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Integrated Diagnosis and Policy Improvement Measures of Ecological Networks for a Spatial Environment Planning*

공간 환경 계획을 위한 생태네트워크의 통합 진단 및 정책 개선 방안

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Abstract: As the mixture of understanding and interest among related ministries in establishing the hierarchy and spatial scope of ecological networks, there has been confusion in implementing relevant policies and establishing various spatial plans. Thus, this study attempted to diagnose the policies, data, and utilization status of ecological networks, and suggest improvement measures. To this end, it investigated, and analyzed the current status and problems of related laws, systems, and policies, as well as relevant literature review. Furthermore, it attempted to suggest the following three policy improvement measures by analyzing spatial data of Jeongmaek-based ecological networks used by the Ministry of Environment and Korea Forest Service. The first suggestion is the preparation of clearer regulations on the hierarchy, components, settings, and management plans of ecological networks through the enactment and revision of relevant laws. The second suggestion is to integrate the linear data set of ecological networks, to construct a consultative group handling an overall control tower and governance of ecological networks chiefly with the central related ministries such as the Ministry of Environment, and the Ministry of Land, Infrastructure and Transport, Ministry of Agriculture, Food and Rural Affairs(Korea Forest Service), and Ministry of Oceans and Fisheries, and to prepare a system for cooperation and continuous management and implementation of matters related to the establishment of ecological networks. The third suggestion is to adjust the table of contents of the Guidelines for Environmental Planning, a related lower statute, and present specific implementation measures. Based on these suggestions, it is expected to be possible to share the common value of ecological networks, integrate the linear networks, and utilize the networks from a national perspective, eventually enabling the conservation of ecological networks, and the establishment of the network restoration policies in a systematical and efficient manner.
Key Words: Spatial Environment Planning, Ecological Axis, Ecological corridor, Biodiversity

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I. Introduction

As carbon neutrality/net-zero and climate crisis response have become important global issues, related policies, technologies, institutions, and industries have been developed as well, along with the recent rise of the nature-based solution concept asserting the solution of these environmental problems through natural elements. The United Nations Convention on Biodiversity adopted the 'Kunming-Montreal Global Biodiversity Framework (GBF)' in December 2022, and interest in biodiversity and the nature restoration of the land has globally increased. GBF seeks to conserve healthy land ecosystems by increasing biodiversity, and sets targets for establishing spatial planning that includes biodiversity, restoring a minimum of 30% of damaged ecosystems, and designating protection areas. Furthermore, South Korean companies have been joining the global consultative group, i.e., Taskforce on Nature-related Financial Disclosure (TNFD).

The maintenance of healthy terrestrial and aquatic ecosystems and biodiversity requires maintaining the continuity of ecosystem functions, which can be achieved through the conservation, restoration, and expansion of ecological networks. Although there have been various policies and ongoing research related to ecological networks, it is necessary to diagnose and reorganize related policies due to mixed understanding among related ministries on the definition and spatial scoping of ecological networks. The policy issues related to ecological networks can be categorized into two main points.

First, there is the question of effectiveness in relation to the mix of laws and systems. Although various laws (ministries) stipulate the establishment of similar networks for spaces under their jurisdiction,

they have been described differently in terms of definition, hierarchy, space, linearity, and notification of individual networks. Although the laws under ministries do not mention ecological networks, they handle networks that can facilitate ecological values and connectivity of national land spaces, which can be regarded as belonging to the scope of ecological networks. However, laws and systems related to ecological networks within the same geospatial scope are mixed; for example, each ministry clarifies and notifies the definition and scope of ecological networks, notifies the origin and destination points of the networks, and specifies management entities of the network, or there are cases where some ministries do not clarify and notify.

Second, the consensus on the linear types of ecological networks is still absent. For example, mountain *Jeongmaek* is utilized for important spatial decision-making in policies, plans, systems, and projects handling the land environment, but the linear type is not consistent among stakeholders. The Baekdu-Daegan linear types are specified in the Baekdu-Daegan Protection Act, but there have been disagreements about other *Jeongmaek*· *Gimaek*, and *Jimaek*. This is assumed to be attributable to the difference between traditional ranges, ridges, and watersheds from the difference between *Sangyeongpyo* (a geography book or table in which mountain ranges throughout the country were arranged during the Joseon Dynasty), and new *Sangyeongpyo* (Park et al., 2022). The origin and destination of nine *Jeongmaek* mentioned in the Baekdu-Daegan Protection Act can be considered clear, but the lines employed in various systems and policies are different from each other, as shown in Table 1.

〈Table 1〉 The origin and destination per government department, researcher, and *Jeongmaek*

Jeongmaek name	EIASS1)	FGIS2)	Ministry of Environment (2023)	Son et al. (2022a)
Hanbuk Jeongmaek	Sewonsan – Military Demarcation Line	Sikgaesan – Jangmyeongsan	Jangmyeongsan – Odusan	Sikgaesan – Hangangbong–Tanhyeonsan
Hannam Jeongmaek	Chiljangsan – Munsusan	Chiljangsan – Munsusan	Chiljangsan – Munsusan	Chiljangsan – Munsusan
Hannam–Geumbuk Jeongmaek	Chiljangsan – Songnisan	Chiljangsan – Songnisan	Chilhyeonsan – Songnisan	Songnisan – Chiljangsan
Geumbuk Jeongmaek	Chiljangsan – Chiryongsan	Chiljangsan – Chiryongsan	Chilhyeonsan – Anheung–jin	Chiljangsan – Baegwolsan – (Wang Gaesan)
Geumnam Jeongmaek	Geumseongsan – Oyochi	Joyagbong – Busosan	Maisan – Busosan	Juhwasan – Ssarijae – (Janggyesan)
Geumnam–Honam Jeongmaek	Oyochi – Muryong–gogae	Yeongchwisan – Juhwasan	Yeongchwisan – Bugwisan	Yeongchwisan – Juhwasan
Honam Jeongmaek	Oyochi – Buramsan	Joyagbong – Baegunsan	Seomjingang River – Baegunsan	Juhwasan – Baegunsan – Geumosan
Nakdong Jeongmaek	Gubongsan – Dadaepo	Maebongsan–Morundae	Maebongsan – Morundae	Maebongsan – Morundae
Naknam Jeongmaek	Yeonsilbong – Sineosan	Jirisan – Bunseongsan	Jirisan – Bunseongsan	Jirisan – Yongjibong – Nojeoksan

Source: Created by the Author based on "Baekdu–Daegan Protection Act"; Forest Geospatial Information Service (FGIS), "Jeongmaek Ridgeway", Search date: Feb.5, 2023; Information Support System for Environmental Impact Assessment, "Jeongmaek", Search date: Feb. 5, 2023.

Thus, it is necessary to establish a reasonable and clear spatial plan by implementing related policies or conducting research using linear data of ecological networks agreed upon by ministries. This study aims to examine the definition, scope, and management system of ecological networks covered by various laws, systems, and policies, and to provide

legal and institutional improvement measures.

II. Concept of Ecological Networks and Current Status of Legal System and Policies

1. Review of laws related to ecological networks

The main laws related to the establishment of ecological networks in the Republic of Korea include the "Framework Act on Environmental Policy, Natural Environment Conservation Act, Mountainous Districts Management Act, Baekdu-Daegan Protection Act", and the "Creation and Management of Forest Resources Act". This study investigated and analyzed relevant laws.

There is no definition of ecological networks in the "Framework Act On Environmental Policy". However, regarding the establishment of the Comprehensive National Environmental Plan pursuant to Subparagraph 5 of Article 15 (Details of Comprehensive National Environmental Plans), the same definition as ecological networks defined in the "Natural Environment Conservation Act" is mentioned, as well as the need to set an environmental plan while including details on ecological networks in the plan.

〈Table 2〉 Main legal details related to ecological networks in the "Framework Act on Environmental Policy"

Relevant Act	Details
Framework Act On Environmental Policy [Enforced on Jul.4, 2023] [Act	Article 15 (Details of Comprehensive National Environmental Plans) A comprehensive national environmental plan shall include the following: 5. Setting the targets of environmental conservation and the phased measures and project programs on the following matters to attain such targets: (a) Matters concerning the conservation of natural environment, such as

No. 19173, Partially amended on Jan. 3, 2023]	biodiversity, ecosystem, ecological networks (referring to an ecological habitation space that links ecologically important areas or areas that need upkeep of ecological functions for the enhancement of biodiversity and continuity of ecosystem functions) and scenery;

The "Natural Environment Conservation Act" suggests several relevant provisions for natural environment conservation on the basis of the definition of ecological networks: 1. Definition, 2. Obligations to establish and implement plans, 3. Obligations to prepare guidelines and evaluation index, and 4. Recommendations for ecological restoration projects. Subparagraph 8 of Article 2 defines ecological networks as "ecological habitation spaces that link ecologically vital areas or areas that should maintain ecological functions for the biodiversity enhancement, and continuity of ecosystem functions, at a national or regional level." Furthermore, it mandates the establishment of plans related to ecological networks in the Basic Plan for Conservation of the Natural Environment at the local government level. This act also addresses the establishment and implementation of measures for constructing and managing ecological networks to maintain ecosystem continuity, conserve ecological networks, restore damaged networks, and develop urban ecological networks to enhance the ecological health of cities.

