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A Framework for Implementation of Eco-Industrial Town (EIT) in Thailand

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ABSTRACT

Eco-Industrial Town (EIT) is one of the important policies of Thailand since 2011 aiming at developing operations of related parties in the target EITs. With emerging concepts, threats and challenges to Thailand, EIT framework and indicators need to be developed to be able to cope with them. This study aims to develop a framework and indicators for monitoring and evaluating progress of EIT implementation in the target EITs in Thailand. Methodology used in the study are the documentary research, two rounds of questionnaires distributed to 30 experts to gather feedback and recommendations and focus group discussion with 52 stakeholders from 6 target EITs in Thailand to gather feedback and recommendations. The results provided an EIT framework which contains of 6 perspectives, 32 dimensions, and 54 indicators which appropriate to EIT implementation in the Thailand context. Implication of the study is that the EIT framework, indicators and recommendations are useful for the future EITs in Thailand and EITs in other countries where under developing the project by selecting perspectives, dimensions, indicators, and recommendations that appropriate to their context.

1. INTRODUCTION

Manufacturing becomes one of the most popular mechanism used for developing economy of the countries to compete with other countries [1]. This may due to western theories of modernization [2, 3]. The Thai Government, like many other countries, used manufacturing as the mechanism aiming at developing the country's economy through promoting and supporting manufacturing both in terms of foreign direct investment and local investment by legislated the Factory Act 2535 B.E. (1992). As a result, Thailand's GDP has increased year by year, for example, GDP have increased 1.15% during 2012 and 2014. However, the dark side of manufacturing is also observed through several objective evidences of the environmental impacts and higher cost for their environmental damages such as deforestation, soil erosion, landslide, flooding, drought in dry season, overexploiting groundwater, mangrove forest destruction, air pollution, dangerous waste, waste water, accident from toxic substances, etc. [4].

With the negative experiences from industrial development and its impacts, Department of Industrial Work (DIW), Ministry of Industry launched the "Eco-Industrial Town (EIT)" policy in order to promote industry to practice their activities in the right way and to alleviate negative impacts on environment and human health. Activities under the EIT policy includes educating the entrepreneurs, communities around industrial zones and industrial parks, local governments and stakeholders to understand the EIT concept and to accept the EIT implementation plan. One of the tasks under the policy is to develop EIT framework and indicators that will be used for measuring and evaluating the progress along the implementation plan. In addition, auditing is conducted to check whether the EIT implementation are able to comply with the established indicators. Then certificate will be granted to the succeed EITs which their developments and implementation conformed to the criteria of the indicators [5].

Primarily, EIT framework and indicators for measuring and evaluating EIT implementation in Thailand were developed from the 9 relevant concepts include industrial ecology, industrial ecosystem, industrial symbiosis, industrial eco-efficiency, eco-city, eco-town, sustainable low-carbon city, eco^2 cities, and livable city. Then, the indicators are established and grouped into 5 perspectives: 1) the physical, 2) the environmental, 3) the economic, 4) the social, and 5) the management [5]. Then, they were used as the pilot indicators since 2011. Some weaknesses are found during use of the indicators due to some inappropriateness such as some indicator are unable to define the suitable collectors of data, some indicators defined are for the national level instead of the lower level, EIT level.

Over the previous decade, the world and industries in Thailand have been forced or disrupted by emerging concepts relevant to sustainability. This may cause EIT stakeholders shall have to reconsider and revise the formerly used concepts in framework of EIT to cover those emerging concepts and turbulent flow. Therefore, it is inevitably impact on the implementation of EIT in Thailand beyond the ground concepts used in the earlier stage. In addition, other industry-related concepts such as circular economy, Bio-Circular-Green (BCG) economy model, sustainable development goals (SDGs), industry 4.0 & Thailand 4.0, aging and aged society, international standard of sustainable cities, smart cities, and resilient cities, and lastly world serious pandemic -- COVID-19 shall also be included in a new EIT framework. The study aims at proposing a new EIT framework for more appropriate

indicators for measuring and evaluating the implementation of eco-industrial town (EIT) in the current Thailand's context.

2. STUDY OBJECTIVES

(1) To develop the EIT framework appropriate to current context of Thailand.
(2) To develop the EIT indicators for measuring and evaluating progress of EIT implementation in Thailand.

