GIS Application for Site Planning

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Abstract

The general urban plan is the plane plan which limits general and uniformed constructions; however, the district unit plan is the solid plan that can leads various constructions by discriminating by plot, housing area and lot. Therefore, for the zone plan, not only the two-dimensional plot information such as plot usage plan, but also the three-dimensional plot information needs to be used to analyze lighting, sewerage and directions. To fulfill such requirements, the information can be gathered using GIS and photogrammetric method for the reasonable and efficient zone plan. In this research, the information about the testing area for the zone plan has been gathered using GIS method, and the three-dimensional model about the area has been built using the satellite image and DEM. As the result, plot usage analysis, direction analyst, water system analysis, and slope analysis has been done and used efficiently to build the district unit plan. Also, after the result after applying the analyzed result to the actual area says this is very appropriate and efficient.

Keywords: GIS Application, 3D Terrain model, Site planning, Slop analysis, Aspect analysis

1. Introduction

Zoning plan is the technology to create external physical environment so that there is no inconvenience in human activities [1],[2]. It is combined field of architecture, engineering, landscaping, urban planning, etc and it is to plan network, green space, residence, neighborhood facilities, parking lot, distance between buildings, privacy, noise, view, ventilation, etc. Process of zoning plan proceeds as goal setting → data analysis & integration → basic plan → basic design → execution design → construction & supervision → maintenance. Especially, physical plan is established through 3 dimensional analysis of topography in basic and execution design and effective zoning is conducted by analyzing data relevant to intellect and land use[3],[4].

Seung Oh et. al (1999) tried to reflect an automated analysis result to the urban plan by improving the manual plan systematically, and Hyojin Yoon (2000) executed the study about limited conditions of GIS applicability for the district unit plan and insisted its category and improvements [8],[9]. The practical approach was fulfilled for the study with the benchmark of foreign examples on GIS application for resident and industrial zone plan from Korea Land Corporation (2001) [11]. GIS studies in zone plan or district unit plan are executing and approaching
on the theory, but the study that indicated basic concept and distribution of function is little.

The purpose of the study is to establish more rational zoning plan through attribute analysis of land and 3 dimensional analysis of topography in conducting zoning plan for specific region. Also, actual zoning plan was established based on the data acquired as a result of the study.

2. Contents of Study

In this study, test target area was selected with virtual goal of technopolis to evaluate how effective zoning planning can be conducted using GIS software. First of all, attribute analysis on land within target area, namely current status of land use, distribution of land parcel area, analysis on land price and spatial analysis, was conducted.

Spatial analysis refers to the available land analysis through slope analysis, aspect analysis and vertical section analysis with goal for effective use of land in planning. For the data, 1:5,000 topographic map, 1:2,000 cadastral map, aerial photo image (1:5,000), basic urban planning, public land price, etc were utilized. Zoning plan for re-development was established using data acquired through GIS software as above.

3. Study Area

It is area at boundary of old downtown of Cheonan and Mokcheon corresponding to 3,404,726. It is located east of Gyeongbu Expressway and it is topography with 3 valleys including long valley developed from southwest to northeast. First valley is stretched about 2.5km toward northeast, second valley is stretched about 1.3km toward east from the center and third valley is stretched 1.8km toward south. It is the basin surrounded by mountains with the altitude of 200-250m and resents average altitude of 60-70m.

4. Land Analysis & Topography Analysis

4.1 Attribute Analysis of Land
4.1.1 Land use Analysis

For the zoning plan, it is necessary to analyze current status of land use for the target area. Current status of land use can easily be grasped with thematic map by extracting classification of land category for lot number. Classification of land category is divided into 28 types in Korea and there are 16 classifications of land category for the target area (Lee, et al, 2000). Number of land parcels and area for each type is as Figure 2. Forest land occupied the most with 68% followed by residential area 12.4%, rice field 8%, crop field 4.3%, road 3.3%, river 1.3% and other usage was less than 1%.

Number of land parcel for each land use was same for building site and rice field with 207 parcels followed by crop field 142 parcels and road 112 parcels. For the other classifications of land category, there were less than 20 parcels. Above result of analysis can be referred to in zone planning for the arrangement of land by purpose considering the limitation in development. Figure 4 is the thematic map for land use using GIS technology of which one can grasp the use of land at a glance.
GIS Application for Site Planning

4.2.2 Land Price Analysis

Data for land price was acquired using land information system of Cheonan city for each land parcel. Also, national land and private land within target area was grasped and excluded for the calculation of land purchase cost.

According to the most expensive lot, the order was habitation, crop filed, rice filed, mixed use, stock farm, physical site, and drain. The most expensive average price of this order was stock farm and the following were physical site, mixed use, and factory area.

Total land price of target area was calculated as 230,593,081,711 won for 891 land parcels including 24 parcels of national land for 77,284,660,008 won and 34 parcels of private land for 16,326,243,315 won. Land price (public land price) of project target area excluding these becomes about 136,982,180,000 won.

