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# Sustainable Indicators for Eco-Industrial Parks

**Aster Woldu[1]**

[1] M.Sc in process engineer: Adama Science and Technology University, School of Mechanical, Chemical and Materials Engineering, Chemical Engineering Department, Adama, Ethiopia. aster.woldu@research.astu.edu.et

**Abstract**

EIP is a cluster of industrial system that aims at conserving the utilization of natural and economical resource, to reduce waste generation and improve the quality of works as well as local communities' life. To do so; the clustered businesses work together, with each other and with local community to effectively share resources (materials, water energy), infrastructure, and the local habitat. In turn; these relationships foster the implementation of Industrial Symbiosis (IS), which seeks to transform wastes, by-products or products of a firm into inputs for another one taking advantage of their own connections. However, the connectivity also propagates failures. The holistic planning and development of these clusters from the three pillars of sustainability (economic, environmental, and social) considerations and the sustainability assessment of these clusters is highly complex. For monitoring and controlling the development and progress of an EIP, an indicator system must be set up to standardize and assess the EIP (sustainability) performance.

This paper aims to review the main EIP indicators with respect to economic, social and environmental aspects of the parks.

**Key word:** industrial ecology, eco-industrial parks, sustainable indicator



## Table of Content

## 1. Introduction

The role of industrial sector is critical in the economic system of any country. Conversely, industries demand a lot of resources and these days every stakeholder of any industrial system is keen to have efficient industrial outputs. The concern about the environment is also important and researchers are working to mitigate the consequences of industrialization. Recreation of sustainable development requires a systems approach to the design of industrial product and service systems. Even if; many businesses have been adapting sustainability goals, the real development of sustainable systems remains difficult because of the wide range of economic, environmental and social factors that need to be considered across the entire life cycle of the business.



In tracking down of inclusive and sustainable industrial and economic development, various forms Economic zones like industrial park, industrial estate, eco-industrial parks, technology parks, and innovation districts, special economic zones, have been extensively practiced in almost all over the world (Boix, Marianne., et al.2015),

An Eco-Industrial Park (EIP) is a cluster of businesses located in a common property that collaborate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and the local habitat) that result in a gain of economy, environmental quality, and unbiased enhancement of human resources for the business and local community (Robert U. et al., 2000; Boix, et al., 2015; Valenzuela, et al., 2018). In other word; eco-industrial parks (EIPs) and industrial symbiosis (IS) motivated by regional cooperation and participation in the eco-city concept (Somchint Pilouk, et al., 2017). Industrial development is placed in a new perspective with the introduction of industrial ecological concepts that tries to understand the potential for environmental, economic and social improvement in industry and around the industry using the analogy of industrial systems as natural ecological systems (C. de Sousa Silva, et al., 2016; Somchint Pilouk, et al., 2017). The new perspective emphasize that industrial cluster should be designed to look a lot like the natural ecosystem as closely as possible (Heeres et al., 2004; Somchint Pilouk, et al., 2017）.

These relationships foster the implementation of Industrial Symbiosis (IS), which is an innovative approach that brings together companies from different sectors in an effort to promote the valorization of waste, improvement of resource efficiency and reduction of environmental impact (Robert U. et al., 2000; B. Suresh, et al.,2016). Industrial symbiosis demand synergy, which is the interaction or cooperation of two or more entities to produce a combined effect greater than the sum of their separate parts (Robert U. et al., 2000). The three sustainability dimensions benefited by applying EIP are: economic, environmental, and social (Robert U. et al., 2000; Boix et al., 2015). The extent of these benefits is related to the outline of an EIP, in other words, to connections among firms and their location. This configuration can be chosen by decision-makers at the design phase of EIPs (Boix, Marianne, et al.2015).