3. METHODOLOGY

In this study, the researcher primarily conducted documentary research from related documents which are research reports, academic articles in Thailand and abroad include the previous 9 concepts, and additional concepts -- circular economy (CE), industry 4.0 & Thailand 4.0, sustainable development goals (SDGs), Bio-Circular-Green (BCG) economy model, aging and aged society, and lastly serious pandemic – COVID-19 in order to formulate a new EIT framework and indicators. The second step is to gather feedback and recommendations from 30 experts who have expertise of eco-industrial town from their knowledge and experiences by using the two-round questionnaires. The 30 experts are composed of 2 policy makers (6.67%) of EIT implementation from Department of Industrial Work, Ministry of Industry, 4 academic lecturers (13.33%) from four universities in Thailand, and 24 executives (80.00%) from each of target eco-industrial town in Thailand (Executives of 12 local governments, and executives of 12 industrial zones/industrial parks) of the target EITs in Thailand. Criteria for selection of the experts are 1) responsibility in supporting of eco-industrial town implementation in Thailand (policy makers), 2) knowledge and experiences relevant to eco-industrial town and development of EIT indicators (academic lecturers), and 3) experiences in eco- industrial town related to eco-industrial town implementation (executives from local governments and executives from industrial estates/industrial zones in the target eco-industrial towns in Thailand). All of chosen experts are familiar with implementation of EIT project in Thailand at earlier phase. These indicate the relationship between the experts and the research in this study. Questionnaires are used for carrying out experts' feedback and recommendations. The first round, questionnaires consisted of 32 questions asking conformance between 6 perspectives and 32 dimensions, and 54 questions asking conformance between 32 dimensions and 54 indicators. Experts' feedback and recommendations of the first round are inputs for revising the questionnaires with criteria of all experts' agreement and researcher's justification, then the revised questionnaires are distributed again to the same group of experts. The second round, questionnaires consisted of 34 questions asking conformance between 6 perspectives and 34 dimensions, and 61 questions asking conformance between 34 dimensions and 61 indicators. Experts' feedback and recommendations with criteria of all experts' agreement and researcher's justification are inputs for revising the EIT framework and indicators. Then, the questions for focus group discussion are constructed and used in the final step. Focus group discussion conducted with 52 stakeholders who are the different people from the expert group. They are stakeholders who relevant to EIT implementation in the twelve target EITs in Thailand which are stakeholders from manufacturing plants in the EITs, executives of industrial zones/industrial parks, local governments of the target EITs in Thailand, as well as representatives from the surrounding communities in the EITs. Feedback and recommendations from focus group discussion are used for finalizing EIT framework and indicators with criteria of all stakeholders' agreement and researcher's justification. The final outputs are EIT framework and indicators that appropriate to EIT implementation in Thailand under current threats and challenges.

For the study, researcher aligned the EIT framework with current indicators (2019 version), emerging concepts related to sustainable development and turbulent concerns. Then, EIT framework and indicators for measuring and evaluating the implementation of eco-industrial town (EIT) in Thailand are suggested to be largely a purposeful modification of the existing EIT framework and which is driven by the relevant emerging concepts and recently turbulent situations as illustrated in Figure 1.

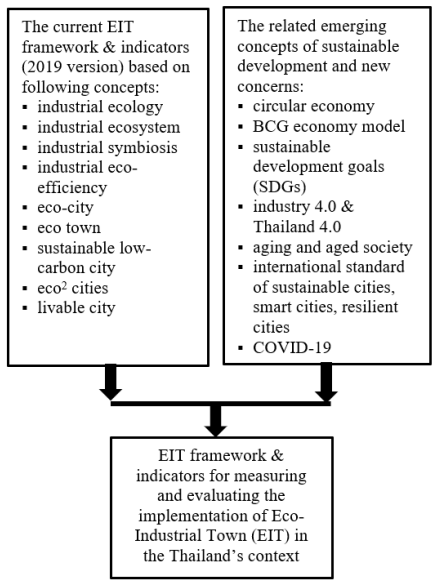

Figure 1. The EIT framework

Descriptive summary, and content analysis are used for qualitative analysis of information obtained from open questions of the questionnaires and questions in focus group discussion by grouping feedback into groups based on frequency of the feedback relevant to problems and obstacles in implementation of EIT in Thailand. Then, they are used for giving advices in the recommendation section.

4. RESULTS

4.1 Definition, concept and development of eco-industrial town

Eco-Industrial Town (EIT) is defined as "a livable town where members of the town, manufacturing plants, business organizations, local governments including surrounding communities, are connected together in terms of symbiosis relationship when the balance among the economy, the social, the environment, and additional two more perspectives - the physical and the management are also considered and attained the happy society as the ultimate goal".

Concept of EIT in Thailand at the early stage arose from several major concepts includes industrial ecology, industrial ecosystem, industrial symbiosis, industrial eco-efficiency, eco-city, eco-town, sustainable low-carbon city, eco^2 cities, and livable city [5]. Most of these concepts are related to the activities of manufacturing plants which try to develop operations inside their plants rather than try to do the activities by cooperation with parties outside the plants. This may be some weaknesses of the EIT at the earlier stage. Therefore, the later stage of EIT framework included other emerging concepts in order that the EIT can response to the outside threats or factors such as situations and requirements outside the EIT by which cooperation with other stakeholders. The example of outside threats are international framework for eco-industrial parks which focus on four key categories - 1) industrial park management, 2) environmental, 3) social, and 4) economic [6]; low carbon city concept [7] to which promote reduction of environmental pollution in manufacturing plants and network concept in order that various activities in the EIT are in line with sustainable development concepts, readiness for response to negative situations and international requirements.