〈Table 3〉 Main legal details related to ecological networks in the "Natural Environment Conservation Act"

Relevant Act	Details
Natural Environment Conservation Act	Article 2 (Definition) The definition of terms used in this Act shall be as follows: 8. The term "ecological network" means an ecological habitation space that links ecologically important areas or areas that need upkeep of ecological functions for the enhancement of biological diversity and continuity of ecosystem functions.
	Article 4 (Responsibilities of the State, Local Governments, and Business Entities) The State and a local government shall bear the responsibility of devising the following measures according to the basic principles of

conservation of the natural environment pursuant to the purpose referred to in Article 1 and the provisions of Article 3. 3. Construction of ecological networks to maintain the continuity of the ecosystem, such as the creation of sub-ecosystems and construction of ecological corridors, and formulation and implementation of management measures
Article 6 (Basic Policies for Conservation of Natural Environment) The Minister of Environment shall establish basic policies for the conservation of the natural environment (hereinafter referred to as "Basic Policies for Conservation of the Natural Environment") to implement the purpose referred to in Article 1 and the basic principles of conservation of the natural environment referred to in Article 3 after hearing opinions of the heads of competent central administrative agencies, the Special Metropolitan City Mayor, Metropolitan City Mayors, the Special Self-Governing City Mayor, Do Governors, and the Special Self-Governing Province Governor (hereinafter referred to as the "Mayors/Do Governors"), and after deliberation by the environmental policy committee (hereinafter referred to as "Central Environmental Policy Committee") referred to in Article 58 of the Framework Act on Environmental Policy and the State Council. 6. Conservation of the ecological networks and restoration of the damaged ecological networks
Article 9 (Details of Basic Plan for Conservation of Natural Environment) The basic plan for the conservation of the natural environment shall contain the following matters: 6. Matters regarding the construction and promotion of ecological networks
Article 34 (Drafting and Utilization of Ecological and Natural Maps) ① For the purpose of use in the formulation and implementation of various development plans, the Minister of Environment shall draft an ecological and natural map of the natural environment of the nation in accordance with the following classifications on the basis of findings of the surveys referred to in Articles 30 and 31. 1. First grade zone: An area falling under the following: (a)An area which becomes a major habitat, place of visitation and major ecological network, or ecological corridor for endangered wildlife referred to in subparagraph 2 of Article 2 of the Wildlife Protection and Management Act (hereinafter referred to as "endangered wildlife")
Article 43 (Enhancement of Ecological Soundness of Cities) ① The State or a local government shall recover urban areas which have been damaged or neglected, or endeavor to prevent the following areas from being damaged in order to enhance the ecological soundness of a city: 5. A natural park referred to in subparagraph 1 of Article 2 of the Natural Parks Act. ② To promote the conservation of the natural environment, enhancement, etc. of ecological soundness of a city, the Minister of Environment may recommend to the head of a relevant administrative agency and the head of local government guidelines and evaluation indexes on conservation of the natural environment and ecological soundness, such as establishing an ecological network, conserving biological diversity, conserving natural scenery, securing a wind passage, and restoring ecology, in consultation with the head of a relevant central administrative agency

	Article 43-2 (Urban Ecology Restoration Projects) ① A Mayor/Do Governor or the head of a Si/Gun/Gu may execute a project to restore urban ecology in any of the following areas where the restoration is deemed particularly necessary to maintain the continuity of ecosystems or to improve ecosystem functions. In such cases, if the area for an urban ecology restoration project extends over two or more local governments, the heads of local governments having jurisdiction over such areas may jointly execute the urban ecology restoration project: 1. An area where an urban ecological network is disconnected or damaged and needs to be connected or restored;
	Article 45 (Installation of Ecological Corridors) ① In conducting, authorizing, or permitting a development project, etc., the State or a local government shall take necessary measures, such as the installation of an ecological corridor, or have such actions to be taken, in order not to sever the mobility of wildlife and ecological continuity. ②The State or a local government shall conduct surveys of and research on areas where the mobility of wildlife and ecological continuity are severed, and formulate and implement ecological corridor installation plans for areas which require ecological corridors. In such cases, it may request the management entity of a road, railway, etc. located in an area requiring an ecological corridor to install an ecological corridor, and the person who has received such request shall install an ecological corridor, except in extenuating circumstances. 〈Amended on Mar. 22, 2013.〉 ③A person who intends to install an ecological corridor pursuant to paragraphs (1) and (2) shall conduct the following surveys: 4. Investigations into connection with a major ecological network, such as Baekdu-Daegan referred to in subparagraph 1 of Article 2 of the Baekdu-Daegan Protection Act

In the "Baekdu-Daegan Protection Act", the term 'ecological network' is not used, but the term mountain range is employed. Subparagraphs 1 and 2 of Article 2 of the Act indicate that 'Baekdu-Daegan' refers to the vital mountain range that runs from Mt. Baekdu via Mt. Geumgang, Mt. Seorak, Mt. Taebaek, Mt. Sobaek to Mt. Jiri, and '*Jeongmaek*' is defined as mountain ranges prescribed by Presidential Decree, which are derived from the Baekdu-Daegan and form water divides of major rivers. The "Baekdu-Daegan Protection Act" indicates that the Ministry of Environment and the Korea Forest Service shall establish master and implementation plans for Baekdu-Daegan after consultation. The Baekdu-Daegan is based on the traditional geographical system,

Sangyeongpyo, which determines the linear type in line with the cadastre of land that branches off according to GIS techniques, and defines broad mountain range patterns by labeling the place names and mountain names. Through related research, a GIS database has been established for the specific linear type of *Jeongmaek*'s mountain ranges, but additional considerations are required due to the absence of details on the plan and scope of managing *Jeongmaek*.

〈Table 4〉 Main legal details related to ecological networks in the Baekdu-Daegan Protection Act

Relevant Act	Details
	Article 2 (Definitions). The terms used in this Act shall be defined as follows: 1. "Baekdu-Daegan" means a vital mountain range which runs from Mt. Baekdu via Mt. Geumgang, Mt. Seorak, Mt. Taebaek, Mt. Sobaek to Mt. Jiri; 1.2.The term "*Jeongmaek*" means mountain ranges prescribed by Presidential Decree, which are derived from the Baekdu-Daegan and form water divides of major rivers; 2. "Baekdu-Daegan Protection Areas" means certain areas of the Baekdu-Daegan designated and publicly announced by the Administrator of the Korea Forest Service as areas requiring special protection in accordance with Article 6. [This Article Wholly Amended on Apr. 6, 2011.]
Baekdu-Daegan Protection Act	Article 6 (Designation of Baekdu-Daegan Protection Areas) ①The Minister of Environment shall set principles and standards concerning the designation of Baekdu-Daegan Protection Areas (hereinafter referred to as "Protection Areas") after consultation with the Administrator of the Korea Forest Service: Provided, That the principles and standards may be modified subject to consultation with the Administrator of the Korea Forest Service where such modification is deemed unavoidable due to changes in social, economic or regional conditions. ②The Administrator of the Korea Forest Service may designate certain areas of the Baekdu-Daegan deemed to require special protection in terms of the ecosystems, natural landscapes, forests, etc. as Protection Areas in accordance with the principles and standards under the main sentence of paragraph (1) after consultation with the Minister of Environment. In such cases, the Protection Areas shall be classified as follows: 1. Core districts: Certain areas along the ridge of the Baekdu-Daegan intended for special protection; 2. Buffer districts: Areas adjoining core districts, which are necessary to protect such core districts. ③Article 4 (3), (5), and (6) shall apply *mutatis mutandis* to procedures for

	the designation of Protection Areas; however, opinions of residents of the relevant areas may be sought if necessary. ④When the Administrator of the Korea Forest Service has designated any Protection Area under paragraph (2), he or she shall publish such fact in the Official Gazette and notify the heads of related central administrative agencies and Do Governors thereof, as prescribed by Presidential Decree. ⑤The competent *Do* Governors or heads of Sis/Guns shall produce documents relating to the designation of Protection Areas available for perusal by the general public.[This Article Wholly Amended on Apr. 6, 2011]
	Article 3-2 (Basic Principles in Protecting and Managing Baekdu-Daegan) The State and each local government shall adhere to the following basic principles in protecting and managing the Baekdu-Daegan: 4. The Baekdu-Daegan shall be preserved and managed in order to maintain and enhance the connectivity with other mountain ranges, such as *Jeongmaek*

