Spatial Analysis and Geovisualization on the Relationship between the Green Land and the Population in the Urban Area – A Case Study in Taipei City

Chia-Yun Chao [(1)], Sendo Wang [(2)]

Dept. of Geography, N.T.N.U., 162 HePing E. Rd. Sec. 1, Taipei 10610, Taiwan, R.O.C.
E-Mail Address: [(1)]40323207l@ntnu.edu.tw, [(2)]sendo@ntnu.edu.tw

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Abstract: Plants are essential to human lives. Green land, such as parks, is the lung of a city. It does not only provide oxygen for people to breathe, but also provide a space for people to relax or to have some social activities. In this study, we would like to figure out the relationship between the green land and the nearby population. The average area of green land for each person is calculated as an index and is mapped as the base layer for the spatial analysis. The first discussion is focused on the distribution of the green land index. The higher index usually suggests a better living quality in an urban environment. The second focus is to examine the relationship between the green land index and the price of the real estate. A special attention is paid to those area where the green land index is high but the price is comparatively low. Finally, a survey is conducted to understand the habitant's feeling about their living quality in different index area. To distinguish the green land in Taipei City, the multispectral images taken by the SPOT satellites are used to calculate the vegetation indices, such as the NDVI (Normalized Difference Vegetation Index) and the greenness index. The green land is classified based on the vegetation indices. Since the government has published the population layer as the open data, the polygons in the population layer are used as the statistical unit. An adequate buffer is grown around the population polygon for calculating the area of green land inside the buffer. So, the average area of green land for each person can be calculated as the proposed index, we call it the "Normalized Green Area Index (NGAI)". This NGAI is served as an evaluation on the living quality associated to the green land in the urban area. Then, the NGAI is mapped as the base layer for further spatial analysis. The price of real estates in Taipei City is the other open data we used in this study. Usually the residential real estates around a park have higher price. The NGAI is used to investigate and to verify this presumption. For those area where has higher NGAI but lower price, we will try to find out the reason behind the phenomenon. To understand the living quality around the city, we conducted a survey to habitants in different NGAI area. The statistical summary of the survey is served as a bridge to connect the NGAI and the living quality about the green land near the habitants. We hope the proposed approach can be applied to different cities and be associated to more domain knowledge in the future.

INTRODUCTION

Nowadays, over half of the human live in the urban area. Especially in Asia, people prefer to live in the center of the city, for the purpose of convenience, but "How to choose a better living quality" has become an important issue for people nowadays. When we are talking about the definition of urban areas, we will usually define it depending on the population or population density of an area. City is constructed by the aggregation of people, high population density become an indicator of urban prosperous, but it usually implies a high house pricing and a narrow living environment. Mostly, there is low green coverage in urban area, especially in the highly developed urban area.(Burton 2002) Luxury houses in Asia citys is an example of combining the two benefits both convenience and green living environment. Now, most luxury houses in Asia city still build in the central part of urban. This area not only have highest population density but also close to a green land like school, park …etc. To provide a better living quality. In this study, I want to combine these two indicates, green land and population density, which may be contradicting but has great impact on people's living quality and house price.

The relation between human health and green land has already been proved in many studies. For example, residents of greener areas had better self-perceived health and lower occurrence of cardiovascular and metabolic conditions(Kardan et al. 2015). The size of green land coverage is important to an area. If too much people share a green land, the area shared to each person is still limited. In this study, the green land coverage of different area will be compared by the green land area per person.

STUDY AREA and MATERIALS

1. Study Area

In this study, I will focus on Taipei city (Figure 1,) the capital of Taiwan located in north Taiwan. Taipei is a classic Asia city with high population density, with highest house price and best amenities of Taiwan. There is some

mountain area in north and southeast Taipei. In this study, we will select flat areas with elevation under 50m as study area. Selection is based on the 20m DEM data provided as open data in Taiwan.

