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RESEARCH ARTICLE

On eco-planning for an eco-demonstration park (EDP) and sustainability—Case study of the Luhua EDP in the Chongming Island of Shanghai, China

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Abstract The background, concept, connotation, principles, and methods of eco-planning for an Eco-Demonstration Park (EDP) and sustainability were examined based on a case study of the Luhua EDP in the Chongming Island of Shanghai, China, which is an important part of Shanghai Eco-city planning and construction in the 21st century. By analyzing natural, social and economic conditions, calculating population using the land capacity eco-model, eco-function zoning, and eco-construction, an innovative eco-industrial structure and technical chain were formulated. A comprehensive eco-planning scheme for the EDP was proposed, including planning and management strategies for subsystems of efficient industry, good quality human settlement, high standard eco-construction and eco-tourism as well as effective environmental protection and attractive landscape. The EDP should be an area with coordinated and sustainable economic, social and environmental subsystems. Eco-planning for the EDP should be a very important part of eco-city planning and sustainability. The paper aims to set up a theoretical framework and practical basis for eco-planning and promoting harmony between human and nature.

Keywords eco-demonstration park (EDP), eco-planning, eco-model, Luhua, Chongming Island, Shanghai

1 Introduction

1.1 Theoretical background

With rapid global urbanization, eco-planning for an Eco-Demonstration Park (EDP) has become increasingly important in eco-city planning and sustainability worldwide. It is one of the important tasks in regional and urban sustainability. Although theoretical methodology concerned with eco-planning has just been developed recently, original research can be traced back as early as the 11th and 12th centuries. For example, in ancient Greece, Pluto, a well-known philosopher, already described the '*Ideal Country*' in his works, while Marcus Vitruvii Pollio, a distinguished Roman architect, presented the philosophy of systematic urban planning in his famous book '*De Architectura Libri Decem*' based on his analysis of construction in Rome and other ancient cities [1–4]. During the 18th and 19th centuries, many other philosophical approaches to eco-planning were developed, such as '*Phalanstery*' by Charles Fourier, '*New Harmony*' by Robert Owen, and '*Lineal City*' by Arturo Soria, all reflecting connotation of the eco-planning concept [5].

Progress in the theoretical concept of eco-planning could be attributed to the practice of George Marsh, John Powel, Patrick Geddes, and other ecologists and planners in the late 1900s [6,7]. Marsh was the first in history to show the feasibility of planning human activities in harmony instead of conflict with nature. Ebenezer Howard's '*Garden City*', Le Corbusier's '*Radiant City*', Frank Lloyd Wright's '*Broadacre City*', and many other theories all contributed significantly to the development of eco-planning and design. At the beginning of the 21st century, eco-planning has become one of the most important guides for urban development and sustainability. Its strategic role in the research of landscape pattern, land use, eco-park planning, greenbelt planning, and keeping human activity in harmony with nature has gained more attention than ever [8–10].

1.2 Concept and connotation of eco-planning

A noted landscape architect, Ian L. McHarg [11], defined the concept of eco-planning in his book entitled 'Design

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with Nature' as a process and method of planning and design which permits reasonable and controllable land-use planning with minimal damage to the natural environment.

Historically, eco-planning had focused on land use planning and was considered recently to play a role in the control of eco-footprints of urbanization and regional development [12–15]. Increasing recognition of the significance of eco-planning has led later to broader applications such as the Nature-Economy-Society complex ecosystem [1,3,4]. Thus, eco-planning should be multi-disciplinary in approach based on ecology, urban planning, and environmental science to give a comprehensive analysis of the relationships between nature and human activities. It provides informed decisions about land use, function zoning, resource exploitation, and design of industrial production process while highlighting the need to recognize and solve the bottlenecks of ecosystem sustainability so that development within the context of environment, social, and economic concerns can be realized [5,15].

