The Necessary Trend of Sustainable Production in Industrial Parks. Proposal Of Parametric Values

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Abstract

Sustainable production in industrial parks implies producing cleaner under competitive parameters. The objective is to propose some parametric variables for determining the productive sustainability of industrial parks in Mexico, as an alternative to reduce environmental pressure. This proposal stems from the review of some technical-regulatory references, which allowed defining variables, whose integration generates a set of indices that explain the presence of said productive environment. It is argued that most of the production systems of industrial parks are not sustainable, since they continue to operate linearly, resulting in strong pressure on the environment, coupled with the absence of programs and actions for the treatment of material and immaterial waste.

Keywords: Sustainable production, Industrial Parks, Production system.

1. Introduction

The perception of sustainability in the production of industrial parks

Industrial activity faces great challenges for its survival and growth, one of the most recent being environmental sustainability, derived from international agreements to change production technologies and consumption patterns; consumer preferences in developed countries; practices of transnational corporations; rules and norms in international trade and domestic pressures as a result of local environmental deterioration, where the business response depends on environmental regulation of industry, international cooperation, national technological capacities and the efforts of the organized productive sector (UN-ECLAC, 2009).

The development of new activities such as automotive, metalworking, chemical and electrical that was developed during Fordism, used hydrocarbons as a production base, which led to an intensive exploitation of non-renewable resources, causing serious negative externalities, whose predatory practices and growing environmental pressure contributed to the loss of natural resources and the increase in pollution problems. therefore, this industrial production system was considered unsustainable.

... in this type of Fordist industrial organization, the most intense environmental consumption in history was provoked, the risk of ecological collapse, social inequality and extreme poverty, factors that today question the economic rationality characteristic of development and that make it clear that man, in his eagerness to accumulate capital, neglected the protection of the (environment) (Carrillo and Hernández, 2011, p. 102).

In the contemporary global context, although the industrial sector has diversified, this has led to an increase in the consumption of water, fertilizers, improved technologies -such as transgenic seeds and pesticides-, as well as other inputs and materials that positively influenced increases in the sector's production, making it possible not only to compensate for losses due to degradation, but also to but also the increase in the availability of food. However, if this trend continues in the coming years, the levels of degradation will be lacerating, without the possibility of compensating for such adversities, to the extent of having a negative impact on industrial rates of return and the rest of the sectors, in the face of the escalation of demand (Austermühle, 2015).

This situation will not only imply, but will already see high financial, social and environmental costs, as well as imbalances, ruptures and discontinuities in the functioning of the industrial production system, translating into a decrease in the rate of economic growth, the loss of jobs and the triggering of frequent and widespread work stoppages. Faced with these facts, at the beginning of the 70's, the irrationality of this production system was questioned, in whose rethinking the incorporation of greater environmental awareness was sought, with the possibility of combining economic development with environmental conservation, and establishing a positive theoretical dialectic between both categories.

Environmental sustainability and economic (and industrial) growth are currently an inseparable concern that requires maintaining patterns of (communication) and coexistence between economic agents and their natural environment, in order to promote actions that lead to an evolutionary process that guarantees the persistence of both systems (Carrillo, 2013, p. 19).

In view of this, in the second half of the twentieth century there was a way to post-industrial or post-Fordist production, where the growing incorporation of innovations influenced the improvement of both products and production processes and forms of business organization. The development of new technologies not only made it possible to significantly reduce the consumption of energy and other inputs based on natural resources, but also contributed to the organization of industry in productive networks, as a determinant of greater productive, operational, and functional efficiency of companies (Iglesias, 2013).

From this perspective, the creation of more competitive, efficient and sustainable industrial environments was stimulated, grouped in specific locations, adapted to the new technological context, with more flexible and segmented production systems and organization. This form of production not only contributed to the reduction of transportation and manufacturing costs, but also led to the increase of economies of scale, external and urbanization, giving rise to the formation of denser and more dynamic geographical spaces, which defined the productive profile of the regions through the formation of industrial production networks and systems (Precedo and Villarino, 1992; Méndez & Caravaca, 1996; Stimson, et. al., 2006; Capello, 2009).

