Applied Environmental Research
- RESEARCH FOR SUSTAINABLE PLANET -

Research Article

# Outlooks and Challenges for Urban Green Space Development: A Review Case Study in Thailand

**Kanawat Paoin, Chanathip Pharino***

*Department of Environmental and Sustainable Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand*

*Correspondence Email: chanathip.p@chula.ac.th

## Abstract

Even though prior studies have provided ample proof of the benefits of urban green space, Thailand's development and exploitation of urban green space remain insufficiently efficient. To assess the prospects for urban green space development in Thailand, our review study highlighted gaps and challenges related to these areas. This review study discussed the rationale for urban green space, its definitions, as well as its benefits and co-benefits (i.e., economic, social, health, and environmental). The review research additionally discussed Thailand's current urban green space issues, associated challenges (such as difficulties valuing and using urban green space, budgetary limitations, low priority for urban green space, and poor urban green space standards), and short- and long-term green space goals. Moreover, this study reviewed the urban green space assessment criteria (e.g., quality, potential urban green spaces, planning and strategy, and location selection), tools, and intriguing green space policies and practice approaches (e.g., planting and protecting trees, increasing public parks, and city taxpayers) from other previous studies and developed countries whose cities rank in the top 10 worldwide in terms of the ratio of green space to population density, for example, the US, Singapore, Germany, Switzerland, Canada, and the Netherlands. There have also been interesting platforms and technology introductions for developing and managing urban green spaces. Finally, the review study proposed guidelines for green space development that may be beneficial for Thai policymakers to improve green space based on lessons learned from other developed countries, such as being more accessible, a proper size, an appropriate distance from neighborhood residents, having suitable facilities and equipment for the users, maintaining the beauty and cleanliness, having recreational activities, tax incentives, and advanced technology platforms. Additional research is required to examine the damage costs associated with urban green space, policy, and cost-benefit analysis to make it more practicable.

ARTICLE HISTORY
Received: 7 Jun. 2024
Accepted: 23 Jul. 2024
Published: 5 Sep. 2024

KEYWORDS
Urban green space;
Definitions;
Benefits;
Challenges;
Guidelines;
Thailand

## What is an urban green space?

In an urban setting, "green space" is a broad term that can refer to any vegetated land or water within an area, including parks, gardens, playing fields, kid-friendly playgrounds, wooded and other natural areas, grassy areas, and allotments. Additionally, green space should also incorporate green corridors like paths, rivers, and canals. There are many types of green space, for example, urban parks and gardens, community woodlands (i.e., trees, shrubs, climbers, wildflowers and fungi), wetlands (i.e., swamp, marshes, bogs, fen, and mangrove), and street trees. This review study focuses on “urban green spaces,” which are public open spaces in urban areas defined primarily by a high proportion

https://doi.org/10.35762/AER.2024040

of vegetation and unpaved surfaces. Figure 1 presents the components of urban green space, which include grass, trees, shrubs, and other vegetation (i.e., community gardens, parks, open spaces, and playgrounds).

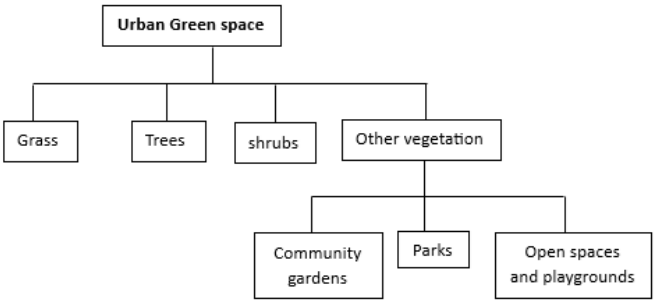


**Figure 1** Urban green space.

The definition of urban green space according to US EPA [1], WHO [2], European Environment Agency (EEA) [3], and Thailand's Natural Resources and Environmental Policy and Planning [4] was displayed and compared in Table 1. The computation of the density of green space (square meter per person or per capita) is affected by variances in the definition of green space used in Thailand compared to that used by WHO, the US EPA, and European Environment Agency. For instance, tiny green areas (i.e., traffic islands and small private gardens) would not be included in the WHO's definition of "green space.". Nonetheless, smaller green areas—like traffic islands and little private gardens—are frequently reported and included in Thailand's overall green space. As a result, the density of green space defined by Thailand is usually higher than that of the WHO. The long-term goal of developing green space in Thailand may be challenging because of its location and the high levels of pollution caused by traffic. As a result, newly generated green space might not be the most beneficial.

A good urban green space should be large, peaceful, clean, well-maintained, and provide amenities as well as a secure atmosphere. It would also be advantageous to be historical, cultural, or natural [5]. The Sustainable Development Agenda's Goal 11.7 (SDG 11.7) states that everyone should have access to safe and inclusive green and public spaces. Moreover, urban green space also contributes to achieving other SDGs, including SDG 3 (good health and well-being), SDG 13 (climate action), and SDG 15 (life on land). Hence, urban planners and designers should consider these crucial factors to build and develop high-quality urban green spaces in cities that are accessible to everyone.

## The value of green space in cities

This section discusses the positive aspects of having green space to help readers see why there ought to be more green space in cities. The benefits of green space are sometimes difficult to quantify but can still be recognized. This literature has emphasized the numerous benefits and co-benefits of green space, including from an economic [6–9, 11–13], social, health [13–39], and environmental perspective [13, 15, 40–48], as shown in Table 2. Our goal is to inform readers about the wealth of opportunities involved in creating green spaces. It is aimed at a wide range of audiences, including real estate and development professionals who want to get the most out of their land ownership, local governments, non-profit organizations, as well as charities who want to improve economic, social, and environmental conditions.

