Abstract
The purpose of this study is to analyze the effects of various spatial characteristics on the land surface temperature (LST) and to grasp the characteristics of thermal environment by land use of urban area in Changwon, Korea. The spatial data were consisted LST, normalized difference built-up index (NDBI) and normalized difference vegetation index (NDVI) obtained from Landsat 5 TM and land use and land cover map classified from high resolution digital aerial photograph (10cm). The unit space for spatial analysis was built by 500m×500m GRID. According to the results of assessment of relationship between thermal environment and spatial characteristics, LST had the highest positive correlation with NDBI by 0.945 and had high positive correlation with impervious area ratio by 0.891. In order to analysis of thermal environment on land use, types of urban area were classified by 4 of residential focus area, industrial focus area, green focus area and mixed area. According to the results of analysis, mean LST of industrial focus area was showed the highest by 30.06 °C. But mean LST of green focus area was analyzed the lowest by 19.65 °C. In conclusion, the results of this study can provide methods and basic informations for the reduction of urban LST and the establishment of environmentally friendly urban planning.

Key words: Thermal Environment, Land use, Land cover, Urban Planning

1. INTRODUCTION
Generally, the process of urban development had changed by methods to supply and develop buildings and facilities from the past to the present (Kim, 2003). And it made artificial environments to be rapidly increased such as apartment, residence, road and industry of concrete and asphalt. The increase of artificial environments caused change of natural environment as well as regional climate and generated new climate condition called 'Urban Climate' that is compared with climate previous urbanization (Landsberg, 1981; Oke, 1987; Oke et al., 1992). One of characteristics of urban climates is the heat island which urban temperature appear higher than suburb. Actually, many previous researchers proved fact that the urban temperature rises gradually because surface covered with vegetations was replaced by artificial facilities of Impervious cover (Lee, 1993; Kato, 1996; Gallo et al., 1996; 1999). Shudo et al. (1997) analyzed that forest and cropland are effect of cooling but town covered with concrete and asphalt is effect of heating about 2°C of urban temperature. The increase of artificial environments which become the primary cause of the heat island connects with the change of land use and land cover. Land use and land cover is changed constantly by human activities from the past to the present and is one of the most visible cause of ecosystem change (Singh, 1996; Weng, 2001). Therefore, it is necessary to construct accurate and up-to-date data on land use and land cover for correct assessment and management of urban environment and climate (Assefa, 2004). Hence, the purpose of this study is to construct spatial data of land surface temperature (LST), normalized difference built-up index (NDBI), normalized difference vegetation index (NDVI), impervious cover, building coverage from satellite imagery and high precise land use and land cover map and to analyze the relationship between thermal environment and spatial characteristics. Also, it is to verify the difference of LST on types of urban area and to establish the basic database for environmentally friendly urban planning.

2. METHODOLOGY
2.1. The study area
The study area is the urban area of Changwon, first planed city in Korea and declared 'environmental capital of Korea' in 2006. The urban area of Changwon is consisted of 12 administrative districts of Sangnam-dong, Uichang-dong and Pallyong-dong etc.. Changwon is located in the southeast park of the Korea Peninsula, between 128°33'43"E~128°45'51"E and 35°8'59"N~35°23'31"N. This City is contacted with Nam sea and the urban area is surrounded by the Naknam Mountains. Total area of the study area is about 125.4㎢ and population is about 425,339. The area has oceanic climate that change of 4 seasons appears clearly and is affected by monsoon. The average annual temperature is about 15°C and the average annual rainfall is about 1,395㎜.
2.2. Processing of study and data

The process of this study is divided into 3 steps of construction of data and analysis of status, assessment of relationship between thermal environment and spatial characteristics, analysis of LST on land use characteristics. At first step, LST was extracted from thermal band (band 6) using NASA’s model, NDBI was extracted from computation of red band (band 3) and near-infrared band (band 4) and NDVI was extracted from computation of near-infrared band (band 4) and mid-infrared band (band 5) after image pre-processing of geometric correction and radiometric correction on Landsat 5 TM satellite imagery (acquired on May 13, 2007). Land use and land cover map were constructed from high resolution digital aerial photograph (10cm). Impervious area and building coverage were extracted from land cover map and types of land use such as residential area, commercial area, industrial area and green area etc. were extracted from land use map. The unit space for spatial analysis was built by 500m×500m GRID that characteristics of land use can be classified clearly and consisted of 580 GRIDS. On the basis of unit space, the thematic maps were made by spatial characteristics and the present conditions were analyzed in the concrete.

At second step, it was assessed that relationship between thermal environment of LST and spatial data such as NDBI, NDVI and impervious area ratio, building coverage ratio and traffic area ratio. The correlation coefficient of factors was analyzed using correlation analysis. And prediction model of LST on spatial characteristics was established using linear regression analysis and scatter plot (linear plot).

