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Analysis and Assessment of Urban Green Space Coverage Using Remote Sensing Spatial Imagery

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Abstract: *With the development of urbanization and the health of city residents, it is necessary to evaluate and analysis the urban green space. Based on the principle of NDVI index, the green space of Sino-Singapore Eco-city was estimated. It is obtained by comparing the building data measured in the field reflect the population number and distribution. By overlapping green space of different levels, the specific condition that residents occupying different levels of green space can be obtained. In this case, the Sino-Singapore Tianjin Eco-city was studied and suggested as a city with good and suitable environment for residents.*

Keywords: *Urban green space, Remote sensing, Sino-Singapore Tianjin Eco-city*

1. Introduction

With the public's rising environmental awareness, the term "green space" has seized more attention than ever before. So what is green space? Greenspace, or urban green space, in land-use planning, means open-space areas reserved for parks and other "green spaces", including plant life, water features and other kinds of natural environment [1]. Lack of green space not only appeals less to the potential property owners, but it also brings concerns to the residents' physical and mental health. Green space contributes tremendously in addressing major public health issues related to non-communicable diseases such as obesity, cardiovascular diseases, type-2 diabetes and cancer [2]. Hence, urban policies that place green space in high priority are suggested in city planning. Effective urban greening policies are crucial for revitalizing communities, reducing financial burdens of healthcare and increasing quality of life. Besides the direct improvements brought to residents' health issues, green space also plays a vital role in combating the deterioration of the environment caused by overurbanization. Most policies focus on community benefits and reducing negative effects caused by rapid urban development, such as surface runoff and the urban heat island effect.[1]. In order to design practical policies, city designers will need to analyze the current green space area first. In the past, they derived the city's green space area from the existing database. But not only was the data outdated constantly, it was usually not an accurate representation either [4]. These errors can greatly hamper designers' progress on developing an effective outline. The inconvenience continued until Remote Sensing imaging was promoted to help analyze the green space. City planners can take advantage of its dynamic and precise images and make adequate decisions. Urban green spaces also have a corresponding impact on the people living in the surrounding area. Our experiments with satellite imagery to analyze green space planning can be effective and more efficient in transforming cities into green space centers and using the space wisely to build more buildings. The benefits of this can be more enjoyable for the people living in the city, and a greater use of the land. "Modern urban life style is associated with chronic stress, insufficient physical activity and exposure to anthropogenic environmental hazards, it can promote mental and physical health, and reduce morbidity and mortality"[1]. Green can provide people with a place to relax and unwind, allowing them to better connect with nature. Green space can also provide fresher air, making the surrounding environment cleaner and more pleasant for people.

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2. Methods

The study area is the Sino-Singapore Tianjin Eco-city, in which the distribution and classification of urban green space are analyzed by processing remote sensing images.

The Sino-Singapore Tianjin Eco-city is located in the northern part of Tianjin Binhai New Area, China, which covers about 150 km^2 in total. The Sino-Singapore Tianjin Eco-city was established in 2007 by the Chinese and Singaporean governments that aims to transform a former saline wasteland into an eco-friendly, socially harmonious and economically sustainable city[3].

The data of the study came from GF 2 and the Sino-Singapore Tianjin Eco-City data platform. The geographic data of the local building has been extracted manually, including the land area and the number of floors of each building. Since 80% of human activities are mainly carried out in indoor spaces, architecture can be used to simulate the distribution of population in urban spaces, and then analyze the number of people in different levels of green space. The remote sensing images are processed through visual interpretation and manual mapping to facilitate the later analysis of data processing. All the remote sensing and GIS data processing was performed using ArcGIS software and was analyzed accordingly.

3. Green Space extraction and analyzing

Based on the Normalized Difference Vegetation Index (NDVI), the green space of SSTEC could be extracted and analyzed. The NDVI values range from -1.0 to +1.0 representing different geographic features among them the vegetation usually has value greater than 0. The NDVI is calculated with the following equation, where ***NIR*** and ***Red*** stand for near infrared band and red band respectively.

