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# Transformation Planning for Resilient Wildlife Habitats in Ecotourism Systems

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**Abstract:** An ecotourism system that is based on wildlife habitats in ecological systems is considered a social-ecological system that has a feedback relationship with social systems. Increases in socioeconomic activities and tourism infrastructure construction are not conducive to the resilience of wildlife habitats, thereby stressing the ecological system and threatening sustainable ecotourism. Managing resilient wildlife habitats by developing transformation plans that can be used to construct new systems through self-organization and the absorption of stress is paramount to perpetuating sustainable ecotourism systems. This study aims to establish transformation plans to enhance the resilience of systems thinking regarding wildlife habitats. Such thinking involves the sequential application of dynamic thinking, causal thinking, closed-loop thinking, and the discovery of strategies. This study examines the case study of Eulsukdo Island in South Korea, and the following transformation plans are derived: (1) high-quality eco-education programs to help tourists become hard ecotourists; (2) subsidies for foraging area restoration; (3) ecosystem services of wildlife habitats; and (4) governance organization led by multiple actors. The results of this study can provide guidelines for the effective use of natural resources at ecotourism destinations and for the ecotourism development of damaged wildlife habitats.

**Keywords:** systems thinking; social-ecological system; sustainable wildlife habitats; decision making of multiple actors; transformation; tourism resource

## 1. Introduction

More than other types of tourism, ecotourism utilizes wildlife and habitats as major resources and involves protecting and preserving areas while contributing to local economic vitalization through educational and guided-tour programs [1,2]. Ecotourism that is based on natural resources in ecological systems plays a role in the construction of a unique social system by creating various social-ecological activities [3,4]. The social system in ecotourism feeds back into the ecological system, with positive or negative effects. Ecotourism therefore takes place in the context of a social-ecological system (SES) in which ecological and social systems closely interact with each other [3,5–9]. However, in recent years, the negative effects of social systems on ecological systems have increased in frequency. Increases in socioeconomic activities and tourism infrastructure construction that is not conducive to the resilience of wildlife habitats are damaging natural resources. Damage to ecological systems negatively influences the social system and threatens the sustainability of ecotourism over the long term [10,11]. Therefore, ecotourism should be managed as an SES to promote sustainable ecotourism [3,12,13]. In this study, an ecotourism system is defined as the SES that exists at an ecotourism site. Within ecotourism systems, various factors that affect wildlife habitats at ecotourism sites (i.e., management, ecology, society, and

economy) exhibit complex interactions [14–16]. Ecotourism systems vary in behavior and structure according to the dynamics of various changes over time and according to the hierarchical feedback structures that constitute ecotourism sites, which are diverse and complex [15].

Understanding the behaviors and structures of dynamic and complex ecotourism systems is essential to plan and manage sustainable ecotourism. A better understanding of these systems can facilitate the identification of alternative solutions to prevent the ecotourism industry from collapsing due to the low resilience of wildlife habitats to SESs at ecotourism sites. Resilient wildlife habitats are habitats with the ability to retain essentially the same function, structure, identity, and feedback as healthy ecosystems despite disturbance from tourism activities [17,18]. Wildlife habitats interact with other environmental variables and shape the ecotourism system. Wildlife habitats with low resilience are easily damaged by minor disturbances, and this damage can negatively affect the entire ecotourism system through cascade effects within the system. Managing wildlife habitats without considering resilience can decrease wildlife, destroy ecotourism resources and change the structure of the entire ecotourism system, ultimately transforming it into an undesirable system [19]. Because an undesirable system can cause the collapse of ecotourism, establishing a strategy for building wildlife habitats with enhanced resilience is necessary. This strategy, which is called transformation planning, can transform ecotourism systems into ideal systems by preventing the negative effects of regime changes on ecotourism systems and enhancing the resilience of wildlife habitats [20,21].

Conservation prioritization, ecosystem management and other wildlife habitat management approaches should be considered to change ecotourism systems into desired systems. Conservation prioritization is a decision making method for wildlife habitat management, such as how habitats should be distributed and which species should be preserved first. Conservation prioritization includes utilizing integrally biological and socioeconomic information [22], setting ecosystem conservation goals through reflection on multiple actors' opinions [23], and finding efficient measures with limited funds, which is similar to the transformation planning of ecotourism systems in this paper. Mathematical models such as the population dynamics model [24], artificial neural networks model [24], habitat suitability index model [25], agent-based model [26], and system dynamics model [27,28] are used as components of quantitative research methods to manage the resilience of wildlife habitats in ecotourism sites. Among these models, the agent-based model and system dynamics model are mainly utilized in the field of resilience and tourism to understand the dynamics of SESs [29–33]. Agent-based modeling is a methodology that can be used to analyze the entire system based on the agents' characteristics that are affected by environmental changes and can inform decision making that depends on scenarios [26]. System dynamics provides a decision making framework based on the behaviors in feedback structures to solve problems for the entire system by identifying the interactions between subsystems. Agent-based models and system dynamics models are useful alongside appropriate decision making to manage the resilience of wildlife habitats from a holistic perspective. The system dynamics methodology has the advantage that systems thinking, a qualitative research method, is required to easily understand the entire system's structure and seek strategic points that can lead to structural changes [34–36]. Systems thinking is necessary to create a boundary of subsystems throughout the system and analyze the feedback relationship from the interactions between social and ecological systems. Systems thinking can identify the variables and structures of the problem and transform the structures and behaviors of systems by finding strategic points and appropriate solutions [37]. Transformation planning, which is suggested in this paper, enhances the resilience of wildlife habitats by altering current feedback loops in the ecotourism system through adjusting variables that pertain to the multiple actors in the management, business, and various tourism activities of the ecotourism system or by introducing new variables [38,39]. Therefore, systems thinking could be an appropriate research methodology to propose alternatives and solutions to stabilize a system or transform it into an ideal system by investing labor and capital from multiple actors [18].

The purpose of this study is to establish transformation plans for ecotourism systems to enhance the resilience of wildlife habitats on the Nakdong River Estuary, Eulsukdo Island, South Korea, where the wildlife habitat is being destroyed by tourism activities, using a transformation planning process with systems thinking. The results of this study identify an ecotourism system with a resilience-focused strategy that can help develop tourism plans to guide decision making. The findings of this study can also be used to establish a new set of guidelines for ecotourism site management by proposing desirable options and roles for various stakeholders. Furthermore, this study can contribute baseline data for future research to evaluate the resilience of wildlife habitats and present specific measures for improvement.

## 2. Literature Review

### *2.1. Ecotourism Systems*

Tourism systems can be classified as open or closed systems. Open tourism systems comprise interactions among the origin, tourist destination, and transit routes [40]. Closed tourism systems consist of systematically connected functions, such as those that are related to tourist attractions, services and facilities, transportation, information and directions, and tourists [41,42]. However, limitations exist in interpreting ecotourism based on these two definitions because ecotourism aims to create economic gains while enhancing the resilience of wildlife habitats by connecting nature preservation activities and benefits to local residents [3,43,44]. One limitation of open systems as a tourism framework is that these systems are too simple to encompass the multiple functions and complexity of an ecosystem structure. A limitation of closed tourism systems is that these systems do not consider that disasters and diverse socioeconomic and political disturbances can reduce the resilience of wildlife habitats. Therefore, we must consider an ecotourism system that can describe the feedback between society and the environment within ecotourism and contribute to the resilience of wildlife habitats.

An ecotourism system can be defined as an SES, in which a feedback structure is formed between a social system that is based on social, economic, and cultural tourism activities and an ecological system of a natural area, such as wildlife habitats at ecotourism sites [45]. Ecotourism provides benefits in terms of ecological, economic, and socio-cultural aspects. These benefits contribute to the conservation of wildlife habitats by multiple actors who are involved in and influence ecotourism systems [46–48]. An ecotourism system can be maintained through self-organization via an SES positive feedback loop [21,49]. However, if a comprehensive understanding of the resilience of wildlife habitats and the feedback structures that constitute ecotourism systems is lacking [1], multiple ecotourism sites are exposed to unintended stresses, which can negatively affect ecosystems [50]. Therefore, an ecotourism system can be destroyed by a negative SES feedback loop. Thus, an ecotourism system is limited to various structures and behaviors by the positive (beneficial) or negative (stress) effects it experiences through the feedback between the social system and the ecological system [1,51]. Benefits result from intentional ecotourism planning, but most stresses occur unintentionally because of supply-and-demand activities in the ecotourism system [52]. Stresses that occur continuously and unexpectedly weaken the resilience of wildlife habitats and cause the collapse of ecotourism [1,53]. As such, we must manage ecotourism systems to maximize benefits and minimize stresses [54]. Attenuating stresses that are caused by stressor activities, such as tourist noise, light pollution, contaminant accumulation, and incorrect restoration activities, among others, which cannot be adequately managed, is especially important to maintain the resilience of wildlife habitats.

