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Green Infrastructure Development in Urban Areas: Case Studies of Samutsakhon, Krathumbaen and Banphaeo Municipalities in Samut Sakhon Province

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ABSTRACT

Though the development of green infrastructure in parks in Samut Sakhon province has been continuously implemented, there are still no research studies that have explicitly demonstrated the parks' potential, nor any public opinions toward the development of urban green infrastructure in the parks that would be productive for the planning to efficiently improve and provide urban green infrastructure. As a result, this study had the following objectives: 1) To analyze the potential and networks of urban green infrastructure in parks in Samut Sakhon province, 2) To analyze the satisfaction of using the services and requirements of the urban green infrastructure development in the parks in Samut Sakhon province, and 3) To propose development guidelines in urban green infrastructure for the parks of Samut Sakhon province. The research instruments comprised a questionnaire, and the data were analyzed by using a scalogram. The results found that high-potential parks were not large in size, but they had all the complete components, as well as green infrastructure featured in the attributes of patch, matrix, and mosaic. Nevertheless, the green infrastructure development featured in the attribute of the corridor had disappeared in several sites of the green infrastructure in the parks. Likewise, the green networks of the parks, specifically those in the high-potential category, were not successive by walking. For this reason, the people were mostly satisfied with the convenient accessibility of the parks, but there were the requirements of paving the footpath, improving the landscape, and adding a variety of activities in the parks. Therefore, the development guidelines of urban green infrastructure in the parks should formulate more areas in the attribute of the corridor at the riverside and on the streets, conserve and increase the park areas by allowing public participation in the management, as well as apply urban planning measures to obtain the park area. In addition, a footpath and bike lane should be safely constructed in the high-potential parks. Simultaneously, the landscape should be adjusted in the low- and moderate-potential parks by launching pilot projects in the parks of the governmental agencies.

Keywords: green infrastructure, park, infrastructure, urban planning, Samut Sakhon

INTRODUCTION

Infrastructure, fundamental services that are essential for human livelihood, can be divided into three categories: 1) Gray Infrastructure, 2) Social Infrastructure, and 3) Green Infrastructure (Pujinda, 2007). Green infrastructure refers to the physical environment in the attributes of a green covered area and water covered areas (The University of Nottingham Ningbo China, 2015). These attributes are composed of patch (green patch), corridor (green strip), matrix (green open space), or mosaic (green patch cluster) (Forman & Godron,1986; Gökyer, 2013). Therefore, green infrastructure comprises gardens, parks, and forests, including recreational areas or public grounds (Inchompoo & Srithanyarat, 2017; Pujinda, 2007).

In considering the urban green infrastructure of parks, it has been found that they encourage people to have good mental and physical health, that they provide a meeting place for urban residents, and that park areas protect nature from encroachment of urban development, as well as maintaining balance of the ecosystem (Pujinda, 2007). As a result, green infrastructure in parks has always been a significant component of urban development in different areas of Thailand such as Samut Sakhon province.

Samut Sakhon is a province near the Thai capital city of Bangkok. It plays a significant role in the Thai economy, as it is the location of a large number of factories; in 2019, there were up to 6,780 industrial sites in the province, the fourth highest provincial total in Thailand (Department of Industrial Works, 2021). This province also produced a gross provincial product (GPP) in 2019 of up to 297,277 million Baht, or 2.67% of the national gross domestic product (GDP) (Office of the National Economic and Social Development Council, 2021). For this reason, the green infrastructure development in parks in the past was implemented through different operations. Examples include prescribing the land use of an open space for recreation and environmental conservation in the Mueang Krathumbaen Comprehensive Plan B.E.2562 (2019) in the area of the *72 Years Rama IX Health Park* (Samut Sakhon Office of Public Works and Town & Country Planning, 2021), and a project to adjust the landscape of the *Tha Chalong Public Health Service Center*, Samutsakhon Municipality in the Local Development Plan B.E.2561-2565 (2018-2022) (Samutsakhon Municipality, 2021). However, there are still no research studies that have indicate the potential of green infrastructure services, or public opinions toward green infrastructure development in parks. Greater understanding of these issues would be advantageous for efficient planning, procurement, and development of urban green infrastructure.

This research aimed to study and analyze the components and networks of green infrastructure in parks, as well as the satisfaction of people using park services, and the requirements for urban green infrastructure development in parks for the people of Samut Sakhon province. The research instrument comprised a questionnaire, and the data were analyzed by a scalogram. The study areas were the Samutsakhon Municipality, Krathumbaen Municipality, and Banphaeo Municipality, where the comprehensive town plans of a few communities in Samut Sakhon has been enforced or revised, and there was no previous research on green infrastructure development in the parks with explicit urban planning measures. Hence, these research results will enhance awareness of problems and increase the potential for effective development of green infrastructure in the parks. Furthermore, recommendations for the development of guidelines regarding urban green infrastructure in the parks will contribute to urban environmental care and protection, coupled with a better quality of life for the local people. The objectives of this research are to analyze the potential and networks of the urban green infrastructure of the parks in Samut Sakhon province, measure the satisfaction of users of the services, and understand the requirements for development of urban green infrastructure of the parks, as well as to propose development guidelines for urban green infrastructure in the parks.

RESEARCH SCOPE

Scope of areas

The study area represented the various municipalities by taking into consideration a city municipality (administrative area featuring a large urban area with more than 50,000 residents), a town municipality (administrative area featuring a moderate urban area with 10,000-50,000 residents), and a subdistrict municipality (administrative area featuring a small urban area with less than 10,000 residents). The urban comprehensive plans had been enforced or revised, and there was no previous research on green infrastructure development in the parks with explicit urban planning measures. One site from each municipality category was selected, for a total of three sites (Figure 1).

The city municipality comprised Samutsakhon Municipality, Mueang Samut Sakhon District, which had a total area of 10.33 square kilometers or approximately 6,456.25 rai. In 2019, there were 67,515 people residing in this district (National Statistical Office, 2021). Moreover, the most recently enforced comprehensive plan of Samutsakhon Municipality was the Samut Sakhon Town Comprehensive Plan, Samut Sakhon Province B.E. 2550 (2007) (2nd revision), which ended on December, 5, 2014. Currently, the former plan is under evaluation as part of the formulation of a new comprehensive plan.

The town municipality selected was Krathumbaen Municipality, Krathumbaen District, which had a total area 2.18 square kilometers or approximately 1,362.50 rai. In 2019, there were 27,827 people residing in this district (National Statistical Office, 2021). Additionally, the most recently enforced comprehensive plan in Krathumbaen Municipality was the Krathumbaen Town Comprehensive Plan, Samut Sakhon Province B.E.2562 (2019) (Samut Sakhon Office of Public Works and Town & Country Planning, 2021).

The subdistrict municipality comprised Banphaeo Municipality, Banphaeo District, which had a total area of 0.76 square kilometers or approximately 475 rai. In 2019, there were 3,242 people residing in this district (National Statistical Office, 2021). Furthermore, the most recently enforced comprehensive plan in Banphaeo Municipality was the Banphaeo Community Comprehensive Plan, Samut Sakhon Province (No. 2) B.E.2560 (2019); its enforcement ended on September 24, 2018. Currently, the former plan is under evaluation as part of the formulation of a new comprehensive plan (Samut Sakhon Office of Public Works and Town & Country Planning, 2021).

