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Intellectual Framework for Transforming Conventional Industrial Zones into Eco- Industrial Parks

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ABSTRACT

Industrial practice is vital to achieving economic growth and prosperity in both developed and developing countries - of which Egypt is one. However, it harms the environment by high rates of consumption, depletion of natural resources and disposal of waste. Therefore, transformation of the conventional industrial system to be compatible with the ecosystem and its capabilities to renew itself is necessary. This approach requires minimization of waste, extraction of raw materials and use of nonrenewable resources. This can be accomplished through Industrial Ecology (IE) and Industrial Symbiosis (IS), which maximize utilization of resources in the production process by using waste as a valuable "by-product" rather than disposing it in landfills. Hence, based on normative and experimental literature in IE, IS and previous eco-industrial parks (EIP) experiences, this research attempts to provide an intellectual framework for the planning process for the transformation of conventional industrial zones (CIZs) into EIPs. It is composed of five stages: selection of industrial zones, local context analysis, planning eco-industrial park (EIP), community participation & raising awareness and organizational structure. we hope that this research will represent a reference starting point in the field of industrial ecology planning for urban planners, practitioners and academics and to be a contribution to the scientific debate related to transforming CIZs to EIPs.

Key words: Eco-Industrial Parks, Industrial Ecology, Industrial Symbiosis, Circular Economy

الإطار الفكري لتحويل المناطق الصناعية التقليدية إلى مناطق صناعية أيكولوجية

الملخص

يعتبر النشاط الصناعي من ركائز تحقيق النمو الاقتصادي والازدهار في كل من البلدان المتقدمة والنامية على حد سواء. ولكن له تأثيرا سلبيا ضارا على النظام البيئي نتيجة ارتفاع معدلات الاستهلاك، الأمر الذي يؤدي الى استنزاف الموارد الطبيعية وتوليد كميات كبيرة من النفايات. لذلك، من الضروري تطويع النظام الصناعي التقليدي ليكون متوافقًا مع النظام البيئي وقدراته على تجديد نفسه. يتطلب هذا النهج تقليل كميات النفايات المتولدة، وتقليل استخراج المواد الخام والاعتماد على الموارد غير المتجددة. يمكن تحقيق ذلك من خلال الإيكولوجيا الصناعية (IE) والتكافل الصناعي المنفعي (IS) عن طريق تعظيم الاستفادة من الموارد في عملية الإنتاج إلى أقصى حد ممكن اعتمادا على استخدام النفايات "كمنتج ثانوي" ذو قيمة بدلاً من التخلص منها في مدافن النفايات. ومن ثم، بناءً على الأدبيات المعيارية والتجريبية في IE و IS والتجارب السابقة بالمناطق الصناعية الأيكولوجية (EIP) ، يحاول هذا البحث توفير إطار للعملية التخطيطية لتحويل ال CIZ الى TEIP. وهو يتألف من خمس مراحل: اختيار المناطق الصناعية، تحليل الوضع الراهن، تخطيط المنطقة الصناعية الأيكولوجية، المشاركة المجتمعية وزيادة الوعي، والهيكل التنظيمي للمنطقة الصناعية. نأمل أن يمثل هذا البحث نقطة انطلاق مرجعية في مجال التخطيط الإيكولوجي الصناعي للمخططين العمرانيين والممارسين والأكاديميين وأن يمثل مساهمة في النقاش العلمي المتعلق بتحويل المناطق الصناعية التقليدية إلى مناطق صناعية أيكولوجية.

الكلمات المفتاحية: المناطق الصناعية الأيكولوجية، الأيكولوجيا الصناعية، التكافل الصناعي المنفعي، الاقتصاد الدائري

INTRODUCTION

- **Background**

Industrial activity is a vital pillar that affects urban, economic, social and environmental aspects of modern cities. Therefore, industrial practice should abide by clear rules and regulations that guarantee harmless economic activity to any ecological system. The industrial sector in Egypt is not an exception. Since it has the potential to be an industrial center in the regions of north Africa and the middle east due to its:

- Geographical location
- Availability of cheap workforce
- Road networks, airports, railroad networks and stations
- Sea fronts on the entire northern and eastern borders
- Suez Canal
- Huge local market (due to Egypt's population of 100 million)

However, despite the existence of policies for sustainable development in Egypt, the actual implementation of such policies is still absent (Shalaby, 2003; ESCWA, 2003). With the rise of economic development trends in Egypt based on industry, it is vital to make the industrial production systems compatible with the natural environment. Here comes the importance of industrial ecology as a global trend. It ensures that there is no contradiction between industrial development in a successful economic manner and preservation of natural environment, but rather the achievement of economic savings because of preserving the natural environment (Shalaby, 2012).

- **Basic definitions**

The transformation of conventional industrial zones to ecological practice is the result of years of observation, monitoring and analysis to realize the negative impact of industry and start thinking of possible solutions. This necessitates a new way of thinking known as "decoupling", which involves breaking the link between economic growth and negative environmental impacts (Alsheyab, M. & Kusch, S ,2013). This approach evolves from theory to practice by passing several Stages-Circular Economy (CE), Industrial Ecology (IE), Industrial Symbiosis (IS) and Eco-Industrial Parks (EIP). Circular Economy is the implementation of restorative industrial systems that minimize the occurrence of waste and usage of nonrenewable resources (Alsheyab, M.& Kusch, S ,2013). It also maximizes the utilization of resources through waste management, which shifts the economy from linear to circular mode (Ellen MacArthur Foundation, 2021).
Industrial Ecology is "the transformation of the traditional model of industrial activity into a more integrated system" where wastes of one process serve as a raw material for another (Frosch & Gallopoulos, 1989, as cited in Marsh, 2008). IE depends on designing shared infrastructures" inter-locking man-made ecosystems "(Tibbs, H.C., 1992 as cited in Bissett, 2014), which minimize the extraction of raw materials, pollution and wastes, increase energy efficiency and number of products with market value (Desrochers, 2001).
Industrial symbiosis, "the emerging field of industrial ecology" (Chertow, 2000). It is the ecological platform for creating symbiotic relationships between industrial actors (Frosch & Gallopoulos, 1989, as cited in Marsh, 2008), involving physical exchange of materials, energy, water, and byproducts based on strong networking on the firm level (Chertow,2000). IS depends on "establishment of close working agreements between normally unrelated industrial organizations" (Jensen, Basson, Hellawell, Bailey, & Leach, 2011) to "foster eco-innovation and long-term culture change" (Lombardi & Laybourn, 2012).
Eco-Industrial Parks are communities of collocated companies managed as a unit (Pierre Desrochers ,2001; Shalaby,2012). EIPs take part in the sustainable

transformation and development of cities by providing shared infrastructures and urban synergy options (UNIDO, 2016 a). EIPs depend on the colocation of mixed land uses (manufacturers and service providers) to support resource-sharing and waste recovery (Roberts, 2004 as cited in Shalaby,2012). There are two types of EIPs. First, the new Eco-Industrial Parks (EIP) are called “green field eco-industrial parks” (UNIDO,2017) or “Planned EIPs”, which are formed by the “industrial urban planning of Eco-Industrial Parks from scratch” (Shalaby & Shalaby,2018). The second is Transformed Eco-Industrial Parks (TEIP) called “brownfield eco-industrial parks” (UNIDO,2017) and “self-organized EIPs” by (Shalaby,2018) defined as “Planned Transformation of existing industrial zones to EIPs by means of self-organization of symbiotic relationships” (Shalaby & Shalaby,2018).