Paragraph 1 and subparagraph 1 of Article 9 (Designation of Restricted Areas for Conversion or Temporary Use of Mountainous Districts) of the "Mountainous Districts Management Act", stipulates that "(The Administrator of the Korea Forest Service may designate any of the following mountainous districts deemed especially required to preserve for public interests) as restricted areas for conversion or temporary use of mountainous districts: 1. mountainous districts, as ridges of main mountain ranges prescribed by Presidential Decree, deemed necessary to preserve natural scenery and forest ecosystem." The "Enforcement Decree of the Mountainous Districts Management Act" indicated three main mountain ranges among mountainous districts, but there is no definition of the ranges. Additionally, the Enforcement Decree indicates the spatial scope of main mountain ranges where the mountainous landscape and forest ecosystems should be preserved. It defines a horizontal distance of 1 km from the centerline of the ridge of a mountain range to the left and right as the spatial area where mountainous landscape and forest ecosystems need to be preserved. The Second Master Plans for

Management of Mountainous Districts (2018-2027), established by Article 3-2 defines ecological networks and mountain range network systems as national, regional, and local mountain ranges. The national mountain range encompasses the preserved mountainous districts (core mountainous district preservation network) including Baekdu-Daegan and *Jeongmaek*; the regional mountain range indicates mountain ranges including *Gimaek* and *Jimaek*, as well as surrounding preserved mountainous districts (connecting mountainous district preservation network); the local mountain range can be defined as the space encompassing the mountain range and surrounding preserved mountainous districts (mountainous district preservation network) within a city and town.

〈Table 5〉 Main legal details related to ecological networks in the "Mountainous Districts Management Act"

Relevant Act	Details
Mountainous Districts Management Act	Section 2. Restriction of Activities within Preserved Mountainous Districts Article 9 (Designation of Restricted Areas for Conversion or Temporary Use of Mountainous Districts) ①The Administrator of the Korea Forest Service may designate any of the following mountainous districts deemed especially required to preserve for public interests as restricted areas for conversion or temporary use of mountainous districts (hereinafter referred to as "restricted areas for conversion or temporary use of mountainous districts"): 1. Mountainous districts, as ridges of main mountain ranges prescribed by Presidential Decree, deemed necessary to preserve natural scenery and forest ecosystem
	Section 2 of the Enforcement Decree of the Mountainous Districts Management Act - Restriction of activities in preserved mountainous districts Article 8 (Designated mountainous districts in restricted areas for conversion or temporary use of mountainous districts) ① The "main mountain ranges prescribed by Presidential Decree" in subparagraph 1 of paragraph 1 of Article 9 of the Act refer to mountain ranges belonging to one of the following subparagraphs: (Amended on Dec. 7, 2010) 1. The mountain range belonging to the Taebaek Mountain Range and the Sobaek Mountain Range from Hyangrobong to Jirisan in Goseong-gun, Yangyang-gun, and Inje-gun, Gangwon-do Province, the Republic of Korea. 2. The mountain range belonging to the Taebaek Mountain Range (excluding the Taebaek Mountain Range under subparagraph 1) extending

	from Samsuryeong in Taebaek-si, Gangwon-do Province to Morundae in Saha-gu, Busan, the Republic of Korea. 3. The mountain range belonging to the Charyeong Mountain Range, which extends from Odaesan in Gangneung-si, Pyeongchang-gun, and Hongcheon-gun in Gangwon-do Province, to Oseosan in Boryeong-si, Cheongyang-gun, and Hongseong-gun, Chungcheongnam-do Province. ②As mountainous districts of the mountain range pursuant to subparagraph 1 of paragraph 1 of Article 9 of the Act, the mountainous districts necessary for the preservation of mountainous landscape and forest ecosystems shall be those located within a horizontal distance of 1 km from the centerline of the ridge of a mountain range to the left and right. However, the mountainous districts falling under any of the following subparagraphs shall be excluded.

Although there is no definition of ecological networks in the Acts under the Ministry of Land, Infrastructure and Transport, the terms of green network or preservation network are frequently indicated in numerous laws, ordinances, and administrative regulations such as the "Enforcement Decree of Act on Urban Parks and Green Areas", and the "Enforcement Decree of National Land Planning and Utilization Act". In general, 'preservation network' refers to a network for preserving ecological value in an area at a regional level, and has been applied to central administrative rules (e.g., Guidelines for Urban Planning, and Guidelines on Basic (Management) Planning for City and *Gun)*. Regarding 'green network,' central administrative rules (e.g., Guidelines on Basic Plans for Parks and Green Spaces, and Guidelines for Green Standard for Energy and Environmental Design), and local government laws (e.g., local urban planning ordinances, green space conservation ordinances, and landscape ordinances) have been utilized to create green spaces and build networks. The green network and preservation network provided by the Ministry of Land, Infrastructure, and Transport are aimed at enhancing ecological values in cities and (urban) development based on the premise of human use rather than the conservation and connectivity of natural environments and ecosystems.

〈Table 6〉 Legal concepts and purposes of ecological networks, and green networks

Classification		Main concepts	Purpose
Environmental legislation	Ecological networks	- The ecological structure that connects ecologically important areas - Network for conserving ecologically important habitats	- Protection of natural ecosystems and enhancement of biodiversity - Higher ecosystem connectivity by securing and connecting parks and open spaces
Land use legislation	Green networks (Green Infrastructure Perspectives)	- Flows of green spaces that broadly connect green space bases	- Human use in consideration - Consideration of ecological significance primarily in urban development

Source: Son et al. (2023)

2. Plans and policies related to ecological networks

The main plans and policies related to ecological networks include official plans such as the Fifth Comprehensive National Environmental Plan (2020-2040), the Third Basic Plan for Conservation of Natural Environment (2016-2025), the Fifth Comprehensive National Territorial Plan (2020-2040), the Second Master Plans for Management of Mountainous Districts (2018-2027), the Second Basic Plans for Protection of Baekdu-Daegan (2016-2025), and the Strategy for the Two Stages of Conservation and Restoration of Ecological Networks on the Korean Peninsula, as well as environmental impact assessment systems.

The top-level supreme plan in the environmental section in the Republic of Korea, i.e., the Fifth Comprehensive National Environmental Plan (2020-2040), suggests a conceptual national ecological network that provides direction for the ecological networks of the entire country. In terms of the ecological green network, the data of ridge networks, mountain range networks, and regional ecological networks based on

ecological environment-related DB in the Baekdu-Daegan Protected Area and DMZ are utilized. As for marine and coastal networks, the data on the five main national rivers, marine legal protection areas such as coasts, and sea level rise vulnerable areas are utilized. Based on the sea level rise vulnerability analysis and marine legal protection areas such as coasts, the shape and width of the marine and coastal network are determined. As such, the basic concept is to implement hyper-connected ecological networks within the country by connecting the basic ecological networks, the marine and coastal networks, Baekdu-Daegan and *Jeongmaek*, the main rivers, and DMZ, and reconnecting disconnected points.

The Third Basic Plan for Conservation of Natural Environment, which is the top-level/supreme comprehensive plan in the natural environment sector in the Republic of Korea, suggests the management systems and measures of ecological networks. Among the six main tasks, Goal 1 of "Protecting Natural Ecosystem Habitats" defines the concept of ecological networks, improves and spatializes the ecological networks-related legal systems, and describes the application of spatial plans and management. Regarding ecological networks on the Korean Peninsula, it handles some achievements in providing the direction for the ecological network conservation, and restoring connections between key ecological networks, but systematic legal and institutional foundations are evaluated as insufficient. Furthermore, the specific scope and boundary of ecological networks to be preserved and restored are vague. In this sense, the followings were clarified as the main target goals: (1) establishment of the management direction of ecological networks in national (core)/regional/urban and living spaces, (2) establishment of laws, systems, and basic information for ecological

network conservation and restoration, and (3) establishment of guidelines for ecological network conservation and restoration.

The Fifth Comprehensive National Territorial Plan (2020-2040), which was established by the "Framework Act on the National Land", the top-level supreme law in land and space in the Republic of Korea based on the "Constitution and the Framework Act on the National Land", reflected and was linked with the Ministry of Environment's national ecological networks in strengthening the network for land environment management. This is included in the integrated management matters of national plans under Article 7 of the Joint Command on the Integrated Management of Land-Use Planning and Environmental Planning. In addition, among the eight paragraphs of Article 8, Paragraph 1 (management and conservation of natural ecosystems related to national ecological networks, and restoration of damaged natural ecosystems), and Paragraph 2 (systematic land and space management, and ecological linkages), were to be achieved by unifying the spatial structure of national land planning, and the spatial environmental structure of environmental planning. The network of national land planning is expressed in terms such as national ecological networks and preservation networks, and environmental planning consists of national, regional, and local ecological networks depending on the hierarchy.