1.3 Basic principles for eco-planning

The following principles should be observed in eco-planning:

Harmony between human and nature

Eco-planning aims for an acceptable environment for human settlement, work, and leisure. Without appropriate regulations, excessive demand on nature will adversely impact human beings.

Respecting and following natural laws

Natural laws must be given more respect in ecological restoration, rebuilding, and construction. Biodiversity and habitat diversity can help keep the ecosystem stable and raise landscape value.

Sustainable development

This principle comprises four aspects: sustainable resource exploitation, sustainable systematic analysis, sustainable holistic benefits, and sustainable social improvement.

Economic efficiency

The economic factor is the major concern of eco-planning. This principle results in industry policy and legislation that helps shape a better industrial structure.

Systematic implementation and public participation

Eco-adjustment should be carried out incrementally until the objectives of eco-planning and design are achieved. Public awareness and support are indispensable to the success of the planning practice.

Demonstration

Eco-planning must be demonstrated to be feasible and acceptable by the public even though its outcome cannot be guaranteed.

1.4 Techniques and methods

Comprehensive techniques and methods employed are as follows:

Complex ecosystem analysis

The structure, functional stability, and self-regulation of the ecosystem of Luhua, Chongming Island are analyzed and evaluated.

Ecosystem support and service evaluation

Human disturbance and regulatory enforcement are evaluated by analyzing the environmental capacity in spatial and temporal distribution and spatial heterogeneity.

Cost-benefit analysis

Both the economic benefits and environmental costs are taken into account to decide the appropriate population scale, economic structure, and development target.

Suitability class analysis

This method is applied in function zoning to forecast the impact of eco-construction and analyze the suitability of different land uses.

3S techniques

The 3S methods include remote sensing (RS), geographic information system (GIS), and global position system (GPS).

Eco-function zoning

Various kinds of construction should be carried out according to the different development targets in different eco-functional zones.

Eco-model of the land capacity for population

The population for each planning year is calculated based on this model.

By focusing on Luhua Eco-Demonstration Park (EDP) in the Chongming Island of Shanghai, China, which is an important part of Shanghai Eco-city planning and construction in the 21st century, the background, concept, connotation, principles, and methods of eco-planning for EDP and sustainability were studied. This paper aims to set up a theoretical framework and practical basis to promote greater social support and economic benefit, better ecological recycling, more efficient use of substances, energy and information, and harmony between human and nature.

2 Significance of eco-planning for EDP—A new opportunity for eco-planning and construction of Shanghai Eco-City

The distinction between eco-planning and traditional planning lies in the prudent application and practice of ecological principles. Eco-planning has become one of the direct means to regional and urban sustainable development in today's world.

2.1 Connotation of eco-planning for EDP

The eco-planning for EDP should be guided by the principles of urban ecology and economics, as well as urban planning. It aims to promote social auspice, higher economic benefit, and better ecological recycling.

The connotation of eco-planning for EDP includes more efficient use of substances, energy and information, as well as co-existence between humans and nature. EDP is defined as an area with completed economic, social and environmental subsystems. The environmental subsystem comprises many features, including a heightened production level, advanced industrial structure, satisfactory life and environmental qualities, beautiful landscape, standardized demonstration efficiency and coordinated ecological relationships.

2.2 New opportunity of eco-planning and construction for Shanghai Eco-city

Shanghai is seeking to be one of the world's economic centers, with the year 2020 as the target date for the establishment of a model eco-city. However, it has to keep pace with accelerating global urbanization. Eco-planning, which has gained wide support worldwide, has not produced any successful pioneering case in China. Eco-planning for EDP is an excellent choice of urban development in Shanghai and will provide the city with an opportunity to create the first EDP in China.

