

Article

Suggestions of Principles to Reduce the Deviation of Steep Slope Evaluation Results through On-Site Evaluation

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Abstract: Geup Kyung Sa Ji (GGSJ) is the term used to refer to steep slopes managed by the Ministry of Interior and Safety (MOIS). The MOIS is a government agency of South Korea in charge of administration and safety, with evaluations and management carried out by local governments. There are 16,071 GGSJs as of March 2022. However, it is difficult to determine whether the evaluation results for these GGSJs are reliable and whether data are managed efficiently. Unlike the Ministry of Land, Infrastructure and Transport and the Korea Forest Service, there are personnel in charge of the relevant administration and welfare operations who are not experts in GGSJs. Therefore, a method for evaluating the currently managed steep slopes and the problems that arise in the process must be identified through evaluation by experts and non-experts in the field. Additionally, methods to increase the consistency and reliability of evaluation results must be determined. This study proposes methods designed to solve the problem of differences in evaluation results caused by the diversity of perspectives on the evaluation of GGSJs and which can be used in the assessment of complex slopes. This study aims to increase the efficiency and consistency of evaluation results in the integrated management of GGSJs to build trust among management staff.

Keywords: steep slope; slope management; natural slope; artificial slope; embankment; vulnerability assessment; slope evaluation



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1. Introduction

In recent times, typhoons, heavy rains, and long-term rainy seasons have been occurring more frequently due to climate change. The rainy season in 2020 brought more than twice the annual average precipitation from late July to mid-August. Landslides caused a lot of damage, which amounted to KRW 393,463,000 in 2020. According to the Korea Meteorological Administration's National Climate Data Centre (KMA), the rainy season and precipitation at 52 locations across the Korean Peninsula have been very unusual from 1 June to 15 August over the past 48 years. A landslide is defined by the United States Geological Survey (USGS) as rocks, debris, or clumps of soil that move along a slope. Typical domestic disaster management agencies that manage disasters, such as landslides, include the Korea Forest Service (KFS) and the Ministry of Land, Infrastructure and Transport (MOLIT), which manages natural and artificial slopes (including retaining walls and embankments) attached to housing sites, local roads, railroads, and park facilities. GGSJs, managed by the Ministry of Interior and Safety (MOIS), are governed by laws [1,2] and include steep slopes around roads, railroads, hiking trails, and residences. Organizations that manage GGSJs include the local government, the local forest service, the Korea Rural Community Corporation, the Korea Land & Housing Corporation, Korea National Railway, the Metropolitan Rapid Transit Corporation of Local Government, and the Korea National

Park Service. As of December 2019, the MIOS managed approximately 16,000 GGSJs. An evaluation grade (A to E) defines an area's risk of collapse and the area is managed accordingly. Evaluation grades are determined based on a disaster risk evaluation table through a pre-selection procedure. GGSJs are maintained to manage risks. There are many steep slopes in the country which are blind spots for damage because they are not designated and managed as steep slopes, and 208 areas have collapsed as of 2020. Notably, 53 out of 208 steep slopes are classified as A or B grade and are therefore considered unlikely to collapse. Hence, it is crucial to establish an evaluation principle for steep slopes and reduce the differences in evaluation results between evaluators.

Steep slopes, such as GGSJs, have similar characteristics to artificial slopes managed by overseas road management agencies. The utilization of institutions has improved with the development of a hazard rating system [3], and a study [4] on slope failure according to site conditions is also in progress. There are differences in the evaluation methods (survey sheets, rating systems, inventories) presented in [5–11]. However, they all have clear goals for investors. Ref. [12] analyzed strengths and weaknesses by summarizing the parameters of the survey sheet in [5–11]. These studies involved structures like steep slopes. The roles and methods of investigators were summarized in detail and the investor clearly explained the goals. However, equipment is used and systems are in place which, together with [13,14], serve to minimize the subjective interventions of investors. Ref. [15] is a study on risk knowledge involving a structure similar to a GGSJ. Refs. [16,17] are studies on the evaluation of slope. However, these studies do not discuss the problems of evaluation results depending on investigators' capabilities. According to [18,19], in the United States, the Colorado Rockfall Simulation Program (CRSP), a simulator applicable to various slopes, has been developed. However, detailed site conditions depend on data quality.

