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Eco-Industrial Parks (EIP) analysis in developing countries

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Abstract

The development of Eco-Industrial Parks (EIPs) is an emerging concept that has being spread worldwide. It's based upon industrial ecology principles suggesting that industrial system can operate in a similar fashion to natural ecological system. The EIP methodology has been spread in developing countries as an alternative to overcome environmental damage and, at the same time, improve industrial and community economy as well as social welfare in order to support their development. The objective of this study is to present an analysis of opportunities and barriers for deployment of EIP in two developing countries. It was analyzed the EIP project in Santa Cruz, Brazil, and in Tianjin, China. The former is in its early stages and the barriers are greater than the opportunities. The later is in the ongoing development of initiatives where the Government incentive has provided support to overcome barriers. This work brings to light that despite Brazil and China being developing countries, the government support is essential to provide the development of the EIP.

Keywords: Eco Industrial Park, Ecology Industrial

Introduction

With growing competition that companies are required to manage, to survive in the market, what is perceived today, is that issues related to innovation and technology are being widely discussed and debated in many different business environments, academic and public.

Much research related to technological innovation as an important factor in promoting sustainable regional development. In this context, the Eco-Industrial Parks and Industrial Symbiosis as its first stage of deployment, solution emerge as productive arrangement for sustainable communities

The establishment of eco-industrial parks (EIPs) is a concept that is being spread in many nations as a new industrial model that can reconcile the dimensions of sustainability, as it reorganizes industrial practices and activities in order to meet sustainable development goals. This mutual benefit to the community, economy and environment is clearly stated in the definition of the EIP concept (VEIGA, 2009).

An EIP is defined as:

> (…) a community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance. The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impacts. Components of this approach include green design of park infrastructure and plants (new or retrofitted); cleaner production, pollution prevention; energy efficiency; and inter-company partnering. An EIP also seeks benefits for neighboring communities to assure that the net impact of its development is positive (LOWE, 2001).

This definition is broadly accepted by major authors in the eco-industrial development field.

In the same way as in developed nations, the EIP concept is being spread in developing and newly industrialized nations as a way to foster sustainable development. In some Asian and Latin American nations, the rapid industrialization process has increased resource consumption and environmental degradation, Chiu (2004). In these nations, EIPs are being considered a possible way to overcome environmental damage and at the same time to improve industrial and community economic and social welfare and development.

In addition, the absence of proper integrated waste management practices instead of only end-of-pipe solutions has contributed to severe environmental damage. So the EIP

program can be considered as a means to foster sustainable development, to ameliorate the environmental, economic and social distress caused by unplanned urban and industrial development.

The objective of this study is to present an analysis of opportunities and barriers for the deployment of EIP in two developing countries. It was analyzed the EIP project in Santa Cruz, Brazil, and in Tianjin, China.

The methodology used was a review on EIP in the main International Journals. From this review, it was performed an analysis about the topic. This review covered: (i) key related concepts to the EIP, i.e. industrial ecology, cleaner production, industrial symbiosis; (ii) opportunities and barriers to implementation of EIP; (iii) creation and deployment of EIP project in Brazil and implementation of EIP in China. The main contributions of this work are the basis for a better understanding of currently existing literature on EIP and present an analysis on the barriers and opportunities to the implementation of EIP in developing countries.

Industrial ecology and industrial symbiosis: key concepts underlying the eco-industrial park idea

Industrial activities were designed independently of the environment and, in the early studies relating to environmental problems, the tendency was to place them outside the productive system. Until then not addressed the causes of pollution arising from industrial systems, so that the first regulatory laws on pollution are focused on the consequences of pollution in the natural environment. The technical solutions that arise with this view are called "end-of-pipe solutions" or end of pipe treatments, consisting of processes of remediation, treatment and disposal of specific pollutants present in industrial waste. However, the practices of the end of the tube did not contain the rise in industrial pollution. With the intensification of environmental problems and increased social pressure, the proposed control mechanisms were not sufficient because it did not attack the causes of the problem. It is in this context, developed the concepts of Industrial Ecology (IE) and cleaner production (CP).

