Chapter

Development of Conceptual Model for Eco-Based Strategic Environmental Assessment

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Abstract

Since the development of mega projects had been contributed, in consequence, the continuous projects were developed and caused some hidden effects. The main target of this chapter is to develop conceptual model for eco-based strategic environmental assessment (SEA) as the tool to consider the kinetic development resulting from project impacts. Three indicators, namely, environmental assessment, land use, and ecological approach, were selected to support the purpose. For environmental dimension, the contents of Environmental Impact Assessment Guidelines and Environmental Impact Statements were analyzed, using content analysis. Land use change for selected areas was analyzed covering the period of mega project development. For ecosystem, the development of ecological pattern from the past to the present was surveyed and investigated in detail. The results illustrated the hierarchical risk areas from the lowest to the highest. Finally, the conceptual model was developed on the basis of the actual impacts according to the area feature.

Keywords: multiple criteria analysis, ecology, land use, Environmental Impact Assessment, development projects, Thailand

1. Introduction

Since the adoption of the National Environmental Policy Act (NEPA) in the United States in 1969, Environmental Impact Assessment (EIA) has become an increasingly familiar term in many developed and developing countries. International agencies and government worldwide have made considerable progress in requiring the use of EIA for evaluating project proposals [1]. In another view, EIA is a knowledge driven to the following theories in the chain of environmental assessment (EA). Strategic environmental assessment (SEA) is one among them. SEA as one of the series of environmental analysis has played an important role since the middle of the 1970s. The origin of SEA was come from the weak point of EIA as the impact specific for only project level. EIA alone makes insufficient to consider cumulative effect and cannot be used as the direction to clarify the environmental management of overall project [2]. EIA mechanism is the process to assess the consequence and impacts only for project levels, whereas SEA focuses on the consideration of impact on the macro-levels of policy plan and programs. The decision-making of both EIA and SEA is different, depending on the jurisdictions in each country [3]. The development of EIA to the higher level in order to

determine and control the impacts from the initial stage of the project decision-making process is essential. Currently, the SEA mechanism is widely used in many countries and international organizations. SEA can operate in various forms and methods, such as SEA for sectorial and regional sections by the World Bank [4]. It is recognized that SEA is one of the key drivers toward the achievement of sustainable development goals.

The extension of the project level (EIA) to the macro-level (SEA) to meet the goals of sustainable development has been conducted by many experts in many regions. The 801 EIA projects in the Czech Republic were evaluated and found the linkage of the project evaluation in EIA follow-up to the SEA [5]. The project level, both positive and negative effects, can be expanded to the policy and planning levels [6]. The setting indicators to study are of primary concerned, depending on the conditions of the study. The classification of indicators influencing a carrying capacity depended on the purpose of application and spatial setting. There are various categories identified by many experts. There are, for example, four components identified, including environmental and ecological, urban facilities, public perception, and institutional categories [7]. Some specific indicators were suggested such as soil, slope, vegetation, wetland, scenic resources, natural hazard, air and water quality, and energy availability; some considered water supply, sewage, waste treatment, railway, road, and housing. These are depended on the purposed of each strategic study.

This chapter aims to illustrate the development of conceptual model of eco-based SEA. The setting of purposes to select the objectives, targets, and indicators was described in Section 2. Section 3 illustrated the case study based on the kinetic development resulting from land use change which brought to consequence ecological impacts. The lesson drawn from the case study leads to the development of conceptual model together with the approach for its fulfillment in Sections 4 and 5, respectively.

2. Eco-based strategic environmental assessment

The setting of objectives, targets, and indicators is necessary for the SEA because the SEA baseline cannot be detailed in-depth, like EIA [8]. Those should be appropriate for the strategic purpose. In order to support the aim to develop eco-based SEA model, the selected factors supporting the purpose are EIA mechanism, land use, and ecological approach. The importance of these can be found from the previous researches, as follows.

2.1 Environmental Impact Assessment mechanism

EIA is an effective tool for managing project life cycles [9]. Research on the mechanism of EIA project began in the early 1980s by studying the role of relevant organizations [10, 11]. The quality of the baseline data that directly concern the selection of environmental components appropriated for such project [12, 13] was important to judge the performance [14]. According to EIA mechanism, EIA follow-up, including monitoring and audit, is the main tool to justify the efficiency of project implementation. Monitoring and audit can be used to measure the actual impact of project activity together with the uncertainty of impact prediction [15]. The study of techniques used to monitor actual impacts during the project operation can suggest some error of impact estimation in EIS, together with the impacts beyond forecasts [16].

The efficiency of project control, including the completion of Environmental Impact Statements (EISs) or EIA reports, the compliance with the conditions of approval, and the factors affecting project decision, was developed during the 1990s [17], together with the suggested criteria to assess the EIA effectiveness [18]. The

studies to conduct EIA follow-up was based on the principles of operational phase analysis. The case studies were found in many regions. These examples are the following. The study of factors affected the effectiveness of project monitoring in Australia [19]. A network of components affected the efficiency of the EIA process in Taiwan [20]. The efficiency of the EIA process through the environmental monitoring network, focusing on coastal development projects, was evaluated in Mauritius Island [21]. Similar studies were conducted in Malaysia and Kenya, respectively [12, 17].

