Global Journal of Human Social Sciences
Geography, Geo-Sciences & Environmental
Volume 13 Issue 1 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-460X & Print ISSN: 0975-587X

# Korea's Urban Regeneration Project on the Improvement of Urban Micro Climate: A Focal Study on the Case of Changwon City

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*Keywords :* *urban regeneration project, urban micro climate, wind environment, KLAM_21, green city, stream restoration, green waterway.*

*GJHSS-B Classification :* *FOR Code : 969999p*

KOREASURBANREGENERATIONPROJECTONTHEIMPROVEMENTOFURBAN MICROCLIMATEAFOCALSTUDYONTHECASEOFCHANGWONCITY

*Strictly as per the compliance and regulations of :*

# Korea's Urban Regeneration Project on the Improvement of Urban Micro Climate: A Focal Study on the Case of Changwon City

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## I. Introduction

Since 2008, Korean government has established and initiated diverse strategies to cope with potential climate changes under a low-carbon green growth paradigm. The green growth initiatives suggested a direction of urban development for green city development, and urban regeneration project has emerged as a mean of realizing a green city development.

The purpose of this study is to evaluate the efficacy of urban regeneration projects in terms of green city development in advance. The present study evaluates the improvements which resulted from planning factors of urban regeneration projects by specifically focusing on urban micro climate. Based on these results, the efficiency of urban regeneration projects on the development of green city is determined.

The study first introduces previous urban redevelopment policies and plans of Korea, and it discusses the significance of the urban regeneration projects. The investigation into the implications of urban micro climate on urban regeneration is followed by the case study of Changwon city on the improvements on urban micro climate. There are diverse methods to analyze urban micro climate but the present study conducts analysis based on the velocity of cold wind; hence, KLAM_21 model (Sievers, 2005), a method devised by the meteorological center of Germany to analyze and forecast the generation and flow of cold wind, is implemented to evaluate the improvement of urban micro climate.

## II. History of Urban Regeneration Policies and Urban Regeneration (from Redevelopment to Regeneration)

The urban redevelopment project in Korea first started in the 1960's with the establishment of an urban planning act. The followings are chronological summary of redevelopment projects.

In the 1960's, urban redevelopment focused on redevelopment of substandard living districts and number of projects focused on the improvement of residential environment. In the 1970's, 'Urban Redevelopment Act' was legislated (1976) and urban redevelopments were covered comprehensively and systematically within the boundary of urban planning policies. In the 1980's, 'Temporary Measures for Residential Improvement for Low-Income Citizens' was legislated to carry out residential improvement projects for low-income families (Go, 2008; Kim, 2011).

In the 2000's, 'Maintenance and Improvement of Urban Areas and Dwelling Conditions for Residents Act' was established (2002) to integrate urban redevelopment, reconstruction and residential environment improvement projects, which were poorly evaluated. Furthermore, 'Special Act on the Promotion of Urban Renewal' was established (2005) to promote the urban rehabilitation project locally and nationally.

In the 2010's, the basis urban planning began to be shifted from physical redevelopment and rehabilitation to a sustainable regeneration with the goal of socio-economic and environmental comprehensive

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redevelopment. The legal basis supporting such initiative, 'Special Act on the Support and Activation of Urban Regeneration', has been proposed on June of 2012 and it is currently under deliberation (Kim, J.Y., & Nam, Y.W., 2012).

Urban regeneration policies in Korea have followed in the footsteps of 'Redevelopment to Regeneration' as suggested by Roberts (Roberts, 2000, p.14) and number of research and projects are being conducted (Kim, M.S., & Lee, W.H., 2012; Seo, J.K., 2006; Kye, K.S., 2010; An, H.S., 2012).

## III. Urban Micro Climate in Urban Regeneration

The urban regeneration paradigm has shifted to secure sustainable living conditions of existing residents and to promote socio-cultural and economic activation. The current urban generation philosophy can be divided into environmental regeneration, economic regeneration and regeneration of urban living spaces (Kim, S.W. et al., 2011).

Environmental regeneration stresses the importance of environmental factors and the restoration of environment's genuine functionalities. It is vital to focus on the environmental factors for the conversion to a green city, especially for the improved quality of citizen's lives, and urban micro climate is assumed to play a pivotal role in the environmental terms.

Urban micro climate referred in this study is not restricted to its traditional sense in meteorology, but a climate directly affected by urban development practices, such as representative factors of wind and temperature. One of the urban problems resulted from the changes in urban climate is urban heat island and the influx of cold wind from mountain areas is important to address urban heat island. Cold wind can reduce the temperature in the urban centers, and ultimately address the issues of urban heat island. Recently, the importance of cold wind from nearby mountainous areas has been discussed widely (Oke, 1987, pp.284-297).

To sum up, urban micro climate is important for promoting an eco-friendly green city, which can promote the pleasantness and health of urban life. Therefore, it is necessary to analyze diverse approaches to improve urban micro climate and analyze the improvement effects.

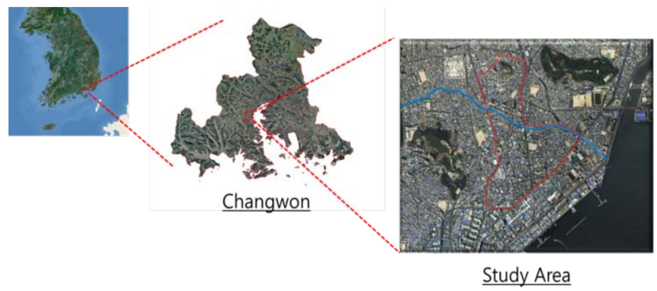
## IV. Case Study : Improvement Effects of Urban Micro Climate Based on Urban Regeneration Factors

### a) *Overview of the Target Area*

The target area is an urban regeneration project area in Changwon city, located in the southern part of Korea. The city has a population of 1,095,733 and total land area of 747.21km$^2$. It is a typical coastal city facing ocean to the east and the south.