Development of EIT in Thailand is emphasized on the roles and responsibilities of the relevant stakeholders as defined in the EIT implementation under framework and their indicators which are under cooperation of specified key players as follows: 1) manufacturing plants in the specified industrial zones and industrial parks, 2) executives of the industrial zones and industrial parks, 3) executives of local governments, 4) leaders or the representatives of communities around industrial zones and industrial parks, and 5) experts from of educational institutes in the area of EIT.

Under different views of the stakeholders, the EIT development in Thailand brings the concept of sustainable development into consideration. Inevitably, the eco-Industrial town concept is framed basically under the three pillars of sustainable development: the economy, the environment, and the social perspectives. In addition, other two perspectives, the physical and the management, are included in order to ensure that performances of related entities comply with the local laws and regulations and be able to sustain the performances consecutively. The Development Plan of EIT implementation in Thailand during the previous period (2003-2020) supported the sustainable development concept due to the indicators established under the three perspectives earlier mentioned. The major purposes of EIT implementation in Thailand were as follows: 1) decrease environmental pollution in the factory massive areas, 2) prepare the readiness for industrial development in the potential areas in the future regarding the environmental pollution, and 3) foster the acknowledgement and cooperation among relevant stakeholders of EIT.

Monitoring and evaluating of progress and performance of EIT implementation are performed by the auditing of the second party and granting the certificates for the EITs when EITs are able to demonstrate that they can perform the activities comply with the established indicators. Up to the present, there are 15 EITs that are implemented and granted the certificate due to the current EIT framework [5]. This shown that their performances comply with the criteria under the indicators of EIT. However, even they granted the certificates, they may comply with the criteria at the minimum criteria of indicators because the EIT performance categorized into five levels as follows: 1) engagement level 2) enhancement level 3) resource efficiency level 4) symbiosis level, and 5) happiness level (livable EIT) as depicted in Figure 2.

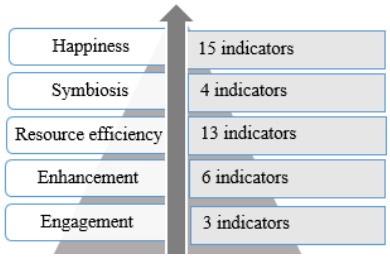

Figure 2. Levels of EIT performance and indicators under five perspectives to be complied, Adapted from [5]

4.2 Development of eco-industrial town against the new challenges

According to the emerging concepts and turbulent flow, they shall be the new challenges faced by EITs in Thailand such as announcement of BCG (Bio-circular-green) economy model in Thailand [8], changes of social perspective of aging and aged society for Thailand since 2021 [9], the serious pandemic of COVID-19 since 2019 [10], The 2030 Agenda for Sustainable Development or SDGs which are an urgent call for actions by all countries - developed and developing countries - in a global partnership [11], convention on the rights of person with disabilities [12], the social and human rights models of disability [13], the publication of the international standard regarding sustainable cities and communitites (ISO 37123) [14] and smart cities [15]. However, the EIT implementation in Thailand also need the continuous development. Therefore, new perspective from the management system standard [16] is added for being the management tools to ensure that EIT shall be implemented continuously. According to aforementioned requirements, the EIT policy makers of Thailand are asked to revisit the existing EIT framework to comply or in line with those challenges. According to the experts' opinions, suggestions, and recommendations, an EIT framework and indicators use for measuring and evaluating the implementation progress of EIT in Thailand will be able to reflect the conformance to the requirements and new challenges from current threats. Therefore, the EIT framework shall include new perspective, dimensions, and also relevant indicators (in italics) as depicted in Table 1.

The explanation of the dimensions included in the perspectives are as follows.

4.2.1 The physical perspective

The first perspective covers five dimensions includes:

1) Location planning and area arrangement:

The manufacturing plants, industrial zones and industrial parks in EIT should be clearly and strictly located at the right places comply with the town plan, local laws and regulations. In addition, the space utilization of the effective infrastructure in EIT should be planned and prepared concordantly with its current and future development. The infrastructure in the EIT includes water supply system, electricity, linkages of transportation system within and outside the EIT.

2) Design of the buildings and surrounding area: The office buildings, manufacturing plants and houses in the EIT should be designed on eco-friendly concepts such as eco-friendly materials are used, energy saving buildings and green

buildings are built.

3) Safety and accessible public green area by all, especially women, children, the elderly and the physically handicapped:

According to the SDG11 [11], safety and accessible public green area are recommended to provide for all people, especially women, children, the elderly and the physically handicapped in order that they can live equal to the others in the city and also to provide social infrastructure [17].