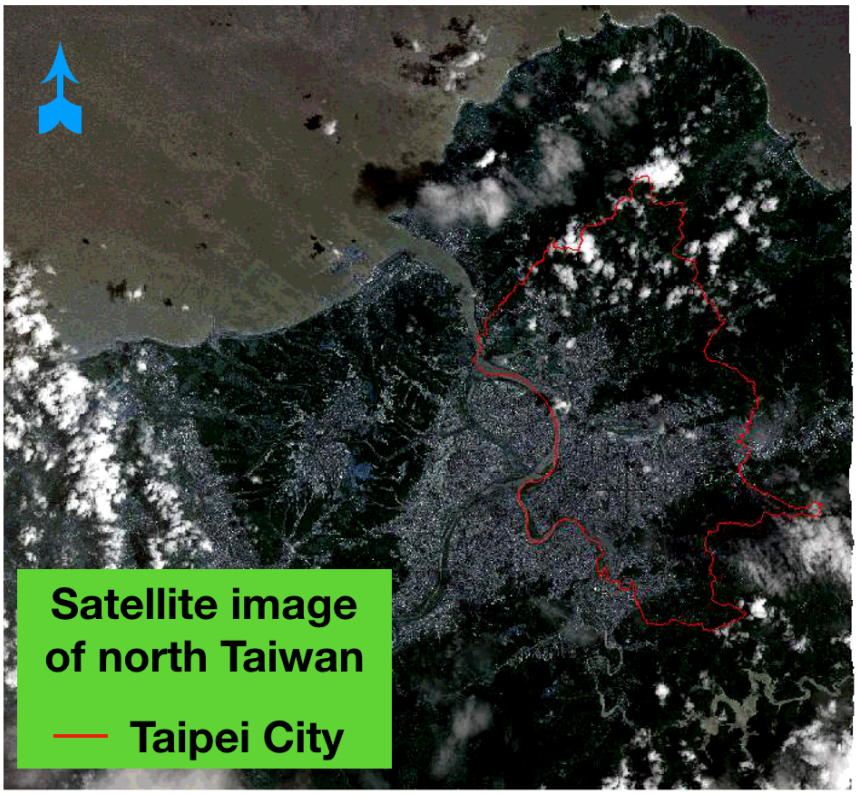

Figure 1, Satellite image of study area_Taipei city

2. Satellite Imagery

We use SPOT 6 image with a resolution of 1.5 meter panchromatic and 6 meter multispectral (blue, green, red, near-IR).

For the shooting time, we choose to use an image taken in summer in Taiwan, because when its summer, Taipei usually have the best vegetation coverage and sunny weather in the morning.

There is only one summer image of Taipei in the near 3~5 years, so the main image we use to map the basic green land is the image collected on AUG,20,2016.

3. Real Estate House Price

The real estate price is provided by the Taiwan government, and it's an open data for everyone. Real estate price data provides the data of house prices, type of usage, construction time, and the detail of house condition. For the personal privacy protection, the address number of trading house has already been de-identification. We chose the first doors number to represent the de-identification area. In this study, we only select the houses not for commercial use. The data used in this study is recorded in 2016, there are 8673 records in total.

METHOLOGY

1. Green lands selection

The green land area in Taipei city is estimated through the Spot image of AUG, 20,2016. The area with GNDVI over 0.3 and elevation below 50m will be selected as urban green lands.

1.1 NDVI Index

The Normalized Difference Vegetation Index (NDVI) index is the most common index used in vegetation remote sensing, first used in 1973 by Rouse et al.(Rouse et al. 1973). The value range of an NDVI is -1 to 1. For areas with better vegetation coverages, there is a higher NDVI value for the reason of higher NIR and lower red light in the vegetation. If the vegetation is densely distributed, the value of NDVI varies from 0.1 to 0.6, depending on the density and greenness of the plant. Soil and rock will produce values close to 0, because the values of NIR and red

band are similar; and water, clouds, will usually have a negative value for higher red band than the NIR reflection.

