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Impact of Physical and Vegetation Patterns on Parks Environment: A Case Study of Gusan Neighborhood Park, South Korea[1a]

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도심산림녹지의 식생 및 물리적 구조에 따른 숲 내부 미기상 변화 연구[1a]

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ABSTRACT

This study aims to investigate the impact of the physical structure, such as altitude, slope gradient, slope direction, and topographical structure, and the vegetation pattern, such as existing vegetation, diameter of breast height (DBH), and crown density, on climate. The analysis results showed the significant difference in relative humidity, wind speed, and solar radiation at varying altitudes, the significant difference in all climate factors except for the wind speed at varying slope gradient, and significant difference in temperature and relative humanity at varying slope direction. The topographic structures were divided into valleys, slopes, and ridges. They were found to differ in relative humidity. However, the differences between constant trends and types were found to be insignificant concerning temperature, wind speed, and solar radiation. Significant differences in temperature, relative humidity, and wind speed were recorded with changing existing vegetation. The DBH showed a significant difference in temperature, wind speed, and solar radiation. The crown density showed a significant difference in temperature and solar radiation. The result of the relationship analysis for the analysis of the effect of vegetation pattern and physical structure on the meteorological environment showed that temperature was affected by slope gradient, slope direction, DBH, and crown density. The relative humidity was correlated with the altitude, slope gradient, slope direction, and topological structure in physical structure and the existing vegetation and crow density in vegetation pattern. The wind speed was correlated with the altitude, existing vegetation, and DHB, and the solar radiation was correlated with the slope gradient, DHG, and crown density. The crown density was the most overall significant factor in temperature, relative humidity, and solar

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radiation, followed by the slope gradient. DBH was also found to be highly correlated with temperature and solar radiation and significantly correlated with wind speed, but there was no statistically significant correlation with relative humidity.

KEY WORDS: TEMPERATURE, SPECIES DISTRIBUTION, CRWON DENSITY, VEGETATION, NEIGHBORHOOD PARK

요 약

본 연구는 도심지 산지형 공원의 물리적 구조 및 식생구조가 기상에 미치는 영향을 분석하기 위해 물리적 구조인 표고, 경사도, 사면 향, 지형구조와 식생 구조인 현존식생, 흉고직경, 울폐도의 기상과의 평균비교를 실시하였다. 분석 결과, 표고의 경우 상대습도, 풍속, 일사에서 유형 간 차이가 있는 것으로 분석되었으며, 경사도의 경우 풍속을 제외한 모든 기상요소에서 유형 간 차이가 있는 것으로 분석되었다. 사면 향의 경우 기온과 상대습도에서 유형간 차이나 있는 것으로 분석되었다. 지형구조의 경우 계곡부, 사면부, 능선부로 구분하였으며, 상대습도에서 측정 값의 차이가 있는 것으로 분석되었으나 기온, 풍속, 일사량에서는 일정한 경향과 유형간 차이가 미미한 것으로 분석되었다. 식생구조 중 현존식생의 경우 일사량을 제외한 기온, 상대습도, 풍속 항목에서 유형 간 차이가 있는 것으로 분석되었으며, 흉고직경의 경우 기온, 풍속, 일사량 항목에서 유형 간 유의한 차이가 있는 것으로 분석되었다. 울폐도의 경우 기온과 일사량에서 유의한 차이가 있는 것으로 분석되었다. 식생 및 물리적구조가 기상환경에 미치는 영향 분석을 위한 관계분석결과 기온의 경우 경사도와 사면 향, 흉고직경과 울폐도에서 영향을 받는 것으로 분석되었으며, 상대습도의 경우 물리적구조인 표고, 경사도, 사면 향, 지형구조와 식생구조인 현존식생과 울폐도에서 상관성이 분석되었다. 풍속의 경우 표고, 현존식생, 흉고직경에서 상관성이 분석되었으며, 일사량의 경우 경사도와 흉고직경, 울폐도간의 상관성이 분석되었다. 전반적으로 기온과 상대습도, 일사량에 가장 큰 영향을 주는 인자는 울폐도로 분석되었으며, 다음으로 경사도에서 상관관계가 높게 분석되는 경향이 나타났다. 흉고직경 또한 기온과 일사량간의 상관성이 매우 높은 것으로 분석되었으며 풍속과의 상관관계도 나타났으나 상대습도는 통계적인 유의성이 나타나지 않았다.

