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Urban Land Use Planning with a PSS-based Land Use Change Projection Model

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Abstract

Planning Support System (PSS), an alternative framework of computer-aided planning system combining geographic information system (GIS), urban models, and visualization tools, has been actively researched and applied in many developed countries. This paper introduces a PSS-based land use change model, What if? PSS, by applying it to Chongju City, Korea. This model application study used the spatial database, Restricted Development Zone (RDZ), and other hypothetical land supply- and demand-related policies of Chongju City.

The collaborative PSS model supported land use planning process by helping users to speedily and easily create and test policy-oriented scenarios. The study found that the fully operational PSS model was readily applicable and useful to Korean local land use planning. The paper discusses the conceptual model framework, data requirement, application process, model output, and practical usage. This study would be considered as a prototypical approach of PSS-based land use plan making for Korean cities.

Keyword : PSS(Planning Support System), Land Use Planning, Land Use Change Projection, Urban Model, What if?, Chongju City

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1. INTRODUCTION

Modern GIS technology has greatly improved the spatial database and visualization of

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traditional planning models including land use change projection models. Customizable off-the-shelf GIS packages have allowed urban modelers to take advantages of versatile GIS database management system, built-in analytic functions, and visualization tools. In developed countries of North America and Europe, some urban modelers have developed a new conceptual framework for computer-based planning tools, named Planning Support System (PSS), which utilizes emerging GIS technology and database to augment the performance and usability of traditional (analytic, predictive, and prescriptive) planning methods and models. Moreover, PSS integrates GIS, urban models, and visualization tools to support systematic and participatory planning processes (Brail & Klosterman 2001; Geertman & Stillwell 2002; Harris 1999; Harris & Batty 1993; Hopkins 1999; Klosterman 1997).

In the field of PSS, there are now two different major emphases. One group of PSS modelers put emphasis on supporting scientific methods and models by adopting advanced information system (e.g., GIS) and visualization technology. Regional science and urban microeconomics, which have theoretical rigorousness based on mathematical certainty, have been the leading disciplines of this type of PSS models. Some examples include METROPILUS, which is a GIS-based version of DRAM/EMPAL, (Putman 2001), TRANUS (De La Barra 2001), CUF II and CURBA (Landis 2001), UrbanSim (Waddell 2001), and CommunityViz (Kwartler & Bernard 2001).

The other major emphasis of PSS researchers is on collaborative planning systems. These researchers are interested in applying computer technologies to support or improve collaborative planning process rather than how to improve complex modeling theories and scientific model calibration methods. They focus on transparent and easy-to-understand model structure and visualization tools including multimedia and hypermedia that can be easily used and comprehended by planners, policy makers, and the public (Klosterman 1997; Shiffer 1992; Shiffer 1995a; Shiffer 1995b; Shiffer 2001). This kind of PSS applications has been attempted by GIS- and rule-based (or GIS rule-based) models. A salient example of this kind is What if? collaborative PSS (Klosterman 2001). The philosophy of the model is to build simple and transparent model structure with rule-based and policy-oriented scenarios, which is assumed to be good for collaborative planning process.

The objective of this paper is to introduce the growing world of PSS modeling to Korean planners by applying What if? to Korean context. The model is a GIS- and rule-based and policy-oriented and has been shown in recent literature on PSS and operational urban models as one of a few fully operational land use change projection models (Brail & Klosterman 2001; US EPA

2001; Klosterman, et al. 2002). First, the paper will review how submodels or modules of What if? correspond to the land use design processes defined by Kaiser et al. (1995). Then, the paper will describe how the PSS model was applied to hypothetical land use design processes of Chongju City. Finally, the model outputs and some conclusions will be discussed.

2. Land Use Planning Processes and What if ?

Kaiser et al. (1995, 278-289) delineated a standardized five-step land use design process as follows, (1) deriving location requirements for future land uses, (2) mapping locational suitability for future land uses, (3) deriving space requirements for future land uses, (4) analyzing the holding capacity for the community's land, and (5) synthesizing or balancing the supply and demand. The What if? submodels (i.e., Supply, Demand, and Allocation scenarios) directly or indirectly correspond to the design processes as explained below. However, the aim of the model is not replacing existing planning process and producing accurate future projection, but at supporting the traditional planning process and sketching possible future under "what-if" type of scenarios. Complete theoretical and technical guides for What if? can be found in Klosterman (1999), Klosterman (2001), and Klosterman (2002).

2.1 Deriving Location Requirement (Land Supply Scenarios)

Location requirements for particular land uses are derived from, and dependent on, community goals, policies, and market analysis. This process is partially supported by the What if? Suitability submodel requiring users to select suitability factors to be considered for each land use before the factor-weighting and -rating procedure is done to determine the suitability of different locations for each land use.

