The Comparison Of Istanbul Simulation Results Of Cellular Automata Based Lucam Land Use Estimation Model With Large Scale Manufacturing Industries Using High Technology

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1 INTRODUCTION

Recently parallel to the technological developments, in the transition process from industrial community to information community, while industrial production is becoming regular and routine, new activities and productions in especially service sector occurred. While service sector is prefering urban areas in tendencies of land use preferences, ındustries using high technology especially in Istanbul tend to prefer hinterlands of metropolitan areas. Another effect of technology is that it offers advantages for freedom to land use preferences of economic activities. Technological developments strengthen connections in economic relations, remove the disadvantages of physical distance, decrease the land preference necessity in congested urban areas, offer preference freedom to workers and enterprises where they live and work.

In Turkey after the liberal economy, the diversity of production activities and the rivalry environment of open market economy have brought industrial regeneration and technological development. These developments have caused rapid expansion in metropolitan areas and variation and transformation of different functional areas.

After 1980's important tools in controlling the differentiation seen in metropolitan cities, planning of the development and transformation have been developed. One of these tools is land use simulation models which use existing relation system and reflect all the properties of development and transformation dynamics of metropolitan areas to the results.

The use of modelling and simulation techniques in getting the development schema of cities, determining of transformations in natural, physical and social environment and defining negative or positive effects of urban developments on natural and cultural heritage in long term will be one of the planning standarts in Turkey and Europa in the future. In Turkey which is in an entrance process to European Union, the use of modelling and simulation tools is an inevitable situation in planning studies, and urban development and transformation studies.

In this article, depend on the relationship system between Istanbul's micro and macroforms how can the development, size and density of the metropolitan city defined as cellular groups and the simulation of the macroform of Istanbul metropolitan area and developments and transformations in city centers by cellular automata based LUCAM model as an urban modelling tool are explained. Furthermore in this article, whether the land use preferences of industrial firms using high technology and having research-development department and industrial areas after the running of LUCAM model to metropolitan area fit into one another are tested.

2 THE CONCEPT OF CELLULAR AUTOMATA AND CELLULAR AUTOMATA BASED MODEL OF LUCAM

In many studies Cellular Automata (C.A.) is an operation system and a feedback mechanism in cellular dividing of events and described subjects and determination of future condition of every cell depend on the nearby cell. Cellular Automata is described as the multi-centered planning of traditional single centered cities in post-modern era (Wu, 1998).

A cellular automata forms from regular cell lattice. Development occurs in time steps. Every cell characterise with a situation. Every cell develop by the same rule only depend on the situation of the cell and neighbour cell number. Neighbour relationship is local and self similar. Two main concepts and their relation is important in the running system of models depend on cellular automata. These concepts are induction and deduction approaches between real world (world of observed events-events to be modelled) and certain world (modelled events world). (Colonna, Stefano, Lombardo, Papini, Rabino, 1998).

The objective of this model developed for estimations about land use in urban sites is to obtain the data, which will contribute to the formation of growth orientations, on the basis of the data about the land use and the wants of the user in the synthesis phase of planning studies. Development of this model (LUCAM) has been founded upon CA developed by G. Engelen and R. White and the simulation model for estimations about settlement land use (Engelen, White, Uljee, 1997; White, Engelen, 1997-a, White, Engelen, 1993-b). The main features and the fiction of the model is based on the method developed by Engelen and White. On the other hand original ways have been followed in data formation and assessment methods. This method has been employed to test the model in Istanbul Metropolitan Area and to evaluate the results. In this model each cell represents a kind of urban land use (residence, industry, trade, facility, vacant. The main features, the operation system and assessment system of this cellular automata based model are mentioned below.

2.1 The Operation System of the LUCAM Model

The automation is divided into 500x500 m grilled shaped cells. Each cell must be in one of the pre-determined conditions i.e. Vacant (V), Residence (R), Industry (I), Trade (T), Facility (F) . The size of the grill changes according to the size of the settlement in which the model is tested. The area size accepted as about 2,5 ha for Istanbul Metropolitan Area.

The neighbour unit of a cell is defined as all the cells that remain in the 6 cell distance from the main cell. The total number of the cells that exist in the area between the core cell and the neighbour cells in the sixth zone is 168. As the cells are in a regular order, every cell in the neighbourhood is found in a 500 meter distance band (zone 1) or 4242 meter distance band (zone 6).