The importance of ecological components in the project level as EIA has been realized for a long time. However, it still found problems in terms of perfection and effectiveness, the main reason being due to the methods used for ecological prediction and project management, which was too general, without focusing on the critical issues [22, 23]. However, the relationship among EIA, ecology, and sustainable development is crucial. These were confirmed by many researches [24–26]. All illustrated that EIA can be guided toward sustainable development principles, by extending the scope of social considerations and environment. These combination mechanisms were classified, and some study indicated at least 3 of 14 mechanisms, which are directly related to EIA follow-up during the operational phase [25]. The relationship of social, economic, and ecological variables that contributed to the integration of EIA in sustainable development was also confirmed [27].

The United Nations Environment Programme (UNEP) [28] has established guidelines for monitoring biodiversity given the priority to the ecological level in the ecological monitoring trail. The criteria of UNEP are useful for narrowing ecological index categories and can be used as a guideline for the selection of ecological index at each level in order to track changes in the ecosystem.

2.2 Land use

Change to urban areas has increased significantly in many regions. Land use change is an indicator of ecological change. The loss of green areas resulting from land use change has a further impact on many environmental components. One of those is climate change, the global crisis, which affects biosphere by surface temperature change [29] on both minimum and maximum surface temperatures [30].

Dynamic of land use change is different depending on the kinetic development of each area. The study in Beijing illustrated the severely damaged during 1986–2001 in agricultural areas, due to the indefinite of urban growth [31]. A similar study is found in the suburbs of Bangkok that the pattern of urban land use had been profoundly influenced by past patterns of agricultural land use and landform transformation. The volume of landform transformation occurred over the last half-century had been calculated at $3.2 \times 107\ m^3$, equivalent to 64 km^2 of area flooded to an average depth of 50 cm. This is clear that land use change had occurred in both horizontal and vertical components, which could not be separated from each other [32]. Those lead to the study concerning the arrangement of green areas to limit the future expansion of the city [33]. The approach of land use change could be used to develop an environmental monitoring system [34] and also environmental management by analyzing the pollutant sources from land use classification [35]. Urban Carrying Capacity Assessment System was suggested as an alternative tool for effective urban planning and management [7].

Land use planning based on an ecological network, focusing on biodiversity and the conservation of the habitat from the species level, was recommended [36]. The similar case defined the greenways for land use planning in order to conserve biodiversity in the city area [37]. This is an alternative approach for land use planning to support sustainable purpose. In turn, ecological principles are the basic tool to green areas planned for the city.

2.3 Ecological approach

Relationships between landscape pattern and ecological structure have been widely recognized. Land use change brings to the kinetic development of ecological change. It directly concerns the habitat which is the determining factor for ecosystem component.

The impacts on ecological mechanism are different depending on the purpose. It may be considered in the form of various energy and nutrient cycles and the benefits to humans such as food production or waste treatment system. The ecological mechanism was classified into five categories, including regulation function, habitat function, production function, information function, and carrier function [38].

Any habitat change as one of kinetic development within the ecosystem has an effect on living organisms. Among them, bird is the sensitive organism and detects a change of habitat for us to consider a carrying capacity in the ecosystem. Many researches insisted the impacts of land use change on bird species. The examples are followed. The patterns of habitat change had a significant impact on migratory birds [39]. The study in the twin cities of Minnesota, USA, found different responses of bird community among the rural, the suburb, and the conservative habitats [40]. The research regarding the distance from urban habitat and the road corridor to bird index insisted that urban habitat had not only an effect on the number of birds but also on the species abundance, especially local species [41]. In this research, buffer zone was recommended, at least 400 m from urban area and 300 m from the road. The study at the Island of Damar, the Eastern Indonesia, found the disappearance of bird species due to the expansion of small-scale agriculture. The comparing change of bird group between 1890 and 2001 found the difference of the number for fruit-eating birds and insectivorous birds in different habitat forests [42]. Habitat changes were likely to result in the decline of habitat quality for birds. Such effects occurred especially with birds that consume insects and fruits. This study also provided the characteristics of habitat change. The obvious change from the original forest that affected the new-generation forest was the loss of leaf shade covering, reducing tree height and changing flora types from trees to grass. These factors had significantly resulted in the declining number of fruit-eating birds. The major consequences were the loss and declining number of wild birds. On contrary, the increasing number of birds with opposite behavior, including meadow bird, was common at the same time.

Ecological principles can be applied to manage the landscape as the study in agricultural areas by determining the yield of rice and habitat conservation in the lowlands [43]. Civic engagement was recommended as the essential tool for the resolution of sustainability because eco-civic region can help to understand local people, together with the boundaries of biophysical framework within the actual environment [44].

The relationships of land use and ecology, as reviewed, are closely concerned for both the cause and the effect within each other. The interaction is useful for environmental management based on the carrying capacity of the area. These lead to identify the objectives, the targets, and the indicators to fulfill the development of conceptual model for eco-based SEA.

3. Case study

The case study to support the development of conceptual model for eco-based SEA considered the consequence of mega project and the kinetic development of the surrounding area. Three approaches, including environmental assessment, land use,

and ecological principle, were the targets to assess the change within the study area. The selected areas to support the purpose were the areas approached by the airport development, as mega project. These areas are located at the suburb of Bangkok, the capital of Thailand, approximately 700 km^2. According to administrative system, four districts are included, namely, Prawet, Ladkrabang, Bangpli, and Bangsauthong.