These prescribed study areas were probably productive or efficiently applied urban planning or green infrastructure development planning in the parks.

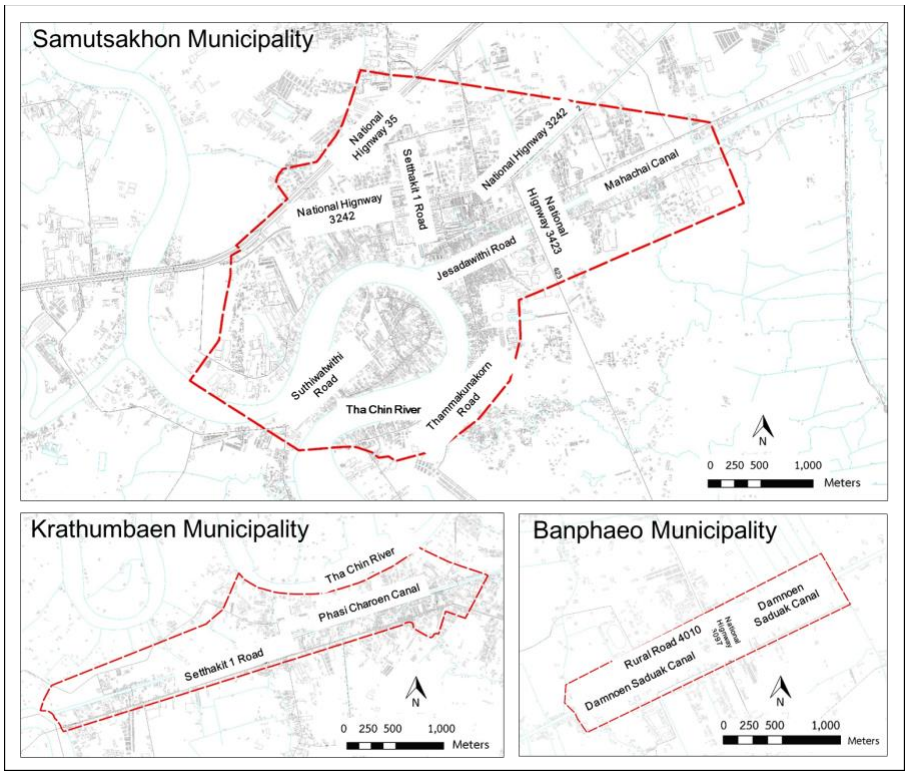
Scope of contents

This research aimed to study green infrastructure in the parks since the area represented basic services, which were essential to the livelihoods and responded to the needs of the urban population; it further aimed to reveal a form of land use through an explicit standard of provision of services in urban planning. This included incorporation of available parks where people could access the services, both shown and not shown, into the urban comprehensive plan, which featured green infrastructure in the attributes of the patch, corridor, matrix, and mosaic, and either included or excluded the water area.

Regarding the analysis of potential or hierarchical ranking of green infrastructure in the parks, this considered the components and park situations that had an effect on provision of services and use of the parks by the public. This followed an academic concept of parks and green area development that includes the distance away from the local and main roads with pedestrian access, being adjacent to the community, having perennial trees, possessing seats, footpaths and bike lanes, as well as offering recreational activities in the form of exercise, playground equipment, and other amenities such as trash bins, food shops, etc. (Horayangkura, 2006; Vásquez Sánchez et al., 2020). In addition, the walking distance in this research referred to the concept of transit-oriented development (TOD) by Calthorpe (1993), in which the accessible walking distance was defined as being within 500 meters.

Figure 1

Study Areas of Samutsakhon Municipality, Kratumban Municipality, Banphaeo Municipality, Samut Sakhon Province



LITERATURE REVIEW

Infrastructure refers to the basic services that are essential to human livelihood, made by humans in order to facilitate better living. It can be classified into three categories: 1) Gray Infrastructure, 2) Social Infrastructure, and 3) Green Infrastructure (Pujinda, 2007). Regarding green infrastructure, this refers to the physical environment in the attributes of a green covered area (vegetation) and water covered areas (water) (The University of Nottingham Ningbo China, 2015). Furthermore, these attributes are composed of patch (green patch; discrete but has an explicit shape), corridor (green strip), matrix (green open space combining different components of green infrastructure), or mosaic (cluster of green patches) (Forman & Godron, 1986; Gökyer, 2013). Accordingly, the green structures can be a garden, park, or forest, including a recreational area or public ground (Inchompoo & Srithanyarat, 2017; Pujinda, 2007).

The mentioned infrastructure should have designed networks, planning, and value-managed natural resources related to the ecosystem (Inchompoo & Srithanyarat, 2017). Since the late nineteenth century, the concept of the green network of Olmsted has been renowned and applied in green infrastructure development, green areas, and park management. Its principles specify that parks or green areas belong to a hierarchy or have different potential depending on size, components, and area linkage. This could be a natural linkage or built landscape for motorized vehicles or environmentally friendly vehicles such as a footbath, bike lane, or pedestrian path in order to give the public convenient and safe access to the parks or green areas in all hierarchies (Beveridge, n.d.; Inchompoo & Srithanyarat, 2017).

Green infrastructure in parks offers relaxational or recreational areas for passive or active recreation (Department of Public Works and Town & Country Planning, 2006). One way of classifying these spaces is to divide them into seven categories according to size: 1) a pocket park or tot lots spanning not more than two rai, 2) a neighborhood park spanning 2-25 rai, 3) a

community park spanning 25-125 rai, 4) a district park spanning 125-500 rai, 5) a city park spanning more than 500 rai, 6) a street park spanning more than 3 meters in width with an indefinite length, and 7) a special purpose park (Department of Environment, Bangkok Metropolitan Administration, n.d.).

Another way to classify the parks is to put them into seven categories: 1) a playground, 2) neighborhood park, 3) community park, 4) district park, 5) city park, 6) regional park, or 7) other green areas. This categorization was used in the Comprehensive Plan Criteria and Standard B.E. 2549 (2006) by the Standard Development Bureau, Department of Public Works and Town & Country Planning, who suggest that an area with a population of 2,000-10,000 should have a neighborhood park of 25-50 rai and a service radius of 12.5 kilometers, while an area with a population of 50,000-100,000 should have a district park of 30-75 rai (Department of Public Works and Town & Country Planning, 2006).

The main development concepts of green infrastructure utilize a combination of green and gray infrastructure, space networks and creation, multiple functions and services delivery and enhancement, and collaborative and participatory planning (Hansen et al., 2017). Urban park design and development should give priority to development of access and linkage, comfort and image, users and activities, and social ability. In addition, parks or urban green areas should be dispersed throughout the area, be a size and shape which supports the complete formation of the ecosystem, linked together with a low level of maintenance due to application of the concept of urban ecology (Horayangkura, 2006; Vásquez Sánchez et al., 2020), and coupled with offering people the opportunity to participate in the decision-making, implementation, benefits, and evaluation of the public space (Cohen & Uphoff, 1977; Sanguthai & Krisanaphan, 2018).

Regarding the urban planning measures involving the green infrastructure development in parks, these also include: 1) negative measures such as land use control, 2) positive measures such as land reservation, 3) incentive measures such as a density bonus, and 4) corrective measures such as corrective financial measures (Steiner et al., 2007).