Knowledge of a site is needed to evaluate its condition and obtain reliable results. This study provides domestic GGSJ evaluation guidelines enumerated by non-experts. However, owing to field conditions, such as unexpected shapes and the inaccessibility of GGSJ sites, it is difficult to ensure the reliability of the results of on-site evaluation processes. Inconsistent evaluation grades result from different evaluation principles and the lack of unified standards. Accuracy may be intentionally undermined by external political influence and the intervention of subjective judgment. The instability of the evaluation methods and non-compliance with evaluation procedures also affect accuracy. Calculation and evaluation grades will remain inconsistent without defined evaluation methods and standards to be observed during the evaluation of GGSJs (natural and artificial slopes, retaining walls, and embankments). In this study, an on-site evaluation involving 12 experts and 33 places was conducted, opinions were collected, and principles to be observed when evaluating GGSJ disaster risk are presented. The aim of the study is to improve the accuracy and ensure the objectivity of evaluations through compliance with evaluation procedures. This study is about the evaluation of steep slopes in all regions, not in any particular region. If the study is recognized, the methodology may be used in areas with problems where non-experts have no choice but to manage steep slopes. The most important objective of this study is to establish suitable criteria for solution of the problems related to steep slopes through recognition of the diversity of the criteria employed by different investigators.

2. Scope and Process of Research

2.1. Study Area Selection

The MOIS carries out evaluations through classifications of natural slopes, artificial slope, retaining walls, and embankments. In this study, the evaluation was conducted by dividing these categories into eight subcategories (natural rock, natural soil, artificial soil, artificial rock, concrete retaining wall, reinforcing earth retaining wall, stonework, and stone mesh), reflecting the classification system in [20]. The management registry of GGSJs contains general addresses. Thus, it is challenging to locate the sites accurately. Therefore, a preliminary survey was first conducted for three weeks in August. The on-site investigation with experts was conducted for ten days, from 27 September to 15 October. Twelve GGSJ

experts participated in the on-site evaluation. They were either in charge of developing and modifying the GGSJ evaluation table or of conducting the evaluation on behalf of the GGSJ Association. Table 1 shows the schedules, regions, and types of field evaluation.

Table 1. Dates and times of site evaluations along with information about the locations, structures, and types of GGSJs.

Date	Region (Si)	Selected Evaluation Target Site
		GGSJ Structure, Type, and Number of Locations
27 September	Samcheok-Si	Natural soil slope 1, artificial rock slope 2
28 September	Donghae-Si	Natural soil slope 2, natural rock slope 1, artificial gabion slope 1
29 September	Gangneung-Si	Natural rock slope 2, natural gabion slope 1
30 September	Gangneung-Si	Natural rock slope 1, artificial soil slope 1,
5 October	Jeongseon-Si	Artificial rock slope 1, artificial soil slope 2
6 October	Jeongseon-Si	Artificial stone embankment and retaining wall 1 Artificial retaining wall 2
12 October	Eumseong-Guen	Artificial rock slope 4, artificial retaining wall 1
13 October	Boeun-Guen	Artificial stone embankment 1
13 October	Cheongju-Si	Artificial retaining wall 2
14 October	Osan-Si	Artificial stone embankment 1, artificial retaining wall 1
15 October	Anseong-Si	Natural soil slope 1, artificial soil slope 1, artificial stone embankment 1, artificial-retaining wall 2

2.2. Research Process of GGSJ Assessment Principles

This study aims to investigate complex cases of GGSJ risk evaluation and to present an evaluation method that can be used to respond to them. The study was conducted according to the process outlined in Figure 1, which divided into two parts. In the first step, a preliminary investigation was conducted. To establish the GGSJ evaluation criteria, problems that may arise in evaluation were identified in advance through GGSJ type segmentation, evaluation table self-investigation, and interviews with local government GGSJ managers (evaluation agents). In the second step, risk assessments of selected evaluation target sites were conducted. While evaluating on-site single-slope evaluations by one to five experts, uncertain criteria that led to discrepancies between the evaluation results were identified and the evaluators’ opinions on the solutions to be found were solicited. If there was a disagreement, a valid basis and a method agreed on by most experts were presented. If the opinions were divided, key points to be considered in the GGSJ evaluation were derived from the evaluation methods and the principles of the Ministry of Land, Infrastructure and Transport.