- **Research Problem**

Research in the field of ecological industry covers many aspects from the environmental and engineering points of view. It comes to the conclusion that industrial symbiosis is not only possible, but also beneficial to all parties involved (Chertow, 2007). Although previous literature and experiences have covered many theoretical and practical aspects, they do not cover how urban planning can guide the way towards possible sustainable transformations in a more practical sense (Conticelli and Tondelli, 2014). This research attempts to cover this gap by providing a conceptual framework of the planning process for transforming EIZs into EIPs.

- **Aim of research**

According to the available literature and prior experiences, this study investigates the philosophy of industrial ecology intellect, the possibility of transitioning to ecological practices and steps of transformation according to the available literature and prior experiences. It is concerned with transformation as a process not as a product in order to conclude the planning process for transformation from EIZ into EIP.

- **Research question and significance**

Having said that, the question posed in this research is What is the intellectual framework of planning transformation from conventional industrial zones into eco-industrial parks? By answering this question, this research contributes to understanding the role of urban planning in the process of transformation. As it studies normative literature and previous experiences to reach the framework of the planning process of the transformation into EIP.

- **Research Methodology**

This research is a theoretical study based on review and integration of existing theories and literature (Jaakola, 2019). In order to form a conceptual framework for the planning process of the transforming CIZ into EIP this study relies on previous literature and practical experiences that addressed the issue. Since, as mentioned before previous literature did not cover the role of urban planning in this transformation process (Conticelli and Tondelli, 2014) this research attempts to look at the subject from the urban planning perspective. Thus, the resulting conceptual framework is seen in this paper to be an essential first step for further investigation towards defining the role of urban planning in creating EIPs from CIZs in Egypt.

1. THE TRANSFORMATION PROCESS OF CONVENTIONAL INDUSTRIAL ZONES INTO ECO-INDUSTRIAL PARKS

Managing to transform existing (running) industrial sites to EIPs is likely to succeed more effectively than creating new Eco-Industrial Parks, as there is already a market share to build upon, unlike creating new parks (Chertow, 2007). In this context the following discuss previous experiences and literature of EIP transformation. It is meant to investigate the process and ideology of transforming existing conventional industrial zones in order to build the intellectual framework for the urban planning of this process.

1.1. International Experiences

1.1.1 Western trade coast (wtc)

Location and urban characteristics: WTC is a 13,723,179 m2 industrial area in Australia. It is composed of four adjacent industrial zones: Kwinana industrial area, Rockingham industry zone, Latitude 32 and Australian marine complex as shown in fig (1). WTC is a costal industrial zone with a sensitive marine environment that suffers from industrial hazards. Furthermore, the WTC is surrounded by residential land use that is expanding in the direction of industries so municipalities have dedicated buffer/protection areas that evolved overtime to control this urban growth and to protect residents from living close to heavy industries (Beers, 2007).

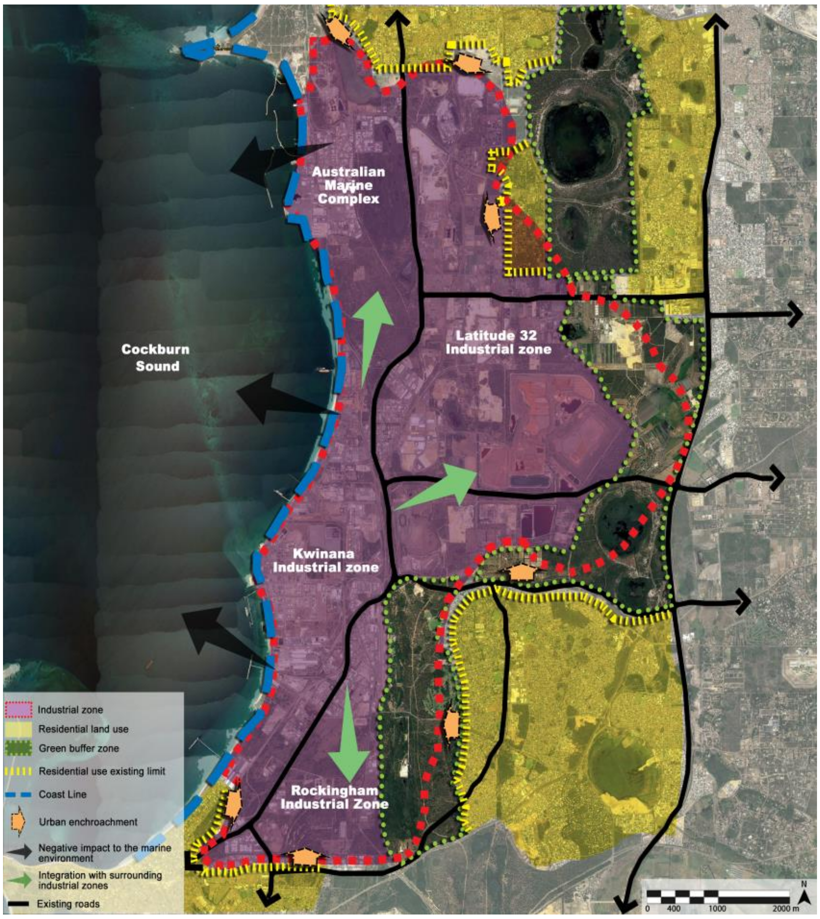

Figure 1 WTC Land use

Source: Western trade Coast Integrated Assessment, 2014 &

Google Earth 2021

The cause of transformation: WTC sensitive marine environment started to be negatively impacted by the industrial hazards. This negative impact was spotted as a result of frequent monitoring by community and municipality. In addition, it was noticed that the surrounding residential communities are growing in the direction of WTC as illustrated in figure (1) (Beers, 2007).

The transformation process: in order to deal with the issues mentioned above, decision-makers (community-municipality-industries) decided to embed IS in the industrial processes of WTC. So, the EIP application in WTC is a planned transformation resulting from monitoring and pressure on industries to manage their environmental problems (Beers, 2007). Hence, core industries decided to form Kwinana Industrial Council (KIC) to address environmental issues and fosters positive interaction between member companies, industries and broader community. KIC initiated the Kwinana Industries Synergies project to improve the economic and environmental outcomes of industry by converting byproducts into value-added products, reducing wastes, greenhouse gas emissions, improving energy efficiencies, reducing use of fresh water, reuse of treated wastewater, and reducing water discharges into adjacent marine environments (Beers, 2007).

Transformation result:

As a result of KIC initiatives synergies in WTC became more diverse, classified into three principal categories: supply chain synergies, by-product synergies and utility synergies as shown in figures (2) (Beers, 2007). Also, they started indicating zones of protection for the following reasons:

1. The protection of both industrial and non-industrial land uses as heavy industrial activities have limited compatible land use and require isolation.
2. Prevent pressure of urban encroachment on industrial zone and lands within buffer zones by transition of land uses to less sensitive land uses from industry to support or commercial land uses (Bainbridge, 2013).