Considerable interest is educed by the development of Kalundborg EIP; Denmark in the application of IS networking (Boix, Marianne. et al.2015). It naked in 1990 and then described in the international press (Boix, Marianne, et al.2015). It demonstrates a regional symbiosis where the participants exchange water, heat, by-products and share wastewater facilities (H.M. Zheng, et al., 2012). The gained benefits of the symbiosis for the industrial park and the surrounding community are: the significant reduction in consumption of resources (water, heat, coal), the reduction in air pollutant emission (sulfur dioxide ($SO_2$) and carbon dioxide ($CO_2$) ), improvement in quality of effluent water, the conversion of traditional waste products such as fly ash, sulphur, and biological sludge, into raw materials for production (reduction in cost of raw material and waste management) (Valenzuela et al., 2016: Valenzuela, et al., 2018). Kalundborg EIP is a successful eco-park taken as an example in every literature (H.M. Zheng, et al., 2012; C. de et al., 2016).

The conference of United Nations about environment and development was the place where the Sustainable Development Commission was created. This agency created a way for the development of three generations indicator for sustainability development. In 1996; the first generation called by the name of environmental indicators because they answer to the complex phenomenon of a productive sector with a singularity or reduced dimensions pollution of air, the contamination of water, in addition indicators like deforestation indicators etc.

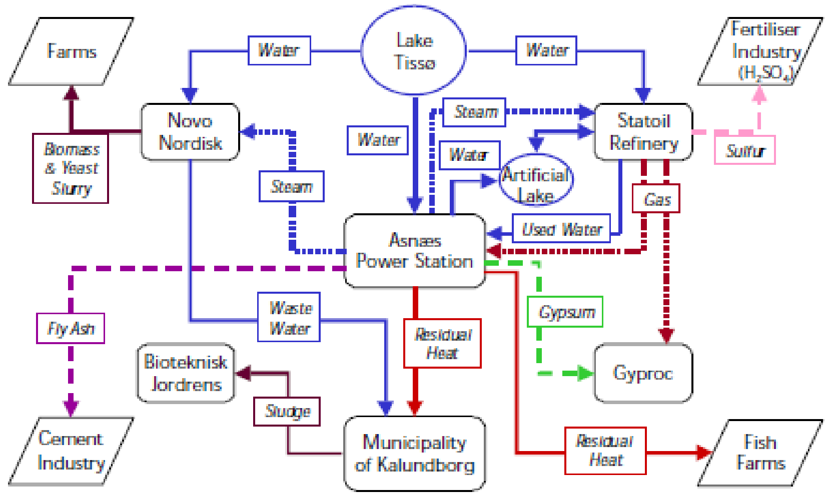


Figure: 1 Material Flows in the Kalundborg Industrial Ecosystem (Edgardo Bastida-Ruiz et al., 2013),

The second generation in 2001 built-in an indicators of environment, social, economic (IE) and institutional type, and are binding initiatives, monetized, communicational powerful but methodologically questionable as they conserve in their individual form their discipline or sectorial profile. In 2006; the third and most recent generation are binding indicators that in few figures permit a fast access to a world of bigger meanings that incorporate the economic, social and environmental aspects in a cross and systematic form. The purpose is to measure the process to sustainable development in an effective way using a limited and binding number of indicators that contain dimensions and sectors from its origin (United Nations, 2007).

In order to analyze the work of industrial park success, it is essential to establish a reference framework, i.e., a set of goals against which to measure performance, along with key performance indicators (KPIs).

## 2. Materials and Methods

Sustainable indicators are essential to assess the effectiveness of an EIP regarding the axes of sustainable development (economic, environmental, and social dimensions) (Azapagic & Perdan, 2000; Harlem, 1987).

These indicators have to capture the main characteristics of an EIP: to compare with other contexts and to support decisions concerning its configuration. The comparison of an EIP can be done with: (i) its historical performance, (ii) a new configuration of the same park, (iii) or other parks. For a complete sustainability assessment, the indicators must quantify all impacts (internal, external, positives, and negatives) produced by the geographical location of firms and their connections through an industrial network.

To fulfill the intended task; search is made in science direct and Google using the following sentence:

- ✓ Indicator/assessment in industrial park
- ✓ Indicator/assessment in industrial symbiosis
- ✓ Indicator/assessment in Industrial cluster

General keyword is used for searching; through this search it is found 25 articles published between 2015 and 2020.

Finally, it is considered 10 articles published between 2015 and 2020 in which industrial assessment is the main topic and which includes a set of indicators , that are dealt from the three pillar of industrial ecology are considered .Then the articles are reviewed, to prepare a summarized material for sustainability indicators for Eco-industrial parks.