4) Public Infrastructure for the elderly and the disabilities:

According to the UN convention on the rights of person with disabilities [12] and aging and aged society situation of Thailand since 2021, the Thai government recognized the problems and announced the national agenda and action plan to handle the problems [9]. To response to these problems, the EIT should also develop the public infrastructure to be ready and appropriate for the elderly and the disabilities. For example, elderly care center in communities, handicapped ramp, Braille block for the disabilities should be constructed.

5) Risk assessment and management of the city regarding disaster, cyber-attack, and political conflict:

Currently, the world and Thailand face with many and diverse situations of natural disaster, cyber-attack, political conflicts, to response to these threats, the management team of EIT should conduct risk assessment and prepare contingency plan to be ready for eliminating or reducing the impact. Risk assessment and management of the city is important for the city in understanding a particular risk from each threat and prepare for readiness for tackle the problems when they occur [14].

4.2.2 The economy perspective

The second perspective covers five dimensions includes:

1) The economy of the industry:

In EIT, economy of industry sector is an important driving force for the economic growth of EIT. Therefore, revenue of industry sector should grow continuously. Its growth could be generated from trading, investment, increased number of the manufacturing plants, and expansion of investment of the existing businesses. Each EIT should have supporting plan and programmes for economic growth especially for the industry sector.

2) The economy of the local:

The economy of the local people should be also grow steadily by supporting of knowledge and skills of the local people in developing the local eco-friendly products, helping to increase the production efficiency of the local people, and promoting marketing of the local products. The expected outcomes from these activities are the number of enterprises launched by local people which promoted by the related agencies, amount of local tax payments, average income of household, employment of the local people, goods of the community produced from industrial waste and leftovers.

Table 1. An eco-industrial town framework

EIT Perspectives	Dimensions under each perspective	References
1.The physical	1.1 Location planning and area arrangement	[5]
	1.2 Design of the buildings and surrounding area	[5]
	1.3 Safety and accessible public green area by all, especially women, children, the elderly and the physically handicapped	[11, 17]
	1.4 Public Infrastructure for the elderly and the disabilities	[9, 12]
	1.5 Risk assessment and management of the city regarding disaster, cyber-attack, and political conflicts	[14]
2.The economy	2.1 The economy of the industry	[5]
	2.2 The economy of the local	[5]
	2.3 Marketing of eco-products and eco-services	[5]
	2.4 Transportation	[5]
	2.5 The BCG economy model	[8, 11, 18, 19]
3.The environment	3.1 Management of water quality	[5]
	3.2 Management of air quality	[5]
	3.3 Management of waste and residue	[5]
	3.4 Management of energy	[5]
	3.5 Management of noise and nuisance	[20]
	3.6 Management of production process	[21]
	3.7 Eco-efficiency	[5, 22]
	3.8 Management of safety and health	[5]
	3.9 Monitoring of quality of the environment	[5]
	3.10 Promotion of the efficient mechanisms to increase capability of planning and management regarding the climate change	[8]
4. The social	4.1 Quality of life and social of the employee	[5]
	4.2 Quality of life of the local people	[5]
	4.3 Elimination of forced labour, child labour and human trafficking	[11]
5.The management	5.1 Participative management of the area	[5]
	5.2 Development and maintenance of international management system	[5]
	5.3 Management of information and reporting	[5]
	5.4 Promotion of sustainably practical guidelines to the multinational company and large company and their reporting	[8]
	5.5 Promotion of measures to prevent the pandemics	[10]
6.The continuous development	*6.1 Corrective and preventive actions*	[16]
	6.2 Internal audits	[16]
	6.3 Management reviews	[16]
	6.4 Permanently cooperate with external parties	[8]

3) Marketing of eco-products and eco-services:

To fulfill the purposes of EIT, industrial entrepreneurs should attempt to produce the eco-friendly products, commit to use the green procurement or sustainable procurement, employ the eco-friendly label such as green label, carbon label, and energy saving label.

4) Transportation:

To support the efficient transportation, entrepreneurs in EIT should cooperate in using green logistics which energy saving mode of transportation is selected, conventional fuel in transportation is replaced by alternative energy such as electric vehicles (EV). In addition, goods collection center and distribution center are established in order to reduce transportation.

5) BCG economy model:

Bio-Circular-Green (BCG) economy model has been introduced by the research community and adopted by the Thai government as a new economy model for inclusive and sustainable growth. The model captures the country's strengths in biodiversity, cultural abundant and applies technology and innovation to transform Thailand to a value-based and innovation-driven economy [8]. The model also conforms with the SDGs [11] and is also intended to align with the Sufficiency Economy Philosophy which is also the significant principle of Thailand's social and economic development. The BCG economy model is applied to emphasize on educating to Thai people [18], promoting to entrepreneur of four industries – namely agriculture and food; medical and wellness; bio-energy, bio-material and bio-chemical; and tourism and creative economy [8, 19].