**Table 1** Definition of urban green space

| | Definition |
|---|---|
| US EPA [1] | Land that is partially or entirely covered in grass, shrubs, trees, or other types of vegetation. This includes urban parks, paths, community farms or gardens, including rooftop gardens. Schoolyards, playgrounds, public seating areas, public plazas or vacant lots are excluded. |
| WHO [2] | Urban green spaces can be described as having "natural surfaces" or "natural settings," but they can also refer to specific types of urban greenery, such street trees, and may also include 'blue space' which represents water elements ranging from ponds to coastal zones. Public parks are a common example of green space in metropolitan areas; however, other definitions may also include private gardens, woodlands, playgrounds, non-amenity places (e.g., roadway verges), riverfront footpaths, beaches, etc. |
| European Environment Agency [3] | Vegetated land separating or surrounding concentrated residential or industrial areas and intended for recreational or park purposes. |
| Office of natural resources and environmental policy and planning (Thailand) [4] | A natural or man-made area in a city or community covered by vegetation as a major component beneficial for the environment, the living ecosystem, and the quality of life for the people. |

### 1) Economic benefits

From an economic perspective, urban green spaces increase property values, attract investment, and promote tourism (Table 2). A high-quality green space can boost the value of vacant areas, open space, and neighboring properties, both commercial and residential [6–9]. A green space could give otherwise undervalued land a use and a possibility for making income. Piaggio (2021) discovered that house owners' declared property values rise with increased proximity to urban parks and neighborhood park size [10]. It also increases the opportunities for investment, development, employment, and tourism in the area [11-13]. In China, it was discovered through spatial measurement that the creation of urban green space may greatly enhance the urban environment, draw in outside investment, assemble talent, and optimize the industrial structure—all of which will help the city's economy grow [11]. As a temporary use for land until additional investment options are possible, green space may draw alternative funding sources, attract new funding opportunities, and promote economic regeneration.

### 2) Social and health benefits

From a social and health perspective, green space promotes good health (i.e., physical and mental benefits, stress relief, and obesity reduction), well-being [13–25], exercise, recreation and cultural activities, social interaction and community engagement [15, 26–33] (Table 2). For example, those who live within 1,600 meters of a green space have a decreased cumulative incidence of loneliness, especially for people living alone [18]. Furthermore, Chinese students seemed to be less stressed when they lived in cities with more greenery [19]. Among a large sample of Australians 45 years of age and older, Astell-Burt et al. (2013) discovered that a greater amount of green space in the neighborhood where they live was linked to healthier sleep length [24]. This could encourage positive behavior, productivity, and motivation in individuals [34–36]. Moreover, green space may foster education, peaceful environments, and food production [37–39]. According to Walsh et al. (2022), there is enough urban green space in Great Britain to sustain the production of fresh fruit and vegetables at a national scale [39].

**Table 2** Benefits and co-benefits of urban green space

| | Benefits and co-benefits of urban green space |
|---|---|
| **1. Economic** | 1.1 A rise in land value for the location and the properties adjacent [6-8]. |
| | 1.2 Practical use of vacant land [9]. |
| | 1.3 Addressing the requirement of the planning to develop open space [9]. |
| | 1.4 Increasing investment potential through improving perceptions of the areas [11]. |
| | 1.5 Attracting inward investment to a wider area and strengthening the reputation of corporate responsibility [11]. |
| | 1.6 Enhancing relationships within the community and lowering the possibility that future development initiatives would be greeted with opposition [12]. |
| | 1.7 Providing opportunities for employment and training in land management and maintenance [13]. |
| | 1.8 Promoting a favorable image for a location, increasing retail sales, and attracting tourists [14]. |
| **2. Social and health** | 2.1 Reducing health risks from contaminated land [13]. |
| | 2.2 Promoting well-being [13–16]. |
| | 2.3 Improving mental health (e.g., reducing stress) [15, 17–22]. |
| | 2.4 Speeding up patient recovery [23]. |
| | 2.5 Promoting a healthy duration of sleep [24–25]. |
| | 2.6 Creating opportunities for physical activities and recreation or active lifestyles [15, 26–27]. |
| | 2.7 Creating opportunities for social interaction [28]. |
| | 2.8 Supporting cultural activities and diversity [29–31]. |
| | 2.9 Promoting community engagement and environmental ownership [32–33]. |
| | 2.10 Improving motivation and productivity [34–35]. |
| | 2.11 Fostering constructive behavior in children [36]. |
| | 2.12 Encouraging education about the environment, landscape, health and well-being [37]. |
| | 2.13 Creating peaceful areas in crowded urban settings [38]. |
| | 2.14 Creating prospects for food production [39]. |
| **3. Environment** | 3.1 Promoting biodiversity [15, 40–41]. |
| | 3.2 Improving the character and appearance of areas [13]. |
| | 3.3 Reducing air pollution, heat, and noise [13, 42–46]. |
| | 3.4 Decreasing the threat of contaminated land to ecosystems [13]. |
| | 3.5 Supporting carbon management and assisting in the control of the effects of climate change [13, 47]. |
| | 3.6 Encouraging the production of carbon-free biomass fuels [48]. |
| | 3.7 Regulating surface water while creating space for controlling floods [13, 15]. |
| | 3.8 Ground stability management [13]. |

### 3) Environmental benefits

From an environmental perspective, green space enhances biodiversity, habitat creation, animal corridors, landscape creation, and a location's aesthetics [13, 15, 40–41] as well as mitigates environmental pollution and disaster [13, 42–46] (Table 2). Urban green zones with a variety of plants can host diverse wildlife communities and increase the number of insect species. It can reduce environmental hazards (i.e., air pollution, heat, and noise) and contaminated land [13, 42–46]. Additionally, green space also supports carbon management, carbon-free biomass fuel production, ground stability, surface water management, and flood control [13, 15, 47–48]. In hot, dry climates, green spaces offer lots of shade and provide protection from dust. In the hot, humid area, it also serves to minimize wind obstruction, increase ventilation, and reduce flooding [45].

Thailand needs to increase the amount of green space per capita and improve accessibility to these spaces in order to satisfy WHO requirements and improve living conditions in urban areas.

## The current situation of urban green space in Thailand

Economic development and rapid urbanization in Thailand have resulted in the reduction of green space in the country and an increase in air pollution, noise, and heat waves, which affect the health of the Thai population. In 2021, it was reported that more than 14 million Thai people, or about 20% of the country, lived in the Bangkok Metropolitan Region (BMR), which is the largest urban area in the country [49–50]. Furthermore, more than half of Thais reside in urban areas [49]. Between 2000 and 2010, the urban area of the whole country increased by 2,400 to 2,700 $km^2$ each year, or 1.4% [49]. Therefore, it is increasingly difficult for urban residents, who account for 35.8% of the country, to access green spaces [51].