## 3. Sustainable Development and Its' Indicators

### 3.1 The Sustainability Concept

The idea of sustainability gathers the different elements contributing to a human life support system on Earth. Literatures have been defined sustainable development (SD) in many ways, but frequently used definition of SD, as it is acknowledged by the Brundtland Report,

> *"It is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs".*

Usually, sustainability is related with norms such as efficiency or equity from an economic, social and environmental viewpoint and deals with interagenerational and intergenerational issues. These days, sustainable development is in the news every day as the world copes with climate change, biodiversity loss, and conflict and resource scarcity (Yu Zeng, et al., 2013). Sustainable development therefore sustainability are related not only by the three-way relationship between the environmental, economic, and social pillars but also by the organizational dimension of sustainable development. Prominent interactions exist respectively between the environmental and economic dimensions regarding feasibility and between the economic and social dimensions denoting equity.

Sustainability indicators is an indicator that allow to measure economic, environmental and social aspects of a process, a company, the development of a product, a city, an industrial park, and others systems (Valenzuela-Venegas G, et al., 2016). As per Braat (1991) sustainable indicators defined as indicators which provide information, directly or indirectly about the future sustainability of specified levels of social objectives such as material safety, environmental quality and natural system amenity. Other authors put that indicators are a way to measure or indicate in an easy clear mode the conditions of a system, provide an added vision of a country, region, zone or state in environmental matter including social dominant interests that are useful in decision making (Bell and Morse, 2008; Edgardo.B, et al., 2013).

In general; Indicators are considered of vital importance for the measurement of sustainability in local contexts as well as for national and international policies, as they allow communicating, discussing and taking decisions on complex facts and trends, using relatively few data.

During the development of indicators; the process should contain a clear scientific base also with a social politic content (Scerri and James, 2010; Edgardo.B et al., 2013). Ever components should frame the base of a statistic instrument that seeks to fulfill the information function that allows taking decisions of economic, environmental and social matters.

Different parties performed and registered considerable work for the development of sets of sustainability indicators for example (European Expert working group on indicators and data for ICZM,). To look back the history of sustainable development and its' indicators; as it is mentioned in different literatures, the first activity is voted for Brundt land Commission in 1987, the World Commission on Environment and Development acknowledged the importance of the sustainable development approach and new techniques to evaluate progress towards sustainable development (SD) (Roberts, B.H., 2004; Edgardo Bastida-Ruiz, et al., 2013; Somchint Pilouk, et al., 2017). The Brundt land Commission call consequently come back in Agenda 21 of the 1992 Earth Summit and through activities that range from local to global in scale (Edgardo Bastida-Ruiz, et al., 2013; Jochen Jesinghaus, 2014; ). In response, significant efforts to assess performance have been made by corporations, non-government organizations, academics, communities, nations, and international organizations (Edgardo Bastida-Ruiz, et al., 2013; Jochen Jesinghaus, 2014; Somchint Pilouk, et al., 2017). Then in 1996, researchers from five continents come to Rockefeller Foundation's Study and Conference Center in Bellagio, Italy. The Bellagio Principles deal with four aspects of assessing progress toward sustainable development as it is shown in table-1. Afterward; the Bellagio Principles were used by many countries and a number of criteria were identified for assessing progress towards SD. These principles function as guidelines for the whole of the evaluation procedure including the selection and design of indicators, their interpretation and communication of the result. They serve as a complete set of guidelines for starting and improving assessment activities of community groups, non-government organizations, corporations, national governments, and international institutions (Jochen Jesinghaus, 2014).

Table: 1 Criteria of Indicator

| Criterion | Description |
|---|---|
| Understanding. | An indicator must be easy to understand. |
| Pragmatism | An indicator must be measurable, its value has to be |
| Relevance | An indicator must be relevant to the goal of EIP |
| Partial | Partial |

When used to an industrial park, those indicators must take pictures of the main characteristics of a process from a definite angle of the sustainability assessment. They must reflect the negative and positive impacts resulting from the activity of an EIP, focusing on a specific dimension of evaluation.