주요어: 기온, 종 분포, 울폐도, 현존식생, 근린공원

INTRODUCTION

The needs for parks have long been realized as they provide venues for improving physical health, psychosocial well-being, self-actualization, spirituality and self-identity, family bonding, child development, environmental education and social skills development(Veal & Lynch, 2001). The importance of urban open spaces have been recognized both in the character and the life they bring to towns and cities around the world(Thompson, 2002). In recent times, changes in the climate due to global abnormalities have negatively affected the surrounding environment. In urban areas, changes in the weather are quite evident and the resulting deterioration in the weather environment has risked the health of urbanites(Her, 2013), as well as altered the number of hot and cold nights(Kim *et al*, 2011). Under these circumstances, green venues in the populated urban centers are of immense importance as they offer ecological and facility values, and improve environmental characteristics such as temperature reduction in the urban centers as well. The neighborhood parks play a positive role in promoting healthy environment as they relieves stress and serve as a rest and leisure spots for urbanites. These parks provides convenience in the living, and serves as a space that promotes the health of the citizens and as a result, the interest and demand for natural green spaces in the urban areas have risen(Konijnendijk *et al*, 2005; Kim *et al*, 2016; Park *et al*, 2017).

Among the functional aspects of green spaces in the cities, studies on weather control in particular has been given consistent attention. Such studies are often carried out on urban centers, where the weather conditions are deteriorating rapidly. There is a possibility that decrease in temperature may be achieved by manipulating the characteristics of urban green spaces. Such studies on temperature reduction in cities involve vegetation cover and geomorphic characteristics of the project area. The Seoul Metropolitan Government conducted a study in order to analyze the effect of mitigating heat island phenomenon of street trees through simulations, while another study was conducted to assess the impact of the street trees and street green areas on the city temperature(Kwon *et al*, 2012; Park *et al*, 2012). It was observed that the prime factors affecting the urban weather condition include the geomorphic characteristics and vegetation cover in the urban centers.

Keeping the importance of climate change and adverse effect of rising temperature on human health, we conducted the current study. In our study, we tried to assess the factors that affect the local weather by measuring the temperature, relative humidity, wind velocity and solar radiation. We also studied the role of vegetation cover and physical structures on the weather conditions of Gusan Neighborhood Park.

MATERIALS AND METHODS

1. Study Site

The Gusan Neighborhood Park is located in Mount Gusan-dong, Eunpyeong-gu, and it is a mountainous park in the city center(Figure 1&2). The park is at an altitude of 92 meters from sea level and covers an area is about 32,300 square meters. Compared to the small park area, the elevation is slightly higher, and there is a relatively steep promenade, and benches are built in the middle of the promenade. The vegetation cover include scattered trees comprising cherry, oak trees and others. Around the park, there are houses and social welfare facilities. The topography of Gusan Neighborhood Park consists of steep slopes because of the elevation difference as compared to the narrow area, while the topography of the ridge was generally distributed widely.