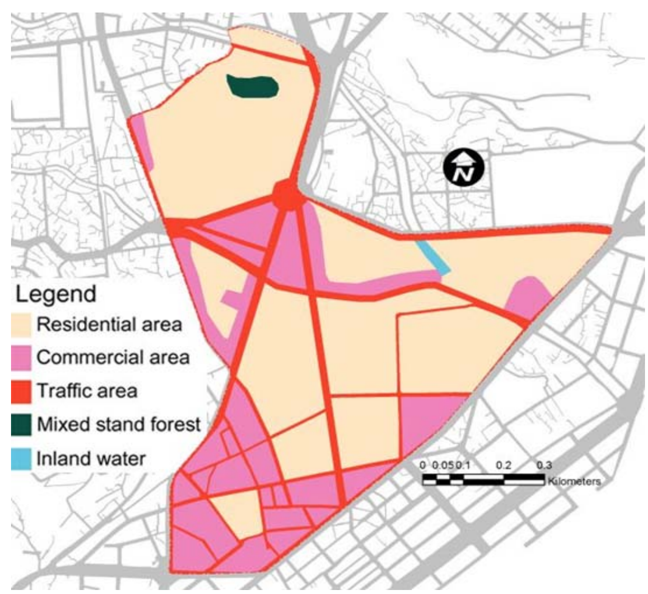
The target area is located at the center of Changwon city, with 0.54 km$^2$ area and a population of 21,453, and it is an urbanized area with typical residential and commercial places.

*Figure 1 :* Location of Study Area




As for the land use patterns, 59.2% are residential areas, 23.7% are commercial areas, and 15.6% are transportation-related area. The environmental condition is relatively poor with mixed stand forest and inland trees occupying less than 1% of proportion respectively (Fig. 2).

*Figure 2 :* Land Use Patterns of Study Area



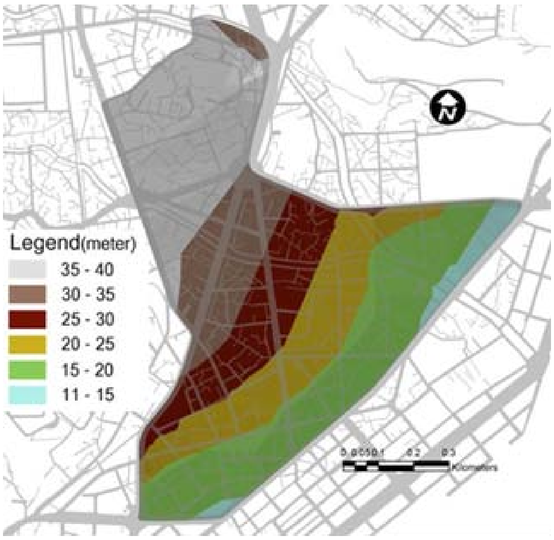

With an elevation of 11m to 40m, the target area has a typical costal topography with a gentle slope descending from north to south (Fig. 3).

### b) *Meteorology of the Target Area*

Monthly wind patterns of the area in 2011, based on the data from Korea Meteorological Association, can be represented in the figure 4. On average, southeaster winds with speed of 2.02 m/s blows into the area.

Divided by months, from January to March tends to be northeaster wind, from April to July southerly wind, in August westerly wind, and from September to December southeaster wind.

*Figure 3 :* Topography of Study Area




*c) Planning Factors of Urban Regeneration*

The goal of the urban regeneration project in the target area is to improve the quality of life and to reactivate the commercial district in deteriorating economy through restoration and regeneration of residential and commercial areas. The urban regeneration project in the area has the following urban planning factors.

- Factor I: Green parking space project in the deteriorating residential areas in Nosan-dong
- Factor Ⅱ: Restoration of ecology of Gyobang stream
- Factor Ⅲ: Green Waterway project for Chang-dong and Odong-dong

i. *Factor I : Green parking space project in the deterioration residential areas in Nosan-dong*

The project refers to the replacement of the 1 public parking space within the deteriorating residential area and 3 parking spaces annexed to the church into an eco-friendly area such as grass blocks. Through this project, more green spaces are established with expected result of considerable improvement of the pleasantness and amenity. Especially, the public parking spaces are planned to introduce a renewable energy generator using the solar power. The specific location and area of the generation facility is represented in the following figure 5.

*Figure 4 :* Wind Patterns of Study Area(Year 2011)

