A STUDY ON THE APPLICATION OF THE COMPREHENSIVE LAND USE/TRANSPORTATION MODELS IN SEOUL CAPITAL REGION

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서울 수도권에 있어서의 토지이용 및 교통 통합모델 응용에 관한 연구

윤 정 섭

ABSTRACT

The external diseconomy has been accelerated by the megaspatial structure of metropolis such as Seoul Capital Region(below SCR), Korea in which the more than 10 million populations inhabit. The main course for it could be elaborated by the overconcentration of the urban and regional function of various kinds. The study is performed to analyze quantitatively the status quo of the region as described above and proceed into forecasting the future population trend, the land use allocation for the increment of regional population and to set the location of new towns in Seoul Capital Region System projected by the methods in computer algorithm of descriptive models such as the simple and multiple regression analysis models, the gravity model and the facility location on a plane model analysis.

The goal and objective of the metropolitan planning are to decentralize the regional growth management to the optimum degree, which will not hinder the economic growth of the region, but the result of the study is that we can not discourage the functional concentration of Seoul Capital Region and, we have to provide the region with the appropriate new towns.

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요 약

본 연구는 서울 수도권계획에서, 종합적 토지이용모형 및 교통계획모형을 적용하여 1995년 이전에 4개의 신도시건설을 제안한 논문이다.

서울 수도권에는 1천만이 넘는 인구가 거주하여 수도권과 같은 대도시권의 거대 공간구조에 의하여 외부불경제가 가속화되고 있다. 이에 대한 주 요인은 여러 종류의 도시 및 지역기능의 과잉집중에 의하여 설명될 수 있다. 본 연구는 상기에 기록된 대로 수도권의 현황을 계량적으로 분석하고 그리고 장래인구추세를 추정하였고, 권역인구 증가분의 소요도는 가용토지배분과 수도권 시스템내에 신도시 위치선정을 제시하였다. 이들은 기술통계모형으로 컴퓨터 알고리즘에 의하여 추정되는데, 단순회귀, 중회귀분석모형, 중력모형과 평탄위상에서의 도시시설입지모형 등이 사용되었다.

대도시권계획의 목적과 실제는 지역성장관리를 적정수준으로 분산시키는데 있다 하겠으며, 이것은 그 지역의 경제성장을 방해하지 말아야 하겠으나, 본 연구의 결과로는 우리는 서울 수도권의 기능적 집중을 억제하기 어려우므로 우리는 적절한 신도시건설로서 수도권 성장에 대처하여야 한다는 사실이 판명되었다. 아울러 본 논문에서는 수도권지도를 GIS로 도면화하였다.

Urban and Suburban Area in SCR

The preliminary findings and observations of Seoul Capital Region show as the following.

The Seoul Capital Region consists of three groups of administrative boundaries ; the special city of Seoul, Gyonggi Province and Cheolwon County which is an adjacent county of Gangweon Province. The total area of the capital region is approximately 12,500km² and accounts for about 13% of the whole country. The population of the region was approximately 11.8 million in 1977 which is proportional to about 32.6% of the total population of Korea.

Population Structure in SCR

The Past Population and Job Distribution and Density in Seoul Capital Region

It is observed that the growth rate of GRP and population for Seoul are quite slowed down. For instance, the annual growth rate of Seoul's GRP has dropped from 21% per year in the period 1960-70 to 10.0% per year in the next period 1970-74. The population growth rate has been slowed down from 9.4% per annum in the