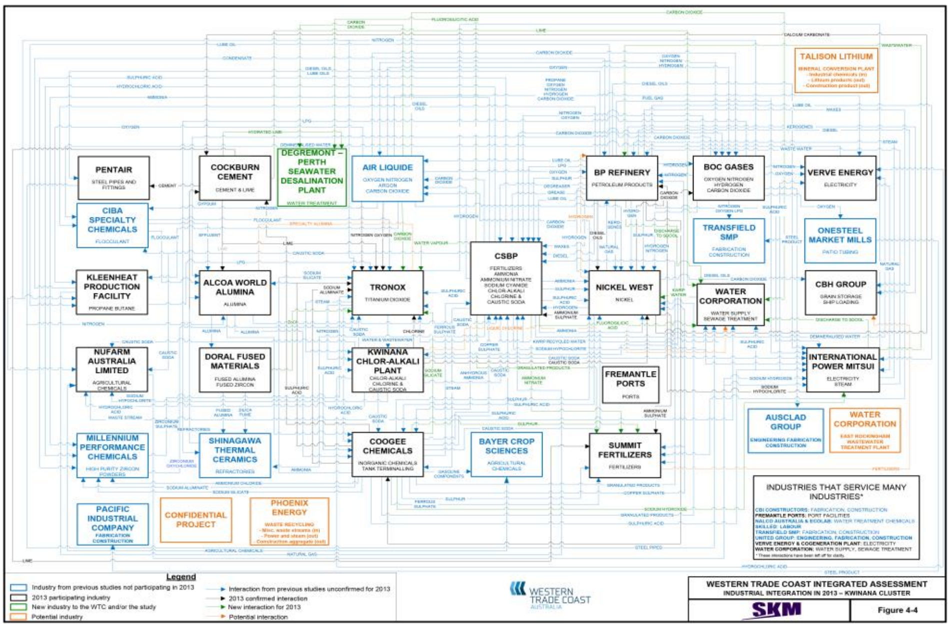

Figure 2 WTC IS in the year 2013, Source: Bainbridge, 2013

1.1.2 Kalundborg

Location and urban characteristics: Kalundborg is an industrial city that lies on the northwest coast of Zealand in Denmark (Momirski, 2019). Kalundborg is composed of industrial facilities, residential land use and farms as shown in fig. (3). In addition, the city is on the sea and contains a harbor. Kalundborg is close to Lake Tissø (the fourth largest lake in Denmark with an area of 12,3 square kilometers). Lake Tissø plays an essential role in the kick start of industrial symbiosis in the city of Kalundborg (Christensen, 1999).

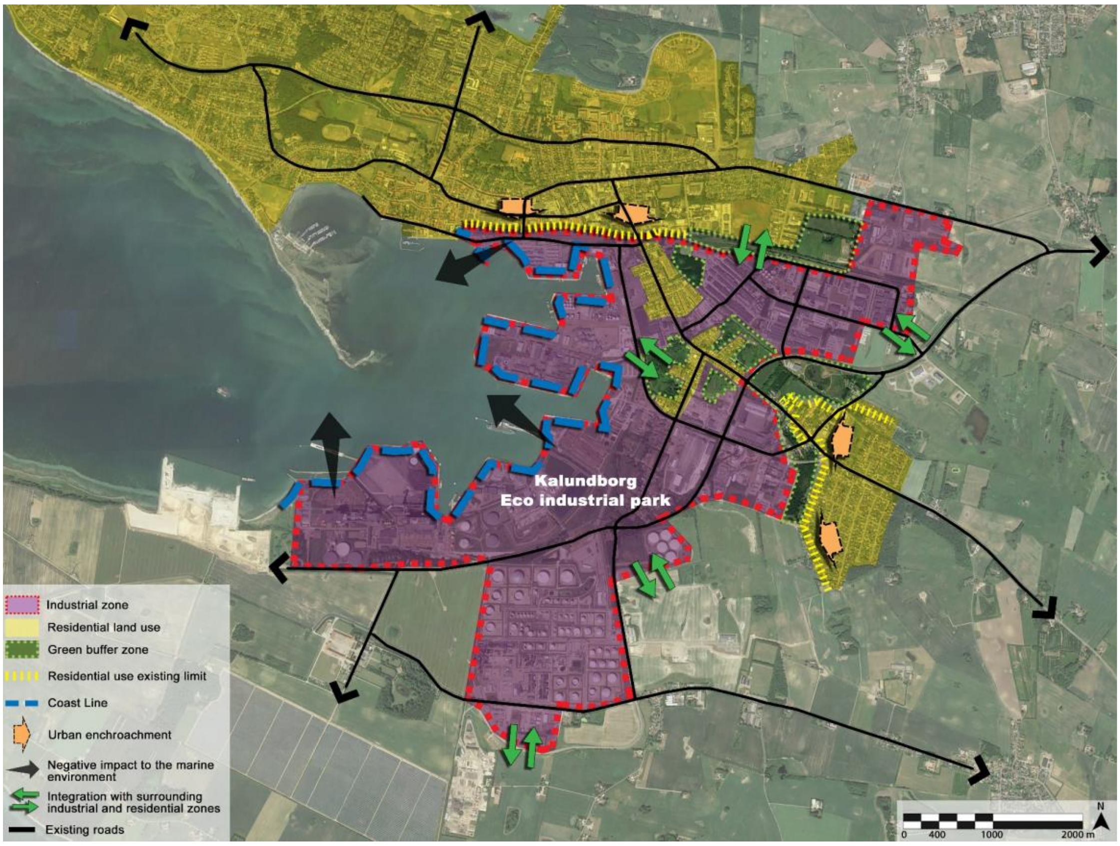

Figure 3 Kalundborg Land use
Source: Marsh, 2008 & Google Earth 2021

The Cause of transformation: The region of Kalundborg depended on limited ground water supplies for both industrial and residential uses. By the time, these supplies were overused by local water consuming industries as they expanded in size and consumption. As a result of this, over the past decades, multiple public/private initiatives to save ground water resources have developed (Jacobsen, 2006). First, replacing the dependency on groundwater with surface water from lake Tissø. Second, optimization of internal water use and increasing external water sources. Third, treatment of surface water to drinking quality, treatment and reuse of waste water and importing ground water from the surrounding regions (Marsh, 2008 & Jacobsen, 2006). So transformation was caused by both sacristy and high demand for water resources (Marsh, 2008).

The transformation process: Kalundborg transformation into EIP, is a result of self-organized IS based on mutual economic benefits between industrial enterprises sharing resources. The use of lake tisso and grey water to replace the ground water sheds light on the economic and environmental benefits of IS, which encouraged companies to join as recipients of materials or energy. Industries organized IS relations among each other that by 1998 it consisted of six main partners: Asnæs power station, gyproc, statoil oil refinery, town of kalundborg, novo Nordisk and bioteknisk Jordrens (Christensen, 1999). In 2018, the number of partners in symbiotic relationships grew to 10 partners with 22 symbiotic relations classified into water, energy and material exchanges (Kalundborg symbiosis, 2018). This symbiosis also included the surrounding residential uses by providing district heating and identifying certain protection zones to control urban growth and protect residential uses from merging with industries. (Momirski, 2019).

