying capacity and the radiation spectrum (in 8 stations);

7) Long-term impact of different agricultural operation systems on environment and ecosystem productivity (in 5 stations);

8) Long-term impact of various ploughing methods on soil environment and land productivity (in 2 stations).

Almost 600 researchers have participated in the study and an encouraging progress has been made. Meanwhile technical regulations for field observations and experiments were set up and a strategic planning of CERN information systems was completed.

In 1991, Chinese government authorized CERN as a national construction project of 'the Eighth Five-Year Plan' (1991-1995) and approved CERN to apply for the World Bank loan. A report on Chinese Ecological Research Network Project Planning has been completed. Experts both at home and abroad have assessed the report many times. The objectives of CERN have been considered scientifically rational, technically feasible and generally realizable. It is commented that CERN will be a feasible and beneficial contribution to the development of China's ecological sciences and can provide usable ecological data for policy-makers and international communities.

III. KEY OBJECTIVES AND FEATURES

The characteristics of CERN are as follows:

1) CERN will be an interdisciplinary and comprehensive research network. CERN is

not only to conduct long–term monitoring of ecological and environmental elements, but more importantly, is also to carry out wide studies on structures and functions of ecosystems, and to reveal the mechanism of ecological processes through long–term site experiments. CERN faces a ecosystem with extreme complexity and multiple disciplinary variables, i.e. ecosystems. Such system is comprises of both biotic and environmental subsystems. The biotic system involves plant, animal and microbes, while the environmental system consists of air, soil and water. It will be dependent on the long–term observations and experiments in the 6 subsystems and on the basis of comprehensive analysis to study trends of changes in the structures and functions of the systems. In the light of the social and economic conditions of the areas where the stations are located, CERN will propose the measures of coordination/ control and management of the ecosystems, and to set up an optimized demonstration models by close cooperation with the local governments and people.

2) CERN will focus on the studies on the trends of changes in structures and functions of ecosystems under the strong actions of human activities. This fits the national conditions of China. China is a developing country with a rapid growth of population. Since 1949, the population of China has increased by more than one fold, which was 1,133.68 million based on the 1990 census. It is predicted that by the year of 2025 the country's population will increase to 1.6 billion. China has less resource per capita that is far bellow the world average level, for example, 1/ 30 of the world average level of land, 1/ 4 of that of water resources, 1/ 6 of that of forest, and 1/ 8 of that of accumulated living wood. The resources have a considerable part in poor quality and uneven distribution. In addition, the resources have been irrationally developed and utilized for a long time. This has caused many ecological and environmental problems, such as land desertification, soil erosion, and aggravated pollution. Therefore, it is an important task for CERN to constantly explore approaches of setting up new artificial complex ecosystems in order to realize the unification of social, economic and ecological benefits.

With the focus on human activities an artificial ecosystem consists of the three components of natural environment, social environment and human beings. The three components are linked and interacted to each other in constituting a complex network with the characters of openness and susceptibility. The artificial ecosystem itself has a dissipated structure in which matter and energy need to be exchanged with the outside to keep the system in a stable state of order.

Thus, an artificial ecosystem usually requires some optimal decisions in order to achieve the highest yield, to obtain the biggest interests, to minimize the instability of production, and to prevent the reduction of productivity.

As a stable system during its long succession, natural ecosystem is also an aspect of CERN research. Long–term stationary studies on structures and functions of natural ecosystems can contribute to understanding the mechanism of processes and the law of evolution that are advantageous to direct the building of optimized artificial ecosystems.

Among the artificial ecosystems, agro–ecosystem is regarded as a main object of the studies because food has been consistently a big problem in our country.

3) As one of the main objectives, CERN will use its network of its many stations to predict macro–ecological environmental problems caused by human activities. This is a very important subject of the earth–system research with a global focus as well as a scientific and social significance.

The basic steps of conducting the earth–system researches are: firstly, to observe phenomena and accumulate data; secondly, to analyze and explain the data measured in order to set up relationships of the processes in the earth–system sciences depending on physical, chemical and biological laws; thirdly, to establish conceptual and numerical models; and finally, to evaluate the models and make predictions with them.