The Second Master Plans for Management of Mountainous Districts (2018-2027), which was established by Article 3-2 of the "Mountainous Districts Management Act" ecological networks, defines mountain range network systems. The Second Master Plans for Management of Mountainous Districts consists of three goals, four strategies, and 16 tasks. Among them, the goals related to ecological networks are to develop strategies of 'building the system for managing preserved

mountainous districts with a focus on mountain range networks on the Korean Peninsula' and 'regional specialization/regional characterization of mountainous district management' by 'strengthening the management of preservation networks for mountainous districts.' The specific tasks related to the mountain range network on the Korean Peninsula include (1) the establishment of the mountain range network system on the Korean Peninsula with national, regional, and local mountain ranges, ② reorganization of the mountain district classification system of preserved mountainous districts, and feasibility studies, and ③ expansion of the mountainous district management foundations in North Korean territories, and construction of ecological connection networks between mountainous districts between the East, West, South and North through supports from residents. As for regional specialization/regional characterization of mountainous district management, there are two tasks: ① urban mountainous district management to create people-oriented green spaces, and ② management of mountainous districts adjacent to main mountain ranges to create a mountain range network. First, regarding the mountain range network in the Korean Peninsula, preserved mountainous districts in Baekdu-Daegan and *Jeongmaek* are set as the 'national mountain range,' and the lower-level mountain ranges (*Gimaek*, and *Jimaek*) connected to Baekdu-Daegan and *Jeongmaek* are set as 'regional mountain ranges.' Additionally, 'local mountain ranges' are set around the ridges around cities and towns connected to the national and regional mountain ranges to construct the mountain range network system on the Korean Peninsula. There has been a need to institutionalize regular surveys of mountain range networks to restore disconnected and damaged forest ecological networks and to establish guidelines. The differentiated

mountainous district management strategy according to local characteristics proposes the creation of urban green networks by utilizing urban forests, arboretums, local gardens, community gardens, building gardens, and street trees, which connect fragmented mountainous districts within cities along the mountain ridge. Additionally, the maintenance of the areas around the ridges of urban mountain ranges as forests, and its utilization as green infrastructure to reduce find dust within cities are highlighted as countermeasures. As for mountain range disconnected areas, it is proposed to restore the area in liaison with forest tending projects, to create ecological migration corridors, to purchase private land near major mountain ranges, and to expand protection areas.

The Basic Plan for Baekdu-Daegan Protection established by the "Baekdu-Daegan Protection Act" suggests the types of damaged areas and the scope of field surveys within the ecological networks. 'Ecological networks' are considered the crucial value of Baekdu-Daegan. To strengthen the protection and management of Baekdu-Daegan's ecosystems, setting the direction for restoration projects (e.g., roads and forest roads, mining and quarrying sites, cultivated land, abandoned military facilities, and hiking trails) is promoted by classifying damaged land types. It is also necessary to restore ridgeway disconnection areas or damaged historical sites to connect the Baekdu-Daegan disconnection areas and manage them as one connected line. 'Guidelines on the Survey Method for Changes in Resource Status in Baekdu-Daegan and *Jeongmaek*' set the scope of surveying damaged areas within ecological networks to be the area within a 2km radius of the ridgeway for Baekdu-Daegan, and the area within a 50m radius of the ridgeway (agricultural land), and within a 300m radius (complex facilities such as

towns and cities) for *Jeongmaek*.

'Baekdu-Daegan·*Jeongmaek* Environmental Impact Assessment Guideline (2010)' aims to prepare environmental impact assessment plans for development plans or development projects that exert environmental impacts on Baekdu-Daegan·*Jeongmaek*. When preparing environmental impact statements, it is necessary to investigate the current status of the natural ecological environment and land environment, to identify the status of damaged ecological networks, and to preserve and supplement their connectivity as a mitigation measure. As an environmental impact assessment plan, the core zone of *Jeongmaek* is set as an area within 150m on each left and right side from the center of the ridge network, and the buffer zone is set as an area between 150m and 300m on each left and right side from the center of the ridge network, which is set as an area corresponding to one of the following criteria. The 'Guide to the Preparation of Environmental Impact Assessment (2023)' also presents the definition of ecological networks, and the setting scope; Strategic Environmental Impact Assessment, Environmental Impact Assessment, and Post-environmental Impact Assessment stated that the current status of the natural ecological environment and land environment, and the damage status of ecological networks and connectivity preservation as a mitigation measure for the impacts of development, should be taken into account. In the Environmental Impact Assessment for Baekdu-Daegan·*Jeongmaek,* the definition and core zone in the "Baekdu-Daegan Protection Act" were referred to for the term 'Baekdu-Daegan', and '*Jeongmaek*' is defined as a mountain range that branches off from Baekdu-Daegan, and forms the watershed of a main river.

Ⅲ. Research Scope and Method

1. Ecological network criteria diagnosis and spatial analysis

As a result of examining ecological network-related statutes, plans, and policies, different ecological network hierarchies and data were found to be utilized in the same land space. This tendency is not due to the use of different data for various purposes by ministries or researchers, but rather due to the ease of data that has been used in the past. To compare and analyze the ecological and topographical values of ecological networks based on spatial criteria, this study utilized and analyzed the spatial data of the Korea Rural Economic Institute (KREI), which has constructed data related to mountain ranges considering topography for a long time, in addition to the data from the Ministry of Environment, and Korea Forest Service (Figure 1). Furthermore, the spatial scope of ecological networks in this study indicates the *Jeongmaek*-based network. To analyze ecological and topographical values, this study utilized data on ① topography and slope, ② land cover, ③ ecosystem and nature map grade distribution and vegetation conservation grade ratio, ④ national environmental assessment grade ⑤ protection areas (e.g., forest protection areas, natural parks, natural monuments, and ecological landscape protected area), and ⑥ forest floor (Higher than Age Class 5) within or around ecological networks.

First, regarding nine *Jeongmaek* of the Korea Forest Service, which was created in 2020 in accordance with the Enforcement Decree of the "Baekdu-Daegan Protection Act", this study utilized data from the Forest Geospatial Information Service (FGIS). The data provided by the Ministry of Environment was obtained from the Information Support System for Environmental Impact Assessment (EIASS) and is spatial data suggested

starting with the 'Baekdu-Daegan·*Jeongmaek* Environmental Impact Assessment Guideline' in 2009. The current *Jeongmaek* spatial data provided by EIASS considers both *Sangyeongpyo* and New *Sangyeongpyo; Geumnam Jeongmaek,* and *Honam Jeongmaek* are unified, and they are labeled as *Honam Jeongmaek*, and *Geumgang Jeongmaek* is separately classified.[1)]

As for the *Jeongmaek* spatial data of KREI, among the mountain range spatial data suggested by Son et al. (2022), the data on *Jeongmaek*, which corresponds to national mountain ranges, were utilized. *Jeongmaek* was constructed based on the new *Sangyeongpyo*, and was defined as the watershed boundary of eight upper basins originating from Baekdu-Daegan (Han River, Geumgang River, Seomjingang River, Nakdonggang River, Imjingang River, Daedonggang River, and Amnokgang River).

The three *Jeongmaek* spatial data constructed by the Korea Forest Service, Ministry of Environment, and KREI, were marked as FGIS, EIASS, and KREI. *Jeongmaek* of EIASS and KREI were compared and analyzed with that of FGIS, which was designated based on the "Baekdu-Daegan Protection Act". Among the nine *Jeongmaek* based on FGIS, seven *Jeongmaek* (*Geumnam-Honam Jeongmaek*, *Geumbuk Jeongmaek*, *Naknam Jeongmaek*, *Nakdong Jeongmaek*, *Hannam-Geumbuk Jeongmaek*, *Hannam Jeongmaek*, and *Hanbuk Jeongmaek*), which have the same name as EIASS and KREI and are assumed to have similar driving directions, were compared and analyzed. *Honam Jeongmaek* is *Jeongmaek* with the most interval differences per spatial data. Based on *Honam Jeongmaek* of FGIS, *Honam Jeongmaek* of EIASS extends to the north, encompassing *Geumnam Jeongmaek* based on FGIS; in KREI, *Honam Jeongmaek* is reduced, so some parts are classified as *Geumgang*

1) Ministry of Environment (2016).

Jeongmaek. This study compared and analyzed the entire *Honam Jeongmaek* of EIASS, which has the same name based on *Honam Jeongmaek* of FGIS, and KREI was analyzed including not only *Honam Jeongmaek* but also *Geumgang Jeongmaek*. *Geumnam Jeongmaek* was analyzed separately because it is only categorized in the *Jeongmaek* constructed by FGIS. ArcMap 10.1 was employed for spatial analysis.