Transformation result:

Energy exchanges: Electricity, heat and natural gas are the main forms of energy exchanged between companies of Kalundborg (e.g. Kalundborg utility, Novo NORDISK, BIOGAS PLANT, Inbicon, Asnæs power station) through the self-organized symbiotic network as shown in fig. (4) (Kalundborg symbiosis, 2020).

Water exchanges: Water exchanges include pure water from lake tisso (the first symbiotic interaction) and treated water exchanges both aim at saving the underground water and minimizing the amount of pure water (from the lake) used in the industrial cycle. Water exchanges are used for cooling like EQUINOR and for industrial purposes such as NOVO ENZYMES, ORESTED and Statoil refinery as shown in fig. (4) (Kalundborg symbiosis, 2020).

Material exchanges: Exchanges of material are the famous application of IS where the byproducts of one company is the raw material of another, this application in Kalundborg is characterized by being self-organized and progressively developed over decades into a mature symbiotic system as shown in fig. (4) (e.g. using Novo ENZYMES Leftovers from the production of fertilizer, Ørsted gypsum by product is used to produce Gyproc plasterboards, etc.). (Kalundborg symbiosis, 2020).

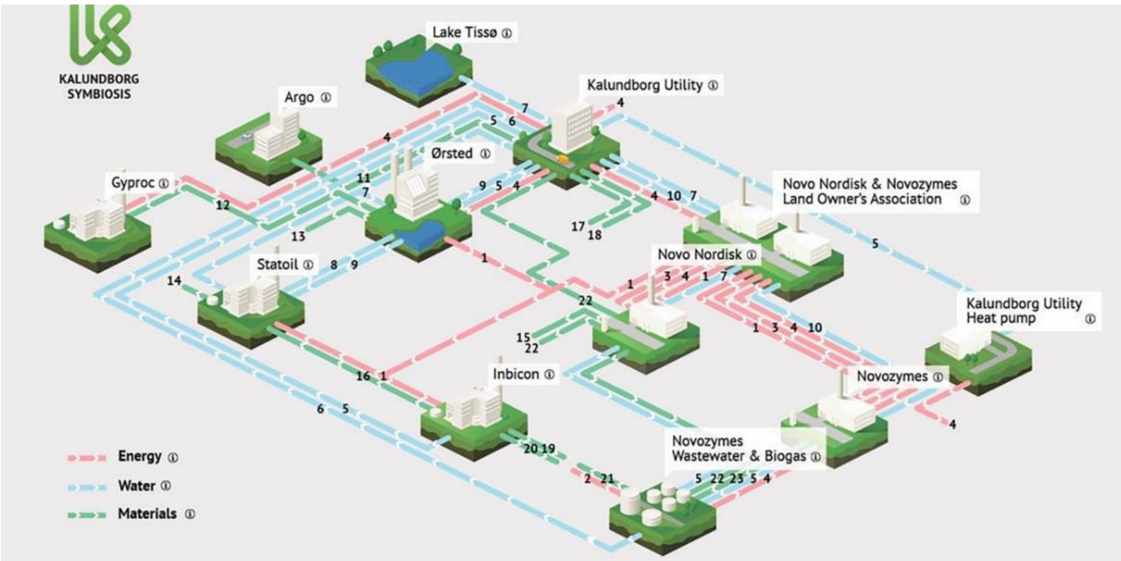

Figure 4 Material Flows in Kalundborg
source: Kalundborg symbiosis, 2020

1.1.3 Tianjin Economic-Technological Development Area (TEDA)

Location and urban characteristics

TEDA is composed of six industrial zones as shown in fig. (5), it has a diverse industrial base including electronics, automobile & machinery, biotechnology & pharmaceutical, and food & beverage industries. TEDA contains Tianjin international airport and

Tianjin port on Bohai Bai, also it connected through a network of roads to the surrounding cities (Shi, Chertow & Song, 2009).

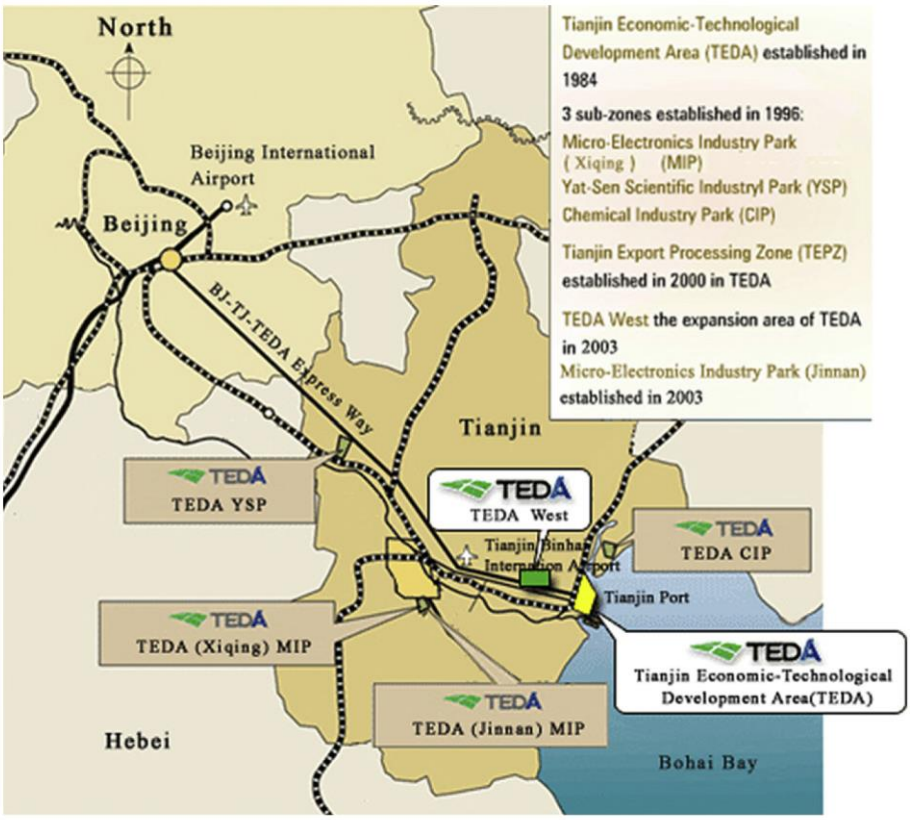

Figure 5 TEDA Industrial zones
Source: (Shi, Chertow & Song, 2009)

The cause of transformation:

First land in TEDA was saline, which needed topsoil and soil conditioning materials to be prepared for industrial and residential development. This top soil was moved from nearby rural area that caused severe farmland degradation. The second issue was sacristy of water resources which were moved 52 km away, the third was water and air pollution as a result of industrial activity (Shi, Chertow & Song, 2009).