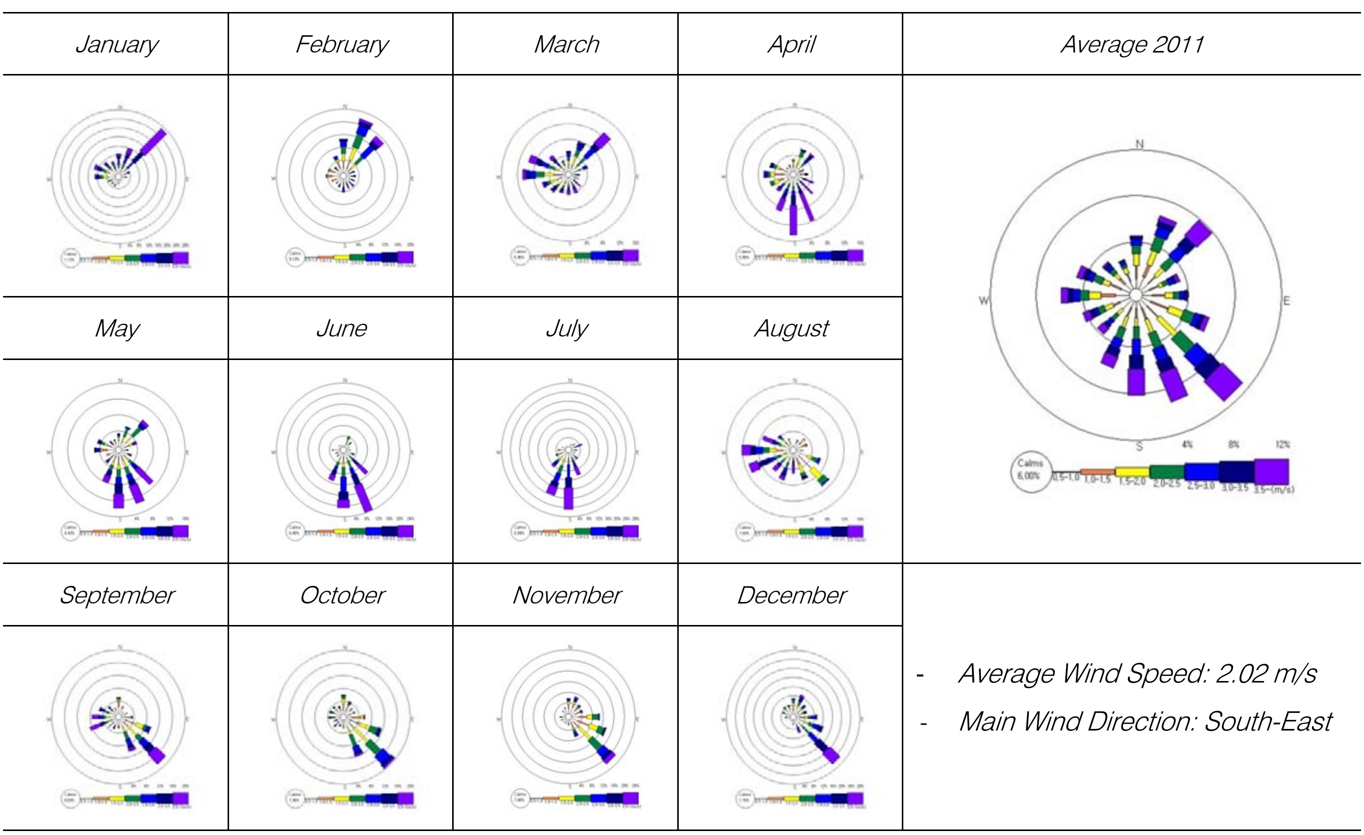



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*Figure 5 :* Location & Area of Green parking space

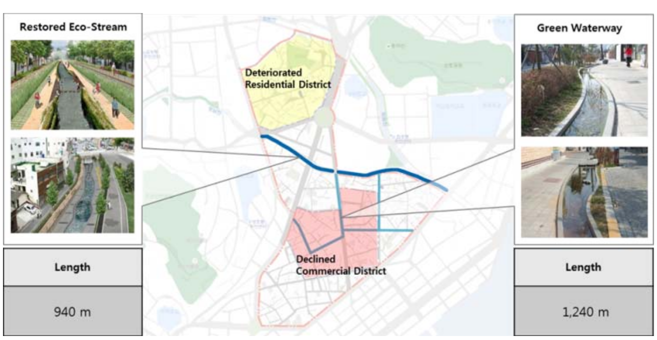

ii. *FactorⅡ: Restoration of ecology of Gyobang stream*

The restoration plan is to reinstate Gyobang stream, a covered stream running through the existing commercial district. A covered stream is a reminiscent of the rapid industrialization and urbanization in Korea and it refers to a stream which is covered with concrete to be transformed into a road for the city transportation.

Since 2000, considerable public interest focused on the pleasant and freshness of urban environments, and the projects to restore covered streams initiated with Cheonggye stream restoration project.

Gyobang stream in the target area was also decided to be restored in this respective, and the stream will be restored to a water-friendly space with walking paths. The stream is 0.94 km in length and the location is shown in the Fig. 6

*Figure 6 :* Location of Gyobang stream and Green Waterway




iii. *FactorⅢ: Green Waterway project for Chang-dong and Odong-dong*

Green Waterway project is the construction of a blue network by connecting the waterway to Gyobang stream. It will create pleasantness and cleanness by providing water spaces in the existing commercial district in addition to creating landmark water-friendly spaces without cars. Continuous provision of water streams will be supplied by green facilities using residential water and underground water. Total length of the stream is 1.24 km and location is presented in the figure 6.

*d) Conditions for Analysis of Urban Micro Climate Based on the Planning Factors*

The analysis factors for evaluating the improvement effects of urban micro climate based on the planning factors are diverse but the present study selected wind as the sole factor for the analysis.

Specifically, the present study focuses on the speed of the cold wind from nearby mountainous areas after a sunset in the summer season, hence makes use of a model appropriate for cold wind generation and flow. The implemented model is developed in Germany and it has a high reliability in analyzing and forecasting the origins and flow of cold winds in urban circumstances.

The modeling conditions for the cold wind speed analysis are represented in the following table 1. The major feature is the fact that local winds are considered to solely reflect the local characteristics in the model. The initial value for the local wind in the simulation is based on the 2011 KMA data of Changwon city.

The total duration of the simulation is set to 8 hours, starting from 20:00 when cold wind normally occurs and blows in the summer after sunset, and ending at 04:00 right before the dawn when the wind generation and flow is stopped.