$$NDVI = \left(\frac{NIR - Red}{NIR + Red}\right)$$

1.2 GNDVI Index

The GNDVI index first use by Gitelson, A., and M. Merzlyak in 1998. (Gitelson and Merzlyak. 1998)This index is similar to NDVI except that it measures the green spectrum from 540 to 570 nm instead of the red spectrum. This index is more sensitive to chlorophyll concentration than NDVI. For the preference of better vegetation recognization, in this study we select green lands base on GNDVI index.

$$GNDVI = \left(\frac{NIR - Green}{NIR + Green}\right)$$

1.3 Field trips

After comparing selection of NDVI>0.5 area, NDVI>0.3area, and GNDVI>0.3 area. We went a field trips in study area. The area with GNDVI index over 0.3 is the area best representing the green land area in Taipei city including small area green covers like roadside shade trees and small green lands.

1.4 Mountain area removal

There are some mountain areas in the northeast and southeast Taipei. (Figure 2.) Green lands impact on living environment on mountain area is different than that on plain area, so we only select green lands with ground elevation below 50m in Taipei city.

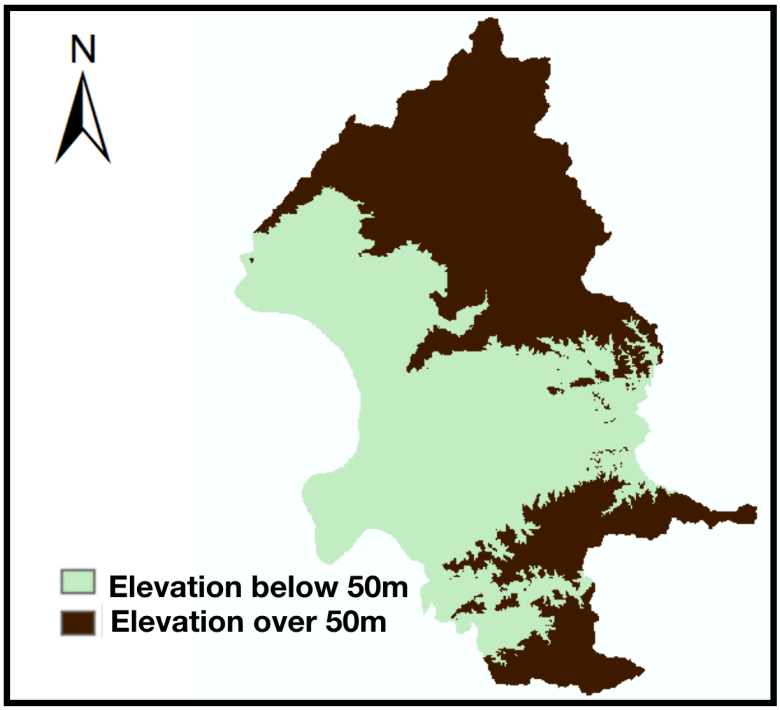

Figure2. Mountain area in Taipei

1.5 Population polygon buffer buffer zone

500m, is the distance used by Taiwan government to conduct public transport construction assessment. If the distance between green land and living place is under 500 meters, we think it could be a walkable distance for people living nearby. In this study a 500m buffer is grown around the population polygon for calculating the area of green land inside the buffer.

2. Normalized Green Area Index (NGAI)

Normalized Green Area Index (NGAI) is the proposed index been calculated by the average green land area for

each person in every minimum statistic unit. This index is calculated by the green land areas within every minimum population statistic unit and green lands within the 500m buffer zone of every unit. This index is calculated to represent how many green lands accessible for people living in one area.

$NGAI = \frac{Greenlandarea}{Population}$ (square meter per person)

3. Real Estate House Price Preprocess

Real Estate House Price is released as open data by Taiwan government, including bargaining price, trading time, construction time, types of housing, trading category (pre-selling house, court-auctioned house…..)
In this study, we excluded commercial houses, pre-selling houses, court-auctioned houses and other special conditions ex: trading between relatives.
There is 9091 acceptable trading records in 2016 . After transforming from address data to XY coordinate data, there are 62 error records on address recording or in the process of transforming.