Based on the above literature review, the research framework was developed in order to analyze the potential of green infrastructure in parks. This framework was based on the consideration of the parks' components and area conditions, as well as analysis of the networks of green infrastructure in the parks, between the parks and community, and between each park. In addition, analysis of public opinion was carried out, with a focus on the level of satisfaction with services, and requirements for green infrastructure in the parks. The results were used in creating the recommended development guidelines for effective green infrastructure in the urban parks.

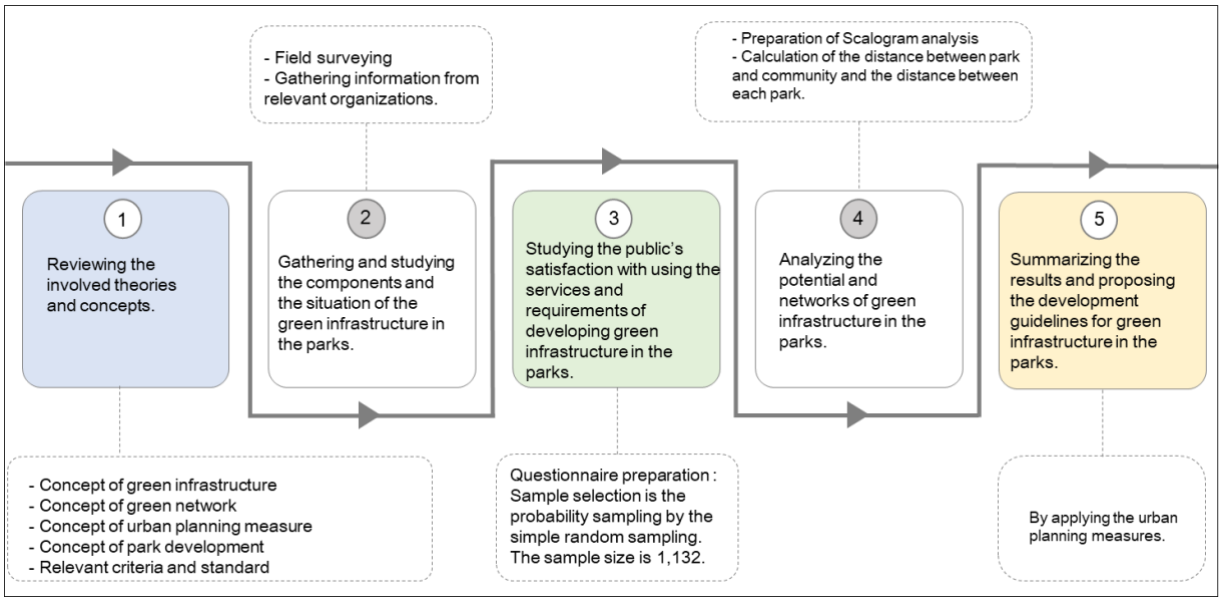
PROCEDURES AND RESEARCH INSTRUMENTS

Research procedures

The research procedures were composed of 1) reviewing the involved theories and concepts, 2) gathering and studying the components and situation of green infrastructure in the parks, 3) studying the public's satisfaction with the services, and requirements for green infrastructure development in the parks, 4) analyzing the potential and networks of green infrastructure in the parks, and 5) summarizing the results and proposing development guidelines for green infrastructure in the parks (Figure 2).

Figure 2

Research Procedure



Research Instruments

Questionnaire: The target population consisted of residents in all three municipalities who were selected by accidental sampling. Following the calculation formula of sampling size by Krejcie & Morgan (1970, as cited in Tontisirin & Anantsuksomsri, 2020) with a 95% of confidence interval, from the Samutsakhon Municipality's population, which was approximately 68,000, a sampling size of 382 questionnaires needed to be collected; however, the total number of collected questionnaires was 405. As Krathumbaen Municipality's population was approximately 26,000, 379 questionnaires needed to be collected; nevertheless, the total number of collected questionnaires was 410. Meanwhile, Banphaeo Municipality had a population of approximately 3,000, from which 341 questionnaires needed to be collected; however, the total number of collected questionnaires was 317. The contents of the questionnaire were divided into four parts: 1) The respondent's general data, 2) data about use of the parks, 3) data about satisfaction with the parks' services, and 4) data about requirements for future park development.

Scalogram analysis: A scalogram was applied to analyze the potential and hierarchical ranking of the parks from their components, following the concept of data arrangement developed by Guttman (1944, as cited in Peerapun, 2013). The park components from the field survey, analyzed by GIS, were extended over nine significant aspects. These comprised 1) being within 500 meters of the local roads, 2) being within 500 meters of the main roads, 3) being adjacent to the community, 4) having perennial trees, 5) possessing seating, 6) possessing footpaths and bike lanes, 7) offering recreational activities in the form of exercise, 8) offering playground equipment, and 9) offering other amenities such as trash bins, food shops, etc. (Horayangkura, 2006; Vásquez Sánchez et al., 2020). Consequently, the potential or hierarchies of the parks of each municipality were classified into three ranges: 1) high potential, 2) moderate potential, and 3) low potential, depending on the dispersal of scores by the data arrangement.

