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# Land Suitability Analysis using GIS and Satellite Imagery

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**Abstract**

A method of improving the correctness and confidence in land use classification as well as urban spatial structure analysis of local governments using GIS and satellite imagery is suggested. This study also compares and analyzes LSAS (Land Suitability Assessment System) results using two approaches-LSAS with priority classification, and LSAS using standard estimation factors without priority classification. The conclusions that can be drawn from this study are as follows. First, a method of maintaining up-to-date local government data by updating the LSAS database using high-resolution satellite imagery is suggested. Second, to formulate a scientific and reasonable land use plan from the viewpoint of territory development and urban management, a method of simultaneously processing the two described approaches is suggested. Finally, LSAS was constructed by using varieties of land information such as the cadastral map, the digital topographic map, varieties of thematic maps, and official land price data, and expects to utilize urban management plan establishment widely and effectively through regular data updating and problem resolution of data accuracy.

Keywords : Land Suitability Assessment System, land use classification, urban spatial structure analysis, high-resolution satellite imagery, urban management plan.

## 1. Introduction

Due to the development-oriented policy of the South Korean government since the 1970s, reckless development of national lands become a social issue. To solve such problem, the government unified in 2002 two national land development laws regulating land use-the National Land Use and Management Act and the City Planning Act-into the National Land Planning and Use Law to manage territories according to the principle of "development after planning" (Ministry of Construction and Transportation, 2004; Korean Land Corporation, 2004, Yoo and Kim, 2002). The National Land Planning and Use Law introduced the use of the land suitability assessment system (LSAS) to guide reasonable and scientific analysis in land use planning related to greenbelt areas and urban planning areas (Yoo et al., 2004; Chae and Kim, 2003; Chae and Oh, 2003).

LSAS is a method of estimating land use characteristics based on physical, spatial, and environmental factors. LSAS, which is based on the Geographic Information System (GIS), constructs a database using various collected data. LSAS classifies each parcel of land in the management district of a local government into suitability grades according to the land's developmental, preservative, and agricultural characteristics. Local governments should have a data updating plan to be able to utilize the constructed database effectively and continually. From this point of view, the topographic information acquisition technique using high-resolution satellite imagery is regarded as a highly reliable method that easily acquires recently changed topographic information. Induction of LSAS with high-resolution satellite images could ensure scientific urban land management and prevention of unplanned urban development in local governments.

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At this point, the paper suggests a method of improving the confidence in the land use classification and suitability analysis, through updating of the constructed GIS database using satellite imagery.

## 2. Land Suitability Assessment System and Satellite Imagery

Nowadays, semi-agricultural areas and forest lands at the outskirts of cities in Korea are subjected to a high degree of pressure for development as urban management areas. Widespread reckless development in these areas has brought about a host of problems, including inefficient land use, water pollution, and traffic congestion, which have surfaced in the past as serious social issues. As a result, The need to evaluate potential environmental effects continues to grow during the planning stage of development projects. The purpose of land suitability assessment in the Act is to yield the fundamental data needed to determine the suitability of the land with respect to the location characteristics, feasibility, and circumference development situation of the management areas (Yoo et al., 2005).

LSAS is a method of evaluating and classifying the land use property of the management areas by considering the areas' various land characteristics. According to the Act, LSAS is applied as a pre-process of planning in the early urban planning stage of the management areas. LSAS is divided into assessment systems I and II. Assessment system I is used to classify the characteristics of the management areas into five grades, and the classified areas should be designated as the conservation, agriculture, or development areas. On the other hand, assessment system II could classify the characteristics of the management areas into three grades by estimating the development suitability values of the areas designated as management areas, green areas, agriculture and forestry areas, or environmental preservation areas under the planning law.

To update the spatial data of the database of LSAS, a 1 m pan-sharpened multi-spectral IKONOS satellite image was used. IKONOS launched on September 24th, 1999. This satellite has a sun-synchronous 681-km orbit and a swath width of 11 kms. It collects available high-resolution imagery at 1-meter panchromatic (PAN) and 4-meter multi-spectral (MS) imageries. A pan-sharpened color imagery can be generated by merging the 1m-resolution panchromatic image with the 4 m-resolution multi-spectral bands to generate true-color or false-color images at a 1 m resolution. IKONOS applications include both urban and rural mapping of natural resources, natural disaster investigation, environment monitoring, agriculture and forestry analysis, urban change detection and etc.