2.2 Mapping Locational Suitability (Land Supply Scenarios)

Locational suitability mapping is a spatial analytic process that identifies the relative suitability of locations for each land use. The Suitability submodel of What if? corresponds to this process. The submodel is comprised of several steps as follows: (1) selecting the factors (e.g., slopes and soils) that are to be considered in locating the most suitable locations for a particular land use; (2) assigning factor weights indicating the relative importance of different factors for locating a particular land use (e.g., that slopes are twice as important as soils for locating industrial sites); (3) applying ratings to different factor types (e.g., a rating of 5 for low slopes and a rating of 1 for high slopes); (4) specifying which land uses can be converted from their current use to a new use; and (5) computing suitability scores indicating the relative suitability of each location for a particular land use. Those steps are based on a simple multicriteria weighting and rating technique which allows users to decide which suitability factors are how much important for each type of land use at each location. The bigger the suitability score of a parcel for a particular land use, the larger the suitability of the parcel for the land use. In addition, the land use conversion option allows model users to decide whether a land use can be converted to other types of land uses, or not. Overall, these steps require users to specify rules for land suitability analysis and land use conversion. The suitability analysis is done for developable lands such as vacant lands and green fields, which can be specified by the users. The suitability scenarios can be visualized by maps and tabular reports.

2.3 Deriving Space Requirements (For Land Demand Scenarios)

Space requirements for future land uses are derived from household and employment projections and assumed land development densities. This step is partially automated by Demand scenario submodel. To run the submodel, users must obtain some exogenous variables (e.g., household and employee projection) and set assumptions such as density rules. Using this information, the submodel automates the computation of the space requirements. The results of the numerical analysis results are visualized by tabular reports.

2.4 Analyzing Holding Capacity

This is a process of calculating the amount of future land demand that can be contained or held by the suitable land. This step is partially supported by comparing Suitability Scenario Report and Demand Scenario Assumption Report. The suitability scenario reports show the amount of suitable land that is available for each type of land use. And the demand scenario reports show the amount of land that is required to satisfy projected land use demand for each land use. The holding capacity can thus be reviewed by comparing the demand of required land and the supply of suitable land.

2.5 Synthesizing Land Suitability and Demand Assumptions (For Land Allocation Scenarios)

Rule-based allocation scenarios of Allocation submodel of What if? incorporate rules for the land use competition of market system, on one hand, and growth control policy, on the other, to allocate future land demand. First, the users have to specify allocation priority of future land uses. For example, if commercial land use is assumed to be allocated before residential uses, the submodel allocates the projected commercial land demand to suitable locations before allocating the projected residential land demand. Second, infrastructure options have to be specified by the users. For example, if residential land uses are assumed to be located only in existing sewer and drainage service area, the submodel would not allocate the residential uses outside the service area. Third, the users can use a growth control boundaries that specify where future development is permitted. The What if? model then allocates the projected demand for each land use - as determined by a particular demand scenarios - to the most suitable locations for that use - as determined by a particular demand scenario. The result is a series of map showing the projected land use in each location - from a set ' of the suitability, demand, and policy assumptions.

3. APPLICATION

The application study focused on a general land use planning procedure (i.e., land suitability analysis, land demand analysis, and land use allocation) that correspond to the process reviewed in the previous section. What if? was chosen for this study because (1) it was fully operational, (2) its model structure was deemed to be transparent and easy-to-understand, which would be advantageous for participatory planning and, moreover, (3) it effectively supported a standard land use design procedure (e.g., land supply and demand analyses and land use location-allocation) described in *Urban Land Use Planning* (Kaiser et al. 1995). What if? has been applied in the United States (Klosterman et al. 2002), Australia (Pettit 2002), and around the world. The study area of this paper was Chongju City, Korea.

3.1 Study Area

Chongju City is the capital city of Chungbuk Province, Korea. With two major highways, i.e., Kyungbu and Joongbu Highways, the mid-sized city has been one of the fast growing urban areas in the country. The City has been one of the fourteen cities that contain a Restricted Development Zone (RDZ), or Greenbelt, which has been an important growth management policy to control disordered urban sprawl for the last 30 years (Jin & Park 2000). Also, the City was one of the first municipalities in Korea that adopted a computer-based geographical information system (GIS) of digitized cadastral mapping and land supply monitoring in the early 1990s. The next section describes information requirement and data sources. It will be followed by the description of scenario-building and -testing processes.