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

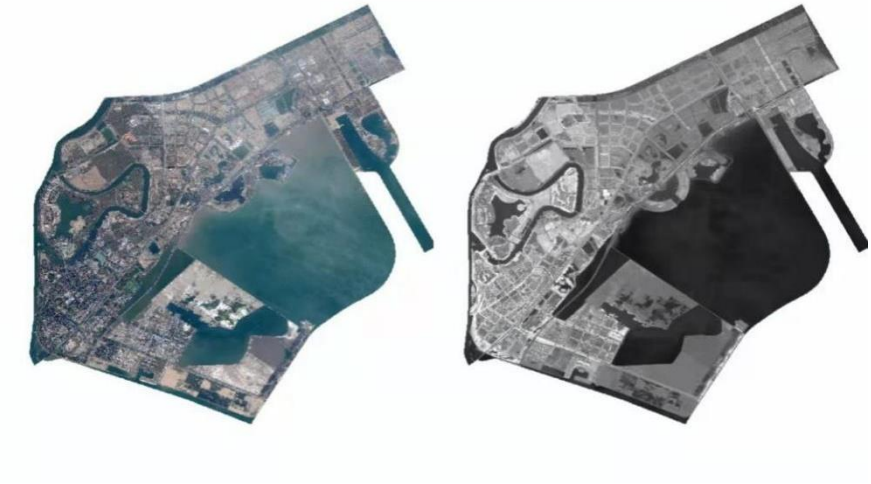

Figure 1: NDVI.tif Layers selected by ArcGIS

Therefore, the image can be derived after selecting the threshold value of NDVI = 0， shown in Figure 1. The left image is a true color image of the Eco-city area, and the four channels of red, green and blue correspond to bands 3, 2 and 1 of the GF-2 image data. On the right is the extracted layer, black indicates NDVI less than 0 and white indicates NDVI greater than 0 which is vegetation cover area. Through the calculation by the ArcGIS, the area of green space is 22.72 km^2 taking over 75% of the total area of SSTEC. The eastern side of the Eco-city is the sea, so no green vegetation is distributed, but the land to the north, west and south has a good vegetation covering.

Furthermore, to evaluate the level and service capacity of the green space of the city, it is necessary to know the distance between each pixel in study area and the closest green space. To calculate the minimum distance from each pixel to its closest green space, the Euclidean distance tool provided by the ArcGIS software was adopted. To facilitate the evaluation, the level of green space is evaluated with the range of the green space distance classified into five categories: 0-100 meters, 100-300 meters, 300-500 meters, 500-700 meters, and more than 700 meters representing from level 1 to level 5 of green space's coverage, shown in Figure 2.

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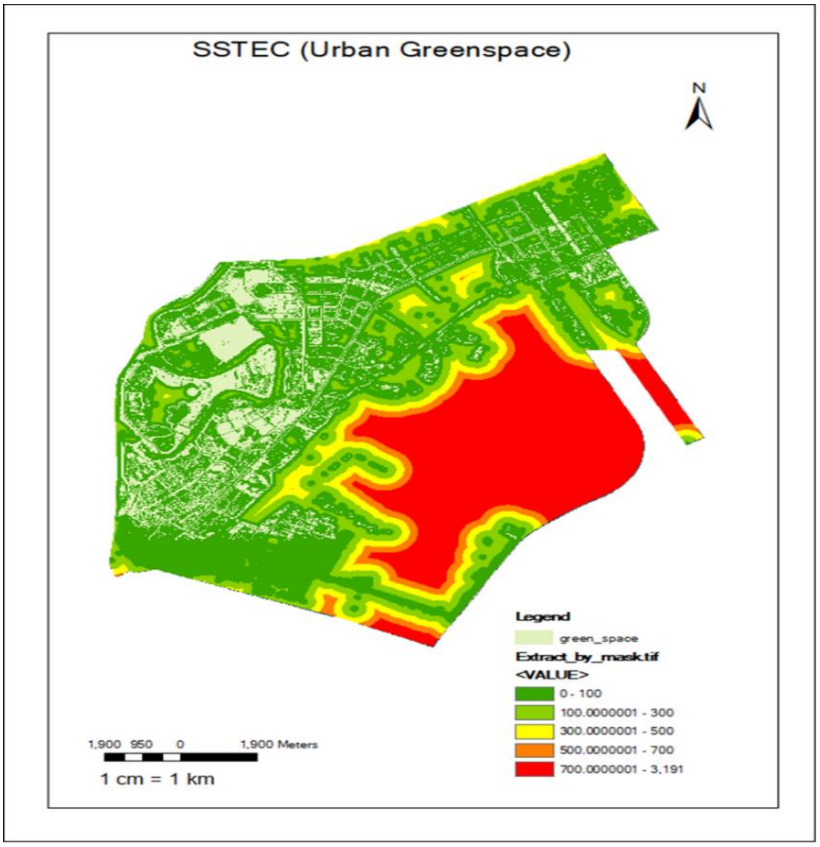