2.3 Superiority for Chongming Island, Shanghai

Located in the Yangtze Estuary of the northern part of Shanghai and south of the Jiangsu Province border, Chongming Island has unique geographic advantages (Fig. 1) that permit easy access to the latest economic and technical information in China. The planned construction of a new tunnel and a bridge at the end of 2004 will make this island a junction connecting Shanghai with Jiangsu Province and even the east transportation corridor of China. Therefore, Chongming Island has been selected as one of the most important components in eco-planning the Shanghai Eco-city. As part of Chongming National Ecological Island, Luhua lies in the west part of Chongming (Fig. 2) and will be the focus of EDP planning in the development and utilization of Shanghai.

3 Studies of eco-planning and sustainability for Luhua EDP, Shanghai

3.1 General background

3.1.1 Research area and its land capacity

Chongming Island is a typical sand island, situated 121°09′30″ to 121°54′00″ E and 31°51′15″ N, with an average elevation of 3.7 m above sea level and fertile soil. Located in the southern part of the middle subtropical zone, the mild climate makes the island a suitable place for agriculture and tourism despite occasional weather downturns. The island is rich in natural resources. The fresh water and biological resources provide it with a promising future to develop agriculture and the fishing industry. Luhua, the research site, was a very important agricultural area in the western part of Chongming Island. Begun in 1971, its inning amounted to 38.4 km^2 by the end of 2005. The systems of roads, rivers, ditches, and an agricultural production base in Luhua have been well organized. The cultivated land area and population density in Luhua in 2005 were about 1700 hm^2 and 240 people per km^2 respectively.

The land capacity for population of the Luhua EDP in a planning year is calculated based on the eco-model as follows:

$$Cn = \frac{1783 \times 183.8\% \times 10000 \times 4.379 \times 10^6 \times 2\% \times 2\%}{9.888 \times 10^3 \times 365} = 1.59 \times 10^4 (\text{people})$$

Where

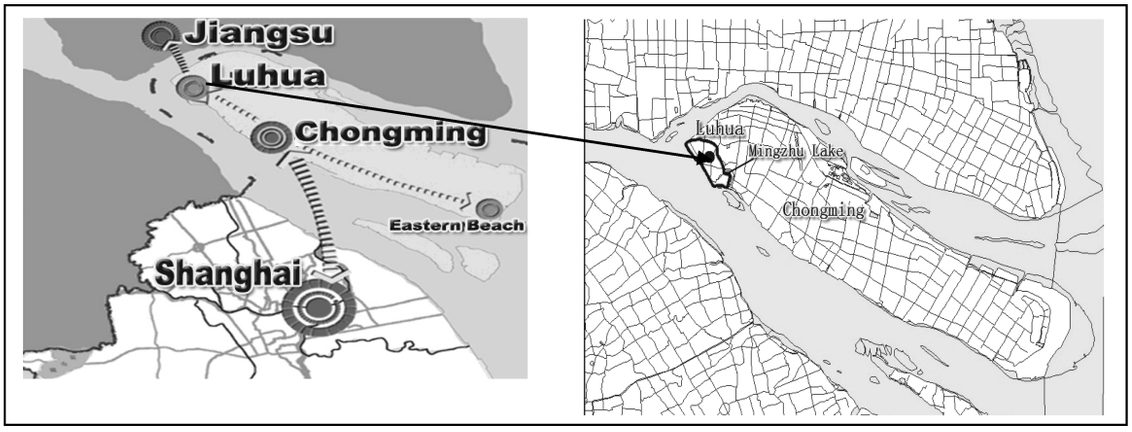

Fig. 1 Location of Chongming Island, China

Fig. 2 Location of Luhua EDP in Chongming Island, China

C_n = land capacity for population in the planning year 'n' of Luhua

Total quantity of sun radiation = 4.379×10^6 kJ/m^2·a

Multiple cropping index = 183.8%

Conversion efficiency to solar radiation = 2%

Bioavailability = 2%

Heat energy consumed per person = 9.888×10^3 kJ/person·d

Assuming that the multiple crop indexes remained constant, the cultivated area decreased at the same rate (3%) during 1996–2005, while bio-availability increased by 2.5% in 2005, 3% in 2010, and 4% in 2020. The heat energy consumed per capital was 1.154×10^4 kJ/person·d. The expected land capacity for population is listed in Table 1.