Multiple criteria analysis (MCA) is one of decision theories used to justify various factors and conditions to achieve the setting aim. It is suitable for addressing complex aspects with different forms of data in both social and scientific systems. This is done by extending decision to accommodate multi-attributed consequences. This approach is acceptable for SEA in many case studies [45–47]. This case study adapted the main stages of MCA which include the setting goal, the provision of criteria to support the goal, the evaluation of setting criteria, and the direction of ranked alternative. To follow those MCA, the study was divided into four main stages:

(1) To establish the main concept associated with what the study aims.

(2) To set the criteria based on relevant theories. This study deals with three theories, including environmental assessment, land use, and ecological issues.

(3) To identify the indicators for each established criteria. These are the variables used in the decision making.

(4) To determine the direction of the variable, by ranking the status of each variable setting from the highest to the lowest.

Stage 1 is the setting of the main purpose. The selected criteria, in stage 2, are based on the circumstance of the areas and their kinetic development; as to the case study, review literature of previous researches was supported. The selected criteria were in-depth investigated and detailed in Section 3.1. These were the baseline to assess the SEA for stages 3 and 4 in Section 3.2. The development of conceptual model of eco-based SEA was clarified in Section 4.

3.1 Results of the case study

Study methods for each set of the criteria, including environmental assessment, land use, and ecological approaches, were appropriately conducted to support the framework of eco-based SEA. The results were shown in **Table 1**. Again, it should be noted that this model is one of the cases from a tropical country under the conditions of mega project development.

3.2 Integration to strategic environmental assessment

The imbalance between the development and the conservation was found from the results of the case study. Some effective tool toward sustainable achievement was required. Among those, SEA is one. The integration of the case study with SEA was conducted by programmatic SEA model since the groups of projects were analyzed in the same boundary area [46]. Hence, the specification of "SEA requirement of project activities" was the first screening process in order to select only the significant activities included in the SEA. The legislation, the Town and Urban Planning, the characteristics of the area, and others were the factors to support this eco-based SEA.

Strategic ecological assessment included the following stages: the scope for analysis, the prediction of future change, the alternative consideration, and the control approach. These can be described as follows:

Study approaches	Results
Environmental assessment; the roles of competent agencies	
Analysis of law and regulation of competent agencies regarding the contents of project control	The environmental control mechanism of different agencies found some question regarding their purposes and collaboration
Environmental assessment; guidelines quality	
Content analysis of EIA guidelines focusing on ecological issues, including: (1) General guideline (2) Project-specific guidelines including: - Airport project - Housing project - Transportation project - Power plant project - Petroleum and oil pipeline project - Industrial project Review criteria were developed. The content in guidelines according to the setting criteria was scored through their quality	*Baseline study*: the specification of boundary of study, focusing on impact area, and method of ecological study was sufficient for the guidance of EIA study. However, general details were found for data analysis and presentation *Impact assessment*: the guidance for impact coverage project life cycle was sufficient; however, the depth details for ecological impact analysis were inadequate *Mitigation and monitoring measures*: the guidelines supported standard format for program presentation. Ecological aspect for program identification was presented only through airport project guideline The score values of EIA guideline content, according to the parts of EIA study, from the highest to the lowest quality were monitoring, mitigation, impact assessment, and baseline study, accordingly
Environmental assessment; EIS quality	
Content analysis of ecological detailed in EISs, including: (1) Airport project and related projects (2) Infrastructure projects (3) Other projects within study area The sets of review criteria, which are different from the guidelines were developed. The quality of EIS response to each review criterion was scored	Ecological details were mostly presented in the stage of baseline study, followed by impact assessment Negligible details were found in mitigation and monitoring. As to their quality, the linkage of ecological factors in baseline detail was weak. In the following stages, impact assessment, the results of ecological baseline were scarcely considered to assess the impacts These bring to the unclear impact direction, especially ecological mechanism within the study area. Ecological mitigation and monitoring identification were not concurred with the result of impact assessment
Environmental assessment; monitoring efficiency	
Two groups of development projects, including: (1) Project that required EIA (2) Project that did not require EIA (industrial projects) These are conducted by: (1) The content analysis of monitoring EISs (only for EIA projects) (2) The investigation of monitoring compliance by auditing the monitoring reports (3) The consistence between project location and the Town and Urban Planning by overlay mapping	In comparison, projects that required EIA were predominant, as follows: - Monitoring details fulfilled the aspects of environmental components, monitoring frequency, and stations which were specific for each project feature However, these lead to the increase in monitoring cost compared with project that did not require EIA - The enforcement by competent agencies was strengthening in terms of the linkage of monitoring performance - Project setting complied with the Town and Urban Planning - The weakness monitoring, especially ecological aspects, was found for projects that required EIA, and the missing was found for projects that did not require EIA
Land use; overall study areas	