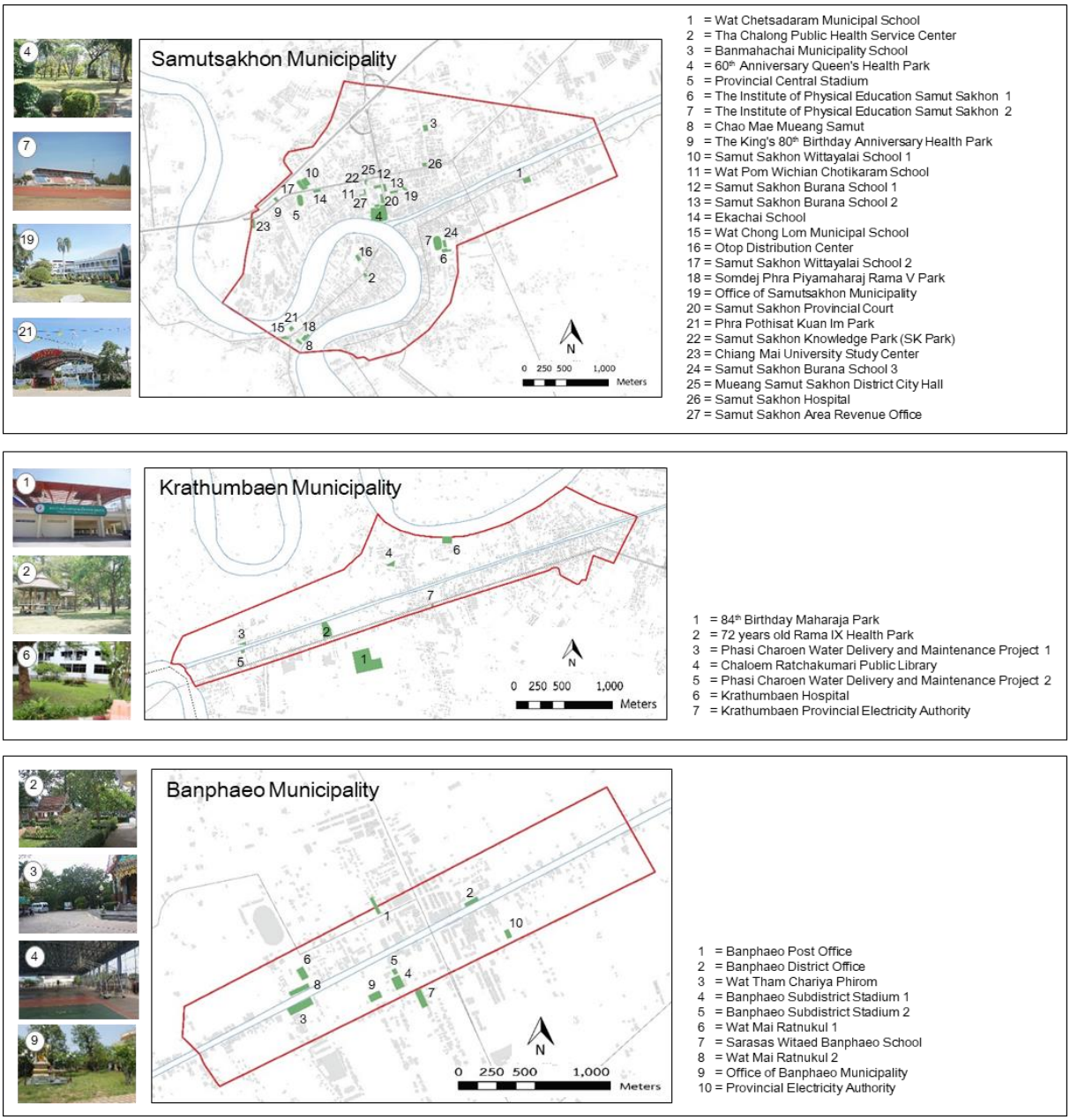
RESEARCH RESULTS

Situations of the green infrastructure in the parks

In taking into consideration the classification of the parks by the Department of Environment, Bangkok Metropolitan Administration (n.d.), it was found that Samutsakhon Municipality was home to pocket parks, community parks, and special purpose parks with a total area of 101,872 square meters, or approximately 63.67 rai. Krathumbaen Municipality had pocket parks, neighborhood parks, and community parks with a total area of 56,288 square meters, or approximately 35.18 rai. Lastly, Banphaeo Municipality had pocket parks, neighborhood parks, and special purpose parks with a total area of 9,952 square meters, or approximately 6.22 rai (Figure 3).

Figure 3

Parks in Study Area



Though the green infrastructure in the parks located in the study area was characterized by the attributes of patch, corridor, matrix, and mosaic based on the concept of green infrastructure (Forman & Godron, 1986; Gökyer, 2013), a few corridor parks were found in spite of the waterfront landscape, particularly in Samutsakhon Municipality and Banphaeo Municipality, which were both suitable for developing the corridor attribute (Figure 4). In addition, the park areas of all three municipalities were clean and well-organized under the management and attention from municipal offices or related agencies. The behavior of public use of the parks varied depending upon the components and on-site activities, while park users comprised the general public, both local residents and those from external municipalities. Moreover, each park's accessibility remained facile since each was adjacent to main and minor roads. In case of the 84th King's Birthday Park, Krathumbaen Municipality, which the Office of Krathumbaen Municipality had developed, although is located outside of the municipal boundary, it is still accessible by the convenient route of Setthakij 1 Road. Nevertheless, there were few park accesses which had separate footpaths and bike lanes in all municipalities.

The parks in the study area also met the questionnaire respondents' requirements for both passive and active recreational areas such as playing football in the 84th King's Birthday Park, Krathumbaen Municipality, relaxing in the waterfront garden of Wat Tham Chariya Phirom, Banphaeo Municipality, and so on.

However, in all three municipalities, the parks size was mostly less than 25 rai (the average area was 3,824 square meters, or approximately 2.39 rai). In addition, there were only two parks larger than 25 rai: the 60th Anniversary Queen's Health Park, Samutsakhon Municipality, with an area of 41,104 square meters, or approximately 25.69 rai, and the 84th King's Birthday Park, Krathumbaen Municipality, with an area of 43,600 square meters, or approximately 27.25 rai. Thus, this transformed Krathumbaen Municipality into being the only urban center having green infrastructure in the parks under the Comprehensive Plan Criteria and Standard B.E. 2549 (2006) of the Standard Development Bureau, Department of Public Works and Town & Country Planning. Krathumbaen Municipality had community park area of 25-50 rai, which supported the population of 27,827 in 2019. Though, none of the parks were in accordance with the population in each municipality, Samutsakhon Municipality also owned a community park with a service radius of 12.5 kilometers, so the radius completely covered the municipal area, whereas Banphaeo Municipality had other green areas scattered throughout the area.

In considering the prescription for the parks in the relevant urban comprehensive plans for each municipality, it appeared Krathumbaen Municipality had two parks designated as open spaces for recreation and environmental quality conservation in the Krathumbaen Town Comprehensive Plan, Samut Sakhon Province B.E. 2562 (2019), comprising the 84th King's Birthday Park and the 72 Years Rama IX Health Park. In addition, Samutsakhon Municipality and Banphaeo Municipality are currently undertaking evaluation, preparation and formulation of new comprehensive plans.

Figure 4

The park characteristics by the attributes of patch, corridor, matrix, and mosaic based on the concept of green infrastructure

Green Infrastructure List	patch	corridor	matrix	mosaic
Samutsakhon Municipality				
Wat Chetsadaram Municipal School	✓		✓	✓
Tha Chalong Public Health Service Center	✓	✓	✓	✓
Banmahachai Municipality School	✓		✓	
60th Anniversary Queen's Health Park	✓	✓	✓	✓
Provincial Central Stadium			✓	
The Institute of Physical Education Samut Sakhon 1				✓
The Institute of Physical Education Samut Sakhon 2			✓	
Chao Mae Mueang Samut				✓
The King's 80th Birthday Anniversary Health Park	✓			✓
Samut Sakhon Wittayalai School 1			✓	
Wat Pom Wichian Chotikaram School	✓		✓	
Samut Sakhon Burana School 1	✓	✓	✓	
Samut Sakhon Burana School 2	✓	✓	✓	
Ekachai School	✓		✓	
Wat Chong Lom Municipal School				✓
Otop Distribution Center				✓
Samut Sakhon Wittayalai School 2	✓		✓	
Somdej Phra Piyamaharaj Rama V Park				✓
Office of Samutsakhon Municipality	✓		✓	
Samut Sakhon Provincial Court				✓
Phra Pothisat Kuan Im Park				✓
Samut Sakhon Knowledge Park (SK Park)	✓			✓
Chiang Mai University Study Center			✓	✓
Samut Sakhon Burana School 3				✓
Mueang Samut Sakhon District City Hall	✓		✓	
Samut Sakhon Hospital	✓		✓	
Samut Sakhon Area Revenue Office	✓		✓	

Green Infrastructure List	patch	corridor	matrix	mosaic
Krathumbaen Municipality				
84th Birthday Maharaja Park	✓		✓	✓
72 years old Rama IX Health Park	✓		✓	✓
Phasi Charoen Water Delivery and Maintenance Project 1				✓
Chaloem Ratchakumari Public Library				✓
Phasi Charoen Water Delivery and Maintenance Project 2				✓
Krathumbaen Hospital	✓		✓	
Krathumbaen Provincial Electricity Authority				✓

