

Ecological construction – An alternative developing way for developing countries

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Abstract—Based on case studies and experience of Chinese urban and rural development, the concept of ecological construction may be the feasible way for developing countries.

Keywords: ecological construction; ecological engineering; ecological planning; ecological management.

Development is the major issue in every society. But any development is bound to alter the nature. What is the appropriate development which has minimum impact on environment? The sustainable development, proposed by the World Commission of Environment and Development in the book "Our Common Future" (1987), is inevitably the right answer. But how to make out the policies and measures to realize sustainable development is still a problem. Based on case studies and experience of Chinese urban and rural development, the concept of ecological construction, which we put forward in this paper, may be the feasible way for developing countries.

THE ORIGIN OF ECOLOGICAL CONSTRUCTION

Since industrial revolution in eighteen century, the western and eastern countries have taken two different ways in development. The western countries have been thriving and prosperous through the industrialization and urbanization. While the eastern countries with ancient civilization, such as China and India, have taken the way by developing traditional agriculture. However, it is noted in the world that China has supported 22 percent of the world population with only 7 percent of the world farmland, and maintained the soil fertility for thousands of years, though she provided only a low living standards. The process of economic development can be illustrated in Fig. 1, in which the development process of eastern countries is shown in

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curve 1 with characteristics of low and stable economic growth, and that of western countries is shown in curve 2, with fast and unlimited increase.

Now the traditional development model can no longer meet the urgent demand of economic development, and alleviate the population explosion in developing countries. So they are keen on pursuing the modernization way of industrialization and urbanization as western countries did. But there is no way to go because the rapid development reached before 1950s was at the expenses of natural damage, and environment deterioration in native or other countries (Kennedy, 1989). At that time these impacts were not a big problem, but at present when more than 5 billion people are plunging into the nature, they cannot be neglected any more. For instance, in China, the rural industry and some cities are expanding rapidly in recent years, which have caused resource shortage and a lot of environmental problems. It is evident that the developing countries can pursue neither their own traditional developing way, nor the modernization way as western countries did. Facing the conflicts between the heavy pressure of population, backward technology and frail environment, we have to search a new developing strategy which is different from both traditional and modernizational ways (Fig. 1), which is called ecological construction (Ma Shijun, 1987).

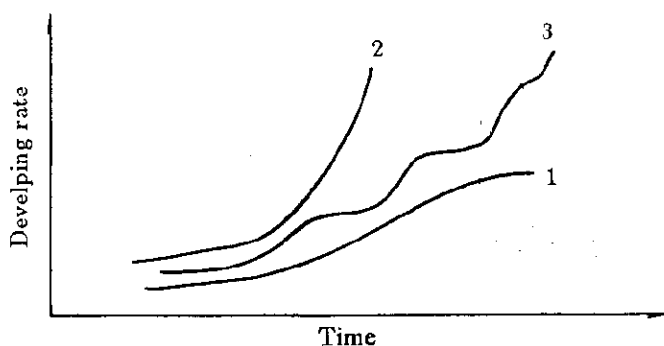


Fig. 1 Developing process

Applied the three eco-cybernetic principle of circulation and regeneration, harmonization and symbiosis, and sustenance and autotrophy, the ecological construction aims at solving the three kinds of ecological problems of low efficiency of resource utilization, inharmonious relationship and weak self-regulation ability by innovation of traditional technological process and production relation, searching alternative ways of resource utilization, and strengthening the ecological awareness of decision-makers and people so as to make full use of local resources, to take advantage of opportunities and to realize high economic efficiency, social harmony and natural balance.

The thought of ecological construction originated from Chinese long standing of ecological culture. China, as a huge agricultural country with the civilization for thousands of years, has

accumulated rich experience of ecological technology in long agricultural practice. In recent years, along with the thriving of ecological agriculture, the traditional eco-engineering technology has been summed up, applied and popularized in many rural areas of China, which has existed significant influence on Chinese rural development. This eco-agriculture has encouraged the application of ecological principles in other fields and caused a series of eco-craze, such as industrial eco-engineering, ecological planing and design of eco-county, eco-city or ecopolis and so on.

THE CONNOTATIONS AND AIMS OF ECOLOGICAL CONSTRUCTION

The ecological construction includes: Eco-engineering construction, eco-institutional construction and eco-cultural construction (Fig. 2).