Study approaches	Results
Land use change was done by GIS layer interpretation of the study area during the year before (1994) and after (2002) airport project development Land use was grouped into three types, including: (1) Development area (2) Semi-developed area (3) Conservative area	- The increase in the development area was prominent, with 40%. Semi-developed area was more or less, with 37%. Insignificant change was found for the conservative area, with 0.05 - The kinetics of land use change was caused mainly by transportation network, which leads to the increase in housing projects and recruited the increase of population. These areas were especially the area around airport development
Land use; the pattern of significant project change (housing project)	
The expansion of housing projects was conducted by satellite interpretation in the years 1981, 1987, 1996, 2002, and 2006 and overlaid with the map of the Town and Urban Planning	The expansion of housing projects had been rapidly increased in the years 1981, 1987, 1996, 2002, and 2006. The increase (%) was: Prawet 4.39, 8.27, 9.66, 13.66, and 22.15 Ladkrabang 0.31, 1.59, 4.03, 5.18, and 8.97 Bangpli 0.42, 1.32, 3.69, 5.08, and 8.95 Bangsauthong 0, 0.75, 1.01, 1.29, and 1.91 According to the results, housing project after the year 2002, in which the airport initially operated, was sharply increased. Only 13% of these housing projects were required EIA, according to the Thai's EIA legislation. Significantly, 4.5% of EIA housing projects conducted monitoring performance Regarding the condition of the Town and Urban Planning, it was found that: - Location of housing projects was mostly in medium-density dwelling stipulated area - The expansion of the housing projects encroached 13.40% (in Ladkrabang) of conservative urban area, whereas the provisions of the Ministerial Regulations of the Town and Urban Planning Act enforce not 10% exceeding - 7.91% of housing projects in Bangpli were located in the industrial area. These reflect to the risk impacts of the projects themselves - The expansion of housing projects was inconsistent with the rate of population increase
Ecological approach; the change of local species	
The study was conducted through: (1) Questionnaire interview to local people (2) Bird count surveys in the designed land use	The pattern of land use change was the main factor. Originally, paddy fields were dominant in the area. After the airport development, the pattern of land use change can be divided into two groups, as follows: (1) Paddy fields to fish farms and to urban area (2) Paddy fields to wilderness and to urban development These affect the change of local species including: - Species disappearance, both in the stages of paddy fields to fish farms and fish farms to urban area - The increasing number of urban species, especially for bird species - The change of species behavior, such as from migratory birds to permanent local birds - The change of ecological index, including species diversity, abundance index, and similarity index The highest values of ecological diversity were found in paddy fields. Local species were significantly changed, especially in the stage from paddy fields to fish farms

Sources: [48–50]

Table 1.
The stages and results of the case study.

Step 1: Determining the scope of strategic environmental analysis

Since there are many conditions to analyze eco-based SEA, the identification of aspects, targets, objectives, and indicators is important. The results of the case study were integrated with the SEA theory [46] to determine the relevant variables. Targets define issues that are likely the impact; objectives are the desired change that should be consistent with the target. Indicators are the variables that represent the direction of change (**Table 2**). These factors are important in considering basic environmental information to support conceptual approach.

Purposes	**Targets**	**Objectives**	**Indicators**
Land use	- Project expansion complied with the provision of the Town and Urban Planning Act - The consideration of ecological aspects in any development projects	- The expansion of the project in the agricultural conservation area and rural agriculture area, not exceeding the requirements in the Town and Urban Planning Act (the stipulation is less than 10%) - The growth of significant development projects is controlled	The audit of incremental rate for development projects meets the requirement of the Town and Country Planning
Environmental Impact Assessment	- Project that required EIA - Project that did not require EIA - Ecological issues in Environmental Impact Assessment	*Project that required EIA* The requirements are: - The guidance of ecological issues in EIA guidelines - The appropriateness of ecological impact study - The relationships of ecological contents in guidelines and EISs - The importance of environmental control mechanism, especially mitigation and monitoring during project implementation	- Ecological issues in EISs are qualified with the criteria established - The number of development projects to meet the requirement of the conditions of approval (mitigation and monitoring measures) is examined
		Project that did not require EIA - Environmental monitoring is the priority as a tool to control projects - Project control mechanism embraces more collaborative and inclusive environmental concern by relevant agencies	- The number of development projects to meet the requirements of monitoring implementation is examined - Monitoring details investigate the effectiveness
Ecological approach	Maintaining biodiversity and local species within the area	The habitats for local species are preserved, with appropriate types and size	- The appropriateness of ecological index and species types are identified and monitored to warn the ecological change

Table 2.
The identification of targets, objectives, and indicators.

Step 2: Future change without control mechanism

Baseline data for the strategic level should not provide definite details, like the project EIA level [46]. From **Table 2**, the baseline data were established, following three main areas, including the change of land use, projects enforced by EIA, and local ecosystem. The identification of the conditions in such areas and the future trends in case of lack of any control mechanism were presented in **Table 3**. The limit of the integrity of the environmental database is the obstacles in some countries, like this case study. Therefore, the appropriate analysis corresponding to the area is necessary for the future trends of a specific area. The environmental trends are variable factors used as the baseline to determine any change of the indicators considered [46].