3.2 Information Needs and Data Sources

What if? requires four types of information (Table 1). First, the model needs an existing land use map. Second, to conduct the land supply analysis, the model needs GIS layers of suitability factors for the study area. Third, population and employment observation and projection information are needed to derive future land demand. Fourth, the land use allocation process requires policy or regulatory

Table 1. Information and Data Sources

Categories	Information item	Data sources
Existing land uses	Parcel-based appraisal and tax information	The City and MOGAHA
Land Supply: Suitability analysis	Slope	MOCT/KRIHS
	Elevation	Ditto
	Farmland index	Ditto
	Forestry index	Ditto
	Roads	The City
	Zoning map	The City
Land Demand: Population/employment projection	Population 1990, 1995, 2000	Chongju City Annual Report
	Population projection 2001 -2021	The City Master Plan
	Employment 2001	The City Annual Report
Allocation Policy	RDZ (Greenbelt) boundary	The City

information such as growth control boundary.

3.2.1 Existing Land Use Map

Existing land uses were classified into twelve categories based on the parcel-based cadastral map of the City and the parcel-based assessed value database of Ministry of Government Administration and Home Affairs (MOGAHA 2001). The twelve land uses included: (1) detached house, (2) row house, (3) apartment, (4) residential/commercial mixed, (5) commercial, (6) industrial, (7) vacant, (8) forest, (9) agricultural, (10) parks, (11) roads, and (12) water (Figure 1). The RDZ or Greenbelt zone was truncated by the city municipal boundary for the study (Figure 1).

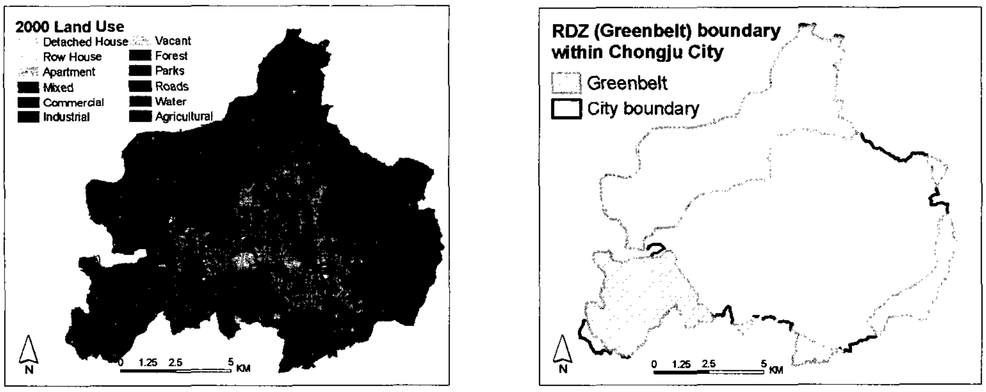

Figure 1. Existing Land Use Map and RDZ (Greenbelt) Boundary

3.2.2 Land Suitability Factors

In this study, six suitability factors were used: four natural factors and two market and legal factors (Table 1 and Figure 2). The four natural factors included slope, elevation, farmland index, and forestry index. The farmland and forestry indices were adapted from KRIHS' s comprehensive guide system for determining valuable agricultural and forest lands which was prepared for Environmental Assessment for Restricted Development Zone (RDZ) by Ministry of Construction and Transportation and Korea Research Institute for Human Settlement (MOCT/KRIHS 2000). Each suitability factor or layer was comprised of up to five suitability classes. The classes for suitability layers are listed in Table 2. In the Suitability Scenarios, the factors are used to compute suitability scores for each parcel, as described above.

Two additional factors addressed important non-natural factors of land developments in Korean cities. First, road accessibility was used as a market-oriented site suitability, which was called "marketability." Three types of roads were identified, i.e., major roads, arterial roads, and neighborhood roads. The road accessibility of each parcel was determined by analyzing whether or not a parcel was adjacent to, i.e., within 20 meters of, each type of roads. Second, local land use zoning regulation was used as a legal factor or what was called the "legal suitability" for developable parcels. A parcel was considered to be highly suitable for the land use that was currently designated by the zoning regulation for the parcel. For example, if a vacant parcel was zoned for row houses, the parcel received the highest rating for row houses, lower rating for mixed or commercial uses, and the lowest rating for industrial uses.