The study of industrial systems that operate more like natural ecosystems is known as industrial ecology, Frosch (1994). The term was coined in the early 1990s, but the actual concepts involved are decades old. It involves the sustainable philosophies of Reduce, Reuse, Recycle applied toward industry. Industrial ecology is based on environmental awareness and good economic sense. An industrial ecology system uses recycled materials instead of, or in addition to, raw materials in the manufacturing process, producing materials that can again be recycled after consumption. In this approach, waste, and environmental and production costs are reduced. The industry saves money on energy, disposal fees for hazardous and non-hazardous materials, permitting fees, transportation, and the cost of new raw materials.

Based on the principles of industrial ecology, a new concept has been evolved. An Eco-Industrial Park, or EIP, is a public/private partnership where this industrial ecology approach to industry is contained in one development. The benefits of this arrangement are that the waste material or product of one company can be recycled into the

manufacturing process of one or more companies with minimal transportation and production costs. EIPs are designed to produce minimal emissions, minimal noise and ground pollution, and minimal waste. EIP firms are designed to fit the environment instead of adjusting the environment to fit the firm (DUNN, 1995).

EIPs and industrial ecology are the evolutionary manifestations of the notion of sustainability, which is defined by William Ruckelshaus (1989) as: The doctrine that economic growth and development must take place, and be maintained over time, within the limits set by ecology in the broadest sense by the interrelations of human beings and their works, the biosphere and the physical and chemical laws that govern it. It follows that environmental protection and economic development are complementary rather than antagonistic processes.

Cleaner production (CP) is a field of research and practice that overlaps with IE, sharing common objectives and principles, Côte (1995). As Pauli (1997), said "The ultimate goal of CP is thus zero waste. This moves industry from pollution prevention and control into the new paradigm that is to become the industry standard. Clusters of industries, where the waste of one is input for the other, will emerge as the solution." IE and CP can be considered the foundations for EIP.

Since the introduction of IE and CP, the industrial symbiosis (IS) concept has been put in a new perspective.

Chertow (2000), in her article "Industrial Symbiosis: literature or taxonomy" defines the concept of IS as: "Industrial symbiosis, as part of the emerging field of industrial ecology, demands resolute attention to the flow of materials and energy through local and regional economies. Industrial symbiosis engages traditionally separate industries in collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity." EIPs are a major application of the IE and IS concepts.

Opportunities

It is believed that a well planned, functioning EIP has the potential to both benefit the economy and substantially relieve environmental pressure in and near the location of its development, HEERES e*t al*, 2004.

Lowe (2001), in Handbook for the Development of Eco-Industrial Parks describes opportunities that can be gained through the implementation of an EIP:

1. **Integration into Natural Systems**: Minimize local environmental impacts by integrating the EIP into the local landscape, hydrologic setting, and ecosystem. Minimize contributions to global environmental impacts, i.e. greenhouse gas emissions.

2. **Energy Systems**: Maximize energy efficiency through facility design or rehabilitation, co-generation (capturing and using of otherwise "wasted" heat from the electrical generating process), energy cascading (energy cascading is using residual heat in liquids or steam from a primary process to provide heating or cooling to a later process) and other means. Achieve higher efficiency through inter-plant energy flows. Use renewable sources extensively.
3. **Materials Flows and 'Waste' Management for the Whole Site**: Emphasize cleaner production and pollution prevention, especially with toxic substances. Seek maximum re-use and recycling of materials among EIP businesses. Reduce toxic materials risks through materials substitutions and integrated site-level waste treatment. Link the EIP tenants to companies in the surrounding region as consumers and generators of usable by-products via resource exchanges and recycling networks.
4. **Water**: Design water flows to conserve resources and reduce pollution through strategies similar to those described for energy and materials – cascading through uses at different quality levels.
5. **Effective EIP Management**: In addition to standard park service, recruitment, and maintenance functions, park management also:
    a. Maintains the mix of companies needed to use each others' by-products as companies change over time;
    b. Supports improvement in environmental performance for individual companies and the park as a whole;
    c. Operates a site-wide information system that supports inter-company communications, informs members of local environmental conditions, and provides feedback on EIP performance.
6. **Construction/Rehabilitation**: With new construction or rehabilitation of existing buildings, follow best environmental practices in materials selection and building technology. These include recycling or reuse of materials and consideration of lifecycle environmental implications of materials and technologies.
7. **Integration into the Host Community**: Seek to benefit the local economy and social systems through training and education programs, community business development, building of employee housing, and collaborative urban planning.