This research is the basis for coordinating human and the nature. Therefore, an measurement index system will be one of the critical factors of CERN construction. It will decide not only the content of the long–term stationary observations and experiments and the data generated but also technical configurations of the network.

CERN has defined an index system for observation variables. The system will comprehensively reflect the structures of ecosystems and the physical, chemical and biological processes in the transmissions of energy, nutrients and water. An index matrix (Appendix 5 and 6)was formulated from the point of view of integrity of ecological data.

The columns of the matrix represent structure and essential functional factors, while the rows refer to different physical systems. There are interfaces between any two of the systems. The variables on these interfaces are mostly interested by IGBP.

Due to the limitations of capital investment and present situations of observations and technicians in CAS the CERN index system will be carried out by step by step.

IV. STRUCTURE

The structure of CERN forms a network with three tiers: ecological research stations, subcenters, and the synthetic center at its top (Fig.2). Four support systems, which will shape CERN a matrix–like system, are research system, information system, technical system, and management system.

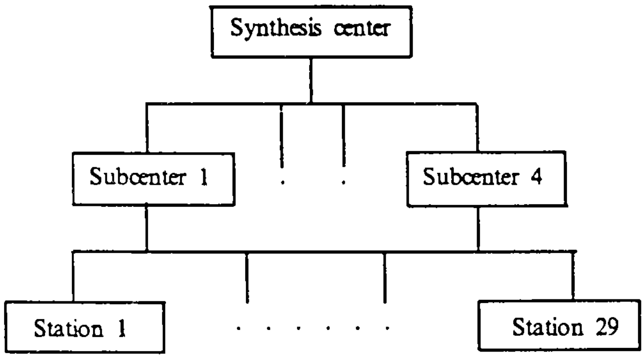

Fig.2 Scheme of CERN's three–level structure

1. The Functions and Distribution of Ecological Research Stations

The ecological research stations are the basic units of CERN to make the long–term monitoring for ecological and environmental elements and also the bodies to conduct comprehensive studies on structures and functions of ecosystems. They will become important information sources of CERN by the distinct features of ecosystem types and the zonalities of natural environment. The main tasks of the stations will include:

1) To demonstrate the optimized models for sustained, stable and coordinated development of the typical eco–types represented by the stations, and to promote the application of new technology, new methods and advanced scientific and technological findings;

2) To perform the long–term observations and analysis for hydrological, soil, atmospheric and biotic elements, the long–term experiments and studies of important ecological processes, and the accumulation of scientific data;

3) To study the structures and functions of the typical ecosystems represented by the stations;

4) To create the conditions for attracting more Chinese and foreign outstanding scientists to work in the stations, to carry out highly level studies, and to promote academic ex-

changes and training.

Due to the present investment intensity and conditions 29 ecological research stations which are firstly selected, including 15 agricultural ecological stations, 7 forest ecological stations, 2 grassland ecological stations, 2 lake ecological stations, 2 marine ecological stations, and 1 desert ecological station, will be networked. These stations forms two profiles in their geographical distribution, which happen to be the same as that designed in the global observation profiles of IGBP, and basically cover the main natural geographical regions (Fig.1).

Eleven leading stations are further selected among the 29 stations considering their stronger regional representativeness, typical features of ecosystem, solidified basis of previous efforts, and powerful research forces. Observation for complete indexes will be arranged, three collections of data (see part Ⅴ) will be built, and the ground calibrations for remote sensing will be set up at these stations.

2. The Functions and Affiliations of 4 Subcenters

The subcenters will be nodes of CERN. They have dominant positions in their disciplinary research. Four subcenters are planned at the present stage. They are Hydrological Subcenter, Soil Subcenter, Atmospheric Subcenter, and Biological Subcenter, with following tasks:

1) To conduct regional-and national-scale ecological research and analysis along disciplinary lines (using Data Sets Ⅰ, Ⅱ, and Ⅳ(see Ⅴ)) to inform policy makers;
2) To formulate and maintain the standards and rules for test items in all the ecological stations;
3) To supervise and control the comparability of data measured at the ecological stations;
4) To establish and maintain disciplinary databases for network research at any levels;
5) To provide training.

