Eco-industrial parks in China: current situation, problems and development suggestions

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Abstract

The purpose of this research is to introduce the context of Eco-Industrial Parks（EIPs）in China, outline the current situation, analyze the success and failure aspects of EIPs, and, then, put forward some feasible development suggestions for China EIPs, from the perspectives of both circular economy and sustainable development. Research questions that arose from literature review led a secondary data analysis concerning challenges that EIPs practices face like economic growth, environmental protection and sustainable urbanization. The present study aims at stimulating more practitioners and researchers' interest concerning EIPs since economic, social and ecological sustainability is a global concern.

Keywords: Eco-Industrial Park (EIP), Circular Economy, Sustainable development.

1. Introduction

Human beings benefit a lot from the continuous development of productivity and technology in all kinds of industrial activities. However, excessive industrial production also bring in a series of environmental ecological problems, such as the depletion of water and energy, the disruption of soil and plants, the reduction of biodiversity, as well as greenhouse effect. Consequently, people have been suffering a very high cost of resource wastage and environmental deterioration. With the extensive recognition of sustainable development proposed in the International Union for Conservation of Nature (IUCN), a new form of industrial organization based on industrial symbiosis and circular economies, the Eco-Industrial Parks (EIPs), have emerged over the last decades and they have drawn wide attention throughout the world.

It is widely admitted that China witnessed rapid economic growth from "Reform and Open door" policy, in 1978. In the transition of almost 40-year economic miracle, China government tried a serial of methods to promote the development of all walks of life, including agriculture, industry and service, some of which really work very well and

fulfil some economic goals.In order to promote economic growth, some attempts have been tried by central and regional governments of China, such as the Economic-technological Development Zone, High-tech Industry Development Zone, National Demonstration Eco-Industrial Parks, and New the Development Zone. Whenever this kind of attempts were launched, they always drew extensive attention rapidly. However, for the past decades, China took the lead as the world's champion in terms of industrial output, surpassing the United States, and becoming the true "world plant" in 2012 (Shi & Yu, 2014). At the same time, in recent years, because fog and haze weather is getting common in many areas of China,sustainable development and circular economy is increasingly getting the public concern.All kinds of industrial parks have played a great role as "policy pioneers"(Shi & Yu, 2014) and, nowadays, more and more researchers and practitioners both in China and foreign countries are interested in such themes as circular economy and Eco-Industrial Park (EIP).According to the definition in the "Law to Promote Circular Economy in People's Republic of China", from January 1st, 2009, circular economy is the integration of activities of reduction, reuse and recycle during producing, exchange and consumption (Shen & Qi, 2012). Thus, Circular Economy is essentially an ecological economy, which requires human economic activities in line with 3R principle, namely Reduce, Reuse and Recycle(Ying & Zhou, 2012).Circular Economy (CE) changes the traditional one-way linear economic model of "resource – product – waste" into the feedback circular economy mode of "resource – product – waste – renewable resource", which conforms to the concept of sustainable development. It also utilizes resources and protects environment more effectively, so as to gain maximal economic and social benefits with minimal resource consumption and environment cost (Ying & Zhou, 2012).

According to the United States Environmental Protection Agency(US EPA), an Eco-Industrial Park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials (Chertow, 2000). Industrial symbiosis is another concept related to EIPs and engages entities that are traditionally separated in a collective approach to gain competitive advantage by involving physical exchange of materials, energy, water, and by-products (Chertow, 2000). An Industrial Park can be classified as an Eco-Industrial Park(EIP) if the community of businesses cooperate with each other, sharing resources (Valenzuela-Venegas et al., 2016). This type of Industrial Parks can receive the denomination of EIPs because on different grounds, related either with sharing materials, energy, or infrastructures. It is also possible to develop green infrastructure or foster scavenger companies in the Park, so Industrial Symbiosis is one possible aspect of EIPs. The most accepted definition of an EIP proposes a community of businesses located together on a common property(Valenzuela-Venegas et al., 2016). These businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. In fact, an EIP is a new type of industrial park which is designed and constructed according to cleaner production requirements, Circular Economy concept and Industrial Ecology Theory. Thus, EIPs also obey to the3R principle of Circular Economy (Paper & Chunyou, 2009).