*Table 1 :* Modeling Conditions for the Analysis of Cold Wind Speed

| Items | | Description |
|---|---|---|
| Adopted Model | | KLAM_21 |
| Range of Analysis | Area | 0.93 ㎢ |
| | Height | 5m |
| Grid | Number of grids | 429 X 542 |
| | Interval | 20m |
| Local Wind | Direction | 135°(southeaster wind) |
| | Velocity | 2.02 ㎧ |
| Time | Start | 8:00 PM (after sunset in summer) |
| | End | 4:00 AM (right before the dawn in summer) |
| | Duration of Simulation | 8 hours |

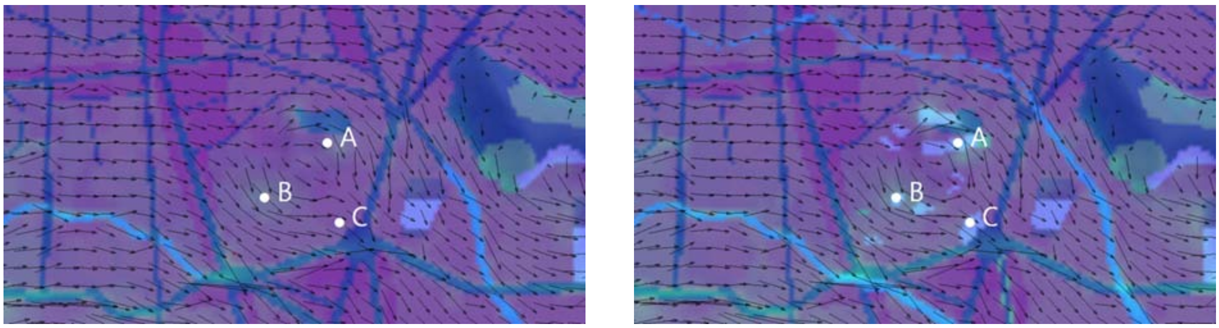
*e) Analysis of the Results of the Improvement of Urban Micro Climate Based on the Planning Factors*

Based on the modeling conditions, the following analysis results are summarized according to the planning factors.

i. *Improvement Effects of Urban Micro Climate by Factor I*

The micro climate improvement effects were analyzed by comparing the speed of the cold wind in the three locations before and after the project. The results are represented in the following figure 7.

*Figure 7 :* Simulation Result of Cold Wind Speed by Factor I




Before After

First of all, within one hour after sunset, the cold wind reduced slightly after the project but the speed of the wind started to increase at 22:00, 2 hours after sunset. The difference in the speed of the wind was exhibited at 22:00 in location A with 5.6% increase rate while 14.5% in location B. Such differences remained consistent until at 04:00, right before the sunset, where it showed the greatest difference of with 17.4% increase rate. At the location C, the increase rate reached 4% at 22:00 similar to the other locations, and the rate was maintained until the time right before the dawn (see Tab. 3).

Comparing the measurements in different locations, the major differences were found in the location B located right behind a hill, with the average increase rate of 10.0%. The location C with the greatest area of green parking space was next with average increase rate of 9.5%. The differences of the speed of cold wind by time and location are summarized in the igure 10 where we can assume the speed of the cold wind to increase to some extent when the ground covers of the parking lots were changed from concrete to eco-friendly areas such as grass blocks.

In conclusion, it is crucial to consider territorial conditions for improved urban micro climate effects through increased speed of cold wind, and to reflect the area of the eco-friendly ground coverage.

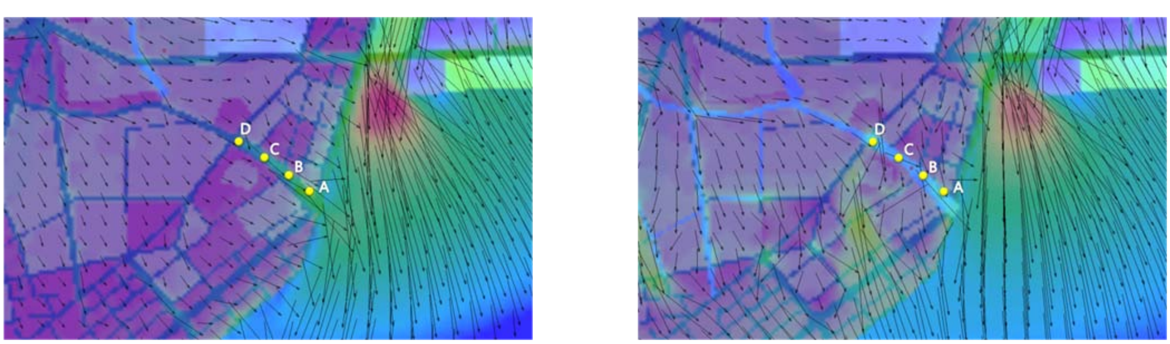
ii. *Improvement Effects of Urban Micro Climate by Factor II*

The Gyobang stream, located to the southeast of the target area, is an urban stream in an ecologically important geography; however, it is still partly covered to provide paths for the vehicle and pedestrian transportation in the city.

The restoration plan has been established to restore the stream as an ecologically sustainable stream and to provide pleasant water-friendly space for the residents.

Four locations were chosen for the analyses of the speed of the cold wind as shown in the following figure 8. The characteristics of the four locations chosen for the comparison are as follows. The location A is situated in a coastal area facing the ocean. Moving northwest towards the city center from the location A following Gyobang stream, the locations B, C, D are located in the respective order.

*Figure 8 :* Simulation Result of Cold Wind Speed by Factor II




Before After

According to the analysis results of each location, excluding the location D, all three locations (A, B and C) showed reduced cold wind speed when the comparison of the speed before and after the project was made. This may be a result of the characteristics of coastal areas; the roughness of interface between the surfaces of the sea and streams is increased after the project, thus obstructing the influx of the cold wind from streams in the northeast of the target area to the sea. On the other hand, the location D located in an established area, not in the coastal ones, exhibited an increase in the wind speed by 73% after the project, when the comparison of the measurement before the project was made.

Time analysis result showed that from 22:00, 2 hours after the sunset, the cold wind speed in the location D started to increase, while, in location A and C, the speed started to decrease from 23:00, 3 hours after the sunset, when compared to the speed before the project. In the location B, the speed slightly increased by 12% to 1.32m/s and steadily reduced from 23:00, compared to the previous speed (see Tab. 4).