Empty cells have no weight and they directly contribute to the transformation potential. The facility areas exist in the settlements as unchanging function areas. These areas are for public use and they can not be transformed into functions such as residence, trade or industrial areas unless there is an extraordinary condition. On the other hand the transformation of facility areas take place if there is a need for another facility for public use. For this reason the cells defined as facility enter the model as they are, do not have any impacts on other cells and do not have any kinds of transformation.

According to the area values and economic effects the hierarchy of the lowest and highest conditions (vacant, residential, industrial, commercial, facility area) in the land use model (White, Engelen, 1993-a, 1993-b; White, Engelen, 1997-a, 1997-b; Yüzer 2001).

In each turn, the transformation potentials are calculated for all possible transformations. For one cell the transformation potentials are calculated as a total (Formula 1).

The Calculation Method of the Cellular Transformation Potential

$$P_{ij} = (\sum_{k,d} m_{kd}) / \sum h \qquad (1)$$

P_{ij} : is the transition potential from state i to state j
m_{kd} : is the weighting parameter applied cells in state k in distance zone d
$\sum h$: is the some of central cell and neigbour cells

Table 1 The Weighting Parameter to be Applied on Each Cell to Calculate the Transformation Potential (White, Engelen, 1994; Yüzer M.A., 2001).

		Vacant ↓ Commerce				Vacant ↓ Industry				Vacant ↓ Housing				Industry ↓ Commerce				Industry ↓ Industry				Industry ↓ Housing				Housing ↓ Commerce				Housing ↓ Industry				Housing ↓ Housing			
		Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility	Commerce	Industry	Housing	Facility
Distance to central cell (d)	1	0,8	0,0	0,3	-	0,0	0,8	0,0	-	0,0	0,0	0,3	-	0,2	0,0	0,0	-	0,0	0,0	0,0	-	0,0	0,0	0,0	-	0,1	0,0	0,05	-	0,0	0,05	0,0	-	0,0	0,0	0,0	-
	2	0,8	0,0	0,3	-	0,0	0,8	0,0	-	0,0	0,0	0,3	-	0,1	0,0	0,0	-	0,0	0,0	0,0	-	0,0	0,0	0,0	-	0,1	0,0	0,05	-	0,0	0,05	0,0	-	0,0	0,0	0,0	-
	3	0,8	0,0	0,3	-	0,0	0,8	0,0	-	0,0	0,0	0,3	-	0,1	0,0	0,0	-	0,0	0,0	0,0	-	0,0	0,0	0,0	-	0,1	0,0	0,02	-	0,0	0,04	0,0	-	0,0	0,0	0,0	-
	4	0,6	0,0	0,2	-	0,0	0,6	0,1	-	0,1	0,02	0,2	-	0,5	0,0	0,02	-	0,0	0,0	0,0	-	0,0	0,0	0,0	-	0,05	0,0	0,02	-	0,0	0,03	0,01	-	0,0	0,0	0,0	-
	5	0,6	0,0	0,2	-	0,0	0,6	0,2	-	0,2	0,03	0,s2	-	0,5	0,0	0,03	-	0,0	0,0	0,0	-	0,0	0,0	0,0	-	0,02	0,0	0,01	-	0,01	0,02	0,02	-	0,0	0,0	0,0	-
	6	0,4	0,0	0,1	-	0,0	0,4	0,3	-	0,3	0,05	0,1	-	0,2	0,0	0,05	-	0,0	0,0	0,0	-	0,0	0,0	0,0	-	0,02	0,0	0,01	-	0,02	0,01	0,05	-	0,0	0,0	0,0	-

In Table 1 each four-column block between the spaces comprise the parameters used in the model. In each block of the table, the first column illustrates the weights applied on trade cells at 1-6 zones, the second the weights applied on industrial cells, and the third the weights applied on residence cells.

In each turn a sufficient number of cells are transformed into all kinds of uses in accordance with the above given hierarchical order. The cell which tests all the statuses, is at the highest potential as long as the conditional hierarchy is suitable for such kind of a case. In other words the end-condition of the cell which tests all the statuses shows the highest possible potential of that cell. The operation is applied on all cells and by this way the scheme following transformation is drawn up. (White, Engelen, 1994). This scheme created by using transformation parameters is operated for the second time to form a basis for the model in case the projected population or the settlement capacity is not achieved. The model is operated until the set size is achieved.

