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Assessing street greenery using imagery of Google Street View

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Abstract

The streets at the old moat of Nakhon Ratchasima City Municipality (NCM) are a critical point of urban landscape. NCM people interact with streetscape in terms of well-being. This paper proposes the application of Google Street View (GSV) for surveying street greenery. This study focused on 15 streets at the old moat of NCM using 49 sampling points for designing and analyzing Green View Index (GVI) and Sky View Factor (SVF) on analysis of GSV images. GVI was used for estimating the percent of vegetation cover and SVF was used for quantifying the ratio of sky cover. According to the result, the GVI calculations were found between 1.41 – 44.18 percent that drivers or walkers could see green cover in the low percent (or < 50 percent). SVF value is between 0.73 – 0.86 that drivers or walkers could see clearly sky on 15-street at the old moat of NCM. These results show that all streets at the old moat of NCM should improve vegetation cover. Moreover, the application of GSV for surveying street greenery will be an alternative tool for geospatial workers or planners in green cities.

Keywords: Street greenery, Google street view, green view index, sky view factor

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1. Introduction

The greenness of urban roads has been one important measure of healthy vegetation in urban where inhabitants have very requirements in the present time [1]. Similarly, street plant communities were so required for urban landscape and urban ecology in providing well-being, healthy, and growing sustainable urban [2, 3]. Thus, the cover of trees and plants has been set in urban planning and development to reduce urban heat with improving conditions of urban environment [4]. Moreover, the study of street greenery reflects the sensory benefits of urban greenery [5, 6]. Although, there are few current studies on urban greenery that focuses on human perspective and considers street greenery [1]. Presently, photos are explored in Google Street View (GSV) which has become cardinal source for geospatial analytics, insight perception, and decision support [7]. Especially, the assessment of street green-based GSV is so interesting as examples of research by Xiao *et al.* [1], Ki and Lee [6], and Ito and Biljecki [8]. There were two patterns for mapping urban trees: point and polygon features [9]. Then, the accuracy assessment of the map was checked by driving and walking surveys or both two integrated approaches in true ground [10] because, in fact, surveying trees on road needs a high cost of time and effort [11].

This study aims to introduce the application of GSV imagery for surveying street greenery on 15 streets at the old moat of Nakhon Ratchasima City Municipality (NCM), Nakhon Ratchasima Province of Thailand. The old moat of NCM was selected as the study area because it has been planned for development as Korat Smart City under the Memorandum of Understanding (MOU) in Korat Smart City Project according to the concept of smart and safe city to the city of happiness, including the development of city greenness [12, 13]. Moreover, GSV images were selected because it is publicly accessible and given the basic road networks forming cities and the interactions of people and environment [13]. At the same time, this study provides ground data of NCM vegetation cover on streets at the NCM-old moat and will help to plan true field surveys and save time and budget. Basically, urban road intersections have signs according to traffic rules that are so essential element of road design such as intersection design and operation of locations for movement of motorists, cyclists, and pedestrians; signal timing for crossing walking through investigating a concept e.g., road safety, mobility, more vibrant, accessible public spaces [14]. Interestingly, trees may help road preserving sight lines at intersections [15].

2. Material and Methods

2.1 Study area and sampling points on NCM streets

This study focuses on 15 streets at the old moat of NCM in Nakhon Ratchasima Province, located in the northeastern region of Thailand. The study location has geographic coordination between 14°58′48.74″ – 14°58′11.41″ N and 102°5′50.52″ – 102°6′51.164″ E (Figure 1). There were 49 sampling points on 15 streets at the NCM-old moat that were used for GVI and SVF calculation as Table 1. Moreover,