## 3. Database Construction and Update

### 3.1 LSAS Database Construction

The administrative district of Jinju City covers an area of approximately 712 sq. kms. in Gyeongnam province, Korea. Its management area spans about 121 sq. kms. Jinju's LSAS construction project began in 2004 and is being implemented by the Environmental and Regional Development Institute (ERDI) of Gyeongsang National University, Korea. The operating environment of LSAS consists of hardware, GIS software, and other operating systems. To perform and construct LSAS, the specialized software that the Korea Land Corporation (KLC) officially offered were utilized. The database was also constructed by integrating the digital cadastral map of the Land Management Information System (LMIS) with the official land price data as the spatial data and the attribute data, and then constructing nearly more than 40 thematic maps from various government departments.

### 3.2 Database Update Using IKONOS Imagery

To update the spatial data of the database, a 1m pan-sharpened multi-spectral IKONOS image was used. Fig. 1 presents the imagery overlaid with the digital cadastral map and the ortho-image, and Fig. 2 shows the magnified imagery overlaid with the ortho-image and the digital cadastral map of the urban and agricultural area. After the checkpoints were evaluated, the total root mean square errors (RMSEs) of the ortho-image were found to have been ±0.99 m and ±1.39 m in the X and Y directions, respectively (top of Fig. 1).

A visual comparison of the digital cadastral map and the overlaid imagery showed some differences in the

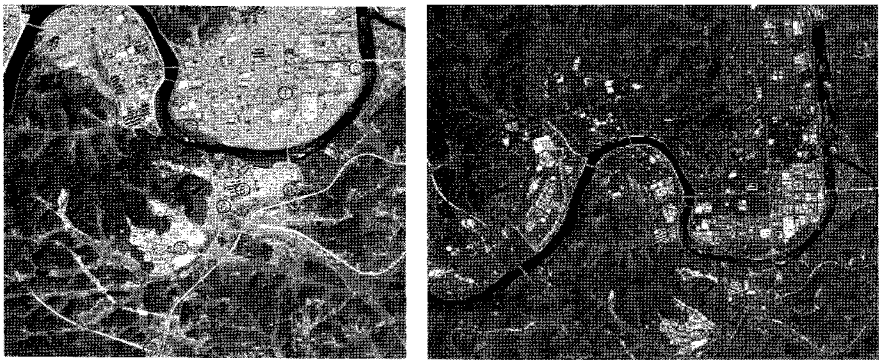


Fig. 1. IKONOS ortho-image and the overlaid digital cadastral map.

classification of the land category in the cadastral record and the satellite imagery. For example, a parcel of land that was registered for paddy field use in the record was employed as a road (Fig. 3 (a)). A parcel of land that was registered for forest use was used as a building site (Fig. 3 (b)). A parcel of land in the submerged area in which a dam was constructed was still not removed but managed as a paddy field on the cadastral record due to lack of updated data (Fig. 3 (c)). Therefore, the visual comparison analysis approach using high-resolution satellite imagery is expected to update spatial data effectively and regularly in local governments.

The accuracy of constructed thematic maps could also be assessed and the developed sites could be updated

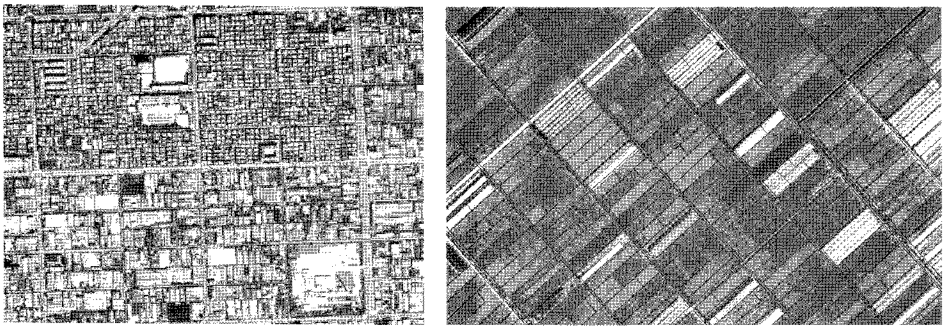
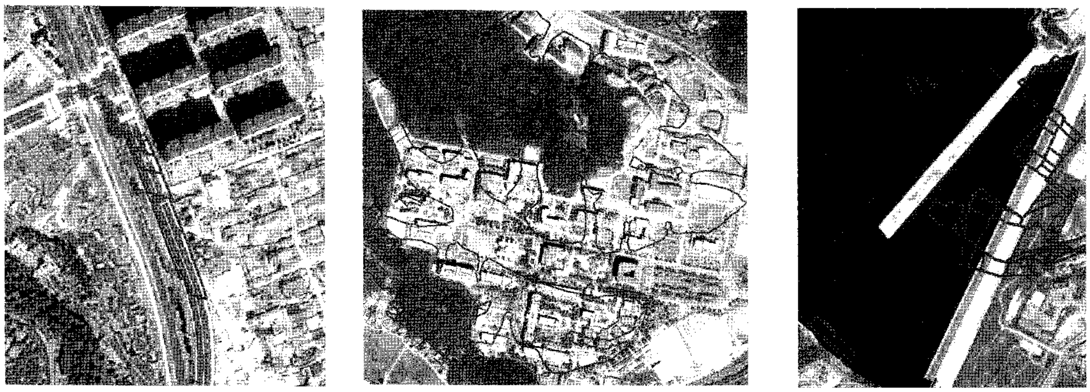