2. Methods

1) Research Procedure

In order to understand the impact of the vegetation and physical structure of the mountainous parks in the city center on the local weather, the topographical and vegetation structures were analyzed through preliminary research and on-site surveys. In topographic analysis, the elevation, gradient and aspect of the target site was analyzed through Auto Cad Map 2016 and QGIS(QGIS Desktop 3.6.1ver) using a numerical map of the national territory information map (2018). For analysis of plantation structure in the target area, the data collected from the field survey was investigated for the existing plant life, and further investigation of the diameter at breast height and the crown density were used in the analysis. For meteorological data, we observed temperature, relative humidity and wind speed by using the air velocity meter (TSI-9545, USA). The data was recorded 5 times taking

Figure 1. Location of Gusan Neighborhood Park

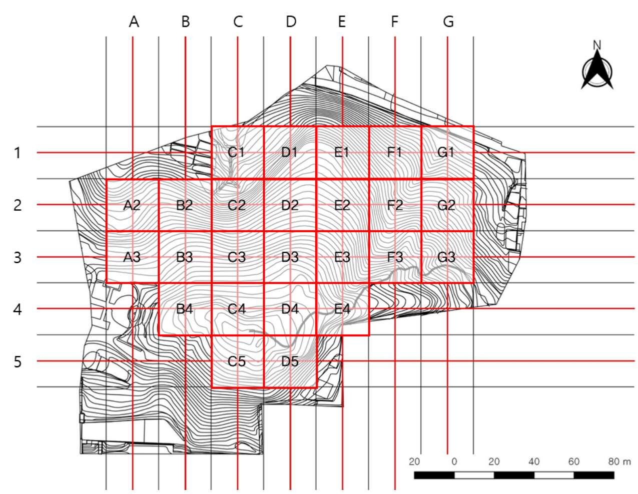


Figure 2. Data collection points of the park

into account the response speed of the heat flux sensor(LP02. Hukseflux) by exposing the sensor to the irradiation zone for 30 seconds. Short wave radiation (285-3,000 nm) was measured using Netherlands. For temperature measurement, we tried to minimize data fluctuations caused by wind direction by collecting data at a height of 1.2m above the ground with the wind behind.

2) Statistical Analysis

For statistical analysis was carried out by using SPSS(version 18.0). The variables used were temperature, wind speed, relative humidity and solar radiation as dependent variables. The existing vegetation, the slope, topography and plant life were taken as independent variables. One-way ANOVA was used to analyze the effects of changes in the physical and vegetation structure of the target site. For dependent variables with less than three variables, the analysis was performed through independent sample t-test. The influence of independent variables on the weather was also analyzed through route analysis. The plant life structure was selected based on the dominant tree species e.g. *Quercus acutissima*, *Quercus mongolica*, *Quercus variabilis*, *Sorbus alnifolia* and *Robinia pseudoacacia*. The variable number setting of the lung capacity was used for analysis by dividing it into variable number 1, 61 - 79% variable number 2, 80% variable number 3 as given(Table 1).

RESULTS AND DISCUSSION

1. Vegetation Cover of Gusan Neighborhood Park

The tree cover of the Gusan Neighborhood Park upper layer comprised of deciduous trees *Robinia pseudoacacia*, *Quercus acutissima*, *Quercus mongolica*, *Quercus variabilis*, and *sorbus alnifolia*. In subsurface types, *Prunus sagentii* was the dominant species. In the shrubby species, *Stefanandra incisa* was found dominant. It was also observed that the average diameter of the upper layer of the bridge deck was 20.42 cm, while the lowest was recorded as 22 cm. The minimum thoracic diameter recorded was 6cm, while 26cm was the maximum size. On the average, 76.92% of the total vegetation were analyzed in the park. In previous studies conducted on neighborhood parks and urban green areas, reported the positive correlation of greenery and a subsequent decrease in the temperature(Kim *et al*, 2018a; Park *et al*, 2017).