A new scientific worldview is emerging today, whose premises and assumptions are more compatible with the networked ways of thinking that underlie the economic model of the third industrial revolution (IRT). The old science understands nature as a set of objects; The new science conceives it rather as a set of relationships. The old science is characterized by distancing, expropriation, dissection, and reduction; the new science characterized by involvement, replenishment, integration and holism. The old science is committed to the goal of making nature productive; The new science aims to make it sustainable. The old science craves power over nature; the new one, however, seeks to associate with it. The old science prioritizes autonomy with respect to the natural environment; the new science prioritizes co-participation with nature (Rifkin, 2014, p. 307).

In the vision of industrial ecology, this agglomerated environment of production was called industrial symbiosis or co-industrialization, which seeks to increase the volume of production, increase social benefits and be more efficient and sustainable. Industrial ecology guides companies and government organizations for the adoption of environmentally sustainable and economically profitable production strategies, with the ultimate goal of optimizing and creating material closure cycles, with the aim of nullifying the amount of emissions, the consumption of inputs and energy for production.

The environment should not only be visualized as a mere natural environment, but rather refers to a large number of biological, physical and landscape factors, conditions and processes. These, in addition to having their own natural structure and dynamics, are affected and intertwined with human behaviors that influence or determine them. Thus, many environmental, economic, political, social and cultural threads are braided and knotted, which together weave an immense network that literally sustains the economy and society. The integrity of the network depends on whether they are sustainable in the long term. Each thread represents a theme, process or discipline, and each knot, a point of interest, analysis or necessary actions to prevent the network from weakening, falling apart or breaking, putting at risk the sustainability (productive of the industry) of regions and countries, even of the planet as a whole (Cuadri, 2012, p. 33).

This productive integration constitutes one of the new forms of organization, production and management of contemporary industry, since it not only influences their efficiency and competitiveness, but has also become a conditioning factor in the location of new business activities, mainly light industry that provides specialized services to these production units (Cotorruelo, 1996).

To this end, production units and conglomerates must include in their equipment the Internet of Things, automation, big data and computer security, considered as the major technological incidences that promote augmented reality, additive manufacturing, robots and cobots, cloud computing and software simulation, which together not only implies technification of the industry, but also environmental care and the sustainability of production, that is, automation, the digital revolution, and the digitalization of the value chain, have given rise to "new models" of organization and co-organization (environment-industry) in industrial parks, so it is decisive to constantly adapt to these advances and innovations.

Protecting the environment and nature, is accepting the existence of natural limits to economic growth and heading towards sustainability-sustainability, is no longer an option to be considered, but rather it is the only option left to us to prevent even more serious damage than what is drawn in the industrial productive slate and the future of planet earth (Austermühle, 2015).

Despite this great technological claim and the relevance of including the environment in this type of productive environments aimed at greater efficiency and sustainability of production, and which is increasingly expanding, few entrepreneurs are fully aware of the dimension of the challenge and rather tend to be alarmed by the increase in costs associated with the control of pollutants. therefore, a reactive business attitude continues to prevail in the face of the greater demands of environmental regulation and only a small number of companies fully assume the challenge (UN-ECLAC, 2009).

This conduct, from the perspective of global efficiency, focuses on the idea of the use of new technologies to increase energy efficiency and the apparent conservation of natural resources, which is the reason for the growing questioning, since their behavior has posed a serious threat to the conservation of the environment and the preservation of resources.