## 3.2 Eco-Industrial Park Performance Evaluation

To measure the success of eco industrial park, it is essential to establish a reference framework, i.e., a set of goals against which to measure performance, along with key performance indicators (KPIs). These indicators can be applied for the whole industrial park, an individual unit, or different processes at the park or an individual process unit. An optimal eco-industrial park minimizes the negative impacts and maximizes the positives ones as a result of the activity of the park. This is done in line with the core 'inclusive and sustainable industrial development' (ISID) principles**. See, tables: 2.-5**

### 3.2.1 General and Resilience Indicator

An eco-industrial park resilience indicator system is needed to be developed for the characteristics of industrial symbiosis (IS) structure, IS activity, IS knowledge transfer, IS system resilience, and adaptability It can be set up in order to generate an overview of the current state and activity level of the IS system and to get a glimpse of where the journey can go in terms of IS (sustainability) performance. The special indicators are resilience and system adaptability.

The definition of resilience given by the authors of the concept in 2003 by Fiksel is, as "the capability of the system to absorb disruptions before it changes its properties that control its functionality. This property allows an IS network to endure the impact of unforeseen event" (Valenzuela-et al., 2018). It takes in to account the dynamic of the participants to withstand an upsetting event and to absorb the shook. The metric can be used by decision-makers to include the resilience in the initial phase of design.

Valenzuela-et al., (2018) reported resilience indicators basing on two main features of an industrial network: (1) the number of connections among members, and the capacity of each flow to change its magnitude when a member's unexpectedly stops sharing flow within the park. The first one measured the number of connection known as Network Connectivity Index (NCI) and the other measure Flows adapt- ability index (ϕ). The resilience indicator is a combination of the two (figure-2). To quantify its flexibility when replace flows, the network is separated in independent layers that each layer contains a single shared material. Weighted summation is then used to calculate the resilience of a multi-layer park.

The following equation is proposed so as to define a resilience indicator

$$Resilience = a \cdot NCI + (1 - a) \cdot \phi$$

Where

- *a* and 1 -*a* indicate the importance of each characteristic
- NCI the connectivity of a park,
- ϕ the capacity of the park to endure a disruptive event by replacing flows

If the same importance is proposed for both aspects *a* = 0.5.

The indicators are checked for the cases of Kalundborg, in Denmark and Ulsan, in South Korea, consistent result is obtained compared to reality.

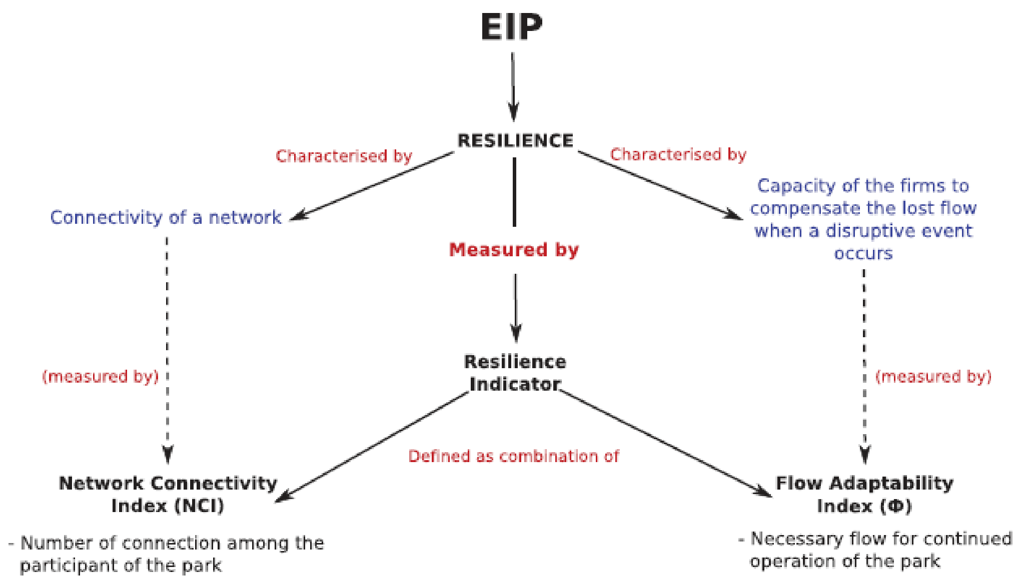


Figure: 2- illustration that shows the main features of the resilience used in an EIP, and structure of the proposed resilience indicator to measure it (Valenzuela-et al., 2018).