2. Effect of Vegetation on Microclimate of the Park

1) Impact of Vegetation on Park Climate

We used 5 plant species colony *Quercus acutissima*, *Quercus mongolica*, *Quercus variabilis*, *Sorbus alnifolia* and *Robinia pseudoacaci*a as test trees to evaluate the correlation of these trees with temperature, relative humidity, wind speed and solar radiations as shown in

Table 1. Dummy variable of physical and vegetation factors of the park

	Elevation	Dummy variable	Slope	Dummy variable	Inclined plane	Dummy variable	Geomorphic	Dummy variable
Vegetational	Foot of mountain	1	15° under	1	North	1	Valley	1
	Hill side	2	16°～30°	2	East	2	Inclined	2
					South	3		
	Hill top	3	31° over	3	West	4	Ridge	3

	Species Distribution	Dummy variable	DBH	Dummy variable	Crown density	Dummy variable
Morphological	*Quercus acutissima*	1	Small wood 6~16cm	1	60% under	1
	Quercus mongolica	2				
	Quercus variabili	3			61～79%	2
	Sorbus alnifolia	4	Medium wood 18~28cm	2	80% over	3
	Robinia pseudoacacia	5				

table 2. We observed that minimum temperature(25.3°C) was recorded for *Quercus acutissima* while highest temperature of 26.98°C was observed for *Sorbus alnifolia* (Table 2). We recorded highest relative humidity (70.4%) for *Robinia pseudoacacia*, lowest wind speed (0.24㎧) for *Quercus mongolica* and minimum solar radiations(44.6 W/㎡) for *Sorbus alnifolia*(Table 2). We observed that the relative humidity was lower in the trees grown on upper ridges, while it was higher in tree stands located in the foothills. The wind speed and solar radiations were also higher in *Quercus* species.

Table 2. Correlation of plant species with environmental factors.

Plant Species	Temperature(℃)	Relative humidity (%)	Wind speed(㎧)	Solar radiation(W/㎡)
Quercus acutissima	25.30az	66.30a	.47b	61.80a
Quercus mongolica	26.16b	67.40ab	.24a	79.20a
Quercus variabilis	25.62ab	67.00ab	.34ab	65.80a
Sorbus alnifolia	26.98c	68.00ab	.28ab	44.60a
Robinia pseudoacacia	25.59ab	70.40b	.28ab	50.10a

Different letters in the same column indicate a significant difference at P < 0.05 according to Duncan's multiple range test

Table 3. One-Way ANOVA in Species Distribution (N=125)

Division		Sum squared	d.f	Mean squared	F	p
Temperature (℃)	Between groups	11.699	4	2.925	6.546	.000
	Within groups	53.613	120	.447		
	Total	65.312	124			
Relative humidity (%)	Between groups	241.9	4	60.475	6.825	.000
	Within groups	1063.3	120	8.861		
	Total	1305.2	124			
Wind speed (㎧)	Between groups	.352	4	.088	2.807	.029
	Within groups	3.76	120	.031		
	Total	4.112	124			
Solar radiation (W/㎡)	Between groups	6200.392	4	1550.098	1.352	.255
	Within groups	137545.4	120	1146.212		
	Total	143745.792	124			

Table 4. Independent sample t-test in DBH (N=125).

Division		M	S·D	F	t	pM.D
Temperature (℃)	Wild species	25.908	.460	2.549	2.809	.380**
	Exotic species	25.527	.795			
Relative humidity (%)	Wild species	70.125	3.831	5.028	.957	.596
	Exotic species	69.529	2.934			
Wind speed (㎧)	Wild species	.248	.115	4.521	-2.118	-.073*
	Exotic species	.321	.203			
Solar radiation (W/㎡)	Wild species	73.975	34.122	5.945	5.316	31.422**
	Exotic species	42.553	29.171			

**p<0.01 *p<0.05

2) Impact of Diameter at Breast Height(DBH) on Park Climate

Current study confirmed the impact of tree DBH on the environment of urban parks. It is quite evident from the significant probability of less than 0.01 in temperature and solar irradiance, excluding relative humidity. This led to the rejection of the null hypothesis that there was no difference between the temperature and the sun radiations due to the difference in the diameter of the thoracic region, and the alternative theory that the temperature and the sun radiations were different in at least one type was adopted. On the other hand, it was analyzed that changes in wind velocity due to thoracic diameter were significant at the level of 0.05, and the alternative theory was adopted that differences in wind speed were found in at least one type according to the difference in thoracic diameter. However, a null hypothesis was adopted that for relative humidity among the items measured, the probability of significance was analyzed to be greater than 0.05 and that significance was not verified, so there was no change in the mean value for relative humidity due to differences in the thorax diameter. It was concluded that the temperature, wind speed, and solar irradiance vary depending on the DBH, and that the relative humidity is somewhat unaffected by the tree stem diameter.