At third step, LST was analyzed on land use characteristics. To classify types of urban area on land use, cluster analysis was executed using 5 items of residential area, commercial area, industrial area, agricultural area and green area. Finally, the difference of LST was verified on types of urban area and sustainable directions of land use planning were proposed on the basis of the result.

3. RESULTS AND DISCUSSION

3.1. Analysis of status by spatial unit

According to the results of construction of thematic maps on spatial unit, LST was showed high in the central parts of urban area and showed low along forest of the outskirts. Also, NDBI, impervious ratio and building coverage ratio were analyzed in distribution patterns such as LST. On the other hand, NDVI was appeared low in the central parts of urban area. In the case of types of land use, residential area, commercial area, industrial area and traffic area were showed high in the central parts of urban area but green area was analyzed high in the outskirts. Agricultural area was scattered by low ratio over the urban area.

3.2. Relationship between thermal environment and spatial characteristics

In order to assess the relationship between thermal environment and spatial characteristics of urban area, correlation analysis was carried out on 580 GRID. According to the results of correlation analysis, NDBI had the highest positive correlation with LST by 0.945 and impervious area ratio and building coverage ratio had high positive correlation with LST by 0.891 and 0.862 (Table 1). On the other hand, NDVI had the lowest negative correlation with LST by -0.914.

In the results of linear regression analysis and linear plot of LST and spatial characteristics, linear plot of NDBI was ranged concentrically along regression line and explanation (R2) of linear regression model was showed very high by 0.893 (Figure 3(a)). Also, models of impervious area ratio, building coverage ratio and traffic area ratio had high explanation by 0.793, 0.744 and 0.384. Linear plot of NDVI had a negative coefficient with LST unlike other item and explanation was showed high by 0.835 (Figure 3(b)).
3.3. Analysis of LST on land use characteristics

To verify the difference of LST on land use characteristics, types of urban area was classified on land use. According to the results of cluster analysis, cluster 1 was analyzed that residential area ratio was showed higher than other clusters by 39.83% and cluster 2 was analyzed that industrial area ratio was showed very high by 72.18%. In case of cluster 3, green area ratio was showed very high by 94.90% and cluster 4 was analyzed that there were no special characteristics. Therefore, cluster 1 was named by 'residential focus area', cluster 2 was named by 'industrial focus area', cluster 3 was named by 'green focus area' and cluster 4 was named by 'mixed area'.

According to the results of verification of the difference of LST by types of urban area, mean LST of industrial focus area was showed the highest by 30.06 °C and mean LST of residential focus area was also analyzed high by 27.30 °C. Mean LST of green focus area was analyzed by 19.86 °C and low more than 10 °C than LST of open areas.

Figure 2. Construction of thematic map by spatial unit

Figure 3. Linear plots of LST and spatial characteristics
industrial focus area. Actually, difference of LST was verified by types of urban area in the significant level of 99% on analysis of variance(one-way ANOVA).

Table 2. Classification of types of urban area on land use characteristics

<table>
<thead>
<tr>
<th>Land use characteristics</th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
<th>Cluster 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential area ratio</td>
<td>39.83</td>
<td>1.43</td>
<td>0.20</td>
<td>6.21</td>
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<tr>
<td>Commercial area ratio</td>
<td>7.16</td>
<td>0.69</td>
<td>0.01</td>
<td>1.28</td>
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<tr>
<td>Industrial area ratio</td>
<td>0.70</td>
<td>72.18</td>
<td>0.42</td>
<td>5.28</td>
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<tr>
<td>Agricultural area ratio</td>
<td>3.60</td>
<td>1.05</td>
<td>1.41</td>
<td>15.14</td>
</tr>
<tr>
<td>Green area ratio</td>
<td>8.02</td>
<td>7.74</td>
<td>94.90</td>
<td>46.22</td>
</tr>
</tbody>
</table>

Table 3. Difference of LST by types of urban area

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Number of Grid</th>
<th>Mean of LST</th>
<th>S.D</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>78</td>
<td>27.30</td>
<td>1.14</td>
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<tr>
<td>Cluster 2</td>
<td>92</td>
<td>30.06</td>
<td>2.54</td>
<td>740.809</td>
<td>0.000</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>287</td>
<td>19.65</td>
<td>1.93</td>
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<td></td>
</tr>
<tr>
<td>Cluster 4</td>
<td>123</td>
<td>23.85</td>
<td>2.33</td>
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<td></td>
</tr>
</tbody>
</table>

4. CONCLUSIONS

This study was researched to assess the effect of thermal environment on spatial characteristics. The results of this study are as follow: LST had the highest positive correlation with NDBI by 0.945, but had high negative correlation with NDVI by -0.914. According to the results of analysis of LST on types of urban area, mean LST of industrial focus area was showed the highest by 30.06℃, but mean LST of green focus area was analyzed the lowest by 19.65℃.

In this study, it is concluded that spatial characteristics such as land cover and land use have influenced high on thermal environment of urban area. Therefore, it is necessary to properly mix types of land use and to secure suitable green space that can reduce the temperature in urban space.

References


