The way to Improve Cadastral resurvey project with making Google Street View using 360 Camera

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SUMMARY

In Korea, cadastral resurvey project is underway. The cadastral resurvey project area is where the boundaries on the drawing do not match the boundaries in reality. Therefore, landowners in the area experience many restrictions in exercising their property rights. In order to solve this problem, surveyors adjust the boundaries of the drawings based on the real boundaries through the project.

However, since the scale of the project varies from region to region, it takes a lot of time to check and adjust each land. Many surveyors in Korea visit the site when they need to adjust the boundaries. Because it's too different about the project quality without seeing(visiting the lands) or with seeing. Also, boundary adjustment is crucial and should be confirmed by site visit and mutual understanding between landowners.

Surveyors usually use drone orthophoto to check how the land is used. But it has limitations for verification because orthophotos are only taken vertically. Therefore, we needed a tool that would give us a horizontal visual tour of our project area.

So this project suggests how to use Google Street View to save time to visit the site each time and explore the project area anytime, anywhere. Therefore, the project aims to improve the efficiency of boundary adjustment by making it as if the surveyor is in the project area, and to ensure the credibility of the project through smooth communication with landowners.

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1. Introduction

Discusses the ongoing cadastral resurvey project in South Korea, focusing on resolving land record discrepancies and establishing a digital cadastre. The project has gained momentum with the implementation of a responsible institution system and the integration of drone imagery, aiming to shorten the project duration and enhance efficiency. This new system has fostered a cooperative framework between LX Korea Land and Geospatial Informatix Corporation, a public entity, and private companies, moving away from a competitive model to one of collaboration, thereby expecting to reduce project timelines and foster a symbiotic relationship.

Furthermore, it's mandated by law for the responsible institution to engage in unmanned aerial photography in cadastral resurvey areas and upload the orthoimages to the cadastral resurvey administrative system for shared use. However, the Aviation Safety Law Article 79 restricts aerial photography in certain cases, limiting the use of drone-captured orthoimages in decision-making and operational efficiency. The document acknowledges the challenges of drone photography, particularly when it's not possible due to legal restrictions or when aerial images are obscured by shadows or vegetation.

To address these issues, surveyors often resort to road view images from portal sites. However, these images usually lack currency and specificity for the project areas, presenting limitations in verification processes, boundary adjustments, and consultations. Additionally, regions difficult for vehicle access, such as ridges or forest roads, are often included in cadastral resurvey project areas, but are rarely covered by conventional road views. This gap necessitates surveyors to manually capture these areas, ensuring comprehensive and up-to-date imagery is available for convenient use in the project.

The text concludes with the aim of this approach being to improve the efficiency and trustworthiness of the cadastral resurvey project. By providing easy access to current and comprehensible visual information, similar to a physical presence at the site, the project aims to enhance its effectiveness and contribute to the development of a digital cadastre.

2. Current Status and Problems of Cadastral Resurvey

The legal system in South Korea regarding land registry defines boundaries based on cadastral maps rather than actual physical boundaries. Since the land survey project of the 1910s, the preserved maps have inevitably aged over a century.
Additionally, the cadastral records have been damaged by events like the Korean War and natural disasters. These various factors have led to the creation of lands where cadastral records do not match the actual state, known as cadastral mismatches. In response, the government established the "Special Act on Cadastral Resurvey" in 2011 and has been conducting the cadastral resurvey project since 2012 to resolve the discrepancies between reality and cadastral records.

The aim of the cadastral resurvey project is to correct the registration details in cadastral records that do not match the actual state of the land and to convert the paper-based cadastral system into a digital format, thus efficiently managing national land and protecting citizens' property rights.

The cadastral resurvey project was originally contracted to be carried out independently. In the past, for the contract settlement of the cadastral resurvey project, the public organization Korea Land and Geospatial Informatix Corporation and private companies registered in cadastral surveying had to compete.
To promote efficiency in project implementation and eliminate this competitive structure, the Ministry of Land, Infrastructure, and Transport introduced the responsible institution system. Korea Land and Geospatial Informatix Corporation, selected as the responsible institution, was entrusted with the cadastral resurvey project and aimed to increase efficiency by subcontracting some of the project processes to private companies without competitive bidding.