In 2021, the ratio of public green spaces per population in Thailand's various cities was between 4.27 and 8.59 $m^2$ per person [51]. For example, Bangkok and Nonthaburi have an average green area of 6 (or 3.54 if counting the latent population) and 3.92 $m^2$ per person, respectively [52]. It was found that the ratio of public green spaces per population was still lower than the standard specified by the World Health Organization (WHO), which determines that the average rate of green space per person should be at least 9 $m^2$ per person [53]. However, the green area in Bangkok would only be 2.3 $m^2$ (if counting the latent population) per person if counting solely the green space as defined by the WHO, because the tiny green areas, such as traffic islands and small private gardens, would not be counted [54–55]. Additionally, the green spaces that can be found on many of Bangkok's traffic islands are still inaccessible due to their location and the high levels of pollution caused by traffic [54–55].

The average distance between a person in Bangkok and the closest green space is currently 4.5 km, which is 9 times more than the 300–500 m WHO-recommended distance. Many urbanites find it difficult to access green areas due to the considerable distance [54–55]. Many Bangkok districts have an average green area of less than 3 $m^2$ per person, including Phra Khanong, Bang Kapi, Bang Khen, Lat Krabang, and Lat Phrao, and some have no usable green space at all, including Bang Na, Wang Thong Lang, and Watthana. This contrasts with areas in commercial areas like Pathum Wan, which have an average green area of 13.8 $m^2$ per person and an average distance of access of only 1.5 km [54–55]. According to the Thailand Development Research Institute (TDRI), only 11 of Bangkok's 50 districts had green spaces larger than 9 $m^2$ per person in 2021. Based on WHO recommendations, Thailand needs to increase its green space, especially in urban areas like Bangkok. The distance and accessibility to the nearest green space in the country also needs to be taken into consideration and enhanced.

## The challenges of urban green space in Thailand

### 1) Challenges for valuing and using urban green spaces

#### 1.1) It is difficult to measure the need for urban green space

Although there is much evidence of the advantages of green space in cities from previous studies and research articles, it is difficult to quantify how these areas are used, which justifies their inclusion in the challenges of urban planning. Without understanding who utilizes public parks, when they are used, and why, it is challenging to make the case for their expansion [56]. Although parks are typically thought of as a cultural service, it is hard to measure how they are utilized. An 'urban green space map' is required in order to make this information easily accessible. We can monitor park usage and determine who visits, when, and why with the use of this technology. It also gives details about who owns and what is contained in all green spaces. This would make it achievable for people, communities, and decision-makers to utilize existing green space to its fullest potential [57].

#### 1.2) There is a lack of robust cost-benefit analysis for urban green spaces

There is a lack of robust and sophisticated methodologies for cost-benefit analysis that can fully capture those aspects of the benefits of parks and green spaces that are more challenging to value [57]. It is crucial to

have robust techniques to support better business justifications to continue making the case for investing in green areas [57]. Academics and policymakers need to develop methods for measuring and monetizing the advantages of urban green spaces for social well-being, physical health, and the environment [57].

### 1.3) Long timescales for establishing the highest quality of urban green spaces

Urban green spaces are components of natural processes, relations, and interactions; therefore, creating the highest-quality green space with observable changes and benefits takes time [58]. Hence, a long-term strategy should be implemented to evaluate the effectiveness of parks or green spaces at regular intervals, such as every year or every two years, in order to demonstrate the project's benefits.

### 2) Financial constraints

There is a greater demand for every square inch of space to be used productively as federal, state, and local budgets become more restrictive. This implies that city planners, investors, and developers usually consider the financial benefits of land use [56]. Green spaces are thought to affect costs, particularly in terms of maintenance requirements. Hence, it is common for green space's potential economic benefits to go unrecognized and unconsidered [58]. Despite the fact that parks and other green spaces have numerous positive effects in various areas, their funding continues to come primarily from one source. In order to reflect the spread of benefits of park investments more effectively, notably the present and future environmental and health benefits, it may be more appropriate to allocate funds from multiple local authority budgets [57].

### 3) Low priority of green space

Planning for green spaces could be given a low priority in the context of exploitation [59]. Along with the increase in urban population, housing demand will increase, making it more challenging to develop infrastructure that allocates green space [56]. Moreover, the demand for urban mobility outweighs the need for green areas [56]. Green space availability in areas undergoing densification may not be adequate [59]. The policy for livable and sustainable urban development should take environmental concerns and the need for increased green space into account.

### 4) Urban green space standards

### 4.1) Poor quality of urban green spaces

Green spaces frequently have issues with inadequate accessibility, obsolete equipment, poor design innovation, and low ecological value [58]. Existing green spaces could lose quality or be replaced with low-quality green spaces, which poses a risk [59]. More attention should be paid to enhancing the quality of green space in order to increase its quality. Thus, more people will value the space [58].

### 4.2) The challenge of accessing green spaces for all people

There has been published evidence of inequalities in access to public park services, especially in areas designed for a specific purpose to serve a specific community. For example, a park designed for basketball events encourages users to play basketball and attracts those who do. Conversely, it will reduce the space used for other sports or other users who will enjoy other activities such as picnics, reading books, etc. [60]. Public parks or green spaces should be built to accommodate all users and offer a variety of activities to increase the number of park users.

### 4.3) Safety in public parks for crime prevention

Insufficient security precautions and lighting in certain parks and other green areas might lead to dangerous circumstances or criminal activity. As a result, fewer people will visit and use public parks, particularly women, the elderly, young adults, and children [61]. Consideration should be given to park safety in order to reduce crime and attract more people to the parks.

## The policy implementation of urban green space in Thailand

The Department of Climate Change and Environment (DCCE) and the Office of Natural Resources and Environmental Policy and Planning (ONEP), Ministry of Natural Resources and Environment, are responsible for managing and maintaining green spaces in Thailand. ONEP created Thai Green Urban (TGU), a database system collecting green space data in Thailand. In addition, Thailand has a Royal Forest Department that is in charge of handling and preserving the nation's forest resources (Figure 2). Thailand's 20-year National Strategic Master Plan (2018–2027) contains numerous proposals to enhance the number of green areas, such as public green space, utility green space, and natural green space throughout the nation [51]. Table 3 lists the short- and long-term goals for Thailand's green space (Figure 3).