Fig. 2. Magnified overlaid imagery in the urban area and the agricultural area.



(a) Road site (b) Building site (c) Submerged site

Fig. 3. Visual comparison analysis using satellite imagery and a cadastral map.

or omitted by overlaying the satellite imagery and the thematic map of legally developed sites (Fig. 4).

## 4. Land Suitability Analysis Using LSAS

After the characteristics of the areas that have been classified into five grades in the management area were analyzed using LSAS, the reservation land, which included the priority reservation area and the first- and second-grade areas, spanned 39.183 sq. kms (42%). The development land, which included the priority development area and the fourth- and fifth-grade areas, spanned 31.786 sq. kms (34%). The third-grade area, which could be preserved or developed according to the planning intention of the local government, spanned 24% of the entire management area (Fig. 5).

Since the LSAS excluded the priority reservation area and the priority development area at the early stage of the assessment, it has some limitations in that it cannot implement scientific and objective assessments of these areas. To overcome the drawback of current processes using LSAS, a rational approach is suggested that should be implemented only with standard estimation factors, without excluding previous reservation or development areas. The paper shows a comparison of the results of two approaches-LSAS with priority classification (case

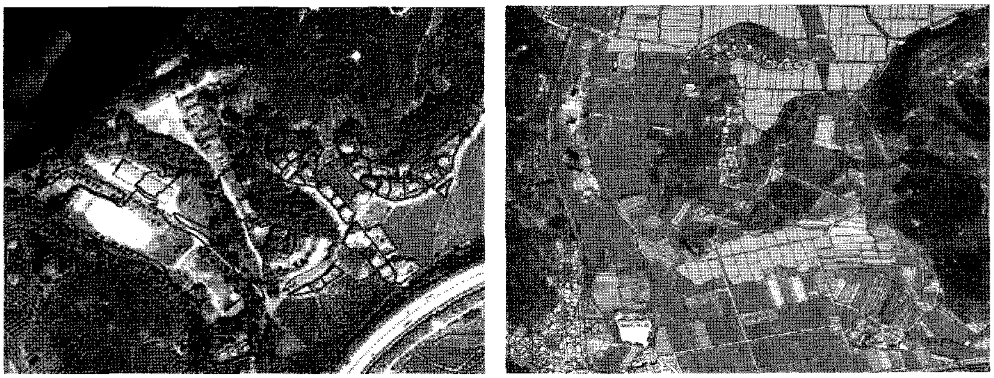


Fig. 4. Omission of legally developed sites (top) and validation of readjusted agricultural region (bottom).