〈Figure 1〉 Locations of main Jeongmaek and comparisons of linear types

Source: Created by the Author

2. Classifications in line with spatial differences of ecological networks

After comparing and analyzing the ecological and topographical

values of ecological networks according to spatial criteria, and classifying the spatial differences, this study examined them through actual environmental impact assessment cases. As for the spatial data of ecological networks, this study only utilized the *Jeongmaek* spatial data of EIASS and FGIS, which are currently employed in policies and practices such as environmental impact assessments, and were constructed by the Ministry of Environment and Korea Forest Service. The number of *Jeongmaek* of EIASS and FGIS is the same (nine *Jeongmaek*, respectively), but as *Geumgang Jeongmaek* is only classified in EIASS, and does not match spatially with other *Jeongmaek* data in FGIS, this *Jeongmaek* was excluded from the analysis. *Honam Jeongmaek* and *Geumnam Jeongmaek* of FGIS, which have similar origin and destination, and driving direction to *Honam Jeongmaek* of EIASS, were combined into *Honam Jeongmaek* for analysis. Thus, this study targeted the eight *Jeongmaek* (*Geumnam-Honam Jeongmaek*, *Geumbuk Jeongmaek*, *Naknam Jeongmaek*, *Nakdong Jeongmaek*, *Hannam-Geumbuk Jeongmaek*, *Hannam Jeongmaek*, *Hanbuk Jeongmaek*, and *HonamJeongmaek*), and categorized and analyzed spatial differences of *Jeongmaek*. The spatial data of the target sites for environmental impact assessment in 2021 provided by EIASS, and its environmental impact statement, were utilized for the development status analysis.

3. Policy suggestions for reasonable ecological network management

This study examined the current Korean laws and systems related to ecological networks, previous studies, and cases in the country and other countries. It also analyzed the current status of the linear data of ecological networks provided by EIASS and FGIS, and types from the

differences on the basis of GIS analysis, and examined the problems incurred when these differences are used in the actual environmental impact assessment system, through cases. In addition to an advisory council, two ecological network-related forums were held to collect the opinions of experts in various fields on the direction of relevant policy improvements. Approximately ten experts from various fields such as landscape, natural ecology, forestry, and cities participated in the council, and forums. Furthermore, experts who have been directly or indirectly involved in the construction and establishment of ecological networks, as well as experts who are conducting actual research and work related to the establishment, utilization, and management of local ecological networks for local governments, participated in the forums, which enabled the collection of practical and in-depth opinions on the establishment and utilization of ecological networks for rational spatial planning.

Ⅳ. Ecological Network Spatial Analysis Results and Policy Suggestions

1. Diagnosis of ecological networks via spatial data analysis

This study analyzed the ecological and topographical values of the ecological networks presented by FGIS, EIASS, and KREI for each of the seven ecological networks. As *Geumnam Jeongmaek* only exists in FGIS, it was possible to analyze only the corresponding ecological networks, Additionally, there were cases such as different lengths or different origins and destinations per ecological network. Among the seven ecological networks, *Geumnam-Honam Jeongmaek* has a similar origin

and destination and the driving direction of the *Jeongmaek*, leading to Hamyang-gun, Gyeongsangbuk-do, Jangsu-gun, Jinan-gun, and Wanju-gun, Jeollabuk-do. The ecological and topographical value analysis results of the ecological networks are as follows. KREI has the longest ridge length of 87,240m, followed by EIASS (72,446m), and FGIS (72,033m). As for a mean slope angle, KREI has the steepest slope (21.4°), followed by EIASS (15.6°), and FGIS (14.8°). Mean elevation was found to be similar across all spatial data: EIASS has 759.5m, KREI has 761.4m, and FGIS has 761.3m.

In the Ecosystem and Nature Map, in terms of the ratios of Grades 1 and 2, FGIS shows the highest ratios (Grade 1 at 27.4%, and Grade 2 at 37.8%), EIASS has Grade 1 at 26.3% and Grade 2 at 36.3%, and KREI has Grade 1 of 24.7% and Grade 2 of 38.7%.

In the vegetation conservation grade, the ratios of Grades 2 and 3 of EIASS, KREI, and FGIS were found to be 26.3% and 24.7%, 27.4% and 23.3%, and 25.0% and 23.7%, respectively. Similar patterns were also found in Grades 4 and 5. As for the ratio of forest-type maps with Age Class 5 of higher, there was no significant difference between each spatial data, with 33.2% for EIASS, 34.1% for KREI, and 33.6% for FGIS.

In the National Environmental Zoning Map, the ratio of Grade 1 was 69.9% for EIASS, 70.1% for KREI, and 71.0% for FGIS; that of Grade 2 was 23.5% for EIASS, 24.0% for KREI, and 23.7% for FGIS; that of Grade 3 was 6.1% for EIASS, 5.4% for KREI, and 4.6% for FGIS, showing that the percentages per grade were not significantly different per spatial data. The ratios of protection areas and forest protection areas were also not significantly different. The percentages of protection areas were 33.0% for EIASS, 33.9% for KREI, and 31.0% for FGIS, and those of forest protection areas were found to be 16.6%, 16.9%, and 15.6%, respectively.

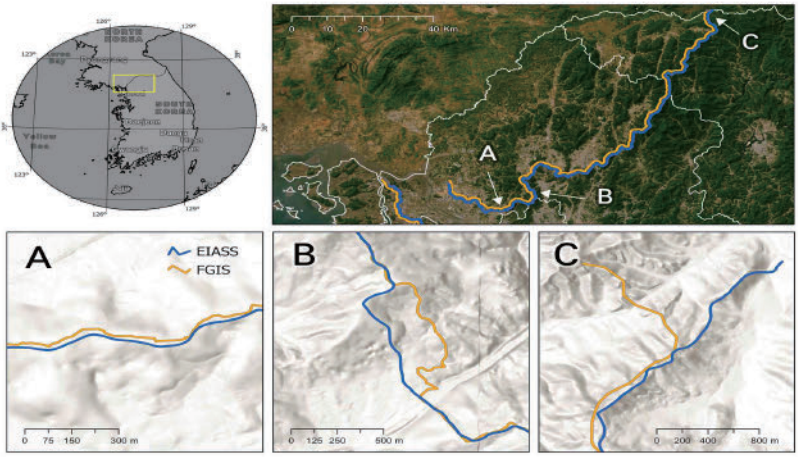
The ratios of natural parks were 10.4%, 9.9%, and 10.2%, respectively, and those of wilderness refuges were found to be 6.0%, 7.1%, and 5.2%, respectively. When comparing the spatial data of *Geumnam-Honam Jeongmaek*, significant differences were not observed, but the KREI data presented a slightly higher slope and longer ridge length. However, other indicators such as ecosystem and nature map, vegetation conservation grade, and map of forest type showed similar patterns and levels across all spatial data.

The *Jeongmaek* management scope of the Ministry of Environment, and Korea Forest Service was set as the criteria for classifying the spatial differences in *Jeongmaek*, while utilizing 'Baekdu-DaeganJeongmaek Environmental Impact Assessment Guideline' and 'Guidelines on the Survey Method for Changes in Resource Status in Baekdu-Daegan and *Jeongmaek*.'

After confirming the results of data analysis between the three ecological networks, and their physical linear locations, the sections, which are negotiable in a short period because the spatial differences between the ecological networks are insignificant, were classified as 'Type 1'. This was classified based on the criteria for the core area (150 meters) of *Jeongmaek* in the 'Baekdu-DaeganJeongmaek Environmental Impact Assessment Guideline' suggested by the Ministry of Environment. In other words, the network where the distance between each ecological network is within 150 meters was classified as Type 1 (see Figure 2, A). Second, the sections where spatial differences between *Jeongmaek* are expected to lead to different development and conservation plans applied, were classified as 'Type 2' (see Figure 2, B). The criteria for the type was selected based on the difference between *Jeongmaek* being greater than 150m, and being within 1,000m. The 1,000m criterion was

based on the 1,000m on both sides of the center of the ridge network within the investigated range of damaged areas in the 'Guidelines on the Survey Method for Changes in Resource Status in Baekdu-Daegan and Jeongmaek' suggested by the Korea Forest Service and National Institute of Forest Science. Finally, sections where the difference between *Jeongmaek* is more than 1,000m, and the origin and destination of *Jeongmaek*, and its driving direction appear differently, requiring long-term consultations, were classified as 'Type 3' (Figure 2, C). Regarding the number of sections per *Jeongmaek* type, the distance difference from the origin to the destination of *Jeongmaek* was calculated, and the sections where other types of conditions were established were set as new sections.

〈Figure 2〉 Example of each Jeongmaek type due to spatial differences



Source: Created by the Author based on the spatial data from Forest Geospatial Information Service, "*Jeongmaek* Ridgeway", Search date: Feb. 5, 2023; Information Support System for Environmental Impact Assessment, "*Jeongmaek*", Search date: Feb. 5, 2023

This study analyzed the classification of *Jeongmaek* spatial data per type, and the status of environmental impact assessment target sites per

type. The overlap analysis with the environmental impact assessment target sites was performed within 300m of *Jeongmaek* as a criterion to calculate the target sites. The 300m-criterion was determined by reflecting the 300-meter buffer zone distance criterion for *Jeongmaek* in the 'Baekdu-DaeganJeongmaek Environmental Impact Assessment Guideline', and the 300-meter distance criterion for *Jeongmaek* in line with restoration plans of damaged sites within development restriction zones in subparagraph 1, paragraph 5 of Article 2-2 of the Enforcement Decree of the Act on Special Measures for Designation and Management of Development Restriction Zones, to consider the guideline for preparing environmental impact statements, and the plans to restore damaged areas within development restriction zones. Except for 'Type 3' where it is difficult to compare environmental impact assessment target sites between FGIS and EIASS, the analysis was performed while only targeting sections of 'Type 1' and 'Type 2.'