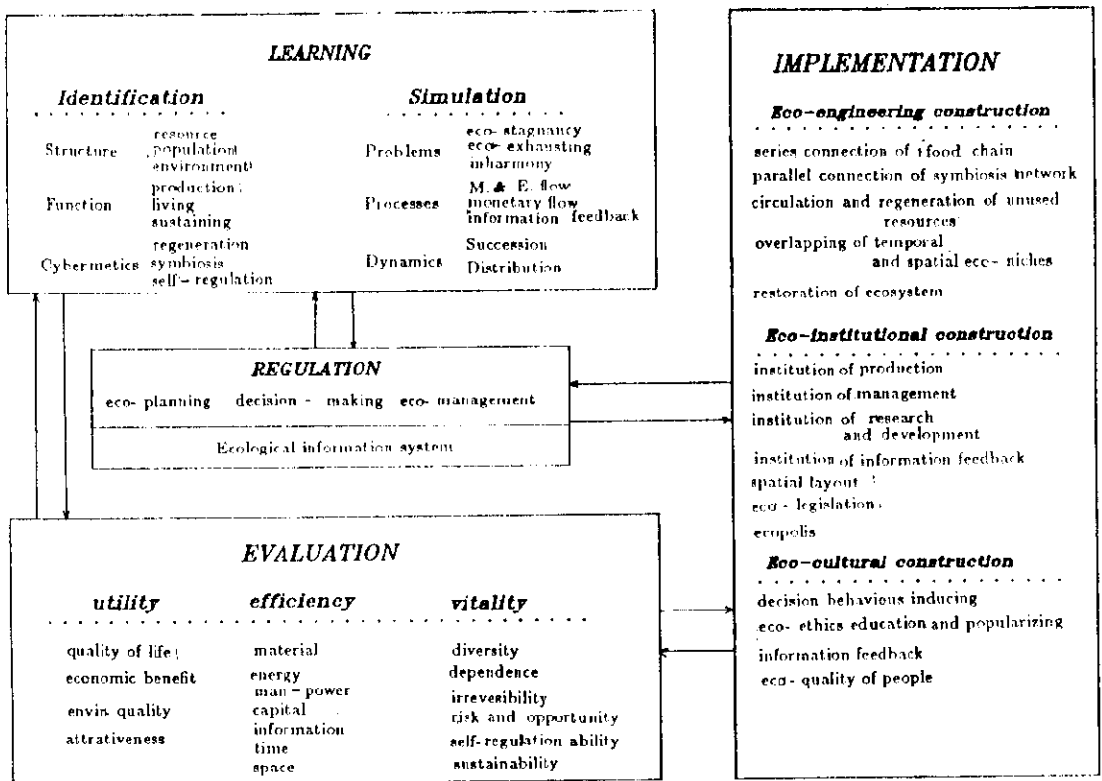


Fig. 2 The scheme of ecological construction

Eco-engineering construction

In the light of the principles of eco-cybernetics and eco-technology, we can design and remake technological process, dredge the channels of material and energy flows, exploit and make best use of the ecological niches of the artificial ecosystems to rise the ecological efficiency, such as alternative resource exploitation, multi-function and multi-purpose use of material and energy, recycling and regeneration of waste, self-purification engineering, eco-rehabilitation and eco-economic complex construction.

Eco-institutional construction

Through eco-planning and adjusting of various kinds of ecological relationship, the unreasonable social and economic institution can be improved, such as the structure of production and products, the spatial layout, the institution of decision-making and management, the eco-legislation and policy-making, and ecopolis construction.

Eco-cultural construction

Human is the principal component of Social-Economic-Natural Complex Ecosystem (SENCE), and the human behavior plays an important role in influencing the properties of SENCE. Nowadays, a lot of ecological problems in the developing countries are mainly caused by the misleading behavior and low ecological awareness of planners, decision-makers, managers and people. Eco-cultural construction should be carried out to enhance the ecological awareness and the vitality of self-regulation, including inducing of decision-making behavior, eco-ethics' educating and popularizing, raising of population eco-quality.