Indeed, after the introduction of the responsible institution system, the participation rate of private companies in the project increased by about 35%, achieving the goal of expanding private sector involvement. Additionally, the start of the project in each district has been moved up from around June to February or March .

<table>
<tr><td>Surveying of district boundaries</td><td>Individual land surveying</td><td>Area measurement and calculation</td><td>Preparation of land status survey reports</td><td>Boundary adjustment and consultation</td></tr>
<tr><td>LX (Public Corp.)</td><td colspan="3">Private</td><td>LX (Public Corp.)</td></tr>
<tr><td>Installation of confirmed boundary points</td><td>Boundary confirmation survey</td><td>Preparation of cadastral confirmation advance reports</td><td>Preparation of ground boundary point registers</td><td>Production of outcomes</td></tr>
<tr><td colspan="5">LX (Public Corp.)</td></tr>
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Table 1 Cadastral Resurvey Project Processes and Roles after the Implementation of the Responsible Institution System

As shown in Table 1, private companies are responsible for individual land surveying, area measurement and calculation, and preparation of land status survey reports in the entire

process of the project. The processes managed by private companies lay the foundation for the cadastral resurvey project, where individual land surveying creates future status survey files, and area measurement and calculation serve as the basis for boundary adjustment data.

Additionally, the preparation of land status survey reports is essential as it captures the basic information of the land, serving as a vital resource for future boundary adjustments and consultations. Before the implementation of the responsible institution system, private companies with less experience in cadastral confirmation surveying often showed significantly lower satisfaction rates, leading to authorities being reluctant to appoint these companies as surveyors.

Therefore, after being selected as cadastral resurvey agents, it was considered important to train them in individual land surveying methods and related tasks, considering the specific characteristics of the actual survey area. Especially for the complex cadastral resurvey projects, field experience is deemed essential for efficient execution, and it has been found that 2-3 prior project experiences are necessary for effective performance. Since private companies handle the actual fieldwork under the responsible institution system, there can be insufficient site understanding compared to previous solo projects if the responsible institution does not participate in the initial overall fieldwork. To resolve this issue, it is suggested that the responsible institution should conduct more meticulous verification of the outcomes.

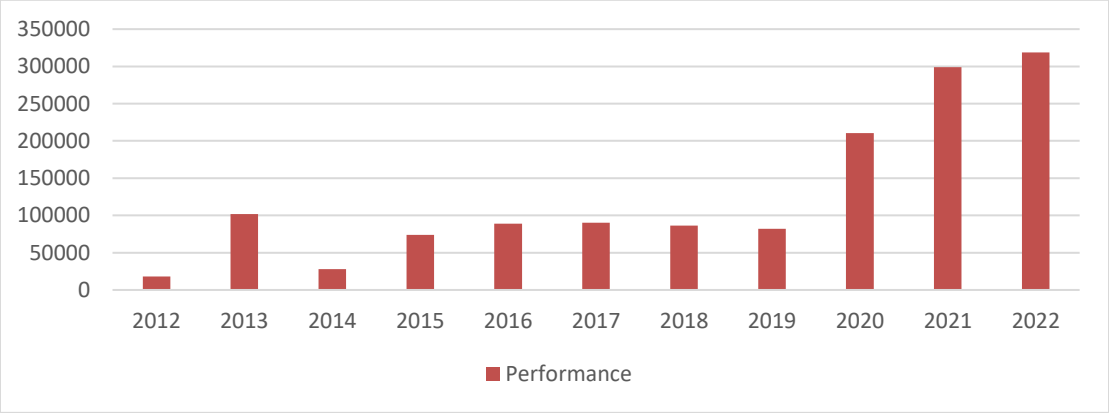

Figure 1 Annual Performance of Cadastral Resurvey Project
Data: Ministry of Land, Infrastructure and Transport Press Release (2022. 1. 25), "Ministry of Land, Infrastructure and Transport to Fully Expand Cadastral Resurvey Project in 2022"

From 2012 to 2019, the average annual performance of the cadastral resurvey project was about 80,000 parcels, but in 2020 it was about 210,000 parcels, in 2021 about 300,000 parcels, and in 2022 about 320,000 parcels, which is more than four times the average of previous years. Despite continuous efforts to shorten the project duration, the average completion time for one district is still 1.5 to 2 years. In the context of ever-accumulating backlog, it is not easy for surveyors to meticulously review and execute the project for each parcel.

