Korean Journal of Geomatics
Vol. 1, No. 1 / December 2001
pp. 61~67

The Development of Extended Urban Land Information System for Sustainable Urban Management

June-Hwan Koh*

Abstract

This study aims to develop the Extended Urban Land Information System (EULIS) which can support the sustainable urban management. Although the existing Urban Land Use Information system (ULUIS) that aids the micro-level land use information is a good means for the understanding of urban spatial structure and district-level planning and management (such as urban design, redevelopment planning and district-level transportation planning, etc.), it has some limitations in supplying the information for sustainable urban management, such as environmental and traffic analysis, urban infrastructure's carrying capacity analysis, etc. The EULIS is designed to efficiently supply the information for sustainable urban management. For the successful construction of EULIS, the followings have to be considered. 1) the integration of topographic maps which contain the building's footprints and cadastral maps which contain the parcel's boundary, 2) the integration of EULIS and FM (Facility Management) system for the full utilization of information about capacity analysis of infrastructure, 3) the construction of standardized georeferencing system and spatial unit for the combined use of environment and traffic census data. This study shows 1) why EULIS is needed for the sustainable urban management and which elements are needed for the system, 2) the E-R data model for the EULIS, 3) the strategies for the construction of EULIS and 4) the conclusion.

Keywords : Sustainable Urban Management, Land Use Information System, and Land Information System, EULIS, ULUIS

1. INTRODUCTION

1.1 The Purpose of the Study

In Korea, the urban developments has been implemented by the designation of zoning and districts according to the urban planning law which was for the growth-oriented urban policies since 1960s. By the rapid urbanization, the shortage of housing was one of the most serious problems. But, with increasing income level, the Citizens now wish to live in the better Quality Of Life (QOL). So, the paradigms of urban policies are shifted from development-driven policies to the growth management. These kinds of policies will make it possible to solve the problems caused by growth-oriented policies. Cities will be more sustainable.

There are some limitations in supplying infrastructure continuously to the over-crowded city. In the transportation field, Traffic Demand Management (TDM) was introduced such as parking permit policy that restricts building parking space in the CBD area which has the mass transportation system such as subway. Environment management policies to reduce the amount of garbage were introduced such as the separate garbage collection, the waste-recycling and the payment by solid-waste weight, etc. Kown (1998) says that the urban development has to be implemented environmentally soundly, sustainable and humanistic.

The paradigm of urban planning and development will be changed as shown Table 1. The type of the data needed by this shoft will be changed from the macro-level, area-wide regional data to the micro-level, detailed data.

The chapter 7 of the Agenda 21 which was adopted at RIO environment and development conference in 1992 suggests the program for promoting human settlement development sustainablely as follows: (1) providing adequate shelter for all, (2) improving human settlement management, (3) promoting sustainable land-use planning and management, etc.

To implement these goals, the following means are suggested: (1) improving urban management, (2) strengthening urban data systems, (3) undertaking a comprehensive national inventory survey for their land resources, (4)

*Member, Prof., Dept. of Geoinformatics, University of Seoul, Korea (E-mail: jhkoh@uos.ac.kr)

The manuscript for this paper was submitted for review on December 10, 2001.

Table 1. The Shift of Urban Planning Paradigm

	Changed aspects		
Planning types	Macro level mater planning	→	Micro level Urban design, detailed planning
Developed	By public sector	→	By private sector
Land use patterns	Segregation	→	Mixed use
Development types	New development	→	Redevelopment, reconstruction

accessing to the modern techniques for land-resource management, such as geographical information systems, satellite photography/imagery and remote-sensing technologies.

However, the above means have little attention to the inner urban sustainability and the relationship and the impact among the components such as people, establishment, land use, etc.

The purpose of this study is to develop the Extended Urban Land Information System (EULIS) that can sustainably manage the highly developed urban area by extending the previous Urban Land Use Information System (Koh, 1995).

1.2 The Study Method

This study is focussed on the highly, densely and vertically developed urban area. The data for the study come from:

- topography map, land and building register, image data from the aerial photograph or remotely-sensed data.
- three-dimensional land use information from Urban Land Use Information System (ULUIS) containing parcel, building and user(establishment) data.