Figure 2: The green space distribution of SSTEC

4. The analysis of urban residents' acquisition of green space

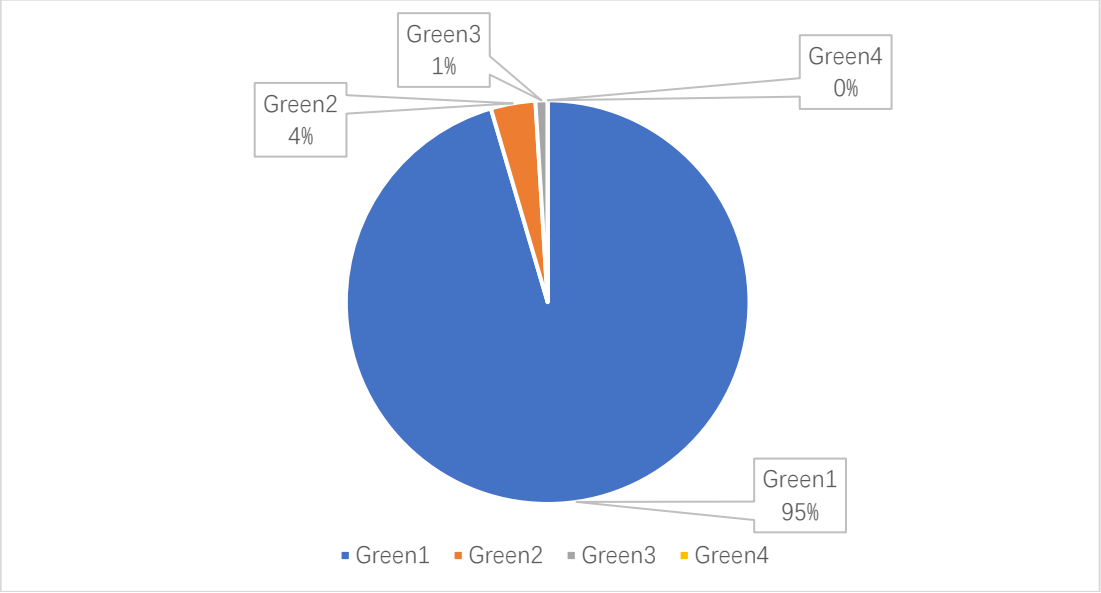

Figure 3: Residents distribution of each greenspace level

To better demonstrate the green space capacity of the city, it is of great importance to have the residential distribution area. However, it is hard to specify the exact numbers of people due to lack of locality census information and fundings. In this case, instead of population, our team used the building's area. People are assumed to be evenly distributed and positively correlated with building area. As a result, the distribution of residences can be viewed as the distribution of the building with varying total areas, which are calculated as the product of the number of layers and the area of the layer.

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Throughout ArcGIS, the area of each building can be generated into the attribute table within the construction file. The specific "population" distribution was created by replacing population with building area. Similarly, the ratio of population distribution under different greenspace levels can be obtained by comparing each area under a specific greenspace. Using the zonal analysis tool in ArcGIS, the building area as the representatives of population was computed out and then made into Figure 3.

5. Conclusion

The green space in the Sino-Singapore Eco-city is widely distributed on the land, as can be seen from the green space distribution map. The proportion of green vegetation to the total land area is 75%, and almost 95% of the population in the Eco-city lives within 100m of the vegetation cover, and more than 99% of the people are within 300m of the green space. Therefore, it can be concluded that the vegetation cover of the Sino-Singapore Eco-city surrounds almost all urban residents and provides very good vegetation space. It is foreseeable that the excellent vegetation cover will attract more people to settle in the city until a state of balanced occupancy is reached.

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