Table 2. Land Suitability Factors and Classes

Suitability Factors	Suitability Classes
Slope	Less than 5%; 5-10%; 10-15%; 15-25%; 25% or higher
Elevation	0-90 meters; 90-130 meters; 130 meters or higher
Farmland Index	Excellent, good, average, fair, poor
Forest Index	Excellent, good, average, fair, poor
Road Accessibility	No road service, major road, arterial road, and neighborhood road accessible
Zoning	Residential, commercial, industrial, green space, and preservation

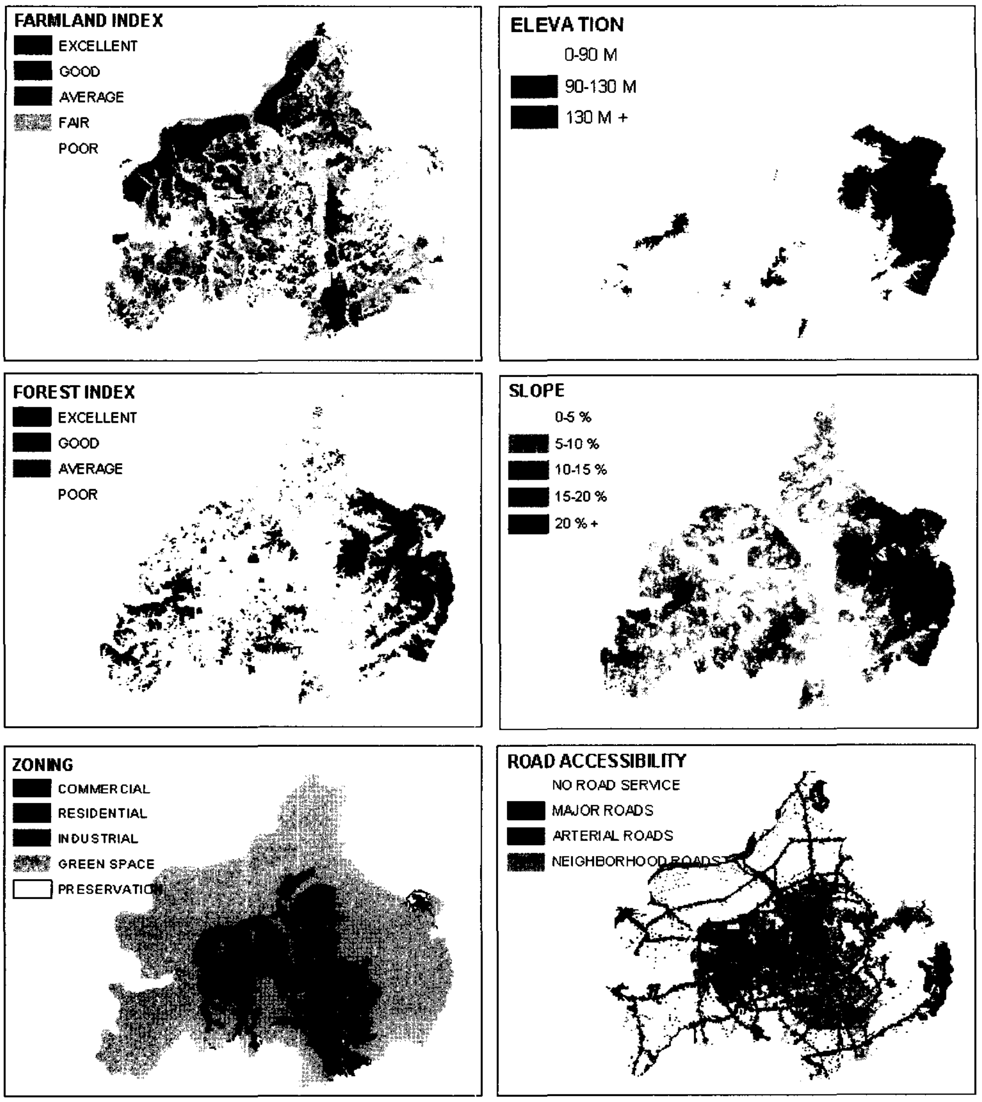

Figure 2. Suitability Factors

3.2.3 Land Demand Parameters

The What if? Demand submodel is based on assumptions of future growth of residential and urban non-residential activities, i.e., the number of households and employees. Tables 3 shows the size and densities of existing land uses.

Table 4 shows the projected number of households, which was derived by dividing the city' s population forecast by the projected average future household size. In order to project the employment growth, the study used a reasonable assumption that the current ratio of employment to population would be remained constant in the future (Table 4). It was assumed that the ratio of future employees to future population would be 0.3 or 30%. The number of future commercial employees was assumed to be 70% of total future employment including commercial and industrial. The "commercial only" employees were computed by assuming that the 80% of the future commercial employees would be located in purely commercial lands and the remaining 20% would be located in residential/commercial mixed land areas.