Category		Total	'12	'13	'14	'15	'16	'17	'18	'19
Objections	Boundary Decisions	3,132	91	460	99	290	868	381	647	296
	Adjustment Money	2,604	91	320	87	151	530	515	871	39
Administrative Lawsuits	Lawsuits	80	6	14	9	14	16	21	-	-
	Judgments	177	2	18	13	35	58	48	1	2

Table 2 Status of Complaints and Litigations Related to Cadastral Resurvey Project (Unit: Cases)
Data: Revised Basic Plan for Cadastral Resurvey, Ministry of Land, Infrastructure and Transport

Furthermore, despite the completion of the cadastral resurvey project, ongoing disputes and grievances related to unrecognized adjustment payments in boundary determinations continue to be raised, affecting overall project satisfaction. To address these issues, unlike previous projects that primarily based their work on actual physical boundaries, the current approach flexibly operates on agreed boundaries among landowners to minimize the occurrence of adjustment payments.

Not basing boundary determinations on physical boundaries but on agreed boundaries requires surveyors to confirm these boundaries on-site and communicate thoroughly with landowners. However, detailed land conditions cannot be fully grasped through observed survey data and drone imagery alone, necessitating site visits for establishing agreed boundaries, which can disrupt the smooth execution of the project. Presently, such issues mainly arise during the individual parcel verification and boundary adjustment and consultation stages.

2.1 Individual Parcel Verification

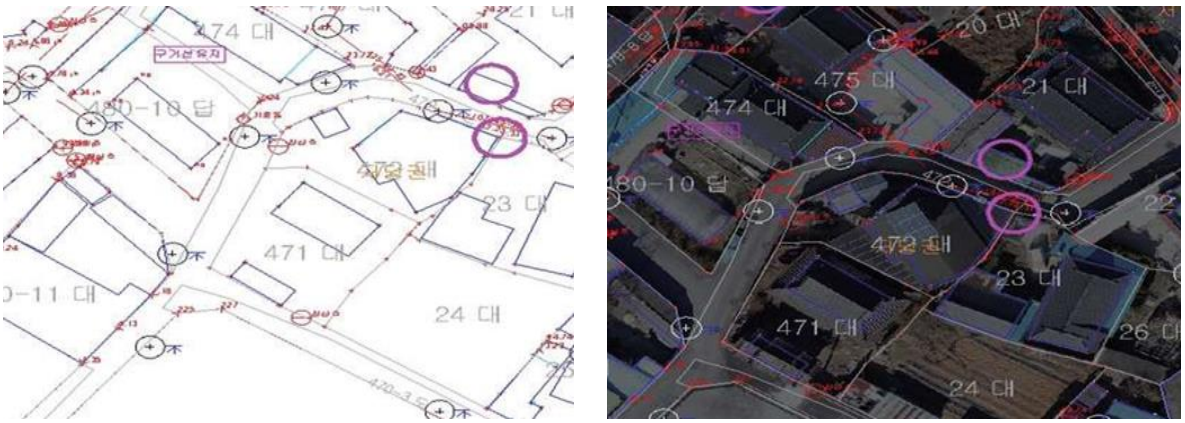

Figure 2 Example of Individual Parcel Verification

Private companies conduct individual parcel surveying and submit the observed files and land status survey reports within the project district. The responsible institution then verifies the surveying results by comparing them with the actual physical boundary results. This involves checking whether observation points have been accurately surveyed according to boundary setting standards, verifying temporary boundary markers installed by agents, or using drone imagery to understand the overall land situation and identifying points that require re-surveying. The verification of individual parcel surveying results is conducted

within 10 days of receiving the survey results (extendable to a maximum of 10 days in consultation with the cadastral authority). Achieving high-quality project goals requires meticulous on-site verification through field visits, but realistically, it's challenging to check and contrast each district's field situation with the survey files daily within the verification period.