As a result of classifying *Jeongmaek* types, the sections belonging to 'Type 2' were the most found from *Honam Jeongmaek* (15), followed by *Nakdong Jeongmaek* (14), *Hanbuk Jeongmaek* (11), *Geumbuk Jeongmaek* (8), *Hannam Jeongmaek* and *Hannam-Geumbuk Jeongmaek* (4), *Geumnam-Honam Jeongmaek* (3), and *Naknam Jeongmaek* (2). *Honam Jeongmaek* and *Nakdong Jeongmaek* are *Jeongmaek* with an average length of more than 400m, assuming that a higher number of 'Type 2' sections was attributable to the longer length of these *Jeongmaek* compared to the rest of the *Jeongmaek*.

〈Table 7〉 Number of sections per Jeongmaek type (Unit: No.)

Classification	*Geumnam Honam*	*Geumbuk*	*Naknam*	*Nakdong*	*Hannam*	*Hannam Geumbuk*	*Hanbuk*	*Honam*
Type 2	3	8	2	14	4	4	11	15
Type 3	-	-	-	-	1	-	1	1

By utilizing *Jeongmaek* spatial data of EIASS and FGIS, as well as spatial data of environmental impact assessment target sits, this study calculated the number of the assessment target sites with a focus on 'Type 1' and 'Type 2' (see Table 4-11). As a result of the analysis, there was a difference in the number per *Jeongmaek* data of FGIS and EIASS, but *Hannam Jeongmaek* showed the highest number of the assessment target sites in the 'Type 1' section with 124 sites in FGIS and EIASS, respectively. In the 'Type 2' section, *Hanbuk Jeongmaek* was found to have the highest number of target sites with 42 sites in FGIS, and 47 sites in EIASS. The lengths of *Hannam Jeongmaek* and *Hanbuk Jeongmaek* were not long compared to other *Jeongmaek*, but as they are located in the metropolitan area, which is the center of development, it is assumed that they recorded the highest numbers of the sites per type.

By only targeting *Hannam Jeongmaek* and *Hanbuk Jeongmaek*, the status of project sites was analyzed per small-scale, linear type, and area type of environmental impact assessment per *Jeongmaek* type of FGIS and EIASS (see Table 4-12). *Hannam Jeongmaek* has the most area-type projects within 300 meters of *Jeongmaek* of EIASS and FGIS, and *Hanbuk Jeongmaek* has the most small-scale projects in progress.

〈Table 8〉 Analysis of development areas per Jeongmaek type (Unit: No.)

Classification		Geumnam Honam	Geumbuk	Naknam	Nakdong	Hannam	Hannam Geumbuk	Hanbuk	Honam
FGIS	Type 1	-	5	-	9	124	3	43	3
	Type 2	-	20	-	32	10	36	42	26
EIASS	Type 1	-	5	-	8	124	6	43	5
	Type 2	1	18	6	35	10	32	47	31

Source: Created by the Author based on the spatial data from the Forest Geospatial Information Service, "Jeongmae kRidgeway", Search date: Feb. 5, 2023; Information Support System for Environmental Impact Assessment, "Jeongmaek", Search date: Feb. 5, 2023.

2. Policy recommendations for rational spatial planning of the national land environment

The policy suggestions related to ecological networks for rational spatial planning of the national land environment are divided into 1) statute revision 2) agreement on linear types (data integration) and 3) lower statute revision.

1) Enactment and revision of relevant statute

In the current statute, there is only a definition of ecological networks, but there are no clear regulations on hierarchy, components, setting, or management plan. Thus, as the aforementioned problems have been incurred, it is necessary to clearly define them in the law. In order to clearly define ecological networks in the law, it is possible to consider the insertion of relevant provisions in the "Framework Act on Environmental Policy", or the "Natural Environment Conservation Act" under the Ministry of Environment, as well as in the "Baekdu-Daegan Protection Act", which defines Baekdu-Daegan as the basis of ecological networks, under the Korea Forest Service and Ministry of Environment. In the current "Framework Act on Environmental Policy", the provisions handling ecological networks can be found only in 'Article 15 (Contents of Comprehensive National Environmental Plan),' but since 'Chapter II Establishment Of Environmental Plans' includes Environmental Standards (Section 1), Fundamental Policies (including Section 2/Article 15), Conservation of Natural Environment and Environmental Impact Assessment (Section 3), it is possible to add details on the hierarchy and establishment of ecological networks from the natural environment perspective. The "Natural Environment Conservation Act" is the supreme

law in the natural environment sector, and indicates ecological networks in the following articles: 'Article 2 (Definitions)', 'Article 4 (Responsibilities of the State, Local Governments, and Business Entities)', 'Article 6 (Basic Policies for Conservation of Natural Environment)', 'Article 9 (Details of Basic Plan for Conservation of Natural Environment)', 'Article 34 (Drafting and Utilization of Ecological and Natural Maps)', 'Article 43 (Enhancement of Ecological Soundness of Cities)', 'Article 43-2 (Urban Ecology Restoration Projects)', and 'Article 45 (Installation of Ecological Corridors).' Furthermore, as there are various provisions related to the conservation and restoration of the natural environment, it would be possible to insert provisions related to the hierarchy and establishment of ecological networks in terms of the natural environment.

The Ministry of Environment[2] is currently in charge of handling the natural environment in general. It seems reasonable to handle ecological networks dealing with the frame of the national land environment in the statute under the Ministry of Environment. It is possible to consider inserting ecological network-related provisions in the "Framework Act on Environmental Policy", and the "Natural Environment Conservation Act" in order to handle the basis of the land and natural environments. As it is desirable to minimize the enactment and revision of laws in general, the preservation of the national land and natural environment can be the main target of the "Natural Environment Conservation Act"; Article 2 of the Act already suggests the definition of ecological networks, and the Act includes Basic Policies for Conservation of Natural Environment

2) Paragraph 1 of Article 40 of the Government Organization Act stipulates that the Ministry of Environment is responsible for the preservation of the natural environment and living environment, the prevention of environmental pollution, and the conservation, usage and development of water resources, and rivers.

(Article 6) and Basic Plans (Articles 8 and 9), enabling the facile enactment and revision. Considering that, this study attempts to focus on amendments based on the "Natural Environment Conservation Act".

The current "Natural Environment Conservation Act defines"[3] an ecological network as "an ecological habitation space that links ecologically vital areas or areas that need to maintain ecological functions for the enhancement of biological diversity and continuity of ecosystem functions, at a national or regional level." Based on the definition, regulations on the classification and establishment of ecological networks at the national and regional levels, should be prepared first. National ecological networks are defined to be established by the State (or the Ministry of Environment) at the national level, and regional ecological networks are defined to be established and managed by metropolitan local governments or primary local governments at the regional level.

[Suggested provision] ☞ (Establishment of national ecological networks) The State (or the Minister of Environment) shall create national ecological networks to construct and manage ecological networks at the national level.

The hierarchy and organization of the national-level ecological networks should be defined, and the legal basis for their establishment should be prepared. The organization of the national ecological

3) In 2020, there were attempts to revise the Natural Environment Conservation Act to set and classify the hierarchy of ecological networks based on national, regional and local levels. However, the attempts became unsuccessful due to opposition from other ministries, and the Natural Environment Conservation Act was revised (Jun.10, 2022) through the arbitration of the Office for Government Policy Coordination in 2021 to agree upon the establishment of the current national or regional ecological networks. Thus, this study tries to make a suggestion based on that.

networks should be based on the components suggested in the Fifth Comprehensive National Environmental Plan (2020-2040) in accordance with the "Framework Act on Environmental Policy". Baekdu-Daegan, *Jeongmaek*, and DMZ should be defined as ecological green networks, whereas the Five major river networks and marine, coastal, and island networks should be defined as coastal networks, providing the legal basis for each case.

[Suggested provision] ☞ (Organization of national ecological networks) The Minister of Environment shall organize national ecological networks, including the following subparagraphs.