Barriers

However, the development of symbiotic exchange relations has been a problematic element of EIPs. A number of authors have addressed the barriers to eco-industrial development. For example, Heeres *et al.* (2004), suggest barriers to the establishment of exchanges may be:

1. **Technical:** where an exchange is technically not feasible;
2. **Economic:** where exchanges are economically unsound or risky;

3. **Informational:** where the appropriate people do not have the relevant information at the right time;
4. **Organizational:** where exchanges may not fit with corporate structures;
5. **Regulatory** or **Legal:** where exchanges are not allowed to occur;

Cognizant of these difficulties, a critique has developed more recently suggesting that the EIP approach may not represent the best means to implement IE.

Chertow (1999) believe the model about which there is so much pessimism is the one where a community tries to design an eco-park from nothing. Not only is this task ambitious, but outsiders happily pile on an even larger wish list of nonmarket items that demand giant steps, not baby steps, in sustainability.

First of all, there are the usual business reasons industrial symbiosis projects might not be attractive, based on barriers any venture faces: risk, finance, mobility of capital, or the availability of higher pay-back options elsewhere. In general, as Ehrenfeld & Gertler (1997) point out, the case for industrial symbiosis is unconvincing when there are not large, continuous process waste streams. Reliable research is clearly needed on the basic economics of symbiosis. If energy or water or waste disposal are but a small percentage of operating costs, these reasons alone will not cause the formation of eco-industrial parks. Neither can there be set heuristics about when symbiosis makes sense because of the enormous variability in ecological as well as economic conditions. For example, fresh water could be scarce at one site and abundant at another. As with all environmental projects, particulars are site-specific and the role of regulation is ubiquitous, both in promoting and obstructing progress, and must be carefully considered in nontraditional development projects.

A first-order consideration is whether there is sufficient flow of materials to make industrial symbiosis worthwhile. In a project designed from scratch, quantities could be carefully designed to match the required scale. However, this could prove more difficult when working with existing facilities.

Analysis of companies

The model of eco-industrial development implies a change in the way of planning, building and managing industrial systems, together with the ecosystem, economy and society for mutual benefit.

For the implementation of industrial symbiosis in the activities of an eco-industrial park, planning actions should include economic analysis (to check the potential return on investment for the allocation of material and people) technical analysis (available technologies) environmental analysis (identifying desired environmental parameters) and regulatory measures (environmental and fiscal).

The success of eco-industrial parks is also conditioned by the breaking of cultural barriers that exist in business: business and government leaders must recognize that natural resources are living systems that are dying off and understand that sustainable technologies are profitable, communities need to be willing policy and resources to extricate themselves from the current model of capitalist development, and it is necessary to adopt laws to tax incentives for companies to inter-relate.

EIP project development in Rio de Janeiro state, Brazil

As around the world, industrialization has brought wealth and development to Rio de Janeiro state; however it has also brought many negative externalities. One of these externalities is the high level of industrial concentration, resulting in increasingly urban concentration, the damage and destruction of many environmental areas and in a high level of soil, air and water pollution, besides a lot of social problems.

The Rio the Janeiro Metropolitan Area (RJMA) is the state region in which the majority of the industries are located. The data presented in Table 1 compare RJMA and RJ state in order to show its relevance to the state's economic development.