3) Impact of Tree Crown Density on Park Climate

We observed that the tree crown density greatly affected the temperature, humidity, wind speed and solar radiations as shown in table 5. The lowest temperature(25.4℃) was recorded for crown density of more than 80% while highest (26.38℃) for crown density of less than 60%. In case of humidity and wind speed, the maximum values were recoded for more than 80% crown density(Table 5). The solar radiation analyzed showed least data for maximum tree crown density. The parameters studied showed significant values except wind speed, and this demonstrated that the effect of crown density on the weather factors is significant.

We carried out one-way ANOVA of the crown density to explain the effect of crown density on weather factors with statistical support(Table 6). The variables were set

Table 5. Effect of crown density on the weather factors of a neighborhood park.

Crown density	Temperature(℃)	Relative humidity(%)	Wind speed(㎧)	Solar radiation(W/㎡)
60% under	26.38c	68.25a	.23a	66.15b
60～70%	25.78b	69.60ab	.31a	66.77b
80% over	25.40a	70.16b	.31a	43.33a

Different letters in the same column indicate a significant difference at $P < 0.05$ according to Duncan's multiple range test (DMRT).

Table 6. One-Way ANOVA for impact of Crown density on climate factors (N=125).

Division		Sum squared	d.f	Mean squared	F	p
Temperature (℃)	Between groups	15.727	2	7.864	19.348	.000
	Within groups	49.585	122	.406		
	Total	65.312	124			
Relative humidity(%)	Between groups	58.170	2	29.085	2.845	.062
	Within groups	1247.030	122	10.222		
	Total	1305.200	124			
Wind speed (㎧)	Between groups	.126	2	.063	1.935	.149
	Within groups	3.986	122	.033		
	Total	4.112	124			
Solar radiation (W/㎡)	Between groups	16133.209	2	8066.604	7.712	.001
	Within groups	127612.583	122	1046.005		
	Total	143745.792	124			

at variable numbers lees than 60%, 60% to 80% and more than 80% respectively. The analysis confirmed significance of the temperature and the solar radiation with a significant probability of 0.01 or lower, rejecting the null hypothesis that there was no difference in the meteorological environment measurement values due to the differences in the crown density, and adopting the alternative hypothesis that at least one type of difference was caused by the difference in the crown density. On the other hand, the null hypothesis was adopted that there was no change in the average value for relative humidity and wind speed due to differences in crown density as significance was not noticed for probability of 0.05% or above, for relative humidity and wind speed.

3. Effect of Park Topography on Environmental Factors

1) Correlation of Elevation with Climate of Park

Current study showed that temperature of the park was not significantly affected by terrain elevation as shown in table 7. However, maximum relative humidity(70.75%) was recorded for mountain foot while least for hill top (table 7). The maximum wind speed of 0.37 m/s was observed on hill top, while the hill side was found to be exposed to least solar radiations as shown in table 7. The temperature changes according to the elevation difference showed no significance, while the relative humidity was least on hill top probably because the hill tops are exposed to wind. Our results are similar and confirms previous studies reporting lower relative humidity and highest wind speeds on elevated terrains(Kim *et al*, 2012; Choi *et al*, 2006).