Traditionally, the data for urban planning are based on land category of the land register or major usage of the building register. This kind of urban land use data showing only the overall trend of land use do not represent the land use characteristics of highly developed area. This will not be appropriate for the analysis of area whose land use is vertically differentiated. (Kim & Koh, 1995, p.184).

This paper proposes the Extended Urban Land Information System (EULIS) model that helps to manage the city more sustainably. Also this study suggests the method for integrating the data from the government computerization projects (such as digitalization of land and building register system, NGIS project for national base map construction, etc). This Paper consists;

First, the related studies are reviewed to show the necessity of development of EULIS model and the necessary data for the sustainability analysis. Second, the usability and limitation of existing Urban Land Use Information System that was suggested by Koh(1995) are identified. Third, the related research works are reviewed to decide the DB items for EULIS model and to identify the indicators for the measurement of sustainability. Entity-Relationship (E-R) model is built. Finally, the strategies (such as integration, standardization, etc.) for the implementation of EULIS model are suggested.

2. Sustainable Urban Management and Land Information System (LIS)

2.1 The Concept of Sustainable urban Management

The most widely cited definition for the sustainable development is that of the World Commission on Environment and Development (WECD, 1987), also known as the Brundtland Commission:

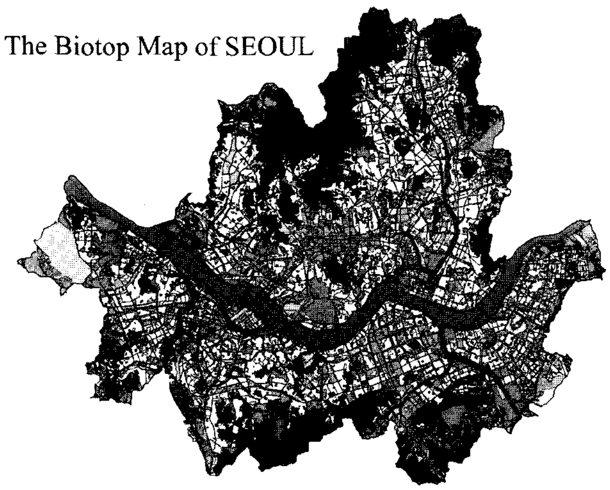
"Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The Rio declaration on Environment and Development in 1992 proclaims some related principles. Principle 3 states the concept of sustainable development as follows: "the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations."

The indicators for the achievement of sustainability in the United States, recommended by the president's Council on Sustainable Development, didn't include the economic propensity, environmental health, social equity and welfare.

Kim, *et al.* (1997) suggest the sustainable urban development strategies as follows: (1) to plan more parks and green areas in the city, (2) to improve pedestrian space and network, (3) to make a city culturally richer place, (4) to reduce the traffic demands, and (5) to build the urban information system, etc.

The land cover and Biotop survey using the GIS and remote sensing technique was conducted by Seoul Metropolitan Government (SMG) recently. The Biotop survey data will be very useful for the sustainable urban planning and management, urban ecosystem conservation and restoration. SMG will periodically produce the Biotop map that shows the current ecological status of Seoul. Below map is the Seouls Biotop Map (from http://green.metro.seoul.kr/). Using Biotop map helps more area-wide land use study and



Map 1. The Biotop Map of SEOUL.

survey, and they are more appropriate for the macro-level and 2-dimensional analysis. But, the future city will be more high-rised and densed than now. Such city's sustainable development and management will be only possible by the continuous monitoring of carrying capacity of urban infrastructure. The sustainable, micro-level, scientific and efficient urban management will be possible by the construction of EULIS that contains parcel, building and user's traffic and environmental characteristics.

2.2 The Construction of Land Information System

As introduced early, the construction of land inventory and LIS are recommended by the Agenda 21. To improve sustainable land-use planning and management, the following means are suggested:

(1) improving urban management,
(2) strengthening urban data systems,
(3) undertaking a comprehensive national inventory of their land resources,
(4) accessing modern techniques of land-resource management, such as geographical information systems, satellite photography/imagery and remote-sensing technologies.