The transformation process:

TEDA transformation to EIP is a planned process as a result of political will and governmental incentives, in order to solve these issues, the administration of TEDA formed the "Environmental Protection Bureau" (EPB). EPB became in charge of environmental upgrading and planning. It worked on management and monitoring programs to upgrade the environmental conditions like "environmental impact assessment", "pollution discharge levels" and other programs such as the "State Environmental Protection Administration" (SEPA), it also started encouraging industrial zones to acquire ISO 14001 certifications. In 2008, TEDA became one of the three national EIP models accredited by China's government. Industrial Symbiosis in TEDA is classified into public utilities and industrial exchanges. (Shi, Chertow & Song, 2009).

Transformation result:

Public utility exchanges: Sharing public infrastructures and utilities to ensure high-quality and cheap water/steam/energy services to all industrial facilities of the industrial park as shown in fig. (6)

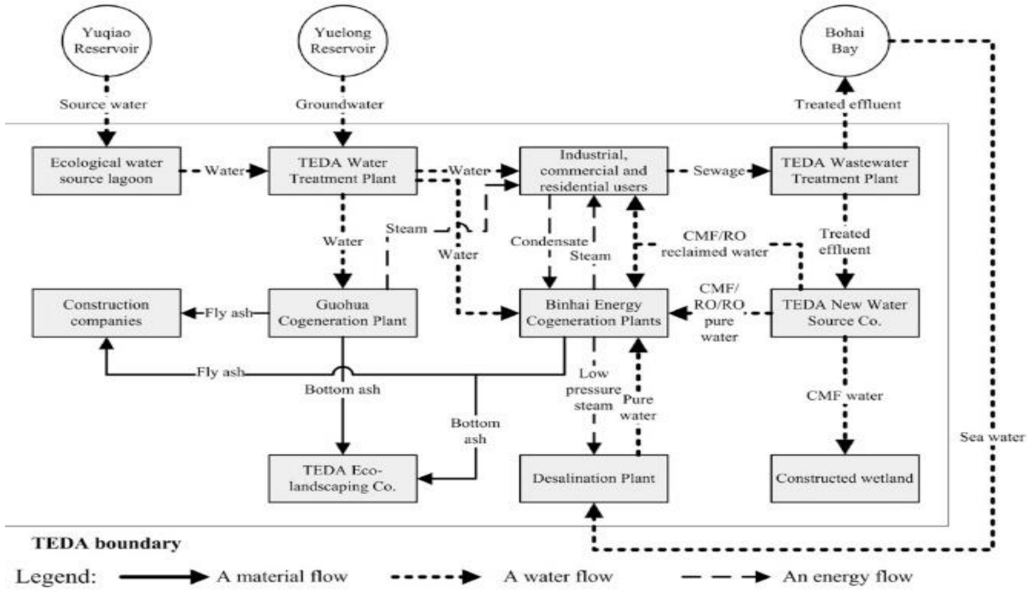

Figure 6 TEDA Public Utilities IS, Source: (Shi, Chertow & Song, 2009)

Industrial exchanges: Symbiotic exchanges of energy and water cascading and solid waste exchanges among the primary industries (electronics, machinery and automobile, biomedicine, and food & beverage sectors) as shown in fig. (7)

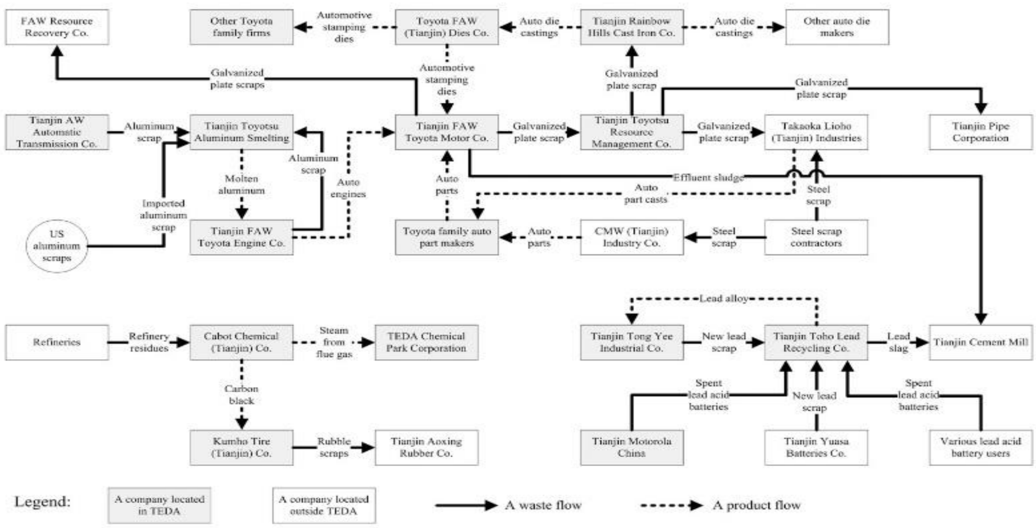

Figure 7 TEDA Industrial exchanges IS, Source: (Shi, Chertow & Song, 2009)

1.2. Planning of Transformed EIPs

In addition to what is mentioned above, the following illustrates the building blocks of planning transformation process into EIP. Based on the lessons learned from the previous international experiences and literature related to industrial ecology. As explained below, EIP represents a new form of urban composition based on collaboration and sharing. However, eventually it is a form of land development and in order to ensure practical transformation to this new trend of development it is essential to realize the role of urban planning in steering this process (Momirski, 2019). The urban planning process of EIPs is composed of three levels. National planning, responsible for steering the political will towards ecological development by forming interdisciplinary teams to prepare national strategies, goals, programs, provides funding and assign responsibilities to different authorities. Regional planning, which is the study of the region for actual and potential sharing opportunities, analysis of communities, indicating "champion industry", preparing participatory learning activities and preparing "regional eco-industrial planning" which includes possible clustering, flow of resources (material and wastes), reprocessing industries and indicating different partner's roles relying on their level of awareness. Local planning includes the design, evaluation and choice of industrial clustering and waste/energy exchange scenarios, detailed plans of the chosen scenario, preparing marketing plan, and monitoring of development. (Shalaby,2012). In this regard and in light of the previous experiences mentioned above the following literature discusses a number of topics as shown in the table below to investigate the role of urban planning in this transformation process.

Table 1-Urban planning of transformed eco-industrial park.

Urban Planning of Transformed eco-industrial parks						
Polices and regulations	Nomination of the appropirate industrial zone	Spatial planning	Organizational structure	Indicating interventions and symbiotic networking	Community support and capacity building	Monitoring assessment

Source: (Author defined)

a. Polices and Regulations

Governmental policies/programs are "a major conditioning factor that represents the "political will" to implement industrial ecology on traditional industry (Shalaby,2012). They create appropriate market conditions, policy and regulatory frameworks, technical guidelines (UNIDO, 2016 a) and overcome regulations prohibiting the possible exchange of waste materials (Francis, Erkman, 2001). The effect of governmental polices is most evident during 1999, when the SEPA in China launched an industrial park-wide ISO 14001 demonstration program in 1999 and an Eco-Industrial Park demonstration program in 2000, which made the Chinese industrial parks compete with pioneers in this field in mixing economic gains with ecological practice (Shin, Chertow, Song, 2009).