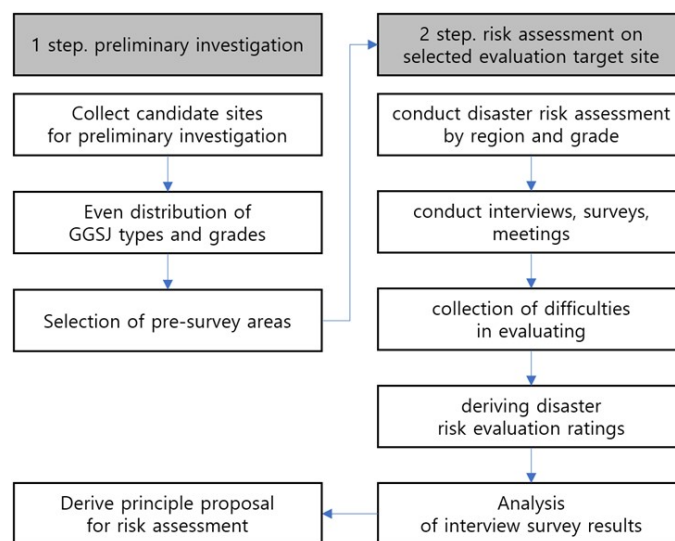


Figure 1. Flow chart of the research process.

Table 2. Cont.

N	Data from MOIS		1st Expert		2nd Expert		3rd Expert		4th Expert		5th Expert		Std.
	Type	Grade	Type	Grade	Type	Grade	Type	Grade	Type	Grade	Type	Grade	
9	(5)	D	(5)	C									
10	(5) Complex slope	C	(4) (5)	D B									
11	(7) Complex slope	B	(4) (7)	D C									
12	(6) Complex slope	B	(6) (5)	C C									
13	(2)	C	(4)	C	(2)	C							4.5
14	(1)	C	(1)	C	(1)	C							4
15	(2)	B	(4)	B	(4)	B							2.5
16	(2)	C	(3)	B	(3)	B							12.5
17	(3)	C	(3)	D	(3)	C							6
18	(3)	B	(3)	C	(3)	C							9
19	(4)	C	(2)	D	(2)	D							2.5
20	(4)	C	(4)	C	(4)	D							10
21	(5)	C	(5)	C	(5)	C							7
22	(8) Complex slope	C	(3) (8)	C A	(3) (8)	D A							10.5 0.5
23	(5) Complex slope	C	(5) (7)	C C	(5) (7)	C C							3 1
24	(5) Complex slope	C	(4) (5)	D D	(4) (5)	D C							0 11.35
25	(8) Complex slope	D	(3) (7)	C C	(3) (7)	C C	(3) (7)	C B					4.64 6.18
26	(5) Complex slope	B	(4) (5)	C B	(4) (5)	C C	(4) (5)	C B					2.49 5.44
27	(6) Complex slope	D	(6) (7)	D D	(6) (7)	C C	(6) (7)	D D					10.27 11.09
28	(7) Complex slope	C	(3) (7)	D C	(3) (7)	C B	(3) (7)	C C					2.6 8.6
29	(5) Complex slope	D	(3) (5)	C A	(3) (5)	E B	(3) (5)	C A					20.07 6.34
30	(5)	A	(5)	C	(5)	B	(5)	C					5.5
31	(7) Complex slope	A	(4) (5) (8)	D B C	(4) (5) (8)	B B B	(4) (5) (8)	C B B	(4) (5) (8)	C B C			12.23 3.09 4.6
32	(2)	B	(4)	B	(4)	B	(4)	C	(4)	C	(4)	C	6.86
33	(4)	B	(4)	C	(4)	C	(4)	B	(4)	B	(4)	C	6.47