Step 3: Alternative consideration

Alternative identification is crucial for SEA. The example provided in **Table 4** was the result from the case study. Alternative conditions in each area were differed,

Purposes	Limitations	Future trends without control mechanism
Land use	- The development of mega projects taking into account economic outcome was the first priority - The expansion of housing projects allocated in the areas that conflict with the Town and Urban Planning, especially in the conservation -agriculture area and rural-agriculture area	- Project expansion will lack control mechanism, especially for the projects, which are unclearly enforced by competent agencies - The expansion of housing projects will over the requirement of the Town and Urban Planning in the conservative area - The increase of urban area will be opposite to the green area
Environmental Impact Assessment	- The proportion of the number of projects that required EIA was minimal compared with all developmental projects Hence, EIA was not the main tool to control impacts of project activities - The quality of ecological contents in EIA guidelines and EISs is still in question - Ecological mitigation and monitoring as the conditions of approval from EIA studies were missing, which further affected ecological control during project implementation	- Ecological issues will be overlooked unless the mechanism to stimulate is sufficient - The importance of EIA declines, whereas SEA cannot be replaced unless defined in the highest legal hierarchy
Ecological approach	- Land use was an important factor for the development of infrastructure within the ecosystem	- Habitat change will be the main factor that affects species types and ecosystems as a whole. The change is due to the urbanization together with the decline of green space. These are the results of the increase of development projects and the decline of green area itself - The change of local ecology will affect ecosystem in macro-level - The target of sustainable development could not be achieved due to the focus only on economic factors, without ecological values

Table 3.
Environmental baseline for the strategic level.

Study areas	Kinetic conditions	Factors to be considered as appropriate alternatives
Prawet	- Urbanization rate was high - The number of housing projects has dramatically been increased. Among these, only few are required EIA - According to the Town and Urban Planning, residential areas are defined as more than 30%. This condition was the limiting factor for the ecological considerations	- EIA mechanism requires more rigorous tool for projects that required EIA - As to projects that did not require EIA, the alternative controls should be enforced by the competent agencies
Ladkrabang	- The housing projects have been expanded in green belt area - The expansion of projects that did not require EIA is limitless	The rural and agricultural conservation areas, which are the city's prosperity to the green area, are the priority to allow any the development projects
Bangpli	- The expansion of housing projects encroached the industrial setting area and went over the limit of rural and agricultural areas - The change of local ecosystem was caused by land use diversity within the area	- The screening of development projects in accordance with the Town and Urban Planning should be the first concern
Bangsauthong	- The change of agriculture types was dominant - Development projects were controlled in the low level	- The alternative methods of project control should be the first concern in this area

Table4.
Kinetic conditions considered as alternatives.

based on the multiple criteria analysis, which provided the score ranking for each factors. The alternative appropriateness in each area should take into account the nature of the development projects within the areas together with the kinetic conditions of the development. Alternative consideration based on existing constraints directly concerns the scope of activity frameworks under sustainable development.

Step 4: Impact assessment

Impact assessment includes impact prediction and evaluation. The methods used are varied depending on the appropriateness. The baseline in **Table 3** and the conditions of alternative in **Table 4** were assessed the impacts. The results of this stage provide the overall possibility of change. This stage is different from the assessment of EIA level which is the proactive assessment. As to the SEA level, the assessment is conducted after the operation of activities in order to find out their future trends.

Step 5: Monitoring

Monitoring of indicators specified is important for SEA in order to detect any environmental change resulting from activities considered for each area. The factors to identify should include:

- The policy support
- The coverage of environmental constraints within the area
- The appropriateness of parameters selection in terms of the budget and its benefit
- The capability to detect any change within the area

- The efficiency to identify and decide the priority of environmental conditions
- The resilience for any unexpected conditions

4. Conceptual model of eco-based strategic environmental assessment

The aims of the SEA [46, 51, 52], focusing on specific ecological issues resulting from the case study, lead to the proposed conceptual model of the eco-based SEA in **Figure 1**.

The relationship of the main factors affecting the environment in the area is presented. At policy and planning levels, legal framework (No. 1) sets the direction of activities at the program and project levels. The Town and Urban Planning (No. 2) is a key factor to scope any development activities in each area. The change of land use is caused by two parts. The first part is due to development projects (No. 4), projects that required EIA (No. 5) and projects that did not require EIA (No. 6). These projects require official monitoring mechanisms and the audit from the competent agencies. The second part is due to the other local activities (No. 7) such as the change in agricultural types within the green area. Land use change caused by project activities can be controlled by the Town and Urban Planning, while another is caused by economic outcome and the unseen disaster.