The Eco-construction has following three objectives:

1. High efficiency

High efficiency of resource utilization such as material, energy, space and so on; high efficiency of production such as labor, capital, technology, time and so on; and high efficiency of holding external opportunity (information, policy, environment and so on). Here, we emphasized the high efficiency rather than the high speed in the developing course. According to the situation in the developing countries, generally speaking, a medium growth of economy and comparatively well-off life can be expected practically.

2. Harmonious relationship

Harmonious relationship among production sectors, between human being and nature, among institutions or individuals, between regions and countries, and among different generations. Here, the harmonious relationship rather than the equilibrium is emphasized. Because any development is bound to break the old equilibrium, the dynamic stability in stead of static stability is needed to realize sustainable development.

3. Robust vigour

Vitalizing resources (circulation, regeneration and sustainable utilization); vitalizing environment (symbiosis rather than restraint, beneficial rather than harmful) and vitalizing ecosystem (high ability of self-organization and self-regulation, sensitive feedback of information).

Here, we emphasize self-regulation in stead of external control. It is the key point of realizing sustainable development to help local people helping themselves and to enhance the vitality of the ecosystem.

PRINCIPLES AND METHODOLOGY OF ECOLOGICAL CONSTRUCTION

1. The principles of ecological cybernetics

(1) Circulation and regeneration principle

Materials in the biosphere are limited. The regeneration, circulation, multiple purpose and hierarchical layer utilization of energy, raw materials, products and wastes are the fundamental strategies for surviving and developing of natural ecosystem. These perfect mechanism of chain, loop and network can be used to design the ecological technology in the SENCE, in which every component is not only the donator to others, but also the donee from others. There are neither sources nor sinks, all substances are circulated and utilized fully.

(2) Symbiosis and coevolution principle

Symbiosis is a common phenomenon that exists among organisms or between organisms and their environment in which all symbionts are cooperated with and benefit from each other. The symbiosis among organisms or production sectors can economize raw materials, energy, save time and space and acquire multiple benefits. The more differences the symbionts have, the more diversity the ecosystem is, the more benefits the symbionts can get.

The symbiosis, in which all organisms and their environment adapt and remake each other, means that, in ecological construction, all kinds of forces and opportunities including natural and artificial, cooperative and antagonistic, should be taken advantage of, and all inner relationships should be harmonized to reach the optimum function of whole SENCE in a long term.

(3) Sustenance and autotrophy principle

Whether there is ability of self-regulation and self-reproduction or not is one of the main differences between mechanical system and ecosystem. SENCE is a kind of self-organization system, owning the sustainable mechanism of self-organization and self-reproduction, and its succession aims at the consummation of overall function, rather than the growth of its components.

In a stable ecosystem, the negative feedback function dominates over the positive feedback. This principle requires that the growth of SENCE components conform the overall function, any useless growth of structures to overall function will not be allowed.

2. Ecological technology

The ecological technology may be classified into five fundamental types by which we can compose different kinds of ecological engineering:

Technology 1 Series connection of food chain

Food-chains make up the basic structure of ecosystems. In agricultural and industrial

production, the "food-chain" is usually short, and cannot make full use of materials and energy. Simulating the food-chain in ecosystem, we can design such technological process as adding new chain components to the series connection, either in the middle or at the end (Fig. 3). For instance, in multi-layer utilization system of crop-stalk (Fig. 4), the sub-system of livestock, edible fungi, earthworms and methane are introduced into the original stalk-fuel chain, the new system has both economic and ecological benefits.