2.2 Boundary Adjustment and Consultation

After the individual parcel verification, the responsible institution confirms with the landowners about any disputes in ground boundaries, and adjustments and consultations are conducted in consideration of the owners' opinions and in consultation with the cadastral authority. Most boundary adjustments and consultations are currently conducted through public meetings held at community centers like village halls. It's not feasible to conduct on-site verifications for every parcel.

Therefore, explanations about the current situation are given to landowners by comparing drone-captured images with observed files, and their opinions are sought during the consultation process. However, it's difficult to fully grasp the specific land use and site conditions just by contrasting the drone imagery with the survey reports and observed files provided by the agents, potentially leading to inadequate communication with landowners.

Often, temporary boundary markers are misplaced or need repositioning due to the absence of landowners or stakeholders during their installation. This results in landowners not fully understanding how their parcels have been surveyed. The observed points in the survey files do not always fully reflect the boundary information. Typically, explanations about specific boundary points are necessary during cadastral surveying, and similarly, in boundary adjustment and consultation, it's crucial to explain the observed points to the owners and ensure effective communication with them. For non-experts in surveying, it's difficult for landowners to fully understand the parcel information solely through maps and imagery.

Figure 3 Difference in Presence of Shadow
Data: Ministry of Land, Infrastructure and Transport, 2021, Study on the Application and Institutionalization of Drone Imagery in Various Stages of the Cadastral Resurvey Process p. 66

Boundary Extraction Possible **Boundary Extraction Impossible**

Figure 4 Comparison of Boundary Extraction in Roads Due to Vegetation
Data: Ministry of Land, Infrastructure and Transport, 2021, Study on the Application and Institutionalization of Drone Imagery in Various Stages of the Cadastral Resurvey Process p. 66

Drone imagery, captured vertically from the air, can still produce shadows and blind spots despite efforts to shoot with overlapping views to minimize distortion. Additionally, ground structures can be obscured by vegetation when viewed from the air, making image acquisition impossible in some cases. These limitations mean that drone imagery alone cannot provide a detailed understanding of the land's current state. Moreover, there are areas where drone photography is inherently restricted, such as near airports or military installations, due to current legal regulations. In such districts, the absence of drone imagery can lead to delays in work due to the lack of necessary decision-support materials.

Therefore, there is a recognized need for new decision-support materials that can complement drone imagery and provide an understanding of the site without requiring field visits. Experiments have been conducted to obtain horizontal visual materials that allow viewing the site from a first-person perspective, in addition to vertical imagery.

3. Experiment

3.1 Experiment Overview

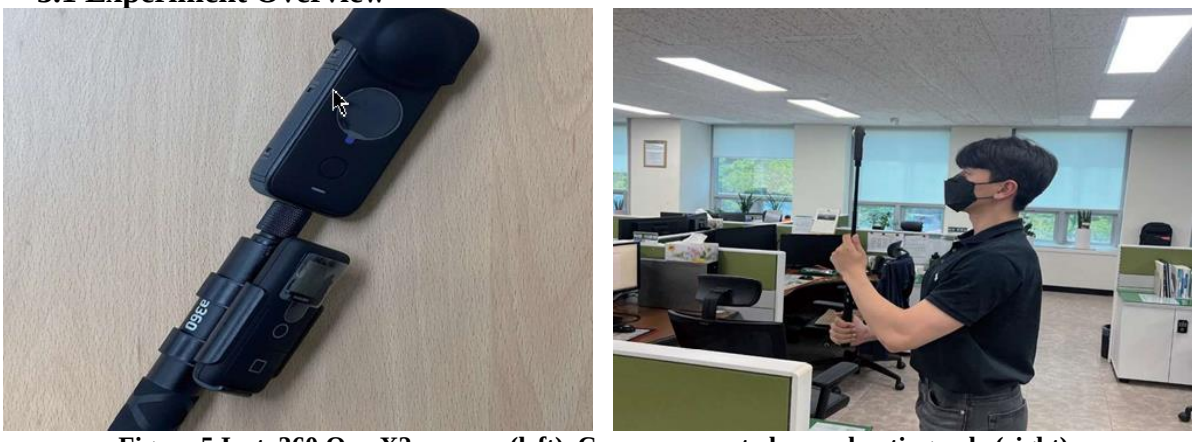

Figure 5 Insta360 One X2 camera (left), Camera mounted on a shooting pole (right)