Table 1 Area and Population of the Capital Region, 1977

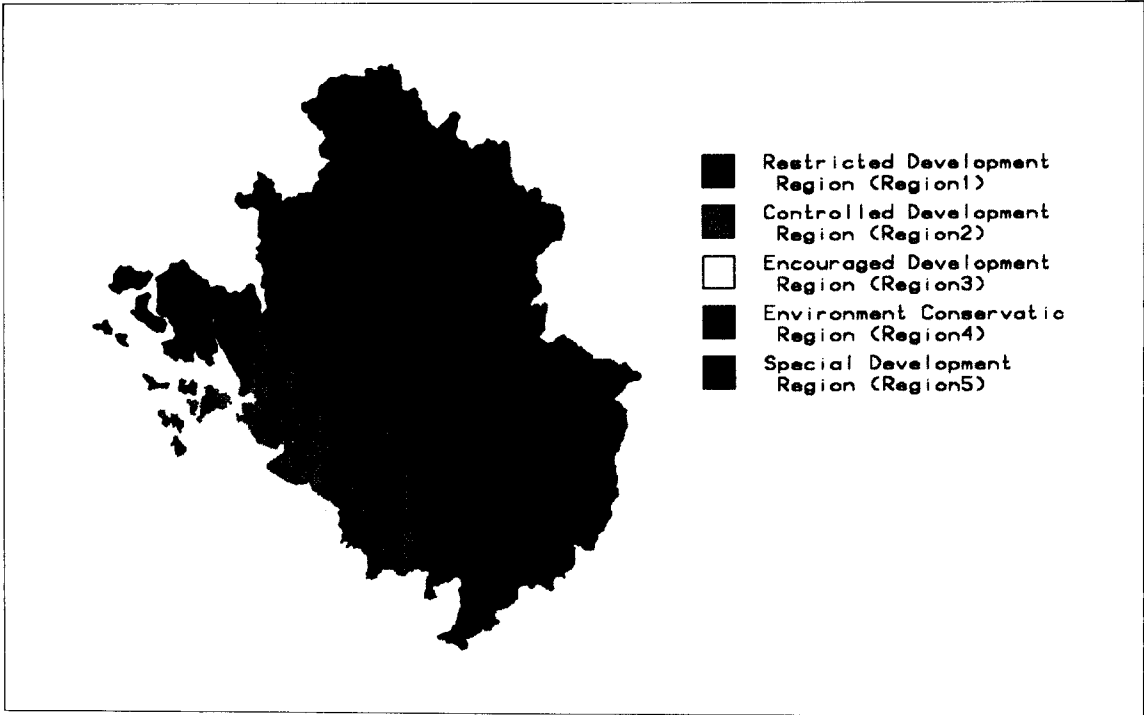|	Area (km²)	Population (1,000 persons)
Seoul City	627	7,525
Gyonggi Province	11,038	4,295
Cheolwon County	824	66
Total	12,489	11,886

Fig. 1 Map of Seoul Capital Region
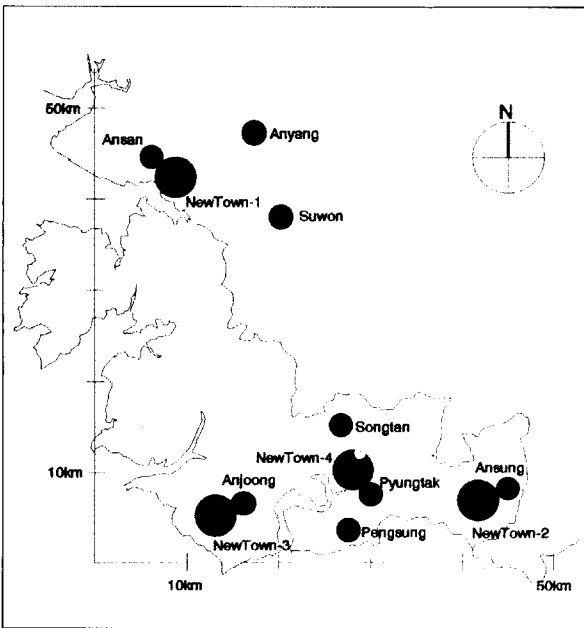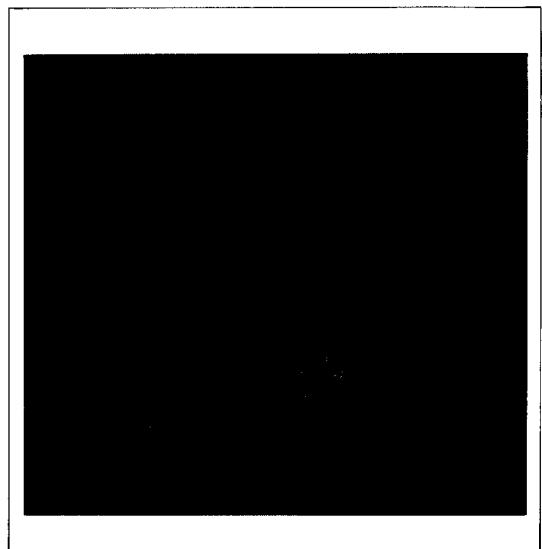