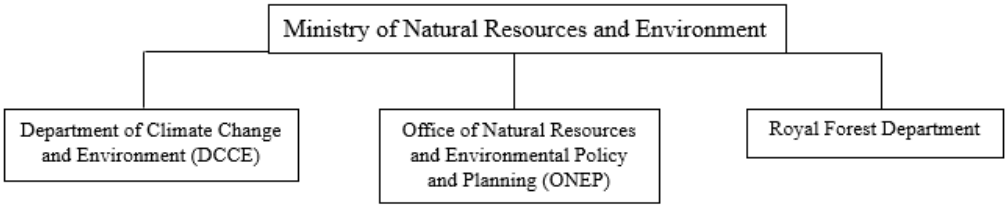


**Figure 2** Thailand's green space management agencies

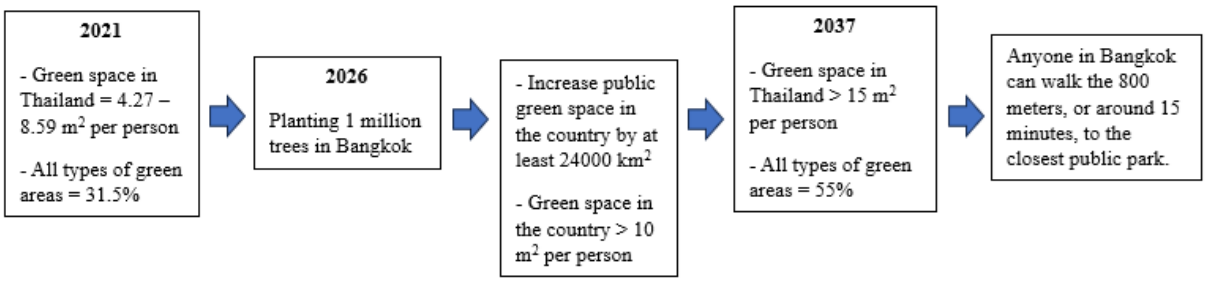


**Figure 3** Thailand's short- and long-term goals for green spaces.

**Table 3** Thailand's short- and long-term green spaces goals

| | Thailand's green space goals |
|---|---|
| 1. Short-term goals | 1.1 There will be an overall public green space in the country of not less than 10 $m^2$ per person [51].<br>1.2 Planting 1 million trees in Bangkok by dividing the planting into 400 trees per district per week to reach 1 million trees by 2026 (A City-Wide Tree Planting project) [62].<br>1.3 Drafting Green Area Regulations. Those who plan to construct, renovate, or install new buildings must follow the proposed green area legislation. There must be green area for 50% of the open space outside the building. According to the building control law, an area of a 100 square meter residential house must have 30 square meters of vacant space, while commercial buildings, offices and townhouses require 10% of the area to be vacant space [63]. |
| 2. Long-term goals | 2.1 There will be an overall public green space in the country of not less than 15 $m^2$ per person by 2037. Thai People can easily access or use green spaces for public benefits [51].<br>2.2 Thailand will have increased all types of green areas from 31.5% as of 2021 to 55% by 2037 [51].<br>2.3 Anyone in Bangkok will be able to access the nearest public park within 15 minutes, or roughly 800 meters [64]. |

For the short-term goals, Thailand intends to achieve a minimum of 10 $m^2$ per capita of public green space in the country [51]. In other words, it intends to add at least 24,000 $km^2$ to the nation's public green space. Bangkok Governor Dr. Chadchart Sittipunt has a city-wide tree planting project to plant 1 million trees by dividing the planting into 400 trees per district per week, with the goal of having 1 million trees by the year 2026 [62]. Furthermore, the draft green area regulations in Thailand also highlight ambitions to expand green spaces [63].

For the long-term goals, Thailand plans to have at least 15 $m^2$ of public green space per capita nationally by 2037 [51]. Thailand will have increased the percentage of all types of green space from 31.5% as of 2021 to 55% (divided into 35% natural green space, 15% utility green space, and 5% public green space) by 2037, according to the 20-year National Strategic Master Plan [51]. In addition, by this time anyone in Bangkok will be able to walk 800 meters, or around 15 minutes, to their closest public park [64]. In many ways, Thailand's strategy is comparable to Singapore's plan to plant a million trees, which aims to put every home within 10 minutes' walking distance of the closest park by 2030. Nonetheless, Bangkok's per-capita green space (less than 7 $m^2$) remains far smaller than Singapore's per-capita (66 $m^2$).

## Best practice and lesson learned

This section covered the methods and tools used in previous studies to evaluate the quality of green space. Besides, we presented case studies of interesting green space practices and policies from various countries. This would be useful for a long-term plan to assess, improve, and develop (urban) green spaces in Thailand by studying case studies in other nations and learning from them regarding innovative tools and methodologies, policies, and practice approaches.

### 1) Instruments or procedures for assessing the quality of urban green space

Table 4 summarizes tools and criteria for assessing green spaces, covering aspects like land ownership, accessibility, biodiversity, and design [65-69].

Nanta et al. (2020) evaluated existing and potential green spaces based on factors such as land ownership, public usage, accessibility, size of the land, ecosystem, activities of diversity, and utilization [65]. Previous studies assessed the quality of green space by looking at management, maintenance, characteristics, functionality, biodiversity value, versatility and flexible use, security, design, network connectivity, facilities, spaciousness, quietness, naturalness, cleanliness, and historical and cultural value [66-67]. Landscape functions, urban character, and urbanization level were used as indicators to assess green space planning and strategy [68]. Gelan et al. (2021) estimated location selection for green space using existing land use, proximity to settlements, roads, water bodies, population density, property ownership, topography, and scenic attractiveness [69].

In order to maximize the benefits for users, it is imperative to utilize the methodologies and criteria outlined in Table 4 to select feasible locations and develop them into high-quality urban green spaces, given the budgetary and space limitations. However, there are some skills and expertise that are required to use these tools. Thus, the project requires the involvement of professionals in this field to maximize the advantages of these instruments.

### 2) Case studies from other countries' interesting green space policies and practice approaches

The interesting practice approaches and policies of green space from many developed countries (i.e., Singapore, United States, Canada, Netherland, Germany, and Switzerland) has been presented in Table 5. We have chosen countries whose cities are among the top 10 globally in terms of the proportion of green space to population density [70].