Productive symbiosis and industrial parks

Part of the serious environmental problems caused by the industry emerges from the functional individuality of the companies and the use of linear production processes, which extract and use raw materials and fossil energies intensively, which, when processed, the waste generated is returned to the natural system, so this type of production pattern is hardly environmentally sustainable. productively and economically (Golf and Molinero, 2009). An alternative that seeks to compensate for this productive unsustainability is the articulation and integration of locally rooted companies (such as industrial parks) that favor competitive maturation, which from the point of view of industrial ecology is called an industrial system, whose interpretation is derived from what the Italian industrial perspective conceived as a local production system (Garofoli, 1992).

From the economic geography, areas of flexible specialization or territories of endogenous industry with an increasing level of complexity, defined by the horizontal relationships maintained by the producing units, accompanied by a certain degree of competition and a dense reticular collaboration with agents of the local and regional environment, which seek to improve the knowledge and decisions in the different industries on the use of materials, reducing waste, promoting recycling, the exploitation of renewable energies and the use of clean technologies, seeking to prevent pollution and the balance between the activities of society and its environment, through the generation of systemic processes, which are fed back from the different wastes preventing them from representing a problem for the environment.

Industrial symbiosis, as a production model, promotes synergies between companies and industries, producing a link of collective benefit for those involved. These synergies occur with the use of a waste as a raw material for another industry, but also the joint use or implementation of a service or infrastructure. This implies that waste becomes a resource for it or any production system. This form of productive integration aims to create a cyclical flow of materials and energy through association and connectivity with various types of companies, allowing the concept of waste to disappear and to generate a transit of materials with the exit in one industry and the entry into another, increasing capacity, work and the useful life of these materials (Alvarado, 2009).

From this perspective, the industrial system must function as a natural ecosystem where one company can be supplied by the other, under the idea of a food chain, which can be extended to other economic and human activities. Its spatial scope can be within the same organization (such as in an industrial park or in a region) or at the macroeconomic level.

The approaches of industrial ecology coincide with the principles of sustainable development, because they seek to have a positive impact on the ecological, economic, and social levels (Carrillo and Hernández, 2011). Thus, industrial symbiosis generates economic, environmental and social benefits such as saving resources, minimizing waste, reducing emissions and polluting loads, depreciating environmental costs, improving jobs, creating networks, renewing the environmental image of companies, entities and municipalities, as well as greater relationship and collaboration within the industrial sector and between it and the social and natural environment (Lowe et al., 1997).

This form of productive organization is considered as a new model of endogenous development, given the established business cooperation agreements, which allow greater competitiveness and sustainability in the production chain, leading to eco-efficiency, conceived as the increase in the value of the product through the reduction of the consumption of materials, energy and reduction of emissions throughout the value chain of industrial production (Livert, 2011). Industrial eco-efficiency not only optimises the use of natural resources and improves the financial profitability of the grouped companies, but also reduces emissions of wastewater and industrial solid waste, rations the use of drinking water and takes care of air quality, thanks to the infrastructure and equipment that the companies grouped together have and share in the industrial parks and systems.

Thus, eco-efficiency in industrial parks constitutes an alternative to produce more cleanly under competitive parameters, centralize general administrative, logistical, productive, commercial and technological functions, optimize the environmental performance of the participating companies and reduce production costs, seek greater favorable impacts in the territorial environments where they are established, promote the saving of energy and raw materials, reduce the generation of waste and toxic materials, reduce environmental civil risks, contribute to savings in pollution control costs, stimulate the availability of a more motivated workforce, improve the public image, give greater consumer confidence, among others (Leal, 2005).

In this symbiotic productive environment, the exchange of materials between several companies in the industrial park is privileged, inducing the production units and the agents involved to share transport, infrastructure, available equipment, materials, energy, water and by-products (Chertown, 2007). Industrial symbiosis becomes the key element for sustainable production, being at the same time one of the main challenges to extend its existence to all productive sectors, mainly in those economies where the forms of production are still linear, whose business interaction is not fully developed.