4. Residential satisfaction questionnaire

To understand the habitant's feeling about their living quality in different index area, a questionnaire is conducted. In this questionnaire, we ask people living in different region to what extend are they satisfy with their living environment. Question including: 1. To what extend are they satisfy with their living environment, 2. To what extend are they satisfy with their environment greenness, 3. To what extend are they satisfy with the accessibly of the green land area.

RESULTS and DISCUSSION

1. The distribution of NGAI in Taipei city

The calculation result of NGAI index in Taipei is in the range of 0 to 1314650 square meters green land area in one minimum population statistic unit. (Figure3 & 4.) For NGAI =0 area is usually a public area like parks, airport, school…etc. with no people living in that area. Therefore, the result of the calculation will be 0. Usually, the highest 5% NGAI results located in some riverside area with large green area nearby and only about 1~5 people living in that area. For these low developed area, the NGAI result is similar to the condition of NGAI distribution in mountain area. Over 90% of the statistic units has a result of NGAI between 5 to 500 ㎡ green lands per person.

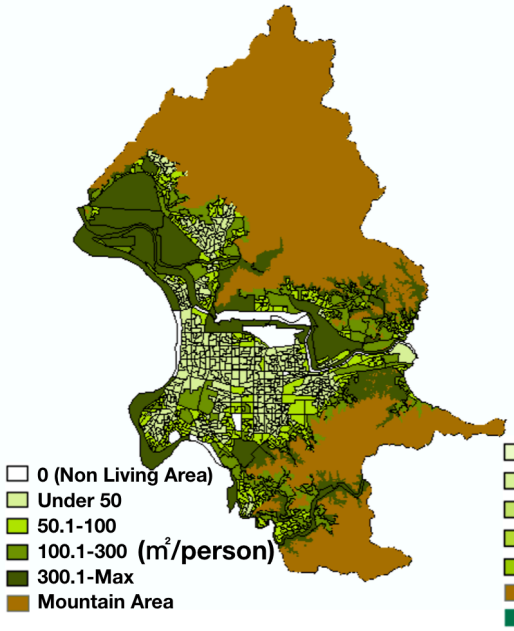

Figure3. The NGAI distribution in Taipei

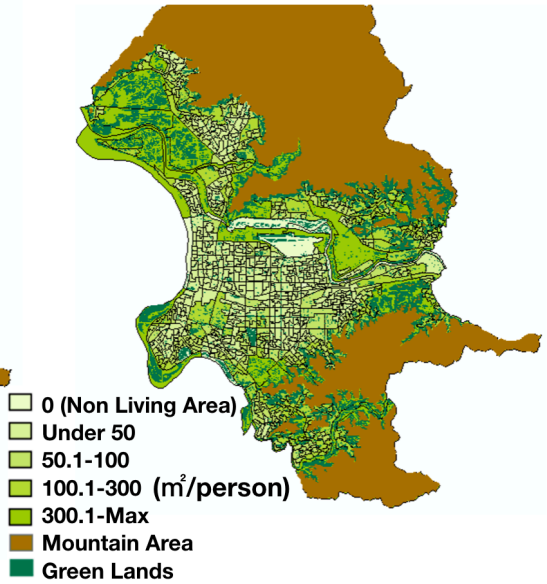

Figure4. The NGAI and Green Lands distribution in Taipei

2. The area of different NGAI results in Taipei

The map of NGAI distribution is perfect fit the urban planning area in different periods. (Figure5.) Areas with noticeable low NGAI index (Area 1 in Figure5.) is perfectly representing the old developed city central of Taipei city.

Areas located in periphery with high NGAI index (Area 2 in Figure5.) mostly represents new developing areas. Areas located in central area of city with a high NGAI result (Area 3 in Figure5.) are areas close to some main urban planning parks. Usually, if there is a high NGAI area covered by low NGAI area, for example area 3 in Taipei, is the most popular living area in a city.