4.2.3 The environment perspective

The third perspective covers ten dimensions includes:

1) Management of water quality:

Management of water quality emphasizes on sufficiency of water supply in the EIT, zero discharge of waste water from industry, management of waste water in EIT comply with the related laws and regulations, and discharge of effluent that is not impact to the local communities.

2) Management of air quality:

Air quality refers to the air without pollution from over concentration of CO, NO_2, O_3, SO_2, Pb, PM10 against the established standards of related laws and regulations. The pollution are often generated by manufacturing plants, therefore the measurement of air quality after treatment in manufacturing plants, and surrounding areas should be performed in order to ensure that the air quality meet the standard requirements in related laws and regulations. Moreover, reduction of GHG emissions from manufacturing processes and transportation must be promoted in various ways such as use of alternative energy, for example use of electricity generated from biomass, biogas, solar energy in place of fossil fuel, development of mass transportation network among the EIT and connected area, conservation of forest, expansion of forest area to be the CO_2 sink.

3) Management of waste and residues:

In order to reduce and eliminate the quantity of waste generated from manufacturing plants and from households, therefore zero waste concept is introduced for management of those waste and residues, which includes 3Rs (reduce, reuse, recycle), waste-to-energy, zero waste to landfill (ZWL), and circular economy (CE).

4) Management of energy:

Management of energy in EIT refers to efficient use of energy and use of alternative energy such as solar energy, biomass energy, biogas energy in place of energy from fossil fuel. The efficient use of energy bring about cost saving and higher returns whereas the use of alternative energy not only bring about the cost saving but also increase stability of energy system in the plants and the EIT. Moreover, use of alternative energy is also resulting in reduction of GHG emissions.

5) Management of noise and nuisance:

Noise and nuisance may be generated from multiple sources such as the manufacturing processes, transportation, treatment of waste water and treatment of solid waste. These noise and nuisance may lead to health consequences [20]. Management of noise and nuisance is necessary for EIT which aimed at creating livable city and happy city respectively. Noise management should be controlling at the noise generating sources by applying engineering modifications and using barriers and screens to block the direct path of sound.

6) Management of production process:

Production process of manufacturing plants in EIT is eco-friendly of environment-friendly production processes which are able to consider from eco-design, eco-friendly raw materials, eco-friendly machines and equipment, eco-friendly production processes, use of clean technology, use of alternative energy in place of energy from fossil fuel in the production processes. In addition, manufacturing plants should be promoted to implement low carbon related activities such as the organizational and product carbon footprint and carbon compensation mechanisms [21].

7) Eco-efficiency:

Eco-efficiency refers to any management of businesses that aims at increasing their competitive advantage together with responsible for natural resources and environment. The eco-efficiency concept initiated by World Business Council for Sustainable Development (WBCSD) through seven key approaches: (1) reduce material intensity, (2) energy intensity minimized, (3) dispersion of toxic substances is reduced, (4) undertake recycling, (5) capitalize on use of renewables, (6) extend product durability, and (7) service intensity is increased. The eco-efficiency can be calculated from product or service value which divided by environmental influence [5, 22].

8) Management of safety and health:

Manufacturing plants must have measures to prevent and control dangers from their operations that may impact to safety and health of employees and of people in the surrounding communities including measure of operations without serious accidents from dust, noise, light, heat, chemical substances, electricity, and machinery. Therefore, improvement of work environment is also necessary for preventing and controlling diseases from work resulting from those dangerous situations. The EIT should also prepare data center of safety and health to monitor health situation of employees and of people in the communities and preparedness of contingency plan with drill due to the plan.

9) Monitoring of quality of the environment:

Participative monitoring of the environment quality shall be performed which not limited to the followings: (1) monitoring system within the manufacturing plants, industrial zones and industrial parks and their surrounding areas. Accompanied by communication the monitoring results of quality of the environment to communities at the regular basis, (2) availability of database system of the quality of EIT's environment, and (3) networks for monitoring the EIT's environment.

10) Promotion of the efficient mechanisms to increase

capability of planning and management regarding the climate change:

Climate change is an urgent agenda for all countries at this moment, the related entities in the country should bear in mind at all times that they should not make the burden to the world but they have to help the world. As a member of the country and the world, the entrepreneurs and all stakeholders in EIT shall be promoted to implement any efficient mechanism in planning and managing activities related to climate change such as reduction of GHG emission from their operations [8].

4.2.4 The social perspective

The fourth perspective covers three dimensions includes:

1) Quality of life and society of the employee:

Employees of any businesses in the EIT shall have good quality of life and society through development programmes initiated by the businesses, especially the manufacturing plants. For example, promotion and support the knowledge about the environment, occupational health and safety to the employees, arrangements and provision of suitable welfare for the employees and their families, and establishment of training and skill development center.

2) Quality of life of the local people:

The local people in the communities shall be educated to have sufficient knowledge and awareness in living together through activities not limited to the followings: (1) education and employment programme to create opportunity of life to the young people in the EIT areas, (2) labour development programme to the people in the communities, (3) training programme about environment, safety and occupational health, and natural resources conservation to the people in the communities, (4) quality of life promotion programme to the people in the communities, (5) employment programme for the local people.