The functionality of industrial symbiosis is defined by the collaboration, cohesion and synergy that can exist between the different economic activities located in geographically close territories, which enables the emergence and growth of industrial ecoparks, considered as production and business units, in which the installed companies cooperate with each other, share their resources to achieve economic and social improvement. they reduce the impact on the environment, improve competitiveness, minimize costs and resource consumption, as well as the promotion and development of new activities (Golf and Molinero, 2009; Messner, 2002; Vázquez, 1993).

In the short term, this industrial environment is seen as a trend to reduce environmental pressures and promote productive sustainability, although it is true that when material and energy waste is not recovered and reused, its uncontrolled disposal disturbs physical and biological systems, whose damage is irreparable in most cases (Seoánez, 1998).

Is it possible to quantify sustainable production in industrial parks? A parametric proposal

The mere integration of companies via industrial parks is not a guarantee of efficiency and productive sustainability, since it is necessary to have internal conditions in terms of infrastructure and industrial equipment, as well as external conditions capable not only of favoring the establishment and operation of companies, but also of making these productive environments sustainable in the temporality. with positive effects on the location environment (Iglesias, 2013).

Therefore, for industry to move towards the creation and maturation of sustainable production systems, it is necessary to take into account both technology and all those factors that are present in the environment, to mention infrastructure, social capital, organizational capacity, financial institutions and the environment itself, the functional capacity of society, the confidence they have to develop some activity, the type of public policies, the organization of local authorities, as well as the patterns and behaviors of the different social groups (Vázquez, 1993; Messner, 2002). These requirements must be quantified and measured through indicators to make decisions and plan their temporal functionality, avoiding at most negative environmental externalities.

Indicators, as precise and punctual data, measure the evolution or behavior of each of the categories and explanatory variables of the industrial production environment. Additionally, it provides relevant information to define mechanisms of action and intervention, since they seek to mediate, through existing information, a final state for each component. To transform qualitative information into indicators, it is necessary that (Friedrich Eber Foundation, 2001):

- Are easy to quantify, add and disaggregate.

- They are simple, easy to use and interpret.

- Are susceptible to constant updating.

- Are available periodically.

- They are reliable or whoever generates it, they must enjoy scientific-institutional reliability and credibility.

- Are comparable over time.

- That they have a conceptual significance.

In this sense, the conditions available to the industrial parks that can be quantified are (Iglesias, 2013; SE, 2011; SE, 2005; Méndez & Caravaca, 1996; UNIDO, 1979):

1) Delimitation and internal organization of the space: limits and size of the industrial lots, urban layout, road network, free zones (green areas), specifications of land uses and type of permitted constructions.

2) Infrastructure: roads, electricity, water supply, wastewater treatment plants, drains and telephone networks.

3) Equipment and services: surveillance and security, cleaning services, post offices, health care, public transport, construction companies, banks and technical advisory services.

In terms of services and infrastructure, the requirements are:

1) Basic services

- Drinking water and/or water for industrial use. The minimum requirement should be 0.5 liters per second per hectare (l/s/ha) and the recommended requirement of 1 l/s/ha.

-Electrical energy. The minimum capacity must be 150 kilo valtios per hectare (kva/ha) and the recommended capacity is 250 kva/ha.

- Telephone networks. The minimum amount is 10 lines per hectare, although it is advisable to have 20.

- Wastewater network. It must be based on the maximum rainfall of the geographical area.

2) Infrastructure and urbanization

- Acceleration and deceleration lanes or access road to the park.

- Roads paved with asphalt concrete or hydraulic concrete.

- Concrete fittings.

- Sufficient and efficient public lighting on roads and sidewalks: average minimum of 8 lux.

- Street nomenclature and official lot numbers.

- Green areas: 3% of the total area of the park.

- Horizontal and vertical signage (informative, restrictive and preventive).

- Electric power networks.

-Drinking water.

-Phones.

- Drainage with any of the following solutions: 1) discharge of wastewater to the municipal network, 2) reuse prior treatment, 3) discharge in the open air, prior treatment, compliance with current regulations and permission from the National Water Commission (CNA).