Table 1 shows that 74% of RJ state's population and 67% of its GDP are concentrated in an area corresponding to 8,3% of the state's landmass.

Table 1A comparison between RJ and RJMA

	RJ State	RJMA	RJMA/RJ state (%)
Municipalities	92	19	21%
Area	43.780,157 km^2	5.292.139	8,30%
Population	15.993.583	11.838.752	74%
GDP	R$ 343 million	R$ 232million	67%

Source: IBGE, 2010.

RJMA: The municipalities that are now part of RJMA are: Duque de Caxias, Itaboraí, Magé, Nilópolis, Niterói, Nova Iguaçu, Paracambi, Rio de Janeiro, São Gonçalo, São João de Meriti, Belford Roxo, Mesquita, Japeri, Queimados, Guapemerim, Seropédica, Tanguá, Itaguaí e Maricá.

The heavy industrial concentration in RJMA has also resulted in an increase in the amount of byproducts and wastes generated. How to better dispose of waste economically without degrading the environment is another problem. The lack of sufficient public funds, waste inventory and waste management and treatment practices, particularly by small and medium sized industries, severely limits the range of options. Proper waste management practices could help to protect the environment and when properly planned, could save considerable disposal fees. It is worth mentioning that the only industrial landfill and industrial waste incinerator in the state is owned by Bayer Corporation, located in Belford Roxo municipality, (VEIGA, 2009).

More recently, the Rio the Janeiro state government, looking for possible solutions to the disorderly industrial settlement of RJMA, Rio the Janeiro Metropolitan Area, and for possible ways to minimize waste management problems, inspired by international experiences, began to consider EIPs as a possible strategic planning alternative to achieve sustainable development.

The first such state government initiative was the promulgation of State Decree 31,339 in June 2002, setting up the Sustainable Eco- Industrial Development Program – Rio ECOPOLO (EIP). The program's major goal is "the achievement of sustainable development by minimizing the impact of industrial activity on the environment, improving economic performance and community well being."

Santa Cruz Eco-Industrial Park Project

Santa Cruz was the first EIP to be launched in RJMA. In September 2002, the fourteen Santa Cruz Industrial District industries located in Santa Cruz municipality signed an agreement with the state government in order to be part of the Eco-Industrial Sustainable Development Program. It was expected that the conversion of this industrial district into an EIP was result in social, environmental and economic advantages to the parties involved.

Since 2002, some of Santa Cruz EIP's initial opportunities have been implemented: development of an environmental management plan; planting native species; incentives to the local community to develop environmental initiatives in the park's surrounding area; compliance with environmental regulations; information and some service sharing, like canteens and recreational areas; community recycling program; social and educational programs; and finaly the existence of a central management association, coordinating the whole program, (VEIGA, 2009).

Despite the increasing awareness of sustainable development among the parties involved, many barriers must be broken. For example, the byproduct and waste inventory has been concluded, but no waste exchanges have taken place. The lack of public and institutional commitment to promote the EIP's dissemination is making it hard for the Santa Cruz EIP to evolve the way it was initially envisioned only with the industries' support and work.

EIP development in Tianjin, China

The concentration of industrial activities can lead to severe pollution and resource depletion exceeding local ecological carrying capacity, particularly when necessary environmental management systems are not put in place as has sometimes been seen in China (UNEP, 1996).

In 2007, 54 national economic and technological development areas (NETDAs) in China, occupying less than half a percent of urban land, absorbed 23 percent of foreign direct investment and accounted for 5 percent of China's Gross Domestic Product (GDP), 4 percent of its tax revenues, and 15 percent of its international trade in 2005. The land and water productivity of 54 NETDAs was also much higher than the national average (MOC, 2007).

Chinese decision-makers and researchers were first exposed to the eco-industrial park (EIP) concept by the United Nations Environment Programme (UNEP) through its publication in Chinese in 1997 of Industry and Environment addressing the environmental management of industrial states. Because an EIP strives simultaneously to increase industrial growth while reducing pollution and waste (Cohen *et al* , 1996), the economic and environmental win-win potential of the EIP approach quickly drew the attention of Chinese environmental policy-makers (XIE, 2002).