b. Nomination of the Appropriate Industrial Zone for Transformation

Selecting industrial sites suitable for ecological transformation is vital to the success of this project. The first approach of selection is a result of governmental or community monitoring of some zones that might be high priority zones facing a major environmental problem, like Tianjin in China or Kwinana in Australia, or that has a valuable and rare resource that needs preservation like Kalundborg in Denmark. The second approach relies on using the selection tool developed by the United Nations industrial development organization (UNIDO). It is composed of multiple stages designed for testing the suitability of different zones. This tool is composed of 4 stages through which industrial zones are filtered gradually. First, Shortlisting "screening the national database" for active CIZ, with available contact information, accessible location and brownfield (> 50% developed) industrial zones. Second, Pre-selection "filtration of the previous shortlist based on Yes/No criteria." Third, prioritization "filtration of pre-selected industrial sites according to a qualitative criterion with scores from 1 to 6." Fourth, "reviewing prioritized sites against an International EIP Framework designed by UNIDO to check EIP "prerequisites and indicators." Finally, the selection of industrial sites for EIP transformation is based on step 3 and step 4 (UNIDO, 2019). These steps are explained in more detail in the part of "selection of industrial zones" of the framework.

c. Spatial Planning

From Urban planning perspective, the difference between CIZ and EIP is that it promotes sustainable development through enhancing environmental quality, services, facilities, ecological value, infrastructure, integration, management, coordination and collaboration. However, previous literature "focused or been limited to industrial process" without paying attention to spatial considerations that are vital to ensure successful land development and transformation into symbiotic operation (Conticelli and Tondelli, 2014). Thus, an "ecological planning approach" is slowly emerging to lead planning and development of industrial areas. This approach fosters going further from "end of the pipe idea of pollution control" into a new approach that works to provide an ecosystem (Conticelli and Tondelli, 2014). In this regard EIP Land use planning is a "multi-criteria decision analysis" that has to investigate various urban, industrial and environmental parameters. Which means studying characteristics, needs and problems caused by different types of land use (industrial, agricultural, existing residential lands …etc.) in details in order to generate viable alternatives for land development decisions (Momirski, 2019). Urban planning for IS transformation should provide suitable and sufficient areas for industrial development while maintaining distances between industries within certain limits to keep the cost of by-product utilization lower than of raw materials. In other words, creating industrial clusters that depend on geographic proximity that offers opportunities for easy collaboration, hence symbiotic possibilities (Momirski, 2019). In cases of transforming CIZ into EIP some urban planning decision for land development must be taken like "protected land" or changing certain uses. Also, indicating types and distribution of land uses (industrial, agricultural residential use…etc.) (Momirski, 2019).

d. Organizational Structure

Based on the investigated literature and previous experiences, there are two kinds of organizations that affect the operation of EIPs, which are the central management body and the industrial association body. First, central management ensures smooth operation of the park (Massard et al., 2014; UNIDO, 2016 a). It plays some key functions such as environmental monitoring and recording, enforcement of the park's code and regulations, risk management, consulting stakeholders (local citizens and governmental official…etc.), fostering knowledge sharing and collaboration between companies, maintenance and financing of facilities and infrastructure, facilitating and monitoring the establishment of new companies at the EIP and representation of the park at local or regional disputes and stakeholder meetings. (UNIDO, 2016 a). However, there is no universal management model to be applied on TEIP. It depends on the nature of the industrial zone, the political environment, the financial investment and capacities of stakeholders. The chosen model should follow a "lean management approach" that maximizes customer value and minimizes inefficiencies in critical resources such as human effort, space, capital or time (McKinsey, 2014). The second is the industrial association formed by the park management to be a legal body responsible for environmental management. By observing environmental problems, fostering positive interaction between industries and central management, preparing symbiosis implementation programs, monitoring and benchmarking, like the Environmental Protection Bureau (EPB) in China and the Kwinana Industrial Council in Australia (Shi, et al 2009; Beer, 2007; Bruk, 2016; UNIDO, 2016 a & Kalundborg symbiosis, 2018).

e. Indicating Interventions and Symbiotic Networking

Frequent monitoring of industrial activity leads to the indication of environmental issues and causes. For example, in Kwinana air pollution, drainage of industrial waste water into the sea and huge amount of solid waste creation caused several issues. The same can be seen in Kalundborg, due to the limited sources of underground water, and in China, due to the scarcity of both water and usable land and deterioration of the surrounding agricultural lands. (Shi, et al 2009; Beer, 2007; UNIDO, 2016 a & Kalundborg symbiosis, 2018). Accordingly, decision-maker indicates the right interventions after establishing the baseline of industrial parks and performs gap analysis to identify the most important gaps to be addressed (UNIDO, 2016 a).

In this context and in light of the previous experiences in Denmark, Australia and China, innovation has several goals, including converting waste into products with added value, minimizing waste creation, reducing GHG emissions, minimizing fresh water consumption, reducing draining waste water into the sea, minimizing decay of surrounding agricultural lands, reducing transportation distances and integration with the surrounding urban settlements. On the local, level researchers set a number of tasks to prepare the symbiotic network. First, modeling the network of exchanges to find new opportunities, second finding new companies to fill the void that may occur if any of key suppliers or customers move or go out of business, third researching technologies and markets for currently unmarketable byproducts (Desrochers, 2001), fourth improving efficiency on "individual company levels" through cleaner production and waste management (UNEP, 2010, UNIDO,2016), fifth improving efficiency on the "industrial park-level" by managing material, energy and water flows (Beers, 2007, UNIDO, 2016 a). This is achieved by creating a symbiosis network composed of three parts: supply synergies responsible for locating the nearest suppliers of raw materials, by-product synergies responsible for sharing byproducts, energy, and treated water between industries and utility synergies responsible for shared use of infrastructure (UNIDO, 2016 a). On the regional level, achieving industrial ecology cannot be done within the boundaries of EIP only. Therefore, the creation of symbiotic network for the industrial park must overcome the shortage in the flow of materials and byproducts that can't be covered depending on local sharing only (shalaby,2012 & 2018). It has to depend on the "networks of firms within a region that can exchange byproducts without having to relocate" (Desrochers ,2001); Thus, connectivity of each company to the surrounding region is a must to increase competitiveness and profit (Leeuwen, et al, 2003).

f. Community Support and Capacity Building

Industrial ecology is an "interdisciplinary field of studying industrial systems in line with nature and society" (Geng and Yi, 2005, Shalaby,2012). It requires a change of perspectives and adaptation by the community (Shalaby,2012). The community role as the main pilot and sponsor of ecological development was proven above in the previous experiences, where Kwinana and Kalundborg used pressure of the local community (government – local stake holders) on the industries to manage their pollution problems, which initiated the meetings to find solutions to the environmental problems caused by the industries. Here comes the importance of awareness raising for the success of TEIP since it is new and not fully understood to general and industrial communities. It is important to gain stakeholders' support and motivate them into participating in development to avoid possible problems and setbacks resulting from a misunderstanding of EIPs (UNIDO,2016a). Otherwise, it has been demonstrated that a lack of awareness can be damaging to developing industrial synergies (Francis and Erkman, 2001, UNID 2016a). Capacity building is responsible for raising awareness by developing, planning and managing skills of all actors in the industrial system (Shalaby,2012). it requires effort throughout all stages of development as it is concerned with upgrading the technical and non-technical capacities of all stakeholders and making sure that under-represented groups of stakeholders (such as women and youth) participate and benefit from capacity-building activities. It is concerned with upgrading transformational competencies, technical competencies, management competencies, and participatory competencies (UNIDO,2016a).

g. Monitoring and Assessment

Government, local community and local authorities (central management and industrial association) should be responsible for observing effects of the industrial activity on the environment, to detect any changes in the eco-system and to trace the causes of this change which helps to spot the problems that need fixing and to keep track of TEIP progress and achievement of goals. Adding on, it should help report any environmental, economic and social outcomes, using performance indicators that allow quantifying resource efficiency and pollution intensity at any point in time (UNIDO, 2016a). This operation is carried out by the park operator, waste operator, waste analyzer and local planning team to prepare "supplementary scenarios of waste and energy exchanges accordingly within the EIP or with other regional counterparts" (Sterr, 2004, Shalaby, 2012).