3) Elimination of forced labour, child labour and human trafficking:

Labour is recognised as an important capital in production and service provision. However, labour participated in the economic activities shall not be forced labour, child labour nor relating to human trafficking [11]. Therefore, the entrepreneurs in EIT should pay attention to the issues.

4.2.5 The management perspective

The fifth perspective covers five dimensions includes:

1) Participative management of the area:

In order to develop the target area to be the desired EIT, participative management of the EIT among the local governmental agencies, industrial zones, industrial parks, manufacturing plants, the communities, and eco-network shall be conducted. The participative management includes sharing knowledge and experience of EIT implementation and development, environmental management and prevention of pollution, establishment of eco-network or EIT development network to establish the policy, development plan, initiatives and follow-up the result of EIT development. Finally, meetings shall be held regularly to communicate and ask for cooperation among relevant stakeholders when needed.

2) Development and maintenance of international management systems:

The international management systems shall be understood, developed, implemented and maintained in manufacturing plants in the EIT. The plants where the certificates are granted shall be ensured that their operations are comply with the practices accepted by their business partners globally. The international management systems such as environmental management system standard (ISO 14001), occupational health and safety management system standard (ISO 45001), social responsibility guideline standard (ISO 26000), energy management system standard (ISO 50001). Granting of the certificates of international management system standards shall ensure the operations of the manufacturing plants in doing the recognized operations globally.

3) Management of information and reporting:

Reporting is one of the conventional communication used by any entity to express the governance regarding their activities. The information for communication should be accurate, and appropriate for the purposes. In order to be ready for communication, procedures of communication shall be as follows: (1) prepared concise communication system among manufacturing plants within the same industrial zone or the same industrial park, and the surrounding communities, (2) prepared communication channel for exchange environmental data of the EIT with the external parties, for example, EIT website, journal, newsletter.

4) Promotion of sustainably practical guidelines to the multinational company and large company and their reporting:

In order that development of EIT is to support the sustainable development goal (SDG12: responsible consumption and production), the manufacturing plants especially the multinational company and large company in EIT shall improve their operations in line with the sustainably practical guidelines and improve the way of reporting their sustainable development or sustainability report in line with international acceptance [8].

5) Promotion of measures to prevent the pandemics:

Recently, COVID-19 is one of the most dangerous pandemics to the human beings, WHO recommended practices to prevent the COVID-19 infection as follows: (1) social distancing, (2) wearing the appropriate face mask, (3) disinfection in the public area. Therefore, EIT shall take lesson-learned from the COVID-19 pandemic into consideration in order to plan and manage EIT in advance if there are other pandemics happen in the future [10].

4.2.6 The continuous development perspective

The sixth perspective covers four dimensions includes:

1) Corrective and preventive actions:

Corrective and preventive actions are often used as the requirements in the international management system standards in order to correct and prevent recurrence of any problems found in the scope of implementation. When the nonconformities are gotten rid of, it implies that the continuous development is occurred [16].

2) Internal audits:

Internal audits refer to the audits that performed by the internal personnel of the organization against the established criteria. For the case of EIT, internal audit is the activities of verification, inspection, or assessment the progress of EIT implementation performed by the personnel of the EIT in order to check whether implementation comply with the criteria of the indicators or not. If not, the nonconformities shall be raised and taken to do the corrective and preventive actions [16].

3) Management reviews:

Basically, management reviews are the activities held by the management team in order to review the past performance, as defined period. Based on the past performance, suggestion and recommendations from the management team contributes to opportunity for improvement of the performance in the future.

It will be a guideline for the personnel under supervision of management team to perform tasks in the same direction with management's vision and policies [16].

4) Permanently cooperate with external parties:

To stipulate and ensure to achieve desired goal and objectives of EIT implementation, management team of EIT shall seek for permanent cooperation with the external parties in terms of budgetary support, knowledge support, and other issues. The external parties may be domestic or international parties who has expertise of related perspectives and dimensions under the EIT framework [8].

4.2.7 The indicators supporting EIT framework

The set of indicators used to determine the progress and success of EIT implementation has been shown in Table 2.