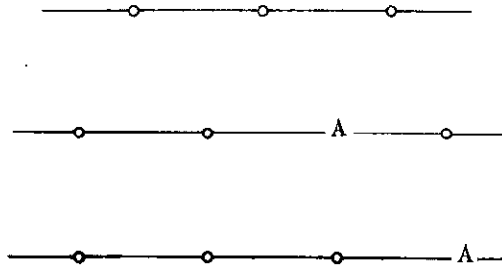


Fig. 3 Series connection of food chain

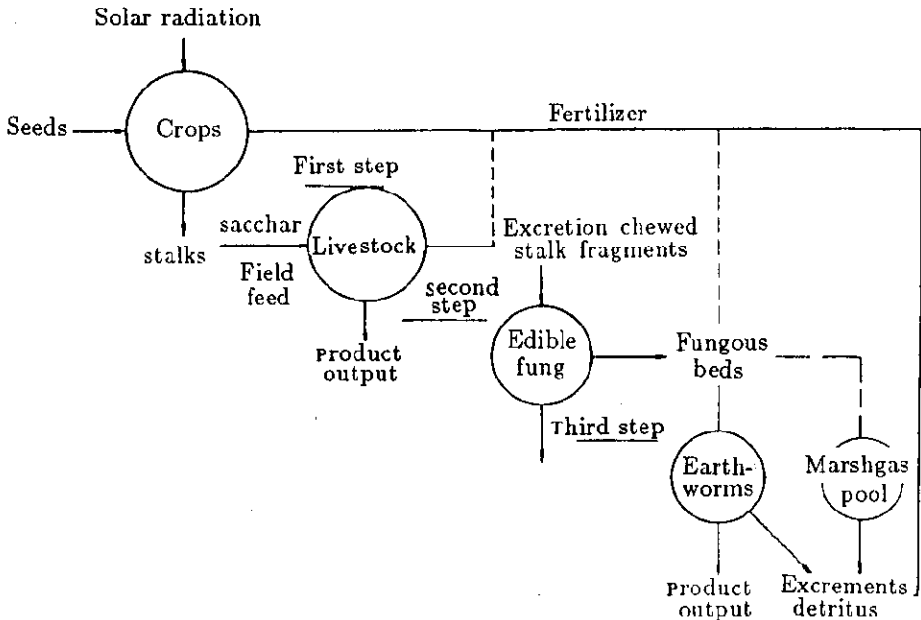


Fig. 4 Multiple step use of crop-stalk

Technology 2 Parallel connection of symbiosis network

This technology is to promote the symbiosis relations between species or different industrial sectors by joining different parallel chains so that they can benefit from each other and make up deficiencies of each other (Fig. 5). The rice-fish-ramie symbiosis system and planting-breeding-processing symbiosis system are the typical examples which are popular in the rural area of the South China.



Fig. 5 Parallel connection of symbiosis network

Technology 3 Circulation and regeneration of unused resources

The reason that the natural ecosystem has inexhaustible resources is due to the circulation and regeneration mechanism within the system. Most of the materials in human production are discharged as wastes or left unused, even the useful products are bound to become waste at last. This technological process includes (1) circulation of unused materials and regeneration of wastes in living and production processes (Fig. 6), (2) exploitation of alternative local resource which is not exploited at present, and (3) designing and remaking of new technological processes which produce no waste.

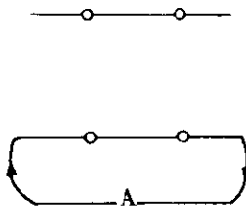


Fig. 6 Circulation and regeneration of materials

Technology 4 Temporal and spatial eco-niches overlapping

Time and space are often the limited factors in ecosystem, which can be expanded through eco-niche overlapping technology to get additional time or space (Fig. 7). In Chinese traditional agriculture, for example, the intercropping and interplanting has been used for thousands of years, such as cotton-wheat, maize-bean, maize-wheat interplanting and the tea-rubber, forest-mushroom intercropping, multi-layer fish breeding and mulberry grove-fish pond model (Fig.

8), are the typical models of this category, which make it possible to plant two or three crops in the same field and period. In industrial production, the staggering of working days and hours off can smooth out the peak of traffic and electricity using, which is the right way of self-solving the problems of resource shortage.

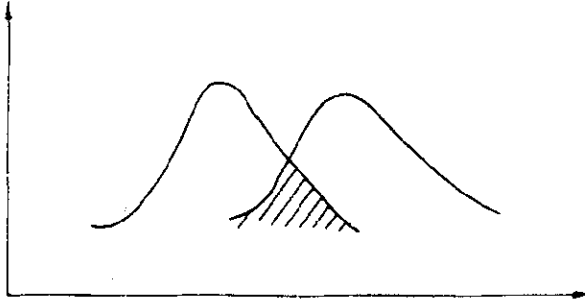


Fig. 7 Temporal and spatial eco-niche overlapping

Technology 5 Restoration of ecosystem

In the construction of agriculture and industry, exploitation of resources is always followed with the deterioration of natural ecosystem. For instance, mining and large hydrological engineering usually cause the irreversible changes of biological communities and landscape. Ecological restoration includes two aspects: (1) to protect ecosystem from being damaged before or during the development, and to minimize the negative impact while exploiting resources, such as choosing ecologically reasonable exploiting technology or integrated utilization of resources. (2) to promote the recovery of damaged ecosystems and to speed up their successive progress or design new ecological landscape by feasible and ecologically reasonable measures, including recovery of flora and fauna, and purification of water body and atmosphere by biological or physical engineering treatment.