2. INTELLECTUAL FRAMEWORK OF TRANSFORMING CONVENTIONAL INDUSTRIAL ZONES INTO TEIPS

TEIP Planning is a "long-term, incremental, multidisciplinary, integrated, and coordinated planning approach" (Geng and Yi, 2005, Gibbs and Deutz, 2005, Roberts, 2004, Shalaby,2012). It should "consider industrial symbiosis as a primary concern, waste as a resource, TEIPs as a means of affording variety and redundancy, and industrial regions as "counterparts for EIPs" (Shalaby,2012). Based on the mentioned literature and previous experiences, transformation of traditional industrial zones to ecological practice is viable. However, the path of transformation differs according to the characteristics and driving forces of each zone. The following diagram and illustration bellow explain the concluded intellectual framework of planning process for transformation into TEIP.

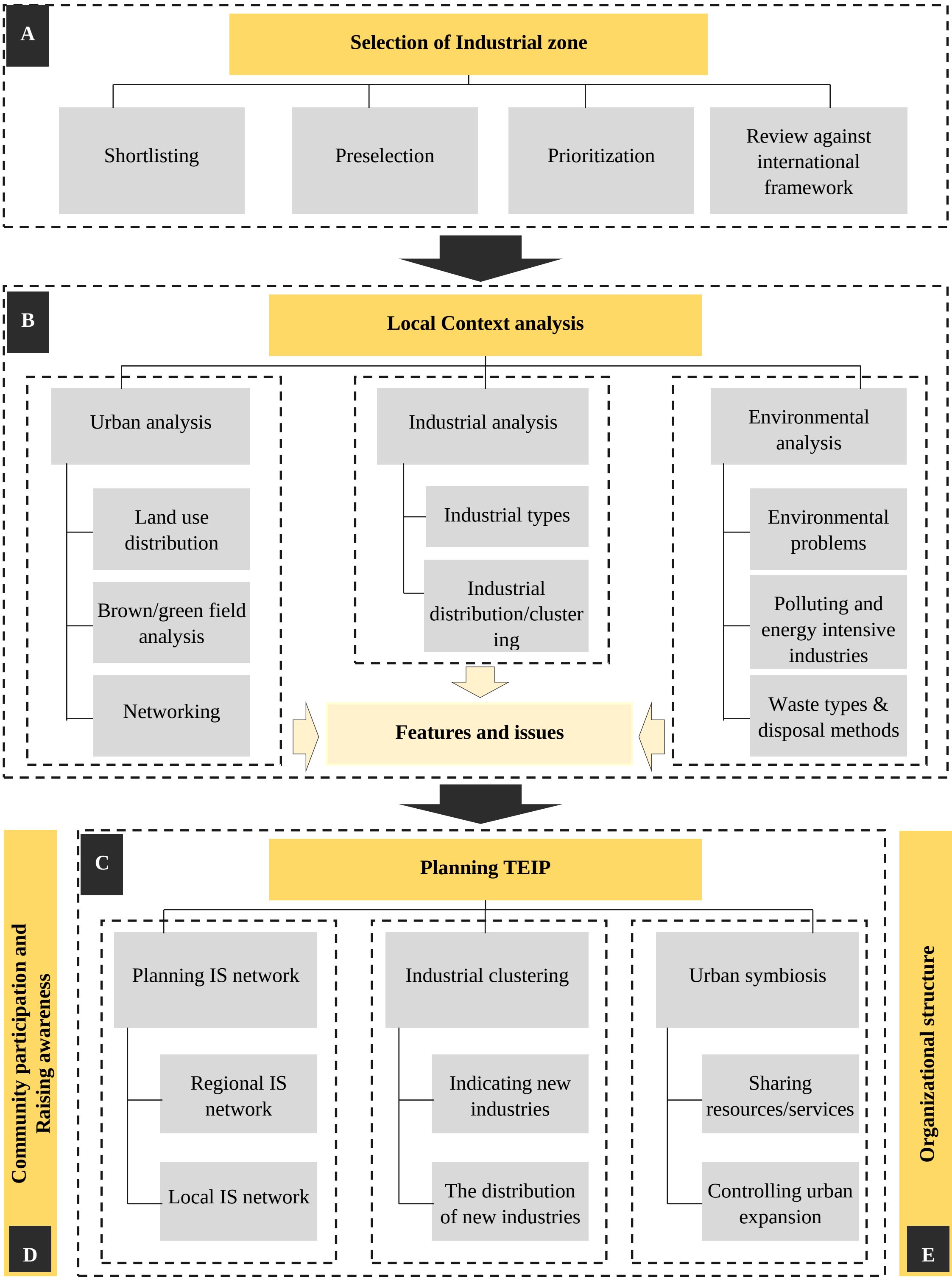

Figure 8 Conceptual Framework
Source: Author defined

a) Selection of the Industrial Zone

Since not all existing industrial zones are appropriate for this kind of transformation, it is important to select the appropriate zone first. The nomination of the most appropriate zone for transformation takes place at all levels of urban planning (national, regional and local). As mentioned above, there are two ways to choose an IZ. However, in the context of this framework, the selection of the industrial zone depends mainly on the UNIDO selection tool. This tool performs a detailed analysis of all industrial zones included in the national database. This analysis, as shown in fig. (8) is composed of several stages through which industrial zones are:

A) Shortlisting: screening the national database of industrial zones, searching for industrial zones with the following characteristics: active park, available contact information, accessible location and brownfield (> 50% developed).

B) Pre-selection of industrial sites: based on a Yes/No criteria checking the following (park management, size, industrial activities, law and regulation, secrecy & confidentiality, risk, location and commitment).

C) Prioritization of pre-selected industrial sites: comparison and evaluation using a qualitative criterion formed in a number of statements that need to be answered by giving scores from 1 to 6, checking the following park management, environmental aspects, social aspects, economic aspects, replicability and visibility.

