Ecological Footprint in Nampong River Basin

Pattaraporn Weeranakin

Department of Social Sciences, Faculty of Humanities and Social Sciences, Khon Kaen University, Khon Kaen 40002, Thailand

Corresponding author. E-Mail address: pattawe@kku.ac.th

Abstract

According to Sustainable Development Goals (SDGs) related to Thailand National Economic and Social Development Plan, Environment is a challenging issue towards country development. This research aimed to examine the ecological footprint in the Nampong river basin, Nam Pong district, Khon Kaen province, Thailand. The data was derived from qualitative research. The focus group discussions with 29 formal community leaders in three sub-districts (three FGDs) were used, and in-depth interviews were applied to collect data from 30 key informants. FGDs guidelines and in-depth interview guidelines were the tools for data collection. The results presented that there were four aspects of the ecological footprint in the Nampong river basin: 1) food, 2) home, 3) good and services, and 4) transport. All aspects were utilized by natural resources such as land resource, water resource and forest resource. The land resource was mostly used for the agriculture, recognized as food aspect and goods and services aspect. Water resource and forest resource were natural food sources for the villagers, making some fish extinct from the poor water quality. This research increases awareness of natural resource utilization through ecological footprint aspects. The stakeholders in local policy level should empower the community participation in natural resource and environment management.

Keywords: Ecological Footprint, Nampong River Basin, Eco Industrial Town, Natural Resource and Environment

Introduction

The Sustainable Development Goals (SDGs), announced by United Nations for the world development during 2016–2030 (B.E. 2559–2573), consist of 17 goals (United Nations, n.d.). Five Goals are correlated to Thailand's environmental development – Chapter 4: The Twelfth National Economic and Social Development Plan on the growth friendly with environment for sustainable development (Office of the National Economic and Social Development Council, 2017). From international to national development goals, the aspect of environment is still a challenge for sustainable national development.

Studies on environment are highly advanced, especially science and engineering. There are several attempts to measure or evaluate human activities that affect environment e.g. residence, agriculture, fuel power, and food. Those activities are called "Ecological Footprint" (Calcott & Bull, 2007), statistically evaluated with a basis of scientific principles as shown in Figure 1.
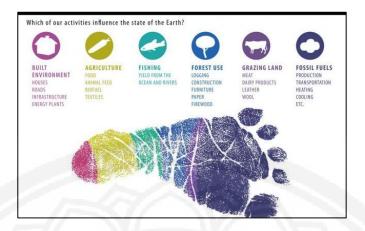
Figure 1 Activities that Humans have done with the Ecological Footprint
Source: Food Climate Research Network (FCRN), n.d.

Figure 1 shows the activities that humans have done with the ecological footprint. According to the figure, the activity that effects on the environment the most is about fuel power, such as production processes and transportations; followed by the activity about agriculture, such as foods (production), animal farming, and fabrics. However, some activities that humans have done with the environment; for example, warship to the Goddess of Grains, ordination of forest, warship to the Gradient Goddess of Boat, are in need to be farther explained along with the social dimension.

In 2012, Khon Kaen Province, a Northeastern province of Thailand, achieved Gross Provincial Product (GPP) at 185,595 million baht and GPP per capita at 106,583 baht, which is ranked the top first province in Northeastern and the thirty-first of the country. Industrial product was the highest earnt, 77,001 million baht (41.5% of GPP) (Khon Kaen Provincial Statistical Office, 2015). In the next year, industrial product was also the highest earnt, 73,955 million baht (38.75% of all product branches) (Department of Industrial Works, n.d.).

In 2018, it was found that Nampong District, Khon Kaen, consisted of 633 workers in industrial business, second to Muang Khon Kaen District where consisted of 799 workers (Khon Kaen Provincial Statistical Office, 2018). Furthermore, in 2015, the eco-industrial estate model scheme of Eco Center, Department of Industrial Works, Khon Kaen Province was 1 of the 15 Eco Center Provinces, which located in Nam Pong District, Khon Kaen Province. The major goal was to support the industrial development to be sustainably friendly with the community.