Fig. 2 Location of New Towns in Ring3

Fig. 3 The presentation of Available Land in Seoul Capital Region with 4-New Towns.

Table 2   Total Employment and Population of SCR, 1989

(unit : persons)

	Total Emp.	Basic Emp.	Non-Basic Emp.	Total Pop.
Ring 1	57,362	42,911	14,451	724,302
Ring 2	796,630	648,275	148,355	4,213,176
Ring 3	81,468	69,086	12,382	495,490
Ring 4	56,744	48,089	8,655	579,534
Ring 5	92,812	77,357	15,455	591,454
Seoul	1,622,045	703,623	918,422	10,948,734
Total	2,707,061	1,589,341	1,117,720	17,552,960

period 1966-70 to 4.4% in the next period 1970-75. The similar trend of declining population growth rate in also found for the capital region as a whole.

Table 3   Annual Population Growth Rate

(unit ; %)

	1960−66	1966−70	1970−75
Nation	2.6	1.9	2.0
Capital Region	4.8	6.2	4.1
Seoul	7.3	9.4	4.4

The distribution of population within Seoul Capital Region has been shown in the following table into the each Ring ; see figure 1 for the designation of the Ring.

The growth rate of manufacturing employment is shown on table 5, in which Ring 3 area(outer south, SCR) had the most outstanding rate.

Table 5   Manufacturing   Employment   Growth Rate, 1970-79

(unit : %)

Ring 1 (including Seoul)	83.5
Ring 2 (immediate South)	271.9
Ring 3 (outer South)	628.2
Ring 4 (immediate North)	259.4
Ring 5 (outer North)	114.6

The regional share of population and economic activities against the nation and Seoul will be as follows :

The Population Projection of SCR (Regression Analysis)

To predict the future population growth of Seoul Capital Region, the simple regression and multiple regression analysis are evaluated for the population increment with the independent variable of number of the basic employment and

Table 4   Population Distribution in the Capital Region

	Population(1,000 persons)		Annual G.R. (%)	Area(km²)
Year	1970	1977	1970−75	1977
Ring 1	5,536	7,525	4.5	627.1
Ring 2	1,364	2,193	7.0	1,652.6
Ring 3	775	848	1.3	4,017.9
Ring 4	425	510	2.6	1,039.1
Ring 5	838	812	-0.5	5,012.7
Total	8,938	11,889	4.2	12,349.4

Table 6 The Regional Share of Population and Economic Activities

	1970			1977		
	Nation	Seoul	SCR	Nation	Seoul	SCR
Population	32,241	5,423	8,715	36,436	7,527	11,888
(1,000 persons)	(100%)	(16.8)	(27.0)	(100%)	(20.7)	(32.6)
No. of Manuf.	24,114	5,708	7,939	26,726	7,259	11,281
Firms	(100%)	(23.7)	(32.9)	(100%)	(27.2)	(42.2)
Manuf. Emp.	861	292	396	1,919	535	924
(1,000 persons)	(100%)	(33.9)	(46.0)	(100%)	(27.9)	(48.2)

the non-basic employment.

By SAS analysis of the simple regression, the intercept a = −122,153 and regression coefficient b = 9.6861 are output as the following equation.

$$\Delta P_{SCR(t/t+5)} = -122,153 + 9.6861 \Delta E_{SCR(t-5/t)} \quad (1)$$

where ΔP_{SCR} : the population change in SCR

ΔE_{SCR} : the change in total employment in SCR

(t/t+5) and (t−5/t) : subscripts denoting 5-year intervals of time (in other words a 5-year lag is being assumed)

Substituting the value of $\Delta E_{SCR(t-5 : \cdot 84/ : \cdot 89)}$ in each Ring Area, we can get table 7.