The feedback within the ecotourism system is determined by variables, behaviors, and their social-ecological effects on wildlife habitats. We must conduct preliminary analyses of the phenomena that are relevant to each ecotourism field to effectively understand the structure and behavior of complex ecotourism systems [1]. The social-ecological effects of several activities should be analyzed for each ecotourism field. According to previous studies that developed a set of criteria to improve

ecotourism, different ecotourism fields can be classified based on regional features and the roles of the actors who manage and operate tourism destinations [55,56]. In this study, business, environment, economy, and society fields were derived based on literature reviews of ecotourism systems [57–59], and the social-ecological effects that are manifested in each ecotourism system field were identified. The business field addresses administration issues that involve land-use change by the development of ecotourism, experience programs and facilities management. The environmental field concerns the management of natural resources, and the economic field concerns topics that are related to the cost-benefits of an ecotourism destination and surrounding areas. Topics regarding the participation of local residents and tourists are the focus in the social field. The departmentalization of the entire ecotourism system enables us to readily identify the activities that are associated with the characteristics of each field, the manner of the actors, and the types of problems for each issue. Each ecotourism system works in association with the others simultaneously and provides insight into the management of the sustainability of the entire ecotourism system [60–64]. If problems that negatively affect the resilience of wildlife habitats in each system and the entire system are discovered, then appropriate transformation plans should be established. Transformation planning, which leads to the transformation of ecotourism systems, proposes the formation of new systems through self-organization and the absorption of stresses based on the feedback structure and behavior in an ecotourism system [65,66]. Such transformation can be realized using systems thinking, which is a research methodology that can reveal the structure and function of a system in addition to transformation strategies [39].

### *2.2. The Link between Systems Thinking and Transformation Planning*

Systems thinking is a method of thinking that is based on system dynamics [36]. This method focuses on the mechanisms by which systems operate and facilitates the understanding of the strategies required to effectively change systems [67,68]. The system that we are interested in is a complex system that comprises the interrelationships and feedback relationships among a large number of variables. Therefore, we can grasp all the variables that comprise the system, but understanding the core structure and behavior of the system becomes difficult. However, the advantages of systems thinking include its ability to clearly reveal the structure of complex systems and analyze the dynamic feedback of the behavior of SESs over time by building a system with a simple structure and behavior based on the main variables [37,69]. This method addresses fundamental matters in both individual and entire systems and can generate appropriate strategies for solving problems [70,71]. The ultimate goals of systems thinking include the understanding of systems and the identification of strategies that can change them. A system archetype is a basic type of major system structure that repeatedly occurs in reality. When system complexity is simplified with system archetypes, we can quickly understand problems and gain insight into identifying strategic intervention points [72,73].

Systems thinking proceeds according to the following steps based on several systems-thinking skills (Figure 1) [35,37,67,74]. The first step is dynamic thinking, in which dynamic problems are discovered. The second step is causal thinking, in which the causal relationships among the main variables are researched. The third step is closed-loop thinking, in which the feedback structure among variables and variable behavior are analyzed. Understanding the dynamic phenomena in a system through this three-step thinking process leads to the fourth step, the discovery of strategies. In the fourth step, problems are recognized and the cyclic structure among variables is explored, which can ultimately lead to the transformation and revolution of the system [37,67]. Strategies are discovered by analyzing entire systems, discussing the main strategic actors, determining strategic points, and formulating strategies to change the system, in that order [69]. To change a system, systems thinking considers the adjustment of the values of pre-existing variables and accepts structural changes to shift feedback structures through the elimination or introduction of variables. In the latter case, we discovered an association between systems thinking and transformation planning.

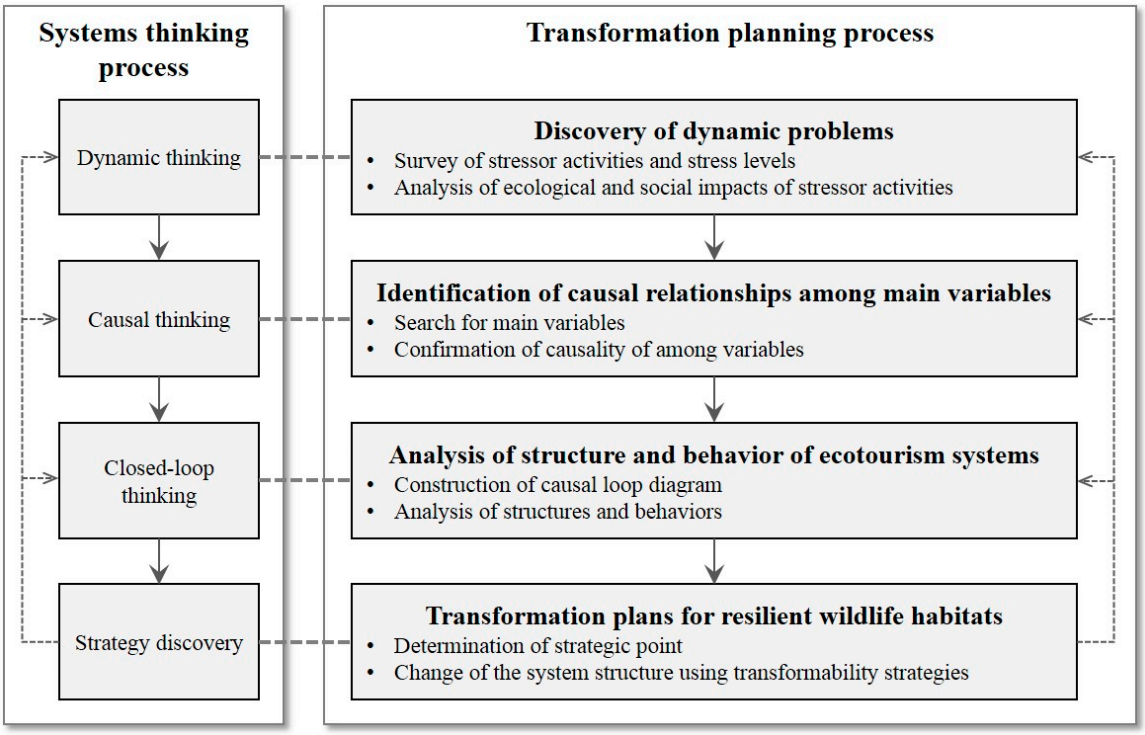


**Figure 1.** Transformation planning process with systems thinking.

When the ecological, economic, or social conditions of a current system form an undesirable regime, transformation planning can create new and stable systems by changing state variables through the introduction of new components and economic opportunities in addition to forming a new feedback structure [21,75]. When a system veers towards sustainable growth, most of the variables of the pre-existing system are included [75]. However, a new feedback structure appears due to the addition or deletion of a few variables related to the strategic actors within the system [38]. These actors may be land managers, governmental agencies, local residents, associations, or private interests, all of whom directly influence or execute polices that influence the ecological system in an ecotourism system [38,76]. To stably transform an ecotourism system, multiple actors that are engaged in the management of wildlife habitats must improve the system's transformability through the planning and design of sustainable landscapes [76,77]. Successful transformation requires transformability that has "the capacity to create a fundamentally new system" [18]. Walker et al. [18] presented four decisive strategies for transformability that actors must execute to facilitate the fundamental and practical transformation of a system. The first strategy is to establish "cross-scale awareness and reactivity, including networking within the SES and between the system and other systems". This strategy implies that new relationships must be built by expanding the social network within both the multi-level governance systems inside the ecotourism system and external systems. The second strategy is to provide "incentives to change vs. not to change, especially subsidies". A typical example of this strategy is the practice of granting financial priority to eco-friendly technologies that are related to ecotourism while imposing fines on technologies that are not eco-friendly. The third strategy is to establish "a willingness to experiment". This strategy can be the driving force in experimentation by promoting ideas based on the policy of transforming ecotourism systems. The fourth strategy is to establish "reserves and highly convertible assets in human, natural, and built capital". This strategy implies that improving the ability of multiple actors to self-organize through the accumulation of knowledge and experience is necessary. These four crucial strategies can be used to successfully transform systems by strengthening decision making communication among multiple actors [78]. An additional advantage of these strategies is that they can provide insight into how best

to change the system by clarifying the discovery of strategy in systems thinking from the standpoint of resilience. In this study, strategies that can enhance the resilience of an ecotourism system are derived by integrating systems thinking and transformation planning.

## 3. Methods and Materials

### *3.1. Transformation Planning Process with Systems Thinking*

Transformation plans were established based on the stages of systems thinking, proceeding from dynamic thinking to causal thinking, closed-loop thinking and the discovery of strategies (Figure 1). Ecotourism plans that were based on the transformation planning process evolved through a critical literature review. Notably, this critical literature review was used to identify issues and concepts, select main variables, and prove causality among the main variables when structuring the dynamic problems that are encountered. The four stages of systems thinking are not necessarily one-way flow. When analyzing a system-by-system thinking approach, one may have to return to the previous step and change the previous way of thinking. This feedback process can flexibly develop the required thinking in each stage to find the optimal policy level.

#### 3.1.1. Discovery of Dynamic Problems

Dynamic problems in the ecotourism system were found during the dynamic thinking stage. At this stage, this study aimed to identify stressor activities that negatively affected wildlife habitats because of ecotourism activities within the study site and the stress levels that affected the ecotourism system. The following describes the steps of this process. Data on ecotourism activities and the dynamic issues of the study site were collected from field surveys and interviews with multiple actors. Secondary data regarding the site, including environmental monitoring data and data that were compiled from government agency policies, news articles, and travel reports, were also compiled. After the collected data were synthesized, the stressor activities were sectored according to the four field categories, and stress levels were categorized as high, middle, or low based on the extent and duration of the negative effects of the stressor activities. The stress level that was associated with socio-ecologically negative effects at an ecotourism site every month or year from regular and sustained stressor activities was high. Although not regular and continuous, the stresses from short-term stressor activities, such as civil and building construction, were labeled middle-level stresses. Finally, low levels were assigned to stressor activities that occurred intermittently. Then, the primary and secondary responses from high-level stressor activities were analyzed with respect to the interplay between the ecological and social systems within the ecotourism system. The issues at the study site were synthesized and the dynamic problems to solve were clearly revealed through this process.