Road-View is a method of capturing the site with a 360-degree camera and then mapping it, essentially creating a road view built by the surveyors themselves. Unlike the traditional method of capturing imagery using a vehicle, this method involves walking through the site to capture video, enabling the acquisition of imagery in areas where vehicle access is limited or challenging, such as rice paddy ridges and narrow alleys.

Size	4.62 * 11.3 * 2.98 cm
Weight	149g
Video Resolution	5.7K@30fps/25fps/24fps
Battery Capacity	1630mAh
Battery Life	80 minutes

Table 3 Specifications of Insta360 One X2
Data: [https://www.insta1360.com/kr/product/insta360-onex2]

Unlike the randomly captured road views on portal sites that don't consider the time of shooting, making it difficult to understand the site from the imagery, Road-View is shot in high resolution of 5K or higher. This allows for detailed observation of temporary boundary markers in the imagery, providing a more detailed understanding of the site situation. It also has the advantage of allowing greater magnification than portal site road views, making it easier to identify markers.

The experiment to capture the entire project district's Road-View imagery was conducted in early April 2022. The target was the Mosan district of Hancheon-myeon, Hwasun County, Jeollanam-do, a cadastral resurvey project district in 2022, with around 380 parcels. The experiment aimed to capture the entire district's imagery and construct a road view. Based on the location information and imagery obtained through the experiment, comprehensive data covering the entire project district was produced, enabling sufficient consultation without the need for a physical site visit.

3.2 Experiment Method

The shooting equipment used was the Insta360 One X2, a 360-degree camera. Additionally, to simultaneously capture the location information of the images, a GPS Remote was attached to the camera during the shooting.

Figure 6 Insta360 One X2 Backpack Mount
Data: [https://www.insta360.com]

The Insta360 One X2, weighing only 149g, can be combined with various equipment. There are accessories like the Backpack Mount, which allows user-centered 360-degree video shooting when attached to a backpack, and the Invisible Stick, which can be used like a surveying rod to attach the camera. Both accessories are designed by Insta360 for the convenience of the shooter and are readily available for purchase. For the construction of Road-View, it was necessary to walk around the project district as if a person were actually surveying the area.

Thus, the Invisible Stick was chosen for comfortable filming. This stick has the functionality to automatically render the 360-degree camera invisible in the video, which helps in creating more natural footage for Road-View. The shooting team consisted of two people: one main cameraman for the actual shooting and one assistant to guide through the routes within the district.

3.3 Experiment

Figure 7 Shooting plan (left), Example of shooting (right)

In April 2022, the Mosan3 district in Hwasun County, Jeollanam-do, a cadastral resurvey project area, was filmed. The target area consisted of about 380 parcels, including paddy fields and residential areas. The plan was to include all important sections for boundary adjustment without overlapping areas, as identified through the comparison of 1/1200 drone images and cadastral maps.

Additionally, to facilitate future site verification, filming was scheduled on the clearest days possible, between 10 a.m. and 2 p.m. The two-person team, consisting of a shooter and an assistant, handled video shooting and guidance via the map, respectively. It took about 3 hours to shoot all the 380 parcels, covering all the pathways within the project district, including areas like rice paddy ridges that are difficult to capture with traditional road views.