Table 7 ΔP_{SCR} Projection by Simple Regression Analysis

(unit : persons)

Zone	ΔE_{SCR} '84~'89	ΔP_{SCR} '89~'94
Ring 1 (w/o Seoul)	18,605	58,056
Ring 2	246,961	2,269,935
Ring 3	31,226	180,305
Ring 4	24,208	112,328
Ring 5	28,948	158,240
Seoul	378,132	3,540,470
Total	728,132	6,319,335

By SAS analysis of the multiple regression the intercept a = −93,746 and regression coefficients b = 4.220478 and c = 10.528293 are output as the following equation.

$$\Delta P_{SCR(t/t+5)} = -93,746 + 4.220478 \Delta B_{SCR(t-5/t)}$$
$$+ 10.528293 \Delta S_{SCR(t-5/t)} \quad (2)$$

where ΔP_{SCR} : the population change in SCR

ΔB_{SCR} : the change in the employment of basic industry in SCR

ΔS_{SCR} : the change in the employment of service industry in SCR

(t/t+5) and (t−5/t) : subscripts denoting 5-year intervals of time (in other words a 5-year lag is being assumed)

Substituting the value of $\Delta B_{SCR(t-5 : \cdot 84/ : \cdot 89)}$ in each Ring Area, we can get table 8.

To summarize the consequence of tables, table 9 is presented.

Among the three methods of population projection, the population of Seoul Capital Region at 1994 is estimated between 19,902,451 and 22,019,634 persons selecting the methods of simple regression (time series) and multiple regression

Table 8 $\Delta P_{SCR('84/'94)}$ by Multiple regression Analysis

(unit : persons)

Zone	ΔB_{SCR} $t-5 \sim t$	ΔS_{SCR} $t-5 \sim t$	ΔP_{SCR} $t \sim t+5$
Ring 1 (w/o Seoul)	14,139	4,466	12,946
Ring 2	199,795	47,166	1,246,061
Ring 3	29,897	1,329	46,425
Ring 4	23,445	763	13,236
Ring 5	38,924	-9,976	-34,498
Seoul	111,679	266,435	3,182,774
Total	417,897	310,183	4,466,944

Table 9 $\Delta P_{SCR('84/'94)}$ by Three Methods

(unit : persons)

Zone	Simple Regression			Multiple Regression		Simple Reg.
	P. ('89)	ΔP_{SCR} ('89/'94)	T.P. ('94)	ΔP_{SCR} ('89/'94)	T.P. ('94)	Time series T.P.('94)
Ring 1	724,302	58,056	782,358	12,946	737,248	12,259,618
Ring 2	4,213,176	2,269,935	6,483,111	1,246,061	5,459,237	5,846,801
Ring 3	495,490	180,305	675,795	46,425	541,915	986,703
Ring 4	579,534	112,328	691,862	13,236	592,770	599,126
Ring 5	591,454	158,240	749,694	-34,498	556,956	210,203
Seoul	10,948,734	3,540,471	14,489,205	3,182,774	14,131,508	—
Total	19,552,690	6,319,335	23,872,025	4,466,944	22,019,634	19,902,451

because it is highly evaluated that using two methods is the reasonable choice for the future population of SCR.

Space Organization and Its Allocation Planning in Seoul Capital Region

The Status Quo of Available Land and Its Projection(by the transport distribution model of double constrained gravity model for area interaction)

Our next question in Seoul Capital Region is where to develop new towns for the future increment of population in SCR, both for day-time and night-time population increment. As indicated below, the area available for future development in Seoul is 108.7km² while the available land for Gyonggi Province is 4,334.1km². The greenbelt surrounding the capital city is 1,556km² and must be conserved at all cost. Approximately 2,064km² in the northern part of the region are and should remain preserved as a military facility protection area(Ring 5 ; Special Development Region). The 3,640km² area in the eastern sector of the region must be protected from intensive development(Ring 4 ; Environmental Conservation Region), because the two upstream reaches of the Han River which passes through the area are vital sources of drinking water for the whole region and therefore must be kept clean.

