Urban Spatial Analysis using Multi-temporal KOMPSAT-1 EOC Imagery

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Abstract: Although sustainable development of a city should in theory be based on updated spatial information like land cover/use changes, in practice there are no effective tools to get such information. However the development of satellite and sensor technologies has increased the supply of high resolution satellite data, allowing cost-effective, multi-temporal monitoring. Especially KOMPSAT-1(KOrea Multi - Purpose SATellite) acquired a large number of images of the whole Korean peninsula and covering some large cities a number of times. In this study land-use patterns and trends of Daejeon from the year 2000 to the year 2003 will be considered using land use maps which are generated by manual interpretation of multi-temporal KOMPSAT EOC imagery and to show the possibility of using high resolution satellite remote sensing data for urban analysis.

Keywords: KOMPSAT EOC, Land Use, Sustainable Development, Urban Remote Sensing.

1. Introduction

With the launch of KOMPSAT-1 a valuable data source for urban analysis became available. KOMPSAT-1 has two earth observation payloads, EOC and OSMI (Ocean Scanning Multi-spectral Imager), and EOC provides panchromatic images around the world.

The modern trend in urban management and planning can be expressed by two key words: sustainable development and quality of life. Efficient urban management and planning requires varied and quantitative spatial data on current conditions and changes. The problem is updating spatial information for large areas such as a whole city. The ways to update spatial databases were by field work and interpretation of aerial photos, which is very time and cost intensive. The rapid development of information technologies, GIS and remote sensing suggest new possibilities for effective and sustainable urban management and planning. But the use of these high resolution satellite images in urban analysis is still rather rare in practice. One of the reasons is that high resolution satellite images, which have an appropriate spatial resolution for urban analysis have only recently become available and that applications are not yet fully developed.

In this study the land-use patterns and developments of Daejeon from the year 2000 to 2003 will be analyzed using land use maps, which were generated by visual interpretation of multi-temporal KOMPSAT EOC imagery.

2. Data used and research method

To analyse land use change, KOMPSAT EOC images of the years 2000, 2001, 2002, 2003 and for comparison a SPOT image of 1995 are used as basic satellite images for the multi-temporal land use map generation. In addition a 1m resolution IKONOS image, aerial photos, statistical data, digital maps(1:5,000, 1:25,000), land use map of year 2000, published by NGII (National Geographic Information Institute), are used as reference for detailed land use classification.

As a first step, orthorectified imagery of KOMPSAT and SPOT are generated using a digital elevation model (DEM), extracted from 1:5,000 digital maps. From this orthorectified imagery, by manual on-screen digitization using existing land use maps and reference remote sensing imagery the land use maps for each year are generated (Fig. 1). Based on the land use maps GIS spatial analysis techniques are applied and some static and dynamic quantitative indicators for urban spatial analysis are extracted.

The indicators, which will be considered in this study, can be divided into three categories: static, dynamic and integrated. In the next paragraph the extraction of such indicators using KOMPSAT EOC imagery will be examined and based on that the meaning of each indicator will be analyzed.

3. Analysis

1) Static Indicators

The static indicators in this study are defined as simple status data at a fixed point in time. If we consider land use as an example, the total area of settlement, commercial use, and industrial use and so on are static indicators. In Fig. 2 the change patterns of each district are compared both visually and quantitatively.

First the characteristics of settlement changes are analyzed. Generally speaking the changes of low residential areas are minimal compared to changes of high-rise residential areas which have increased in all five districts, especially in Seogu and Yusunggu the increase of high residential area is immense.

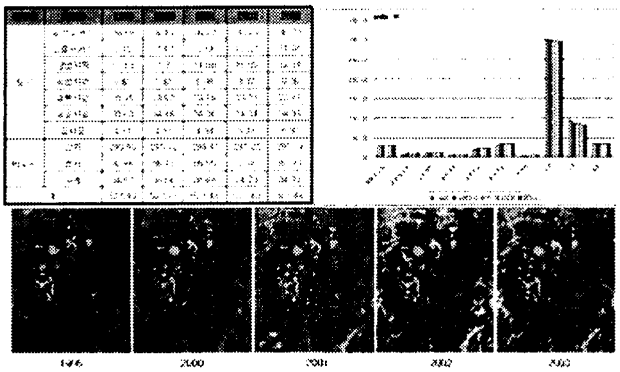

Fig. 1. Land use maps generation using Manual on-screen digitization

Based on this result we can conclude that living in apartments has become a modern living pattern of urban inhabitants. It was a known fact that the most urban inhabitants lived in apartment, but the results from this study prove this numerically as well. From the Fig. 3 an important fact can be derived, namely that the increase of urbanized area is closely related to the decrease of agricultural land use. That means, the urban development of Daejeon is mostly based on outer expansion instead of effective reuse of inner city land, and from this fact we can conclude that the greater part of urban development in Daejeon was not sustainable and effective.

More diverse and detailed static indicators can be defined and extracted using remote sensing data. From the end of the year 2005 the 1m spatial resolution images of KOMPSAT-2 MSC (Multi Spectral Camera) will be delivered, and because of its resolution more accurate classification of land use can be attained. It is also expected that small commercial area, small parks in the city, which could not be classified using KOMPSAT-1 images, can be accurately classified using KOMPSAT-2 MSC imagery.