| Indicator | Unit | Reference |
|---|---|---|
| number of overarching/special IS organizational units | # | UNIDO 2019<br>Anna Lütje, et al., 2020 |
| number of participating entities in the IS system | # | |
| density of IS system | IS entities per # entities in entire IP | |
| number of joint disposal companies | # | |
| number of joint supplier companies | # | |
| number of joint logistics companies | # | |
| number of IS connections | # | |
| degree of interconnectivity | IS connections per # IS entities | |
| number of exchanged resources | # | |
| degree of resource exchange activity | # exchanged resources per # IS entities | |
| number of water networks | # | |
| activity degree of water network | $m^3$IS water network per $m^3$ IP water consumption | |
| number of material networks | # | |
| activity degree of material network | kg IS material network per kg IP material consumption | |
| number of energy networks | MWh IS energy network per MWh IP energy consumption | |

| | | |
|---|---|---|
| activity degree of energy network | # | |
| number of knowledge networks | # | |
| number of EIP meetings addressing EIP measures | # | |
| number of identified EIP opportunities | # | |
| number of planned EIP activities | # | |
| number of EIP activities that are being implemented | # | |
| number of implemented IS activities | # | |
| number of EIP consultations | # | |
| number of EIP system analyses | # | |
| investments in EIP consultations | birr | |
| investments in EIP system analyses | birr | |
| investments in EIP measures | birr | |
| received (public) funding to expand EIP system | birr | |
| number of education/training events addressing EIP | # | |
| number of educated/trained persons concerning EIP | # | |
| network connectivity index flows adaptability index | | ValenzuelaVenegas Guillermo et al. 2018 |
| | | |



### 3.2.2 Economic Indicator

An EIP economic indicator system is shown in table-3; the input- and output-related indicators generally address cost savings achieved through EIP due to it connectivity activities. UNIDO's four proposed key indicators related to the inclusive sustainable industrial development with a Pillar of Advancing Economic Competitiveness are:

- Good economic governance
- Economically-enabling site & infrastructure 'hardware'

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- Economically-enabling services ‘software’
- Economically impactful nature

### 3.2.3 Social indicator

**Table: 3- Economic and Social indicator**

| Indicator | Unit | Reference |
|---|---|---|
| **Input output economic indicator** | | Anna Lütje, et al., 2020 UNIDO 2019; Ulhasanah and Goto 2012; Lütje et al. 2018; Lütje et al. 2019a; Geng et al. 2014; Sun et al. 2016; Liu et al. 2018 |
| cost savings for human resources | | |
| cost savings for material | | |
| cost savings for water | | |
| cost savings for energy | | |
| cost savings for land use | | |
| Emdollar value of Total Emergy Savings (ETS) | | |
| production-cost-specific IS cost savings | IS cost savings per production costs | |
| cost savings for CO2 taxes | | |
| cost savings for (CO2) emission trading certificates | | |
| created added value | | |
| cost savings for disposal/recycling | | |
| specific resource productivity | yield ($) per unit resource | |
| created yield | | |
| yield-specific IS cost savings | IS cost savings ($) per yield ($) | |
| specific area-related IS value-added ratio | IS value added ($) per area used ($m^2$) | |
| **Good Economic Governance** | | |
| Robust economic system tracking economic analysis quantitatively | # | UNIDO 2019 |