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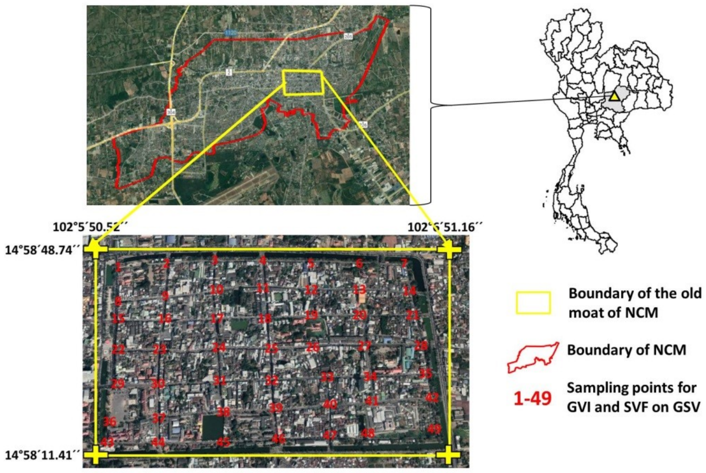
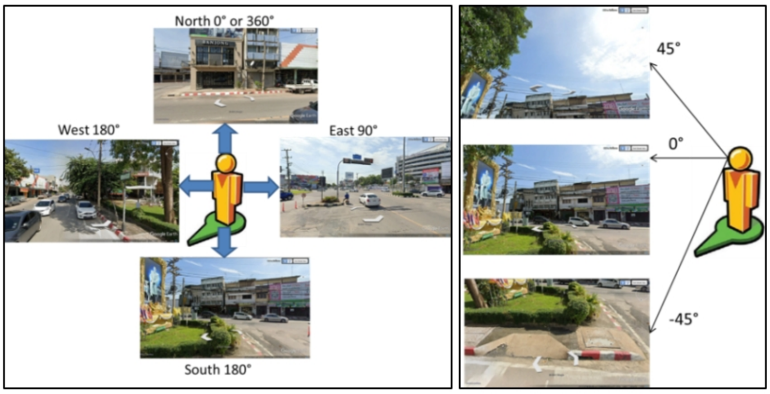


Figure 1: Study area and sampling points for GVI and SVF calculation on NCM streets.



(a) 4 horizontal directions (b) 3 vertical directions

Figure 2: Example of GSV images for GVI calculation.

the area used for the study includes most build-up areas and streets that consist of extraordinarily cultural places such as Thao Suranaree monument and 6 significant temples (Bueng, Sakaeo, Bon, E-San, Phra Narai Maharat, and Phayap) [13].

2.2 Analysis GVI and SVF on NCM streets

2.2.1 Calculating GVI

Generally, GVI values were calculated using multiple Tencent Street View (TSV) images and the GVI equation [5]. GVI indicates the percent of green cover from the relationship between observation and position of person and viewpoint of greenness [6]. So, GVI can be calculated by GSV image (6 horizontal directions and 3 vertical directions at each sample site) as the equation [2, 3]:

$$GreenView = \frac{\sum_{i=1}^{6}\sum_{j=1}^{3} Area_{g\_ij}}{\sum_{i=1}^{6}\sum_{j=1}^{3} Area_{t\_ij}} \times 100\% \tag{1}$$

Where $Area_{g\_ij}$ is the number of green pixels in a GSV image from each sample site-based view of each camera direction and vertical angle, and $Area_{t\_ij}$ is the total number of pixels in each GSV image (overall 18 GSV images) to one sampling point. This GVI indicates the relationship between greenery cover and an eyesight of person in GSV images. This study modified GVI methods of [2] and [3]. This GVI calculation based on GSV image for 4 horizontal directions (north (0° or 360°), east (90°), south (180°) and west (270°) and 3 vertical directions (45°, 0° and -45°) at each sampling points as shown in Figure 2 (this modified SVF method was used in the research of [16]. And then these GSV images were used for GVI calculation with the formula (1) above.

2.2.2 Calculating SVF

The first step of SVF was calculated by digital cameras and was mounted with fisheye lens [17], for example, Steyn' method [18] and pixel counting methods [19]. Presently, GSV online is used for supporting the SVF calculation to overcome highly time and expense consumption in field collection. Various geophysical parameters of SVF were measured by ratio of the sky visible from a certain position [20]. And then SVF was calculated by portioning the synthetic fisheye photo into n annular rings, which was done by summing up the contribution

Table 1. Sampling points for GVI and SVF calculation on 15 NCM streets.