**Table 4** Assessment criteria for urban green spaces

| | Assessment criteria for green spaces |
|---|---|
| 1. Existing green spaces | 1.1 The land ownership and public usage level [65].<br>1.2 Accessibility [65].<br>1.3 Land size [65].<br>1.4 Ecosystem [65].<br>1.5 Activities of diversity and usage [65]. |
| 2. Potential green spaces | 2.1 The land ownership and public usage level [65].<br>2.2 Accessibility [65].<br>2.3 Land size [65].<br>2.4 Ecosystem [65]. |
| 3. Quality | 3.1 It is linked internally and externally as part of a wider network [66-67].<br>3.2 Building frontages overlook [66].<br>3.3 Well-maintained and appropriately managed [66-67].<br>3.4 Designed to support management over a lengthy period of use and accessible to all [66-67].<br>3.5 High biodiversity value [66].<br>3.6 Characteristics and functionality that vary to fulfill identified needs [66].<br>3.7 Capable of providing possibilities for multipurpose action to everybody [66].<br>3.8 Secure and Safe [66-67].<br>3.9 Sufficient in design and equipment to become a destination [66].<br>3.10 Well-connected to walking and cycling routes [66].<br>3.11 Connected to smart infrastructure to promote flexible use of the area for people of all ages and for a wide range of activities [66].<br>3.12 Provisioned with facilities, seating, and resting spots [66-67].<br>3.13 Legible to all users with clear wayfinding [66].<br>3.14 Provisioned with shelter and shade [66].<br>3.15 Quietness, spaciousness, and cleanliness [67].<br>3.16 Naturalness, historical and cultural value [67]. |
| 4. Planning and strategy | 4.1 Landscape functions [68].<br>4.2 Urban character [68].<br>4.3 Urbanization level (urban density) [68]. |
| 5. Location selection | 5.1 Existing land use [69].<br>5.2 Proximity to settlement [69].<br>5.3 Road and water body [69].<br>5.4 Population density [69].<br>5.5 Land ownership [69].<br>5.6 Topography [69].<br>5.7 Scenic attractiveness [69]. |

**Table 5** Interesting green space points (practice approach and policy) from other developed countries

| Country | City | Response agency | Practice approach or policy | Interesting points |
|---|---|---|---|---|
| 1. Singapore | 1.1 Singapore city | • Ministry of Education<br>• Ministry of National Development<br>• Ministry of Sustainability and the Environment<br>• Ministry of Trade and Industry<br>• Ministry of Transport | Singapore Green Plan 2030 | • Practice approach: Planting 1 million trees with the goal of ensuring every household can reach a park within 10 minutes by 2030 (Singapore Green Plan 2030) [70].<br>• Practice approach: Increase the land area of natural parks by more than 50% over the 2020 baseline [70].<br>• Practice approach: Increase green space by 1,000 hectares by 2035 [70]. |
| 2. United States | 2.1 St. Louis, Missouri | • The Great River Greenway | Greenway Plans and Projects | • Policy: The Great River Greenway is a public agency in St. Louis, Missouri, that was developed to connect sidewalks between the city's green spaces and its residents. Hence, people want to walk more because there are over 1,200 kilometers available. The agency receives about $100 million a year from city taxpayers. It is used to manage the creation of green spaces, which costs about $5 million per square mile every year [71]. |
| | 2.2 Seattle, Washington | • The Green Seattle Partnership (GSP) | Green Seattle | • Policy: Seattle, Washington, has a goal called 'The Green Seattle Partnership' (GSP) to restore and maintain the parks in Seattle. GSP has worked with thousands of volunteers since 2005 to plant more than 150,000 trees and reclaim over 1,000 acres of gardens across the city [72]. |
| 3. Canada | 3.1 Vancouver, British Columbia | • The Vancouver Board of Parks and Recreation (The Vancouver Park Board) | Green Vancouver | • Policy: Vancouver, British Columbia, increased green space in the city by planting 150,000 extra trees between 2010 and 2020, including promoting the city's population to walk in a green space for at least 5 minutes every day [72-73]. |
| 4. Netherland | 4.1 Amsterdam | • Amsterdam's department of Planning and Sustainability | Amsterdam 2040 | • Policy: Amsterdam is the world's second-most bicycle-friendly city. The city has over 30 parks and 156 canals that run through it to provide larger spaces for people to walk and reduce car traffic [72-73]. |
| 5. Germany | 5.1 Frankfurt | • Frankfurt Urban Planning Office | Frankfurt 2030 | • Policy: There is a policy in Frankfurt not to construct buildings in green spaces to encourage a better quality of life for city residents. Environmental issues and more green space are being incorporated into the policy for livable and sustainable urban development (Frankfurt 2030) [72]. |
| | 5.2 Berlin | • The Berlin horticultural/landscape gardening administration<br>• Division Climate Action, Nature Conservation and Urban Green Space (Senate Department for Urban Mobility, Transport, Climate Action and the Environment) | Berlin 2030 | • Policy: Berlin has strict environmental laws, such as those controlling pollutants from car exhaust and protecting trees, which require authorization from a government agency before cutting trees with a circumference of 80 cm or greater. Despite the fact that the tree may be in a residential area, violators face a fine of up to 50,000 euros [74]. |
| 6. Switzerland | 6.1 Geneva | • The Green Spaces and Environment Department | Geneva 2020 | • Policy: Geneva has been committed to sustainable development since 1995. The Green Spaces and Environment Department manages and maintains numerous green spaces or parks, as well as the richness of Geneva's wooded heritage [75]. |

As part of Singapore's Green Plan 2030, a million trees will be planted, which aims to put every dwelling within 10 minutes of walking distance of the closest park by the year 2030 [71]. Additionally, it plans to increase green space by 1,000 hectares by 2035 and the land area of natural parks by more than 50% compared to the baseline year of 2020 [71].

In the US, a public organization called the Great River Greenway was established in St. Louis, Missouri, to connect sidewalks between the city's open spaces and its citizens. As a result, people want to walk more because there are over 1,200 kilometers available. In return, taxpayers in the city give the organization roughly $100 million a year. It is employed to oversee the building of green spaces, which has an annual cost of $5 million per square mile [72]. The Green Seattle Partnership (GSP), a project of Seattle, Washington, aims to maintain and repair the city's parks. Since 2005, GSP has worked with thousands of volunteers to restore over 1,000 acres of gardens throughout the city and plant more than 150,000 trees [70].