In China, industrial development was promoted, firstly in the form of Economic and Technological Development Areas (ETDA), in 1984, and then, as High-Tech Parks (HTP), in 1988. Up to the end of 2013, China had around 300 national industrial parks, including 210 ETDA and 113 HTP (Shi et al., 2012).Chinese Government has initiated an ambitious national demonstration EIP programme, in 2001, and some trial EIP programmes later on (Shi et al., 2012)to increase environment awareness in harmony

with industrial growth. With the quick development of urbanization in China over the past decade, it is getting more and more urgent to create a win-win relationship between economy and environment during urbanization in an industrialized town(Yu et al., 2015a).Another common definition presents the EIP as "a community of businesses that cooperate with each other and with the local community to efficiently share resources (e.g. information, materials, water, energy, infrastructure and natural habitat) leading to economic gains, gains in environmental quality and equitable enhancement of human resources for the business and local community"(Popescu, 2008).The EIP concept by the United Nations Environment Program was introduced to China in 1997 (Hashimoto et al., 2010; Shi et al., 2010). EIPs can improve the economic performance of participating companies and minimize their environmental impact(F. Yu, Han, & Cui, 2015). EIP practices in developed countries, such as Denmark, USA, Germany, and Japan, have provided useful references for EIP development in China(F. Yu et al., 2015). The State Environmental Protection Administration (SEPA) of China launched EIP pilot projects in Guangxi, Inner Mongolia, and Shandong provinces in 2001, and explored EIP planning and construction at the national level in 2003. In 2007, SEPA, the Ministry of Commerce, and the Ministry of Science and Technology jointly issued the Management Method for the National Demonstration EIP Program to facilitate the development of Chinese EIPs. Among these national demonstration of EIPs, the Tianjin Economic and Technology Development Area, the Suzhou Industrial Park, the Yantai Economic and Technology Development Area, and the Dalian Economic and Technology Development Area are popularly used as typical case studies for EIP construction in China(Yu et al., 2015). The research interest on China's EIP includes EIP management, material and energy integration, IS, planning methods, performance assessment, and low carbon development (Tian andWei, 2012).

Chinese Government initiated an ambitious national demonstration EIP programme in 2001and some trial EIP programmes later on(Behera et al., 2012; Shiet al., 2012)to increase environment awareness in harmony with industrial growth. With the quick development of urbanization in China over the past decade, is getting urgent to create a win-win relationship between economy and environment during urbanization in an industrialized town(Yu et al., 2015).There are some successful experiences and failure lessons to be learnt as well, particularly because, circular economy and sustainable development are increasingly getting of public concern. So, in this paper, the implications of some empirical cases are also addressed. Thus, the following core research questions provide guidance to the investigation:

- RQ1: Why did Chinese Government initiate a national demonstration and trial of EIPs?
- RQ2: What is the *status quo* of EIPs in China? What are the success and failure issues over the past decades?
- RQ3: How to generalize and promote the successful experiences? What kind of suggestions can be put forward for future sustainable development?

2. Research Method

This paper presents a systematic literature review and a content analysis based on the adopted database. The main secondary data cited in this paper are from the data centres of EIPs administration departments in China, Ministry of Environmental Protection, Ministry of Commerce and Ministry of Science and Technology of People's Republic of China. Some documentary information and a few statistics figures were treated and refined in tables to facilitate the study and the readers' understanding.

