Urban Forestry & Urban Greening 27 (2017) 43–49

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Original article

Analysis of micro-climate on the programs of urban infrastructure regeneration in J city, Republic of Korea

Kiyong Park[a], Daewuk Kim[b], Manhyung Lee[a], Changkyoo Choi[c,*]

[a] Dept. of Urban Engineering, Chungbuk National University, Chungdae-ro 1, Seowon-gu, Cheongju, Chungbuk, 28644, Republic of Korea
[b] Future Urban Research Center, EGIS Co. Ltd., ICT Park 1, 104 Myeongdeok-ro, Nam-gu, Daegu, 42403, Republic of Korea
[c] Global Desalination Research Center, Gwangju Institute of Science and Technology, 123 Cheomdangwagi-ro, Buk-gu, Gwangju, 61005, Republic of Korea

ARTICLE INFO

Keywords:
Urban infrastructure regeneration technology
Micro-climate
Wind flow
Temperature

ABSTRACT

The purpose of this study is to simulate urban micro-climate change due to the variation of wind flow and temperature assuming situations before and after applying programs using urban infrastructure regeneration technologies (UIRTs), and to then quantitatively estimate effectiveness on the urban regeneration schems. UIRTs focus on improving the recycling efficiencies of reclaimed water and biogas produced and to enforce the linkage among all environmental infrastructures associated with water, waste, and energy in an urban block. To implement the micro-climate analyses, data such as land use, topography, building height and materials, and weather conditions were collected, and the results estimated based on fluid simulations of cold wind and temperature variation pathways. There were three programs used in the urban regeneration project in J city: river restoration, traditional market revitalization, and a primary school eco-school. The height of cold wind from the ground level was significantly elevated, and the maximum wind velocity differential between before and after increased by 0.12 m/s due to the expansion of the waterfront space and grassland through the three programs. Overall, a temperature at the ground level dropped by 1.6 °C. Based on these results, the three programs improved the urban environment at ground level, and might ultimately be capable of diminishing the urban heat island effect and mitigating the energy consumption of urban areas.

1. Introduction

Urbanization in the 20th century was focused on increasing economic growth based on resource intensive consumption, which has subsequently caused rapid damage of eco-systems and deteriorated the living quality of residents. Cities release 40%–70% of the greenhouse gasses (GHG) emitted from artificially generated sources, consuming about 75% of the entire energy supply (Boone and Ganeshan, 2012).

The ecological environment is important for human beings because it is directly related to our survival and provides the raw materials that are needed for human life. However, human economic and social activities have caused serious damage to nature and have threatened its sustainability. The ecological environment of citizens plays an important role, not only in terms of human survival but also in socio-economic development. Thus, the concept of an eco-city originated from an affordable city that focuses on ecology and sustainability (Song, 2011).

Much urban planning for climate change is properly to reduce and mitigate carbon dioxide emission. Nowadays, CO_2 emission accelerates the severity of climate change, but there is little efficient solutions (Hulme et al., 2002). The World Wide Fund for Nature has focused on the urban warming at capital cities in Europe (WWF, 2005). The historic CO_2 emissions deeply related to climate change over 40 years due to the long life of CO2 at atmosphere (Hulme et al., 2002). It means that it must have an effort to decrease the greenhouse gas emissions for preventing climate change.

With regards to climate change, the ability for greenspace to contribute was significantly improved in urban areas (Healey, 1995). In the UK, climate change scenarios (UKCIP02) have warned that the average annual temperature may increase by 5 °C in the 2080s, with summer changes being more serious than winter. There would also be a change in the locality and seasonality of precipitation, with up to 30% wetter winters and up to 50% drier summers; these phenomena are dependent on the region and emissions scenario (Hulme et al., 2002). The precipitation intensity is also likely to increase, especially in winter, with increases in the number of high temperature days, especially in the summer and autumn seasons. These reports further indicate that urban hazards are likely to be more serious than in rural areas (Wilby and Perry, 2006).

Recently, urban regeneration policies world-wide have focused on

* Corresponding author.
E-mail address: simonchoi@gist.ac.kr (C. Choi).

http://dx.doi.org/10.1016/j.ufug.2017.06.002
Received 2 March 2017; Received in revised form 19 May 2017; Accepted 2 June 2017
Available online 28 June 2017
1618-8667/

the concept of 'Redevelopment to Regeneration', as suggested by Roberts and Sykes (2000), with a number of projects have since been conducted (Kim and Lee, 2012; Seo, 2006; Kye, 2010; An, 2012). To date, however, most projects have oriented on urban sustainability: increase the recycling rate of waste resources, reduce the use of natural resources, and improve the amenity in urban area.

The urban micro-climate is not restricted in a traditional sense in meteorology, but the climate directly affects the urban development and renovation, especially in terms of significant factors such as wind and temperature. One of the urban problems incurred from these climate changes is the creation of an urban heat island, in which cold wind from grassland and mountain areas is seen to be important in reducing its effects. In other words, cold winds can decrease the temperature in urban centers, and ultimately resolve issues surrounding urban heat islands. Hence, the importance of cold wind from adjacent grassland and mountain areas is actively being discussed (Oke, 1987).