2) Dynamic Indicators

A dynamic indicator can be defined as the information about changes of the static indicators. As a dynamic indicator land use changes between the year 1995 and 2000, and between 2000 and 2003 are compared for the whole territory of Daejeon. The land use for transport, public facilities have increased mostly between the year 1995 and 2000, but there are still lots of developments after 2000. The decrease of agricultural areas is larger than that of mountainous areas. This again shows quantitatively that the urban expansion of Daejeon is closely connection to the decrease of agricultural land use.

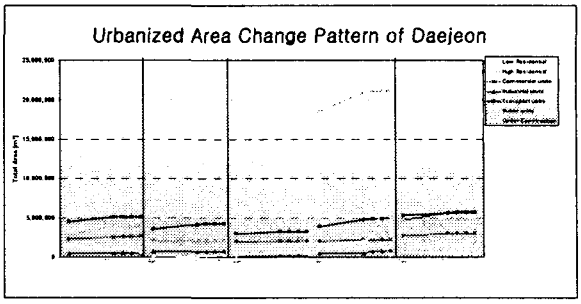

Fig. 2. Land use change pattern of urbanized area

The comparison of the changes between 1995–2000 and 2000–2003 is also interesting. Between 1995–2000 there were many development activities in the whole city especially the changes in Seogu and Yusung were immense. On the other hand the changes between 2000–2003 were not as large except in Yusunggu. The reason for these different patterns of changes between the two time periods can be follows. The new town development in Dunsandong, Seogu was finished at that time, and thus the development of inner city, Seogu, Donggu and Junggu, was completed. Around the year 2000 the development of Noeun, Yusunggu was started and is now under construction. In addition the development plan for the southwestern part of Daejeon is also confirmed and the development project will be launched soon.

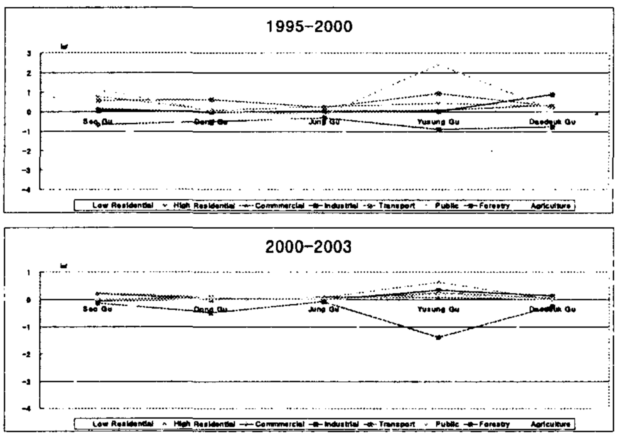

Fig. 3. Land Use Change Pattern between 1995-2000 and 2000-2003

3) Integrated Indicators

Integrated indicators are defined in this study as indicators, which are extracted from static and/or dynamic indicators in combination with socio-economic statistical data. These integrated indicators can express for instance environmental stress, degree of sustainable development or quality of life and so on. In this study we will consider an integrated indicator in connection with population density. The population density is generally calculated by dividing the whole population by total area. But this method of calculation does not match the reality. It is rather correct to assume that people can only live in the urbanized area, so that the population should be divided by urbanized area. This effective population data based on land use map is a good example for the integrated indicators using remote sensing data. There exist other kinds of integrated indicators as well.

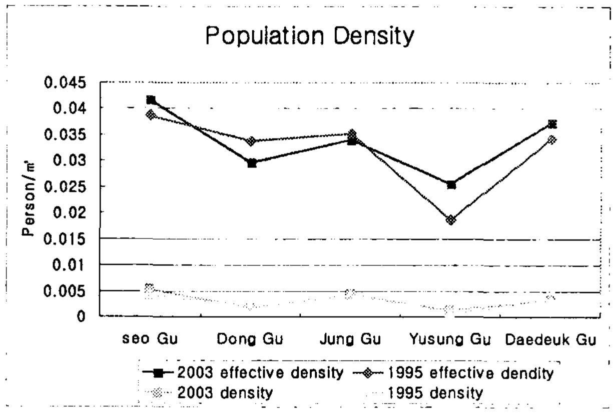

Fig. 4. Integrated Indicators about Population Density

3. Conclusions

This rapid expansion of big cities causes diverse ecological and environmental problems, so that the need for sustainable and effective urban planning and management has increased greatly in recent years. For this reason the land use changes of inner cities must be monitored regularly and all of this basic information should be managed within a database, so that the planning and management can be based on these quantitative data. It was not easy to gather such data, as it is very time-consuming and cost-intensive. The rapid progress in satellite and sensor technologies suggests new possibilities to use high resolution satellite images in urban analysis. Sub-meter resolution satellite images are provided commercially now. KOMPSAT-2, which will provide 1m resolution panchromatic and 4m multi-spectral images is now under development and will be launched by the end of the year 2005. With this more detailed KOMPSAT-2 data we can further develop the method, which is shown in this study. And the urban remote sensing research activities can contribute to more sustainable urban development and thus to higher quality of life for mankind.

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