This study is an investigation of related concepts and theories in order to analyze and apply as the research framework, including ecological footprint concept and eco-industrial concept. Ecological footprint is the measurement or evaluation of human actions to the environment through activities both on ground and in the water (Wackernagel & Rees, 1996). According to Calcott & Bull (2007), the ecological footprint elements consist of 4 areas: (1) residence, e.g. fuel, electricity; (2) transportation, e.g. private vehicles, trains, planes; (3) foods, e.g. land for planting and enriching; and (4) consumer goods, e.g. fuel power for production and transportation. The concept of ecological footprint attempts to explain the sustainability from natural resources use by humans — if humans use natural resources too fast instead of replenishment, risk in unsustainable living will occur as a consequence (Calcott & Bull, 2007).

The eco-industrial concept, proposed by Frosch & Gallopoulos (1989), is the adaptation with sustainable industrial development which is friendly with environment. There should be a new design of industrial system similarly to natural eco system, based on interdependent principles. The system should use adequate and appropriate energy, raw materials, and substances, for the least waste. There should also be the interdependent relationship among two industries or more with exchanging energy or matters in which each industry gains benefits from it. This relationship can apply E2-Efficiency (Economy and Ecology) as the principle which will be advantageous for economy and environment. Therefore, Eco Industrial Town will be the industrial developing city based on eco-industrial concepts, with the connection among industrial estates, local organizations, and overall communities to be growing together with the good eco-control (The Industrial Environment Institute, The Federation of Thai Industries, n.d.).

This study examines the general state of four areas of ecological footprint: food, residence, goods/services, and transportations. It focuses on Nam Pong area, where the eco-industrial area of Nam Pong District, Khon Kaen Province, is located.

Methodology

The study applies qualitative research methodology to explore the general states of ecological footprint around Nampong area. The criteria to select an area consist of: 1) the area is the main target of eco-industrial town; 2) the area is surrounded by industrial factories; and 3) the area is the source of Nampong river basin. Therefore, sub-districts as the main targets of this study consist of Kudnamsai sub-district, Nampong sub-district, and Muangwan sub-district. The data was collected during May-June 2019.

The data were collected through Focus Group Discussion (FGD) among three groups of 29 community leaders. The participants who gave important information were the formal leaders, including 1) two sub-district headmen; 2) 18 village headmen; 3) seven deputy village headmen; 4) one village committee; and 5) one sub-district doctor. The tool for data collection was the FGD guideline for the information of each sub-district concerning its physical and environment, as well as its usage of natural resources based on ecological footprint concepts. This FGD is advantageous because it can collect data from several participants in a short-time period and it opens an opportunity for those participants to brainstorm for the resolution together (Potisita, 2006).

The in-depth interview purposively selected 30 participants from the FGD with the leaders of the communities where industrial factories are located. Those selected participants are varied by their careers and positions of the community: 1) 16 farmers; 2) three general labours; 3) four housekeepers; 4) two factory workers; 5) four shopkeepers; and 6) one retired government officer. The tool for data collection was the in-depth interview guideline purposed to gain general issues about natural resources and the usage based on ecological footprint. The gained data was derived from the group conversation.

This study verified information via triangulation of data verification (Nontapattamadul, 2003) from FGD and in-depth interview. The content analysis was applied to analyse data.

Results

The results of the general state around Nampong river basin based on ecological footprint are presented in two sections: 1) area context; and 2) ecological footprint in Nampong river basin.

1. Area Context

The area context information of three target sub-districts: Kudnamsai Sub-district, Nampong Sub-district, and Muangwan Sub-district, including area state, area size, number of industries, number of populations, state of economy and society, and religion and belief, is shown in Table 1.

Table 1 Area Context Information of Nampong River Basin

Issue	Kudnamsai	Muangwan	Nampong
Number of Villages	10	14	21
Area State	Alternation between hill and plain area, suitable for planting	Alternation between fen and dry land	Alternation between hill and plain area, suitable for planting
Area Size	22,211 Rai approx. 17.5 km. from Nam Pong District	53,250 Rai approx. 10 km. from Nam Pong District	45,000 Rai approx. 3 km. from Nam Pong District
Number of Industrial Factories	11	9	14
Number of Populations	1,395 houses, 4,293 populations	3,294 houses, 10,014 populations	4,933 houses, 13,929 populations
Economy and Society	Mostly agriculture and livestock, some out of agriculture (workers in areal factories)	Agriculture (rice) in fen area while farm plants in dry land (sugar cane/cassava), migrant labors (Laos/Myanmar) working in areal factories	Agriculture (rice) in fen area while farm plants in plain area (sugar cane/cassava), migrant labors (Laos/Myanmar) working in areal factories
Religion and Belief	Buddhism, The Twelve-month and fourteen-rule tradition	Buddhism, The Twelve-month and fourteen-rule tradition	Buddhism, The Twelve-month and fourteen-rule tradition