Green infrastructure means an interconnected network of green space to conserve natural ecosystem functions and provide the benefits to human living. The urban greenspace for the micro-climate improvement and surface water runoff reduction has a potential to enhance the urban temperature. It is not known how much greenspace is needed in urban area to reduce the CO_2 emission (Benedict and McMahon, 2002).

The biophysical features of greenspace in urban areas, through the provision of cooler microclimates and reduction of surface water runoff, therefore offer potential to help adapt cities for climate change. However, little is known about the quantity and quality of greenspace required. The green infrastructure is 'an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations' (Benedict and McMahon, 2002).

The focus of this paper is to simulate micro-climate variations assuming situations before and after applying urban regeneration programs using urban infrastructure regeneration technologies (UIRTs), which are considered one of the most economical and efficient technologies for rejuvenating urban infrastructure. In particular, the ultimate goal of urban regeneration programs is to reduce carbon dioxide in urban, and to quantitatively analyze urban microclimate as an index. Therefore, this study confirms the effectiveness of urban regeneration programs to analyze and compare wind flow and thermal environments.

2. Analysis area

The primary area is located in the core of J city, and includes both residential and commercial regions (Fig. 1). A waterfront is close to the area, as two streams pass through. The area for this urban regeneration program includes small stores, a conventional market place, and many buildings for City Hall and business offices; however, urban decline and shrinkage in this area are accelerating due to the age of the buildings and a general population decline. Here, urban decline has led to not only a decline in the population and in environmental conditions but also economic a decline, e.g., an increase in the vacancy rate of shops and a decrease in the land prices.

To quantitatively estimate the micro-climate change due to regeneration programs in this area, the eight points used to determine the present micro-climate were investigated in order to consider the wind direction, designated as Nosong stream, a primary school, and a traditional market place, which is located in center of this area.

Annual average wind velocity was 1.95 m/s and maximum wind velocity was 13.6 m/s over last 10 years on this region of J city. As shown in detailed wind direction on season, summer season was southeast wind and winter was northwest wind. The status of wind velocity and direction is as Table 1.

As referred to land cover classification map constructed by Ministry of Environment (2007), the residential area accounted for about 60%, commercial area was about 12%, traffic way was about 20%, and grassland was about 6%. Based on this, this region was much vulnerable to micro-climate due that grassland was so small portion compared to other region in J city. Therefore, to decrease the micro-climate deterioration in this region, the urban regeneration projects related to open space, grassland, ecological networks and waterfront space was strongly recommended.

3. UIRTs

'Reclaimed water production technology for existing wastewater treatment facilities (ReWaT)' is a technology used to produce reclaimed water by renovating existing small-scale sewer treatment facilities in an apartment complex. The treated water can be used in small brooklets, and in gardening and cleaning, and it disembogues surplus water into rainwater pipes to use as instream water.

'Energy production technology from organic waste (EPT)' is on-site technology used to produce biogas from organic waste (food waste and excretions) discharged from residential and commercial areas. The effluent of EPT can be used as plant fertilizer (Park et al., 2010).

'Reuse technology of storm water (ReTS)' is technology used to store and reuse the rainwater after treating the high suspended solids (SS) load contained in the initial raw water. ReTS can be installed at specific locations to drain rainwater from sidewalks, outdoor parking lots, playgrounds, etc., and contributes to decreasing the pollution in the initial rainwater in a city.

'Urban farm technology (UFT)' is technology used to cultivate plants and vegetables using the water reclaimed from ReWaT and the biogas and manure (as fertilizer) from EPT, and can be an additional supply of renewable energy. UFT can also provide leisure and productive activities to citizens. Table 2 shows the summary for introduction of urban infrastructure regeneration technologies.

4. Urban regeneration schemes

There are three programs focusing on green urban regeneration in J city: the river restoration program of Nosong stream, the traditional market revitalization program, and the eco-school program of the primary school. These programs were implemented not only to maximize the recycling of resources but also to revitalize the urban core. It has the additional advantage of creating a synergistic effect through intimate relationships with each another (Fig. 2).

4.1. River restoration program

The focus of the river restoration program was to uncover and revive the dried brooklet to continuously maintain water quantity and quality by using the reclaimed water as an urban stream by refreshing the rainwater and sewage (Fig. 3). ReWaT and ReTS were applied to produce the reclaimed water for the instream water. This program can maximize the reuse rate of sewer and rainwater in an urban area (Choi et al., 2010).

4.2. Revitalization program of the traditional market place

Fig. 4 shows the concept for the revitalization program of the traditional market using ReTS. Rainwater was primarily treated and stored in an underground storage tank. The treated water was then passed through and circulated throughout the artificial waterway, before eventually flowing into an adjacent stream (Park et al., 2015). This program revitalizes the marketplace and encourages customers to walk from downtown to the traditional markets.

4.3. Eco-school program of primary school

The concept of the eco-school (Fig. 5) is to maximize the recycling