#### 3.1.2. Identification of Causal Relationships among the Main Variables

The main variables that were related to the dynamic problems of each field of the ecotourism system were selected during the causal thinking stage (Appendix A, Table A1), and the relationships among them were confirmed. An ecotourism system consists of elements, such as natural resources, multiple actors, tourism facilities and programs, and the relationships among variables that are properties of the elements. A natural resource, which is a typical element of ecotourism systems, can be measured as various properties such as the quality of habitats, the populations of organisms, and the carrying capacity. These properties were treated as variables. The variables that could explain the main issue in each field were searched for in the system boundary, which was defined as a range of contents and fields around the geographical range. Among these variables, variables that could concisely and clearly reflect the dynamic problems from high-level stressor activities and the resulting primary and secondary responses during the dynamic thinking stage were selected as the main variables. Then, causal relationships among the main variables were confirmed based on the data that were collected during the previous stage and critically selected literature reviews. A causal relationship is defined

as a relationship between an independent variable (causal variable) and a dependent variable (effect variable). The following three conditions must be met for a causal relationship to exist [35,36,79]. First, the values of the two types of variables must not be fixed. Second, the dependent variable also changes after the independent variable changes. Third, causal relationships should be verified to eliminate spurious relationships. The types of causal relationships in systems thinking include direct causality, indirect causality, spurious causality, interact-direct causality, defiant causality, and causality that includes moderating variables [37,68,74,79,80]. The causalities among the main variables in the ecotourism system should be confirmed based on this theoretical foundation.

#### 3.1.3. Analysis of the Structures and Behaviors of the Ecotourism System

In this stage, the structures of the ecotourism system were constructed based on the causalities among the main variables, and then the behaviors were interpreted based on closed-loop thinking. The structures and behaviors could be analyzed by constructing causal loop diagrams (CLDs). CLDs show the causal relationships among variables in a system with arrows that indicate the nature of the relationship, including positive (+), negative (−), and delay (//) [70]. Combinations of causal relationships can be demonstrated in two types of feedback loops: reinforcing (R) and balancing (B). Reinforcing loops are loops in which the values of all the variables in the loop change in the same direction. For example, when tourism infrastructure increases, the number of tourists increases, and when tourism infrastructure decreases, the number of tourists decreases. This type of connection implies that the variables in the loop continuously change either in a 'virtuous circle' or in a 'vicious cycle' [34,80]. In virtuous circles, self-reinforcement is oriented towards policy goals, whereas in vicious cycles, reinforcement is oriented away from policy goals (Figure 2a). In contrast, balancing loops exhibit ongoing fluctuation between decreases and increases as the value of one variable in the loop changes based on the value of the other variable in the loop [74]. For example, as the number of tourists increases in an ecotourism system, the pollution level increases, which decreases the number of tourists; this change, in turn, decreases the level of pollution, thus increasing the number of tourists again. In this example of a balancing loop, the number of tourists continually fluctuates and eventually converges to a certain number. This outcome implies that the variables in the loop are becoming a 'stabilizing circle' or a 'stagnating circle' [34,80]. In a stabilizing circle, stabilization is oriented either towards or away from policy goals. In a stagnating circle, variables are locked in position and oriented away from policy goals (Figure 2b). Systems become structured with a combination of several feedback loops, and systems exhibit different behaviors depending on which loop is dominant. When a reinforcing loop and a balancing loop are combined (Figure 2c), a reinforcing loop can be activated at the beginning when a strong tourism infrastructure exists and the number of tourists increases. However, as time progresses, a balancing loop activates when the system reaches a tipping point, and the growth of the system stops due to the increased levels of pollution and decreased tourism growth, i.e., the system's behavior shows limits to growth. Peter M. Senge summarized combinations of complex and various feedback loops using 10 system archetypes, including the "limits to growth", "fixes that fail", "success to successful", and "shifting the burden" archetypes [81]. After drawing a CLD by combining these archetypes, one can rapidly analyze the structure and behavior of a complex system. In this study, CLDs that are based on system archetypes were constructed using Vensim PLE version 6.3 (Ventana Systems, Harvard, MA, USA).

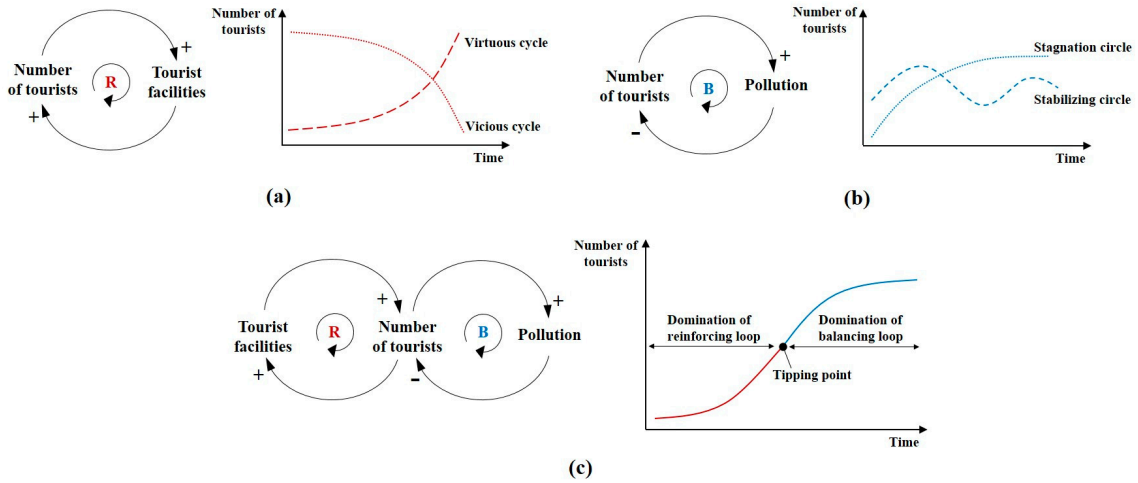


**Figure 2.** System structures and general behaviors of feedback loops: (**a**) structure and behavior of a reinforcing loop; (**b**) structure and behavior of a balancing loop; (**c**) typical example of combinative loops.

#### 3.1.4. Transformation Plans for Resilient Wildlife Habitats

Systems thinking assists in the discovery of strategies that can produce substantial change from small efforts and provide methods to effectively change the system. All the elements that were considered in the previous three stages influence the discovery of a strategy, either directly or indirectly. In addition, the four decisive strategies for transformability [18] can serve as a guideline to select the strategic point and actors of strategy. The discovery of the strategic point follows from deciding which variables decisively affect the system and which variables must be removed to re-establish the system. The determination of these variables allows the point of policy intervention to be identified [35]. The discovery of the actors results from a discussion regarding which actors can directly change the system and their roles in implementing the strategy. Transformation plans can be established by these considerations.

### *3.2. Study Area*

We selected a target area in need of greater resilience for its wildlife habitat and that was suitable for the transformation planning process with systems thinking. The target area was selected using the following criteria. First, the site had to exhibit the characteristics of the four fields of ecotourism systems. Second, the site had to exhibit clear causal relationships between ecotourism activities and the outcomes of those activities within the ecotourism system. Third, the site had to have multiple actors that could execute transformation plans for ecotourism systems.

Eulsukdo Island was chosen in accordance with these criteria. This island is the largest wintering site for migratory birds in Asia and is located in the Nakdong River Estuary in Busan, South Korea (Figure 3). This island, which is a river delta formed by fertile soil deposits, is a brackish water zone where saltwater meets freshwater. This area used to be the largest habitat for migratory birds due to its abundant fish and shellfish populations, including clams, and extensive fields of reeds and *Scirpus planiculmis* Fr. Schm. Endangered species in South Korea, such as *Cygnus cygnus*, *Anser fabalis*, and *Tringa nebularia*, overwinter on Eulsukdo [82]. The island has a high diversity of plant and animal species, including insects, amphibians, and macroinvertebrates. Based on these natural resources, Eulsukdo was designated National Treasure number 179 in 1996. This island is an important ecotourism destination for ecological experiences and birdwatching programs [82]. However, the number of migratory birds has significantly changed each year due to damage to wildlife habitats, including roosting and foraging areas, from development activities and high-intensity tourism activities on and around the island [82]. An unstable ecosystem on Eulsukdo during the past decade has threatened

the sustainability of the ecotourism system. For these reasons, transformation plans are needed to enhance the resilience of the wildlife habitats on Eulsukdo and promote the sustainability of its ecotourism system.