3. Eco-Industrial Parks in China

3.1Evolvement of EIPs in China

From 1984 to 1988, Chinese industrial parks were first built in the eastern coastal areas, such as Tianjin, Yantai, Shanghai, and Guangzhou. After several decades, the number of industrial parks was at least 1568 in 2011 (FYu et al., 2015). In the same year, the gross domestic product (GDP) growth rate of industrial parks(30.3%)was significantly greater than that of the national average (9.2%)(F. Yu et al., 2015). Thus, industrial parks became one of the major contributors to the economic growth in China. Despite early environmental pollution control actions and management measures (such as end-of-pipe pollution control approach and environmental impact assessment), they have been unable to ease the environmental pressure caused by the high economic development of industrial parks. Thus, some parks have paid severe resource and environmental costs (Yu et al., 2015). In order to resolve the contradiction between economic development and environmental pollution, the Chinese government has adopted the EIP program in the hope of benefiting both the economy and the environment. At the national level, the issue of Circular Economy (CE) was officially considered in the government decision-making agenda in 2003, and CE development was brought into the National 11th Five Year Plan in 2005. A series of policies about CE pilot city and parks establishment were published to promote CE development(Yu et al., 2015).

Kennedy & Johnson(2016) point out that *The Draft Outline of China's 13th Five-Year Plan on National Economic and Social Development* highlights that China should focus on improving environmental quality and solving prominent eco-environmental problems, devote greater efforts to eco-environmental protection, enhance the efficiency of resource utilization, provide more high-quality green products to consumers, and promote Chinese people's well-being and prosperity in a beautiful China. The *Draft Outline* proposes: (i) to strengthen integrated environmental governance, innovate in terms of concepts and methods of environmental governance, carry out the most stringent environmental protection system, emphasize polluter's liability, establish a co-governance system for government, enterprises and the public, and generally improve environmental quality; (ii) to fully implement the action plans on pollution prevention and control, mitigate against environmental risks, strengthen the development of environmental infrastructure, and reform the fundamental systems in environmental governance. The *Draft Outline* also proposes (i) to strengthen ecological protection and remediation, give priority to the protection and restoration of nature, facilitate the protection and remediation of natural ecosystems, establish ecological corridors as well as biodiversity conservation networks, comprehensively enhance the stability and the capacity of natural ecosystems to provide services, and construct sound ecological security barriers; (ii) to comprehensively enhance ecosystem functions, promote ecological remediation of key areas, increase the supply of green products, and preserve biodiversity. Finally, the *Draft Outline* proposes (i) to foster the green industry and the environmental protection industry, support the development of service providers, promote energy-saving and environment friendly products, support innovation for technical equipment and services, improve policies, facilitate the development of the energy-saving and environmental protection industry; (ii) to increase the supply of environmental protection products and services, and develop technical equipment for environmental protection(www.mep.gov.cn, Ministry of Environmental Protection of the People's Republic of China)

To sum up, the evolution of the EIPs in China can be divided into three stages: (i) stage one is about twenty years from 1980s to 2001; (ii) stage two is the period between 2001 to 2015; and, (iii) stage three, is from 2015 on (Table 1).

In the first Stage, Chinese government started to set up a serial of Economic-technological Development Zones and high-tech industry development zones under the background of *Reform and Open door* policy from 1978, *Reform of the Economic System* from 1984 and the exploration of institutional innovation, market mechanisms, technology and economic growth during those twenty years. The goals of these activities can be broadly summarized as attracting foreign investment through industrial projects, improving export, and promoting manufacturing industry, hi-tech and high added value. All these development zones are the sound background of EIPs in China, even though most of them are not called with a name of Eco-Industrial Parks. Almost all development zones kept the original names after they were approved as demonstration EIPs.

For the second stage, the symbol is the ambitious national demonstration of EIP programme initiated by Chinese government in 2001 and some trial EIP programmes later on. People recognized the unsustainable limitation of natural resources and, also, the disruption of the ecosystem caused by industry development, so the goal of setting up EIPs is to explore and coin new economic development modes with keeping balance in economic growth, social development and environment protection.