| | | |
|---|---|---|
| showing a positive economic return | | Anna Lütje, et al., 2020 Ulhasanah and Goto 2012; Lütje et al. 2018; Lütje et al. 2019a; Geng et al. 2014; Sun et al. 2016; Liu et al. 2018 |
| Private participation in industrial park planning | # | |
| Private participation in industrial park ownership | # | |
| Operator sourced on the basis of an open competitive tender | # | |
| Private sector represented on Board of Regulator | # | |
| Existence of 60% occupancy rate within 6 years (ha of land used by companies for productive use ) | # | |
| Existence and functioning of a formal Industrial Park marketing department/unit | # | |
| User Maintenance & Operation fees or charges collected by the Operator | birr | Anna Lütje, et al., 2020 UNIDO 2019; Ulhasanah and Goto 2012; Lütje et al. 2018; Lütje et al. 2019a; Geng et al. 2014; Sun et al. 2016; Liu et al. 2018 |
| % user enterprise satisfaction with the services provided by the Industrial Park Operator | # | |
| Operator Customer Relationship Management (CRM) system in place | # | |
| **Economically-enabling site & infrastructure 'hardware' (appropriate site selection** | | |
| Operator ISO 9001 certification | # | Anna Lütje, et al., 2020 UNIDO 2019; Ulhasanah and Goto 2012; Lütje et al. 2018; Lütje et al. 2019a; |
| Unencumbered land title | # | |
| Phased site development strategy and implementation | # | |
| Proximity to urban center (with country significant population | # | |
| Proximity to appropriate highway | # | |

| | | |
|---|---|---|
| Proximity to power transmission or distribution grid | # | Geng et al. 2014; Sun et al. 2016; Liu et al. 2018 |
| Proximity to gas transmission mains and gas 'city-gate | # | |
| Proximity to microwave tower for broadband GSM mobile telephony and Wi-Fi connectivity | # | |
| Appropriately-sized (wide) internal roads | | |
| Proximity Operational Public Port, Airport of use and of interest to the Industrial Park's users* | # | |
| [% hours power outage per period in Industrial Park /% hours power outage nationally] | # | Anna Lütje, et al., 2020 UNIDO 2019; Geng et al. 2014; Sun et al. 2016; Liu et al. 2018 |
| Unencumbered land title | # | |
| [% hours of interruption of water supply, quality or quality in INDUSTRIAL PARK/% hours of interruption of water supply, quality or quality nationally] | # | |
| **Economically-enabling services 'software** | | |
| Regular, Scheduled Maintenance of buildings, as well as dedicated Rapid-Response or Emergency Maintenance, Repair, Rectification & Restoration Service, including for utilities and superstructure assets | # | Anna Lütje, et al., 2020 UNIDO 2019; Geng et al. 2014; Sun et al. 2016; Liu et al. 2018 |
| Dedicated or localized industrial park Business Support, Business Association Support, Incubation, Innovation or Competitiveness programs on effective offer | # | |
| Industrial park user enterprises have access to specific financial support | # | |

| | | |
|---|---|---|
| programmes | | |
| Dedicated One-Stop Shop/Single-Window in industrial park | # | |
| E-government services dedicated to the industrial park | # | |
| [#services offered through One-stop shop in industrial park /# services offered through One-stop shop in nearest urban community] | # | |
| Formal industrial park B2B Gatherings held on formal Industrial Park B2B Platforms on regular basis | # | |
| Operator landscaping, gardening and cleaning services | # | |
| Presence of mechanical cargo loading and off-loading services for users | # | |
| Operation of product exhibition centres, product display areas, conference centres, and/or auditoria | # | |
| Presence of on-site banking, bureaux-de-change and ATM Facilities | # | |
| Presence of Human Resources Agency & Recruiting Services | # | |
| Presence of manpower training services, in coordination with recognized specialized technical training institutions in various fields | # | |
| Presence of dedicated on-site R&D, patenting, and product commercialization services, in conjunction with recognized universities and/or legal services providers | # | |

| | | |
|---|---|---|
| Presence of dedicated on-site matching, twinning, and local supplier and buyer forward and backward linkages schemes | # | |
| Presence of Quality, Product, Process Standards, and/or Trade Certification services | # | |
| **Economically impactful nature: Employment, investment, turn-over** | | |
| Per Capita Income in the industrial park /Per Capita Income Nationally | # | Anna Lütje, et al., 2020<br>UNIDO 2019;<br><br>Liu et al. 2018 |
| [Full-time equivalent employment/hectare in industrial park]/ Full-time equivalent employment/hectare / In industrial parks Nationally] | # | |
| [(Investment/ha) In Industrial Park /(Investment/ha) Nationally] | # | |
| [(birr sales revenues/ha) In Industrial Park /(birr sales revenues/ha) Nationally] | # | |
| | | |