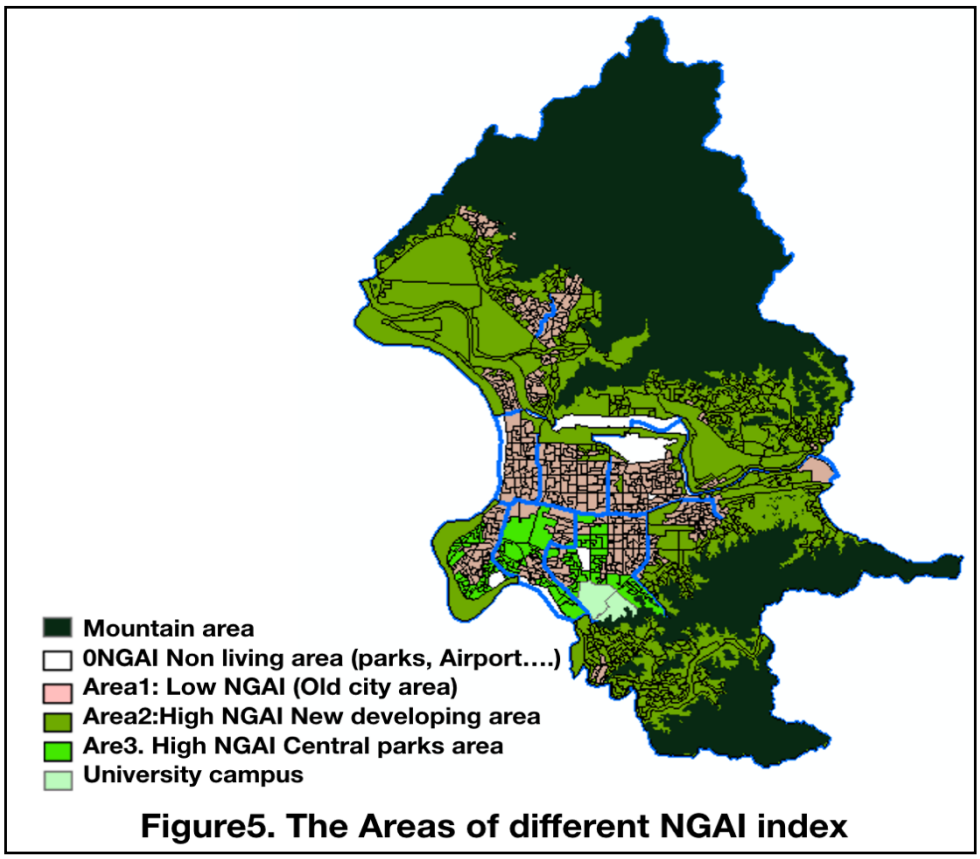

Figure5. The Areas of different NGAI index

3. The green land index and the price of the real estate

In the whole Taipei city, the relation between NGAI and house price is negative. Because in a large scale like the whole city of Taipei, both NGAI index (green land and population) and house price can only sort the different