Source: Kudnamsai Community Organization Network Center, 2018; Muangwan Municipality, 2016; Lumnamphong Municipality, 2016

According to the conversation with the leaders from three target sub-districts, the areal context information shows that Kudnamsai Sub-district is close to Pong River, and some area is next to Mittraphap Road. Kudnamsai is a sub-district full of industrial factories such as paper factory, natural gas factory, and electricity plant. There were convenient consumption and transportation e.g. electricity, water supply, concrete roads. The career job is strong in terms of unity, obviously found from people joining activities together. Furthermore, the community leader has been awarded from Ministry of Inferior (*Naeb Thong Kam* Award). This sub-district contains a variety of population, both local and migrant people, due to the fact that there were many industrial factories with a lot of labors moving into the area. As a result, there are purchases and sales of lands which lead to convenient transportation.

Meanwhile, in Muangwan sub-district, there are famous OTOP products such as knives and *Dawk Payawm* Rice. In addition, this sub-district contains a lot of enterprise groups e.g. textile group, fattening cattle raising group, bamboo litter group, and sub-district chicken raising knowledge center. Nampong Sub-district also contains several famous local enterprises such as peanut bar business and knives business (like Muangwan Sub-district); as well as integrated agriculture which consists of variety of plantings including rice, sugar cane, cassava, pumpkin, watermelon, musk melon, corn. In addition, there are a lot of natural tourist destinations, such as Nong Wai Public Park, Nong Wai Dam, Sua Ten brook, Thung Teaw Marsh, Wha Marsh; and energy industrial factories, such as electricity, natural gas. People have unity and usually join activities together.

According to natural and environmental resources of those three sub-districts, the study shows that there are land resources, water resources, and forest resources. Each place has its own identity based on its own areal context as described below.

Kudnamsai Sub-district is found full of water resource because the most area is close to Pong River and other water resources. Having water resources in the area is advantage for agriculture. People plant rice, sugar cane and cassava, circulated each year due to the market demand. The forest resource in this area is community forest and public forest about 80 rai in Moo 1, 2, and 8. The forest is plentiful with natural plants such as mushroom, *mlientha suavis*, forest stuff.

Muangwan Sub-District area is a land of swamps with several forests located in forestry monastery; for example, 107-rai Thum Sua Temple in Moo 14 and Jai Temple in Moo 12. There are also public water resources such as Yang Brook, a large water resource where people use for living. It flows through Thum Sua Temple and almost every village in the sub-district. Another natural water resource is called Kud Pond, approximately 7 rai of land. Khon Kaen Land Development Department Office 6 has helped developing the area to be a pond in order to store water for community use. Later, people in the community turn to use water supply, and Kud Pond becomes the public pond for feeding fish. Apart from Kud Pond, Kham Yai Pond is also a natural water resource, believed as a holy pond where a Buddha Image was found and is now enshrined in a temple.

In Nampong Sub-district, the land resource is plentiful with plants, mostly agricultural ones such as rice, sugar cane, cassava, corn, vegetable, pumpkin, watermelon, generated a lot of income to local people. Regarding the forest resource, there are small community forests as public forests, for example, 100-rai Kog Hinlard Forest and some parts of Kog Hinkhaw, approximately 400-500 rai. Moreover, there are natural water resources in the area such as Nong Wai Dam that flows through villages including Moo 2, Moo 4, Moo 13, and Moo 15. Nong Wai Dam is located in irrigation area, a travel destination and a living place. There are rules for using the area, including Pong River, canals and other marshes.

2. Ecological Footprint in Nampong River Basin

According to group conversation with the community leaders and in-depth interview with the significant answerers, the results showed that general issues of ecological footprint in three target sub-districts in Nampong sub-district were classified into four parts including foods, residence, goods/services, and transportations (as shown in Table 2), as described below.

2.1 Food

2.1.1 Land Resource

As reported, the resource had been mostly used for agriculture such as rice field, sugarcane, cassava, vegetable. Rice and vegetable were for family consumption while sugar cane was sold at the sugar factory in Nampong Sub-District, and cassava was sold at the village cassava court. Meanwhile, in some villages near industrial factories, most of villagers worked in the factories as the main job whereas agriculture was the minor one.