As indicated by the data above, there is still much space left for further development in Luhua area.

3.1.2 Economic development

Agriculture dominates the economy in this region. In 2004, the GDP was 82×10^6 RMB (10×10^6 US dollar) with 65% attributable to agricultural production. However, economical forests, vegetable cultivation, aquaculture, and herbal planting have now been selected as the four features of the eco-agriculture of Luhua, while production of fruits, vegetables, crabs, drugs, poultry, and livestock have been preferentially consolidated.

3.1.3 Land use

Land resource can be classified according to utilization as build-up land, cultivated land, orchard, forest, fishery cultivation, woodland, and river. The detailed information is listed in Table 2.

3.1.4 Problem analysis concerning sustainability of the Luhua Ecosystem

Isolated ecosystem

The island makes a relatively isolated ecosystem, which restricts development substantially.

Land use pattern

The random distribution of present human settlement and industry has led to a waste of land resource, severe non-point source pollution and depreciated aesthetic value.

Deteriorated water quality

The dredge problem has become a rising concern because of an inept discharge policy, unregulated trenches, and poorly guided fishery cultivation resulting in the clogging of river ways and eutrophication.

Weak environment monitoring

Only one environment monitoring station for water quality was set up and detailed information is not available to assess environment quality.

Greening pattern

Present vegetation is mostly economical forests, thus resulting in the lack of biodiversity and landscape diversity.

3.2 Procedure and detail design of eco-planning for Luhua EDP

Although some scholars such as Ouyang Zhiyun and Wang Rusong [7], Wang Xiangrong, et al [1,3,4] had studied the procedure of eco-planning, a satisfactory scheme for eco-planning is still lacking. The eco-planning for Luhua EDP was investigated according to the procedure shown in Fig. 3.

Directed by ecology, eco-economics, urban planning, and other principles, eco-planning of the Luhua EDP aimed at favorable characteristics such as higher economic benefit, social auspice, better ecological recycling, more efficient use of substances, energy and information, as well as harmony between humans and nature. Therefore, focus was given to enhancing basic ecological functions, including primarily reasonable planning of land exploitation, design of the industrial and technical chain, arrangement of human settlements, landscape and eco-tourism. The following four subsystems were designed through function zoning to achieve this objective. Each subsystem was composed of several sub-regions of various ecological functions that led to overall planning pattern success and enriched the idea of Luhua EDP.

3.2.1 High efficient eco-industrial subsystem

The principles of industrial ecology served as a guide in eco-industrial subsystem planning. All industries in the Luhua EDP were united into a close industrial and technical chain (Fig. 4), with minimal harm to the environment. Each step such as raw material gathering, pretreatment, technology, product selling, and waste recycling has been given appropriate attention to accomplish the objectives of better resources sharing, higher efficiency, and less pollution.

Table 1 Land capacity for population in Luhua

year	cultivated land area/ha	multiple cropping index/%	total quantity of sun radiation/ kJ·m^{-2}·a^{-1}	conversion efficiency to solar radiation/%	bio-availability/%	heat energy consumed per person/ kJ·person^{-1}·d^{-1}	land capacity for population/person
2000	1783	183.8	4.38×10^6	2.0	2.0	9.888×10^3	1.59×10^4
2005	1531	190			2.5	1.154×10^4	1.51×10^4
2010	1397	195			3.0		1.70×10^4
2020	1030	200			4.0		1.71×10^4

Table 2 Classification of the land use in Luhua (2005)

types	area/ha	ratio/%	area/m^2 per capital*
build-up land	408.9	10.6	434.9
cultivated land	1518.7	39.5	1615.3
orchard	846.6	22.0	900.4
forest land	64.2	1.7	68.3
sapling base	169.0	4.4	179.7
aquaculture	338.6	8.8	360.1
river	494.0	12.9	525.4
total	3840.0	100.0	4084.2

*Note: Data were collected from the Statistical Year Book published by the local government.