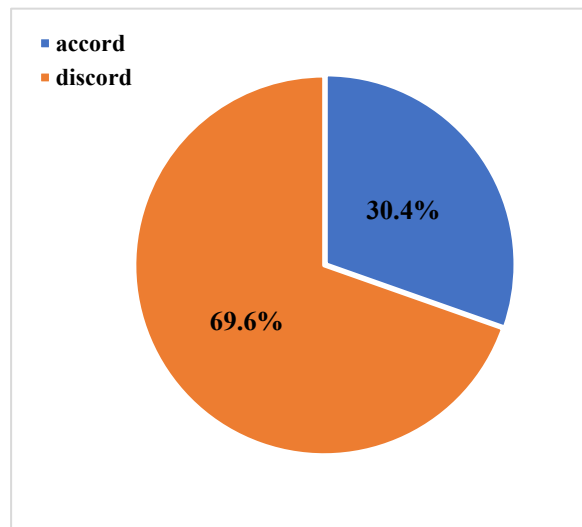


Figure 2. Rate of consistency between experts and management staff.

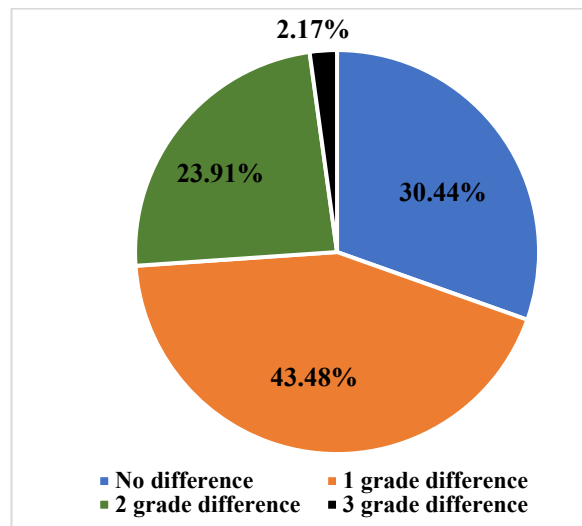


Figure 3. Differences in evaluation grades between experts and management staff.

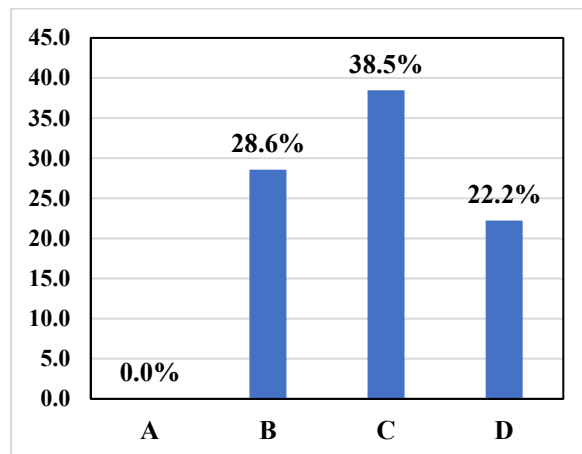


Figure 4. Rates of agreement between experts and management staff by ratings.

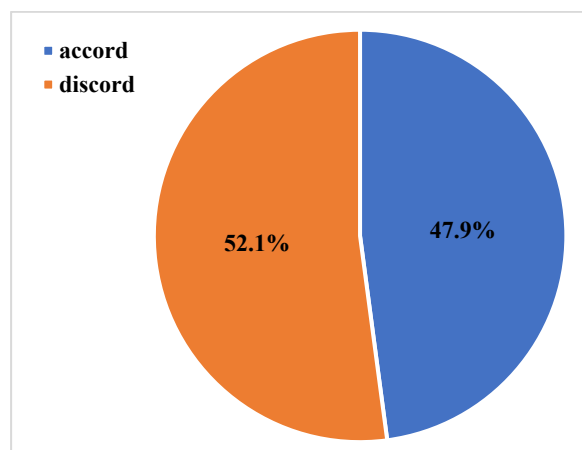


Figure 5. Slope type selection consistency.

Regarding slope type selection, the agreement rate between practitioners and experts was 47.9%, indicating that less than half of the slopes were being evaluated as the right type of slope. These comparisons show that the lack of a standard evaluation method causes inconsistent results even if the same evaluation table is used. Thus, the evaluation results for GGSJs managed by the MOIS in Korea are rendered questionable. It is therefore necessary to introduce a standard evaluation method to ensure consistency. The GGSJ evaluation grades are numerically stratified in bands of 20 points. For example, a score of more than 60 points would translate to a D grade while a score of 59 points would translate to a C grade, the one-point difference determining whether a slope is designated as a collapse-risk area the maintenance of which is to receive support from the government budget. There is room for the intentional adjustment of evaluation grades through subjective judgment. Therefore, it is necessary to minimize the differences in scores by establishing standard criteria and evaluation methods.