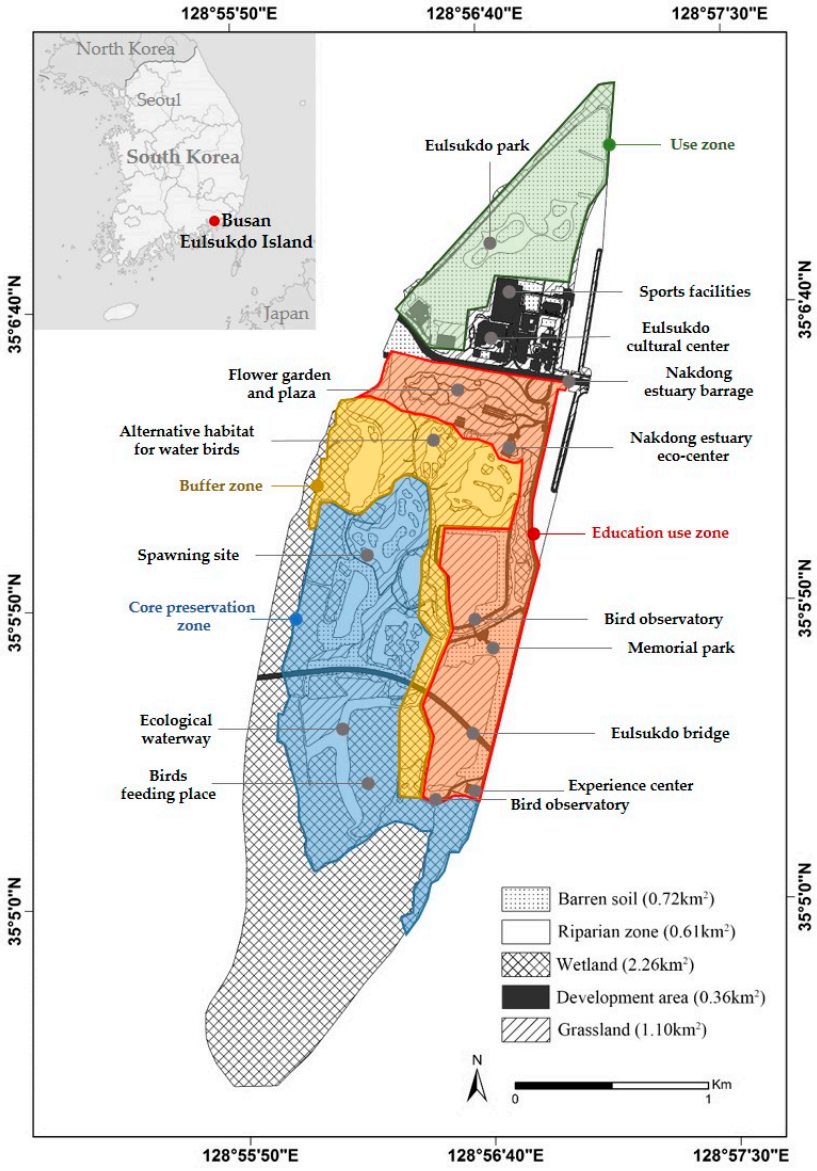


**Figure 3.** Types of land cover and infrastructure on Eulsukdo Island.

The ecotourism system on Eulsukdo has the characteristics of the four fields: a business field that concerns tourism facilities and program management; an environmental field that includes facility construction and the preservation of biodiversity; an economic field that concerns the re-investment of benefits; and a social field that includes the use of local human resources and the participation of the local community. Various tourism activities, such as the construction of tourism infrastructure, birdwatching festivals, winter bird feeding events, and the operation of electrical sightseeing carts and boats on Eulsukdo, have resulted in ecological and social stresses. Eulsukdo's ecotourism system has multiple actors that could intervene: the city government of Busan as the general management organization; the Sahagu District Office as the administrative agency, the jurisdiction of which includes Eulsukdo; the Nakdong River Estuary Management Office, an environmental management organization; the Nakdong Estuary Eco-center, an ecotourism management office; the

Busan Development Institute, a research institute; the Busan Environmental Movement Association and the Busan Green Association as NGOs; local residents in Sahagu; and tourists in Eulsukdo. Together, these multiple actors might be crucial to the transformation of this site to a desirable ecotourism system that enhances the resilience of wildlife habitats.

### *3.3. Data Collection*

To discover the dynamic problems and causal relationships among the main variables in the Eulsukdo ecotourism system, it is necessary to collect data through various approaches, such as field research; in-depth interviews; and reviews of monitoring reports, related research papers, and newspaper articles. Field research and interviews with experts and stakeholders were conducted from October 2014 to December 2014. The existing land use was surveyed through field research, which focused on tourism facilities and wildlife habitats, and the tourist behavior and management of the operator on Eulsukdo were observed. Interviews were conducted with two managers of the Nakdong Estuary Eco-center and city government of Busan, an ecological experience teacher that was certified by the natural environmental training program of the Ministry of the Environment in Korea, and an expert on ecological monitoring in the Busan Development Institute for half an hour per person on 6 November 2014. The interview questions involved the contents of Eulsukdo's ecotourism operation, the management of wildlife habitats, visitor characteristics, and multiple actors (Table 1). The interviewees provided precise and reliable information regarding tourism effects and other trade conditions in Eulsukdo's ecotourism system.

**Table 1.** List of interview questions.

| Contents | Interview Questions |
| --- | --- |
| Ecotourism operation | What activities were used to promote ecotourism?<br>What are the effects of tourism facilities and programs on habitats? |
| Management of wildlife habitats | What are your efforts to manage migratory birds and habitats?<br>Why did the artificial food supply of migratory birds begin?<br>What are the adverse effects or side effects of artificial food supplies for migratory birds?<br>Did you try fundamental methods such as habitat restoration to secure migratory bird feed? |
| Visitor characteristics | What types of tourists are visiting?<br>What is the difference between the characteristics of visitors to cultural facilities and those of ecotourists? |
| Multiple actors | Who are the stakeholders that are involved in Eulsukdo ecotourism?<br>What efforts are being made by each stakeholder to maintain ecotourism in Eulsukdo? |

Nakdong River estuary ecosystem monitoring reports from 2003 to 2015 by Busan City alongside operational reports from the Nakdong Estuary Eco-center from 2012 to 2014 by the Busan Nakdong River management agency were primarily used as references. These reports included anthropogenic and social status information, inorganic environmental surveys, bird surveys, vegetation surveys, benthos and fish surveys, ecotourism operations, and visitor characteristics in and around Eulsukdo. In addition, we collected news articles and websites that covered social and ecological issues that involved Eulsukdo over the last five years by searching for terms such as "Eulsukdo", "ecotourism", and "migratory birds" in Korea's major search engines. Additionally, www.google.com and www.naver.com provided secondary data. The collected data were used to derive valid information for the purpose of this study and within the scope of the study.

## 4. Results and Discussion

### *4.1. Discovery of Dynamic Problems in Eulsukdo's Ecotourism System*

On Eulsukdo, stressor activities occurred in various categories of the four fields. In the business field, stressor activities included processes related to facility management and program management. According to one manager of the Nakdong Estuary Eco-center, Eulsukdo is divided into a use zone, education zone, buffer zone and core preservation zone. To promote ecotourism, the Nakdong Estuary

Eco-center was opened in 2007, and then the experience center, bird observatories, rest and convenience facilities and sightseeing routes were installed in the education zone. In addition, tourism programs such as ecology experiences, ship tours, and narrative exhibitions operated throughout the year [82,83]. An ecological experience teacher said that tourism activities in the use zone and education zone cause habitat fragmentation, noise, repression and disturbances that indirectly affect the other two zones. When the number of tourists increased, the tourist activities exerted a high level of long-term stress on the ecotourism system [84,85]. In the environmental field, stressor activities included the construction of cultural sports facilities, the building of Eulsukdo Bridge, the construction of concrete pavements for eco-trails and the manual feeding of migratory birds [86]. Among these stressors, the manual feeding of migratory birds was a unique ecology preservation activity to Eulsukdo. According to an expert on ecological monitoring, migratory birds must replenish their energy during their stay on Eulsukdo before they fly to their next stop. Recently, *Scirpus planiculmis* Fr. Schm., which is a main food resource of migratory birds on Eulsukdo, has sharply decreased in abundance. Migratory birds did not stay in Eulsukdo for a long time but left to find food elsewhere. To prevent this issue, artificial feeding of migratory birds was implemented. However, this activity requires 100 million KRW annually [83], and artificial feeding produces a high level of stress because migratory birds could lose resilience without this food source. Another manager of the Nakdong Estuary Eco-center said that artificial food supplies require a large amount of money despite being an easy way to maintain migratory bird populations. Thus, this method is associated with a long-term economic burden, and a concern exists that migratory birds may lose wildness. In the economic field, stressor activities included providing benefits to the local community and reinvesting these benefits. Eulsukdo has coexisting ecotourism facilities and cultural-sports facilities. One manager suggested that the number of visitors to cultural facilities becomes higher than that of ecotourists and the operating income of cultural facilities becomes larger than the ecotourism income as the frequency of use of cultural and sports facilities by local residents increases. According to the ecological experience teacher interviews, cultural facility visitors tend to be more anthropocentric than ecotourists. As Eulsukdo reinvested in highly profitable facilities, such as the Eulsukdo Culture Center and sports facility, the wildlife habitats experienced a high level of stress [87]. In the social field, a high level of stress occurred because Eulsukdo is primarily managed by the local government. Busan City governs the overall operation of the Nakdong Estuary Eco-center and tourism facilities and performs program management, ecological monitoring and research on habitat restoration. According to another manager, the efforts of environmental organizations and local community organizations to preserve Eulsukdo have not been reflected in government decisions.

This diversity of stressor activities at Eulsukdo ecotourism sites has produced ecological and social stress. The primary effects have been ecological, such as habitat fragmentation, the trampling of vegetation and soil, and changes in the populations of migratory birds, and the stressor activities have weakened the resilience of the wildlife habitats [88]. This weakened resilience results in secondary social stresses, including a decline in the attractiveness of tourism destinations, expenditure in feeding birds, and socioeconomic costs of habitat restoration. These social stresses are the result of ecological stresses that occurred in each field. The dynamic problems in Eulsukdo's ecotourism system are summarized in Table 2.