"Villagers do not have much area to do for a living because there have sold their lands. People usually work in the factories while farmers are those who have a land to do so."

(Community Leader, interviewed, June 25, 2019)

Moreover, the community leaders agreed that the quality of land resource had been deteriorated, resulting in lower productivity and more chemical usage.

"Recently, the quality of land has been so deteriorated that farmers cannot produce adequate agricultural goods. This is because they use chemicals for a long time."

(Community Leader Group 1 & Community Leader of Kudnamsai Sub-district,

Khon Kaen Province, Focus Group Discussed, June 15, 2019)

2.1.2 Water Resource

According to the study, villagers usually used water at Yang Brook as the main water resource for a living such as fishing, because this brook was fertile. There were other living things such as bamboo shoot, tree shrew, squirrel, leech, shell, shrimp. Apart from local villagers, people from other surrounding sub-districts also came to use this brook for a living. Each village had brooks flowing through, and the villagers used them for a living such as fishing for family consumption and selling.

"They find shells, fish, shrimps, frogs, and tadpoles for eating. They'll sell the remaining around the village or market. When it comes to the season, there are a lot of fish such as Jullien's Mud Carp, Nile tilapia, Minnow."

(Community Leader, interviewed, June 24, 2019)

According to the interviews, villagers usually used water resources for consumption, depending on the area or how close it was to the water resource. The further villages did not have much opportunity to use water resources like the near ones. Nong Wai Dam, located at Nampong Sub-district, was where people used the most, like Thung Teaw Marsh, a 450-rai size of water resource. In brief, the villagers used the water resource that was close to their residence.

2.1.3 Forest Resource

It has been found that community forest is the most seasonally useful for finding forest things; for example, mushrooms and bamboo shoot in rainy season, and eggs of red ants, ground lizards, chameleons, Siam Tulips, and Melientha suavis in summer. Those forest items are for family consumption. If there are too many of collected forest things, the villagers will sell them. Currently, the villagers turn to plant sugar cane so that the area becomes the field of sugar cane.

"The villagers do not get into the forest recently because most of the forest area becomes the fields of sugar cane. As a result, forests are hard to find and the villagers find mushroom and eggs of red ants around their area."

(Community Leader Assistance, interviewed, June 24, 2019)

"Most of the land becomes the fields of sugar cane and cassava. There are only 5-6 rai left as the forest where people can find forest things. However, the forest things are already hard to find. People turn to feed or plant their own edible things such as feeding red ants for eggs."

(Community Leader, interviewed, June 24, 2019)

2.2 Resident Context

2.2.1 Land Resource

From the interviews, the land resource in the sub-districts turned from farms to residences, causing the enlargement of the village size. There were 2-3 houses increasing each year which resulted in the

increasing number of the residents. In addition, there was a higher number of land selling and buying in order to renovate the area within the villages.

2.2.2 Water Resource

People did not usually use water from the canals for consumption, but water supply instead, because the natural water resource in the community was smelly. Some sub-districts where the factories were located used purified water according to the factory welfare.

> *"The factories release water every day during 14.00-17.00 hours, approximately. The time is not certain, but the water is quite muddy."*
>
> (Community Member, interviewed, June 25, 2019)

2.2.3 Forest Resource

There was no tree cutting for making a residence because the forest was public so that everyone owned it. Therefore, people only used logs from dead or broken trees to make firewood. Apart from the villagers in the sub-districts who used the forest resource, there were people from surrounding villages using it as well.

> *"In the past, there was the finding of firewood in the forest. However, this activity has not disappeared, but people turn to build a cement house instead of a logged house."*
>
> (Community Leader, interviewed, June 24, 2019)

> *"There was tree cutting for building houses in the past when there were a lot of trees. In the present days, there are not many forests, and tree cutting is illegal. So, people turn to use iron frames to construct."*
>
> (Community Leader, interviewed, June 25, 2019)

2.3 Goods/Service Contexts

2.3.1 Land Resource

From the study, agricultural products such as rice, sugar cane, cassava, had faced a problem of high cost but low production, resulted from the economic crisis. Plants were rotated each year depending on the prices and market commands. Above all, rice and sugar cane were the most planted.