3. Ecological planning

Based on eco-cybernetic principles, expert experiences and system analysis, ecological planning can be defined as to learn, to simulate, to optimize and to design the structure, function, dynamic relation of SENCE, with the objectives of establishing ecological institution and seeking the development opportunity, increasing benefits, minimizing risks, and improving the environment of SENCE.

Ecological planning includes individual planning and integrated planning. The individual planning is to analyze, design and evaluate the effects and regulation strategies of single problems, such as population planning, resource allocation, crops distribution and land use, the targets of these problems are usually unitary, but they often cause many other side impacts. The major differences between individual ecological planning and traditional planning are that the former aims at overall eco-economic benefits of SENCE, rather than local, sectional, or tem-

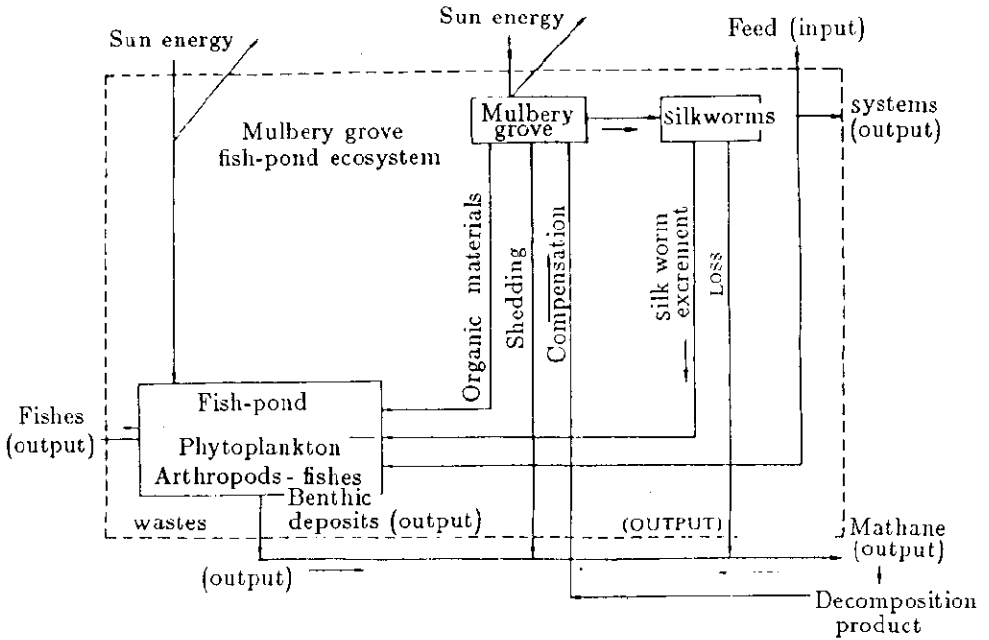


Fig. 8 Mulberry grove-fish pond model

poral benefits. While the integrated planning is concerned with a complex of society, economics and nature, with the relation of population, resources and environment, such as community planning and urban integrated planning.

Ecological planning consists of system learning and system design. System learning aims at identifying the structure, function and dynamic mechanism of the systems, at simulating the system behavior, its opportunities and risks. System design is to rearrange to relation among components or between system and its environment, to search feasible strategies, to trace its operations and behaviors. Many methods can be applied in ecological planning, for instance, linear programming, dynamic programming, non-linear programming, system dynamics and so on, among which the Pan-Objective Ecological Planning (POEP) (Wang Rusong, 1988) and Decision Supporting System (DSS) developed in recent years, are the powerful ones for ecological planning.