**Table 2.** Dynamic problems due to stressor activities and their ecological and social effects in four fields of Eulsukdo ecotourism.

| Field | Categories | Stressor Activities | Stress Levels | Primary Response; Ecological Stress | Secondary Response (Reaction); Social Stress |
|---|---|---|---|---|---|
| **Business** | Facility management | Management of the Nakdong Estuary Eco-center, experience center, and Eulsukdo Culture Center | Middle | Habitat fragmentation Trampling of vegetation and soils Noise pollution | Decline in attractiveness of tourist site |
| | Program management | Management of ecology experiences, ship tours, narrative exhibition programs | High | | |
| **Environment** | Facility construction | Construction of cultural-sports facilities and Eulsukdo Bridge | Middle | Decline in resilience of migratory birds Change in the populations of migratory birds | Expenditure in feeding birds Inactivity of ecological programs Decline in revenue from ecotourism |
| | Preservation of bio-diversity | Manual feeding of migratory birds | High | | |
| **Economy** | Land use | Change in land use from protected area to development area | Middle | Change in the quality of habitat Indifference in ecological preservation | Cost-benefit imbalance |
| | Re-investment of benefits | Large investment in the Eulsukdo Culture Center and sports facilities | High | | |
| **Society** | Utilizing local human resources | Dependence on short-term employees and volunteers Absence of local experts | Low | Change in habitat quality | Weakening of local qualities Reduction in the role of multiple actors Increases in time and cost necessary for ecosystem preservation |
| | Participation in local community | Government-initiatedmanagement Failure to reflect the efforts of environment organizations and local community organizations to preserve Eulsukdo | High | | |

### *4.2. Causal Relationships among the Main Variables in Eulsukdo's Ecotourism System*

The main variables in each field that could explain the dynamic problems created by high-level stressor activities and the resulting primary and secondary responses in Eulsukdo were identified. In addition, causal relationships among the main variables were confirmed from many references (Table 3). These results were fundamental to the next step: closed-loop thinking.

**Table 3.** Main variables and their causal relationships in Eulsukdo's ecotourism system.

| Fields | Main Variables | | Causal Link Mark | References [1] |
|---|---|---|---|---|
| | Independent Variable | Dependent Variable | | |
| **Business** | Deregulation of protected areas | Tourism infrastructure | + | NA and ID |
| | Tourism infrastructure | Experience programs | + | ID |
| | Tourism infrastructure | Wildlife habitats | − | ID, MR, and NA |
| | Experience programs | Tourist attraction | + | ID |
| | Experience programs | Wildlife habitats | − | ID and LR |
| | Tourist interest | Number of tourists | + | RJ |
| | Wildlife habitats | Tourist attraction | + | ID and LR |
| | Number of tourists | Wildlife habitats | − | NA and LR |
| | Number of tourists | Ecotourism revenue | + | MR |
| | Ecotourism revenue | Benefits to the local community | + | LR |
| | Benefits to the local community | Tourism infrastructure | + | NA |
| **Environment** | Lack of natural food sources for migratory birds | Artificial food supply | + | ID and MR |
| | Artificial food supply | Lack of natural food sources for migratory birds | − | ID and MR |
| | Artificial food supply | Wildlife habitats | −, // | ID, NA, and LR |
| | Wildlife habitats | Lack of natural food sources for migratory birds | − | LR |
| **Economy** | Ecotourism revenue | Benefits to the community | + | LR |
| | Benefits to the community | Investment of profitable resources | + | ID |
| | Investment of profitable resources | Wildlife habitats | + | RJ |
| | Wildlife habitats | Tourist interest | + | ID and LR |
| | Tourist interest | Number of tourists | + | RJ |
| | Number of tourists | Ecotourism revenue | + | MR |
| | Ecotourism revenue | Benefits to the local community | + | LR |
| | Benefits to the local community | Investment of profitable resources | + | LR |
| | Investment of profitable resources | Cultural facilities | + | NA |
| | Cultural facilities | Satisfaction of local residents | + | NA |
| | Satisfaction of local residents | Utilization of local residents | + | RJ |
| | Utilization of local residents | Cultural facilities revenue | + | LR |
| | Cultural facilities revenue | Benefits to the community | + | LR and NA |
| **Society** | Government-initiated management | Wildlife habitats | + | MR |
| | Wildlife habitats | Government-initiated management | − | ID |
| | Management of multiple actors | Wildlife habitats | + | ID |
| | Wildlife habitats | Management of multiple actors | −, // | ID |
| | Government-initiated management | Capabilities of multiple actors | − | LR |
| | Capabilities of multiple actors | Management of multiple actors | + | LR and RJ |

[1] ID = in-depth interview, MR = monitoring reports, NA = news articles, LR = literature review, RJ = researcher's judgment.

### *4.3. Structures and Behaviors of Eulsukdo's Ecotourism System*

CLDs of the ecotourism system were constructed based on the causal relationships of the main variables by applying the system archetype in individual fields (Figures 4–7). These loops were integrated into the entire ecotourism system (Figure 8), and the behaviors of all the systems were analyzed by closed-loop thinking.

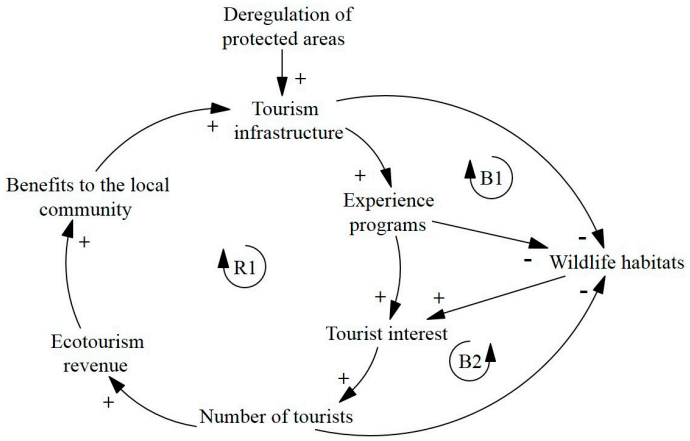


**Figure 4.** The business field was analyzed based on the limits to growth archetype. Growth is immediate at the beginning of the system based on the reinforcing loop, whereas the effect of the balancing loop in the latter half of the system becomes more powerful and slows growth.

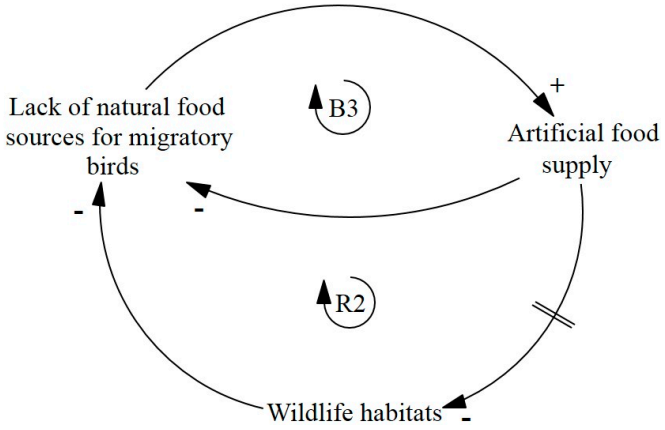


**Figure 5.** The environmental field was analyzed based on the fixes that fail archetype. This archetype exhibits a short-term effect based on a balancing loop (B3). Over time, however, an unexpected outcome occurs based on the reinforcing loop (R2), which yields a worse outcome than expected. This system highlights the need for a long-term perspective at the time of system analysis because of the unexpected outcomes that emerge as time passes.

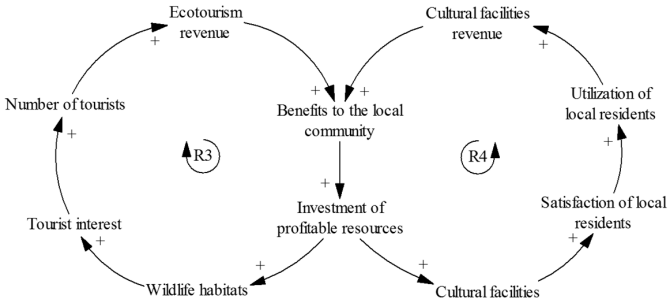


**Figure 6.** The economic field was analyzed using the success to successful archetype. This archetype is a feedback structure in which the winner of the competition over resources obtains even more resources in the next competition. One reinforcing loop (R4) exhibits a virtuous-circle behavior that continues to grow, whereas the other reinforcing loop (R3) exhibits a vicious-cycle behavior that continues to decline.

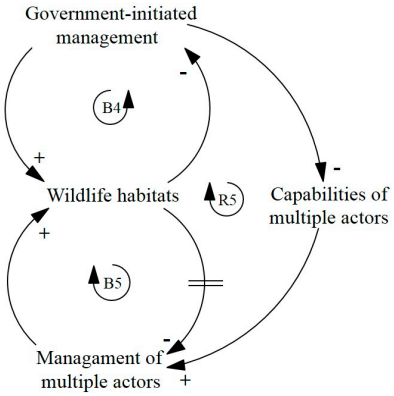


**Figure 7.** The social field was analyzed using the shifting the burden to the intervenor archetype. In this archetype, members of an organization depend on outside experts or external solutions to relieve the symptoms of a problem and lose the ability to cope with problems on their own.

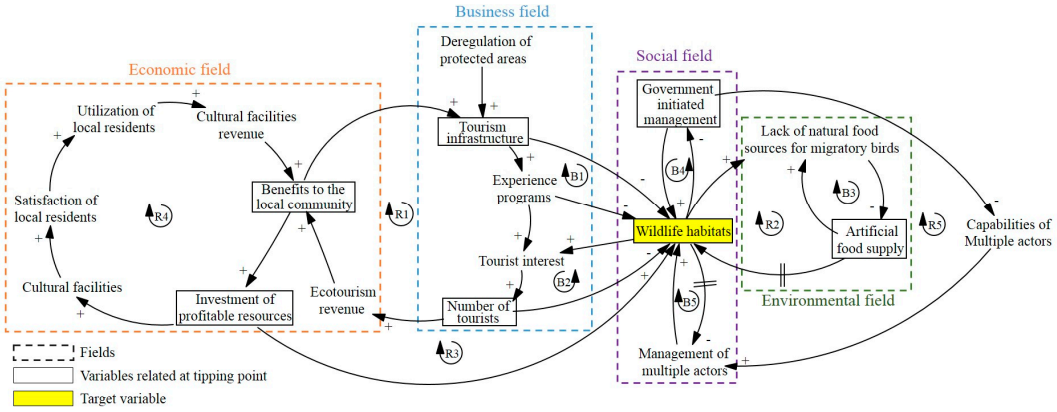


**Figure 8.** The integrated CLD of business, environmental, economic, and social field relationships that influence wildlife habitats in Eulsukdo's ecotourism system.