D) Reviewing prioritized sites against the international EIP Framework designed by UNIDO which target industrial sites with high prioritization scores to be reviewed against the International framework for Eco-Industrial Parks (UNIDO, WBG, GIZ, 2017) with scoring in terms of percentage criteria fulfilled. This framework checks EIP prerequisites and performance indicators (UNIDO, 2019).

b) Local Context Analysis

Urban analysis: first, understanding the urban characteristics (land use distributions, clusters, brown/green field analysis, etc.) to indicate the main issues and potentials of the site, then understanding the relation of the industrial site with the surrounding settlements to study current urban problems caused by or to the industrial site like urban encroachment, pollution and noise. Second, understanding current road networking in moving materials, workers, products and byproducts around the industrial site indicates current issues like traffic jams, lack of parking spaces, public transportation…etc. Industrial analysis: indicating the types, numbers, percentages and distribution of each industry to understand the relations among the industrial zone and start realizing the issues that need to be solved. This analysis will support the IS planning stage illustrated below to indicate the actual need of industries to effectively close the industrial cycle. Environmental analysis: indicating the polluting industries, the types of their pollutants, energy and water intensive companies, waste types and disposal methods, then the planning team is able to understand the level, types and sources of environmental problems that need to be solved in the next planning stages. (Momirski, 2019, Shi, et al 2009; Beer, 2007; UNIDO, 2016 a & Kalundborg symbiosis, 2018).

c) Planning TEIP

Industrial Symbiosis Networks: First is local symbiotic networking: preparing IS networking scenarios that fill the gaps in current industrial cycles where wastes are dumped (Shalaby, 2018). This scenario depends on a dominating industry "anchor company approach" searching for new opportunities to share byproducts, energy, and water to be the leading player. Larger industries have "large and stable waste flows", less tendency for relocation due to the cost of moving and "their production processes are embedded in local production networks" (Leeuwen, et al, 2003). Finally, converting the IS scenario into a detailed IS map that includes all industries and material flows. It consists of four categories: supply synergies, utility synergies, service synergies and by-product (waste) synergies (UNIDO,2017). Second is regional symbiotic networking: it is responsible for the byproducts that could not be recovered or used locally. It requires the surrounding industrial regions to receive byproducts. Thus, the planning team has to scan the surrounding region to study the spatial distribution and quantity of industrial flows of byproducts, energy, and waste water in the surrounding region (Roberts, 2004, Boons et al., 2011), then investigate the possibility of integrating the TEIP into symbiotic agreements regionally to share wastewater, material and energy that cannot be used locally (Shalaby, 2018).

Industrial Clustering: "IE works best when there is a strong agglomeration or clustering of establishments" (Shalaby,2012). So it requires collocating linked industries in one location as distance is an important factor for the success of IS and utility sharing. Minimum distance between facilities is required to achieve minimum costs of energy (Leeuwen, et al, 2003), minimum costs of transportation and more possibilities of symbiosis, which is proven in Kalundborg symbiosis that relies on physical proximity of compatible plants in terms of material flows (Desrochers, 2001). It is also tested in Tianjin where symbiotic networking is categorized according to each cluster (automobile cluster symbiosis, public utility cluster symbiosis, etc.) (Shi, Chertow & Song, 2009).

Urban Symbiosis: Integrating with surrounding urban settlements by sharing resources, products, utilities and infra-structures "exchanging waste, not only industrial but also urban" (Shalaby & Shalaby, 2018). This kind of symbiosis involves two aspects. First, controlling urban expansion of the settlements on the EIP and vice versa. It is tested in WTC after committing to buffer zones around the industrial area and changing some of the polluting land use to less sensitive uses like commercial or services, which increase the environmental quality and protect the surroundings from the industrial pollution (Beers,2007). The second is sharing resources which includes sharing services, products, byproducts, energy and water, for example sharing residual heat produced by the power station to the residential district for town heating in Kalundborg (Kalundborg symbiosis, 2018).

d) Community Participation and Raising Awareness

"interconnected networking constellations of public and private actors" play an indicative role in development towards EIP (Boons et al, 2011, Shalaby, 2012). This was proved in Kwinana and Tianjin as the first step towards IS was taken due the pressure of the community to solve the environmental issues (Shi, et al 2009; Beer, 2007). However, sometimes "communities do not accept change" and require a participatory approach that includes a process of education and raising awareness of the benefits of the running developments. (Roberts, 2004 as cited in Shalaby,2012). First, by identifying stakeholders and understanding their current awareness-levels (stakeholders are any organization or group that are affected by or can affect the TEIP like local government officials, park management, companies, industry association…etc), then preparing and implementing awareness-level activities (based on the information obtained during the previous steps) like meetings, workshops, interviews…etc. However, activities should not stop after the initiation phase in order to make sure that a sufficient level of information is maintained amongst key stakeholders (UNIDO, 2016 a).

e) Organizational Structure

TEIP is a complicated structure of networking and collaboration that requires delivering different types of tasks simultaneously like infrastructure management, service management, coordination with various stakeholders…etc. First, TEIP management is either a preexisting managerial body or a new managerial body formed from scratch according to a specific management model (associative management model, government management model, mixed public private management model and private company or individual management model) that avoids recreating the management from preexisting bodies as this may lead to bureaucracy. (Massard et al., 2014; UNIDO, 2016 a). Second, formation of an industrial association to be in charge of environmental management like Kwinana industrial council in Kwinana and Environmental Protection Bureau (Shi, et al 2009; Beer, 2007; Bruk, 2016 & Kalundborg symbiosis, 2018).

3. Research Results

Transformation of conventional industrial zones into eco industrial parks is likely to succeed as there is already a market share to build upon (Chertow, 2007). Since this transformation is a type of land development it is essential to start realizing its parameters from the urban planning perspective. In this context, this research provides a conceptual framework that covers the urban planning process of this transformation. It covers multiple aspects and layers like nomination of the most appropriate industrial zone, analysis, planning, awareness raising, community participation, management and organization. For example, as mentioned in details in the framework part, it is essential to choose a CIZ with a diverse industrial base, well defined managerial body, accessible location, available contact information…etc. The chosen CIZ has to pass through a certain analytical processes (urban, industrial and environmental analysis) in order to understand the issues and potentials of each CIZ. Accordingly, ecological planning is executed by preparing symbiotic networks, industrial clustering and urban symbiosis. This is achieved simultaneously with awareness raising, community participation and preparing organizational structure to supervise, sustain and lead environmental developments and management.

Since this framework is a part of an ongoing research discussing the transformation of Egyptian CIZ into EIP, it was essential to put it together in order to have a theoretical platform to be tested in the local context of Egypt and be modified accordingly. However, initially for this framework to be applicable some recommendations might need to be taken into consideration such as:

- Excluding the informal CIZs that are not built according to accredited urban plans like “Qaluiob”, “Shaq Al-thoban” and other zones from this development program.
- Updating current databases and masterplans by performing urban and cadastral surveys could be essential depending on the accuracy of the available information acquired from the relevant governmental authorities

However, these recommendations are tentative and subject to ongoing research that will result in more modifications to the suggested framework to be applicable on the Egyptian industrial zones.

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List of Symbols

IE	Industrial Ecology
IS	Industrial symbiosis
CE	Circular Economy
CIZ	Conventional industrial zones
EIP	Eco-industrial parks
TEIP	Transformed Eco-industrial parks
UNIDO	United Nation Industrial Development Organization
WTC	Western Trade Coast
KIC	Kwinana Industrial Council
TEDA	Tianjin Economic and Development Area