3 ISTANBUL METROPOLITAN AREA, INDUSTRIALISATION AND THE USE OF TECHNOLOGY

The Importance Of Istanbul Metropolitan Area In Turkey:

With 5512 km^2 area, Istanbul covers nearly 0.71 % of total area of Turkey and it's the greatest province of country for population size (Figure 1). As a result of the industrialisation and engineering in agriculture in 1950's and the migration from rural to urban areas increase the proportion of Istanbul Metropolitan Area in Turkey's population from 5.6 % in 1950 to 14,8 % in 2000 (Table 2).

Table 2. Population Values Of Turkey and Istanbul

Years	Population		Istanbul/Turkey Proportion (%)
	Turkey	Istanbul	
1950	20.947.188	1.166.477	5,57
1960	27.754.820	1.882.092	6,78
1970	35.605.176	3.019.032	8,48
1980	44.736.957	4.741.890	10,60
1990	56.473.035	7.309.190	12,94
2000	67.844.903	10.033.478	14,78

Istanbul has 20% of Turkey's industrialisation labour and 38% of Turkey's industrial firms. Istanbul which contains 55% of country's trade and 45% of wholesale trade, has 21.7% of Turkey's Gross National Product. Istanbul contains 75% of Turkey's financial institutions and 50% of Turkey's universities. 42.2% of taxes are gathered from Istanbul and 20-25% of government investment encouragements are done to Istanbul. 43,4% of total exports from Turkey are done from Istanbul. 80% of textile sector and 67% of metal things are exported from Istanbul. 40,7% of Turkey's imports are done to Istanbul. In chemical sector 94,2% of Turkey's import are done to Istanbul. In the sectoral distribution of Istanbul's Gross National Product, while industrial sector proportion is 28.06%, service sector proportion is 71.40% (DİE, 2000; İBB, 2001).

As the upper data shows, Istanbul is always a center of attraction for investors.

Figure 1: The Hierarchy of Metropoliten Cities in Turkey According to Population Growth (DIE, 1998, 2001)

The Reason Of Industrial Agglomeration In Metropolitan Areas;

Historically, cities have arisen and grown as centers of transactions and commerce, largely because of the need for physical proximity among firms, suppliers and customers. Agglomerations of people, commerce and industry allowed efficient production, transport and distribution of goods and services. Technology, particularly new transportation modes (cars, trains, electric trolleys etc) helped shape the first industrial cities as new technologies particularly information technologies do today. New and powerful information and telecommunications technologies continue to be developed and their impacts on industrial and residential location are still evolving. These technologies are central to the reshaping of the post-industrial metropolis. While places with the advantages - including a skilled, moderately priced labour force, low urbanization diseconomies (crime, congestion and environmental pollution etc), an industrial base of advanced innovative companies and high quality of life- will continue to do well, places without these advantages are likely to continue to lose out economically (Atkinson, R. A., etc. 1995).

As advance in technology and telecommunications have offered more freedom to economic sectors, industrial locations also changed from being dependent to natural sources to market.

As the advantages of metropolitan areas below continues, in the future most of the economy will be locating in these areas.

- Metropolitan areas continue to provide advantages for industry, including large labour markets, frequent and cheap air transportation and availability of repair and technical services.
- Metropolitan areas offer an environmental conducive to innovation and learning which, as technology increases the importance of continual product and service development, is an advantage to many firms.
- Metropolitan economies have larger, more diverse amd more skilled labour markets, which gives firms acces to a sufficient number of qualified personnel.
- Since there are more customers in larger metropolitan areas than in smaller ones, firms choose to expand in larger metropolitans to minimize distance from the customers.

Wıth the development of information technology, demography, social structure and, changing industrial organization, interaction among economic activities makes differences according to time and space, and reform metropolitan areas by the effects on industry and trade. It's an important potantial that cause the growth and diminish of some areas.

Industrial Distribution of Istanbul Metropolitan Area

When the spatial structure of Istanbul's industry is examined, it is seen that manufacturing industries are in a tendency of scattering from center and show a lineer view along transportation web (Figure 2). Manufacturing industries settled in Istanbul prefer city center because of existing labour and market possibilities. Especially untill 1990's firms connected to market as newspaper and printing prefer city center because of close relation with information and advantage of distribution. Organized and integrated industries dense along E-5 and TEM Highway axes. While high quality housing areas haven't take part near industry, labour houses lacking quality have developed near E-5 highway and close environment since past. New large scale industries settle in Gebze ve Tuzla in east part and Hoşdere, Firuzköy in west part where suburbs with cheap land and easy to get (Yüzer A.Ş,2002).