Agricultural products such as rice, sugar cane, cassava, and corn, were the high income of the community. They were rotated planting each year depending on the market price. However, people usually planted, especially rice, for family consumption and selling the remaining.

> *"Sugar cane was not very famous depending on each area because it was sold to the capital and then sent to the sugar factory."*
>
> (Community Leader Assistance, interviewed, June 24, 2019)

2.3.2 Water Resource

As reported, people went fishing mainly for family consumption. They also sold fish in the community and the nearby markets.

> *"Fish are processed to be pickled fish, dried pickled fish, and sun-dried fish."*
>
> (Community Leader Assistance, interviewed, June 24, 2019)

"Those who can find a number of fish will sell them. The sold fish include carps, snake-head fish, Jullien's golden carp, and stripped catfish. Meanwhile, shrimps, shells, frogs, and bullfrogs are only for family consumption because there are rare."

(Community Leader, interviewed, June 25, 2019)

2.3.3 Forest Resource

The villagers found forest food for family consumption rather than selling, for example, mushroom, eggs of red ants, and ground lizard. They also grew eucalyptus trees and sold them at the sub-district paper factory. The earned money to be spent for the community activities.

"The eucalyptus trees are sold, and the money are taken to the village fund."

(Community Leader, interviewed, June 25, 2019)

However, some houses had their own fields for selling.

"Some houses plant their own eucalyptus trees in their area, around 100-200 rai or less. If the price is low, they will make them firewood for selling. They will not go into the forest for finding firewood, using left logs and their own eucalyptus instead."

(Community Leader Assistance, interviewed, June 24, 2019)

2.4 Transportation Context

2.4.1 Land Resource

The villagers went to their farms by several types of vehicles such as pick-up truck, motorcycle, bicycle, truck, and motor tricycle. Tractors and harvesters were used in farming seasons.

2.4.2 Water Resource

The villagers went to the public water resources by trucks, motorcycles, and tractors for water pumping. They usually went by a motorcycle because it was more convenient.

2.4.3 Forest Resource

The villagers went to find food in forests by pick-up truck or motorcycle. If the forest was not too far, they mainly went by bicycle or on feet.

Table 2 General State of Ecological Footprint in Nampong River Basin

Dimension of Ecological Footprint	Land Resource	Water Resource	Forest Resource
1. Food	– Agriculture (rice/ sugar cane/ cassava) – Animal feeding (cows/ buffalos) – Soil quality is deteriorated	– Source of foods (fish/ water creatures) – Low quality of water causing extinction of some kinds of fish	Source of food (mushroom/ eggs of red ants/ ground lizard/ bamboo shoot/ Melientha suavis)
2. Residence	– Enlargement of area for building houses – Land covering for soil quality	– Consumption – Agriculture	Use logs from died/ broken trees as firewood

Table 2 (Cont.)

Dimension of Ecological Footprint	Land Resource	Water Resource	Forest Resource
3. **Goods/Services**	– Agricultural products (rice/ sugar cane, cassava) – Plants based on market prices (sugar cane, cassava)	– Plenty of fish sold in rainy season (in the community/market) – Processed fish (pickled fish/ dried pickled fish/ sun-dried fish)	– Enlargement of area into the forest for planting (sugar cane) – Community planting eucalyptus trees for community income
4. **Transportation**	pick-up truck/ motorcycle/ bicycle/ motor tricycle truck/ harvester/ tractor	Truck/ motorcycle/ tractor for water pumping	truck/ motorcycle

Source: Synthesis of group conversation with the community leader and in-depth interview with the important answerers

Considering the general state of natural resources in the sub-district area where eco industrial factories are located, it was found that the three natural resources: land, water, and forest, were significant as an eco-industrial city directly and indirectly. It can be explained that the land resource was directly important as an eco-industrial city because it was the location of the factories. The indirect importance of the land resource was the factories tending to extend into the community. The soil quality might be deteriorated and resulted from the chemical absorption.

Water resource was directly important for being an eco-industrial city as a usable resource and water release resource. The indirect importance of water resource was the quality of water resource, an indicator for good or bad water quality. In case that toxin element was released into the water, this affected the water creatures. The forest resource was directly important as an eco-industrial city. Most of the forest resource were newly planted forests. This was resulted from people planting eucalyptus trees to sell at the paper factory. In addition, the indirect importance of forest resource was the forest that gave the factories green environment in a small area.