Table 3. Existing Land Uses

Future Land Uses	Area (Hectare)	%	Residential Units	Employees	Density[a]
Detached House	1,265.8	8.3	37,062	n/a	29
Row House	40.8	0.3	95,608	n/a	162
Apartment	408.0	2.7	7,066	n/a	234
Mixed	159.1	1.0	4,777	n/a	30/140
Commercial	359.5	2.3	n/a	89,128	248
Industrial	456.9	3.0	n/a	54,121	118
Other Land Uses					Developability
Vacant land	272.6	1.8	n/a		Developable
Forest	4,760.6	31.0	n/a		Developable
Park	72.2	0.5	n/a		Not developable
Road	1,226.9	8.0	n/a		Not developable
Water	1,048.3	6.8	n/a		Not developable
Agriculture	5,016.6	32.7	n/a		Not developable
No data	253.7	1.7	n/a		Excluded
Total	15,341.0	100.0			

a. Density means dwelling units per hectare for residential land uses while it means employees per hectare for commercial and industrial uses.

Table 4. Population and Employment Projection

Year	Population	Household size	Total Households	Percent Employment	Total Employment	Percent Commercial	Commercial Employment	Industrial Employment	Commercial Only
1990	477,783	4.09	116,827	n/a	n/a	n/a	n/a	n/a	n/a
1995	531,676	3.52	151,123	30.2	160,379	0.62	99,327	61,052	n/a
2001	587,000	3.26	179,799	28.2	165,531	0.67	111,410	54,121	89,128
2006	657,000	3.20	205,313	30.0	197,100	0.70	137,970	59,130	110,376
2011	726,000	3.10	234,194	30.0	217,800	0.70	152,460	65,340	121,968
2016	786,000	3.05	257,705	30.0	235,800	0.70	165,060	70,740	132,048
2021	835,000	3.00	278,333	30.0	250,500	0.70	175,350	75,150	140,280

3.2.4 Land Use Allocation Policies

The Allocation submodel of What if? can incorporate spatially explicit policy layers such as urban growth control boundary or infrastructure availability. These layers can be used to determine the spatial impact of those growth management policies in the study areas. This case study used the city' s Greenbelt policy to prepare scenarios to explore the future alternatives of urban land use growth with and without the policy.

3.3 Parcel-based Uniform Analysis Zone (UAZ)

This study used a pioneering approach, which has rarely been used for in land use projection models, let alone for What if?, that used land parcels as the basic analysis unit. The spatial unit of analysis normally used in What if? is a uniform analysis zone, UAZ (Klosterman 2002). UAZs are created by combing the land use, suitability, and land use policy layers used in the analysis together to create irregularly shaped polygons each of which contains all the attributes of the unioned layers. These irregular small polygons create an unrealistic setting for considering future land use changes since they do not match existing ownership-based land units. Instead, this study used the city' s parcel map to define the analysis units used to project future land uses.

The next section reviews how the standard land use planning processes was applied to Chongju City using the three scenario-based submodels of What if?.

3.4 Land Suitability Scenarios

The analytic process was initiated by using the What if? Suitability submodel to conduct a traditional land suitability analysis. The model' s user-friendly interface made it much easier to conduct the traditional factor-selection and weighting-and-rating procedure than with manual process of suitability analysis. Also, the submodel quickly generated summary reports and maps of the suitability analysis, which could be very difficult if done manually, hampering the speedy sketch planning processes.

Although the What if? Suitability scenarios were based on natural suitability factors, a new approach was used in the case study by considering the market and zoning suitability of land parcels for each land use. As explained before, road accessibility was used to determine marketability of a parcel for a particular land use and the zoning law was used to consider the legal restriction on developing the parcel. These two factors were used in every suitability scenarios to generate more realistic suitability analysis.

In the study, two suitability scenarios were created. The “Preservation” scenario considered all of the suitability factors in determining the land suitability for all future land uses, i.e., residential, commercial, and industrial uses. The objective of this scenario was to protect valuable forest and agricultural lands and prohibit future developments in significantly high slopes and elevation areas. The "Development-oriented" suitability scenario considered only one natural factor, i.e., slopes, along with marketability and legality factors. Therefore, the scenario provided much more developable lands for future developments than the Preservation scenario.

There were significant spatial differences of land areas available for future land uses under two different land supply scenarios (Table 5). As explained, the Preservation scenario significantly restricted future land supply compared to Development scenario.

