IV－38

Modeling Land Uses and Environmental Indicators

Tohoku University, Student Member, Antonio Paez Robles Mtz.
Tohoku University, Fellow, Kazuaki Miyamoto

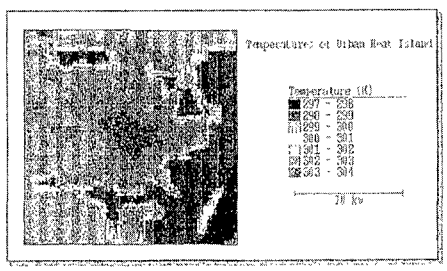
1. Background and Purpose of the Study.

Urban Modeling has been a tool used now for well over 20 years to help planners design urban development policies and to predict impacts that changes in the land use and transport systems impose to the city. Urban modeling has found its niche performing two main functions, namely describing the main mechanisms operating in a metropolitan system (most commonly land use and transport) or else trying to find optimal configurations for a city under given optimizing criteria Urban systems modeling surged in an epoch in which infrastructure placement and its effects over the city were the prime concern of planners, and accordingly its uses were defined by the necessities of its age. However, time and circumstances shape perceptions and there are now new issues which are considered to be at least as important as accommodating growth. Environment is one of such issues and the need to design policies that take environmental concerns into account call for models capable of describing the relationships that occur between urban activities and environmental systems. Recent efforts have focused in analyzing energy consumption and the city, and there is a bulk of investigation addressing that point of the agenda, not only in the modeling field but in the urban studies and planning field in general. This is a logic result of world trends and currently exists a generalized concern with assessing the effects that energy consumption, particularly in the transport sector have on the environment. However and as far as the modeling field is concerned, less attention has been paid to other issues, such as COx contributions by other sources and environmental impacts other than air pollution. Recent papers have made a point of the need to count with environmental indicators and it follows that such indicators should be integrated into models. In this study, Urban Heat Island effect was selected for analysis, in part due to data availability but mainly because of its very own nature characteristic of the city, and the link that offers to connect city and the environment. Hopefully the analysis now in embryonic form will help suggesting ways of incorporating'environmental indicators into a model of the city.

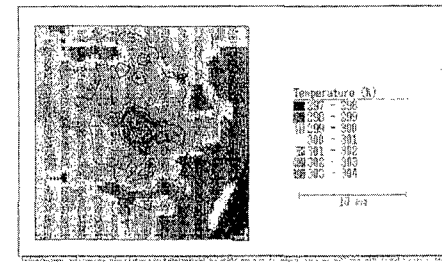
2. Heat Island and Urban Activities.

Urban Heat Island is an atmospheric effect that consists of a temperature differential between the city and its surroundings. It is a well documented fact that temperatures in a city are usually higher than in the surrounding countryside and although the exact mechanisms that lead to the formation of it are as yet not fully understood, research has shown that it is unique to the city and partly explained by the presence of it. A heat island is basically a thermal anomaly with spatial and temporal variations and its identified controls include some intrinsic to the physical characteristics of the city as well as meteorological factors. Weather factors include wind speed, cloud cover and air mass stability, while physical controls are city size, building density, and land use distribution among others. Interested more in the distribution of the heat island than in predicting or else its intensity, we find that the heat island offers a significant link between city and the environment. On the other hand, urban environmental indicators can be explained to some extent by land prices, since land price is itself a good indicator of urban activities (Miyamoto, 1995). It is also possible to observe a close resemblance between the distribution of temperatures during heat island and the distribution of land prices. Temperature stands as the most direct effect of heat island, and analysis is conducted to find out whether the physical factors of the city can be represented by land prices or not. Parting from the point that land prices can resemble this environmental phenomenon, a statistical relationship between the two variables is sought.

Temperatures of Urban Heat Island



Heat Island and Land Price Isocurves



3. Methodology.

Heat Island information was provided in spreadsheet format, with fields for X and Y coordinates, temperature, and humidity. A map with one reference point was also made available. This information was then transformed to be used for analysis in a GIS and SPANS GIS was utilized. The conversion of the data was more or less straightforward, but no geographical projection was selected for the project. Rather, a customized projection was created to match the reference that accompanied the heat island information. This same reference was later employed to convert the rest of the data to the same projection. Point information for temperature was then converted to contours using the GIS contouring function based on a TIN algorithm. Following, contours for land prices in 1995 were provided by the laboratory team and digitized for GIS based analysis. Those contours were formerly drawn parting from the map of land price information distributed by the Sendai City Information Center. Visual inspection gave the general impression that a good degree of similarity existed between the land price distribution curves and the temperature distribution during heat island. To prove the existence of a statistical relationship between the two variables, the next step was to append land price values from the price contours to those temperature punctual observations falling inside the curves. The resulting set of data was found to be too aggregated to be meaningful, so the input of more information on land prices was called for. This was done by digitizing a new set of land price punctual observations, right form the land price map but this time using more recent (1996) data. Once this was accomplished, new contours were drawn which again conformed neatly to the general distribution of temperatures. Since observations for the temperature variable were far more numerous than those for land price (over 2000 to a little less than 500), resulting contours for temperature were appreciably smoother. Therefore it was decided to append temperature information to the land price points, in order to make out the most of the available data. The point data set that was so obtained could then be exported to be analyzed in a spreadsheet. As a complement, the general distribution of both variables with respect to their distance from central Sendai Station was obtained by making use of the GIS buffering capabilities. Those values were then graphed against distance for comparison purposes and they confirmed the general impression that distributions follow a similar pattern. Statistical analysis was conducted in a spreadsheet for each set of points.

4. Conclusions.

After examining the results of the statistical analysis we conclude that although a good statistical relationship exists, it can be further refined by introducing more relevant variables into the analysis. A brief review of the literature available on heat island suggests other variables to be introduced, including land cover and perhaps uses. Nevertheless, as a first approximation it was found that land prices provide a good indicator of land use intensities and their effect on environment, as it is seen in the case of heat island. It should be stressed that no causal relationship is implied or sought. The heat island is a complex effect and results of a combination of many different factors, and it would be a gross oversimplification if we suggested that any single factor can fully explain it. Rather, the objective is to find a statistical relationship which can be of any use in linking an environmental effect to some physical characteristics of the city in which we are interested or to information of which we have reasonable accessibility. Since heat island is at least partially explained by physical factors as city size, distribution of land uses, and building height, and since land price distribution resembled to a good degree the temperature distribution, it was thought that land prices could give a good measure of them. As it turned out to be, they do to a limited degree but leaving room for improvement in the case of Sendai city. The GIS proved to be an invaluable tool for analysis, and albeit the operations performed with it were relatively simple it is our strong belief that some can be effectively incorporated into a model of the city, not only for its display capabilities but also to exploit its analytical and database management capabilities. More research in that direction is guaranteed.

Reference.

Miyamoto, K, Sathyaprsad, S, An Estimation System of Urban Land-Use and the Environment for Metropolitan Areas in Developing Countries. *Studies in Regional Science*, 25-1, 1995.

Acknowledgments.

The authors express their gratitude to Prof. Saito for kindly granting permission to use the heat island data collected by the Department of Aeronautics and Space Engineering which made possible
the present analysis.