3) Surface

The industrial development must have a minimum of 10 hectares of urbanized area to be considered an industrial park, and it is recommended to have a reserve of land for its growth of at least 10 hectares of usable land.

4) Industrial land

All buildings must comply with the following characteristics:

- Construction density: maximum floor area 70%, open spaces 30%, land area 100%.

- Construction restrictions, minimum distance to the front of the street or avenue of 7 meters; minimum distance to lateral and rear boundaries of 2.5 meters; Minimum distance to the loading dock of 32 meters and sidewalks in front of companies in operation.

- Green areas. Allocate a minimum of 5% of the land area for this use.

-Parking lots. They must have a sufficient parking area to accommodate vehicles (cars, bicycles, personnel transport, motorcycles, trucks and others), which must be paved or covered with gravel. Likewise, each industrial lot must have the following minimum parking areas:

- 1 parking space for every 200 m2 of storage area.

- 1 parking space for every 150 m2 of production area.

- 1 parking space for every 50 m2 of office area.

- 1 parking space for trailers per 1000 m2 of industrial warehouse area.

Loading docks must not be located in front of the main access, except if the land has 2 or more fronts. The area of the parking space, including circulation area, must be a minimum of 25 m2 for cars.

5) Relative Location

Proximity to:

- Residential areas.

- City center.

- Federal highway, highway, railway line, airport or seaport.

- Customers and suppliers.

- Border, cargo terminal and customs.

6) Environmental Impact

The Environmental Impact Statement must be available, which specifies that the industrial activity to be developed does not generate negative environmental impacts in the locality or region of settlement.

Integrating and grouping the information, nine categories are defined as basic requirements for the operation of industrial parks, whose conditions allow detecting the presence and level of sustainable production in these business conglomerates, as can be seen in Figure 1. Each of the categories shown in Table 1 includes a set of variables, which, through its indicator as a measurable or quantifiable unit, and relating it to other variables, allows defining indices that explain in a timely manner the conditions of these aspects and their influence on the sustainable production of industrial parks.

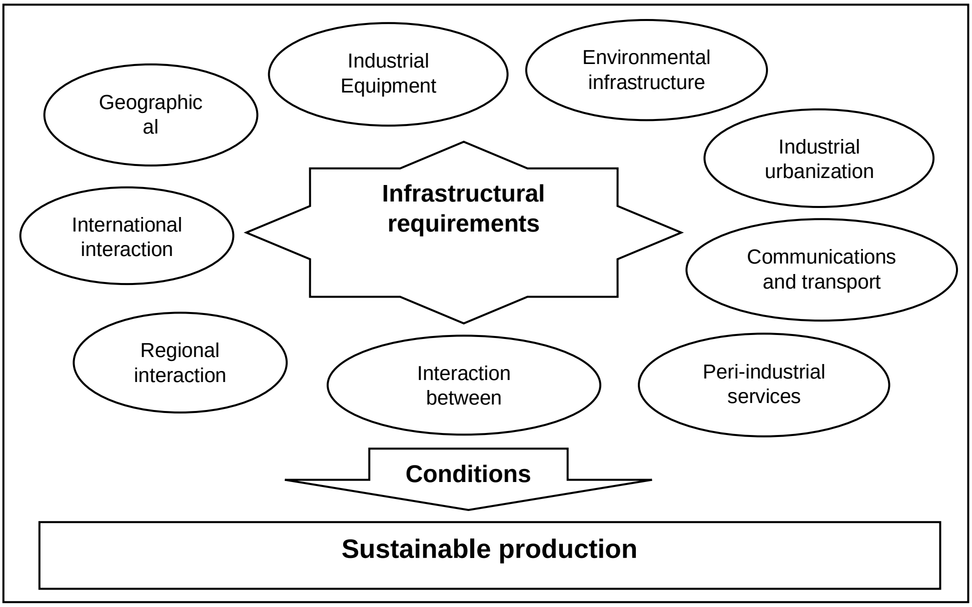

Figure 1. Requirements for sustainable production in industrial parks. In original language: Spanish

SOURCE: Authors.