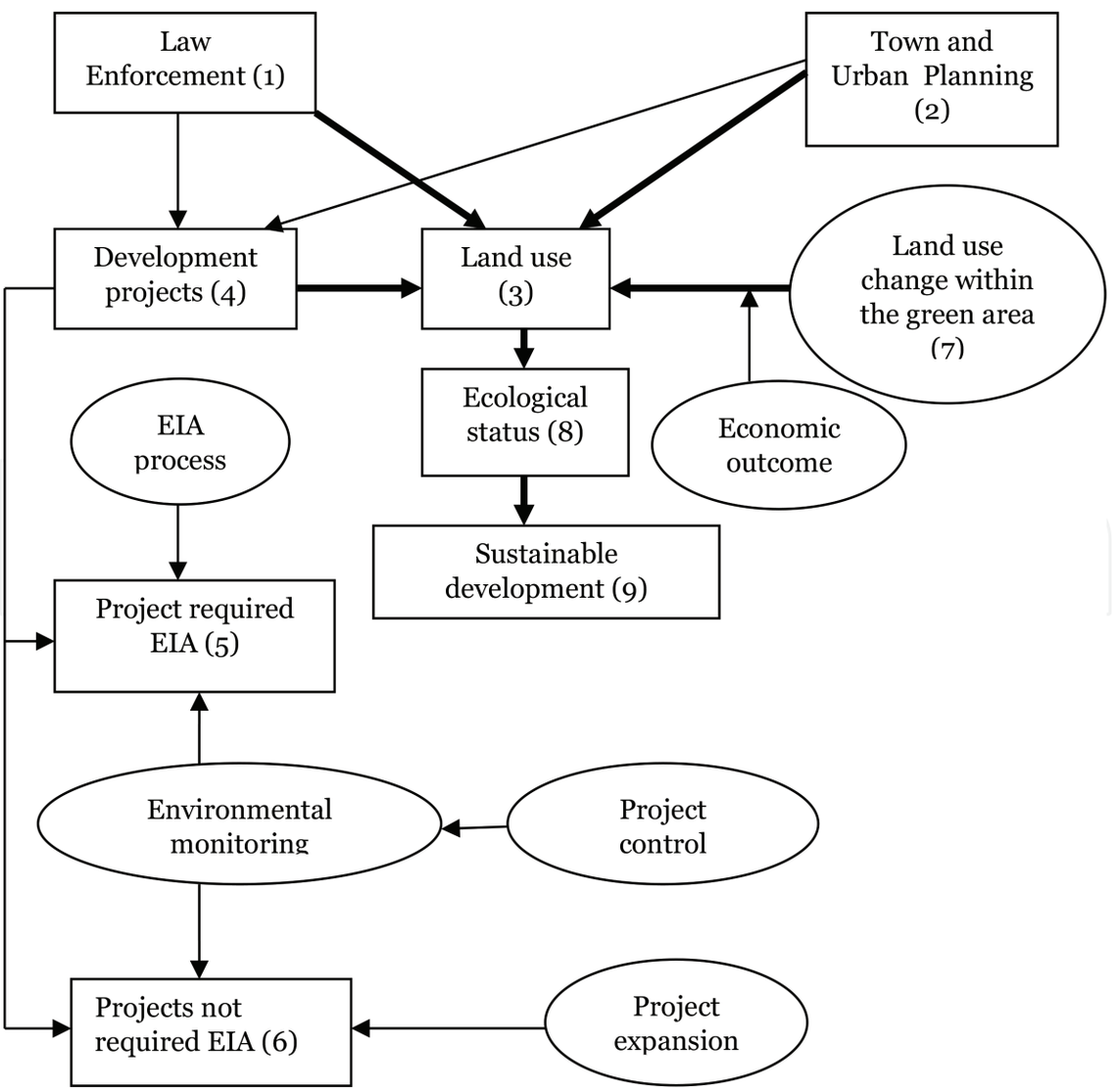

Figure 1.
Conceptual model of eco-based strategic environmental assessment.

Three aspects are raised from the conceptual model, including projects that required EIA and projects that did not require EIA, and the change of land use within green areas. These are discussed as follows.

Projects that required EIA: the main factors are the environmental impact study and environmental quality monitoring.

Ecological issues in EIA guidelines have a direct effect on the details in the EISs. The quality of data in one step will affect another. It seems that EIA is a satisfactory tool for identifying the adverse impact of projects and, consequently, monitoring the administrative procedures of government agencies. The environmental studies reported in an EIA are detailed and specific to the individual project. Furthermore, the prescriptions to reduce the impact that raised from a project are the mitigation and monitoring programs included in an EIS as project control mechanism.

The achievement of mitigation and monitoring depends on several factors including (1) the compliance by the project proponents. This is due to the details contained in the measures that encourage the performance and (2) the control by relevant agencies. This is depending on the legislation of the respective agency. It is essential that the regulations of the relevant agencies require the concurrence with the EIA legislation. A definition and allocation of roles and responsibilities to cover the requirements of follow-up activities among all key actors are required.

Projects that did not require EIA: the main factors are the Town and Urban Planning, project controlled by competent agencies and project expansion.

Monitoring performance of projects that did not require EIA depends on the requirements of competent agencies. The normal practice is that, for one type of project, only a particular suit of issue will be considered. In effect, these issues reflect the legal responsibilities of the agency based on past experience.

Another question concerns the expansion of projects that defined as non-severe impacts, especially housing project. The finding from the case study was that only 12% of the total required EIA and among 4.5% of these conducted monitoring performance. It seems that environmental control mechanism of these projects was too weak. The Town and Urban Planning is another tool to control; however, the unlimited expansion of housing projects was found in some restricted areas. These are crucial factors contributing to ecological change.

The change of land use within green areas: the change within green areas due to economic outcome is another hiding factor affecting ecological change. The factors causing these changes are difficult to control. It is a silent disaster that causes kinetic ecological change. The example of case study clearly showed that the change from paddy fields to fish farms affected species, habitat, and ecological mechanisms (No. 8), one of the sustainable approaches (No. 9).