3.2. Deriving the Problems of the Current Evaluation Method through Field Expert Evaluation

This section summarizes the results of the interviews and surveys undertaken to increase the consistency and reliability of evaluation results. Currently registered and managed GGSJ sites were selected for the field evaluation. The local government managed these sites, and their selection, evaluation, and management history were unclear. Unlike in foreign countries where GIS-based platforms manage similar structures, it was challenging to identify the sites' exact locations, which made it difficult for the experts to conduct their field evaluations. Various problems occurred during the evaluations owing to the absence of a standard evaluation method. The two procedures which vary among experts in GGSJ evaluations are: (1) the determination of the scope of an evaluation; and (2) the selection of the type of assessment table to be used.

Difficulties arise in determining the scope of an evaluation on a large and on a small scale. It is challenging to select the scope of a GGSJ slope on a large scale. The difficulty lies in the criteria for each index of the evaluation table on a small scale, as the existing guidelines for GGSJs do not include a clear definition of steep slopes for the purposes of classification. According to a recent report by the steep slope association, it is appropriate to divide the evaluation around the valley. However, while some of the 16,071 steep slopes being managed are approximately 10–30 m, there are also some which are more than 100 m. However, they are designated and managed under a single management number. Thus, there is no way to distinguish a GGSJ when evaluating and designating it as a registration management target. Therefore, regardless of the length of the GGSJ, a single risk assessment result is derived. Figure 6 shows a GGSJ spanning 500 m, and the evaluation was performed using a single evaluation table. As every meter of the slope has different material properties, it is difficult to determine the point and range to be evaluated

during the field evaluation. When performing the evaluation, the state differs depending on where the evaluator is located and the time of viewing. In general, the evaluator scans the entire slope and performs the evaluation.

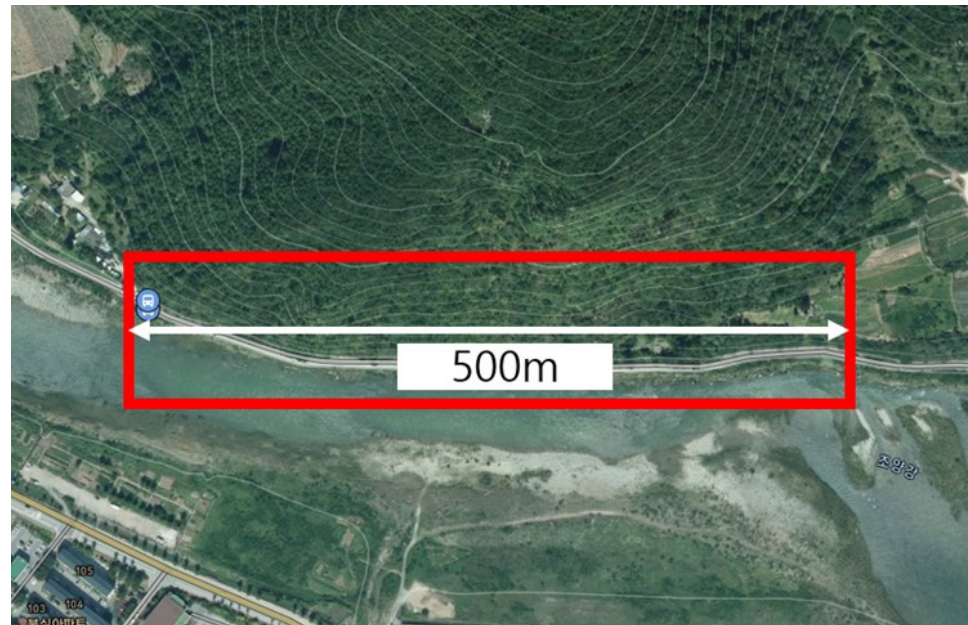


Figure 6. GGSJ area with a length of 500 m.