Discussion

The 4-dimension ecological footprint: food, residence, goods/service, and transportation around Nampong River basin, where the eco industrial city is located: Nampong District in Khon Kaen, has been found connected to the use of natural resources: land, water, and forest. Land and water resources are used the most. The result of the study shows that the quality of soil and water is low. Soil has been deteriorated due to the fact that farmers do intensive agriculture by planting food plants (rice) and energy plants (sugar cane and cassava), so that the ecological value has been continually destroyed (Sueethorn, 2012). The other cause of low-quality soil is the use of chemical fertilizers for rice, sugar cane and cassava, of which the productions are still low. The production of sugar cane in the past ten years, B.E. 2545-2555, has been continually reduced from 20 tons per rai to only one ton per rai as the soil fertility has been lower (Promphakping et al., 2012).

The study reveals that the quality of water has been low due to the fact that the factories release contaminated things into the water of the target sub-districts, which result in the extinction of some types of fish (Galli, Wackernagel, Iha, & Lazarus, 2014). Unlike the study of Muangthong & Shrestha (2015) which evaluated the quality of the water surface at Phong River, Khon Kaen Province, and Songkram River, Nakorn Panom Province, it was found that the quality of water had been effected from the natural process and human behavior such as development and enlargement of the cities, factories, and agricultures. The study of Muangthong & Shrestha

(2015) stated that the quality of water surface had been affected from several factors such as water temperature (natural temperature), toxic from organic substance (used water from houses), and other nutrients (agriculture).

In this study, the size of forest resource has been turned to the fields of sugar cane, cassava, and eucalyptus. The natural forest around Phong River basin has been turned to the agricultural forest since B.E. 2535. It is found that the forest that covers 80% of Phong River has been 30% left because people use the forest area for agriculture (Wilk, Andersson, & Plermkamon, 2001). The remaining are cultural meaningful for the villagers, as for it is the place where holy spirits live, for example, temple, cemetery, forest (Promphakping et al., 2012).

According to Thailand's industrial area development to be eco-industrial in *A Case Study: Maptaphud Industrial Estate, Rayong Province, Thailand* (Aruninta, 2012), environment has been cruelly affected. Maptaphud Industrial Estate has been categorized as a pollution control area where pollution must be controlled, reduced, and eradicated. Nampong District, Khon Kaen Province, is one of 15 eco-industrial provinces, enlisted in B.E. 2558. As a result, as Aruninta mentions, it is significant for all sectors to be prepared for the eco-industrial city. The design of eco industrial area is required to be full of trees. This will be widely useful in encouraging the beauty of the area, the condition of economy, and the ecosystem. The result of this study reflects that there are less green areas considered as important forest resources to be the eco industrial city. Moreover, the community area contains hills and grounds where the weather is dry. This is one of limitations as a green area. The related persons should consider the following issues.

The development of eco-industrial cities is mainly aimed to solve environmental problems caused by industrial development. It focuses on reducing contaminated things and rotating worthy energy usage (Muyjeen, 2016). The development factor for eco-industrial cities is to have a group or team of eco industrial management. The key factor is government support of eco industrial management for sustainable economic development (Teeravaraprug & Podcharathitikull, 2016; Dong et al., 2013). The result of this study indicates that developing a city to become an eco-industrial city should consider the effects, especially society and environment. Related organizations including government organizations, private sectors, and people should be acknowledged about the concept and the phenomenon of being an eco-industrial city. It is also important to communicate with communities because they are the center of coordination and running activities in the community (Phoochinda, 2014). This encourages the community to participate in the local natural resources' management.

Conclusion and Suggestion

This study has been found that the general ecological footprint around Nampong river basin consists of four areas: food, residence, goods/services, and transportation. Every area is related with the use of three natural resources: land, water, and forest. They are both directly and indirectly important for being an eco-industrial city. Understanding an eco-industrial city is still limited in local administrative organizations.

This study highlights people's realization of using natural resources in four areas as indicated in the ecological footprint conditions around Nampong river basin. The suggestions are as follows:

1. Local related persons such as local administrative organizations, local industrial factories, and civil society should acknowledge people about the eco-industrial city development.

2. Local administrative organizations should encourage the factories. People need to realize the worth of using natural resources and the replacement of the used resources such as increasing green area and soil fertilizing.

3. Local administrative organization should encourage community power to participate in natural resources and environment management.

Acknowledgements

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