Table 1 –Timeline and characteristics of China's industrial parks

Three stages	Forms of industry parks	Background	Goals
From 1980s on	• Economic-technological Development Zone • high-tech industry development zone	• "Reform and Open door" policy in 1978. • Reform of the economic system in 1984 • Exploration of institutional innovation, market mechanisms, technology and economic growth	• Attract foreign investment through industrial projects • Improve export • Promote manufacturing industry, hi-tech and high added value
From 2001 on	• National Demonstration Eco-Industrial Parks	• Keep economic growth, social development, and environment protection • Natural resources limitation	• To coin demonstration economic development modes with high energy efficiency and industrial symbiosis
From 2015 on	• New district • Eco-city	• Urbanization • Environmental concerns	• To pursue sustainability and balanced development

With the release of China's *13th Five-Year Plan on National Economic and Social Development*, it comes to the third stage of EIPs, in China, with the expansion of resources consumption and the aggravation of environmental decay, coupled with increasing urbanization, rising population size in almost all big and medium sized cities in China. It seems hard to focus on accelerating economic development only by considering EIPs themselves and neglecting environmental concerns. In order to pursue sustainability and balanced development Chinese government had to combine industrial

growth with city development, so the concepts such as new district and eco-city are put forward. A lot of EIPs are located in the new district of a city, for instance, the Huayuan Technology Park is located in Tianjin Binghai New District. Suzhou is called an eco-city, with the first and recognized most successful EIP of China, Suzhou Industrial Park and Suzhou High-tech Industrial Development Zone in Suzhou city. The policies of planning and designing new district and eco-city can impose a considerable impact on both the operation of EIP and the development of the city. As is shown in Table 1, the timeline of three stages, main characteristics of China's industrial parks, backgrounds and goals are listed by and large.

3.2 Status quo of EIPs in China

According to the official website of the Ministry of Environmental Protection of the People's Republic of China (www.sepa.gov.cn), the latest published list of eco-industrial parks in China shows that there area total of 48 National demonstration EIPs approved since their start in 2001 (Table 2), and 45 National EIPs are still under assessment and improvement (Table 3).

Table 2 –Extract of the list of approved National Demonstration EIPs in China

National Demonstration EIPs	Approved date	Province
1.Suzhou industrial park	Mar 31 2008	Jiangsu
4.Yantai economic and technological development zone	Apr 1 2010	Shandong
12.Shanghai Jinqiao export processing zone	Apr 2 2011	Shanghai
15.Nanjing high-tech industry development zone	Mar 19 2012	Jiangsu
19.Shandong Guxiangguang Eco-industrial park	Feb 6 2013	Shandong
23.Shenyang economic and technological development zone	Jan 10 2014	Liaoning
34.Ningbo economic and technological development zone	Jul 31 2015	Zhejiang
48.Changchun Car industry economic and technological development zone	Nov 29 2016	Jilin

Table 3 –Extract of approved under assessment National Demonstration EIPs in China

National Demonstration EIPs	Approved date	Province
1.Guigang sugar industry national eco-industrial park	Aug 14 2001	Guangxi
2.North Lu corporation group company	Nov 18 2003	Shandong
3.Nanchang high-tech development zone	Apr 1 2010	Jiangxi
8.Taiyuan economic and technological development zone	Apr 2 2011	Shanxi
11.Guangzhou Nansha economic and technological development zone	May 30 2012	Guangdong
13.Qingdao economic &technological development zone	Feb 5 2013	Shandong
24.Langfang economic and technological development zone	Oct 14 2014	Hebei
45.Changsha high-tech development zone	Sep 21 2015	Hunan

Based on the secondary data shown in Tables 2 and 3, some analysis is conducted and depicted in Figures 1 and 2.In order to facilitate the analysis, both approved and under assessment national demonstration EIPs are equally treated. So, the total amount of EIPs is 93. As a matter of fact, most of the EIPs under assessment were approved four or five years ago, even far back to 2001, e.g. the Guigang Sugar Industry National Eco-Industrial Park. From these two figures, it is obvious that : (i) only in Jiangsu province,