The evaluations by experts and management staff are dependent on their locations at the time of evaluation. Therefore, even with the same slope, there are differences in evaluation results, as shown in Table 2, and the evaluation scores are inconsistent, as shown in Figure 2. Thus, it is necessary to propose a standard evaluation method for various GGSJs.

The selection of assessment table type is another concern during evaluation. The following question arises when evaluating a complex slope: “Which evaluation table should be used for the GGSJ, and which structure and type should be used as data?” Looking at the evaluation results of the complex slopes among the types in Figure 2, it can be seen that if the assessment table types used in field evaluations differ, the results of steep slope evaluations will differ accordingly. Therefore, since type selection is a significant factor in determining the grade of a slope, different scores and grades are likely to be derived by each evaluator, which is a key point that requires the introduction of a standard. As shown in Figure 7, when a slope is made of one material, the structure may be recorded as rock and evaluated using an artificial assessment table. There is also a problem with evaluating soil and rock simultaneously because there is only one artificial assessment table. Nonetheless, there is no problem with the records of the management ledger. However, as shown in Figure 8, a single type is very rare in GGSJs. As shown in Figures 8–10, there are many complex forms in which rock, soil, concrete embankment and gabion exist together in artificial or natural slopes. The GGSJ evaluation table currently consists of only three types (natural slopes, artificial slopes, and embankments). Therefore, the evaluation table to be referred to and the structure and type to be used for data management need to be determined if the slope consists of a diverse composition of materials. This problem may arise when the MOIS manages steep slopes. Figure 11 shows the register format used by the Ministry of Public Administration and Security in 2020, divided into Purpose, Structure, Type, etc. For example, No. 2 Si-do in Figure 11 is complex artificial. It is classified as complex and is depicted in Figure 10. The type is artificial, but it is not known which assessment table was selected for the evaluation. For experts, evaluation can be performed by selecting critical types among structures and types based on experience. However, the

reality is that it is difficult for local government officials to perform an evaluation and select a collapse risk area. Evaluations are undertaken in areas for which it is challenging to select an evaluation table, interpret managed data, and determine the GGSJ to be managed because there are no set rules. Therefore, when evaluating GGSJs, selecting an evaluation table and proceeding with the evaluation according to a standard method is essential to create a management system that everyone can understand.



Figure 7. Single type (artificial rock) GGSJ.



Figure 8. Complex GGSJ (concrete, gabion, artificial soil).



Figure 9. Complex GGSJ (artificial rock slope, concrete embankment).



Figure 10. Complex GGSJ (artificial soil slope, artificial rock slope, gabion, concrete embankment).

Si-do	Si, gun, gu	Ueb, myun, dong	Address	Purpose	Structure	Type	Name	Administrative institute	Public / Private
1	Gangneung	Wangsan-myeon	302-5 Godan-ri	Road	complex	natural	Gordan 118th District	Gangwon-do Road Management Office	Public
2	Gangneung	Wangsan-myeon	821-1 Daegi-ri	Road	complex	natural	Daegi 120th District	Gangwon-do Road Management Office	Public
3	Gangneung	Wangsan-myeon	768-4 Daegi-ri	Road	complex	natural	Daegi 121th District	Gangwon-do Road Management Office	Public
4	Gangneung	Wangsan-myeon	811 Daegi-ri	Road	complex	artificial	Daegi District	Gangwon-do Road Management Office	Public
5	Gangneung	Wangsan-myeon	1-1 Eoheul-ri	Road	complex	natural	Seongsan 125th District	Gangwon-do Road Management Office	Public
6	Gangneung	Wangsan-myeon	847 Daegi-ri	Road	complex	natural	Seongsan District	Gangwon-do Road Management Office	Public
7	Gangneung	Wangsan-myeon	181 Daegi-ri	Road	complex	natural	Wangsan 123th District	Gangwon-do Road Management Office	Public
8	Gangneung	Wangsan-myeon	715-4 Daegi-ri	Road	complex	natural	Wangsan District	Gangwon-do Road Management Office	Public
9	Gangneung	Naegokdong	9-2	House	Rock	natural	Naegok District	Gangneung	Public
10	Gangneung	Gangdong-myeon	45-49 Aninjin-ri	Park	embankment and wall	natural	Security Exhibition Hall	Gangneung Tourism Development Corporation	Public
11	Gangneung	Gangdong-myeon	114-1 Simgok-ri	House	Rock	natural	Gangdong Simgok District	Gangneung	Public
12	Gangneung	Gyodong	163-1	House	Soil	artificial	Gyo-2dong District	Gangneung	Private
13	Gangneung	Gyodong	11-30	House	Soil	artificial	Gyo-1dong 3th District	Gangneung	Private
14	Gangneung	Gujeong-myeon	285-0 Jebi-ri	Road	embankment and wall	artificial	Jebi-ri 1th District	Gangneung	Public
15	Gangneung	Yeongok-myeon	273-1 Samsan-ri	Road	Soil	artificial	Yeongok Samsan 3th District	Gangneung	Public
16	Gangneung	Noam-dong	740-2	Park	Soil	natural	Noam District	Gangneung	Public
17	Gangneung	Gyodong	739-1	House	Soil	natural	Gyo-1dong 2th District	Gangneung	Private
18	Gangneung	Gangdong-myeon	494-10 Jeongdongjin-ri	Road	Rock	natural	Jeongdongjin District	Gangneung	Public
19	Gangneung	Gujeong-myeon	285 Jebi-ri	Road	Soil	artificial	Jebi-ri District	Gangneung	Public