The four subcenters will be adhered to the excellent institutes in CAS. They are:

1) Hydrological Subcenter, in the Institute of Geography;
2) Atmospheric Subcenter, in the Institute of Atmospheric Physics;
3) Soil Subcenter, in the Nanjing Institute of Soil sciences;
4) Biological Subcenter, in the Institute of Botany.

3. The Functions of Synthetic Center

The Synthetic Center plays the role of the pivot of the network. The center is affiliated with the Commission for Integrated Survey of Natural Resources. It will conduct large–scale and interdisciplinary research and processing procedures, standardized where necessary for network data collection, will ensure that scientifically valid, high–quality data sets will be the basis for CERN analysis and information provided to policy makers, other institutions, and international scientific programs.

V. CERN INFORMATION SYSTEMS

In order to predict the trends of changes in ecosystems and environments and to develop the control strategies and technologies, it is necessary to provide the long–term data related to environmental changes and ecosystem successions and the data management. Therefore, the establishment of information systems become an important task of CERN.

CERN Information System will be a distributed system with the following six data sets:

1) Data Set I: Reflecting the results from the long–term site observations on the basic ecological measurements, including meteorological factors, hydrological factors, soil factors, biomass production, and the qualities of air, water, soil, and biotic environment, which are required to study the structures and functions of ecosystems in an ecological station.

2) Data Set II: Reflecting the information required to study the processes of ecosystems. Currently, the long–term stationary experiments are carried out on five processes; i.e. water cycle and equilibrium in soil–biotic–atmospheric system; nutrient substance cycle and equilibrium; energy flow process; generation, transport and transformation of trace gases; and decomposition, accumulation and transport of organic pollutants and heavy metals.

The content of Data Set I and II is measurements of the index system.

3) Data Set III: Reflecting the social and economic indicators of the areas where the ecological stations are located and basic conditions of demonstration areas, as will as research project data catalogue and managerial data at ecological stations.

The data of the above three sets will all be generated by CERN ecological stations. The Data Set II will be arranged at leading stations.

4) Data Set IV: Reflecting the disciplinary information required to study the ecosystem and environment of a medium and large scale in the network, collected and compiled by the four subcenters.

5) Data Set V: The information on ecosystems, resources and environment of large scale (nationwide) features, collected and maintained by the synthesis center information system.

6) Data Set VI: The information from the outside of CERN through data exchange.

In order to reenforce data management and data quality control CERN will set up its Data Management Committee and assign Data Administrators in stations, subcenters and the synthetic center. Current efforts include designing data management systems, making a data management training plan, formulating relevant regulations and procedures in data quality assurance and quality control (QA/ QC), arranging existing data and information at stations, and planning experimental instrument and facilities.

VI. CONCLUSION

The development of CERN is strongly supported by the Chinese government. It has been listed on "the Eighth Five-Year Plan" as an important development project and is applying for the World Bank loan.

Once succeeded, an ecological research network in CAS consisting 29 stations, 4 subcenters and a synthesis center will be established, which will improve the ecological research in China from a traditional and qualitative discipline to a modern ecological science well equipped with contemporary theories, methodologies and technologies. Through networking stations it will be possible to scientifically predict the trends of changes of our living environments and the impact caused by human activities, to provide scientific evidence to national economic development, and to make greater contributions in dealing with global environmental issues.