According to the issues of the agenda of Habitat II conference held in Istanbul in 1996, the necessity of construction of LIS for the more integrated and better land management was emphasized. And the existing urban infrastructure has to be fully utilized and the development has to maintain the proper density based on the carrying capacity of facilities.

At the same time, the International Federation of Surveyors (FIG), particularly Commission 7 that is responsible for cadastre and land management published "the statement on the Cadastre" in 1994. Among the roles of cadastre, the sustainable development and environmental protection were emphasized.

"A Cadastre is normally a parcel-based, and up-to-date land information system containing records of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature, ownership or controls of those interests, and often the value of the parcel. It may be established for fiscal purposes (e.g. land value estimation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection."

The theme of the conference sponsored by ISSS and ITC is "Geo-information for Sustainable Land Management". The concept of Sustainable Land Management (SLM), the construction of Geo-Information Infrastructure (GII) for SLM, etc. were treated in the conference.

In Korea, the government and the research institutes have participated in the development of Land Information System development since mid 1980s. As a part of the administrative information system of government, the land register was computerized in the late 1980s. Korea Research Institute for Human Settlements (KRIHS, 1985) performed a research about the Urban Information Management System. The researches and developments on Land-related information system as the National Information Infrastructure (NII) have been accomplished such as follows: (1) the research on the development of Parcel-based Land Information System (PBLIS) by Ministry of Home Affairs (MOHA, 1993) and Korea Computerization Agency, (2) National Geographic Information System (NGIS) project by Ministry of Construction and Transportation (MOCT, 1995), (3) the research on the development of Land Use Information System (LUIS) for Seoul by Seoul Development Institute (SDI, 1996), etc.

3. The Analysis of the Existing Urban Land Use Information System (ULUIS) Model

3.1 The Characteristics of Urban Land Use

The users, such as people and establishments, generate the urban land use. The land use create the foundation of urban infrastructure. The land use that is represented by the urban activity has the close relationship with the infrastructure. The appropriate combination of the activity and the infrastructure will make the city more pleasant and safer for the citizen. The types of the future activities will be more diversified than before. It will gradually arouse the mixed land use patterns.

According to Procos(1976), the multi-purpose and mixed use of parcels and buildings do not change easily for a certain period of time. That is, the industrial area that is developing to the residential use is considered as industrial use. But, the purpose of large-scale comprehensive developments is the round-the-clock use of the buildings. So, in the measuring the changes of land use, the time variable has to be considered.

3.2 The Analysis of Existing ULUIS Model

The study on the development of Urban Land Use Information System (ULUIS) Model (Koh, 1995) is focused on the urban land use, especially detailed and vertically differentiated land use. The vertical expansion of big cities makes it difficult to understand the land use pattern with the aerial photograph and remote sensing data only.

3.2.1 The data collection system

The data collection system of the ULUIS Model is as follows: (1) the digitizing of the buildings footprints from the aerial map (1:1,200 scale) and the parcel boundary from cadastral map, (2) the input of attribute data, such as address, area, land value and owner from land register, use, year of built, number of floors from building register, industry classification code, total floor area and number of employees from establishment register, (3) the field survey for parking lot, open space, etc.

If the digitalized attribute data should to be opened to the public and fully utilized for the maintenance of ULUIS database, it will reduce cost for the construction of the database.

3.2.2 The entities of ULUIS database

The ULUIS Model is based on the relational database. After the conceptual model is built, the E-R model is fully normalized for the perfect retrieval without duplication. The entities of this model are parcels, buildings and establishments.

3.3 The Usefulness and Limitations of ULUIS Model

The usefulness of Urban Land Use Information System can be found as follows:

- The characteristics of urban land use can be represented by attribute datas statistical analysis.
- The differentiation of land use of buildings or block units can be understood easily.