Two sub-regions in this subsystem were designed based on the status of Luhua:

(1) **A green eco-agriculture sub-region** was built based on current agricultural conditions. An economical forest, aquaculture, vegetable planting, poultry, and livestock breeding were integrated for mutual benefits. Waste material recycling, an important way to demonstrate significance of the EDP, is shown in Fig. 4.

(2) **An eco-industrial sub-region** encouraged the development of industries related to the use of solar energy, wind energy, software, bioengineering, ecological food, and other related products. In addition, tertiary industries such as catering trade, agro-product processing, eco-tourism, and transportation service were also welcome. The construction of these sub-regions will greatly promote eco-construction of the EDP by establishing demonstrative signs, publicizing eco-construction, attracting investments, and increasing sales.

3.2.2 High quality human eco-settlement subsystem

As the present human settlements of the Luhua area have various statuses, three types of human eco-settlements were planned according to the rules of Chinese Eco-town Standard (2003), thus guaranteeing the high quality of human eco-settlement system here.

Farmer houses spread around the Luhua EDP will be rebuilt on the **Living Park of Native Farmer-house.** All houses will be centralized in the town or villages. Current randomly distributed houses will form the base of eco-agriculture tourism.

A demonstration eco-community should have a higher construction standard to provide a satisfactory and healthy living environment. Strict detailed standards have been set for building material, structure design, plane, 3-Dimension vertical greening, and waste reuse.

3.2.3 High standard environmental protection and ecological construction subsystem

Ecological planning for this subsystem was divided into six networks as follows:

Network of greening system—this network was made up of four components: **green corridor** consisting of orange, gingko, and other economical forest trees; **green circle** around the town; **green belt** of coastal protection forest and riverside forest, and **green landscape zone** of the Mingzhu Lake. Subsequently, the total forest area will increase to about 1800 hm^2 in 2008, approaching half the area of Luhua.

Network of clean energy use—the demonstration center of comprehensive clean energy usage is the core of this network. This center is based on a solar-wind-biogas combined energy system, which can work continuously regardless of the weather.

Network of solid waste recycling—the classification and recycling of solid waste are listed in Table 3 and Fig. 5.

Network of wastewater treatment—Collecting rain and wastewater separately and maximizing their use is the key point of this network. The treatment methods may be based on self-purification of water or principles of the food chain. Oxidation ponds can be utilized here. If there were non-biodegradative or hazardous compositions, physical and chemical pretreatments were also required.

Network of natural reserves—Natural Reserves play an essential role in eco-construction.

At present, the Luhua EDP has only one cormorant nature reserve around Mingzhu Lake. This situation contrasts sharply with the abundance of natural resources of Luhua. The authors suggested putting forward some counter-measures to hasten the construction of nature reserves to justify the name of the EDP.

Network of green product distribution—How to transform natural capitals into developing incentives for economics and society is the major duty of eco-planning and eco-construction. Ecological industries in the Luhua EDP must be supported by government and grass-roots propaganda.

3.2.4 High attractive landscape and eco-tourism subsystem

General pattern of landscape planning

A general landscape pattern of the Luhua EDP was planned as follows:

Ecological corridor from the west to the east;

Axes of agriculture, industry, and settlements from the north to the south;

Circle of ornamental forest landscape around the town;

Shelter forest belt along the coastline;

Network of roads, rivers, ditches, and levees around the park.