### 4.3.1. The Business Field of the Ecotourism System

The construction of various tourism infrastructures increased tourist interest and visitation at the ecotourism site [89,90]. Eulsukdo's revenues from tourism rose because of the increase in the number of tourists, which benefitted Eulsukdo's local community. The increase in benefits to the local community increased residents' desire for further development and led to demand for the construction of additional tourism infrastructure and experience programs. Since 2007, the tourism infrastructure, including the Nakdong Estuary Eco-center, the experience center, bird observatories, rest and convenience facilities and sightseeing routes, has been steadily developed in Eulsukdo. In addition, experience programs such as ecological experiences, ship tours, and narrative exhibitions are operated throughout the year. This feedback structure formed a reinforcing loop (R1, Figure 4) with a virtuous circle. Eulsukdo's managers desired to maintain the reinforcing loop and continued to expand tourism infrastructure and implement decision making and marketing to create additional revenue from ecotourism [91]. However, the decision making that fed the reinforcing loop negatively affected Eulsukdo's ecosystem. For example, these decisions resulted in the fragmentation of local wildlife habitats, trampling of vegetation and soil, and environmental pollution because of increases in tourism infrastructure, experience programs, and the number of tourists. The decline in wildlife habitats reduced the tourist interest and created two balancing loops with a stagnating circle (B1 and B2, Figure 4), which decreased the number of tourists and limited the development of Eulsukdo's tourism [92,93]. These findings suggest that the managers of Eulsukdo's tourism should restrict the construction of tourism

infrastructure, which is the variable that is associated with the tipping point that impedes the growth of tourism, and strive to avoid undesirable conditions by restoring wildlife habitats. Habibullah et al. [94] showed through statistical evidence that the degradation of wildlife habitats could negatively affect biodiversity and claimed that the number of residents and tourists should be controlled below the appropriate level. According to their research, the relationship between the increase in the number of tourists and local residents and the decrease in the biodiversity of plants, mammals, birds and fishes was statistically significant. The study of Habibullah et al. [94], which statistically proved the effects of human activities on wildlife habitat, and this study, which defined human activity and wildlife habitat as one feedback relationship, differ in terms of feedback thinking but provide the same opinion, which suggests that ecotourism cannot be continued if human activity that is associated with ecotourism exceeds a tipping point.

#### 4.3.2. The Environmental Field of the Ecotourism System

The management of any natural resource requires measures that can be reliably sustained over the long term [11,95]. One way to improve the availability of natural food sources for migratory birds would be to improve Eulsukdo's wildlife habitats, which form the foundation of Eulsukdo's food sources [96]. However, building food sources, providing stable food sources, and managing the capacity of Eulsukdo's wildlife habitats are expected to take a long time.

When the population of migratory birds decreased drastically due to a lack of food sources, the Nakdong Estuary Eco-center, under the management of Busan City, launched a program to provide an artificial food supply for migratory birds. The Eco-center provisioned the stems of sweet potatoes to birds at the southern end of Eulsukdo. Initially, the artificial food supply appeared to be an effective solution to this lack of natural food sources. This feedback system formed a balancing loop with a stabilizing circle (B3, Figure 5). However, this provisioning might harm the wildlife habitat over the long term if the population of migratory birds at Eulsukdo exceeds the island's capacity, leading to a reinforcing loop with a time delay and vicious cycle (R2, Figure 5). Therefore, a fundamental solution must be proposed with the artificial food supply as a tipping point.

#### 4.3.3. The Economic Field of the Ecotourism System

The District Office of Sahagu has established a variety of facilities, including the Eulsukdo Culture Center, a performance center, a drive-in theater, a sports facility, and other projects, to encourage local residents to utilize Eulsukdo and to satisfy their cultural needs. The local government has developed programs to increase the revenues from Eulsukdo's art and culture industry, which was more successful than its ecotourism industry. Thus, the local government increased the budget for cultural resources (R4, Figure 6). Subsequently, this reinforcing loop (R4, Figure 6) became more dominant than another reinforcing loop (R3, Figure 6). Successful industries, such as Eulsukdo's art and culture industries, continue to obtain larger investments, whereas unsuccessful industries, such as the ecotourism industry, have lost investments because of their repeated failures [74,80]. If investment is concentrated on the development of art and culture programs within the budget that is allocated to Eulsukdo, the amount that is invested in the conservation of wildlife habitats may be reduced. According to an interview with a manager at the Nakdong Estuary Eco-center, the investment cost of cultural facilities has increased, but the amount that is allocated to the conservation of biological habitats has decreased. The deterioration of Eulsukdo's ecotourism and the success of its art and culture industry resulted from a lack of awareness of the risk that Eulsukdo's ecological value and current ecotourism system could collapse. This lack of awareness gradually weakened the resilience of the wildlife habitats. Therefore, managers must intervene at the policy level and reduce the gap between the two reinforcing loops [90]. Busan City and Sahagu, the main actors in Eulsukdo's management, should mediate investment in key variables such as allocation to wildlife habitats instead of cultural facilities and benefits to the local community. This mediation could minimize the gap between development that is based on cultural resources and development that is based on ecotourism. Particularly, ecotourism

management that is based on environmental knowledge is required for successful mediation because the environmental knowledge of stakeholders can increase the participation of local residents [97]. Therefore, transformation planning from an economic perspective should propose a new ecotourism system that includes environmental education.

#### 4.3.4. The Social Field of the Ecotourism System

Ideal management systems for ecotourism sites have a bottom-up approach in which multiple actors, such as government organizations, private organizations, local residents, and non-governmental organizations (NGOs), constitute a consulting body of governance and adjust strategic goals and stakes [1]. However, in Eulsukdo's case, a top-down management system that was led by the local government established a balancing loop (B4, Figure 7). Therefore, the role of relevant research institutions, residents, and NGOs was minimized in another balancing loop (B5, Figure 7). A transition to a bottom-up approach is difficult when the role of multiple actors is minimized because a top-down approach allows decision making and financial sponsorship to rapidly occur [63]. The more dependent an organization is on top-down management, the weaker the problem-solving ability of multiple actors becomes. Thus, multiple actors exert less effort in solving problems [90], which leads to more damage to wildlife habitats. Eventually, organizations with a top-down structure heavily depend on top-down solutions (R5, Figure 7). During the early stages of developing ecotourism sites, top-down management can contribute to speedy stabilization. However, building a cycle that can avoid variables that are related to the tipping point (government-initiated management) and improving the problem-solving abilities of multiple actors such that management can gradually shift to bottom-up management is necessary. Unfortunately, the responsibilities of ecotourism, which includes multiple actors, can be divided into very different interests based on ecotourism resources [98]. Thus, establishing an agency that can integrate and represent various components and communicate smoothly with each actor is important.

#### 4.3.5. The Whole Eulsukdo Ecotourism System

The weakening of resilience in wildlife habitats can accelerate over time because the four fields of the ecotourism system exist simultaneously. Therefore, an integrated analysis must be conducted to understand the overall flow of Eulsukdo's ecotourism system and identify the dominant feedback loop in addition to the level and rate of the stresses that variables place on the wildlife habitats. An integrated understanding of the ecosystem through the four fields is illustrated in Figure 8. In 2007, when the Nakdong Estuary Eco-center was launched, Eulsukdo's ecotourism rapidly grew based on reinforcing loops 1 and 4. The tipping points in these two reinforcing loops were the tourism infrastructure, number of tourists, benefits for the local community, and allocation to wildlife habitats instead of cultural facilities, and all these variables rapidly changed Eulsukdo's ecotourism system. In particular, the tourism infrastructure and number of tourists directly stressed wildlife habitats and activated balancing loops 1 and 2, which impeded the growth of ecotourism. However, efforts towards the business, environmental, and social fields to manage the wildlife habitats manifested in reinforcing loops 2, 3 and 5. Nevertheless, these activities formed a vicious cycle that destroyed wildlife habitats over the long term. The tipping points in these three reinforcing loops were the artificial food supply, allocation to wildlife habitats instead of cultural facilities, and the capabilities of multiple actors. These variables slowly changed Eulsukdo's ecotourism system by weakening the resilience of the wildlife habitats. Slow variables can manipulate the threshold of the system and thus determine whether the system will shift to an undesirable system (i.e., an ecotourism system in decline) or a successful transformation [99]. Therefore, actors should pay careful attention to slow variables when managing the resilience of wildlife habitats. This integrated analysis of Eulsukdo's ecotourism system enabled us to identify the dominant feedback loops and the response speeds of variables that were related to the tipping point.