The One-Way ANOVA demonstrated the effect of terrain on the climate factors. The analysis showed the significant probability for temperature(0.161), and confirmed the null hypothesis that changes in elevation do not affect the temperature in neighborhood parks. In case of relative humidity, the alternative hypothesis was adopted that the change in relative humidity caused by the difference in elevation, at least one group gives significantly lower result probability level 0.05. For both wind speed and solar radiation, a significant probability was analyzed at 0.01

Table 7. Effect of terrain elevation on climate factors (N=125)

Elevation	Temperature(℃)	Relative humidity(%)	Wind speed(㎧)	Solar radiation(W/㎡)
Foot of mountain	25.93az	70.75b	.23a	73.15b
Hill side	25.58a	70.64b	.29ab	40.40a
Hill top	25.63a	66.73a	.37b	69.43b

Different letters in the same column indicate a significant difference at $P < 0.05$ according to Duncan's multiple range test (DMRT)

Table 8. One-Way ANOVA showing correlation between terrain elevation and climate factors (N=125)

Division		Sum squared	d.f	Mean squared	F	p
Temperature (℃)	Between groups	1.924	2	.962	1.852	.161
	Within groups	63.388	122	.520		
	Total	65.312	124			
Relative humidity(%)	Between groups	352.303	2	176.152	22.553	.000
	Within groups	952.897	122	7.811		
	Total	1305.200	124			
Wind speed (㎧)	Between groups	.246	2	.123	3.889	.023
	Within groups	3.866	122	.032		
	Total	4.112	124			
Solar radiation (W/㎡)	Between groups	28109.875	2	14054.938	14.828	.000
	Within groups	115635.917	122	947.835		
	Total	143745.792	124			

level, rejecting the null hypothesis that there was no difference in the measured values due to differences in elevation, and adopting a counter-argument that the difference in elevation affected the wind speed and the solar radiation as shown in table 8.

2) Correlation of Mountain Slope with the Climate of the Park

Current study showed that mountain slope do play an important role in determining climate of neighborhood parks. The temperature, relative humidity and solar radiations were significantly affected by the slope gradient, although wind speed was not significantly affected as shown in table 9. According to the slope gradient, we observed that there are significant differences between types of weather factors except wind speed, and overall, the higher the gradient, the higher the temperature and wind speed, and the lower relative humidity.

One-way ANOVA was performed with three slope variables i.e. less than 10°, 10° - 30° and above 30° gradient respectively in order to determine the effect of difference in slope gradient on the climate factors. The analysis proved significant at 0.01 level for the temperature, wind speed and solar irradiance, thus rejecting the null hypothesis that there was no difference in climate factors due to varying slope gradient. However, for relative humidity, the null hypothesis that the relative humidity does not change due to the difference in gradient was confirmed, although the differences in other climate factors were significant with changing slope gradient(Table 10).

3) Correlation of Aspect and Climate Factors of Park

The aspect plays an important role in vegetation cover, temperature, humidity and other climate factors. In current study, we observed that the temperature, wind speed and solar radiations were not significantly affected by aspect(shown in Table 11). However, relative humidity was significantly affected and maximum relative humidity of 70.97 % was recorded for north facing slope while least

Table 9. Effect of slope gradient on climate factors (N=125)

Slope gradient	Temperature(℃)	Relative humidity(%)	Wind speed(㎧)	Solar radiation(W/㎡)
10° under	25.32az	71.05b	.28a	49.78ab
10°～30°	25.46a	69.10a	.29a	38.40a
30° over	25.99b	69.09a	.31a	62.42b

Different letters in the same column indicate a significant difference at $P < 0.05$ according to Duncan's multiple range test (DMRT).

Table 10. One-Way ANOVA showing a positive correlation between slope gradient and climate factors (N=125).

Division		Sum squared	d.f	Mean squared	F	p
Temperature (℃)	Between groups	11.670	2	5.835	13.271	.000
	Within groups	53.642	122	.440		
	Total	65.312	124			
Relative humidity(%)	Between groups	104.055	2	52.027	5.284	.006
	Within groups	1201.145	122	9.845		
	Total	1305.200	124			
Wind speed (㎧)	Between groups	.022	2	.011	.330	.720
	Within groups	4.090	122	.034		
	Total	4.112	124			
Solar radiation (W/㎡)	Between groups	11670.235	2	5835.118	5.390	.006
	Within groups	132075.557	122	1082.587		
	Total	143745.792	124			

for south facing slope(Table 11). This difference is due to the fact that the south facing slope is exposed to sunlight for longer period as compared to north facing slopes.