Table 2. Indicators for EIT framework

EIT Perspectives	Dimensions under each perspective	No. of Indicators
1.The physical	1.1 Location planning and area arrangement	3
	1.2 Design of the buildings and surrounding area	1
	1.3 Safety and accessible public green area by all, especially women, children, the elderly and the physically handicapped	1
	1.4 Public Infrastructure for the elderly and the disabilities	1
	1.5 Risk assessment and management of the city regarding disaster, cyber-attack, and political conflicts	1
2.The economy	2.1 The economy of the industry	1
	2.2 The economy of the local	5
	2.3 Marketing of eco-products and eco-services	1
	2.4 Transportation	1
	2.5 The BCG economy model	1
3.The environment	3.1 Management of water quality	4
	3.2 Management of air quality	2
	3.3 Management of waste and residue	2
	3.4 Management of energy	2
	3.5 Management of noise and nuisance	1
	3.6 Management of production process	2
	3.7 Eco-efficiency	3
	3.8 Management of safety and health	2
	3.9 Monitoring of quality of the environment	1
	3.10 Promotion of the efficient mechanisms to increase capability of planning and management regarding the climate change	1
4. The social	4.1 Quality of life and social of the employee	1
	4.2 Quality of life of the local people	6
	4.3 Elimination of forced labour, child labour and human trafficking	1
5.The management	5.1 Participative management of the area	1
	5.2 Development and maintenance of international management system	1
	5.3 Management of information and reporting	2
	5.4 Promotion of sustainably practical guidelines to the multinational company and large company and their reporting	1
	5.5 Promotion of measures to prevent the pandemics	1
6.The continuous development	*6.1 Corrective and preventive actions*	1
	6.2 Internal audits	1
	6.3 Management reviews	1
	6.4 Permanently cooperate with external parties	1

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The EIT framework and indicators for measuring and evaluating the implementation of eco-industrial town (EIT) in Thailand arising from integration of the existing EIT framework and indicators for EIT implementation in Thailand and additional perspective and dimensions obtained from the new threats and challenges to Thailand. Therefore, it is necessary for stakeholders of EIT in Thailand in revising the EIT framework to be able to cope with threats and challenges. The threats and challenges to EIT in Thailand include aging and aged society situation of Thailand since 2021 [9], pandemic of COVID-19 throughout the world since 2019 [10], SDGs [11], the rights of persons with disabilities [12, 13], new international standard of sustainable cities, resilient cities and smart cities [14, 15], and the sustainability challenges [23]. According to these threats and challenges, they are new threats and challenges that extraordinary and completely unprecedented. The EIT have reached a point where society is demanding a response to these threats and challenges from related bodies. When considering these threats and challenges, it is important for policy makers to focus on the entire spectrum of interrelated factors. In the context of EIT, it is mandatory for EIT policy makers who responsible for promoting EIT implementation in Thailand in revisiting and revising the existing EIT framework and indicators to encover and to be able to cope with the threats and challenges. Indicators are also important tools to develop the potential EIT to be the EIT of happy society as required. However, the good and practical indicators shall also be obtained from the appropriate framework. The appropriate EIT framework will provide the indicators appropriately for measuring and

evaluating the implementation of eco-industrial town (EIT) in recent situation because they are derived by integrating new concepts, and concerns related to new threats and challenges to Thailand and EIT to the previous EIT framework. However, five perspectives of the previous framework and indicators for EIT implementation shall need more perspective and dimensions. Under each perspective, it is consisted of the following dimensions:

1) The physical perspective consisted of five dimensions includes location planning and area arrangement, design of the buildings and surrounding areas, provision of safety and accessible public green area by all, especially women, children, the elderly and the physically handicapped, development of public infrastructure for the elderly and the disabilities, and risk assessment and management of the city regarding disaster, cyber-attack, and political conflicts.

2) The economy perspective consisted of five dimensions includes the economy of the industry, the economy of the local, marketing of eco-products and eco-services, transportation and the BCG economy model.

3) The environment perspective consisted of ten dimensions includes management of water quality, management of air quality, management of waste and residues, management of energy, management of noise and nuisance, management of production process, eco-efficiency, management of safety and health, monitoring of quality of the environment, and promotion of the efficient mechanisms to increase capability of planning and management regarding the climate change.

4) The social perspective consisted of three dimensions includes quality of life and social of the employees, quality of life of the local people, and elimination of forced labour, child labour and human trafficking.

5) The management perspective consisted of four dimensions includes participative management of the area, development and maintenance of international management systems, management of information and reporting, promotion of sustainably practical guidelines to the multinational company and large company and their reporting, and promotion of measures to prevent the pandemics.

6) The continuous development perspective consisted of four perspectives includes corrective and preventive actions, internal audits, management reviews, and permanently cooperate with external parties.

Concept of sustainable development is generally accepted as the popular framework for any actions which aims at creating the benefits for the present generation and for the future generation. EIT implementation in Thailand is also adopted the sustainable development concept in designing its framework since 2011 [5]. Therefore, EIT concept preliminary consisted of three fundamental components – economic, environment, and social which are also referred to as profit, planet, and people [24]. Moreover, the EIT policy makers need to ensure that the operations of manufacturing plants in the industrial zone and industrial park in EIT are comply with laws and regulations and implementation of EIT is able to do continuously. Therefore, two more perspectives – the physical and the management - are added. Each perspective under the framework consisted of dimensions derived from relevant concepts such as industrial ecology [25, 26], industrial ecosystem [27], industrial symbiosis [28], eco-efficiency [20], low carbon society [29, 30], etc.