Figure 3 displays different spatial patterns of suitable lands under the two scenarios. The most significant difference between them was in the eastern part of the City, i.e., the Woo-Am Mt. area that contains valuable forestry and elevated area. The area was assigned to be not suitable for future apartment development in the Preservation scenario and assumed to be available for apartment under the Development scenario. The southwestern part of the City showed another visible difference. It is notable that for apartment land use, scenarios assumed

Table 5. Land Suitability Scenarios: Available Suitable Land

Allocated Land Uses	Scenario1: Preservation		Scenario 2: Development	
	Area (hectare)	%	Area (hectare)	%
Detached House	2,283.6	22.7	5,177.6	51.5
Row House	3,434.9	34.2	6,417.1	63.9
Apartment	3,474.9	34.6	6,457.8	64.3
Mixed	3,434.9	34.2	6,417.1	63.9
Commercial	1,164.5	11.6	1,283.5	12.8
Industrial	2,042.2	20.3	5,146.3	51.2

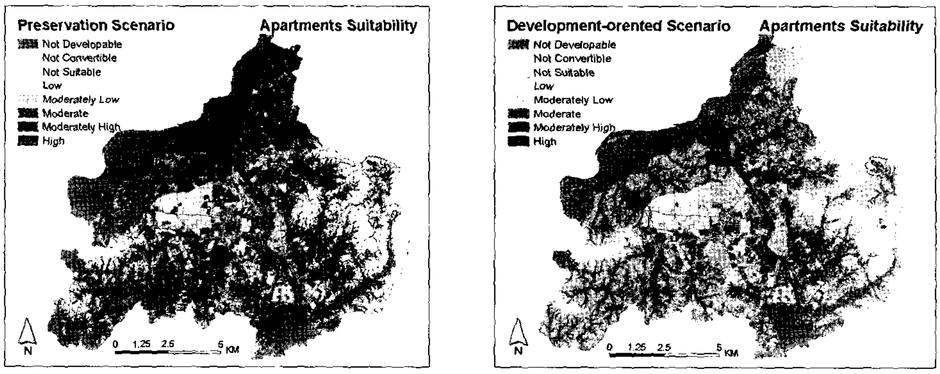

Figure 3. Suitability Maps

that detached housing sites were convertible to future apartment developments. That is why a significant portion of existing detached housing parcels was suitable for apartment use in both scenarios.

3.6. Land Demand Scenarios

A land demand scenario was generated with the Demand submodel of What if? based on information and assumptions about future households and employees and future land use densities. The information and assumptions were exogenous variables for the submodel, that is, prepared outside the submodel. However, the submodel helped organize and visualize the information by providing a easy-to-use model interface and summary tabular reports. It generated two types of reports. One report showed the assumptions about the future households and employments and density rules while another showed future land demand by land use type in hectare. Although it was feasible to create multiple land demand scenarios, this study used only one demand.

Table 6. Classification of Residential Units

Years	Detached houses		Apartments		Row houses		Mixed residential		Vacant houses		TOTAL	
	Units	%	Units	%	Units	%	Units	%	Units	%	Units	%
1990	38,540	56.7	22,026	32.4	4,419	6.5	3,019	4.4	n/a	n/a	68,004	100.0
1995	37,911	34.2	62,361	56.3	6,659	6.0	3,903	3.5	2,641	2.4	110,834	100.0
2000	37,062	25.6	95,608	66.2	7,066	4.9	4,777	3.3	5,551	3.8	144,513	100.0
2006	44,040	26.0	111,793	66.0	8,469	5.0	5,081	3.0	5,081	3.0	169,383	100.0
2011	51,757	26.0	131,383	66.0	9,953	5.0	5,972	3.0	5,972	3.0	199,065	100.0
2016	58,628	26.0	148,825	66.0	11,275	5.0	6,765	3.0	6,765	3.0	225,492	100.0
2021	65,130	26.0	165,330	66.0	12,525	5.0	7,515	3.0	7,515	3.0	250,500	100.0

Table 7. Growth Scenario: Land Demand

Allocated Land Uses	Additional Hectare Required			
	2001~2006	2006~2011	2011~2021	2001~2021
Detached House	171.1	200.2	306.0	677.3
Row House	6.2	7.2	11.0	24.4
Apartment	56.6	66.3	101.3	224.3
Mixed	19.7	23.1	35.3	78.2
Commercial	103.4	45.1	71.4	219.9
Industrial	41.7	51.8	81.8	175.2
Total	398.8	393.7	606.9	1,399.3

The study used the number of residential dwelling units for each type of housing based on the Census (Table 6). The current proportions of different housing types were assumed to remain constant for the next twenty years. Finally, demand scenario submodel of What if? computed the final figures of future land demands for residential, commercial, and industrial land uses, based on the assumptions and information described above (Table 7).