Table 10 Land Available for Future Development

(unit : km²)

	Total Area	Developed Land	Unsuitable Land	Developable Land
Seoul City	671.1	275.3	243.1	108.7
Gyonggi Pro. & Cheolwon C.	11,722.3	744.1	6,644.1	4,334.1
Total	12,349.4	1,095.5	6,887.1	4,422.8

Subtracting already developed areas as well as the area which are unsuitable for development including the agricultural land classified as permanent greenbelt and the land physically impossible to develop, from the total area of the capital region, the total area available for future development is approximately 4,422.8km² in the capital region. The developable land lies by and large south of the Han River and it is there where the most of the future development must take place.

The above statements are the status quo and the amount of future available land in Seoul Capital Region and the projection of new towns to be built in the region whose built-up area and its location in the region are predicted by the simulation model in computer algorithm, has been estimated as follows.

will accommodate the future population of new towns with the application of urbanization ratio to the population projection in the region.

Step 2 : In the projection of new town, to evaluate the built-up area size for the day-time population attracted to new town from the other area to use public facilities in new town. The projection of the day-time population is estimated by the traffic volume of trip attraction to new town using the double constrained gravity model in transport model.

Adding the amount of the built-up area of new town of Step 1 and Step 2, the final land area requested for new towns in the region are calculated as the following.

By Step 1, the total demand amount of urban available land projection will be such as below.

Table 11 Demand Amount of Urban Available Land in SCR

(unit : persons, ha, persons/ha)

	Ring 1	Ring 2	Ring 3	Ring 4	Seoul	Total
Proj. Pop('94)	734,248	5,459,237	541,915	88,915*	4,131,508	20,958,823
Built-up Area('89)	1,862	17,224	2,811	433	28,894	51,204
Proj. Pop Density('94)	300	260	120	200	260	—
Total U.D. Area	2,520	20,551	4,585	405	38,725	66,786
Excess U.D. Area for New Towns	658	3,327	1,774	—	9,851	15,610

Step 1 : In the projection of new towns, to evaluate the optimum area size that

*Population in Ring 4 is estimated to be 88,915, 15% of 592,770, total population

Table 12 O-D Trip Distribution(T$_{ij}$) among 5 Sub-region in SCR by Double Constrained Gravity Model

(unit : P.T.)

	Ring 1	Ring 2	Ring 3	Ring 4	Ring 5
Ring 1	19,849,000	3,387,855	292,942	741,905	410,425
Ring 2	4,562,630	3,361,654	347,702	143,356	246,987
Ring 3	230,703	203,324	397,647	15,292	52,610
Ring 4	411,782	59,080	10,777	477,819	24,536
Ring 5	357,252	159,634	58,149	38,479	311,031

by the method of multiple regression, because of the function of Ring 4, which is Environmental Conservation Region, and population in Ring 5 is disregarded because of Special Development Region. (table 9)

By Step 2, to evaluate the additional built-up area size for the day-time population attraction to four Rings in SCR.

If we subtract the internal O-D trip between the same sub-region from the total O-D trip of each sub-region, we will get table 13.

Multiplying the traffic volume of new urban area(Ring 1~4) in trip attraction by the population ratio of new urban area in each Ring, we obtain the trip attraction of new urban area as table 14.

For the necessary land area to accommodate the trip in each sub-region the following equation is established.

Table 14 Distribution of Trip Attraction to New Urban Area in 4 Sub-Regions

(unit : P.T.)

	Population Ratio of new Urban Area(%) *	Trip Attraction of New Urban Area : I
Ring 1	2.1	113,889
Ring 2	2.4	83,949
Ring 3	20.0	103,838
Ring 4	72.5	210,376

*Population ratio of New Urban Area is derived from the population ratio of urbanization above county level cities.

$$A = I/1.66(P.T./P.) \times 1/\rho \qquad (3)$$

where, A : supplemental new urban area(ha)

I : Trip attraction of new urban area(P.T.)