Green Infrastructure List	patch	corridor	matrix	mosaic
Banphaeo Municipality				
Banphaeo Post Office	✓		✓	
Banphaeo District Office	✓	✓	✓	✓
Wat Tham Chariya Phirom	✓	✓	✓	
Banphaeo Subdistrict Stadium 1			✓	
Banphaeo Subdistrict Stadium 2			✓	
Wat Mai Ratnukul 1	✓		✓	✓
Sarasas Witaed Banphaeo School	✓		✓	
Wat Mai Ratnukul 2	✓	✓	✓	
Office of Banphaeo Municipality				✓
Provincial Electricity Authority				✓

According to the field surveying and the attributes of patch, corridor, matrix, and mosaic due the concept of green infrastructure. (Alattar, 2019; Ercan Gökyer, 2013; Forman & Godron,1986)

Potential and networks of the green infrastructure in the parks

Samutsakhon Municipality

According to the analysis of the potential and hierarchical ranking of the green infrastructure in the parks by scalogram, the green infrastructure in the parks in Samutsakhon Municipality were classified into three categories: 1) high potential (score of over 60), 2) moderate potential (score of 40-60), and 3) low potential (score less than 40). Regarding the high potential parks, there were three sites: the garden in Wat Chetsadaram Municipal School, the garden in Tha Chalong Public Health Service Center, and the stadium of Ban Mahachai Municipal School. These three park areas were less than four rai and had a variety of park components, particularly footpaths, bike lanes, recreational activities in the form of exercise, and playground equipment that affected the calculated scores more positively than other larger parks (Figure 5 and 6).

In considering the networks of the green infrastructure in the parks, it was found that the high-potential parks were the only ones without easy pedestrian access to the others (within or beyond the same group) due to the internal distances of 2,200-10,360 meters, and the external distances of 2,440-11,440 meters (Figure 7).

Krathumbaen Municipality

In analyzing the potential and hierarchical ranking of the green infrastructure in the parks by applying a scalogram, it found that the green infrastructure in the parks in Krathumbaen Municipality were classified into three categories: 1) high potential (score of over 200), 2) moderate potential (score of 100-200), and 3) low potential (score of less than 100). Regarding the high-potential parks, there were two sites: the 84th King's Birthday Park, and the 72 Years Rama IX Health Park, Krathumbaen Municipality. Each had a total of nine park components. In addition, with areas of 27.25 rai and 6.78 rai, respectively, these parks were larger than the green infrastructure in the other parks (Figure 5 and 6).

In considering the networks of the green infrastructure in the parks, it was found that the parks of every category were not within easy walking distance of the other parks within the category due to the nearest internal distance of 651.73-747.89 meters. Furthermore, only the high-potential parks lacked pedestrian access to the parks from different categories due to the shortest walking distance being between 928.51-1,010 meters (Figure 7).

Figure 5

Scalogram analysis results: The scores of park components in each municipality.

The components of the parks for scalogram analysis

1 = being a distance within 500 meters from the local roads
2 = being adjacent to the community
3 = having perennial trees
4 = being a distance within 500 meters from the main roads
5 = offering other amenities; such as, trash bins, food shops, etc.
6 = possessing seats
7 = possessing footpaths and bike lanes
8 = offering recreational activities in the form of exercising
9 = offering playground equipment

Scalogram analysis results: Samutsakhon Municipality

Green Infrastructure List	Area (rai)	The components of the parks for scalogram analysis									Total
		1	2	3	4	5	6	7	8	9	
Wat Chetsadaram Municipal School	0.70	3.70	3.85	4.17		5.88	5.88	6.25	12.50	25.00	67.23
Tha Chalong Public Health Service Center	0.23	3.70	3.85	4.17			5.88	6.25	12.50	25.00	61.35
Banmahachai Municipality School	3.39	3.70	3.85	4.17	5.88	5.88	5.88	6.25		25.00	60.61
60th Anniversary Queen's Health Park	25.69	3.70	3.85	4.17	5.88	5.88	5.88	6.25	12.50		48.11
Provincial Central Stadium	6.64	3.70	3.85		5.88	5.88	5.88	6.25	12.50		43.95
The Institute of Physical Education Samut Sakhon 1	1.39	3.70	3.85	4.17		5.88				25.00	42.60
The Institute of Physical Education Samut Sakhon 2	11.55	3.70	3.85	4.17		5.88	5.88	6.25	12.50		42.23
Chao Mae Mueang Samut	0.36	3.70	3.85	4.17			5.88	6.25	12.50		36.35
The King's 80th Birthday Anniversary Health Park	0.09	3.70	3.85	4.17	5.88			6.25	12.50		36.35
Samut Sakhon Wittayalai School 1	2.47	3.70	3.85	4.17	5.88	5.88	5.88	6.25			35.61
Wat Pom Wichian Chotikaram School	0.85	3.70	3.85	4.17	5.88	5.88	5.88	6.25			35.61
Samut Sakhon Burana School 1	0.75	3.70	3.85	4.17	5.88	5.88	5.88	6.25			35.61
Samut Sakhon Burana School 2	0.33	3.70	3.85	4.17	5.88	5.88	5.88	6.25			35.61
Ekachai School	0.21	3.70	3.85	4.17	5.88	5.88	5.88	6.25			35.61
Wat Chong Lom Municipal School	0.28	3.70	3.85	4.17		5.88			12.50		30.10
Otop Distribution Center	0.84	3.70	3.85	4.17		5.88	5.88	6.25			29.73
Samut Sakhon Wittayalai School 2	1.81	3.70	3.85	4.17	5.88	5.88	5.88				29.36
Somdej Phra Piyamaharaj Rama V Park	1.59	3.70	3.85	4.17			5.88	6.25			23.85
Office of Samutsakhon Municipality	0.59	3.70	3.85	4.17	5.88			6.25			23.85
Samut Sakhon Provincial Court	1.03	3.70	3.85	4.17	5.88	5.88					23.48
Phra Pothisat Kuan Im Park	0.39	3.70		4.17		5.88	5.88				19.64
Samut Sakhon Knowledge Park (SK Park)	0.25	3.70	3.85		5.88	5.88					19.31
Chiang Mai University Study Center	0.72	3.70	3.85	4.17	5.88						17.60
Samut Sakhon Burana School 3	0.49	3.70	3.85	4.17			5.88				17.60
Mueang Samut Sakhon District City Hall	0.44	3.70	3.85	4.17	5.88						17.60
Samut Sakhon Hospital	0.32	3.70	3.85	4.17	5.88						17.60
Samut Sakhon Area Revenue Office	0.26	3.70	3.85		5.88						13.43

Scalogram analysis results: Krathumbaen Municipality

Green Infrastructure List	Area (rai)	The components of the parks for scalogram analysis									Total
		2	1	4	3	7	6	8	9	5	
84th Birthday Maharaja Park	27.25	14.29	14.29	16.67	20.00	25.00	25.00	33.33	33.33	50.00	231.90
72 years old Rama IX Health Park	6.78	14.29	14.29	16.67	20.00	25.00	25.00	33.33	33.33	50.00	231.90
Phasi Charoen Water Delivery and Maintenance Project 1	0.12	14.29	14.29	16.67	20.00	25.00	25.00	33.33	33.33		181.90
Chaloem Ratchakumari Public Library	0.30	14.29	14.29	16.67	20.00		25.00				90.24
Phasi Charoen Water Delivery and Maintenance Project 2	0.10	14.29	14.29	16.67		25.00					70.24
Krathumbaen Hospital	0.61	14.29	14.29		20.00						48.57
Krathumbaen Provincial Electricity Authority	0.01	14.29	14.29	16.67							45.24