Appendix 1 Agro-ecosystem stations and their positions

No	Stations	Positions
1.	Hailun Experimental Station of Agricultural Ecology	E126°38′ N47°26′
2.	Sanjiang Plain Experimental Station of Marsh	E133°31′ N47°35′
3.	Shenyang Experimental Station of Ecology	E123°23′ N41°32′
4.	Datun Experimental Station of Agricultural Ecology	E116°24′ N40°00′
5.	Luancheng Comprehensive Station of Agricultural Ecology	E114°40′ N37°50′
6.	Nanpi Experimental Station of Agricultural Ecology	E116°40′ N38°06′
7.	Yucheng Comprehensive Experimental station	E114°36′ N36°56′
8.	Fengqiu Comprehensive Experimental Station of Agro-Ecology	E114°24′ N35°00′
9.	Changshu Experimental Station of Agricultural Ecology	E120°38′ N31°33′
10	Yingtan Experimental Station of Red Soil Hill	E116°55′ N28°13′
11	Qianyanzhou Comprehensive Experimental Station of Red Soil Hill	E115°00′ N27°00′
12	Taoyuan Experimental Station of Agricultural Ecology	E111°30′ N28°55′
13	Ecoenvironmental Observation and Research Station in Guizhou plateau Karst Mountain Area	E106°06′ N36°06′
14	Yanting Purple Soil Experimental Station of Agricultural Ecology	E105°12′ N30°58′
15	Naiman Comprehensive Experimental Station of Desert Management	E120°19′ N42°14′
16	Ansai Comprehensive Experimental Station of Soil and Water Conservation	E109°17′ N36°45′
17	Changwu Experimental Station of Agricultural Ecology	E107°41′ N35°14′
18	Guyuan Experimental Station of Ecology	E106°28′ N36°02′
19	Mu Us Experimental Station of Desert Ecology	E109°49′ N39°22′
20	Shapotou Experimental Station of Desert	E104°57′ N37°27′
21	Linze Experimental Station of Desert	E100°09′ N39°20′
22	Turpan Experimental Station of Desert	E89°11′ N42°56′
23	Fukang Experimental Station of Desert Ecology	E87°45′ N44°30′
24	Tarim Experimental Station of Water Balance	E80°45′ N40°27′
25	Mosuowan Experimental Station of Desert	E86°01′ N45°06′
26	Hotanqira Experimental Station of Desert Management	E80°03′ N35°17′

Appendix 2 Forest stations and their positions

No	Stations	Positions
27	Changbaishan Forest Ecosystem Research Station	E128°06′ N42°24′
28	Xinmin Experimental Station of Forest Ecosystem	E122°47′ N42°01′
29	Beijing Experimental Station of Forest Ecosystem	E115°28′ N40°01′
30	Yuanshi Experimental Station of Forest Ecosystem	E114°15′ N37°54′
31	Jiulianshan Experimental Station of Forest Ecology	E114°28′ N24°33′
32	Huitong Experimental Station of Subtropical Forest Ecosystem	E109°39′ N26°48′
33	Heshan Comprehensive Experimental Station of Subtropical Hill	E112°55′ N22°40′
34	Dinghushan Experimental Station of Subtropical Forest Ecosystem	E112°34′ N23°16′
35	Xiaoliang Experimental Station of Tropical Artificial Forest Ecosystem	E120°54′ N21°27′
36	Xishuangbanna Experimental Station of Tropical Ecology	E101°46′ N21°54′
37	Ailaoshan Experimental Station of Forest Ecosystem	E101°01′ N24°32′
38	Maowen Experimental Station of Ecology	E103°40′ N31°50′
39	Gonggashan Experimental station of Alpine Ecosystem	E102°00′ N29°33′

Appendix 3 Grassland stations and their positions

No	Stations	Positions
40	Inner Mongolia Experimental Station of Grassland Ecosystem	E116°42′ N43°38′
41	Wulanaodu Experimental Station of Grassland Ecosystem	E119°39′ N43°02′
42	Wuxihongchiba Experimental Stations of Subtropical Alpine Artificial Grassland	E109°37′ N31°38′
43	Haibei Experimental Station of Alpine Meadow Ecosystem	E101°33′ N37°45′
44	Bayanbulak Experimental Station of Grassland	E83°43′ N42°54′

Appendix 4 Lake and sea stations and their positions

No	Stations	Positions
45	Huangdao Experimental Station of Marine Biology	E120°15′ N36°00′
46	Shantou Experimental Station of Marine Biology	E116°40′ N23°21′
47	Dayawan Experimental Station of Marine Biology	E114°31′ N22°31′
48	Zhanjiang Experimental Station of Marine Economical Animals	E110°24′ N21°11′
49	Hainan Experimental Station of Tropical Marine Biology	E109°28′ N18°13′
50	Taihu Comprehensive Experimental Station of Lake	E119°54′ N30°56′
51	Dongshan Experimental Station of Lakes	E120°25′ N31°02′
52	Donghu Experimental Station of Aquatic Ecosystem	E114°23′ N30°33′