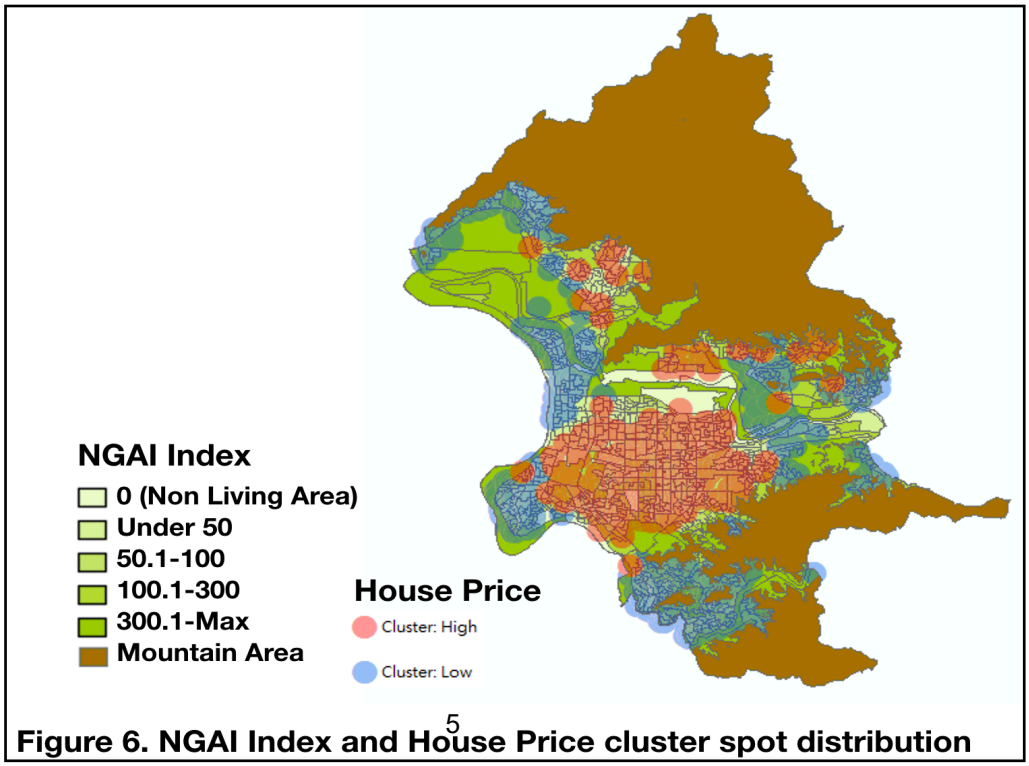

Figure 6. NGAI Index and House Price cluster spot distribution

between central part and periphery part of city. In the central of city, there is high population density, relatively low green lands cover and high house price. (Figure6.)
In order to understand the relation between green land index and the price of the real estate in a smaller index, we room in to the central part of Taipei city, the connection between NGAI and house price become positive.(Figure 7.)
If we focus on NGAI index and house price in the central area of Taipei city, there is 6 districts in this area.In the central area of Taipei city, there is only 31% of statistics unit having a NGAI over 50 m2 per person. But when it comes to high price houses, there is 60 trading records within the top 20% highest trading price of all records in Taipei. For this top 60 high price record there is 27 (45%) of them located in these rare green area.
On the other side, for all 48 records in the range of 20% lowest price trading record. there is 37 (77%) of them located in the few green cover areas. (Figure7,)