Sampling points	Latitude	Longitude	Road name	Sampling points	Latitude	Longitude	Road name
1	14.978965	102.098106		29	14.973095	102.098605	
2	14.979282	102.100663		30	14.97315	102.100642	
3	14.979380	102.103056		31	14.973276	102.103595	
4	14.979405	102.105461		32	14.973367	102.105984	
5	14.979379	102.109191		33	14.973473	102.108638	
6	14.979252	102.111457		34	14.973517	102.110670	
7	14.979147	102.112742		35	14.973636	102.113346	
8	14.977201	102.098284		36	14.971369	102.098720	
9	14.977413	102.100687		37	14.971678	102.100836	
10	14.977753	102.103033		38	14.971905	102.103726	
11	14.978037	102.105581		39	14.971964	102.106056	
12	14.977896	102.109360		40	14.972190	102.108702	
13	14.977836	102.111255		41	14.972320	102.110753	
14	14.977664	102.112986		42	14.972558	102.113450	
15	14.976202	102.098349		43	14.970482	102.098662	
16	14.976264	102.100665		44	14.970584	102.100975	
17	14.976336	102.103214		45	14.970655	102.103861	
18	14.976438	102.105754		46	14.970747	102.106234	
19	14.976503	102.108579		47	14.970788	102.108604	
20	14.976519	102.110689		48	14.970751	102.111290	
21	14.976542	102.113073		49	14.970831	102.113449	
22	14.974711	102.098430					
23	14.974755	102.100620					
24	14.974898	102.103324					
25	14.974848	102.105921					
26	14.975058	102.108749					
27	14.975041	102.110607					
28	14.975049	102.113224					

Polsean	San-Prasit	Prajak
Yommarat	Kamhaengsongkram	Kudun
Ussadang	Chumphon	Pollarn
Chomphon	Jaggree	Vatcharasarid
Mahatthai	Manat	Chainarong

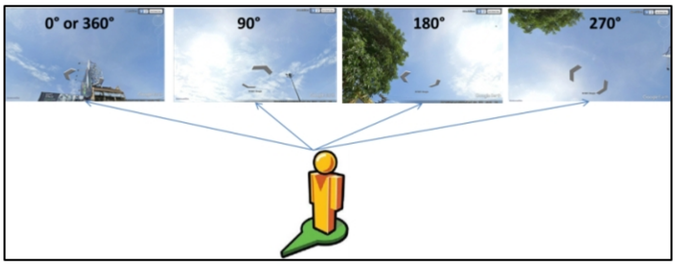


Figure 3: Example of the GSV images for SVF calculation.

of each ring [21] as formula below:

$$SVF = \frac{\pi}{2n} \sum_{i=1}^{n} \sin\left(\frac{\pi(2i-1)}{2n}\right)\left(\frac{p_i}{t_i}\right) \qquad (2)$$

Where $\frac{p_i}{t_i}$ is the portion of the number of sky pixels and the total number of pixels in ring i.

In addition, this study decided to mainly used and modified GVI method of [2, 3] and SVF method concentrated on concept of [21], for exploring NCM roads' greenness because they are in accordance with this purpose of study. This study modified SVF methods of [21]. We retrieved GSV images from Google Earth using rotating 4 directions of sky view 0° or 360°, 90°, 180° and 270° as in Figure 3 (this modified SVF method was used in research of [16]). And then the sky views from GSV were used for SVF calculation with formula (2) above.

3. Results and Discussion

3.1 Results of GVI

GVI shows the percent of vegetation cover in GSV images between 0 – 100 percent. The 0 value has not green cover while the 100 value defines full green cover in GSV image. The average of GVI calculations on 15 streets at the old moat of NCM was found between 1.41 – 44.18 percent (as in Table 2), drivers or walkers could be seen green cover in the low percent (or < 50 percent). Pollarn road shows the highest green value and Vatcharasarid road has the lowest green value. In other words, at that time, drivers or walkers on Pollarn road could see green cover higher than on other studied roads. In a comparison of GVI between this paper and other papers, the GVI values in Boston from Li et al. (2017; 2015) showed the range of GVI from 5.22 to 36.05 which is higher than our studied area. For this reason, roads in Boston include a lot of trees on street than on the streets at the old moat of NCM.

3.2 Results of SVF

SVF shows the ratio of sky cover in GSV images between 0 – 1. The 0 value has full obstruction (e.g., building, tree canopies, electric poles and lines) while the 100 value defines full sky cover in GSV image. For the results of SVF calculation, we found that average of SVF value on 15 streets at the old moat of NCM is between 0.73 – 0.86 (Table 3), drivers or walkers

Table 2. Results of GVI on 15 streets at the old moat of NCM.