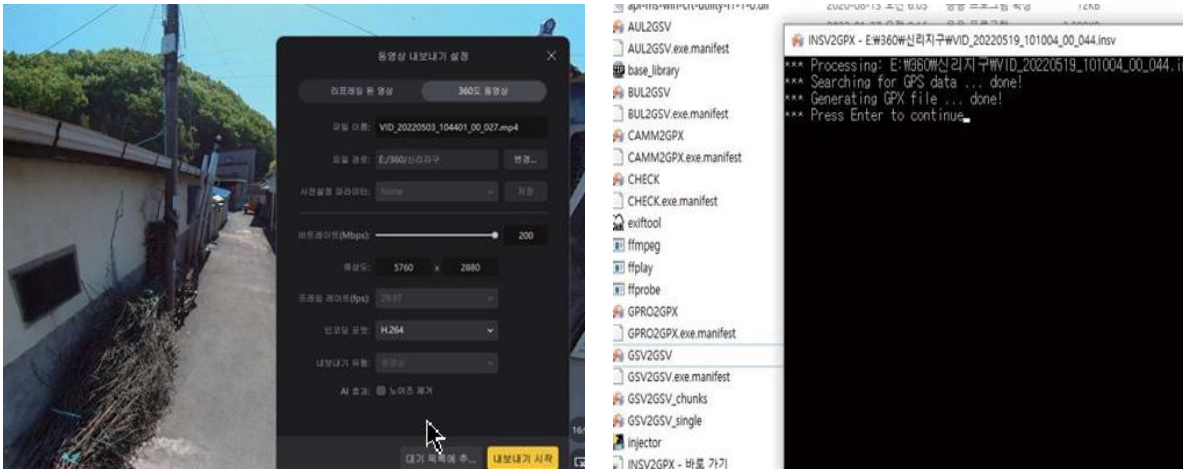

Figure 8 Insta360 Studio program for Windows (left), Dean Zwikel's UL2GSV program (right)

The captured footage was transferred to a computer, and the Insta360 Studio program provided by Insta360 was used to encode the footage from its native .insv format to the more universal mp4 format, suitable for uploading to Google Street View.

Figure 9 Rendered Street View (left), Street View footage uploaded directly (right)

The captured footage was transferred to a computer and encoded from .insv to mp4 format using Insta360 Studio. Then, Dean Zwikel's UP2GSV program was used for automating the process of extracting the location data from the videos as gpx files, which were then uploaded with the mp4 videos. After a day of processing, the images were published as Street View on Google. The uploaded videos were automatically masked to protect personal information like car license plates or faces.

Figure 10 Brightness comparison at the same location, KakaoMap Road View (left) vs. Self constructed Road-View (right)

Following this process, Street View was created on Google Maps, accessible to anyone. Not only existing roads but also rice paddy paths, forest roads, and areas behind house fences that are accessible by foot can be registered as Street View.

4. Improved Work Methods through the Introduction of Road-View

As-Is	To-Be
Previously done using office computers with on-site visits for detailed verification, even for simple field verifications. Drone shadows often required on-site reviews. Previously conducted in community centers with landowners, lacking the sense of the actual site due to drone imagery limitations.	Using Road-View in addition to drone and survey file comparisons for simple field checks. Drone shadow issues are resolved by Road-View, providing vivid imagery for boundary consultations as if present on-site. Road-View allows for detailed on-site checks without physical presence, identifying missing points in conjunction with drone images. Road-View serves as an alternative for areas where drone footage cannot be captured due to military areas or flight restrictions.

Table 3 Work Methods Comparison Post Road-View Introduction

4.1 Individual Parcel Verification

The primary focus of the responsible institution during parcel verification is to ensure that the observed boundary points are accurately determined according to skilled surveyors' standards. Instead of relying solely on vertical drone images, it's crucial to understand the actual usage of the land, such as who built a wall, the topography of ridges, or crop planting patterns.

Road-View, unlike drone imagery that provides a rough outline of the land, allows for a detailed understanding of land use. By displaying Road-View alongside drone images during parcel verification, missing or incorrectly observed points are easily identified.

Figure 11 Example showing visibility differences in boundary markers, Road View (left) vs. self-constructed Road-View (right)

Introducing Road-View into individual parcel verification allows surveyors to easily understand the on-site situation without having to visit each district frequently. This approach can make the cadastral resurvey project more economically feasible and reduce the burden of frequent site visits for survey teams, facilitating more efficient communication with agents.