In order to understand the effect of the aspect on the weather conditions, we used 4 variables i.e. north facing slopes, east facing slopes, south facing slopes and west facing slopes. The statistical analysis rejected the null hypothesis that there was no significant changes in temperature and relative humidity values at 0.01 probability level. However, for wind speed and solar radiation, the probability of significance was analyzed to be greater than 0.05 and the null hypothesis was adopted that there was no change in the average value due to the difference in the direction of the slope. Differences in weather factors due to differences in aspect were significant in relative humidity, but the changes in temperature, wind speed and solar radiation were insignificant under different aspects(Table 12).

4) Correlation of Park Terrain with Climate Factors

In current study, we observed that the temperature, wind speed and solar radiations were not significantly affected by the varying park terrain(shown in Table 13). However, relative humidity was significantly affected and maximum

Table 11. Effect of slope direction on climatic factors of the park (N=125).

Aspect	Temperature(℃)	Relative humidity(%)	Wind speed(㎧)	Solar radiation(W/㎡)
North facing	25.43az	70.97b	.28a	44.82a
East facing	25.88a	69.16ab	.33a	61.91a
South facing	25.62a	67.00a	.34a	65.80a
West facing	25.87a	67.33a	.27a	51.47a

Different letters in the same column indicate a significant difference at $P < 0.05$ according to Duncan's multiple range test (DMRT).

Table 12. One-Way ANOVA showing correlation of aspect and climate factors (N=125)

Division		Sum squared	d.f	Mean squared	F	p
Temperature (℃)	Between groups	5.991	3	1.997	4.073	.009
	Within groups	59.322	121	.490		
	Total	65.312	124			
Relative humidity(%)	Between groups	230.022	3	76.674	8.629	.000
	Within groups	1075.178	121	8.886		
	Total	1305.200	124			
Wind speed (㎧)	Between groups	.103	3	.034	1.034	.380
	Within groups	4.009	121	.033		
	Total	4.112	124			
Solar radiation (W/㎡)	Between groups	8426.631	3	2808.877	2.512	.062
	Within groups	135319.161	121	1118.340		
	Total	143745.792	124			

Table 13. Effect of different terrains on the weather conditions of the park (N=125).

Terrain	Temperature(℃)	Relative humidity(%)	Wind speed(㎧)	Solar radiation(W/㎡)
Valley	25.76az	70.89b	.26a	53.37a
Inclined	25.69a	70.28b	.30a	49.08a
Ridge	25.50a	68.00a	.34a	56.35a

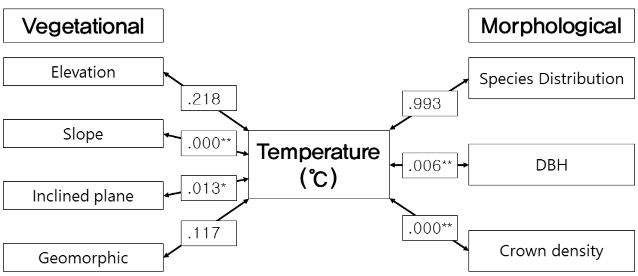
Different letters in the same column indicate a significant difference at $P < 0.05$ according to Duncan's multiple range test (DMRT).

relative humidity of 70.89 % was recorded for the valley(Table 13).