Appendix 5 Index system of the lake and sea ecosystem

Index system		Structure	Energy	Nutrients
Atmosphere and territial		Current input and output, Tidal current	Time of radiation, Total radiation, Temperature, Wind speed and direction	Nutrients of input and output, Acidity of rainfall
Edge		Rainfall, Evaporation	Evaporation, Effective, Radiation for photosynthesis	
Lake or sea	Water	Physical properties: Temperature, Color, Transparancy, Electronic conductivity, Chemical properties: pH, Dissolued oxygen, Total alklinity, Total hardness, Na, K, Ca, Mg, So_4, Cl, No_3, Co_3	COD, BOD	Total contents of N, NH_4-N, NO_3-N, NO_2-N, Total dissolued N, Total P, Total dissolued P, PO_4-P, and total organic carbon, SiO_2
	Organ-ism	Community type and structure, dynamic of plant, Animal and microbe, Population density, richness, dominant and spacial structure of major species	Biomass of dominant of plant, Biomass of primary producter, Productivity of plant, Biomass of plankton, benthic animal, Biomass of heterotrophic bacteria	Nutrient elements of primary producter, planckton, benthic animal and heterotrophic bacteria
	Sedi-ment	Particle size, Oxade/redux potential, Total content of N, P, Organic mater, BOD		Sediment, Nutrients contents in the sediment and their release

Appendix 6 Index system of terrestrial ecosystem

Index system	Structure	Function		
		Energy	Element	Water
Aerosphere	Surface edge, Roughness Turbulence, Cloud quantity Cloud height	Atmosphere pressure, Wind direction and speed, Temperature, Solar radiation, Time of solar radiation, Ultraviolet radiation, Net radiation, Long-wave radiation	Nutrients and heavy metal of peltier and acidity of rain fall, dry fall	Total and density of rain fall, Time of snow beginning and ending,
Edge		Effective radiation of photosynthesis	CO_2, O_3, CH_4, N_2O leaching	Interaception, Stem flow, Transpiration
Organism	Type, structure and dynamic of main plant, animal and microbes community, Number, density, abundance, dominant and phenlogy of main organism population, Disease and insect pest	Plant: Temperature of canopy and leaf surface, Biomass and leaf area index of community, Primary productivity, Biomass and energy value of stem, leaf fruit (flower) and root of dominant species, Photosynthesis rate and respiration rate Animal: Grazing, egest, biomass and energy value, raspiration rate Microbes: Biomass and oxygen consumption	Plant: Concentration of elements (N, P, K, C, Ca, Mg, Fe, Na, Zn) in stem, leaf, fruit (flower) and root of dominant species Animal: Concentration of elements (C, N, P, K, Ca, Mg, Fe, Na, Zn) in different part and egest, Vegetative metabolism	Plant water content, Stomata character evaporation, Hydrological physiology
Edge		Standing crop and energy value of litter, Present litter and energy value	Element concentration of standing litter, Element concentration of present litter, Decomposition rate of litter	Displacement, Water content of litter, Irrigation
Soil	Soil particle size, structure bulk density specific weight	Soil temperature, Siol heat flux	Background: Total nitrogen, phosphate, potassium, Organic matter, Soil chemical, composition (Ca, Mg, Na, Fe, Al, Si), Soil microelements (B, Mn, Mo, Zn, Fe, Co, Cu), Chemical properties, Heavy metal Dynamic test: Available N, P, K, Available microelements (Fe, Cu, Mo B, Mn, Zn), Organic matter leaching (soil)	Soil moisture content, Field capacity, Water potential, Soil wilting moisture content, Seepage of paddy field, Rate of water conductivity, Runoff surface water, Change of groundwater table
Edge	Evaporation		Chemical properties of surface and underground water to aerosphere	Evaporation
Aerosphere			diffusion of N_2O to aerosphere	