there are 30 EIPs, which occupy almost one third of the total;(ii) most EIPs are located in the east of China;(iii) only the total of Jiangsu, Shandong, Shanghai and Zhejiang is 58, which account for 62.4%;(iv) by calculating all coastal provinces and cities of eastern China, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong respectively, the total amount reaches 68, which takes a proportion of 73.1%. This means the EIPs are highly concentrated in eastern China. Among the four municipalities directly under the Central Government, Beijing, Shanghai, Tianjin, and Chongqing, there is no any EIP in Chongqing so far, and only one EIP in Beijing. At the same time, there still are some other provinces without EIPs such as Heilongjiang, Henan, Ningxia, Qinghai, Tibet and Hainan.This means a very unbalanced situation; on the whole there are very few Eco-Industrial Parks in the central and western areas of China.

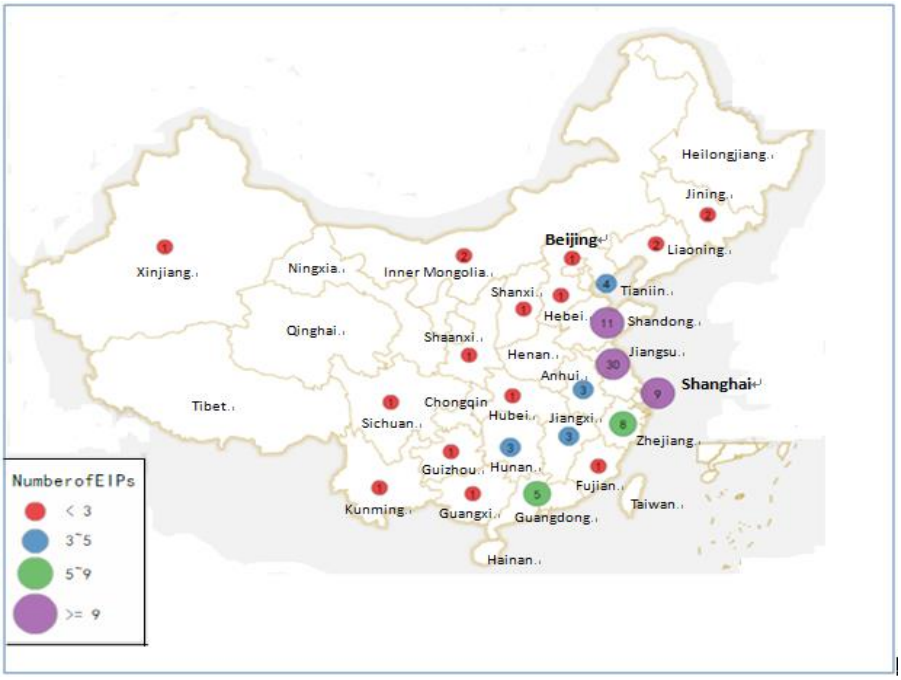

Figure 1 –Distribution of EIPs in China

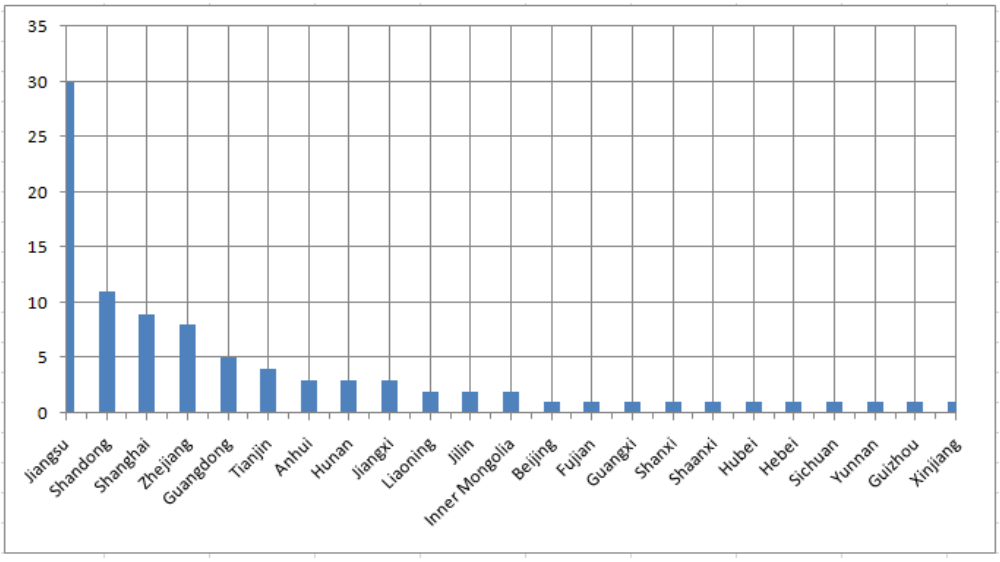

Figure 2 –Numbers of EIPs in China based on Provinces

4. Discussion

4.1Successful aspects of China EIPs

China's economic success generated a lot industrial development, and to a large extent, all kinds of industrial parks greatly facilitated industrial development. The performance in these aspects facilitates the success of China EIPs, as well as laws and regulations, policy guidance and advertising, and enterprises involvement.

Firstly, laws and regulations play a critical role in the evolvement of EIPs in China, e.g. the *Environmental Pollution Prevention and Control Law of Solid Wastes* issued in 1995, the *Regulation to promote cleaner production* that has been passed and come into effect since 29th Jun 2001 (Yu, 2008),the *Cleaner production promotion law 2002*, and the *Circular Economy Promotion Law 2008*(Yu et al., 2015).

Secondly, EIP performances also result from government policy guidance and advertising. Therefore, Chinese Governments (both state and local) play an essential role in improving EIPs' development, especially when it comes to the integration and balanced development of industrialization and urbanization.Chinese central government has published thirteen *Five-Year Plans on National Economic and Social Development*since the foundation of new China in 1949. They are the fundamental principle guidelines and impose a considerable impact on economic and social development. At the same time, Industrial policies emphasize and guide resources utilization efficiency and environmental protection, promote the strategic