ρ : facility accommodation population density(1,800 persons/ha)

Table 13 Distribution of Trip Attraction into 4 Sub-Regions

(unit : P.T.)

	Trip Attraction	Distribution of Trip Attraction	
		New Urban Area	Other Area
Ring 1	5,562,367	5,423,308	139,059
Ring 2	3,809,893	3,497,863	312,030
Ring 3	709,570	519,192	190,378
Ring 4	991,032	290,174	700,858

Table 15 Supplemental Land Area for new Town (New Urban Area)

(unit : ha)

	Supplemental Land Area
Ring 1	37.86
Ring 2	27.91
Ring 3	34.52
Ring 4	69.84
Total	170.13

Now adding the amount of land area by Step 1 and Step 2 of new town in each sub-region, we obtain the total land area of new towns.

Table 16 Total Land Area of New Town

(unit : ha)

	Step 1 : (table 11) by Population Projection	Step 2 : (table 15) by Trip Attraction	Total Land Area
Ring 1	10,509.0*	37.86	10,546.86
Ring 2	3,327.0	27.91	3,354.91
Ring 3	1,774.0	34.52	1,808.52
Ring 4	0.0	69.84	69.84
Total	15,610.0	170.13	15,780.13

*For Ring 1's land area by Step 1, it is the added area of 658ha (Ring 1) plus 9,851 ha (Seoul) by table 11.

The Site Selection of New Town in SCR

The Location of New Town in Ring 3 by Facility Location and Plane Model

After the optimum area of new towns was computed on table 16 as above, it is requested to determine the optimum location of new towns so that the land use planning of SCR is to be completed.

The site selection of new towns in the region is deliberately considered and the new town's location in Ring 3 is finally selected and the four new town's site in Ring 3 are analyzed quantitatively by manipulating the facility location on a plane model as follows.

By the Metropolitan Planning of SCR the region was divided into five sub-regions as described above. Among five sub-regions the best site location for new towns is to be in Ring 3-Encouraged Development Region, which will properly accommodate the new urban area, e.g. new towns.

To analyze the new town location by the facility location model, the coordinates of major existing cities in Ring 3 are set as the following table and figure.

Inputting the coordinates of major cities and the total trip generation into the facility location PGM, the required

Table 17 The Coordinates of Major Cities in Ring 3

(unit : km)

City	X-Coordinate	Y-Coordinate
Ansan	6.8	44.0
Pyungtak	30.8	6.8
Songtan	28.2	15.2
Ansung	47.0	8.6
Pensung	28.2	4.2
Anjoong	16.6	6.4

Table 18 Coordinates of Four New Towns in Ring 3

(unit : km)

	X-Coor	Y-Coor	Location
New Town-1	6.80	44.00	Vicinity of Ansan
New Town-2	47.00	8.60	Vicinity of Ansung
New Town-3	16.60	6.40	Vicinity of Anjoong
New Town-4	30.79	6.83	Vicinity of Pyungtak

coordinates of four new towns in Ring 3 are output as table 18 and figure 2.

and to locate the necessary new towns in the region.

Summary and Conclusion

It must be pointed out in summary and conclusion that first, the study takes into account the population increment and projection of SCR, which represent the centrality force of national population into SCR by the demand for living and convenience factor and economic factor as well. Second, the study tries to estimate the space organization and its allocation planning in SCR, the need for new towns and the site for new towns are also analyzed in SCR.

Projection estimations for the future population, the land area of new towns and the location of new towns in SCR are analyzed quantitatively using computer algorithm. The conclusion of the study is that the need for population and land area in the region will be continuously increasing and we must provide for new towns to accommodate these increment in SCR.

Whether the development strategy of the region is the centralization or the decentralization of centrality is not the goal of this study. The main goal of the study is to predict the future trend of population, available land in the region

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