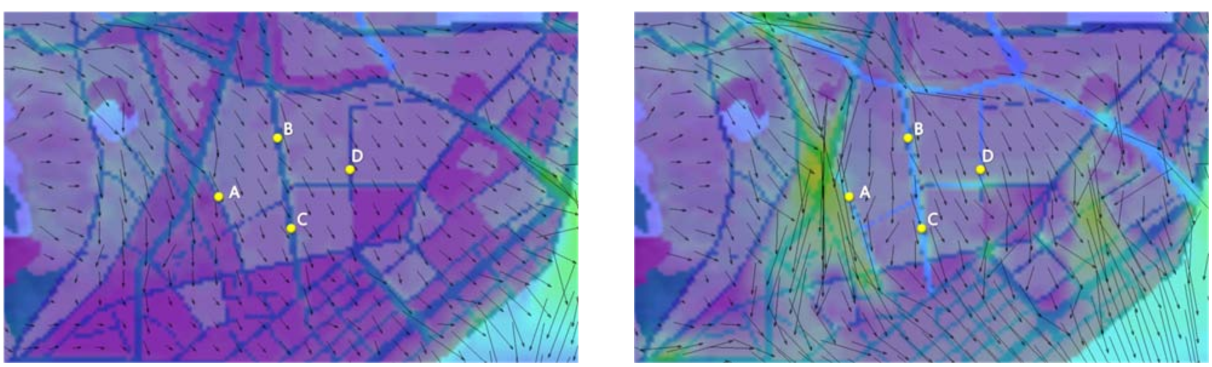
The analysis of results concluded that in all the locations, except for D, the stream restoration project had no significant impact on the improvement of the cold wind speed (see Fig. 11). This is probably due to the disturbance by the characteristics of coastal areas and surrounding area, hence a more detailed plans and strategies to cope with this problem are required.

iii. *Improvement Effects of Urban Micro Climate by Factor III*

The Chang-dong and Odong-dong Green Waterway Project was established to create a streamlet along the part of the inner road to reactivate the deteriorating commercial district and to create more pleasant urban spaces. The present study measured the speed of cold wind in four locations in the target areas to evaluate the improvement effects from the green waterway development project.

The four locations are represented in the following figure 9; two locations are in the south-north line in the space which represents the locality (location B and C in the figure); one is in the Odong Buk-gil (location D); and another one in the Chang-dong Geori Gil (location A).

*Figure 9 :* Simulation Result of Cold Wind Speed by Factor III




Before After

According to the measurement results of each location, the speed of the wind increased in all four locations after the stream development project. Especially in the location D, the increases rate was the highest with average of 179.6%. Such a result implied that the location D was the place where the development plan affected most directly.

The speed of cold wind increased steadily as time elapsed in all locations and the differences also increased slightly. Especially in the location D, within an hour after sunset, the cold wind was most created and the difference was up to 746.4%, and the increase rate maintained at around 170%. The result suggested that the area was the most effected by the development project (see Tab. 5).

According to these results, we can assume that the green waterway development contributed to the overall increase in the speed of cold wind in all the four locations. Especially in the location D, situated in the

Odong-buk 5 gil, the improvement effect was the highest possibly due the stream development of the Gyobang stream largely affecting the speed of cold wind. This result directly demonstrated the importance of nearby natural resources in the urban micro climate improvement, and it can be suggested that this implication should be reflected in the relevant projects to maximize the improvement effects of urban micro climate (see Fig. 12).

*f) Comprehensive Discussion on the Analysis Results on Urban Micro Climate*

- Green Parking Space Project is targeted on an area in relatively high altitude, which can be classified as a hill, and the area has the characteristic of being windy. Although the level of improvement varied according to the location, the speed of the cold wind improved by around 10% on average after the project. The result represents the possibility that the speed of the cold wind can be an urban planning factor which can be ultimately used for the improvement of urban micro climate.

- The analysis of the result of the improvement effects by the Gyobang Stream Restoration Project demonstrated more significant effects in established locations and lesser effects in coastal area. However, as for the established locations, the wind speed improved by 73% after the project. The result suggests increase in the proximity to coastal region results in lower improvement effects. The roughness of interface between the surfaces of the sea and streams increased after the project, which resulted in the obstruction of the influx of the cold wind from streams in the northeast of the target area to the sea. Therefore, a more reasonable approach to handle these characteristics of coastal areas for the improved urban micro climate is needed in the future.
- In the Chang-dong and Odong-dong Green Waterway development project, the stream played the role of passage for the cold wind to travel, resulting in the increase in the wind speed by an average of 40% in all of the four locations. The result suggested that the possibility of green waterway project as not only improving the flow of cold winds and but also serving as a planning factor that contributes to the improvement urban micro climate (Tab. 2).

## V. Conclusion

The present study demonstrates the shift in urban regeneration policies from physical redevelopment to social-economic-environmental regeneration, and shows that this is now a major paradigm for urban development. The present study evaluates planning factors of urban regeneration projects in Changwon city, a coastal city in the southern part of Korea to investigate whether the urban regeneration project can pave the way for a green city development.

The present study selected urban micro climate as an evaluation factor for a green city development, and speed of cold wind, which can address the urban heat island phenomenon, as specified evaluation item for the precise analysis of the improvement effect of urban micro climate.

The analysis result suggested that Green Parking Space Plan and Green Waterway projects increased the speed of cold wind, thus improving the micro climate. On the other hand, stream restoration project had no significant effect on the speed of cold wind as it even reduced the wind in 3 out of 4 targeted locations, which was probably due to the local territorial characteristics and their interferences.

According to the analysis results, the need for a comprehensive plan which can reflect territorial and natural characteristics of target area and its surrounding areas seemed eminent for the creation of green city project in the true sense. In conclusion, we can assume that when based on such plans, eco-friendly planning methodologies can promote green city projects and determine the success of the relevant development urban projects. These projects will pave the way for a green city development where healthy and pleasant environment is ensured.