adjustment of economic structure, and balance social harmony development. For instance, the following examples might be cited: *Policies about value added tax on waste materials recycling business 2001*,*Guidance of Resources Comprehensive Utilization* in the 11th Five Year Plan 2006, *Notification about value added tax policies on resource comprehensive utilization products 2008*, and *Policies of resource comprehensive utilization of technologies in China 2010* (Yu et al., 2015).

There also is a great amount of polices and guidance at both national, provincial and local city level For example, at Shandong Province level, the *Regulation of Resource Comprehensive Utilization in Shandong Province* was introduced to guide the enterprises to utilize solid and water waste and gas, heat, and pressure in production processes, and to propose local government to give financial support in 2001. In 2005, the Shandong government released the *Suggestions on Developing Circular Economy and Building Resource-Conserving Society*, which claimed to promote CE development through pilot, demonstration, and publicity. At city level, the Rizhao government formulated the *Eco-city Construction Plan of Rizhao* and the *Outline of Plan for the Circular Economy Development of Rizhao* in 2002, to clear the orientation of urban development. Published in 2005, *Promoting Methods for Circular Economy* in Rizhao also outlined the implementation plans of CE development(Yu et al., 2015).Thirdly, enterprises involvement have greatly contributed to the success of EIPs. In most places, EIPs are very attractive to all kinds of firms and manufactures, they can benefit a lot from local governments and EIP management, in terms of preferential tax policy, employee recruitment, commuting support ,convenient logistics service and even as regards some financial subsidies, as well. All of these factors greatly facilitate the success of national and regional industrial parks in China.

4.2 Failure aspects of China EIPs

Although the performance of EIPs in China is highly recognized, there are still some obvious shortcoming aspects so far, namely: (i) the failures regarding employee

participation, (ii) the support from ordinary citizens, and (iii) the deficiency of overall planning from the different levels of government.

Firstly, employees in the enterprises in a EIP are poorly involved in the circular economy inside or outside the EIP, and their attitude, to a large extent, depends on their self-consciousness, since there are little mandatory or suggestion ways to promote the sustainable development.