Figure 11. GGSJ data management format of the MOIS in 2020.

4. Results and Discussion

The purpose of evaluation criteria is to resolve the inefficiency of management through consistency and reliability in field evaluations. We gathered expert opinions through interviews and questionnaires for suggestions relating to (1) decision methods for GGSJ evaluation and (2) GGSJ assessment table type selection. When there was a conflict of opinions about the principles to be adopted, the majority opinion was accepted. Other suggestions were considered by the MOLIT and the Korea Forest Service.

4.1. Length Range in Slope Evaluation

Range classification in slope evaluation needs to be considered because GGSJs of longer lengths are managed as single management areas. Three criteria for dividing an evaluation range were considered in this study based on expert interviews and survey results. First, the evaluation unit (extension standard) used by the Facilities Corporation was determined, with the evaluation being conducted at intervals. Three out of twelve people opted for the method, and the average grade of the entire slope was lowered in the case of a slope spanning 500 m, such as the one shown in Figure 12. There is a problem in that subjectivity is involved in determining the section to be designated. If the average grade is lowered, there is room for exclusion from the designated management list despite the area being at high risk. Opposite cases may also occur despite low risk.



Figure 12. GGSJ management district with a length of 500 m.

Second, an evaluation target was evaluated by separating it relative to a valley. Four out of twelve people opted for this method, and it was the most appropriate method for distinguishing the range. This is also the method used by the MOIS. However, it is necessary to separate the start and end points for the valley and to evaluate the slope between valleys when evaluating such a site. The subjective judgment of the evaluator determines this. Structures and safety levels differ between valleys. Furthermore, it is easy to select the criteria of the evaluation index if one side is in the same state as that in Figure 12A. However, if the structure or safety grade is different, such as Figure 12B,C, the criteria for evaluation will be disrupted. The right part of the slope (B) has a high stability grade because the gabion and concrete wall improve safety. The left part has the same shape as an unstable slope because there is only a small concrete wall at the bottom. Thus, the safety of slope (B) cannot be ascertained. If the average is used, grade D can be upgraded to grade C. However, disasters are not managed this way. It is best to reduce the damage, regardless of cost. Disaster prevention is possible only when approached with a methodology for preventing maximum losses. Therefore, the most reasonable method to suggest for use as a standard is to select the evaluation criteria based on the most dangerous

point of the slope. In addition, the method selected by eight out of twelve experts must be considered. In selecting the extension, condition, and length of a range, without subjective judgment, it is possible to make the selection according to the detailed description for a photo and a guide, thus preventing intentional damage. This can lead to consistent evaluation grade determination for GGSJs nationwide for the effective management of GGSJ DBs. It is necessary to evaluate a critical point to be managed, where maintenance projects can be achieved, so as to prevent disasters.