3.7. Balancing Land Supply and Land Demand

The allocation submodel process was quick and easy to use. Users had to select a suitability scenario and a demand scenario along with growth control policy to create an allocation scenario. This process can be repeated by using different supply and demand scenarios and different policies to create many different allocation scenarios. When preparing the Chongju city master plan with manual GIS operations, one of the authors spent a substantial amount of time conducting the lengthy process of land use allocation design. However, when using What if? allocation submodel, the authors could quickly and easily create a variety of allocation scenarios once the policies or rules reflected in suitability and demand scenarios and development control policies were decided.

Four allocation scenarios were generated by combining land suitability and growth control scenarios; only one demand scenario was used. The allocation scenarios were named as follows, "Preservation-No Greenbelt", "Development-No Greenbelt", "Preservation-Greenbelt", and "Development-Greenbelt" (Table 8). In order to examine the impact of alternative public policy on future land use patterns, the study considered scenarios with and without the Greenbelt policy and with and without environmental policies.

The policy goals and objectives of the four allocation scenarios were clear. The Preservation-No greenbelt and Development-No greenbelt scenarios did not incorporate the Greenbelt policy while the first tried to preserve

Table 8. Matrix of Allocation Scenarios

		Growth Control Assumption	
		No greenbelt	Greenbelt
Land Suitability Assumption	Preservation	Preservation-No Greenbelt	Preservation-Greenbelt
	Development	Development-No Greenbelt	Development-Greenbelt

important natural factors and the second assumed minimal preservation. In contrast, the Preservation-Greenbelt and Development-Greenbelt scenarios did not allow any future urban land uses to be located inside the greenbelt growth control area.

The case study found an interesting policy implication during the model-run. The Preservation-Greenbelt scenario ran out of lands after a decade, i.e., between 2011 and 2021, where land supply was adequate to accommodate future land demand under the other allocation scenarios. This suggests that if the City implemented the Preservation and Greenbelt policies, it would need to raise its current land use densities. The City can alternatively lower the environmental preservation standards to allow more lands for future urban growth. This kind of policy issues might generate constructive discussions between planners, decision makers, citizens, and other interests groups about alternative futures of their community' s land use.

The output of the allocation scenarios was mapped (Figures 4-6). The spatial patterns of those scenarios can be understood by referring to the existing land use layer, the Greenbelt zone, and suitability factors shown in Figures 1 and 2. The development-oriented scenario with Greenbelt policy created a more compact land use development pattern. Alternatively, the development-oriented scenarios with Greenbelt, encroached over on valued forest and agricultural areas.

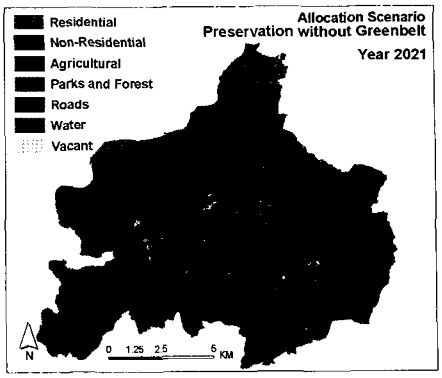

Figure 4. Allocation Scenario: Preservation No Greenbelt

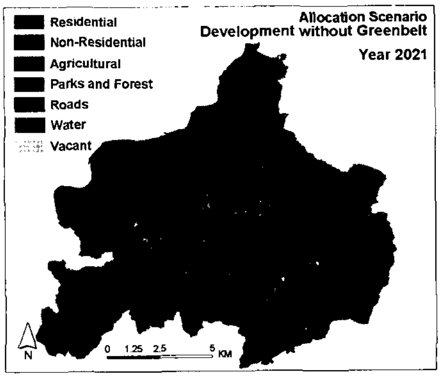

Figure 5. Allocation Scenario: Development No Greenbelt

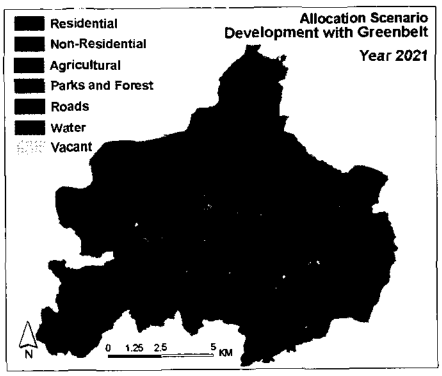

Figure 6. Allocation Scenario: Development Greenbelt

Table 9 shows useful and interesting information on the impact of the allocation policies in the loss of farmland and forestry land. Under the just Peservation scenario, the city did not lose any high quality farmland and forestry. However, the Development scenarios allowed future land development to high quality farmland and forestry land. An interesting fact was found that the Development-Greenbelt policy lost more farmland than the Development-No Greenbelt scenario. This happened because the RDZ policy forced development to be located outside Greenbelt zone, allowing development in farmland and forest areas under a less restrictive land suitability policy.