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## Websites

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2. Korea urban renaissance center: http://kourc.or.kr

*Table 2 :* Overall Improvement of Cold Wind Speed by Urban Regeneration Planning Factors

| | | 60Min. | 120Min. | 180Min. | 240Min. | 300Min. | 360Min. | 420Min. | 480Min. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| I | A | -0.3% | 5.6%) | 3.6% | 2.5% | 3.8% | 2.5% | 3.9% | 3.9% | 3.1% |
| | B | -19.5% | 14.5% | 13.9% | 14.4% | 16.0% | 16.3% | 16.7% | 17.4% | 10.0% |
| | C | - | 4.7% | 3.9% | 5.1% | 4.8% | 4.4% | 4.9% | 4.9% | 9.5% |
| II | A | - | -20.9% | -28.2% | -28.0% | -28.7% | -28.8% | -29.0% | -29.3% | -23.5% |
| | B | - | 12.3% | -6.5% | -7.0% | -6.5% | -7.0% | -6.6% | -6.2% | 0.8% |
| | C | - | -42.4% | -37.0% | -35.5% | -34.9% | -34.4% | -34.2% | -34.2% | -32.0% |
| | D | - | 46.2% | 66.1% | 65.9% | 65.9% | 64.7% | 64.2% | 64.2% | 72.9% |
| III | A | - | -8.5% | 19.1% | 29.7% | 36.3% | 38.9% | 41.5% | 41.5% | 39.5% |
| | B | - | 25.6% | 40.8% | 42.0% | 42.0% | 42.3% | 43.7% | 43.7% | 47.3% |
| | C | 700.0% | 52.3% | 96.4% | 104.5% | 110.5% | 110.5% | 110.5% | 110.5% | 108.6% |
| | D | 746.4% | 123.8% | 177.2% | 177.4% | 177.9% | 175.6% | 175.6% | 175.6% | 179.6% |

*Table 3 :* Comparison of Changes in the Speed of Cold Wind by Factor Ⅰ (Unit: m/s)

| | | 60Min. | 120Min. | 180Min. | 240Min. | 300Min. | 360Min. | 420Min. | 480Min. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Before | 0.706 | 0.611 | 0.588 | 0.566 | 0.552 | 0.552 | 0.545 | 0.545 | 0.583 |
| | After | 0.704 | 0.645 | 0.609 | 0.580 | 0.573 | 0.566 | 0.566 | 0.566 | 0.601 |
| | Increment (Rate) | -0.002 (-0.3%) | 0.034 (5.6%) | 0.021 (3.6%) | 0.014 (2.5%) | 0.021 (3.8%) | 0.014 (2.5%) | 0.021 (3.9%) | 0.021 (3.9%) | 0.018 (3.1%) |
| B | Before | 0.570 | 0.690 | 0.512 | 0.439 | 0.412 | 0.405 | 0.396 | 0.396 | 0.478 |
| | After | 0.459 | 0.790 | 0.583 | 0.502 | 0.478 | 0.471 | 0.462 | 0.465 | 0.526 |
| | Increment (Rate) | -0.111 (-19.5%) | 0.100 (14.5%) | 0.071 (13.9%) | 0.063 (14.4%) | 0.066 (16.0%) | 0.066 (16.3%) | 0.066 (16.7%) | 0.069 (17.4%) | 0.048 (10.0%) |
| C | Before | 0.000 | 0.729 | 0.611 | 0.572 | 0.560 | 0.550 | 0.547 | 0.547 | 0.515 |
| | After | 0.199 | 0.763 | 0.635 | 0.601 | 0.587 | 0.574 | 0.574 | 0.574 | 0.563 |
| | Increment (Rate) | 0.199 (-) | 0.034 (4.7%) | 0.024 (3.9%) | 0.029 (5.1%) | 0.027 (4.8%) | 0.024 (4.4%) | 0.027 (4.9%) | 0.027 (4.9%) | 0.049 (9.5%) |

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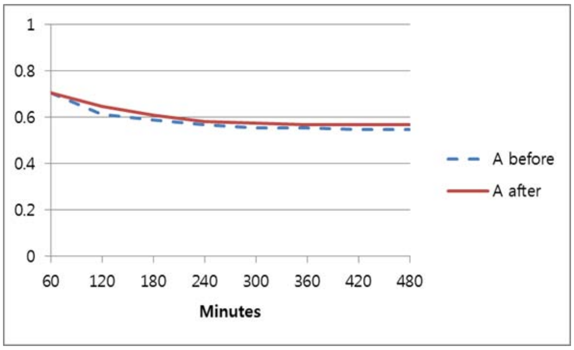
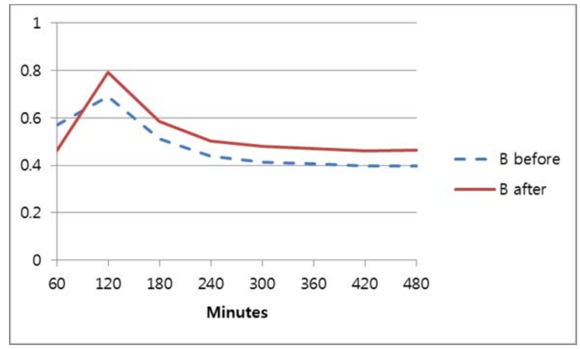
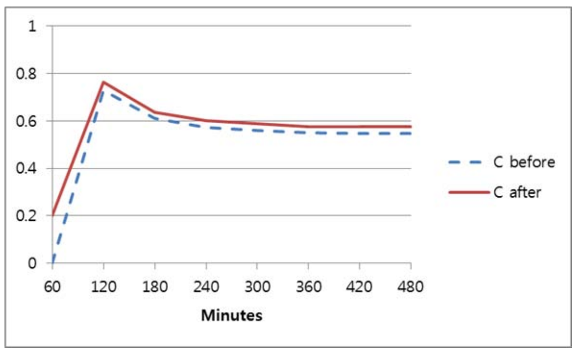
*Figure 10 :* Simulation Results Comparison of Cold Wind Speed between Before and After by Factor Ⅰ