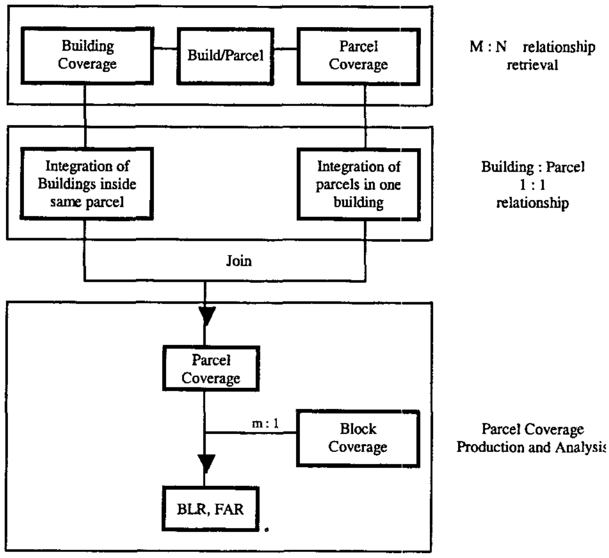


Fig. 1. The Flowchart for BLR and FAR.

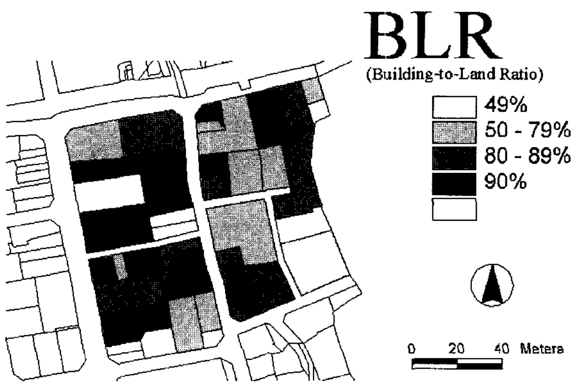


Fig. 2. The BLR Map.

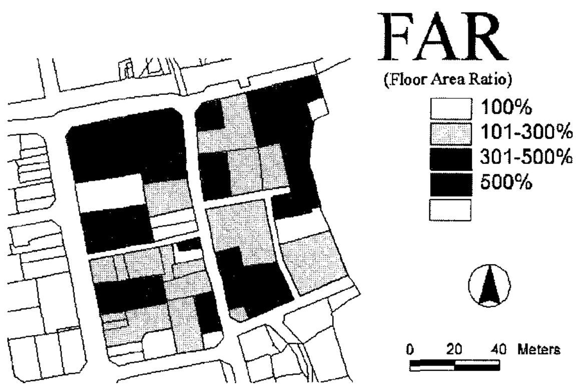


Fig. 3. The FAR Map.

- The accumulation of land use is shown by the geographical analysis on linkages among uses (Koh, Junehwan, 1995).

- The suitability of zoning and the development potential by parcels can be evaluated by the Building-to-Land Ratio (BLR) and Floor Area Ratio (FAR) by buildings or blocks (Lee, Yangjae and Junehwan Koh, 1997).

The FAR, which implies the density of urban development, can be calculated and shown with this system. Fig. 1 is the flowchart for BLR and FAR. Fig. 2 and Fig. 3 are the result maps of BLR and FAR each. Those information can be utilized in the designation of redevelopment area and detailed area planning (such as Germany's B-planning).

This kind of Urban Land Use Information System model utilizing the SIC (Standard Industrial Classification) code of establishment can provide more accurate and scientific land use information than the existing land use information acquisition system using land register's land type or building register's building usage type data.

This model is more useful than traditional methods in the understanding of land use patterns for densely developed urban area such as CBD. But, It has some limitations as follows:

- This model can not provide the urban infrastructure-related information such as traffic generation, parking lot needs, water usage and environment-related establish-ments waste production and fuel usage, etc.
- This model can not be used for the future sustainable urban management.

Recognizing these limitations, Extended Land Information System model is proposed for the sustainable urban management.

4. The Construction of the Extended Urban Land Information System (EULIS) for Sustainable Urban Management

4.1 The Necessity of EULIS Model

The necessity of EULIS development is designed to enable the sustainable urban management. The basic analysis of vertically differentiated land use is possible by the existing ULUIS. But, for the more detailed sustainablity analysis on the urban land, the ULUIS has to extend the entities and fields such as environment, traffic and infrastructure-related items, etc.

In order to successfully manage the city's sustainablity, more efficient land information system has to be built. And the sustainable urban management must be conducted within the carrying capacity of infrastructures and urban eco-system. Namely, the urban land use, energy consumption, traffic generation and waste disposal system has to be balanced between the urban eco-system and built environment system.