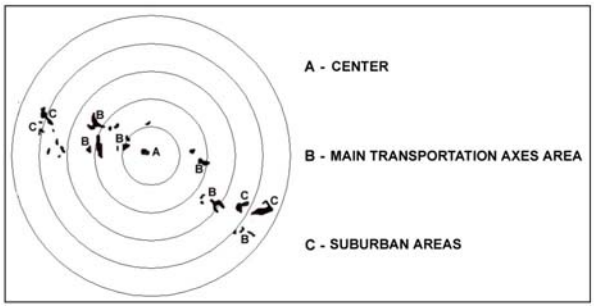

Figure 2: Industrial Distribution of Istanbul Metropolitan Area Along Highway Axes

4 THE SIMULATION OF ISTANBUL METROPOLITAN AREA BY LUCAM MODEL, INDUSTRIAL DESANTRALIZATION AND TENDENCY OF INDUSTRIAL INVESTORS

First of all existing land use data is entered to LUCAM Model (Figure 3, Table 3). Througout İstanbul Metropolitan Area at the base of year 2023 LUCAM Model is run and the figure 4 below is obtained. When the schema is examined, mostly the developments and transformations are in commerce and service sector and industrial sector area. Because of not having much vacant areas in Metropolitan area and having forest areas in the north prohibited to settlement, transformations are occurred mostly from residential areas to industrial and commercial areas or from industrial areas to commercial and service areas. As it is defined in high scale master plan, 1st, 2nd ve 3rd degree sub-centers in İstanbul metropolitan area are defined and the decentralisation in these areas are suggested. Simulation results after LUCAM Model also supports the necessity of decentralisation.

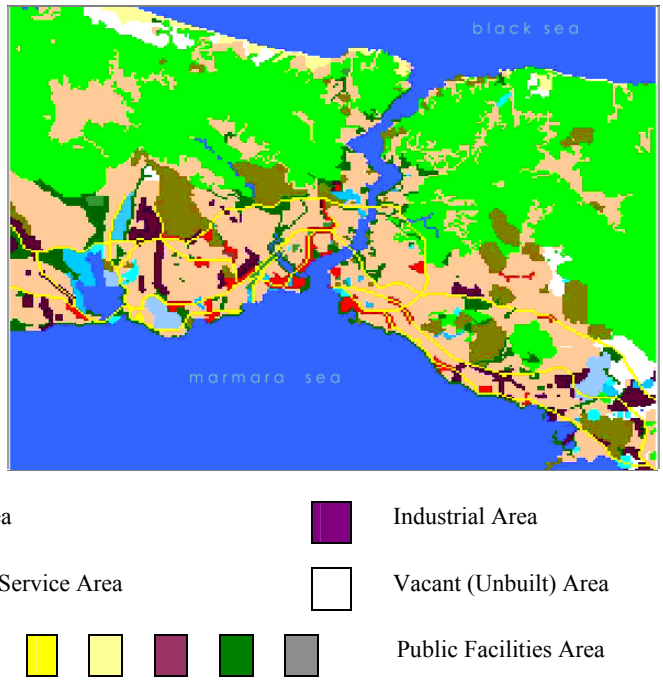

Figure 3 Existent Land Use of Istanbul Metropolitan Area

Table 3 Existent and After Simulation Land Use of Istanbul Metropolitan Area

	Area Size (Ha)	
Functions	**Land Use 2000**	**After Simulation 2023**
Vacant	2545	0
Residential Area (ha)	27917	27200
Industrial Area (ha)	2762	4060
Commercial and Service Area (ha)	1312	3277
Public Facility Area (ha)	114583	114583

After the simulation ran throughout İstanbul Metropolitan Area, transformation tendencies from industrial areas to commerce and service functions are occurred in sub centers. New industrial areas after transformation are occurred close to residential areas. Although out of metropolitan area is suggested for industrial decentralisation in master plan, when the simulation results are evaluated, it is seen that the decentralisation is still in metropolitan area.