4.2.3 Accessibility Analysis

It is prerequisite to consider basic urban planning of associated administrative district for zoning plan. Since there are new establishment plan for 2 circular roads and Cheonan-Jincheon arterial road for network plan of Cheonan-Si as illustrated in Figure 5, accessibility is determined to be very good. Especially, internal circular road in green will provide direct access to the target area.

4.2 Topographical Analysis

For the spatial analysis, DEM (Digital Elevation Model) was created by extracting contour layer of 1:1,000 topographic map relevant to the target area. Also, 3 dimensional topography model was created by geometric correction of 1:5,000 aerial photo (resolution: 0.4m) photogrammetrically and overlapping with DEM. Various 3 dimensional spatial analysis such as slope analysis, aspect analysis, section analysis, etc was attempted from constructed DEM and image. (Figure 6)

4.2.1 Slope & Available Land Analysis

It was analyzed in 6 levels that are slope 0-8°, 8-15°, 15-20°, 20-25°, 25-50° and over 50° by using DEM. Although proper slope is up to 15°, up to 20° is currently
possible for the bold development [7],[10]. Slope thematic map was created using ArcGIS Desktop

9.2 and number of cells associated to each slope was counted with re-classification (Table 1). Since size of 1 cell is 10m*10m, area can easily be acquired. As a result of analysis, area with slope of up to $15^\circ$ was 1,255,200 and area with slope of up to $20^\circ$ was 1,779,700 that is about 50% of total area. Although considerable earth work may be necessary, availability of 50% is determined to be not bad.

4.2.2 Aspect Analysis

Total project target area is in east and west direction. The ridge line is developed left to right and it is relatively concentrated on northwest and west side.

South, east, west, southwest and southeast direction appropriate for residence occupy about 19,373 cells out of total 34,037 cells that are about 57%(Table 2). Therefore, problem brought about by inferiority of direction would not occur.

<table>
<thead>
<tr>
<th>Slope degree</th>
<th>Number of cells</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8°</td>
<td>8,042</td>
<td>804,200</td>
</tr>
<tr>
<td>8-15°</td>
<td>4,510</td>
<td>451,000</td>
</tr>
<tr>
<td>15-20°</td>
<td>5,245</td>
<td>524,500</td>
</tr>
<tr>
<td>20-25°</td>
<td>6,436</td>
<td>643,600</td>
</tr>
<tr>
<td>25-50°</td>
<td>9,620</td>
<td>962,000</td>
</tr>
<tr>
<td>Over 50°</td>
<td>184</td>
<td>18,400</td>
</tr>
<tr>
<td>Sum</td>
<td>3,403,700</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Aspect analysis**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Number of cells</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>1,725</td>
<td>172,500</td>
</tr>
<tr>
<td>North</td>
<td>4,071</td>
<td>407,100</td>
</tr>
<tr>
<td>Northeast</td>
<td>2,826</td>
<td>282,600</td>
</tr>
<tr>
<td>East</td>
<td>2,838</td>
<td>283,800</td>
</tr>
<tr>
<td>Southeast</td>
<td>3,037</td>
<td>303,700</td>
</tr>
<tr>
<td>South</td>
<td>3,443</td>
<td>344,300</td>
</tr>
<tr>
<td>Southwest</td>
<td>3,688</td>
<td>368,800</td>
</tr>
<tr>
<td>West</td>
<td>6,367</td>
<td>636,700</td>
</tr>
<tr>
<td>Northwest</td>
<td>6,042</td>
<td>604,200</td>
</tr>
<tr>
<td>Total</td>
<td>34,037</td>
<td>3,403,700</td>
</tr>
</tbody>
</table>

4.2.3 Section Analysis

Vertical slope was analyzed for profile 1 from entrance to teenager camp, profile 2 toward valley near information technology education center and profile 3 toward Jisan-Ri. Also, analysis on crossing section, vertical toward the entrance, was performed as well. For the crossing section, 4 places of interest were selected and analysis on section 1, section 2, section 3 and section 4 was carried out. In regards to profile illustrated in Figure 9, vertical and crossing section was analyzed.

In general vertical and traversal analysis, the vertical analysis gave 6-8% of slope, and has very slow change in altitude compare to the long entering line. However,
Table 3. Shape of profile and cross section

<table>
<thead>
<tr>
<th>profile/section</th>
<th>shape</th>
<th>slope and shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>profile 1</td>
<td><img src="image" alt="Profile 1" /></td>
<td>1.5%/800m, 5.9%/600m, generally gentle slope</td>
</tr>
<tr>
<td>profile 2</td>
<td><img src="image" alt="Profile 2" /></td>
<td>2.0%/600m, 8.6%/370m, 18% slope up to border</td>
</tr>
<tr>
<td>profile 3</td>
<td><img src="image" alt="Profile 3" /></td>
<td>1.9%/700m, 6.7%/250m, generally gentle slope</td>
</tr>
<tr>
<td>section 1</td>
<td><img src="image" alt="Section 1" /></td>
<td>-23.3%/570m, 0%/360m, +2.7%/335m, +8.7%/413m, +21%/415 usable width= about 1km</td>
</tr>
<tr>
<td>section 2</td>
<td><img src="image" alt="Section 2" /></td>
<td>-23%/201, +1.5%/136m, +14%/147m, +1%/254m, +4.2%/258m, +23%/up to peak</td>
</tr>
<tr>
<td>section 3</td>
<td><img src="image" alt="Section 3" /></td>
<td>-27.3%/down hill, +2.6%/153m, +10.2%/242m, +3%/202m, +35%/310m usable width= about 0.7km</td>
</tr>
<tr>
<td>section 4</td>
<td><img src="image" alt="Section 4" /></td>
<td>-34%/193m, +0%/115m, +3%/104m, +19.4%/162m, +34%/130m usable width= about 0.36km</td>
</tr>
</tbody>
</table>