### *4.4. Transformation Plans for Resilient Wildlife Habitats*

For an undesirable system to transform into a desirable system, the tipping point in the system's structure must be identified. The seven variables that were related to the tipping point were selected as key variables to determine the strategic point. A system that is composed of only these key variables was formed by closed loops of two reinforcing loops and a balancing loop (Ra, Rb, and Ba, Figure 9a). The behavior of the system showed a rapid decline in the resilience of the wildlife habitats. To avoid this undesirable behavior, we eliminated existing variables that functioned as barriers and introduced new variables that functioned as bridges based on the four decisive transformation factors proposed by Walker et al. [18]. Though these strategies, Eulsukdo's ecotourism system is transformed into a system that combines two reinforcing loops to enhance the resilience of the wildlife habitats (Figure 9b). These two reinforcing loops (Rc and Rd, Figure 9b) form virtuous circles. In addition, these virtuous circles are facilitated by two variables (financial support for foraging area restoration and management by multiple actors) that are determined outside the loops.

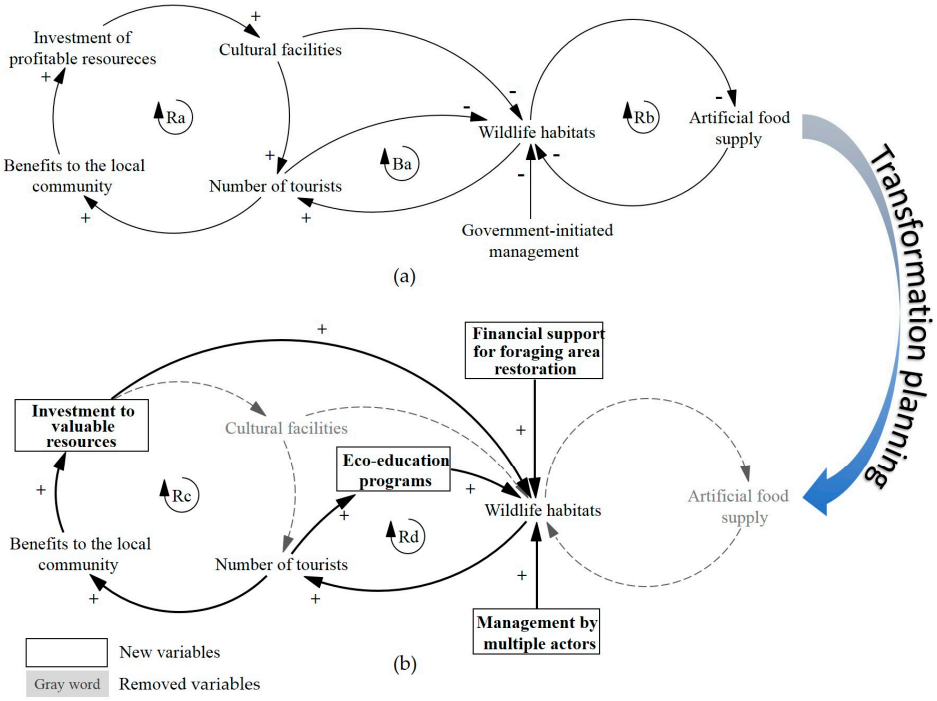


**Figure 9.** (**a**) Eulsukdo ecotourism system with only key variables and (**b**) Eulsukdo ecotourism system applied to transformation plans for resilient wildlife habitats.

The detailed transformation plans for each field, which specify the actors of the strategy, the types of actor roles, and other aspects, are as follows. In the business field, transformation planning that includes "reserves and highly convertible assets in human, natural, and built capital" can alter the system structure by introducing eco-education programs that teach tourist ethics; the goal of such programs is to prevent damage to wildlife habitats from the increasing number of tourists. Such programs would enable more tourists to contribute to the preservation of wildlife habitats. To limit stress from tourists on wildlife habitats, tourists should be educated about how human activities correlate with wildlife, habitats, and tourist ethics before they are allowed to observe the wildlife. Actors who can administer tourist education at ecotourism sites include the general management organization, local residents, and the ecotourism management office. The general management organization should establish a training program for Eulsukdo residents to become experts on ecology education, which would increase opportunities for local residents to participate [57,100–103]. A group of ecology park interpreters that consists of local residents should develop a high-quality ecology

education program and improve self-organization skills through the accumulation of professional knowledge and experience in wildlife resources and wildlife habitats that are unique to Eulsukdo [104]. The ecotourism management office should establish a mandatory education system for all Eulsukdo ecotourists and visitors to the cultural sports facility. Ecology education programs established by multiple actors can inspire visitors to develop a sense of responsibility toward wildlife habitats and provide an opportunity for them to become hard ecotourists [105,106]. Hard ecotourists can withstand a lack of infrastructure at ecotourism sites and practice wildlife habitat management throughout their tours [2,52,103]. A reinforcing loop (Rd, Figure 9b) was formed when this transformation plan was applied to Eulsukdo's ecotourism system. Even if the number of tourists increases, most of the general tourists will be hard ecotourists because they can change their ecocentric perception based on high-quality eco-education programs, which will help manage wildlife habitats. Additionally, well-preserved wildlife habitats can heighten the attractiveness of ecotourism sites and attract additional tourists. Additionally, this plan can serve as a back-up measure against an increase in the number of tourists from another reinforcing loop (Rc, Figure 9b), which is based on the third transformation plan.

In the environmental field, transformation planning that includes "incentives to change vs. not to change, especially subsidies" should discontinue the artificial food supply, which was hastily introduced to solve the phenomenon of food scarcity affecting migratory birds (e.g., the scarcity of *Scirpus planiculmis* Fr. Schm.), and provide financial support for restoring natural food sources. The general management organization should ensure that the government fund that is designated for the artificial food supply is spent on improving the environment for current food sources (*Scirpus planiculmis* Fr. Schm.) or discovering new, alternative sources of food. Measures for improving the environment for food sources include controlling water levels, controlling the salinity of the water, and preventing the spread of reeds. Alternative food sources for migratory birds include plants that grow in brackish water, such as *Zannichellia palustris* L., *Zostera marina* L., and *Ruppia maritima* L., and plants that grow in fresh water, such as *Zizania latifolia* (Griseb.) Turcz. ex Stapf. and *Nelumbo nucifera* Gaertn. [107,108]. It is crucial to create a habitat for food sources that has suitable growing conditions. Restoring food sources involves transformation planning that directly enhances the resilience of wildlife habitats. Stable sponsorship from the general management organization is necessary for effective long-term management because substantial time and financial investments are required to develop areas that can support a stable food source [11]. Moreover, the restoration of food sources can affect the environment and tourist activities. Therefore, such restoration activities would require strict management by Eulsukdo's management organization and affordable, frequent monitoring. In the economic field, transformation planning that includes "a willingness to experiment" involves shifting investment from supporting resources that create immediate profits to valuable resources that are worth investing in. This shift would involve discontinuing the construction of infrastructure that may directly damage wildlife habitats, such as tourism infrastructure or cultural sports facilities, and focusing on the restoration of wildlife habitats. Such a change must be validated by thought experiments and tests, which can be realized by a group of experts at a research institute. Therefore, improving the impression of the ecosystem service in Eulsukdo's wildlife habitats among the general management organization and administrative agency that are in charge of the development of Eulsukdo and its surrounding areas is necessary for this transformation plan to be successful. Furthermore, it is necessary to gauge the effectiveness of investing in resources based on future value by developing tools that can quantitatively assess and compare the value of present and future ecosystem services. In addition, stakeholders must be convinced by building specific investment processes that facilitate the direct receipt of rewards [109]. A virtuous circle was formed when this transformation plan was applied to Eulsukdo's ecotourism system (Rc, Figure 9b). When the benefits to the local community are used to restore wildlife habitats instead of building additional infrastructure through investment in resources with future value, the benefits to the local community are recouped based on the increase in the number of tourists. As such, a virtuous circle that utilizes the improvement of resilience of wildlife habitats as collateral

can increase the sustainability of Eulsukdo's ecotourism. The transformation plan should be based on a cost-benefit analysis of environmental policy to sustainably realize a plan that is based on economics in an ecotourism system. Cost-benefit analysis provides important information to make decisions regarding investment in socially and environmentally valuable resources. The economic evaluation of environmental policy provides a method to minimize the social burden of enforcing environmental regulation or investment and a measure to prepare for opposition from stakeholders that are economically affected by environmental policy [110,111].

In the social field, transformation planning that includes "cross-scale awareness and reactivity, including networking within the SES and between the system and other systems" should involve avoiding government-initiated management and establishing a management strategy to restore ecology by building governance through multiple actors, including the general management organization, the administrative agency, experts, NGOs, and local residents [90,112]. This plan should reflect changes in ecological and environmental spaces in the design of the ecotourism system, connect the ecological system and social system, and identify the causes of wildlife habitat destruction from the perspective of the ecotourism system. To construct this plan, the general management organization should first host regular meetings with multiple actors so that they can be actively involved in the decision making group that is in charge of restoring Eulsukdo's ecology. Through such meetings, the general management organization could guide the formation of a close network between the actors who represent the interests of the community and those who represent ecological values [101,113]. Communication and a horizontal collaboration structure should be established to construct such a network [113]. As such, the general management organization must launch governance education and discussion programs to understand the language and motives of each actor such that the participants can understand the problems in restoring Eulsukdo's ecology from a holistic perspective. Understanding the role of each actor that constitutes the governance of this system is as important as forming the network among actors [113,114]. The government organization should disclose data acquired in regular governance meetings, and local residents should collect oral traditions related to the management of Eulsukdo. Experts and NGOs should share the research data collected from monitoring Eulsukdo's ecosystem with individual actors so that knowledge can accumulate. Such knowledge accumulation can provide an opportunity for an unprecedented, revolutionary Eulsukdo eco-restoration program to develop. The main goal of this plan would be to enhance the resilience of wildlife habitats in Eulsukdo. The governing body must maintain a positive view of the restoration of the ecosystem. For this positive view to develop, the local government should ensure the transparency of the eco-restoration program by disclosing the budget for eco-restoration to the governing body and ensuring the validity of the eco-restoration program by quantitatively assessing the resilience of wildlife habitats in Eulsukdo.