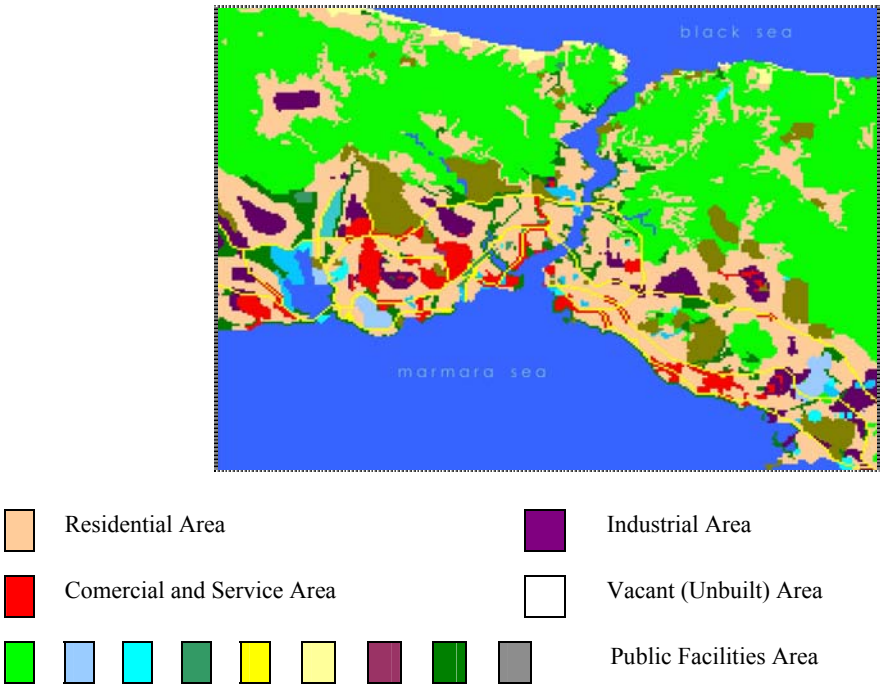

Figure 4. Istanbul Metropolitan Area Distribution After Transformation

The model is run to define the area need for 2023 and the values in Table 4 is obtained. While the residential areas don't change much, indutrial area rises to 1,5 times, commerce and service areas rises to 2,5 times. No variation happens in public facility areas as the necessity of model.

Tablo 4. The Distribution Of Functions After Simulation

Functions	**Tranformed Functions (ha)**		
	Residential Area (ha)	**Industrial Area (ha)**	**Commercial and Service Area (ha)**
Vacant	2397	147	0
Residential Area (ha)	-	2332	782
Industrial Area (ha)	-	-	1182
Total	2397	2480	1965

At the end of simulation 3, 95% of 2545 ha unsettled area is turned to residential area and 5% is turned to industrial area. 75% of the transforming 3115 ha residential area turns to industry and 25% of it turns to commercial area. 1182.5 ha industrial area turns to commercial area. Totally 2397,5 ha turns to residential area, 2480 ha turns to industrial area, 1965 ha turns to commercial area.

With these results, the decentralisation tendencies of large scale industries having research-development unit and using high technology are evaluated below:

In 18 large scale manufacturing industries of Turkey that settle in İstanbul Metropolitan Area, to determine the structural properties, technology use, Research-Development potential, factors of land preferences and to put forward the decentralization and transformation tendencies questionnaires were done.

In the prefernces of the firms, besides the properties like various area, various sector and various size, the location of the firm in İstanbul were taken into account. The main activity subjects of large scale manufacturing industries inquired almost in every sector were 33% of chemistry,17% of food, 22% of methal things, 11% of textile, 11% of paper products and 6% of methal sector.

Questions related with the firm's quality and structural properties are asked. While 94% of large scale industries stated no activity change, 4% expalined an expansion in their activities. When the qualities of investigated firms evaluated, 48% factory, 30%, headquarters, 7% branch, 7% warehouse, 4% selling area and 4% office use is determined.

The foundation year in the investigated large scale industries is 33% in between 1991-2002 years, 28% in between 1966-1970 years, 22% in between 1981-1990 years, 11% in between 1971-1980 years and 7% before 1965. 48% of the small scale manufacturing industries founded in 1990's. This shows that small scale manufacturing industries can move easier than large scale industries. 78% of firms stated no variation in branch number connected to the factory in 3 years. Firms changing branch number stated either by opening new branchs in foreign countries or closing the firm.