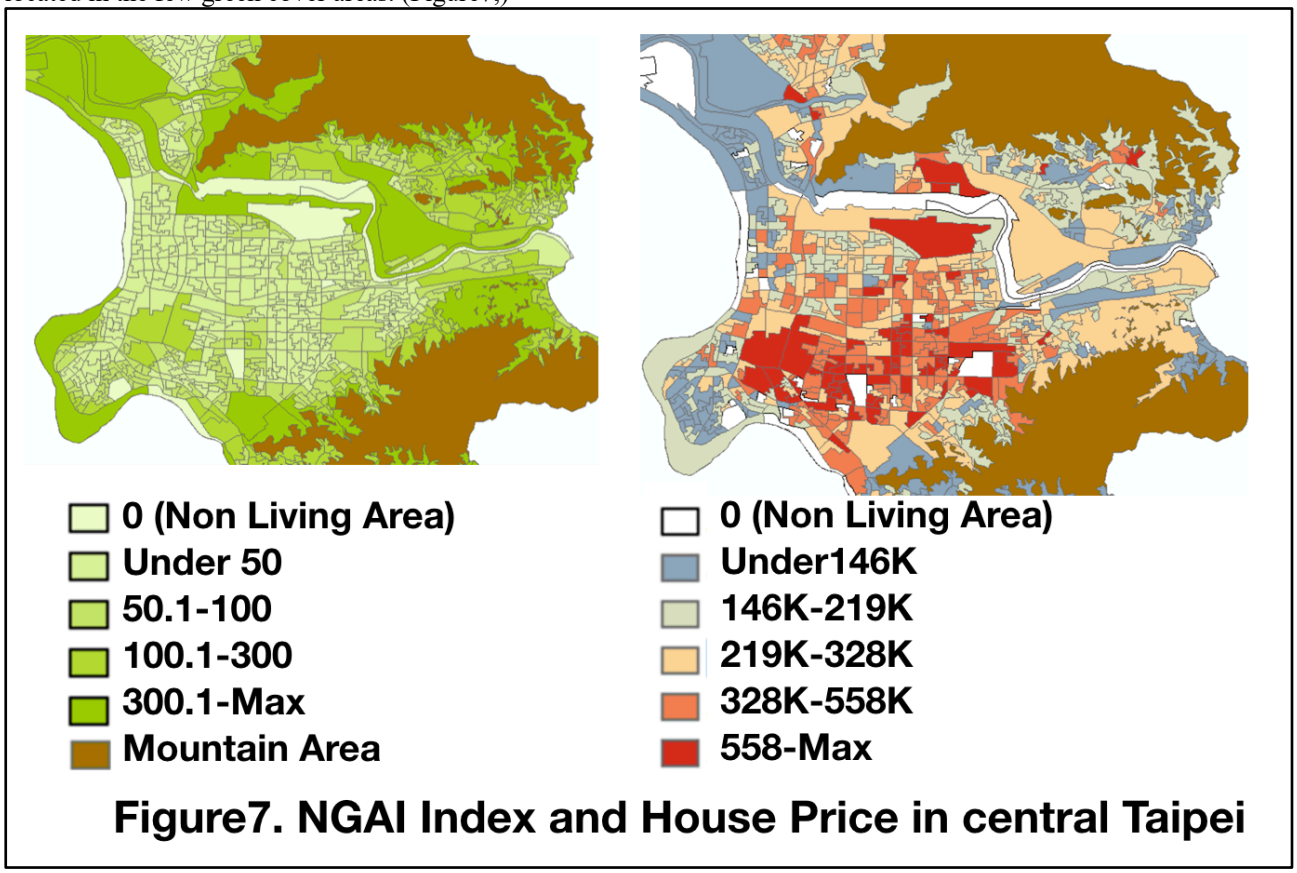

Figure7. NGAI Index and House Price in central Taipei

4. The result of residential satisfaction questionnaire

Base on 117 questionnaires collected from people living in Taipei city, the correlation coefficient between living quality and environmental greenness is 0.56, much more than correlation coefficient between living quality and convenient life function 0.40. The questionnaire shows that green cover have a better impact on living quality than convenient environment. In the limit of numble of samples, the distribution of high score and low score living locations are almost random distribution in Taipei city. (Figure 8,)