Planning for eco-tourism

As far as natural and landscape resources are concerned, Luhua is definitely advantageous in developing eco-tourism. Four distinctive eco-tourism themes were designed to reflect these unique features:

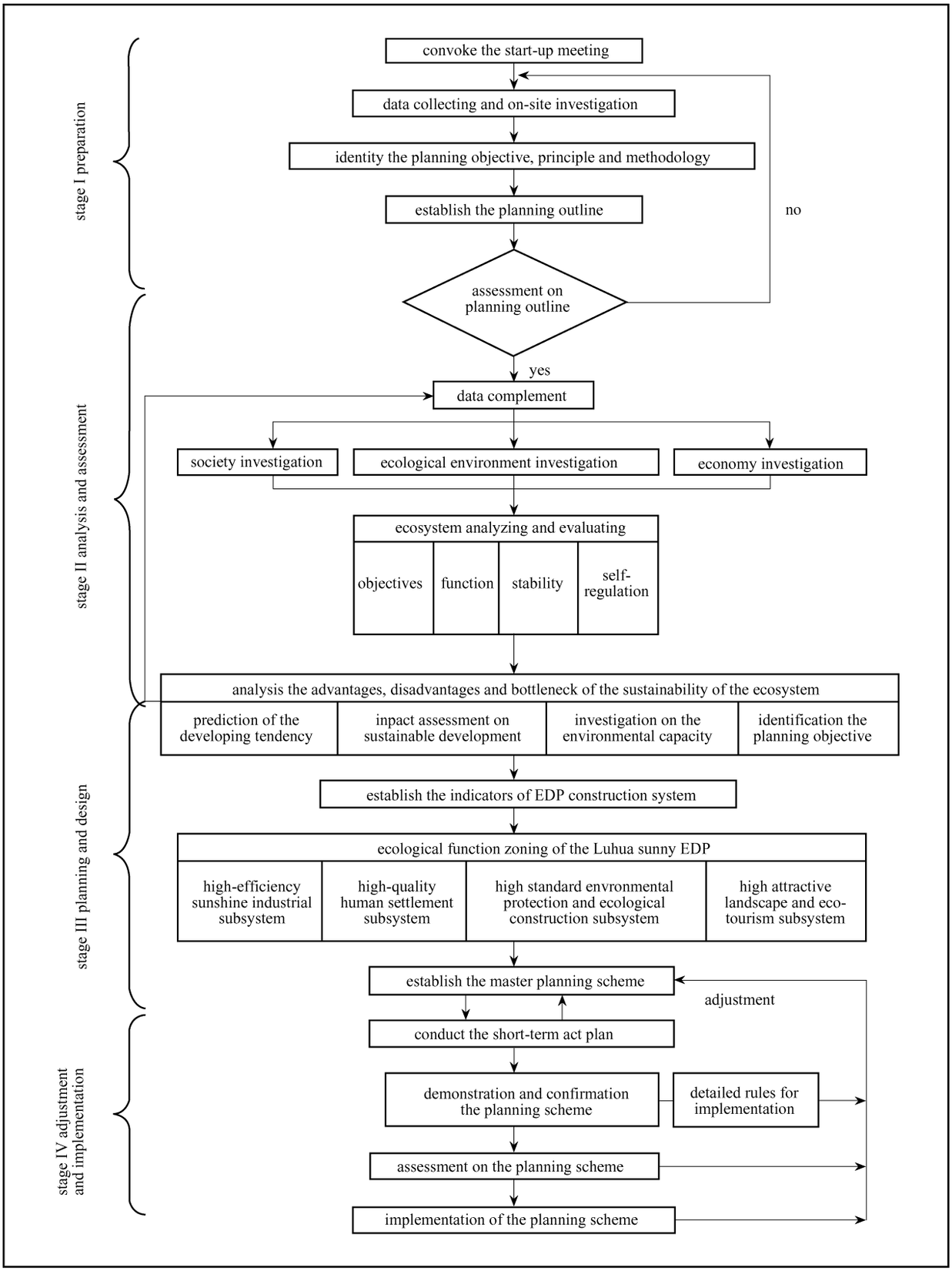

Fig. 3 Eco-planning procedure for the Luhua EDP

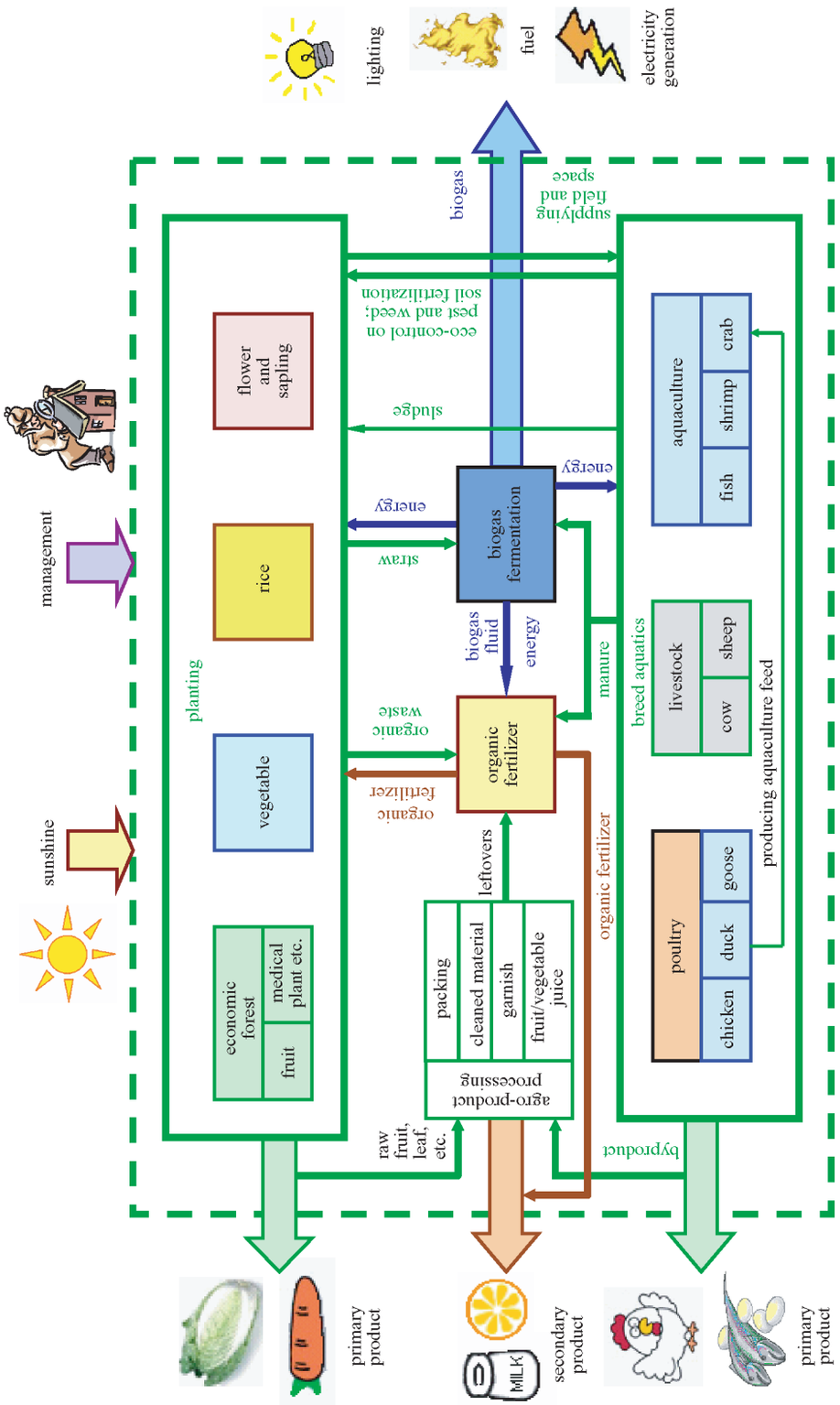

Fig. 4 System pattern of the eco-industrial subsystem

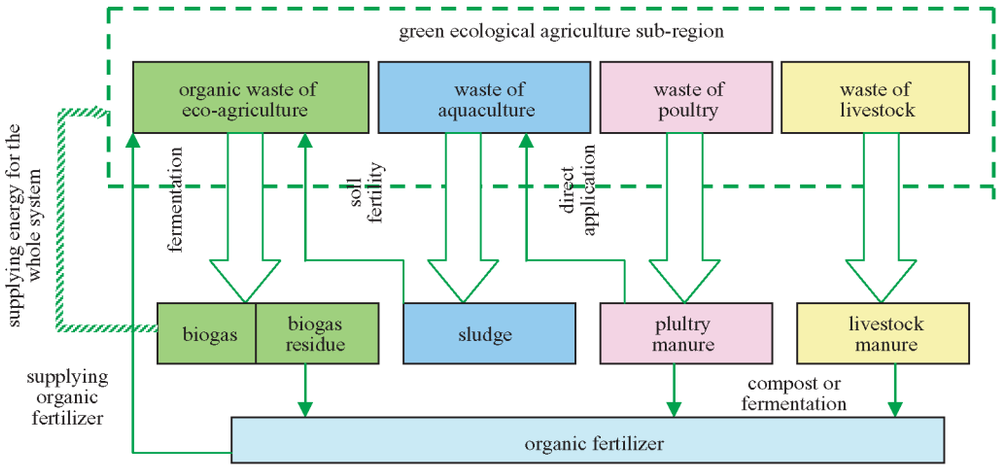

Fig. 5 Waste material recycling in green ecological agriculture sub-regions

'Folk-custom' eco-agriculture tourism was combined with the Living Park of native farmer-houses. Tourists would experience the pure flavor of traditional local customs.

'Field surviving' experience tourism was especially designed for the youth. All programs such as camping, barbecuing, and bulrush maze would satisfy their adventure needs.

'Mysterious harbor' popularizing science tourism—— The design of this theme made full use of the deep water shoreline of Luhua to simulate a 'real' harbor for citizens.

'Three-island' native cultural tourism was a theme park combining culture, custom, and native specialties of Chongming Island, Hengsha Island, and Changxing Island.