ex) 1.5%/800m means 1.5% slope up to 800m

the valley area on Route 4 has +18% of slope, which is somewhat steep(Table 3). Changes in traversal slope have developed ridge line on left and right sides, therefore has altitude around 250m. Inner side of the valley has 70-80m of altitude; hence the land has a steep slope of 20-30% except the plain land area. Therefore, large scale of construction work needs to be done and tiers of zones plan should be needed to improve the rate of usage of the land.

3.2.4 3 Dimensional Scenery Analysis.

In devising basic plan of zoning plan, actual world can be viewed from all directions and altitudes using three-dimensional topographic model constructed with aerial photo image. Therefore, it can be utilized very effectively[5],[6].

Also, plan can be devised as if you are at the site with simulation of model from the desk without actually visiting the site. Figure 10 illustrates the direction of view for constructed 3 dimensional model.

Figure 11 3D View of each point

Figure 11 illustrates bird eye's view from different altitudes and 8 directions. Construction and simulation of topographic model was produced with utilization of PG Steamer 4.2. It helps zoning planner to help devise realistic plan by matching design proposal and situation at the site.

5. Zoning plan

5.1 Distribution of Function and Basic Concept

The result from Chapter 4 was provided to experts of the district unit plan. Experts could establish the plan using more specific and various data than old traditional method. They distributed the functions within districts with following basic concepts using the results provided.
5.1.1 Distribution of Function
a. Industry-university cooperation research: Technopolis + industry-university research cluster
b. Global research: Global research cluster
c. University cultural education: Univ. education & Culture of Univ.
d. Training & domitory: Training & Guest house
e. Park & Physical: Central park & physical; site
f. Road & Transformation: Road & Parking area

5.1.2 Basic Concept
a. With 6 lane main road of 35m as its center, total site is divided into 3 and it was specialized as industry-academic research, college culture & education and global research complex.
b. At the center where 3 roads meet, central green park and sports facilities are arranged to not only stress out centrality but also maximize the utilization of surrounding area.
c. Industry-academic complex (technopolis, industry-
academic research cluster) was arranged at north of the site and college culture complex was planned to construct cooperative system of industry and academic.
d. High technology specialized university is located on east side and global research cluster is located on south side. By securing training and accommodations between the 2 regions, utilization of both function was maximized.
e. Small scale pocket park was arranged to each region other than central green space to create green network. By saving some of hills in university education space and securing the road for pedestrian, environment-friendly zoning plan was implemented.
f. Principle was to establish common parking lot alongside the college cultural space and central

Figure 11. 3D View of each point

Figure 12. Function distribution and basic plan

Figure 13. Final Zoning Plan
sports facilities to secure publicness and accommodate other demand for parking at each zoning plan.

The district unit plan require balanced plan for land usage in 2 dimensional respect and also need spacious analysis for 100 % exertions of functions by districts. The example is like limit slope of residential and public facility areas. By using GIS analytical method, it can make efficiently to decide. Also the space relation by districts according to usages must have flexible, so that topology of GIS can identify this relationship reasonably and scientifically.

5.2 Result of Zoning Plan
Final zoning plan as following was completed with basic concept prescribed in 5.1 using various information acquired through execution of land use and 3 dimensional spatial analysis.

Main road was arranged in Y shape from the entrance and it was arranged so that it could face university, research center and industry-academic cluster. Global enterprise research cluster was arranged left side of entrance and technopolis was secured at opposite side to support development and business of enterprise. Training and guest house zone was arranged at boundary of college education center and global enterprise research cluster so that it can be utilized by both sides. By arranging green space to each intersection of arterial road, freshness and comfortableness was brought into the space.

6. Conclusion
(1) Land usage plan was established by space analysis, and GIS topology could decide efficiently for experts with reasonable and precise district unit plan.

(2) Through aspect analysis, it was found out that direction appropriate for residence was about 19,373 cells out of total 34,037 cells that are about 57% of total area and available width of the target site could be determined through vertical and crossing section analysis.

(3) As a result of analysis, it was found out that area with up to slope 15° is 1,255,200 and area with slope up to 20° is 1,779,700 which is about 50% of total area. Although considerable earth work may be necessary, availability of 50% was determined to be not bad.

(4) Zoning plan was established based on result drawn from attribute analysis of land and 3 dimensional topography analysis and it was determined to be competitive compared to previous methods in aspect of rational plan establishment.

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