1. Ecological green network
   (a). Baekdu-Daegan: Baekdu-Daegan protection areas notified under Article 6 of the "Baekdu-Daegan Protection Act"
   (b). *Jeongmaek*: *Jeongmaek* in accordance with subparagraph 1(2) of Article 2 of the Baekdu-Daegan Protection Act
   (c). DMZ: Demilitarized Zone pursuant to subparagraph 13 of Article 2 of the "Natural Environment Conservation Act"
2. Coastal networks
   (a). Five major river networks: National rivers in accordance with Article 7 of the River Act, which are specially recognized as necessary to construct national ecological networks stipulated by the laws under the Ministry of Environment.
   (b). Marine, coastal, and island networks: Marine ecological networks pursuant to Article 9 (2) of the "Conservation and Management of Marine Ecosystems Act"
3. Others: Other matters stipulated by the laws under the Ministry of Environment to efficiently establish, connect, and manage national ecological networks

The ecological green network indicates the Baekdu-Daegan and *Jeongmaek* cited in the "Baekdu-Daegan Protection Act", and DMZ cited in the "Natural Environment Conservation Act". The rivers (Five Major Rivers) that are recognized as necessary among national rivers pursuant to the "River Act", and marine ecological networks in accordance with the Conservation and "Management of Marine Ecosystems Act", are stipulated as marine, coastal, and island networks. It is further required

to revise the legal basis so that the national ecological networks stipulated in the "Natural Environment Conservation Act" can be identically presented as the Comprehensive National Environmental Plan pursuant to the "Framework Act on Environmental Policy".

As for the Baekdu-Daegan protection area, they are clearly notified in the form of areas; as for national rivers, the origin and destination, and linear types are separated by notification and ownership; as for marine ecological networks, the origin, and linear types are notified through the Notification of Designation of Marine Ecological Networks, and asterisks. The demilitarized zone does not have a clearly defined spatial area, but it mostly indicates the area from the Military Demarcation Line to the Civilian Access Control Line in accordance with the "Protection of Military Bases and Installations Act"; considering the jurisdiction of the Republic of Korea, it was attempted to define it as a demilitarized zone among the natural reserve areas of the "Natural Environment Conservation Act".

2) Integration of linear ecological network data

The ecological network, which covers the entire country of the Republic of Korea, is a comprehensive core zone covering all areas of the national land environment, and is comprehensively utilized in various environmental sectors, including the conservation, restoration, and management of the natural environment, as well as natural landscapes, atmosphere (wind paths), water resources, and water quality. In the natural environment and biodiversity sector, it can be chiefly utilized to prepare the National Biodiversity Strategy Action Plan (NBSAP) for the adoption of the 'Kunming-Montreal Global Biodiversity Framework (GBF)' and its implementation, as well as to restore and manage the

damaged natural environment.

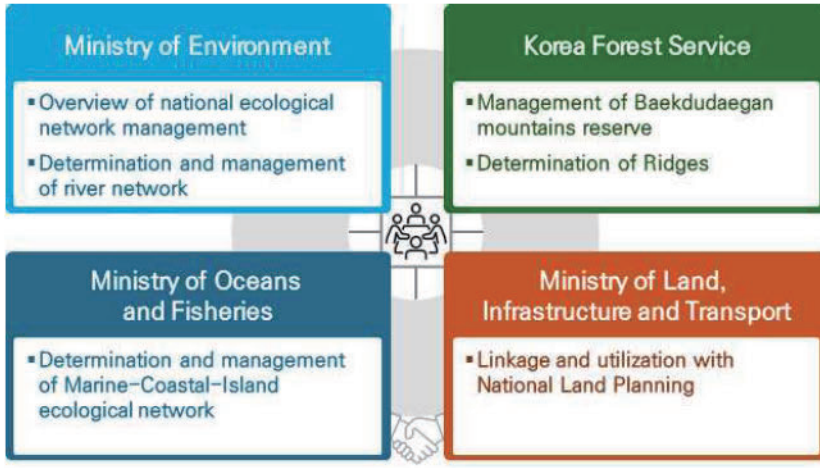
Jeongmaek, which is currently employed as one of the most key zones in constructing ecological networks, is legally stipulated in the Enforcement Decree of the "Baekdu-Daegan Protection Act" as a ridge network connecting mountain ranges originating from Baekdu-Daegan. However, as linear types are not yet clearly determined, they remain a subject of jurisdiction and conflict of interest between the Ministry of Environment, the Korea Forest Service, and the Ministry of Land, Infrastructure, and Transport. In practice, regarding linear types, each ministry has different standards applying to various policies [e.g., Ministry of Environment (Environmental Impact Assessment)/ Korea Forest Service (mountainous district management) / Ministry of Land, Infrastructure and Transport (development restriction zones)], but since there is no specifically agreed linear types of *Jeongmaek,* it is necessary to agree on linear types to ensure policy clarity and coherence.

Since diverse ministries and local governments face conflicts of interest in *Jeongmaek*, it is first necessary to agree on linear type determination among stakeholders, and to this end, a general control tower and governance construction regarding ecological networks centered on the central related ministries are required. To organize a general control tower over various ministries, the 'Council for National Tourism Strategy' can be referred to. The 'Council for National Tourism Strategy' is a statutory body based on Article 16 of the "Framework Act on Tourism", and was established to deliberate and coordinate matters concerning the establishment and coordination of directions and key policies for tourism promotion, the formulation of tourism promotion plans, etc., under the jurisdiction of the Prime Minister. It is stipulated by the Regulations on the Organization and Operation of Council for

National Tourism Strategy (Presidential Decree No. 30186). The Regulations state that the 'Council for National Tourism Strategy' is chaired by the Prime Minister, and consists of 12 ministers including the Minister of Culture, Sports and Tourism, and if necessary, it is also possible for the heads of relevant ministries, and non-members to attend the council. Furthermore, it stipulates the function of the 'Council for National Tourism Strategy', holding meetings, and coordination committees of vice ministers for submitting bills and operating the strategy council efficiently.

Similarly, on the basis of the "Baekdu-Daegan Protection Act" and the "Natural Environment Conservation Act", the '(tentative) National Strategic Council for Ecological Networks' is prepared, a consultative group consisting of the Ministry of Environment, Ministry of Land, Infrastructure and Transport, Ministry of Agriculture, Food and Rural Affairs(Korea Forest Service), and Ministry of Oceans and Fisheries is organized, cooperation on matters related to the establishment of ecological networks and a continuous management and implementation system is explored, and a working-level consultative body is separately established to provide a venue for prior consultation between ministries.

〈Figure 3〉 Composition and details of the National Strategic Council for Ecological Networks (draft)



Source: Created by the Author.

While consensus through consultative mechanisms such as the '(tentative) National Strategic Council for Ecological Networks' is important, if it is necessary to stipulate agreed contents to make it more legally binding and ensure institutional stability, it is also possible to consider the enactment of a joint command between ministries.

The Joint Command on the Integrated Management of Land-Use Planning and Environmental Planning was jointly prepared by the Ministry of Land, Infrastructure and Transport, and the Ministry of Environment (enacted on Mar. 28, 2018, and revised on Mar.14, 2023) in order to strengthen the linkage between two plans for more efficient mutual planning for sustainable land use and environmental conservation. It stipulates procedural and content integration on the basis of the ten points of integrated management in the establishment of national land planning (e.g., comprehensive national territorial plan, provincial comprehensive plan, and Master Plan for City and County) and environmental planning (e.g., Comprehensive National Environmental

Plan, Environmental Plan for City/Province, and Environmental Plan for City/Gun/Gu). It also stipulates the construction and operation of national (vice-ministerial level) and local (vice-mayor, and vice-governor level) planning councils and the process of discussing integrated management matters from the stage of preparing planning guidelines to the determination of the final plan.

To this end, the "Framework Act on Environmental Policy" (Amended on Dec.1, 2015), and the "Framework Act on the National Land" (Amended on Dec. 2, 2016) were amended, respectively, to prevent excessive land development; to achieve the sustainable development through the harmony with the environment, the environmental planning established by the Ministry of Environment and the national land planning developed by the Ministry of Land, Infrastructure and Transport are interconnected, and the establishment cycles are coordinated for the mutual linkage, and the provision of evidence was prepared for the joint command in order to jointly determine the application scope, linkage methods, and procedures.

Such an approach enables securing institutional stability by preparing matters that can be agreed upon and jointly secured for national ecological networks via a joint command. The ecological networks suggested in the "Natural Environment Conservation Act" under the Ministry of Environment and the "Baekdu-Daegan Protection Act", which is jointly managed by the Korea Forest Service and the Ministry of Environment, should be amended to provide evidence for joint interconnections, and a joint command (tentatively titled "Joint Command on Integrated Management of Ecological Networks") can be prepared to determine the consensus and linear types of ecological networks involving the interests of various ministries, as well as the

methods and procedures for their construction.

The joint command may include the following details: purpose - basic idea - definitions - scope of application - relationship with other commands - integration of ecological networks at the national level (National Council of Ecological Networks - Integrated management matters of national ecological networks - utilization of national ecological networks) - Integration of ecological networks at the regional level - sharing of basic data - data disclosure. It can also stipulate matters related to integrations of ecological networks.