Table 1. Functional and quantifiable requirements of industrial parks

Category	Variables	Indicator	Index
Conditions Geographic	Total area Built-up area Undeveloped area Booking area	Hectares	Spatial distribution
Equipment Industrial	Electrical energy Electrical substation Gas network Drinking water Storm drainage Railroad Spurs	Kw/hectare Units Units Units Liters/second/hectare Units	Availability
	Wastewater Treatment Plant Sanitary drainage network Industrial Discharge Network Solar heaters/boilers Solar Cells	Liters/second/hectare Liters/second/hectare Liters/second/hectare	

Environmental Infrastructure	Containers for special waste Collection center for special waste Special Waste Disposal Centre Wastewater reuse	Units Units Units Units Units Liters/second/hectare	Availability
Urbanization Industrial	Access roads Garrison Sidewalks Paving Streetlight Street nomenclature Signages Street furniture Green areas	Kilometers Proportion* Proportion Proportion Luminaire Units Units Units Units Proportion	Availability
Communications and transport	Telephone network Fiber Optic Network Satellite communication network Urban transport Ascent and descent stations	Lines/hectare Units Units Units Units	Availability
Services Peri-industrial	Association of industrialists Guard houses Administration Office Special Events Room Maintenance Services Fire system Fire Station Gas Station Stations Babysitting Medical Services Financial institutions Recreational areas Restaurants Hotels Commercial area Inland customs	Units	Availability
Interaction between Companies	Linkage with internal companies Linking with external companies Linking Parks	Frequency/Time	Degree of connectivity
INTERACTION Regional	Distance to residential areas Distance to customs Distance to Highways Distance to Federal Highways Distance to railway lines Distance to urban area Distance to the central city Distance to Supply Center Distance to the merchandising center	Kilometers	Degree of regional accessibility
Interaction International	Distance to ports Distance to airports Distance to international borders Distance from international markets	Kilometers	International space interaction

* Percentage with respect to the area destined for such infrastructure.

Source: Authors' elaboration based on SIMPPI, 2015.

It should be noted that each of the aforementioned indicators has a range defined both by the Official Mexican Standard for Industrial Parks and by the guidelines for their operation, proposed by the United Nations Industrial Development Organization, which are taken as a basis to generate the corresponding index.

The indices are determined for each of the variables, in order to identify the conditions of each requirement. With the aggregation of the data refined in a segmented manner, an average value is obtained, which reflects punctually and concretely the attribution of each category, which is taken as a reference to know the behavior of the variables. From this, it is possible to determine and know the environment of sustainable production in industrial parks.

By way of example, each of the expressions used to determine the corresponding indices and grades is listed (Iglesias, 2013).

Distribution Index (1)

$$IDij = \left(\frac{Jij}{Aij}\right)$$

Where:

J: surface area destined for the variable i in space j.

A: total area of the space j.

Whose values obtained give guidelines to the definition of the following ranges:

IDij=1. The target surface is "evenly" occupied.

IDij>1. Some space of the target surface has a greater dimension of occupation than what is defined.

IDij<1. Some space on the target surface is smaller or not fully occupied.

Availability Index (2)

$$IEij = \left(\frac{Xij}{Yij}\right)$$

Where:

X: actual availability of equipment i in the lot or hectare j.

Y: recommended availability of equipment i in the lot or hectare j.

The ranges are:

IEij<0.5. The availability of equipment i in industrial park j is insufficient.

0.6>IEij<1. The availability of equipment i in industrial park j is sufficient.

IDij>1. The availability of equipment i in industrial park j is more than sufficient, the specified requirement is exceeded.