To sum up, the relationships of eco-based SEA are depended on three components, including:

(1) Land use: the main factor is No. 3, with relevant elements (Nos. 1, 2, 4, and 7).

(2) Environmental assessment: the main factor is No. 4, with relevant elements (Nos. 5 and 6).

(3) Ecosystem: the main factor is No. 8, with inputs (Nos. 1–7) and output (No. 9).

The main conceptual model has been expanded to sub-frameworks, focusing on development projects, in **Figure 2**. The main factors of this sub-model are the Town and Country Planning due to its enforcement to specify land use development within the area and the legal enforcement by competent authorities.

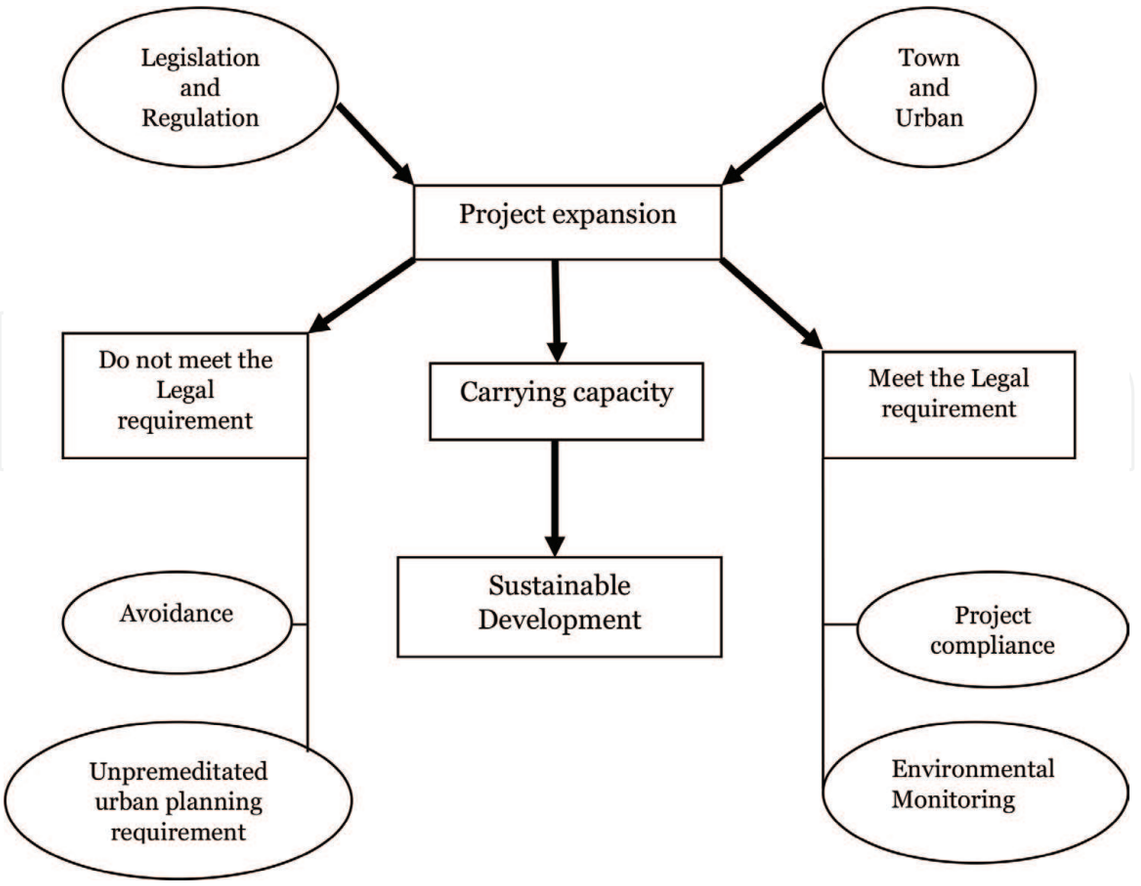

Figure 2.
Sub-conceptual model of development project expansion.

The expansion of two main types of development projects, mentioned previously, directly affects land use change within the area. The characteristics of change can be divided into two groups, according to the compliance with the legal specification.

The case does not meet the requirements of the law: the causes are followed. The first cause is avoidance, with emphasis on real estate development projects. Indeed, both housing projects and industrial projects are in this condition. However, the enforcement by control agencies is somewhat different. Industrial projects are controlled by Department of Industrial Works which has a strict control mechanism, whereas the unclear environmental control agency is put into housing projects. The second cause is unpremeditated which is mainly caused by the expansion of the project beyond the land use requirement specified in the Town and Urban Planning.

The case is in accordance with the requirements of the law: there are two factors concerned. The first factor is the project location that meets the requirements of the Town and Urban Planning. However, negative effects cannot guarantee for this group without the effective monitoring mechanism. The results of the case study were found that the land use regulations affect the slowdown of new real estate development. It seems that urban expansion is somewhat beneficial for green area preservation. The second factor is the environmental impact monitoring of the projects. This is an important mechanism to control the environmental impact from project activities. The lesson was learned from the case study that only 22.67 and 20.52% of projects that required and did not require EIA, respectively, were performed. Notably, in compliance group, the performance was inefficient.