4 Conclusions

As discussed in this paper, the EDP should be an area with coordinated and sustainable economic, social and environmental subsystems. Eco-planning for the EDP aims to promote social auspice, higher economic benefit, better ecological recycling, more efficient use of substances, energy and information, as well as sustainability.

Through the practice of eco-planning for the Luhua EDP, the significance and conclusions of eco-planning for an EDP are summarized as follows:

To provide a practical framework and scientific basis for an eco-city;

To co-ordinate economic growth, social development, and environmental protection;

To promote sustainable development of a rapidly growing urban area;

Eco-planning should be carried out based on environmental, social and economic investigations, as well as capacity of the population derived from the eco-model;

Eco-planning is an important way to provide an opportunity to enhance mutual understanding and co-operation between officials and technicians majoring in ecology, environmental science, urban planning, and environmental management.

However, it will still take a long time to advance eco-planning to a higher level. Although the noteworthy

Table 3 Classification and recycling of solid waste

sub-region	categories of solid wastes	representative composition	treatment	recovery and reuse
eco-settlement sub-region	organic waste	food residues	compost	producing organic fertilizer
	inorganic waste	glass, metal, plastic etc.	classification	producing raw materials for concerning industries
			pretreatments	
eco-agriculture sub-region	organic waste	straws	compost	producing organic fertilizer
			biogas fermentation	producing cleansing energy
			transportation	producing paper-making material
livestock breeding sub-region	organic waste	poultry manure	feed processing	producing aquaculture feed
			compost	producing organic fertilizer
		livestock manure	compost	optimizing compost by N/P adjustment
whole park	hazardous waste	batteries	classifying reuse or sanitary landfill	recovering what can be reused to produce raw materials for concerning industries

significance of EDP eco-planning is acknowledged, more attention by both administrators and the general public is much desired.

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