| Indicator | Unit | Reference |
|---|---|---|
| **Socially-Appropriate Site & Social Infrastructure** | | |
| Project ESIA conducted and filed with appropriate authorities | # | UNIDO 2019<br>Anna Lütje, et al., 2020<br>Azapagic and Perdan 2000; |
| Proximity to public transportation (i.e., bus, subway or light- rail) | # | |
| Proximity to residentially zoned areas | | |
| Power lines in Industrial Park are buried, for workforce safety | # | |
| Presence of outdoor street-lighting throughout the Industrial Park | # | |
| Childcare facilities | # | |
| Faith and prayer facilities for major denominations and religious groups represented in the workforce | # | |
| Climate-appropriate (ideally centralized and resource-efficient/ sustainable) HVAC equipment and systems in buildings | | |
| Proximity to mini-mart or supermarket retail services | # | |

| | | |
|---|---|---|
| Park or greenspace as % of total area(as per international standard) | # | |
| Presence of On-site Incident Response Centre and Public Announcement (PA) system | # | |
| Complaints box or Hotline available in industrial park | | |
| Separate women's and men's restrooms in each building | # | |
| Disabled-inclusive building design (i.e., access ramp and elevator in each building) | | |
| Site is not on traditional, indigenous or tribal land | | |
| [Average commute time to Industrial Park workplace for employees / Average commute time to workplace nationally | # | |
| Construction materials are domestically-sourced | # | |
| Industrial park provision of utilities to adjacent communities | # | |
| Operable windows in Industrial Park buildings, ensuring natural ventilation | # | |
| ILO/IFC standard worker accommodations on-site | # | |

| | | |
|---|---|---|
| Drinking fountains in place throughout industrial park buildings | # | |
| On-site common cafeteria/canteen/restaurant/catering | # | |
| On-site multi-purpose athletic fields, gym, recreation, leisure, entertainment, community and cultural facilities | # | |
| **Quality social management system and services** | # | |
| Social impact management & monitoring system (SMS) in place in industrial park | # | |
| Social audits of each firm on at least biennial basis | # | |
| Existence of Emergency Preparedness and Response system in industrial park | # | |
| Presence of public or subsidized transportation system for workforce between key points in or near Industrial Park | # | |
| Industrial Park Community Solidarity Program and Involvement in community projects | # | |
| Annual public/published Social Performance Report for industrial park | # | |
| % firms with ISO 26000 Certification | # | UNIDO 2019 |
| % firms with SA 8000 Certification | # | |

| | | |
|---|---|---|
| | | Anna Lütje, et al., 2020 |
| % firms with AA1000AP Certification | # | |
| % firms with AA1000AS Sustainability or AA1000SES Stakeholder Engagement Standard Certification | # | |
| % Employees satisfied with Social Systems and Services | # | |
| % firms with ISO 9001 Certification | # | |
| Dedicated/enhanced industrial park social regulations, including S-IA requirements, and community dialogue mechanism | # | |
| Industrial Park Operator ISO 26000119 Certifications | # | |
| **Occupational health & safety** | # | |
| [Expenditure on health and safety (EHS) per capita in industrial park /EHS per capita nationally] | # | |
| [% firms with OHSAS 18001 Certification123 In industrial park /% firms with OHSAS 18001 Certification Nationally] | # | |
| Existence of Internal Park Operation Fire Safety Guidelines | # | |
| Perimeter fencing and access control posts | # | |
| On-site hospital, clinic or dispensary within industrial park | # | |
| Public or common night transportation or blue-light system in place in industrial park | # | |
| [(# fire alarms/building) in Industrial Park /(# fire alarms/building) nationally] | # | |