4.2 The Construction of EULIS Model

4.2.1 The data collection system

EULIS's data collection system is based on the existing land use information system. Fig. 4 shows the inclusion of the environment and traffic census data for sustainable urban management. Digital map produced by government's National Geographic Information System (NGIS) project was used as the base map.

The Ministry of Government Administration and Home Affairs (MOGAHA)'s Parcel-Based Land Information System (PBLIS) is also the base of the EULIS. The comprehensive urban land use census that shows the

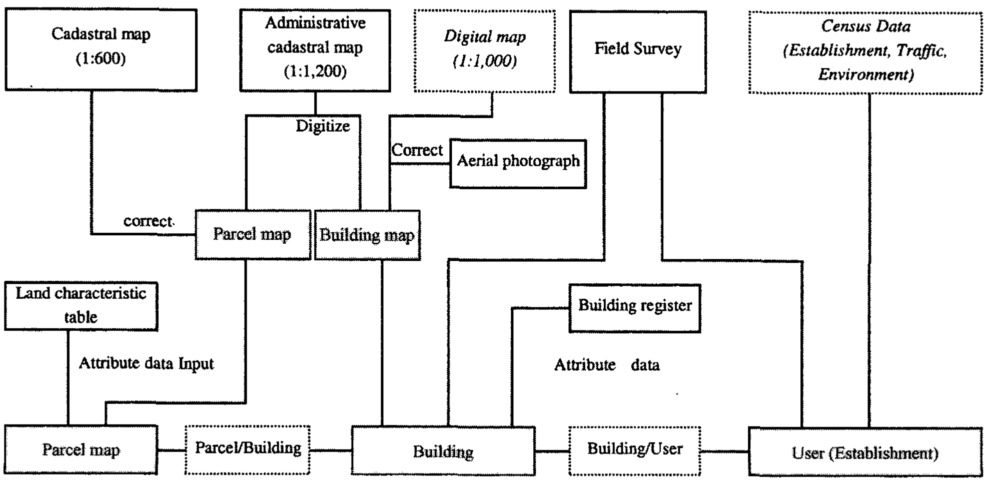


Fig. 4. EULISs Data Flowchart.

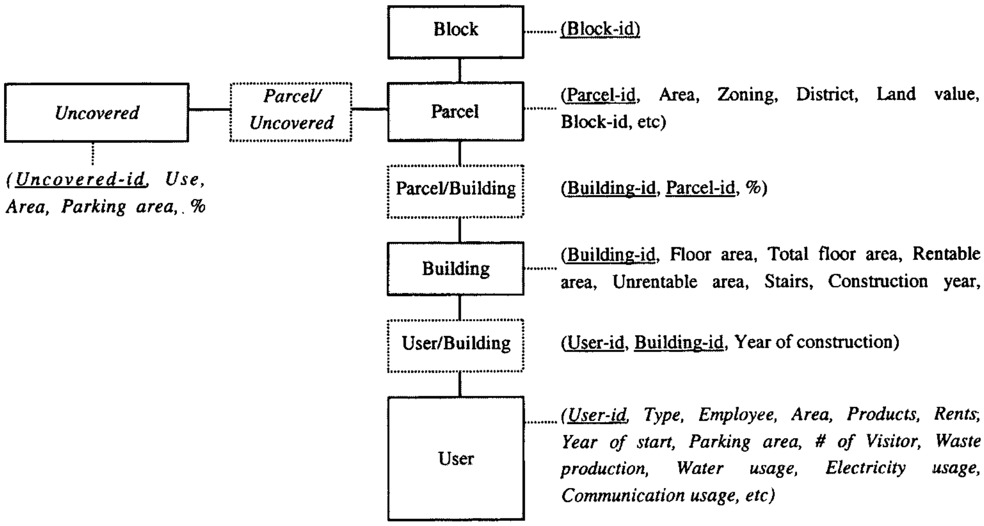


Fig. 5. EULIS's E-R Data Model.

environmental and traffic condition, etc. has to be conducted periodically. The spatial unit of these data has to be based on the user of building.