In Canada, between 2010 and 2020, Vancouver, British Columbia, enhanced the amount of green space in the city by planting 150,000 additional trees. The city also encouraged residents to stroll in a green area for at least 5 minutes each day [70, 73]. Meanwhile, the second-most bicycle-friendly city in the world is Amsterdam, Netherland. With more than 30 parks and 156 canals crisscrossing the city, there are more areas for people to wander around and fewer cars on the road [70, 73].

In Germany, Frankfurt has a policy called Frankfurt 2030 that prohibits the construction of structures in green spaces in order to improve the quality of life for city dwellers. A policy for livable and sustainable urban growth is being developed, and more green space and environmental concerns are being taken into account [70]. Moreover, Berlin has stringent environmental regulations, including those that manage traffic-related pollution and safeguard trees and call for permission from a government body before felling trees with a circumference of at least 80 centimeters. Even if it is a tree in a residential neighborhood, those who violate the law could be fined up to 50,000 Euros [74].

Since 1995, Geneva, Switzerland, has been dedicated to sustainable development. The richness of Geneva's woodland history, as well as a number of green spaces and parks, are managed and maintained by the Green Spaces and Environment Department [75]. Table 6 shows the proportion of green space to population density in each city that we mentioned in this section when comparing it to Bangkok, the capital city of Thailand.

**Table 6** Proportion of green space to population density in each city

| City | Proportion of green space to population density |
|---|---|
| 1. Singapore [72] | 29.3% per population density 7,797/km$^2$ |
| 2. Frankfurt, Germany [72] | 21.5% per population density 3,000/km$^2$ |
| 3. Geneva, Switzerland [72] | 21.4% per population density 12,000/km$^2$ |
| 4. Amsterdam, Netherlands [72] | 20.6% per population density 4,908/km$^2$ |
| 5. Seattle, Washington, US [72] | 20% per population density 3,151/km$^2$ |
| 6. Vancouver, British Columbia, Canada [72] | 25.9% per population density 5,249/km$^2$ |
| 7. Bangkok, Thailand [76] | 2.6% per population density 5,300/km$^2$ |

### 3) Innovative technological platforms to increase and manage urban green spaces

This section covered advanced platforms and technologies that can expand urban green spaces and enhance their management. Table 7 displays all of the interesting instances of them.

First, drones can be used to map and monitor changes in urban green spaces. Drones offer an efficient and precise way to survey wide, scattered areas, and the data they collect can be utilized to monitor changes in soil, water levels, and vegetation over time [77]. For example, drones can be used to measure the height, width, and quantity of plants in urban parks and other green spaces. This data can be used to spot patterns in plant growth or pinpoint locations where invasive species are spreading. Drones can also monitor water levels in ponds and other wetland areas, which aids in early drought or flood prediction [77]. Researchers and urban planners can obtain high-resolution photos and videos of green spaces with the help of drones, giving them a comprehensive grasp of the area and its characteristics. When it comes to urban planning and design, this can be especially helpful because it can help guide decisions about which places should be maintained and which should be developed [77]. However, there are a lot of limitations to drones. These include the possibility of weather and other interference affecting drone operations, restricted drone flight times, the need for skilled operators, the cost of high-quality drones, the application of legal and regulatory requirements, the possibility of safety risks, the time it takes to process data, the potential for limited detail, and potential privacy concerns [78].

**Table 7** Interesting technologies and platforms to increase and manage urban green spaces

| Innovative technological platforms | Advantages | Limitations |
|---|---|---|
| 1. Drones | • Urban green space monitoring [77].<br>• Urban green space mapping [77]. | • Weather and other interference can have an impact on drone operation.<br>• Drone flight time is restricted [78].<br>• Drones require skilled operators [78].<br>• High-quality drones can be somewhat expensive [78].<br>• Drones must adhere to legal and regulatory requirements [78]<br>• Drones can pose safety risks [78].<br>• Processing data can take a lot of time [78].<br>• The level of detail may be limited [78].<br>• Privacy issues could surface [78]. |
| 2. Remote sensing | • Mapping street trees [80].<br>• Detecting species within urban green spaces [81].<br>• Invasive shrub mapping in urban green spaces [82].<br>• Evaluating the health of the vegetation in urban green spaces [83]. | • High cost [84].<br>• Specialized skills required [84].<br>• Atmosphere and sun angle can have an impact on data from remote sensing [84].<br>• Limitations on resolution and quality [84].<br>• Remote sensing raises ethical considerations [84].<br>• The limit of technological evolution [84]. |
| 3. Satellite Imagery | • Improved site selection [85].<br>• Evaluating environmental factors [85].<br>• Enhanced connectivity and accessibility [85].<br>• Optimizing park design [85].<br>• Planning and Maintaining Vegetation [85].<br>• Microclimate analysis [85]. | • Satellite imagery is limited by its resolution [86].<br>• Weather, clouds, and other environmental factors can reduce the quantity of available imagery [86].<br>• The accuracy of satellite imagery is limited [86].<br>• High cost [86]. |

Second, remote sensing offers a useful set of capabilities that can reduce the need for field surveys, particularly in extremely complex and heterogeneous urban environments [79]. Remote sensing has been shown to be an effective tool for mapping street trees [80]. In urban green spaces, it may also map invasive bushes and identify species [81-82]. In addition, remote sensing can be used in urban green spaces to assess plant health [83]. Nevertheless, there are a few drawbacks to remote sensing that should be considered. These include the fact that remote sensing may not be as widely available as it could be due to a number of reasons. First, there are high implementation and maintenance costs in some areas; second, the need for specialized knowledge and skills to interpret remote sensing data, which could prevent it from being widely used; third, the possibility that the accuracy and applicability of remote sensing data could be limited in some applications due to factors like sun angle and atmospheric conditions; and finally, the possibility that technical constraints could limit the quality and resolution of data obtained through remote sensing. Moreover, remote sensing is restricted due to ethical and legal issues that arise, especially when it is used for monitoring in some areas. Furthermore, the compatibility and interoperability of remote sensing technologies are continually affected by upgrades and modifications that must be made to hardware and software. These changes can be expensive and time-consuming [84].