It should be clarified that the naming of the ranges may change according to the specifications of each variable. This value is the one previously established by the corresponding bodies (at the international level the United Nations Industrial Development Organization and in Mexico the Ministry of Economy), as minimum standards to guarantee the operation and growth of companies that settle in industrial parks.

$$GC = \beta = \frac{ra}{qa}$$

Degree of Connectivity (3)

Where:

RA: Number of times a company relates to an agent or institution in a given period (ARC).

QA: Number of agents or institutions with which links are maintained in a given period (node).

The specified ranges are:

β=1. Connectivity is weak.

β<1. Connectivity is necessary.

β>1. Connectivity is strong or high, which can also be interpreted as exaggerated or unnecessary.

Regional Accessibility Grade (4)

$$GAR = \left(\frac{Aij}{Iij}\right)$$

Where:

A: Availability of service i in the place j where the industrial park is located.

I: Coverage or length of service i in the place j where the industrial park is located.

With the following ranks:

GAR<1. Accessibility is low.

1>GAR<2. Accessibility is average.

GAR>2. Accessibility is high.

Degree of international space interaction (5)

$$IEa,b = \left(\frac{Pa}{Da2}\right) = \left(\frac{Pb}{Db2}\right)$$

$$IEa,b = \left(\frac{Pa}{Pb}\right)\left(\frac{db}{da}\right)2$$

Where:

a: Industrial park.

b: Space (which can be a market or country).

P: Units of the service or infrastructure (ports, airports) existing in the country b.

D: Distance between a and b.

With the following ranks:

EI=1. International interaction required.

IE<1. International interaction is low.

IE>1. International interaction is high.

Once the behavior of each of the variables is known through their respective index, it is possible to determine the presence and level of sustainability of the production of the industrial parks through the following expression:

$$YSij = \propto 0 + \propto 1CG + \propto 2EI + \propto 3IA + \propto 4CT + \propto 5SPI + \propto 6IEm + \propto 7IR + \propto 8II + en$$

(6)

$$\text{YSij} = \sum_{n=1}^{7} \propto \text{nRI}$$

Based on the result, if the index is equal to or greater than unity, it implies that the internal and external conditions existing in industrial parks are adequate, not only to promote the operation of companies in these spaces, but that their characteristics favor less pressure on the environment. Otherwise, a lower index infers that some of the requirements do not meet the attributes demanded by companies to operate efficiently.

2. Conclusions

The grouping of companies in the form of industrial parks not only contributes to reducing environmental pressure, but also has a favorable impact on the development of the locality and region where they are established. From this perspective, this business group continues to be considered one of the main instruments, in terms of costs and effectiveness, to promote the sustainable production of companies and industry in countries in the process of industrialization, as well as to promote the economic interaction of the regions. It is clear that the functionality of these business developments depends on a set of internal and external factors that determine their development, so it is to be expected that when some of them are not available in the necessary conditions, the achievements will be minimal compared to the high levels of investment made, even their dynamics contribute to rapid environmental deterioration. the depletion of productive resources and the generation of waste with different degrees of danger in volumes that go beyond nature's capacity for assimilation. Therefore, the aforementioned conditions must meet the requirements demanded by companies, not only to attract them, but also to retain them and promote their full development, seeking the generation of economies of scale, agglomeration, urbanization and above all that can influence the improvement of the local and regional productive structure.

To achieve this goal, the participation of different industries and all economic agents is essential to form eco-parks or eco-industrial parks, which, unlike traditional industrial parks, seek to promote collaboration between firms for better management of environmental and energy by-products or waste in order to minimize environmental impacts. These productive environments, in addition to privileging the sustainable performance of companies, also encourage the formation of inter-firm cooperation networks based on the transfer of material and energy waste for its reincorporation into various production systems, making room for exchange opportunities with other companies to generate collective benefits.

The set of variables and indicators presented show the possibility not only of knowing the conditions referred to, but also of determining their influence on the existence of sustainable production environments, as an alternative to reduce environmental pressure, seeking the temporary stay of the environment so that the various generations can continue to enjoy the goods and services it provides.

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