Land use change directly effects on the appearance of ecological status. It is the crucial factor for the achievement of project activity control. Is it sustainable? For example, the agricultural changes directly affect kinetic change in species,

confirmed by the case study result. This is beyond the control of the Town and Urban Planning since the activity continues to be classified as green! But issues need to be realized how these areas are not being compromised by the legal enforcement from the activities of some development projects. The study was found that green belt area was affected by urban expansion, with more than 10% as defined in the Town and Urban Planning. Therefore, the expansion of development projects should be concerned and rigorous by the relevant agencies.

5. The approach for ecological fulfillment

Integrating ecological issues into the environmental impact study (**Table 5**) was crucial to achieve the model setting. It could be channeled into projects that are

Steps	The integration of ecological issues	The enhancement of relationship between EA guidelines and EISs
Ecological level	- Ecological impact should be cleared at all stages of the environmental impact study. Such eco-level considered is appropriate with project activities and the features of their location - Biodiversity should be focused by consideration on ecosystem integrity from the relationship between project and site development, which is a determinant of habitat and ecosystems - The flow of ecological details should be balanced at all steps of impact study	- The integration of ecological details in each level of environmental impact study should be taken into account the budget and time constraints - The establishment of review criteria is required in EIS submission process
Ecological baseline	- The scope of ecological study should be comprehensive and flexible, based on the feasibility of the impacts - Ecological information should cover the space and period of impact possibility - The formal guidance should provide the clarification of the biodiversity and the minimum requirement for the direction of EIA study - A comprehensive study of each ecological level for such issue should be based on project details and location - The linkage of ecological baseline and its impact assessment is required	- The role of expert committee in EIS submission is significant for the quality of ecological impact assessment - The linkage of ecology and EIA disciplines is required for appropriate integration - Ecological information to be used as a basis for the assessment of ecological impacts should be emphasized
Ecological assessment	- Ecological impact assessment should be based on ecological baseline - The guidelines should set the criteria for ecological impact analysis, focusing on biodiversity issues - Integration of biodiversity issues should consider the coverage of ecological details and their flexibility depending on project conditions and location - The flexibility of techniques and methods used to identify and analyze impacts under the principle of sustainable development is required	- The agreement of responsible agencies in EIA process is essential for project performance - The role of all agencies concerned during EIA process and EIA follow-up is necessary for the quality of EIS and the efficiency of project implementation
Ecological mitigation and monitoring	- The set of criteria for mitigation/monitoring measures is required, with ecological standard based on clear references - Mitigation/monitoring identification should be done by prioritizing the significance of ecological impacts	- EIA guidelines should provide the definite mitigation/monitoring identification - The essential role of project control agencies and project proponents is necessary to support and control project performance

Table 5.
The integration of ecological issues in EIA study.

subject to EIA through the mechanism of SEA. The importance of EIA guidelines is a fundamental tool in studying the ecological impact. The accuracy and appropriateness of baseline data are prominent. Data presentation should be appropriate, not too short or too long to identify their subsequent impacts. Biodiversity is firstly considered for ecological information in order to understand the overall ecological pattern within the area. The composition of the ecological level should be of great importance, such as the indicators species, the relationships between local and regional factors, the species of habitats [40, 53], the habitat loss, and the change of species distribution [54–56]. Quantitative approach is the possibility to integrate ecological science in the environmental impact study by the consideration of the variation of species, extent, and timing [39, 54].

In the process of EIA study, the impact of project activities to any kinetic habitat change should be highlighted because it is the main cause to the change of ecosystem composition, especially the change to species index [56, 57]. Ecological impact study should be conducted based on cognitive theoretical knowledge [58]. Drawing these theories together with the details of the project is very important and that is often overlooked. Good ecological baselines together with the minimal error of ecological impact study directly satisfy mitigation and monitoring measures. The reflect mitigation and monitoring can be examined through the possibilities of biodiversity change due to project activities. The concern agencies are crucial to enforce the project implementation as a result of environmental impact studies.

6. Conclusion

Eco-based SEA model here was developed from the case study derived from mega project development, which both direct and indirect effects on complex conditions, finally, to ecosystem which is one of the key indicators in sustainable development. When each issue was pinpointed, the main cause of impacts within the area was not only from the established mega project but also from the change of continuous activities. The kinetic changes due to development projects, themselves, and the kinetic changes due to land use pattern in the same group, particularly the change within agricultural areas from paddy fields to fish farms, were included.

From the three dimensions of model, these were EIA, land use, and ecology to support the setting purpose focusing on ecological issues. The integration of existing strategies and the results of the case study could be adapted for the appropriateness of the area. Ecological outcomes were considered as a result of activities within such area and the status of the area to support any activities. The conceptual model clearly illustrates in three cognitive, in particular their relationships. All three variables were integrated into SEA in accordance with the limitations of each area, focusing on the priority of ecosystem.

In summary, the model illustrates the importance of considering environmental issues as a whole from their cause to the final output. That is the kinetic ecological change. It can answer the question of large-scale project development, which is a continuation of the macro-level. Is in line of the sustainable development approach?

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Conflict of interest

The author would like to declare that there are no conflicts of interest for the entirety of this text.

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