Scalogram analysis results: Banphaeo Municipality

Green Infrastructure List	Area (rai)	The components of the parks for scalogram analysis									Total
		2	1	4	3	6	8	5	7	9	
Banphaeo Post Office	0.18	10.00	10.00	14.29	16.67		25.00			100.00	175.95
Banphaeo District Office	0.21	10.00	10.00	14.29	16.67	16.67	25.00	25.00	25.00		142.62
Wat Tham Chariya Phirom	2.33	10.00	10.00		16.67	16.67		25.00	25.00		103.33
Banphaeo Subdistrict Stadium 1	1.38	10.00	10.00	14.29		16.67	25.00	25.00			100.95
Banphaeo Subdistrict Stadium 2	0.31	10.00	10.00	14.29		16.67	25.00	25.00			100.95
Wat Mai Ratnukul 1	0.31	10.00	10.00		16.67	16.67			25.00		78.33
Sarasas Witaed Banphaeo School	0.29	10.00	10.00	14.29					25.00		59.29
Wat Mai Ratnukul 2	0.79	10.00	10.00		16.67	16.67					53.33
Office of Banphaeo Municipality	0.31	10.00	10.00	14.29	16.67						50.95
Provincial Electricity Authority	0.11	10.00	10.00	14.29							34.29

Scalogram analysis follows the process of 1) filling color in the row of the parks' components no.1-9 discovered in each park; otherwise, empty the row, 2) converting the colored row in each column to the proportion from the score of 100, and 3) total the component scores of each park, then put in the rightmost column. Lastly, the total scores would then reveal each park's potential.

Figure 6

Scalogram analysis results: Classification of parks according to the potential of park components.

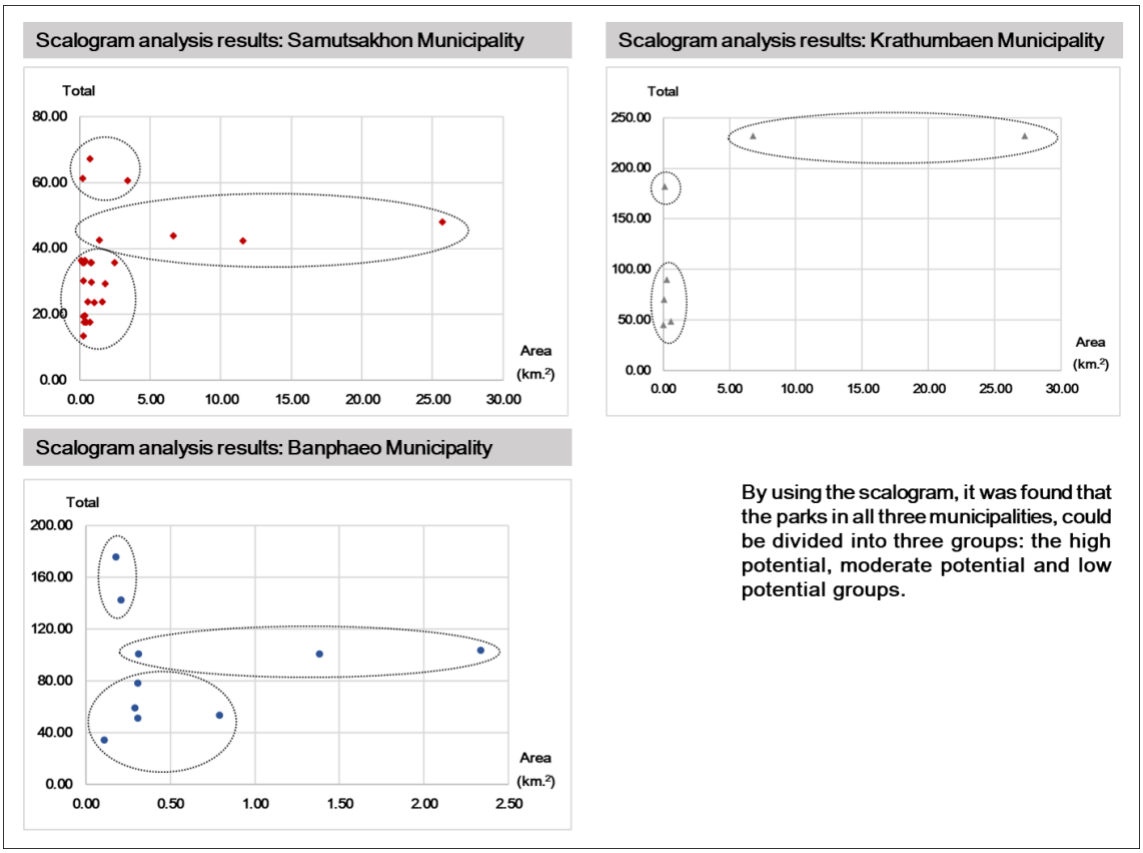
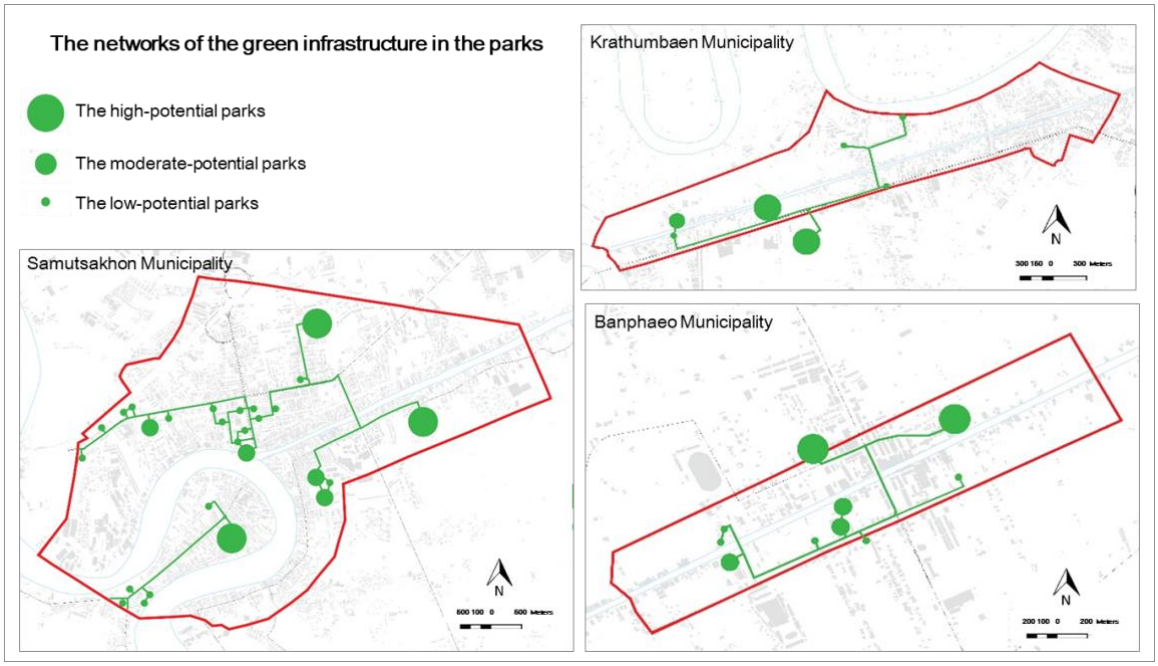