4.2.2 The entities of EULIS

EULIS is based on the relational database concept similar to existing ULUIS. The EULIS's E-R model included some additional fields for sustainable urban management as Fig. 5. The added fields, that can be used as basic data for urban infrastructure's planning and capacity analysis, are the solid waste production by type, the number of visitors, the parking area, the water and electricity use, etc.

4.3 The Strategies for EULIS Construction and Application

The successfulness and usefulness of EULIS depends on how well the system can be applied to the sustainable urban planning and management. The application system has to be developed that can provide the indicators and monitor sustainability. And for the full operation of EULIS, the followings have to be considered.

First, the topography map that contains the building's footprint and the cadastral map have to be merged into one digital map. Second, the comprehensive survey and census have to be conducted for the integration of land use data, the transportation and environmental data, which can be the attribute data of EULIS. Third, EULIS has to be integrated with the facility management system to provide information for deciding the size and the location of urban infrastructure. Finally, the Biotop map data also has to be integrated into the EULIS system.

5. Conclusion

In this paper, the model of Extended Urban Land Information System (EULIS) that can aid in the sustainable urban management was suggested. Existing Parcel-based Urban Land Use Information System (ULUIS)'s usefulness was also mentioned. The ULUIS helps the analysis of current land use and urban spatial structure, and the more detailed urban planning and developments. Since it was impossible to provide the information for the sustainable urban management with ULUIS. Some items added into the ULUIS, and E-R model was built. Also, the development strategies for more efficient system were suggested.

The further research for more efficient EULIS system development should be conducted in the following aspects; (1) the more precise and detailed demand analysis of sustainability, (2) the implementation of land use census and the development of the field survey methodology, (3) the development of the land use classification system such as USA's Land-Based Classification Standards(APA, LBCS), and (4) the improvement of the institutions about the data sharing and the privacy protection.

References

1. Agenda 21, from http://www.igc.apc.org/habitat /agenda21/.
2. APA, LBCS, from http://www.planning.org/lbcs/ index.html.
3. Burrough, P.A. and Rachael A. McDonnell, *Principles of Geographical Information Systems*, Oxford University Press, Oxford, 1998.
4. Devas, Nick and Carole Rakodi, *Managing Fast Growing Cities*, Longman Scientific & Technical, London, 1993.
5. ITC, *ITC Journal 1997-3/4: Special Congress Issue Geo-information for Sustainable Land Mangement (SLM).*

6. Kaiser, Edward J., David R. Godschalk, and Chapin, Jr. F. Stuart, *Urban Land Use Planning: The Fourth Edition,* University of Illinois Press, Urbana and Chicago, 1995.
7. Kim, C.S. and Koh, J.H. A study on the development and application of urban land use information system, KRIHS Journal, No. 24, 1995.12, pp. 169-188, in Korean, 1995.
8. Kim, Hyunsik, *et. al.*, A study on the sustainable urban development strategey, KRIHS, in Korean, 1997.
9. Koh, J.H. A study on the development of urban land use information system using geographic information system, University of Seoul, Graduate school, Ph.D. Dissertation, in Korean, 1995.
10. Korea Research Institute for Human Settlements (KRIHS), The development of Urban Information Management System, in Korean, 1985.
11. Kwon, W.Y., The directions and problems of urban development for Seoul under the IMF era, University of Seoul, in Korean, 1998.
12. Lee, Y.J. and Koh, J.H. A study on the development of land use information system for Seoul, Seoul Development Institute(SDI), in Korean, 1996.
13. Ministry of Home Affairs, Korea Computerization Agency (MOHA), A study of development of comprehensive land information system in Korean, 1993.
14. Ministry of Construction and Transportation (MOCT), The National Geographic Information System, in Korean, 1993.
15. Procos, Dimitri, *Mixed Land Use*, Dowden, Hutchinson & Ross, Inc., Stroudsbourg, 1976.
16. UNDP, The Habitat Agenda, from http://www.undp.org/un/habitat/agenda/index.html.
17. Walter, Bob, Louis Arkin, Richard Crenshaw, *Sustainable Cities: Concepts and Strategies for Eco-city Development*, Eco-Home Media, LA, 1992.