| | | |
|---|---|---|
| [(# sprinklers/building) in Industrial Park /(# sprinklers/building) nationally] | # | |
| [# crimes reported per capita in Industrial Park /# crimes reported per capita nationally] | # | |
| Access by fire services to all parts of Industrial Park | # | |
| [% employees with private health insurance coverage in Industrial Park / % employees with private health insurance coverage nationally] | # | |
| [# of nurses per capita in park / # of nurses per capita nationally] | # | |
| First-aid room or kit in each building | # | |
| Dedicated, 24/7 health services inside the Industrial Park | # | |
| Defibrillator in every building | # | |
| [Mean Emergency (Police, Fire, Ambulance) response time in Industrial Park / Mean Emergency (Police, Fire, Ambulance) response nationally | # | |
| CCTV cameras and security patrols in place | # | |
| **Good labor relations & welfare** | # | |
| Presence of aggregated, publicly accessible labor complaints or incidents and Complaint Measurement mechanism data available | # | |
| Presence of on-site Regulator, Operator or Third-Party Authorized Labor Inspectors or Counselors | # | |
| Absence of instances of child labor and forced labour124 | # | |

| | | |
|---|---|---|
| [Aver. Salary in industrial park /Aver. Salary Nationally | # | |
| [% employees on term or open-ended contracts in industrial park /% employees on term or open-ended contracts nationally] | # | |
| [# annual complaints per capita about working conditions received in industrial park/# annual complaints per capita about working conditions nationally] | # | |
| | # | |
| Rights to Assemble, Unionize, engage in Collective Bargaining, and Strike | # | |
| [% workforce unionized in industrial park /% workforce unionized nationally] | # | |
| **Social inclusiveness** | # | |
| [% employees from legally-recognized minority or disadvantaged groups, or with disabilities in industrial park /% employees from legally-recognized minority or disadvantaged groups, or with disabilities nationally] | # | |
| [% female workforce in industrial park /% female workforce nationally] | # | |
| [% women in Management of Operator and Resident firms /% women in Management nationally] | # | |
| Industrial Park Operator-organized Inclusiveness or Sensitivity training or events | # | |

| | | |
|---|---|---|
| [% employees between ages of 16 and 30 in Industrial Park /% employees between ages of 16 and 30 Nationally | # | |
| [(# new domestic MSMEs/year/ha) in Industrial Park / (# new domestic MSMEs/year/ha) nationally | # | |
| | # | |
| [Female wages as % of male wages in industrial park / Female wages as % of male wages nationally] | # | |
| [Domestic MSME % total investment in Industrial Park /MSME % total investment nationally] | # | |
| [Domestic MSME % of US$ in Sales in Industrial Park /MSME % of US$ GDP nationally] | # | |
| [Domestic MSME % of US$ in exports in Industrial Park /MSME % of US$ in exports nationally] | # | |
| | | |

2.2.4 **Environmental Indicator**

Table 4 shows an EIP environmental indicator system, particular to the performance of IS cascading loops/systems (resources, emissions, etc. saved through IS activities). It determines input- and output-related indicators. Since most of the presented indicators are easier to understand, the following two require further explanation:

**Table: 4- Environmental performance indicator**

| Indicator | Unit | Reference |
|---|---|---|
| Saved primary material resources | Kg | Valenzuela-Venegas Guillermo et al. 2018; Sun et al. |
| Saved primary water resources | $M^3$ | |
| Saved primary energy resources | J | |
| Saved land use | $M^2$ | |

| | | |
|---|---|---|
| Recycled solid waste | kg | 2016; Li et al. 2017; Taddeo et al. 2017; Mauthoor 2017; Morales et al. 2019; Marinos-Kouris and Mourtsiadis 2013; Geng et al. 2014; Sacchi and Ramsheva 2017; Marconi et al. 2018; Martin and Harris 2018; Chertow et al. 2019; UNIDO 2019) |
| Recycled liquid waste/water | l | |
| Material recovery rate | $M^3$/hr | |
| Recycled water rate | $M^3$/h | |
| Renewable energy produced in the EIP system | | |
| Recycled/used gaseous/aerosol waste | | |
| Reduced $CO_2$ emissions | kg $CO_2$e | |
| reduced NOx emissions | kg $CO_2$e | |
| reduced $SO_2$ emissions | kg $CO_2$e | |
| change in chemical exergy | | |
| Relative Emergy Savings (RES) | | |



## 4. Conclusion

The paper reviewed the main EIP indicators with respect to economic, social and environmental aspects of the parks. The reviewed indicator guide helps the members in the industrial parks to set sustainability objectives and to assess and track their performance over time with a quantitative indicator system.

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