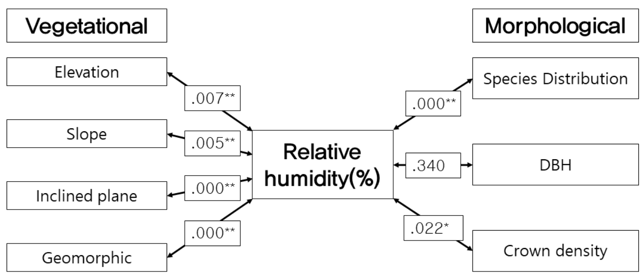
To understand the effect of terrain on the environmental factors, three variables that is Valley, Slope and Ridge were subjected to One-way ANOVA. The statistical analysis rejected the null hypothesis that there was no difference in the values due to the difference in the terrain structure as significant probability was less than 0.01 and adopted the alternative hypothesis that differences in terrain structure resulted in differences in at least one type i.e. relative humidity, but the differences were insignificant in all other factors studied(Table 14).

Table 14. One-Way ANOVA showing terrain correlation with climate factors (N=125).

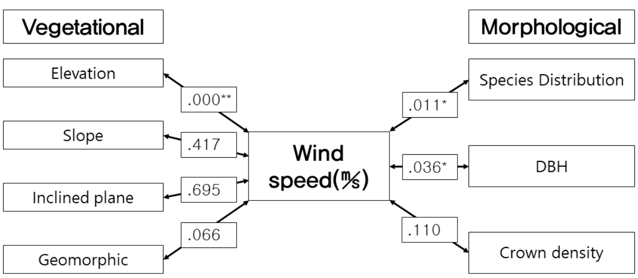
Division		Sum squared	d.f	Mean squared	F	p
Temperature (℃)	Between groups	1.429	2	.714	1.364	.259
	Within groups	63.884	122	.524		
	Total	65.312	124			
Relative humidity (%)	Between groups	181.577	2	90.789	9.858	.000
	Within groups	1123.623	122	9.210		
	Total	1305.200	124			
Wind speed (㎧)	Between groups	.112	2	.056	1.704	.186
	Within groups	4.000	122	.033		
	Total	4.112	124			
Solar radiation (W/㎡)	Between groups	1202.841	2	601.420	.515	.599
	Within groups	142542.951	122	1168.385		
	Total	143745.792	124			



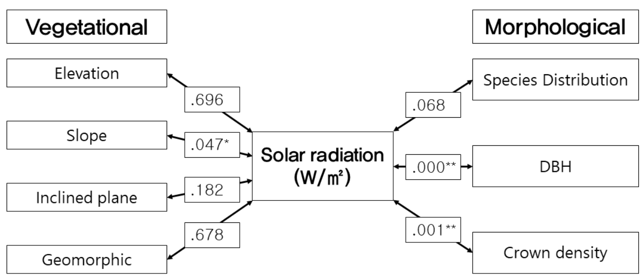
(a) Impact on temperature (℃)



(b) Impact on relative humidity (%)



(c) Impact on wind speed (㎧)



(d) Impact on solar radiation(W/㎡)

Figure 3. Overall schematic impact of vegetation and Physical patterns on climatic factors of Gusan Neighborhood Park.

4. Overall impact of vegetation and physical patterns on the climate factors of park

In current study, we investigated the impact of vegetation and physical features of the Gusan neighborhoods park on the temperature, relative humidity, wind speed and solar radiations of the park. Our study showed that the effect of two physical patterns i.e. elevation and topographical structure ($p>0.05$) was not significant on temperature, and the slope gradient was correlated at significant probability of 0.01 level. Overall, the changes in the temperature of urban neighborhood parks were significant under the influence of slope gradient, DBH, the stern diameter, and the terrain elevation. On the other hand, relative humidity was significantly affected with varying elevation, slope gradient, aspect, and vegetation cover. In the case of wind speed, there was a correlation of wind speed with the elevation in the physical structure ($p<0.01$), but no statistical significance was observed in the slope gradient, aspect and terrain structures at $p<0.05$(Figure 3). The DBH analyzed showed very high correlation between temperature and solar radiation, but little correlation with wind speed.

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