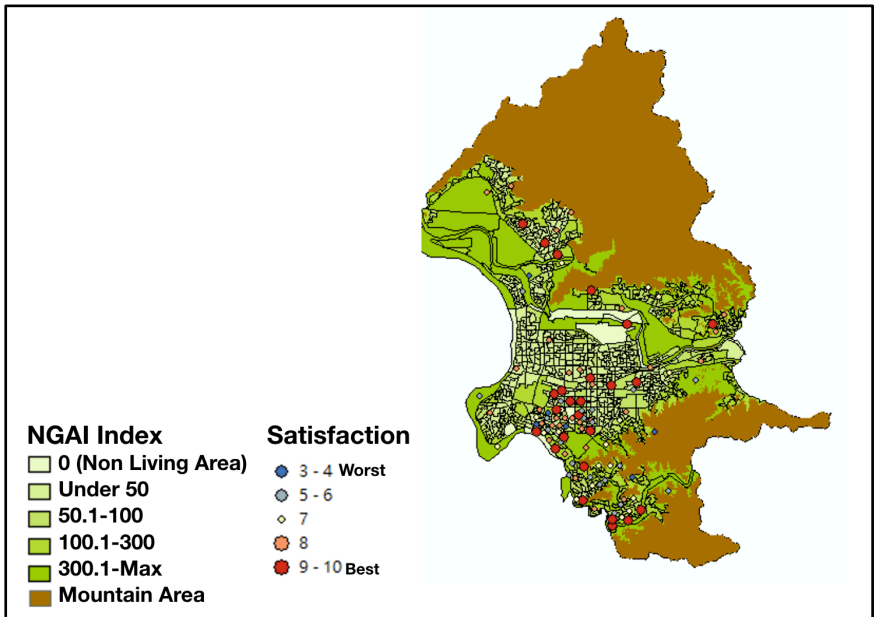

Figure 8. NGAI Index and Residential quality satisfaction distribution

We compared different indicators in the questionnaire. Most of area with high overall environment satisfaction are located in NGAI area 3, high greenness satisfaction area are located in NDVI area 2 and 3, and high convenience satisfaction are located in area 1 and 2. (Figure 9,) This questionnaire shows that compare to the average satisfaction of convenience, people feel more unsatisfying to green cover than the convenience. Green cover is also a better way to improve living quality. (Table1.)

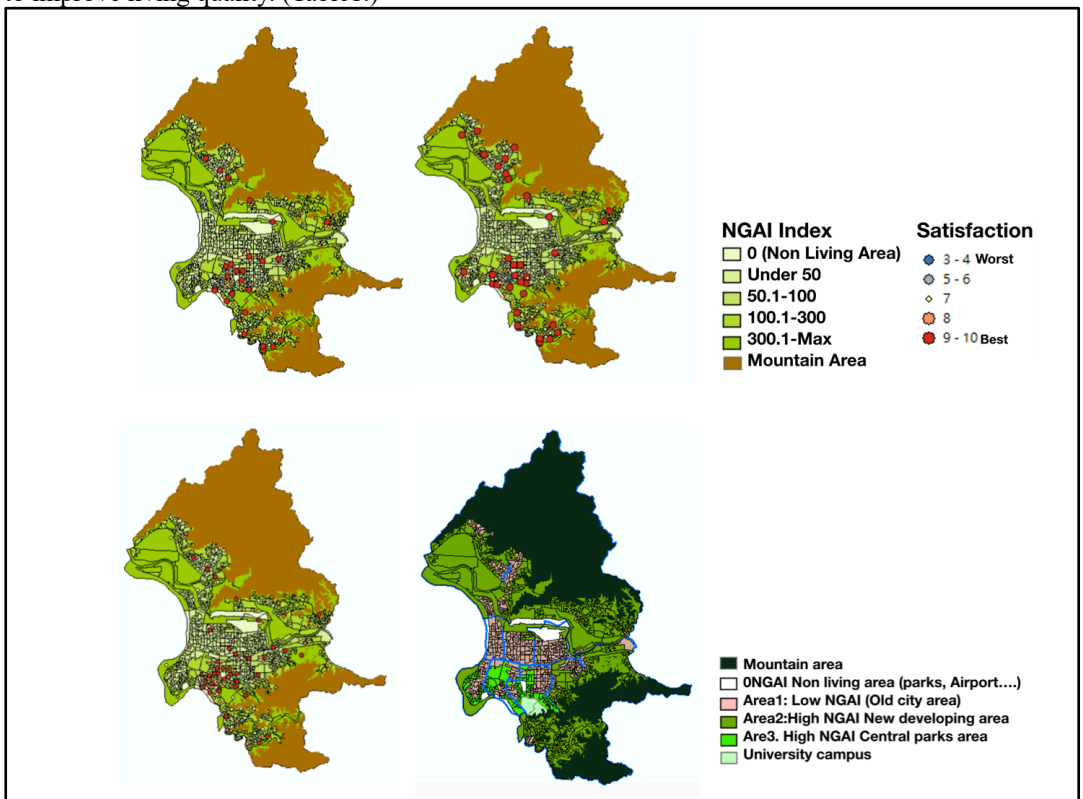

Figure9, The questionnaire result And different NGAI areas
1.Living environment quality 2.Greenness satisfaction
3.Location convenience satisfaction 4.NGAI area

	High NGAI area	Low NGAI area
Total satisfaction	7.3	7.3
Green environment satisfaction	7.4	7.2
convenience satisfaction	7.9	8.9

Table1. Satisfaction compare of different NGAI area

5. Further research

In the real estate house price data, there is the building time record in it. This study also shows the NGAI index reflects the urban developing periods, so we can find dig into the forming time and historical background of current green cover and population distribution.

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