'*Jeongmaek*' is the one factor with the most disagreements on linear types of ecological networks. *Jeongmaek* refers to mountain ranges prescribed by the Presidential Decree, which are derived from the Baekdu-Daegan and form water divides of major rivers, specified in Article 2 of the "Baekdu-Daegan Protection Act", and nine types are specified in Article 2 of the "Enforcement Decree of the Act". However, the origin and destination of *Jeongmaek* were stipulated, but there are no main starting points and routes of specific linear types, and since it is most often used in practice, such as environmental impact assessment and identification of damaged areas in development restriction zones, it is necessary to determine and agree on the *Jeongmaek* linear types in order to establish national ecological networks from a unified national land perspective.

In terms of data, *Jeongmaek* is an imaginary line connecting mountain ranges, and the existing linear type data of *Jeongmaek,* which are provided by the Ministry of Environment (EIASS) and Korea Forest Service (FGIS) systems, are distributed and operated in an inconsistent condition. Therefore, it is necessary to first make an agreement between ministries (Ministry of Environment-Korea Forest Service, etc.) on the

consistent linear type data, and based on this, it is necessary to prepare a methodology that can scientifically analyze the actual main ridges of the Korean terrain through joint research and present clear linear types based on evidence.

3) Revision of relevant lower statute

As examined earlier, ecological networks are defined in the "Natural Environment Conservation Act, Framework Act On Environmental Policy", but there are no laws (including enforcement decree and enforcement regulations) that stipulate the hierarchy, composition, and setting of linear types. Furthermore, other laws and regulations, or lower statutes (administrative rules such as command, established rules, and notices), unannounced guidelines, and local government ordinances have little content on the establishment of ecological networks, and most of them focus on the utilization of existing ecological networks. It is possible to confirm the contents related to the application and utilization based on the existing ecological networks such as permitting and authorizing project plans, establishment of survey scope, and identification of target sites. On the other hand, Environmental Plan for City/Province, and Environmental Plan for City/Gun/Gu under Articles 18 and 19 of the "Framework Act on Environmental Policy" are considered important for the establishment of plans to solve local environmental issues at the local government level because they include the establishment of regional ecological networks in their contents. In the 'Guidelines for Environmental Planning,'[4] regional ecological

4) In this study, 'Guidelines for Environmental Planning' refers to the combination of the Guidelines for Environmental Plan for City and Province (Ministry of Environment, 2021d), and Guidelines for Environmental Plan for City/Gun/Gu

networks are suggested to first set in the sense of establishing the spatial structure of the region, and then conducting regional environmental management, and it is also suggested to establish strategies and plans in the ecological environment, natural ecology, and natural landscape in sectoral plans. However, setting regional ecological networks only suggests a broad direction in terms of spatial environmental structure, but specific plan contents and management plans are absent; the survey of disconnected areas (including damaged areas), establishment and restoration of conservation areas, and management plans are included in the ecological environment, natural ecology, and natural landscape parts of the sectoral strategy and plan. The current status of the regional ecological network setting is spatialized (mapped) in the spatial environmental structure plan, but the mapping of strategies and plans for conservation and restoration to manage regional ecological networks, in reality, is insufficient.

'Guidelines for Environmental Planning' consists of general theory – basic principles – planning items and basic research – planning standards per item – establishment procedures and execution. Among them, the matters related to ecological networks are currently included in the planning standards per item, and in terms of the establishment procedure, it is stipulated to present the vision and goals of the plan (Section 5), the indicators, and spatial environmental structure plan (Section 6), and the strategy/plan and spatialization plan per environmental sector (Section 7) in the table of contents of the local governments' environmental plans. Furthermore, in terms of integrated management of land-environmental planning, the establishment of conservation areas and regional ecological

(Ministry of Environment, 2021c) established by metropolitan and primary local governments under the Framework Act on Environmental Policy.

networks is considered to be consistent with the spatial formation direction of the Master Plan for City and County, and key areas are jointly established or inter-connected to integrate ecological networks (preservation networks) in the land-environment sectors. The current 'Guidelines for Environmental Planning' enabled the establishment of conservation areas in terms of regional spatial environment before the 'strategy/plan per sector (Section 7)', and to determine networks by themselves at a regional level (Section 6: Spatial environmental structure plan). However, the practical management details after the plan remain in one section of the strategy/plan per sector (Section 7) - 'Ecological Environment Sector' (City/Province)/'Natural Ecology and Natural Landscape' (City/*Gun/Gu*) -, which may limit the linkage between the two contents.

Therefore, it is necessary to adjust the table of contents in order to prepare practical ecological networks and environmental management measures, by developing implementation plans for conservation, restoration, and management based on spatial environmental strategies/plans, such as determining regional ecological networks, while meeting the purpose of establishing environmental plans. The existing "Section 6: Spatial environmental structure plan" should be deleted, and "regional ecological networks" should be added as a sector in the existing "Section 7: Establishment of Sectoral Strategies (City, and Province) / Plans (City/Gun/Gu)" to establish ecological networks for each metropolitan local government or primary local government.

The ecological networks proposed in local governments' environmental plans should be based on national ecological networks and spatial environmental strategies per zone, which are suggested by the Comprehensive National Environmental Plan, while comprehensively considering the natural ecological and natural landscape conservation

value, biodiversity, and development direction of the region, and ensuring coherence/consistency in order not to undermine the regional ecological networks proposed in the environmental plans when setting the spatial formation direction (e.g., establishment of living areas, and spatial structure planning.) of provincial comprehensive plans and master plans for cities and counties in accordance with the Joint Command.

V. Conclusion

As the mixture of understanding and interest among related ministries in establishing the hierarchy and spatial scope of ecological networks, there has been confusion in implementing relevant policies and establishing various spatial plans. Thus, this study attempted to diagnose the policies, data, and utilization status of ecological networks, and suggest improvement measures. To this end, it investigated, and analyzed the current status and problems of related laws, systems, and policies, as well as relevant literature review. Furthermore, it attempted to suggest the following three policy improvement measures by analyzing spatial data of *Jeongmaek*-based ecological networks used by the Ministry of Environment and Korea Forest Service.

This study confirmed that there are various previous studies related to ecological networks in the Republic of Korea, with a main focus on concepts and scopes of ecological networks, and related management measures, improvement of related laws and systems, and creating datasets of ecological networks. It was found that the clear concept and scope of ecological networks have been handled from different perspectives by different ministries and researchers.

As a result of analyzing the spatial data of ecological networks, it was found that there are differences in the linear types presented by relevant ministries, but the differences in ecological and topographical values within the individual linear type and management areas are insignificant. Next, this study classified the separation distances of *Jeongmaek*-based ecological networks suggested by the Ministry of Environment and Korea Forest Service, in line with the linear type differences as follows.

The distance standards suggested in the classification were determined by referring to the distance of restriction of activities from *Jeongmaek*, which has inherent environmental values mentioned in the laws and systems of relevant ministries. Additionally, as a result of examining whether ecological networks were well considered by utilizing spatial data of projects subject to environmental impact assessments, there were numerous cases of environmental impact assessments that did not mention *Jeongmaek* even though the development site was adjacent to *Jeongmaek*, or that judged the impact of the development to be insignificant by presenting other *Jimaek* instead of a linear type with a close separation distance.

Based on the aforementioned laws and systems, ecological network-related plans, and spatial data analysis, this study proposed three improvement measures.

The first suggestion is the preparation of clearer regulations on the hierarchy, components, settings, and management plans of ecological networks through the enactment and revision of relevant laws, in order to prevent confusion from being incurred when constructing ecological networks. The second suggestion is to integrate the linear data set of ecological networks, to handle an overall control tower and governance of ecological networks through a consultative group consisting of the

central related ministries such as the Ministry of Environment, the Ministry of Land, Infrastructure and Transport, the Ministry of Agriculture, Food and Rural Affairs (Korea Forest Service), and the Ministry of Oceans and Fisheries, and to prepare a system for cooperation and continuous management and implementation systems of matters related to the establishment of ecological networks, in order to achieve the sustainable discussions and development of ecological networks from a national perspective. The final suggestion is to adjust the table of contents of the Guidelines for Environmental Planning, a related lower statute, and present specific implementation measures, in order to facilitate the establishment of ecological networks for local governments in planning.

This study identified problems, and suggested improvement measures to establish rational spatial planning related to ecological networks, it is necessary to contemplate various considerations when discussing related issues for each stakeholder. Since ecological network data were built and utilized according to the unique purposes of each stakeholder, it is necessary to create consensus from the phase of presenting problems. This study indicated the problems incurred when utilizing ecological network data for policy and planning, but it is necessary to predict the problems that can be expected. It is also necessary to prioritize setting principles and standards for the establishment of ecological networks, and to provide a system for consultation by ministries in the short, medium, and long term, in consideration of the organization, tasks, and budgets of each stakeholder. If there is discussion and consensus on the linear type, hierarchy, and scope of ecological networks at the national level, it is possible to establish a plan that fits local situations, including management measures at the regional level. It is expected to be possible

to share the common value of ecological networks, integrate the linear networks, and utilize the networks from a national perspective, eventually enabling the conservation and restoration of ecological networks in a systematic and efficient manner.

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