A




B




C

*Table 4 :* Comparison of Changes in the Speed of Cold Wind by Factor Ⅱ (Unit: m/s)

| | | 60Min. | 120Min. | 180Min. | 240Min. | 300Min. | 360Min. | 420Min. | 480Min. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Before | 0.000 | 1.454 | 2.032 | 2.168 | 2.238 | 2.266 | 2.287 | 2.295 | 1.474 |
| | After | 0.633 | 1.150 | 1.458 | 1.562 | 1.596 | 1.613 | 1.623 | 1.623 | 1.127 |
| | Increment (Rate) | 0.633 - | -0.304 (-20.9%) | -0.574 (-28.2%) | -0.606 (-28.0%) | -0.642 (-28.7%) | -0.653 (-28.8%) | -0.664 (-29.0%) | -0.672 (-29.3%) | -0.347 (-23.5%) |
| B | Before | 0.000 | 1.174 | 1.634 | 1.634 | 1.620 | 1.620 | 1.613 | 1.606 | 1.090 |
| | After | 0.457 | 1.318 | 1.528 | 1.519 | 1.515 | 1.506 | 1.506 | 1.506 | 1.099 |
| | Increment (Rate) | 0.457 - | 0.144 (12.3%) | -0.106 (-6.5%) | -0.115 (-7.0%) | -0.105 (-6.5%) | -0.114 (-7.0%) | -0.107 (-6.6%) | -0.100 (-6.2%) | 0.009 (0.8%) |
| C | Before | 0.000 | 1.586 | 1.685 | 1.657 | 1.643 | 1.629 | 1.629 | 1.629 | 1.146 |
| | After | 0.224 | 0.914 | 1.062 | 1.069 | 1.069 | 1.069 | 1.072 | 1.072 | 0.779 |
| | Increment (Rate) | 0.224 - | -0.672 (-42.4%) | -0.623 (-37.0%) | -0.588 (-35.5%) | -0.574 (-34.9%) | -0.560 (-34.4%) | -0.557 (-34.2%) | -0.557 (-34.2%) | -0.367 (-32.0%) |
| D | Before | 0.000 | 0.835 | 0.778 | 0.771 | 0.771 | 0.771 | 0.771 | 0.771 | 0.547 |
| | After | 0.236 | 1.221 | 1.292 | 1.279 | 1.279 | 1.270 | 1.266 | 1.266 | 0.946 |
| | Increment (Rate) | 0.236 - | 0.386 (46.2%) | 0.514 (66.1%) | 0.508 (65.9%) | 0.508 (65.9%) | 0.499 (64.7%) | 0.495 (64.2%) | 0.495 (64.2%) | 0.399 (72.9%) |

*Figure 11 :* Simulation Results Comparison of Cold Wind Speed between Before and After by Factor II

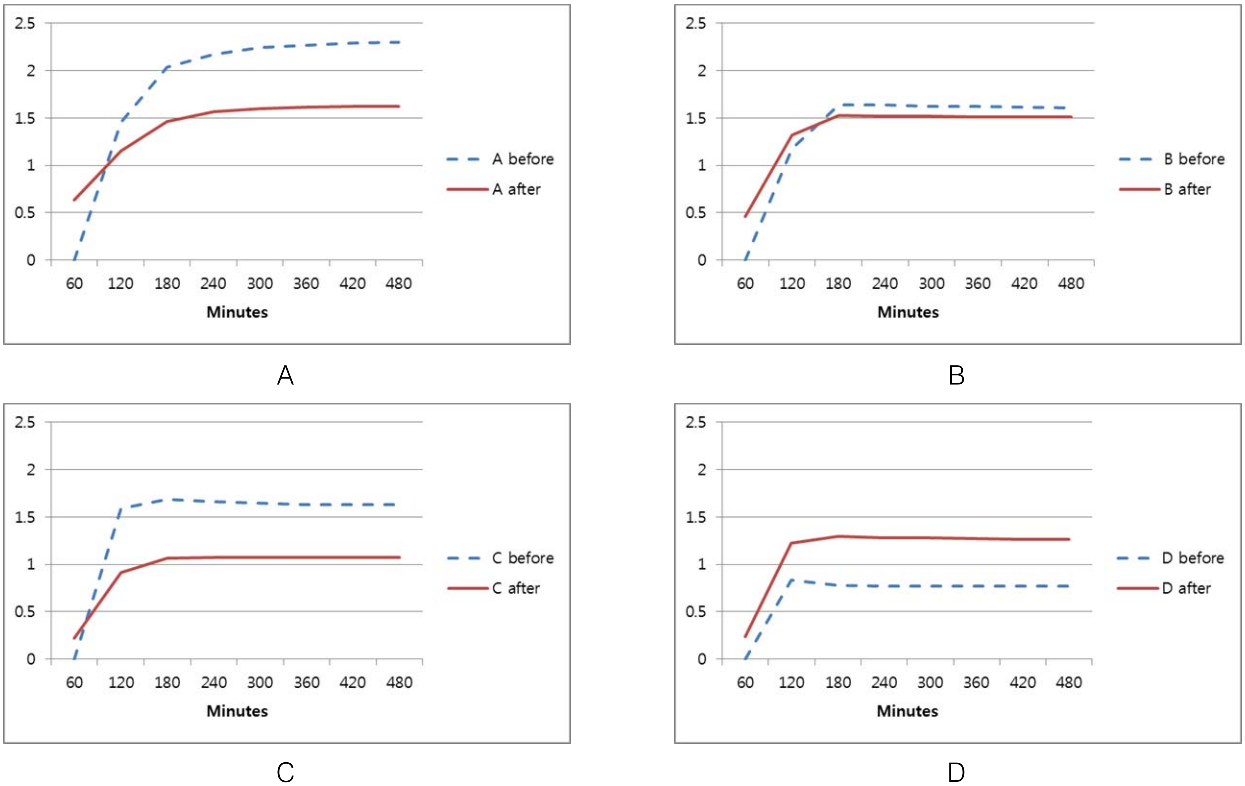
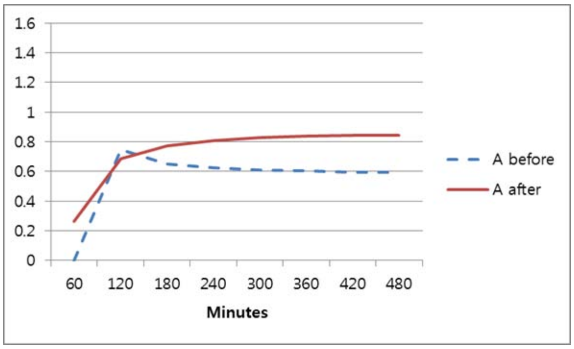