Figure 7

The networks of the green infrastructure in the parks in each municipality



Banphaeo Municipality

According to the analysis of the potential and the hierarchical ranking of the green infrastructure in the parks by applying a scalogram, the green infrastructure in the parks in Banphaeo Municipality were classified into three categories: 1) high potential (score over 140), 2) moderate potential (scores of 100-140), and 3) low potential (score less than 100). Regarding the high-potential parks, there were two sites identified: the playground beside the Banphaeo Post Office, and the garden in Banphaeo District Office. Though both of these areas were less than one rai in size, they had a diversity of park components, particularly in offering recreational activities in the form of exercise and playground equipment. This resulted in higher scores than those of the green infrastructure in other larger parks (Figure 5 and 6).

In considering the networks of the green infrastructure in the parks, it was found that there was comfortable pedestrian access between parks of any given category due to the internal distance being between 54.05-454.93 meters. In the case of pedestrian access between parks from different categories, the low-potential parks were the only category with access to the parks in different categories due to the shortest distance being between 266.57-453.88 meters (Figure 7).

In addition, according to the ranking by scalogram, the criteria of being within 500 meters of the local and main roads were met in almost all the green infrastructure in the parks of all three municipalities.

Public opinion toward the development of green infrastructure in the parks

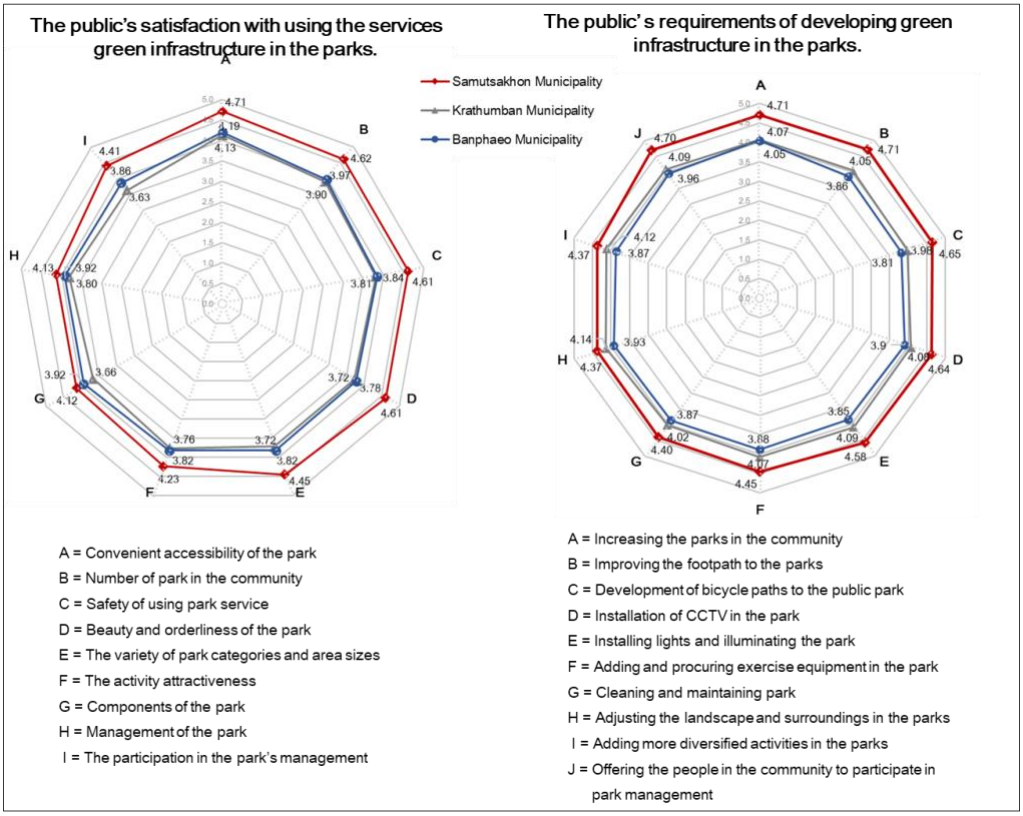
Samutsakhon Municipality

The survey respondents were mostly female (53.58%), aged 45-54 years (27.41%), Buddhist, (98.77%), with a bachelor's degree (38.02%), employed (33.09%), had resided in the municipality for five-10 years (48.64%) or longer than 10 years or more (48.64%), traveled to the parks mostly by private motorcycle (70.86%), followed by walking (12.10%) and by private car (8.89%) respectively, for the purpose of exercise such as jogging, aerobic exercise, etc. (77.53%).

Mostly, the respondents had a high level of satisfaction with the park management. Convenient accessibility of the park had the highest average (mean=4.71); satisfaction with the park's components such as benches, street lights, etc. had the lowest average (mean=4.12). Moreover, the respondents identified park management as the most significant requirement; particularly of the highest level of concern was increasing the amount of parks in the community (mean=4.71), and improving the footpaths to the parks (mean=4.71) (Figure 8).

Figure 8

The public opinions on the park area development



Krathumbaen Municipality

The respondents were mostly female (65.37%), aged 35-44 years (20.98%) or 45-54 years (20.98%). All were Buddhist, with a bachelor's degree (33.17%), self-employed or trading (33.66%), having resided in the municipality for 10 years or more (81.46%). They mostly went to the park by private motorcycle (49.76%) for the purpose of exercise such as jogging, aerobic exercise, etc. (81.95%).

The respondents mostly had a high level of satisfaction with the parks management; park accessibility had the highest average (mean=4.13), and participation in the park's management had the lowest average (mean=3.63). Furthermore, the three highest-ranking requirements identified by the respondents comprised adjusting the landscape and surroundings in the parks (mean=4.14), adding more diversified activities in the parks (mean=4.12), and offering the people in the community an opportunity to participate in park management (mean=4.09) (Figure 8).

Banphaeo Municipality

The respondents were mostly female (57.41%), aged 25-34 years (42.59%), Buddhist (99.05%), with vocational certification (23.97%), employed (53.63%), had resided in the municipality for 10 years or more (91.17%), mostly went to the park by bicycle (29.97%),motorcycle (24.29%) or private car (23.97%) for the purposes of relaxing and sightseeing (72.87%).

The respondents were mostly very satisfied with the park management, with the park's accessibility getting the highest average score (mean=4.19). The variety of park categories and area sizes had the lowest average (mean=3.82) along with the activity attractiveness in the parks (mean=3.82). In addition, highest-ranking requirements identified by the respondents comprised increasing the parks in the community (mean=3.96) and adjusting the landscape and surroundings in the parks (mean=3.93) (Figure 8).