Road name	No. of sampling points	GVI							Total	Average
		1	2	3	4	5	6	7		
1. Polsean	7 (1-7)	19.75	10.96	12.45	9.34	9.78	14.65	60.16	127.75	18.25
2. Yommarat	7 (8-14)	8.97	3.24	4.12	2.12	3.45	3.23	51.25	74.26	10.61
3. Ussadang	7 (15-21)	2.13	2.15	2.11	1.23	1.12	2.12	51.43	61.06	8.72
4. Chomphon	7 (22-28)	2.16	1.15	1.19	2.01	2.16	2.12	52.16	60.94	8.71
5. Mahatthai	7 (29-35)	10.45	2.18	1.17	2.06	1.13	2.15	50.12	67.20	9.60
6. San-Prasit	7 (36-42)	8.90	2.32	1.25	2.16	1.15	2.18	52.13	67.93	9.70
7. Kamheangsongkram	7 (43-49)	10.45	9.05	12.68	9.57	8.18	10.31	51.34	102.01	14.57
8. Chumphon	5 (1,8,15,22,29)	19.75	8.97	2.13	2.16	15.45	0.00	0.00	46.30	9.26
9. Jaggree	4 (2,9,16,23)	10.96	3.24	2.15	2.26	0.00	0.00	0.00	16.3	4.09
10. Vatcharasarid	4 (23,30,37,44)	1.15	2.18	2.32	2.18	0.00	0.00	0.00	5.65	1.41
11. Manat	6 (3,10,17,24,31,38)	12.45	4.12	2.11	1.19	1.17	9.34	0.00	29.19	4.87
12. Prajak	4 (4,11,18,25)	9.34	2.12	1.23	2.01	0.00	0.00	0.00	12.69	3.17
13. Chinarong	4 (25,32,39,46)	2.01	2.06	2.16	8.92	0.00	0.00	0.00	6.23	1.56
14. Kudun	6 (6, 13,20,27,34,41)	14.65	3.23	2.12	2.12	2.15	2.18	0.00	24.33	4.06
15. Pollarn	6 (7,14,21,28,35,42)	60.16	51.25	51.43	52.16	50.12	52.13	0.00	265.09	44.18

Table 3. Results of SVF on 15 streets at the old moat of NCM.

Road name	No. of sampling points	SVF							Total	Average
		1	2	3	4	5	6	7		
1. Polsean	7 (1-7)	0.85	0.95	1.00	1.00	0.95	0.80	1.00	5.55	0.79
2. Yommarat	7 (8-14)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	0.86
3. Ussadang	7 (15-21)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	0.86
4. Chomphon	7 (22-28)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	0.86
5. Mahatthai	7 (29-35)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	0.86
6. San-Prasit	7 (36-42)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	0.86
7. Kamheangsongkram	7 (43-49)	1.00	0.95	0.92	0.95	0.75	0.75	0.75	5.12	0.73
8. Chumphon	5 (1,8,15,22,29)	0.85	1.00	1.00	1.00	1.00	0.00	0.00	3.85	0.77
9. Jaggree	4 (2,9,16,23)	0.95	1.00	1.00	1.00	0.00	0.00	0.00	2.95	0.74
10. Vatcharasarid	4 (23,30,37,44)	1.00	1.00	1.00	1.00	0.00	0.00	0.00	3.00	0.75
11. Manat	6 (3,10,17,24,31,38)	1.00	1.00	1.00	1.00	1.00	1.00	0.00	5.00	0.83
12. Prajak	4 (4,11,18,25)	1.00	1.00	1.00	1.00	0.00	0.00	0.00	3.00	0.75
13. Chinarong	4 (25,32,39,46)	1.00	1.00	1.00	1.00	0.00	0.00	0.00	3.00	0.75
14. Kudun	6 (6, 13,20,27,34,41)	0.80	1.00	1.00	1.00	1.00	1.00	0.00	4.80	0.80
15. Pollarn	6 (7,14,21,28,35,42)	1.00	1.00	1.00	1.00	1.00	1.00	0.00	5.00	0.83

could see almost clear sky on 15 streets at the old moat of NCM. The highest SVF value is shown at Yommarat Road, Ussadang Road, Chomphon Road, Mahatthai Road, and San-Prasit Road. These values mean drivers or walkers could see almost clear sky (or does not have obstruction cover).

4. Conclusions

The GVI calculations were found between 1.41 – 44.18 percent and SVF value is between 0.73-0.86. These results show that vegetation cover should be improved on 15 streets at the old moat of NCM. Moreover, the application of GSV for surveying street greenery will be an alternative tool for geospatial workers or planners in green cities. This study can help to explore street greenery-based GVI in preliminary surveying before the field survey. These data will help to plan the field survey by saving time and budget. In a traditional survey, we used remote sensing images and aerial photos for surveying street trees which is limited and missed some trees due to the resolution of imagery.

For further study, The relationship between drivers and walkers on 15 streets at the old moat of NCM should be studied, because we believe that, especially, if drivers interact with the streetscape in positively driving emotion, it will reduce driving speed and road accidents.

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