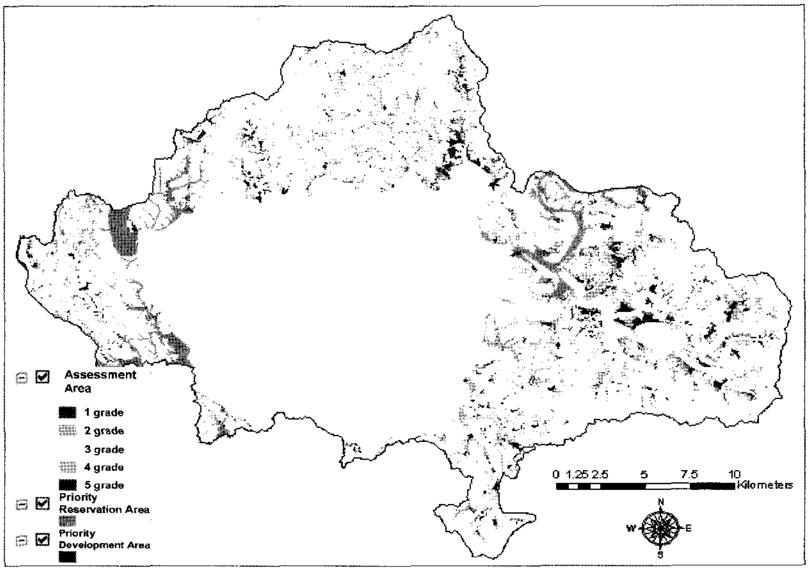



Fig. 5. Result of land suitability assessment of Jinju

1), and LSAS using standard estimation factors without priority classification (case 2). Table 1 shows a comparison of the results of two approaches. The first- and second-grade areas (the reservation land) in case 1 spanned 25.921 (27.97%) and 13.263 (14.31%) sq. kms. In case 2, however, these areas spanned 5.780 (6.24%) and 20.963 (22.62%) sq. kms., respectively. The difference between the areas in the two approaches was estimated at 13.2%. The authors think the result was caused by excessive zoning regulation and environmental conservation in the reservation land. Also, the development area (the fourth- and fifth-grade areas) in case 1 was slightly smaller than in case 2. The third-grade areas in the two cases also had slight differences.

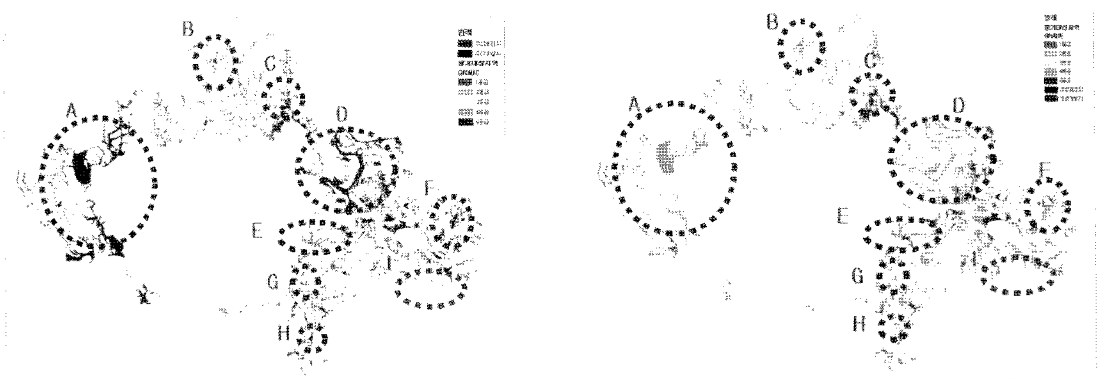
In this study, the propriety of the LSAS process, focused on the management area where there was a difference in the grade classifications in the two cases, was analyzed via field investigation and the long-term development plan of Jinju. Fig. 6 shows the LSAS results of the two approaches.

In Fig. 6, areas A and G are classified as priority reservation areas in case 1 but as fourth-grade areas in case 2. Area E was classified as a priority development area in case 1 but as a second-grade area in case 2. In the case of area E, it might be evaluated as being more suitable as a reservation area than a development area.

To verify the assessment results in detail, a field investigation was conducted around area G. Area G was an undeveloped area with narrow roads and old buildings, and which adjoined to a four-lane national road. The area was classified as a priority reservation area in case 1 but as a fourth-grade area (suitable for development) in case 2 (Fig. 7). As a result of the field investigation, this area was designated as an ecosystem reservation area, but area G was also located near the candidate areas of the Gyeongnam Innovation City. The areas have high development potential because of the high degree of development pressure in the neighborhood. Therefore, area G was as requiring a more environmentally friendly urban development plan with the development plan of Innovation City.