DISCUSSION AND CONCLUSION

According to the analysis of the potential and the hierarchical ranking of green infrastructure in the parks using the scalogram method, the high-potential parks were frequently small areas in governmental offices that possessed complete park components due to the concept of park development (Horayangkura, 2006; Vásquez Sánchez et al., 2020). Moreover, the green infrastructure was characterized in the attributes of a patch, matrix, and mosaic due to the concept of green infrastructure (Forman & Godron, 1986; Gökyer, 2013), which was demonstrated, for example, by the garden in Wat Chetsadaram Municipal School, Samutsakhon Municipality (area of 0.70 rai) and the playground beside the Banphaeo Post Office, Banphaeo Municipality (area of 0.18 rai).

However, the components identified by the respondents in the high-potential, moderate-potential and low-potential parks comprised being nearby a community, within walking distance from the local and main roads, and the park components (such as available recreational activities in the form of exercising, available playground equipment, explicit footpath and bike lane establishment, and other available amenities like trash bins, food shops, etc) were not frequently found among the low-potential parks. Additionally, many of the low-potential parks were pocket parks in governmental offices or other agencies, created primarily for decoration.

In considering the green infrastructure network in the parks, it was found that all categories of parks were mostly located in a community within a distance within 500 meters from the local and main roads, aligned with the principles of green infrastructure development in combining green and gray infrastructure (Hansen et al., 2017) and the concept of urban ecology in the linkage (Horayangkura, 2006; Vásquez Sánchez et al., 2020). However, the high-potential parks often were beyond walking distance from other parks within or between the categories. According to those components and the network features, the public accessibility of green infrastructure in the parks in each municipality could be described as being convenient, but without easy pedestrian travel from high-potential parks to others within or between categories.

According to the results of the questionnaire, the respondents went to the parks, particularly in Samutsakhon Municipality, and Krathumbaen Municipality, to enjoy recreational activities in the form of exercise. This aligns with the concept of green infrastructure in that the parks were both passive and active recreational areas (Department of Public Works and Town & Country Planning, 2006). However, going to the park by motorized vehicles chiefly indicated the scarcity of a developed landscape for environmentally friendly vehicles; otherwise, the people would be able to access the parks or green areas in all hierarchies conveniently and safely (Horayangkura, 2006; Vásquez Sánchez et al., 2020).

Still, the respondents were satisfied with the parks' accessibility, despite identify in the need for adjusting the footpaths. Regarding the results of the questionnaire, this convenient park accessibility was the most satisfactory aspect with the highest average. This was aligned with the analysis of the parks' potential, in that each park was often located in a community and within walking distance from the local and main roads. Moreover, the respondents' requirements were much or more concerned with developing or adjusting the footpaths, adding the diversity of activities in the parks, and adjusting the landscape and surroundings in the parks. This all aligned with the survey results and findings that there was a scarcity of explicit footpaths and bike lanes, recreational activities in the form of exercise, playground equipment, and other amenities such as trash bins, food shops, etc., particularly in the low-potential parks.

This revealed that the green infrastructure in the parks in all three municipalities of the study area were similar in several aspects. High-potential parks were present in each municipality, which were not vast in area, but had full components (Horayangkura, 2006; Vásquez Sánchez et al., 2020). The green infrastructure found in each municipality featured the attributes of patch, matrix, and mosaic rather than a corridor, even though each municipality was partially adjacent to a waterfront area, which contributed to the mentioned green infrastructure development (Forman & Godron, 1986; Gökyer, 2013). Although the green infrastructure in the parks

was nearby the communities, there were still large distances for pedestrian travel between high-potential parks, either internally or between the categories (Horayangkura, 2006; Vásquez Sánchez et al., 2020). In addition, respondents expressed satisfaction with the parks' convenient accessibility, but there was still a requirement for adjusting the footpaths and the surroundings in the parks as well.

RESEARCH RECOMMENDATIONS

The green infrastructure in the parks, whether in the high-potential, moderate-potential, or low-potential categories, which were located close to the river and the roads; for instance, Banphaeo Subdistrict Stadium, Banphaeo Municipality, etc., were omitted from the green infrastructure development in the attribute of the corridor. Any appropriate development or management enhancement would likely elevate the parks' components and increase their potential in accordance with the concept of image design in urban parks (Horayangkura, 2006; Vásquez Sánchez et al., 2020) and green infrastructure (Forman & Godron, 1986; Gökyer, 2013)

In addition, according to the respondent's opinions, particularly in Samutsakhon Municipality, there was a need for more parks in the community and a lack of parks larger than 25 rai, particularly in the area of Samutsakhon Municipality and Banphaeo Municipality. Furthermore, from the analysis of the potential and the hierarchical ranking of the green infrastructure in the parks with a scalogram, it was found that the high-potential parks were regularly located in the governmental places, and that there was a need for conservation and increase of green infrastructure in the parks. Consequently, public participation should be promoted; this could be in the form of establishing a community council in cooperation with the municipality, conducting procurement, purchasing and development (Cohen & Uphoff, 1977; Sanguthai & Krisanaphan, 2018), or applying urban planning measures (Steiner et al., 2007). Incentive measures could also be offered to encourage new park development. In cases where the land owner comes from the private sector, examples of such incentives could include land trade-offs with the state in an appropriate location, tax deductions, etc. Additionally, corrective measures like compensation and solutions for landowners who willingly sell the rights of development could be implemented, in conjunction with resolving negative measures such as the prescription of the park area in all levels of the urban plan, etc.

Regarding the result of the potential and green infrastructure network analysis among the high-potential parks, it was found that the green infrastructure network was not connected completely for pedestrian travel, including the public's opinion that improvement and development of footpath access to the parks was required. Therefore, developing explicit footpaths and bike lanes would help reduce the amount of pollution and enhance good health for the people in the community. This would also promote the formation of a more tangible green infrastructure network, which would correspond with the concept of the significant principles of green infrastructure development and the parks' design and development (Horayangkura, 2006; Vásquez Sánchez et al., 2020). This could initiate the launching of a pilot construction on Thaprong Road that would connect to the stadium of Ban Mahachai Municipal School, Samutsakhon Municipality, Setthakij 1 Road, connecting to the 84th King's Birthday Park and the 72 Years Rama IX Health Park, Krathumbaen Municipality, and Rural Road 4010, connecting to the garden in Banphaeo District Office, Banphaeo Municipality.

Regarding the moderate-potential and low-potential parks where there was frequent scarcity of recreational activities in the form of exercise, playground equipment, and other amenities such as trash bins, food shops, etc., the surroundings and the conditions of these parks should be developed by communicating the needs of these parks to the different relevant agencies; for instance, building a sports ground with a medium-size area (futsal ground and basketball court) in the 60th Anniversary Queen's Health Park in Samutsakhon Municipality, planting perennial trees in the garden of the Chaloem Ratchakumari Public Library, the garden of Krathumbaen Hospital in Krathumbaen Municipality, as well as adding more seats and a waterfront pavilion at the waterfront garden in Wat Tham Chariya Phirom and in the garden of

the Office of Banphaeo Municipality, Banphaeo Municipality would all be positive developments that align with the analysis result of the potential of the green infrastructure in the parks and the concept of the principles on green infrastructure development and the parks' design and development (Horayangkura, 2006; Vásquez Sánchez et al., 2020). This would also meet the respondents' requirements in each municipality (Cohen & Uphoff, 1977; Sanguthai & Krisanaphan, 2018).

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