Table 10 shows how much land was consumed inside and outside the Greenbelt zone under thedifferent scenarios. It was clear that land would not be developed inside the Greenbelt zone when RDZ-based scenario was used. The Preservation-No RDZ policy resulted in a larger amount of land development inside the Greenbelt zone than the Development-No RDZ scenario. This happened because under the latter scenario some of the future development was located in the western part of the city, outside Greenbelt zone. In contrast, the former scenario prevented future development from being located in the preservation areas (e.g., forestry and steep slopes) that were outside the Greenbelt zone.

Table 9. Farmland and Forestry Loss

Scenarios	Existing (2000)		Projected (2020)		Area Lost (2000~2020), Hectare			
	Farmland	Forestry	Farmland	Forestry	Farmland	Percent	Forestry	Percent
Preservation + No RDZ	1,417	2,625	1,417	2,625	0	0.0%	0	0.0%
Development + No RDZ	1,417	2,625	1,388	2,074	29	2.0%	551	21.0%
Development + RDZ	1,417	2,625	1,403	1,871	14	1.0%	754	28.7%

Table 10. Development Inside and Outside Greenbelt

Scenarios	Area Developed (2000~2020), Hectare			
	Inside Greenbelt	Percent	Outside Greenbelt	Percent
Preservation + No RDZ	779	11.8%	14,560	88.2%
Development + No RDZ	584	8.8%	14,755	91.2%
Development + RDZ	0	0.0%	15,339	100.0%

4. CONCLUSION

In Korea, the current efforts of NGIS and local initiatives have greatly increased the availability of GIS-based spatial data, creating a favorable environment for PSS land use projection models. The paper examined the applicability of a collaborative PSS model for land use design processes in Korean cities by applying the What if? PSS to Chongju City. The study used the same data and design processes that were used for Chongju City master planning processes. This allowed the authors to evaluate the applicability of the GIS rule-based PSS model to the City' s parcel-based GIS data and other planning policy assumptions for evaluating a variety of policy-oriented land use change scenarios.

The model obviously had limitations in predicting future land use change by applying a simplified rule-based projection procedure. However, every model has its own strengths and weaknesses in terms of model structure, data requirement, model calibration, and visualization. Also, there is little evidences that more complex models outperform simpler models. Moreover, to be able to support collaborative planning processes, computer-based PSS models should be simpler, more transparent, more visual, and more interactive than traditional urban models. As a result, the What if? PSS had much potential to be used in interactive planning processes by providing a user-friendly interfaced, simple and clear model structure, policy-oriented scenario testing, and highly visual and speedy reporting tools.

The rule-based submodels of What if? used policy choices (e.g., suitability factors, weightings, ratings, conversion scheme, land use densities, and growth control policies) specified by model users, providing a transparent and policy-oriented model structure. The user-friendly interface of the model made it easy to understand and use the policy options to specify the rules required by the model. For example, as Suitability submodel' s intuitive interfaces made scenario-building easily understandable. Also, the land use allocation, which would be a lengthy iterative and complex process when done manually, was done speedily and easily by the model' s Allocation submodel.

All the scenario-building and -testing processes were transparent to model users. The model used simple multiattribute weighting-and-rating technique that was more comprehensible to non-expert users than many other expert-oriented complex models. Another chief merit of the PSS model was the speedy visualization of model outcome. What if? produced tabular reports and maps for all the submodels so that the users could immediately see the impacts of their policy choices on future land use pattern. Also, the users could examine and compare the locational and quantitative differences of various scenarios in real-time by the reporting system. If necessary, the maps and reports can be exported to a variety of file formats used in many other GIS and spreadsheet software.

The rule-based land use change projection model, What if?, which has been described by diverse terms such as GIS- and rule-based, policy-oriented, and scenario-based, and collaborative, was applicable to Chongju City and apparently to the other comparable Korean cities. The model supported the well-established processes of land use planning that are currently used by Korean land use planners. Land suitability and land demand were analyzed by the policy-oriented rule-based scenarios and were combined to produce land use allocation scenarios. Also, the data needs of the model could be easily met by the spatial database of Chongju City. In general, planners would be able to easily and quickly prepare standardized planning information. The model-driven planning information can be easily used and understood by planning participants including the general public. A variety of standardized policy options or rule-based scenarios provide an environment for constructive discussion in a collaborative planning context. As a result, this type of GIS-based PSS models has the *potential to become a valuable tool in* Korean land use planners' toolbox.

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