## 5. Conclusions

Compared with other types of tourism, such as cultural tourism and adventure tourism, ecotourism regards wildlife habitats as significant tourism resources. These habitats are considered significant because they provide unique landscapes, food sources, and nesting areas for diverse wildlife, including birds, and provide opportunities for ecology education and experiences for tourists. However, wildlife habitats can easily lose resilience due to numerous socioeconomic factors, such as the construction of tourism infrastructure, adverse tourist behaviors, development of the surrounding area, use of natural resources by other industries, and mismanagement. When the resilience of wildlife habitats is weakened, the balance between the ecological system and social system within an ecotourism system is lost. When multiple actors who manage wildlife habitats do not perform their roles, the ecosystem is more likely to experience undesirable ecotourism and decline. To transform an undesirable ecotourism system into a desirable system that can support sustained growth, multiple actors should establish plans that enhance the resilience of wildlife habitats and create an ecotourism system in which the ecological system and social system harmoniously interact [48]. However, existing uniform plans do not support the sustainability of ecotourism systems because the ecotourism system

can manifest in many different ways based on the local, political, and ecological characteristics of individual ecotourism sites. Therefore, this paper suggests undertaking new transformable planning to ensure resilient wildlife habitats and the sustainability of ecotourism systems on Eulsukdo in the Nakdong River Estuary in South Korea.

Eulsukdo's ecotourism system was subdivided into the fields of business, environment, economy, and society and was analyzed as a system archetype to understand the system structure and behaviors formed by the dynamic problems that create high-level stress for wildlife habitats in each field and to establish an intuitive transformation plan. The business field was analyzed using the limits to growth archetype. A transformation plan was developed wherein multiple actors provide tourists with educational programs that can instill a sense of responsibility. The environmental field was analyzed using the fixes that fail archetype based on the behavior of manually feeding migratory birds. A fund-providing plan to restore natural food sources for migratory birds was suggested. The economic field was analyzed using the success to successful archetype based on weighing the investment of local benefits in supporting resources. In this field, the developed transformation plan demanded that general management organizations and administrative management organizations be educated by experts to recognize the value of wildlife habitat services within the ecosystem. Finally, the social field was analyzed using the shifting the burden to the intervenor archetype based on Eulsukdo's dependency on government management. The transformation plan involved establishing the governance of multiple actors and building a comprehensive eco-restoration program. These four transformation plans contained the key components of ecotourism: the preservation of wildlife habitats, the creation of benefits for the local community, the reinforcement of ecology education and interpretation, and the formation of harmonious governance with multiple actors.

This paper emphasized the importance of the resilience of wildlife habitats. Social-ecological knowledge exchange and cooperative study among multiple institutions and actors are necessary to enhance the resilience of wildlife habitats. This paper outlined a meaningful and interesting discovery-of-strategy process to optimize transformation planning. The transformation planning process outlined in this paper and its implications provide numerous possibilities for the transformation of undesirable ecotourism systems to systems that can realize sustainability.

In this study, we analyzed Eulsukdo's ecotourism system using only the main variables that were simplified through system boundary reduction. Although we emphasized analyzing the system in a time-efficient manner and the importance of the restoration of biological habitats at ecotourism sites, a disadvantage of this method is that it may not include the specific conditions of the site or parameters outside the system boundary. Future studies must discuss appropriate system boundary settings for the management of wildlife habitats at ecotourism destinations. Detailed spatial planning is required for this transformation plan to be successful. Aliani et al. [115] used a social ecological model to introduce a weighted linear combination (WLC) using a geographical information system (GIS), fuzzy logic, and analytical network processes (ANP) but did not consider the close relationship between social systems and ecological systems. However, these authors emphasized ecotourism space planning based on highly quantitative data. In addition, the ecotourism system in this study includes various ecosystems, such as forests and wetlands; therefore, ecotourism plans should be introduced according to the characteristics of each ecosystem. Moreover, an ecotourism system should incorporate various types of ecosystems, such as wetlands, forests, and poles. In future research, we will apply the transformation plans derived from this study and spatial planning according to the ecosystem characteristics of ecotourism sites.

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**Author Contributions:** Yun Eui Choi designed this study and participated in all phases. Junga Lee also participated in the development of this study and provided structural discussion. Kihwan Song and Min Kim helped conduct the literature review and analyze the results. All the authors contributed to the work in this paper.

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## Abbreviations

The following abbreviations are used in this manuscript:

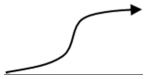
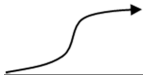
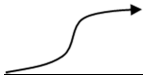
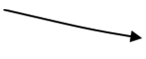
| | |
|---|---|
| SES | Social-Ecological System |
| CLD | Causal Loop Diagram |
| R | Reinforcing loop |
| B | Balancing loop |
| NGO | Non-Governmental Organization |
| ID | In-depth interview |
| MR | Monitoring Reports |
| NA | News Articles |
| LR | Literature Review |
| RJ | Researcher's Judgment |

## Appendix A

**Table A1.** Explanation and trends of the main variables in ecotourism system fields.

| Field | Main Variables | Explanation | Observed Trend | Desired Trend through Transformation Planning |
|---|---|---|---|---|
| **Business** | Deregulation of protected areas | The deregulation of protected areas indicates that the local government of Busan has made environmental regulations less strict to develop protected areas in Eulsukdo. |  |  |
| | Tourism infrastructure | A tourism infrastructure has been built in Eulsukdo for tourism, such as roads, amenities, cultural facilities, parks and trails. |  |  |
| | Experience programs | Experience programs are the number of environmental education activities that have been designed and conducted by the Nakdong Estuary Eco-Center to improve tourists' interests in Eulsukdo. |  |  |
| | Tourist interest | Tourist interest is a variable to indicate the standard of interest of Eulsukdo, where tourists visit. |  |  |
| | Number of tourists | The number of tourists refers to how many people visit Eulsukdo for tourism. |  |  |
| | Wildlife habitats | Wildlife habitats are areas with food, water, cover, and space for wildlife in Eulsukdo. |  |  |
| | Ecotourism revenue | Ecotourism revenue refers to the amount of local income from ecotourism, such as programs for feeding migratory birds. |  |  |
| | Benefits to the local community | Benefits to the local community include environmental, economic, and social benefits that local residents could receive. Environmental benefits include a sound residential environment and improved wildlife diversity. Economic benefits include the local residents' incomes, and social benefits refer to a sense of community and fellowship. |  |  |

**Table A1.** *Cont.*

| Field | Main Variables | Explanation | Observed Trend | Desired Trend through Transformation Planning |
|---|---|---|---|---|
| **Environment** | Lack of natural food sources for migratory birds | A lack of natural food sources for migratory birds indicates insufficient food, such as *Scirpus planiculmis* Fr. Schm., for migratory birds. |  |  |
| | Artificial food supply | Foods such as sweet potatoes have been artificially provided through programs to feed migratory birds. 'Artificial food supply' indicates the amount of food that humans provide annually. |  |  |
| | Wildlife habitats | Wildlife habitats are areas with food, water, cover, and space for wildlife in Eulsukdo. |  |  |
| **Economy** | Ecotourism revenue | Ecotourism revenue refers to the amount of local income from ecotourism, such as programs for feeding migratory birds. |  |  |
| | Benefits to the local community | Benefits to the local community include environmental, economic, and social benefits that local residents could receive. Environmental benefits include a sound residential environment and improved wildlife diversity. Economic benefits include the local residents' incomes, and social benefits refer to a sense of community and fellowship. |  |  |
| | Investment of profitable resources | The investment of profitable resources is a method to distribute money that would be used for the benefit of local residents. In this paper, the decision maker could select two businesses that are preserving wildlife habitats for ecotourist business and building cultural facilities for cultural projects. |   |   |
| | Wildlife habitats | Wildlife habitats are areas with food, water, cover, and space for wildlife in Eulsukdo. |  |  |
| | Tourist interest | Tourist interest is a variable to indicate the standard of interest of the places where tourists visit. |  |  |
| | Number of tourists | The number of tourists refers to how many people visit Eulsukdo for tourism. |  |  |
| | Cultural facilities | The cultural facilities in Eulsukdo include places such as the Nakdong Estuary Eco-Center, Theme Parks, and Eulsukdo Culture Hall |  |  |
| | Satisfaction of local residents | The satisfaction of local residents is the standard for the degree to which local residents are satisfied by cultural projects, such as concerts, exhibitions, and art training courses. |  |  |
| | Utilization of local residents | The utilization of local residents refers to the number of local residents who use all types of cultural facilities. |  |  |
| | Cultural facilities revenue | Cultural facilities revenue refers to the income from cultural facilities through concerts, exhibitions, and art training courses. |  |  |
| **Society** | Government-initiated management | Government-initiated management is a variable regarding whether ecotourism management systems are led by the local government without other stakeholders. |  |  |
| | Wildlife habitats | Wildlife habitats are areas with food, water, cover, and space for wildlife in Eulsukdo. |  |  |
| | Management of multiple actors | The management of multiple actors is a variable regarding whether ecotourism management systems are implemented by consulting a governance body, including government organizations, private organizations, local residents, and non-governmental organizations (NGOs). |  |  |
| | Capabilities of multiple actors | The capabilities of multiple actors indicate how much power the consulting governance body, including multiple actors, has to make decisions about ecotourism business issues. |  |  |

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