4.2 Boundary Adjustment and Consultation

Currently, boundary adjustments and consultations in the cadastral resurvey project are conducted in limited spaces like village halls, based on newly adjusted cadastral maps and survey data, without visiting the actual parcels. This leads to a lack of direct visual confirmation of the subject matter for consultation by the cadastral authority or landowners, potentially causing communication issues.

Using Road-View for boundary adjustments and consultations allows for direct visual representation of the concerned parcels, clarifying mutual intentions and expressions. This can enhance the trust in land administration involved in the cadastral resurvey project, improve communication with clients due to reduced spatial constraints, and thus increase overall satisfaction. When explaining the proposed boundaries to landowners, it can be challenging to

understand the land use under eaves or to identify structures within the parcel using only drone imagery. Road-View, in contrast, allows landowners to precisely communicate their concerns to surveyors by viewing their properties directly on the screen.

4.3 Cases Where Drone Imagery Cannot be Acquired

There are cadastral resurvey project districts that overlap with no-fly zones due to air traffic control and national defense or security reasons, where drone imagery cannot be acquired. In the past, such areas relied only on aerial satellite imagery for project execution, leading to lower accuracy and precision. Road-View can serve as an alternative to drone imagery in such cases.

While capturing drone footage requires sophisticated technology, the process of shooting and processing 360-degree images is automated and straightforward, making it easier to fill the gap in decision-support materials without the need for a dedicated drone team. Road-View is also capable of capturing observations on windy days or in adverse weather conditions, making it a versatile tool for understanding project districts.

5. Colclusion

Despite the importance of understanding the on-site situation of project districts for individual parcel verification, time constraints make it impossible to check every parcel on-site. Road-View overcomes this temporal limitation. Furthermore, using Road-View for boundary adjustments and consultations can clarify the intentions and expressions of all parties involved by directly broadcasting the concerned parcels on the screen. This can enhance trust in land administration, facilitate smoother communication with clients, and increase satisfaction.

In addition to cadastral resurvey projects, Road-View can also be beneficial in performance consultations, offering a more detailed understanding of on-site conditions compared to just using survey data and site photos. The affordability of the required equipment and the efficiency in video processing are significant advantages, making it easy for survey teams to apply Road-View in practice. Integrating Road-View directly into decision-support systems being developed by the Korea Land and Geospatial Informatix Corporation, rather than relying on Google Maps, could provide even greater synergy, allowing survey teams to shoot project districts as needed.

REFERENCES

1. Ministry of Land, Infrastructure and Transport, 2016, Study on Job Creation through Cadastral Resurvey
2. Ministry of Land, Infrastructure and Transport, 2021, Study on the Efficiency Improvement of Cadastral Resurvey Responsible Institutions
3. Ministry of Land, Infrastructure and Transport, 2021, Study on the Application and Institutionalization of Drone Imagery in Cadastral Resurvey Processes
4. Ministry of Land, Infrastructure and Transport Press Release (2017. 9. 13.), Innovative Overhaul of the Cadastral Resurvey Project Execution System by the Ministry of Land, Infrastructure and Transport
5. Ministry of Land, Infrastructure and Transport Press Release (2019. 9. 30.), Accelerating the Cadastral Resurvey Project in 2020
6. Ministry of Land, Infrastructure and Transport Press Release (2022. 1. 25), Ministry of Land, Infrastructure and Transport to Fully Expand Cadastral Resurvey Project in 2022
7. Lee Jae-hyuk, Hong Sung-eon, 2022, Study on the Efficiency Improvement of Cadastral Resurvey Responsible Institutions Operation. Industrial Convergence Research. 20(8):33-41
8. Jung Su-yeon, Drone Companies Must Inform About No-Fly Times and Places on Websites, Yonhap News, 2020.06.17
9. Revised Basic Plan for Cadastral Resurvey, Ministry of Land, Infrastructure and Transport
10. Operating Regulations for Cadastral Resurvey Responsible Institutions
11. Special Act on Cadastral Resurvey

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