Land use preferences of large scale manufacturing industries are evaluated in two types:

In the first approach, the sum of preferences of all firms and the proportion of every factor in this sum are counted and ordered. In this approach the most prefered factor of firms are "economic development potential". "Cheap land supply", "skilled labour supply", "accessibility of market", "having no transportation problem", "accessibilty of good supply" factors are the other preferences.

In the second approach, the preferences are ordered according to preferences and evaluated. In this approach "accessibility to market" factor is the first prefered factor.

Large scale manufacturing industries prefer Istanbul to use the advantage of labour and market. Firms become advantageous in supply of good from domestic or foreign countries by using input-output or transportation facilities.

The advantages of İstanbul for firms are:

The easiness of tarnsformation 31%,
Market facility 15%,
Skilled staff and professional manager potential 7%,
To be an industrial area 7%,
To have a harbour 7%,
High consumption in İstanbul 5%,
The existence of main sectors 5%,
The existence of sub-industries, easy contact with other firms, prestige to foreigners, closeness to customs, to be a commerce center, financial sector gathered in this area, accessibility to goods, cheaper sale of goods, communication possibilities are the other advantages described by investors.

72% of the firms stated that they invest for the innovations in last 3 years. These investments are the formation of Research-Development, the purchasing of machine to adapt technological changes, purchasing of packaging patent rights, following all the innovations that the sector and communication technology bring.

61% of the firms don't want to move. 39% of the firms tend to move because of inadequate land, problem of transportation, staying in settlement areas and neglected environment. While half of the firms thinking to move prefer inner İstanbul, the others prefer Marmara Region (close environment of Istanbul) for the new settlement area. For example MERCEDES automative firm will move from Davutpaşa and gather bus and lorry production in it's Hoşdere factory (west side of Istanbul), FAKO chemical firm prefer Silivri (east side of Istanbul), AKSA generator firm prefer Hadımköy (west side of Istanbul), BETEK, MEGES painting firms, ALTINTEL melamine firm prefer Gebze Organized Industrial Region (east side of İstanbul), ALEMDAR chemical firm prefer İzmit Dilovası (close to Istanbul).

Questions are asked about how the firms want to move will use their area after the evacuation. The answers are 35% commercial use, 30% marketing unit connected to the firm, 15% administrative unit connected to the firm, 15% the sale of the area and gathering the firm together (Yüzer A.Ş,2002).

5 EVALUATION AND CONCLUSION

In consequently according to industrial enterprises in metropolitan and the results of simulation, some evaluations related with decentralization and development are below:
Since "transportation", "market" and "cheap land supply" factors of industrial land use prefered highly by users, in the future planning studies of Istanbul Metropolitan Area these factors and industrial allocations after simulation should be dealt with together.

While labour tendencies were in center and sub-centers dense with industry, today "easiness of transportation", "closeness to family", "cost of house" factors are important and labours tend to prefer industries in unurbanised areas.

Nowadays technological variation vawe plays an şmportant role in the development of metropolitan areas and Metropolitan cities have been keeping to be an attraction centers for industrial investors. In planning studies and big scale planning decisions developed among regions, this kind of politics should be developed and area allocations need for investments in metropolitan cities should be planned orderly.

While areas were allocating in hinterlands of metropolitan cities for industrial investments forming research-development units, as in the results of simulation, functional definitions related with administration and marketing services for centers after transformation should be done.

As it is understood from evaluations done highly in industries having research-development unit and using high technology, large scale manufacturing industries determined to move their production units in metropolitan centers to another place in Istanbul or hinterlands of metropolitan.

Simulation model done throughout Istanbul metropolitan area produced simular results. After simulation, transformations are occurred in industrial areas in 1st, 2nd and 3rd degree sub-centers and these areas are defined mostly as commerce and service sectors. If the user demands are taken in to consideration, a tendency of using production units after simulation as administration units is occurred.

After simulation new areas defined for industry shows similarities with user tendencies. Although the decentralisation of industy from metropolitan areas in high scale plans is considered, the results of simulation and user tendencies shows that the decentralisation is necessary but it has to be in metropolitan area.

LUCAM model is a model that gives important results to be used in the estimation of transformation and development of metropolitan cities. Since the user tendencies are taken into account in defining the parameters used in the model, data after simulation and the expectations of industrial investors show similarities. These results shows that the model is successful and usable.

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