Recently, EIT under Thailand implementation policy face many threats and challenges. This generates new concerns because they mostly come from outside of the EIT. In order to be able to cope with those threats and challenges, EIT policy makers and executives of the EITs tried to adopt a more-well integrated, long-term approaches. Those threats and challenges include concept of SDGs, serious pandemics, the national agenda and action for aging and aged society situation of Thailand, natural disaster, international labour organization (ILO) requirements of forced labour, child labour and human trafficking, and other related international standards. The list is daunting for the EITs but these threats and challenges are precisely why a more systematic approach such as EITs is needed. Clearly, taking on all these challenges at the same time may not be possible for most EITs, and they will need to adopt an incremental, phased approach as used in initiative of Eco^2 cities [31].

With the responsibility of Department of Industrial work (DIW), Ministry of Industry of Thailand in promoting and expanding development of EIT continuously and to be in line with the challenges, documentary research, questionnaires ask for feedback and recommendations of the experts in the field, and focus group discussion with stakeholders of EIT are conducted. The previous EIT framework and indicators which consisted of five perspectives - the physical, the economy, the environment, the social and the management perspective, and twenty dimensions, may not be sufficient for the current situations. Therefore, it is necessary to integrate more perspective – the continuous development and twelve dimensions to the EIT framework as follows: 1) safety and accessible public green area by all, especially women, children, the elderly and the physically handicapped, 2) public infrastructure for the elderly and the disabilities, 3) risk assessment and management of the city regarding disaster, cyber-attack, and political conflicts, 4) the BCG economy model, 5) promotion of the efficient mechanisms to increase capability of planning and management regarding the climate change, 6) elimination of forced labour, child labour and human trafficking, 7) promotion of sustainably practical guidelines to the multinational company and large company and their reporting, 8) promotion of measures to prevent the pandemics, 9) corrective action and preventive actions, 10) internal audit, 11) management reviews, and 12) permanently cooperate with external parties. All additional dimensions is used as the inputs for establishing indicators for measuring and evaluating of the implementation of EIT in Thailand both in terms of implementation progress and compliance with certification criteria.

Moreover, the procedure for revising the EIT framework to a threats and challenges is able to use as the guideline in developing the new (revised) framework of EIT and indicators in the future whenever EIT facing with any new threats and challenges and need to meet the ultimate goal of EIT development in Thailand as “the happy society”.

5.2 Recommendations

To ensure that a new EIT framework and indicators for Thailand are established, understood, and implemented seriously, the related stakeholders of EITs shall have to pay much attention on their responsibilities relevant to the followings.

1) The major problem in promoting the EIT implementation in Thailand was that the budget allocation in each fiscal year from Bureau of the budget was not suitable for the activities to be done under the policy both in terms of the amount of the budget and the time of budget allocation. Therefore, the EIT

policy makers, Department of Industrial Work, Ministry of Industry, shall have strategically well planned to get the suitable and sufficient budget in order to ensure that the short-term (annual), medium-term, and long-term action plans of EIT implementation are allocated which it can be also ensured that the EIT policy can be achieved. In addition, the monitoring and evaluating of implementation progress shall be done annually.

2) Moreover, the EIT development in Thailand is quite slow. This may due to staffs of local governments in the target EITs have not much pay attention because the works and activities of EIT implementation are additionally assigned to their routine works which is not linked to the criteria of the performance evaluation. Therefore, to solve this problem, the works and activities related to EIT implementation shall be added to their routine works, and take them to be one criteria in evaluating their yearly performances.

3) For the industrial zones, industrial parks and manufacturing plants in EIT, they shall have to improve their operations in various activities to support related indicators in order to meet the EIT requirements. Therefore, they shall appoint the competent personnel and to engage with all activities at all stages of the implementation such as engaging in training, preparing and supporting data required by EIT data center, attending the EIT committee meeting, participating in auditing continually.

4) Manufacturing plants in the EIT are the important stakeholders because they are often accused as the major polluters in the EIT. Therefore, they shall be the key players in doing the right things and showing clearly that their operations conform to all legal requirements and contribute to the related EIT framework and indicators.

5) The people in communities located around the industrial zone or industrial park are also the very important stakeholders of EIT because they will reflect the effectiveness of EIT implementation. If the leaders or representatives of the communities are engaged at all activities launched in the EIT implementation, the development of EIT is able to achieve the desired goal, the happy society, without difficulty. The EIT policy makers and EIT project manager need pay attention to the communities no less than other stakeholders. It is also fostering cooperation among the public sector and the private sector which then will be creating a strong network for sustainable development of EIT in Thailand.

Implication of the study is that EIT framework and indicators for EIT implementation in Thailand context can be applied for the future EITs in Thailand and EITs in other countries where under developing EIT project by selecting perspectives, dimensions, indicators, and recommendations that appropriate to their context.

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