Third, using satellite imagery, urban planners can identify underutilized or vacant sites that could be converted into green areas. Planners can identify places that are currently barren of greenery and strategically plan where to build urban parks by analyzing satellite data [85]. Satellite imagery can be used to assess a variety of environmental factors, including air quality, tree cover, and heat islands. With the use of this data, urban planners can create more sustainable and healthful environments by providing natural places that offset the negative consequences of urbanization [85]. Moreover, planners can give priority to the construction of parks and gardens in these impoverished communities by utilizing satellite imagery to identify places with restricted access to green spaces [85]. When choosing the best plan for urban parks, designers might use satellite images to take into account factors like accessibility, land slope, and existing infrastructure. Consequently, park planners are able to maximize available space while taking community needs and preferences into consideration by analyzing satellite data [85]. Satellite photos also provide important information about the local vegetation. Landscape designers can choose the best plant species to provide maximum biodiversity and minimal maintenance needs by evaluating this data [85]. In order to create a pleasant and engaging outdoor atmosphere for park visitors, planners can add appropriate shade, water features, and landscaping solutions

with the assistance of satellite photography, which helps identify locations prone to such issues [85]. Nonetheless, it is critical to comprehend satellite imagery's limitations to guarantee that it is utilized efficiently. First, the resolution of satellite imagery limits its use. It is yet unable to deliver comprehensive information at the ground level. This might make determining the degree of a particular feature challenging. Second, weather, clouds, and other environmental conditions might reduce the amount of imagery that is available. Third, even though imagery from satellites can give a broad perspective of a region, it might not be able to precisely identify some features or changes. Lastly, the cost of acquiring and processing satellite imagery, as well as maintaining a satellite system, can be high [86].

## Opportunities for developing future green spaces in Thailand

In the previous section, we discussed issues relating to urban green space with examples of green space policies and practices from other countries. This section offers potential remedies for Thailand's existing urban green space problems based on successful cases from previous studies or other nations. Table 8 shows the guideline recommendations for urban green space in Thailand, including improved accessibility, appropriate size, proper distance to the community, suitable facilities and equipment for the users, preserving the beauty and cleanliness, recreational activities, tax incentives, and innovative technology platforms.

**Table 8** Opportunities for Thailand's future green space development

| Important guidelines for the development of urban green spaces to serve as models for sustainable, health-conscious cities in Thailand | | Possibility* | Cost* | Availability* | Practical* |
|---|---|---|---|---|---|
| 1. Accessibility | 1.1 Integration of green space and public park should be considered as part of an urban development master plan [86]. | High | High | Medium | High |
| | 1.2 Design for accessibility for all populations, such as children, adults, the elderly, the disabled, and low-income groups [86-87]. | Medium | Medium | Medium | High |
| | 1.3 Maximizing the park's accessibility features, such as the sidewalks and bike lanes surrounding the park, to foster the community and boost usage of the service [86-89]. | Medium | Medium | Medium | High |
| 2. The bigger, the better | 2.1 The size of green space is essential for maximizing utilization especially for physical activity [86,89-90]. | Medium | High | Medium | High |
| | 2.2 In cases where large areas are not allocated, designing a small network of parks can be useful for bridging activities such as running and cycling paths [86-87]. | Medium | Medium | Medium | Medium |
| 3. Arranging equipment and facilities suitable for users | 3.1 Should provide facilities for a variety of activities [86-90]. | Medium | Medium | Medium | High |
| | 3.2 Allocate open space for group activities or public activities [86,90]. | Medium | Low | Medium | High |
| | 3.3 Provide facilities to support indirect activities such as drinking water points, chairs, and picnic tables [86-88]. | Medium | Medium | Medium | High |
| | 3.4 Take into account the diversity of users' age groups and genders [86-87]. | Medium | Medium | Medium | High |
| 4. Preserve the public parks beauty and cleanliness | 4.1 Designing a natural space that can be maintained easily in all seasons and weather conditions [86]. | Medium | Medium | Medium | High |
| | 4.2 Design and use equipment according to safety standards [86,88]. | High | Medium | Medium | High |
| | 4.3 Engage with communities and user networks to jointly monitor safety [86]. | Medium | Low | Low | High |
| 5. Recreational activities | 5.1 Set up a calendar of activities to attract park visitors. For example, sports competitions, music events, talk shows, meditation, etc. [86]. | High | Low | Medium | High |
| 6. Tax incentives | 6.1 The landowner should receive a tax reduction for providing the green space to the public for general access [91]. | Medium | High | Low | High |
| | 6.2 Empty space should be required to pay an additional tax every 3 years [92]. | Medium | High | Low | High |
| 7. Innovative technological platforms | 7.1 Drones [77]. | Medium | High | Low | High |
| | 7.2 Remote sensing [79]. | Medium | High | Low | High |
| | 7.3 Satellite imagery [85]. | Medium | High | Low | High |

First, an urban development master plan should take into account integrating green space and public parks [87]. In 2023, the Bangkok Council passed Agenda 1, 'Draft Green Space Ordinance', stipulating that every newly constructed, repaired, or extended building must have green space of 50% of the available space outside the building [63]. Like many other countries, such as Singapore, the US, and Switzerland, Thailand should have specialized institutions that oversee and maintain its national urban green spaces. In keeping with SDG Move's suggestions, all demographics, including children, adults, the elderly, those with disabilities, and low-income groups should be considered when designing for accessibility [87-88]. The park's accessibility features, such as washrooms, vault toilets, change houses, parking, adaptive equipment for disabilities, surrounding bike lanes and sidewalks, should be utilized to promote community and increase service use [87-90]. Additionally, public transit is required to get to public parks (e.g., bus, subway, monorail, tram, and ferry).

Second, the size of a green space is essential for maximizing its use, particularly for physical exercise [87, 90-91]. In line with SDG Move's recommendations, designing a small network of parks can be helpful for bridging activities like jogging and cycling pathways in situations where vast areas are not allocated [87-88].

Third, facilities for a range of activities should be available [87–91]. Open space should be set aside for communal or public events [87, 91]. Indirect activities will be supported by the provision of amenities, including drinking water stations, chairs, and picnic tables [87–89]. A range of age and gender categories among users should be taken into account [87–88]. Moreover, it is important to use techniques or instruments for evaluating the quality of urban green space. These could help in establishing high standards for urban green space. Examples of well-designed public parks in Thailand include: Nongnooch Garden Pattaya, Queen Sirikit Botanic Garden, Suan Luang RAMA IX, Mae Fah Luang Garden, Vachirabenjatas Park (Rot Fai Park), Santi Chai Prakan Park, Romaneenart Park, Benjasiri Park, CU Centenary Park, Benchakitti Park, and Lumphini Park.