The POEP is a decision-making method embodying ecological principles and optimization techniques through man-computer dialogue. It aims at regulating the function of an ill-structured system under a changing environment rather than getting an optimal solution

within a definite structure of the system. POEP can be expressed as follows:

$$\begin{aligned} & \text{Opt. } A \\ & \text{s.t. } Y = A * X \quad Y \in N \\ & \quad N = (\underline{b}, \bar{b}) \end{aligned}$$

where A is a relationship matrix of the target system, X is a state vector of the system, $*$ is an operator, projecting X into a new vector of $Y = A * X$, $N = (\underline{b}, \bar{b})$ is a certain realistic ecological niche space, \underline{b} and \bar{b} is respectively the lower and upper boundary restrain vectors of the ecological factors. A, N, X are all changeable in POEP and the data are allowed to be incomplete and vague.

The objective of POEP is continuously to regulate and harmonize the system relationship within the ecological niche N along an optimization path. The output of POEP is not one or more optimal results but an optimum-towards adjusting process or a learning process to reach the optimum.

Evaluation in ecological planning is concerned with multiple attribute analysis. The indices should reflect the function, efficiency and the cybernetics of SENCE. We divided it as three aspects, e.g. benefit, efficiency and maturity:

Efficiency	resource utilization
	energy conversion
	technology progress
	labor productivity
Benefit	turnover of capita
	economic contribution
	life quality
Maturity	environment quality
	recycling and reproduction
	harmony and symbiosis
	sustainability and vitality

4. Ecological management

The main tasks of ecological management are to put the results of ecological planning into practice, to treat and solve the problems in implementation, to revise and adjust the original strategies and institution, to ensure and supervise the realization of predetermined objectives.

A good planning does not necessarily lead to good results because the results also depend on the man's behavior in SENCE. The main contents of ecological management include the following aspects:

(1) Inducing and regulation of ecological behavior

Man is one of the most important factors in SENCE, but he is never the master of the nature, man's behaviors must follow the natural laws. Most of the eco-problems in developing countries were caused by the short-term, short-sighted and intuitional behavior of decision-makers. Inducing human behavior by ecological cybernetics is to lead people regulating their

behavior consciously with an aid of using reasonable administrative, economic, legislative and medial measures which are made out ecologically and feasibly. According to the carrying capacity of environment and resources as well as the social and economic level, the behaviors should seek and take the half-optimum strategy, the judo-like strategy and the function optimizing strategy (Wang Rusong, 1988).

(2) Popularization and education of ecological awareness

Ecological awareness mainly consists of system awareness, efficiency awareness and vitality awareness. The system awareness requires us to realize that the sub-system and their components are connected and interacted with each other in SENCE. Man's behaviors to the nature will at last react on himself through the feedback webs. The efficiency awareness means that we should pursue the high efficiency of resource utilization through circulation and regeneration of materials and energy, instead of focusing on economic growth rate, and the development of SENCE should depend on its self-regulation and self-reproduction ability, on its self-perfecting function rather than rely on growth of its structure. Through ecological education, we can input ecological idea to every student, every habitant as well as every officer to enhance their ecological awareness.

The ecological philosophy should be popularized through different kinds of media to change the traditional value of resource utilization and the misleading attitudes of man to nature, to switch mono-function, antagonism between symbiosis, and the outer control into self-regulation.

(3) Ecological information system

Sensitive and flexible information feedback is the key to realize the sustainable development for decision-makers and managers. The main task of ecological management is to provide a set of simple and convenient Ecological Information Systems (EIS) to local decision-makers, planners and managers to analyze, plan and predict various problems, relations, processes of the SENCE, to let them change the parameters, and information, revise the data base according to the varying circumstances.

This system supports decision and management processes by way of dialogue. It can communicate with decision-makers and managers directly and conveniently. This mutual way ensures them to fully express their priorities and favoritism in the modelling process. Not only does it depend on data and method base, but also it is supported by knowledge of experts.

CONCLUSION

Ecological construction is a developing way to realize the sustainable development. Contemporary ecology theory and modern science and technology provide ecological construction with new methodology and technique. In addition, the re-recognition of the relation between man and the nature will promote ecological construction research and practice. However, ecological construction is still at its beginning line, how to design ecological technological process, how to improve ecological planning and management is a challenge facing the ecologists, agri-

culturists and the experts of other fields.

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