Table 1. Grade Distribution of Jinju's LSA

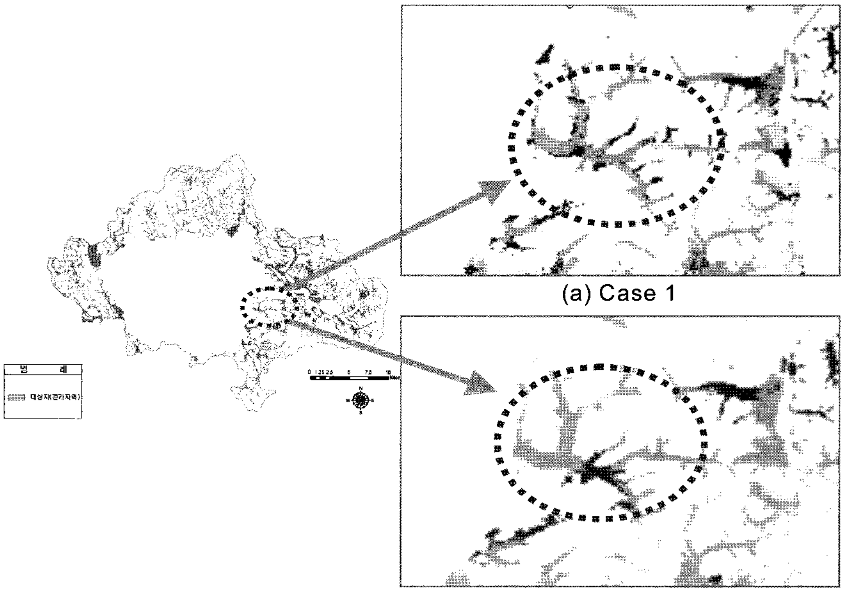
| | LSA with priority classification and standard factors | | LSA using standard factors without priority classification | |
|---|---|---|---|---|
| 1 grade | 25.921 $km^2$ | 27.97% | 5.780 $km^2$ | 6.24% |
| 2 grade | 13.263 $km^2$ | 14.31% | 20.963 $km^2$ | 22.62% |
| 3 grade | 21.697 $km^2$ | 23.41% | 33.026 $km^2$ | 35.64% |
| 4 grade | 16.754 $km^2$ | 18.09% | 25.497 $km^2$ | 27.57% |
| 5 grade | 15.033 $km^2$ | 16.22% | 7.402 $km^2$ | 7.99% |
| SUM | 92.668 $km^2$ | 100.00% | 92.668 $km^2$ | 100.00% |




(a) LSAS results of case 1

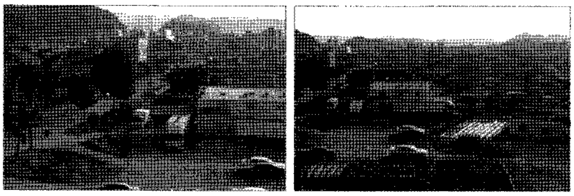
(b) LSAS results of case 2

Fig. 6. Comparison of the results of the LSAS in the two cases.



(a) Case 1

(b) Case 2



(c) Field photos

Fig. 7. Analysis of the comparison of assessments in area G.

## 5. Conclusions

In this study, a method of improving the correctness of and confidence in the land use classification and the urban spatial structure analysis of local governments using satellite imagery was suggested. The results of the following two approaches were also compared and analyzed: LSAS with priority classification, and LSAS using standard factors without priority classification. The conclusions that can be drawn from this study are as follows.

First, a method of updating local government data by updating the LSAS database using high-resolution satellite imagery, and of improving the accuracy of the analysis of urban spatial structures, was suggested.

Second, in the LSAS that focused on Jinju, some differences in the results of the two approaches were seen. There were times when the two LSAS approaches had conflicting results, and the current LSAS (the first approach) was affected by legal regulations. To formulate a scientific and reasonable land use plan from the viewpoint of territory development and urban management, a method of processing the described two approaches together was suggested. This method is expected to establish a stable land use plan in the future.

Third, Jinju's LSAS construction project, implemented under the National Land Planning and Use Law, had some problems such as updatedness, gaps in data generation and scale, and process accuracy, which prevented the integration of various land data such as the cadastral map, the digital topographic map, varieties of thematic maps, and official land price data. Therefore, LSAS expects to utilize urban management plan establishment widely and effectively through regular data updating and problem resolution of data accuracy.

## References


CHAE, M., O. and KIM, J., H. (2003), *Policy Alternatives for Land Suitability Assessment System*, Korea Research Institute For Settlements.

CHAE, M., O. and OH, Y., J. (2003), *Land Suitability Assessment Manual*, Korea Research Institute For Settlements.

Jinju City (2002), *2021 Jinju City Master Plan*, Jinju City, pp. 12-18.

Korea Land Corporation (2004), *LSA Program User Manual*, Minstry of Construction and Transportation, Korea.

Ministry of Construction and Transportation (2004), *Guideline For Land Suitability Assessment*. Korea.

Yoo, H. H., Kim, S. S., Goo, H. D. and Jeong, D. G. (2004) Construction of Land Use Suitability Assessment System for Establishing Urban Management Plan - Focused on Jinju City-, *KSGPC Fall Conference Proceedings*, NGII, Korea, pp. 311-318.

Yoo, H. H., Kim, S. S., Kim, W. S. and Park, K. Y. (2005), Errors Verification for Constructing Database of Land Use Suitability Assessment System, *Journal of KSGPC*, Vol. 23, No. 2, pp. 177-188.

Yoo, H. W. and Kim, S. J. (2002), *A Guide to Land Related Laws*, Korea Research Institute For Settlements, pp. 79-91.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