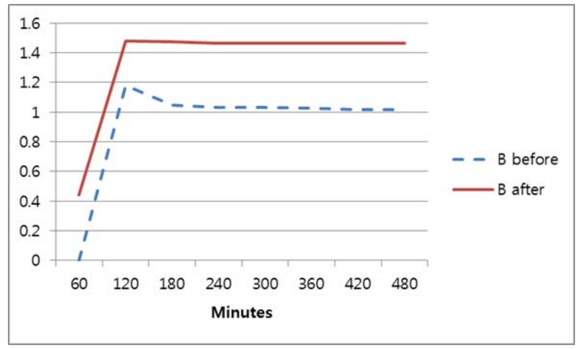

*Table 5 :* Comparison of Changes in the Speed of Cold Wind by Factor III (Unit: m/s)

| | | 60Min. | 120Min. | 180Min. | 240Min. | 300Min. | 360Min. | 420Min. | 480Min. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Before | 0.000 | 0.749 | 0.650 | 0.623 | 0.609 | 0.604 | 0.595 | 0.595 | 0.443 |
| | After | 0.264 | 0.684 | 0.774 | 0.808 | 0.830 | 0.839 | 0.842 | 0.842 | 0.617 |
| | Increment (Rate) | 0.264 - | -0.064 (-8.5%) | 0.124 (19.1%) | 0.185 (29.7%) | 0.221 (36.3%) | 0.235 (38.9%) | 0.247 (41.5%) | 0.247 (41.5%) | 0.175 (39.5%) |
| B | Before | 0.000 | 1.180 | 1.048 | 1.031 | 1.031 | 1.028 | 1.019 | 1.019 | 0.735 |
| | After | 0.441 | 1.481 | 1.476 | 1.464 | 1.464 | 1.464 | 1.464 | 1.464 | 1.083 |
| | Increment (Rate) | 0.441 - | 0.302 (25.6%) | 0.428 (40.8%) | 0.433 (42.0%) | 0.433 (42.0%) | 0.435 (42.3%) | 0.445 (43.7%) | 0.445 (43.7%) | 0.348 (47.3%) |
| C | Before | 0.014 | 0.721 | 0.603 | 0.598 | 0.592 | 0.592 | 0.592 | 0.592 | 0.430 |
| | After | 0.112 | 1.099 | 1.184 | 1.223 | 1.246 | 1.246 | 1.246 | 1.246 | 0.897 |
| | Increment (Rate) | 0.098 (700.0%) | 0.377 (52.3%) | 0.581 (96.4%) | 0.625 (104.5%) | 0.654 (110.5%) | 0.654 (110.5%) | 0.654 (110.5%) | 0.654 (110.5%) | 0.467 (108.6%) |
| D | Before | 0.028 | 0.496 | 0.403 | 0.398 | 0.394 | 0.394 | 0.394 | 0.394 | 0.294 |
| | After | 0.238 | 1.110 | 1.117 | 1.104 | 1.095 | 1.085 | 1.085 | 1.085 | 0.821 |
| | Increment (Rate) | 0.209 (746.4%) | 0.614 (123.8%) | 0.714 (177.2%) | 0.706 (177.4%) | 0.701 (177.9%) | 0.692 (175.6%) | 0.692 (175.6%) | 0.692 (175.6%) | 0.528 (179.6%) |

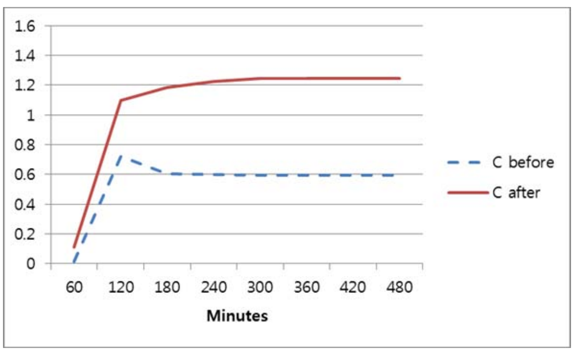
*Figure 12 :* Simulation Results Comparison of Cold Wind Speed between Before and After by Factor III



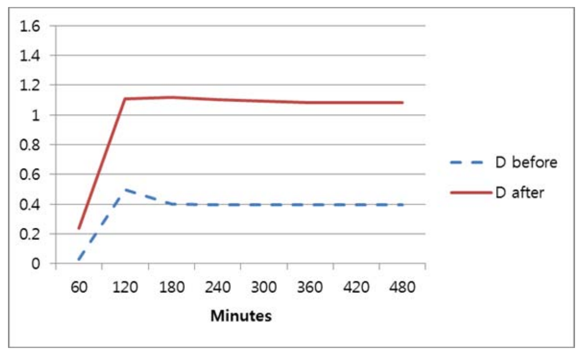

A




B




C




D

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