Secondly, from the perspective of ordinary citizens, they know about the EIPs in their city but it seems irrelevant to them if they are not working either in the industrial parks or in development zones located far or near to the communities where they live. In other words, compared to Corporate Social Responsibility (CSR), another CSR, Consumer Social Responsibility should be worthy of equal attention, when implementing circular economy and promoting eco balances and social development.

Thirdly, local governments tend to initiate and advocate similar industrial parks in an impulsive way, just in order to attract investment and promote economic development. However, there are little scientific concerning overall planning concerning the local economic growth, the urbanization development and environmental protection, and the industrial symbiosis. However, it is obvious that firms in EIPs tend to demonstrate more ecology awareness and bear more environmental responsibility than those manufacturers outside any kind of industrial parks. That is to say, the importance of manufactures outside those zones and parks cannot be neglect, not only because they are much more in quantity but also because they play an equal role in employment tax and economic growth.

4.3 Development suggestions for China EIPs

All kinds of economic and technological development zones and industrial parks have been facilitating China's economy growth over the past decades. Nevertheless, there are still some problems to deal with. In this paper we are trying to put forward some suggestions for the sustainable development of China EIPs, namely:

(1) To learn from other mature circular economy modes from developed countries; for example, Japan is well known for its hundreds of laws and legislations in the domain of CE, and Dual System of Germany works very well(Wharton, 2017).
(2) To enact more feasible laws and legislation, in most cases, laws and legislation are too advanced or too hysteretic, despite some laws are too old to regulate the current situation, because the economic and social transition is accelerating.
(3) To enhance the advertising of some concepts related to circular economy and sustainable development; people should not realize the importance of environmental protection only by witnessing some environmental disasters.
(4) To encourage more engagement from all kinds of enterprises and companies both inside and outside the EIPs. There are various kinds of ways for them to embody CSR, for instance, whole lifecycle design and management, returned logistics and green supply chain management.
(5) To appeal to more support from employees, who can contribute to the performances of EIPs in matters such as energy saving, waste disposal, water recycling, etc.
(6) To arouse vast environmental and circular economy awareness from urban citizens. An eco city involves everyone in the city. EIPs are only part of the sustainable cities.
(7) To introduce more advanced technology and methods to keep traceability on cleaner production, environmental management and EIPs performance monitoring.
(8) To conduct more scientific urban planning and construction, in order to maintain a sustainable and resilient morphology, which should be inclusive and liveable in a harmony way for future social, environmental and economic development.

5. Conclusions

From the systematic literature review that was carried out, this research outlines three stages of development of industrial parks in China, summarizes the current approved national EIPs and also the under assessment national EIPs, depicts their distribution in some figures (Figure 1 and 2), and analyzes the success and failure of EIPs. For the success aspects, laws and regulations, policy guidance and advertising and, enterprises involvement are the most obvious contributing factors. On the other hand, the following problems are still common: low employee participation, little support from ordinary citizens, and deficiency of overall planning from the different levels of government. Finally, some feasible suggestions are put forward for China EIPs development.

To sum up, this study tries to be inspiring to current research in the area of Eco-industrial parks based on circular economy. For researchers, this is also an attempt to stimulate more systematic thinking. For practice, it is argued for the awareness that EIPs are playing an increasingly role in China's sustainable economic growth and transformation as a significant contribution. Of course, there are some obvious limitations during this study, such as the lack of primary data and a detailed field study. Nevertheless, one might conclude from this preliminary study that future research on the theme of EIPs and in-depth theoretical exploration is worthy of much more effort, e.g.to conduct an empirical comparison among EIPs all over the world, or to do a grounded case study in some exemplary EIPs in China, and then comparing the results with those from successful EIPs in developed and developing countries as well. The research initiatives might be very helpful to stimulate more practitioners and researchers' interest since economical, social and ecological sustainability is, indeed, a global concern requiring attention.

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