4.2. Assessment Table Type Selection

The photos and management tables show that natural slopes, artificial slopes, and embankments are often complex. By definition, an artificial slope is a slope produced in a development. Thus, instability is inherent and retaining wall facilities are used to improve safety as a structural measure. Twelve of the thirty-three sites where the field survey was conducted were made up of complex slopes. Although there was an assessment guideline when the experts conducted the evaluation, there was discussion about whether it would be meaningful to evaluate the concrete bedrock with an artificial evaluation table when exposed, as shown in Figure 10. The opinion that the safety of the concrete wall and the safety of the upper rock should be considered as one was dominant. Similarly, with regard to the retaining wall and the stone mantle shown in Figure 9, controversy arose over whether it would be possible to make an accurate evaluation for the retaining wall and embankment with one evaluation table. The slopes in Figures 9 and 10 were evaluated as artificial slopes. The problem here was that it was difficult to check the state of each material.

Therefore, for the slope in Figure 9, the evaluation table, with the consent of 9 out of 12 experts, was evaluated three times by determining the emblem, gabion, and the artificial slope attached to it as the respective materials. There are two advantages to the conduction of an evaluation in this way. First, accurate evaluation results can be obtained because evaluation can be performed for each structure. Therefore, a dangerous structure cannot be ignored because a comprehensive at-risk judgment is not warranted overall. Second, efficiency in GGSJ data management is increased. Suppose all types are recorded as management DB and stored as the representative grade of the area where the low grade is evaluated. In that case, the confusion over selecting and evaluating on the basis of the evaluation table from the viewpoint of the evaluator is reduced, and consistent and reliable data management can be achieved.

5. Conclusions

This study re-evaluated existing managed GGSJs. The goal was to propose an evaluation method to improve the efficiency of management by solving the difficulties in the evaluation process. To achieve the research goal, the following steps were conducted: first, various slopes were selected for a field survey and the survey was performed and evaluated by experts. Second, by analyzing the evaluation results of the experts, difference in grades were confirmed. Third, the necessity of having a standard evaluation method was justified by comparing the evaluation results among experts and confirming the deviation of the evaluation results. Fourth, during the evaluation, the problems encountered were recorded and analyzed in terms of the two aspects of evaluation and management, and solutions were sought. Fifth, the methodology for managing slopes was reviewed, and appropriate solutions were presented through expert interviews and questionnaires. Finally, the results of the study led to a conclusion about the two aspects of results and discretion.

In conclusion, the method for determining the scope of a GGSJ and selecting the evaluation table type should be based on safety and not on subjective judgment. At the time of evaluation, it is necessary to move in the direction of data management by evaluating all types without being concerned about the type of assessment table used. Various kinds of slopes are encountered during evaluations. In the GGSJ evaluation and management system, where experts also generate mixed evaluation results, the difficulties

for practitioners are further revealed. Countless issues in small units are selected for each index of the evaluation table. However, without a standard from a large-scale perspective, the evaluation results and managed data will inevitably become meaningless. In addition, the current GGSJ guidelines present an evaluation method and scope for each index; however, many of the current problems deviate from the business guidelines. Therefore, this study focused on maximizing the efficiency, consistency, and reliability of field evaluation and management methods. Additionally, this study focused on GGSJs and cannot be fully generalized for other geospatial distributions. However, it can be generalized to some extent if a similar research procedure to that employed in this study on field evaluation results is carried out.

There are limitations to the field surveys of this study. During the evaluation, as the experts were familiar with the existing evaluation method, there were times when the evaluation was conducted without fully following the work manual. In addition, it may have been difficult to make the assessments because the slopes were not fully exposed during the evaluation owing to bushes. However, this does not affect the field evaluations. Thus, it is considered acceptable to some extent. Supposing that the MOIS introduces legal and administrative changes to the relevant principles and the conduction of on-site evaluations, it will be possible to judge the legitimacy of the results in light of this study by confirming the similarity of the evaluation results of practitioners and experts. In addition, the MOIS will be able to increase the efficiency of its management system. This study analyzed the causes of differences in evaluation results in on-site evaluations and has suggested criteria to reduce such differences. More work is needed for the validation of this study so that it can be applied more widely. While applications will be valid in areas where there are differences in on-site evaluation results, additional research and analysis are required for other areas.

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