During the 1990s, while resource-poor Chinese environmental authorities were waging an uphill battle against rampant non-compliance at the enterprise-level, they turned increasingly to flexible environmental policy tools, such as voluntary instruments, to pursue environmental protection at the industrial park and regional levels, Shi (2006). Against this backdrop, the State Environmental Protection

Administration (SEPA), the national environmental watchdog, launched an industrial park-wide ISO 14001 demonstration program in 1999 and an eco-industrial park demonstration program in 2000. Around this time, a number of countries embarked on deliberate attempts to develop eco-industrial parks (EIPs) to enhance business competitiveness while reducing resource consumption and mitigating environmental pollution through a systems approach to cycling of critical resources (LOWE, 2001).

Tianjin Eco-industrial Park

Tianjin Economic-Technological Development Area (TEDA) was founded in December 1984 as one of the first 14 national economic development zones in China. TEDA is located 45 kilometers east of Tianjin downtown and 130 kilometers southeast of Beijing city. By all standards, TEDA is a large and multi-faceted industrial area, which, like so many other Chinese business developments, includes both industrial and commercial/residential areas.

Four "pillar industries" have evolved to be most significant in TEDA. These are electronics, automobile & machinery, biotechnology & pharmaceutical, and food & beverage industries contributing a gross industrial output value of RMB 308 billion. Breaking this down, electronics accounted for 49%, automobile & machinery for 32%, biotechnology & pharmaceuticals for 6%, and food & beverage sectors for 4%, of gross industrial output values in 2007.

The excessive scarcity of both water and usable land has driven TEDA to conserve and make very efficient use of these critical natural resources since the early 1990s. Subsequently, numerous industrial symbiosis activities involving energy, materials, and water were developed involving the public infrastructure system with key milestones over 20 years (Shi, 2010).

TEDA has shown several special features on the path to becoming an EIP. First, TEDA itself was established as a result of experimentation within China's reform policy, thus institutional innovation has been built into the DNA of TEDA with TEDA management eager to learn and implement international best practices. Second, TEDA is pro-business and responsive to business requirements. A number of multinational corporations have introduced to TEDA sustainable production practices that were implemented in other countries. Third, TEDA is very sensitive to competition and has tried its best to maintain its leading position in China as an industrial park in the face of the heated struggle for foreign direct investment triggered by the Asian financial crisis in 1998 and subsequently China's accession to the World Trade, SHI *et al*, 2010.

Barriers were observed related to cleaner production, prices and bankruptcy. Waste exchange between businesses were harmed by changes in production processes, changes in the prices of some products made it impossible to trade within the EIP, exit of firms endangered the symbiotic exchange, limited capacity for innovation by firms located within the EIP without prejudice to possible trade could be made.

Conclusion

The project of EIP in Rio de Janeiro was launched as a means to foster sustainable development and for possible ways to minimize waste management problems. It was expected that the conversion of this industrial district into an EIP was result in social, environmental and economic advantages to the entities involved.

The EIP project in Brazil is in its early stages and barriers are greater than the opportunities. The difficulties related to social, economic and environmental added to the lack of government support affect the development of the EIP, so the EIP project has not achieved the expected development.

Tianjin Economic-Technological Development Area (TEDA) is a large and multi-faceted industrial area, includes both industrial and commercial/residential areas. TEDA was launched as an EIP to pursue environmental protection at the industrial park and regional levels.

The ongoing development of initiatives for environmental programs in TEDA, such as obtaining approvals, implementing best practices, diversity of businesses and industries, actions to maintain the leadership status among the areas of national economy development, as well as Government support has provided a leap in the development of the EIP.

This work brings to light that despite Brazil and China being developing countries, the government support and public incentives Industries can help to continuously improve the environmental and social development of the EIP.

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