Fourth, it is important to create a natural area that is easy to maintain throughout the year, regardless of the weather, which is consistent with SDG Move's advice [87]. The park's equipment has to be created in accordance with safety regulations [87, 89]. Participation in user networks and communities is necessary to cooperatively monitor safety [87]. Owing to current park maintenance, staff and volunteers run the park primarily. As of yet, not many residents in the surrounding communities are involved. Fifth, a calendar of events should be established to entice visitors to the park. For instance, these could include sporting events, musical performances, talk shows, meditation, etc [87]. Every Saturday and Sunday during specific months in Thailand, there are music festivals held in parks but most of them are limited to Bangkok. Sixth, the provision of the green space to the general public for access should result in a tax break for the proprietor, which corresponds with the suggestion of Pranisa Boonkham, Vice President for Academic Affairs and Assistant Professor in Landscape Architecture, Thammasat University [92]. Moreover, there should be a new tax on vacant space assessed every three years. This recommendation was supported by Korakoch Atthasakulchai, Senior Executive Director, Chief Non-Capital Market Solution, KBank Private Banking, Thailand [93]. Like the US, Thailand may use city taxpayers to manage the development of urban green spaces. The revenue from these new taxes can be used to develop urban green space in Thailand due to financial limitations. However, Thailand still does not have this type of green space tax. Finally, the application of innovative technological platforms is necessary to develop and maintain urban green spaces, such as drones [77], remote sensing [79], and satellite Imagery [85]. Nevertheless, the availability of these technologies is now restricted due to their high cost and the requirement for specialized skills.

## Discussion and conclusions

We have covered a variety of topics relating to urban green space in this review study, with a particular emphasis on the situation in Thailand. First, we talked about the general understanding of urban green space and how Thailand's long-term goal of developing urban green space may be impacted by the different definitions of "green space" used by Thailand compared to those used by the WHO, the US EPA, and the EEA. Second, we discussed the rationale, benefits, and co-benefits of having more urban green space, including those related to the economy, society, health, and environment. Third, we reviewed the current challenges facing Thailand's green spaces, such as the average distance from the community to the nearest green space, the unequal distribution of the city's public green spaces, financial constraints, the low priority of green space, and the quality, accessibility, and safety of urban green spaces or public parks. Fourth, we showed Thailand's short- and long-term goals to increase green space in the country. Fifth, we discussed the techniques or instruments for evaluating the quality, planning, strategy, and location selection of urban green spaces. Sixth, we presented the intriguing policies and practice approaches related to green spaces in various developed countries, such as Singapore, the United States, Canada, the Netherlands, Germany, and Switzerland. Several of

these countries have their own organizations or agencies that construct and manage green space. In addition, they place a strong premium on developing green spaces in their nation and have numerous initiatives with sufficient funding. Urban green spaces in Thailand should be maintained and administered by particular government agencies, such as the Green Spaces and Environment Department. Furthermore, the development of urban green spaces may be overseen by city taxpayers. Interesting platforms and technologies have also been introduced in the development and management of urban green spaces. Lastly, we suggested guidelines for improving green space that are appropriate for Thailand's circumstances, such as improved accessibility (i.e., public transit, parking, restroom, disability-specific equipment, sidewalks and bike lanes), appropriate size, appropriate distance from the community, suitable facilities and equipment for the users (e.g., drinking water stations, chairs, and picnic tables), preserving the beauty and cleanliness, recreational activities, tax incentives, and modern technology platforms. The long-term development, management, and maintenance of Thailand's high-potential urban green spaces could benefit from the recommendations of this study for policymakers.

Our review study identified gaps and issues with urban green spaces in Thailand in order to assess the potential for their development. The restricted funding for utilizing it to create, develop, and maintain urban green space is one of the primary problems. We propose that tax incentives, such as those paid by local taxpayers, could be additional sources of funding. More research is required to make it more practical by examining policies, damage costs associated with urban green space, cost-benefit analysis, and the willingness of city taxpayers to annually fund the expansion of urban green space in Thailand.

## Acknowledgement

The Second Century Fund (C2F) from Chulalongkorn University provided funding for this study.

## References

[1] Adopted from United States Environmental Protection Agency's 'What is open space / green space?'. [Online] Available from: https://www3.epa.gov/region1/eco/uep/openspace.html [Accessed 26 July 2023].

[2] The WHO Regional Office for Europe. Urban green spaces and health. 2016. [Online] Available from: https://apps.who.int/iris/handle/10665/345751 [Accessed 26 July 2023].

[3] Adopted from European Environment Agency Website's 'Green Space'. [Online] Available from: https://www.eea.europa.eu/help/glossary/gemet-environmental-thesaurus/green-space [Accessed 27 September 2023].

[4] Office of natural resources and environmental policy and planning (Thailand). Green Space, 2021. [Online] Available from: https://www.onep.go.th/พื้นที่สีเขียว/ [Accessed 26 July 2023]. (in Thai)

[5] Stessens, P., Canters, F., Huysmans, M., Khan, A. Z. Urban green space qualities: An integrated approach towards GIS-based assessment reflecting user perception. Land Use Policy, 2020, 91, 104319.

[6] Wu, J., Wang, M., Li, W., Peng, J., Huang, L. Impact of urban green space on residential housing prices: Case study in Shenzhen. Journal of Urban Planning and Development, 2015, 141 (4), 05014023.

[7] Zambrano-Monserrate, M.A., Ruano, M.A., Yoong-Parraga, C., Silva, C.A. Urban green spaces and housing prices in developing countries: A Two-stage quantile spatial regression analysis. Forest Policy and Economics, 2021, 125, 102420.

[8] Saeed, A.A., Mullahwaish, L.T. Effect of green areas density on real estate price in Ramadi city. International Journal of Design and Nature and Ecodynamics, 2020, 15(2), 253–259.

[9] Sanches, P.M., Pellegrino, P.R.M. Greening potential of derelict and vacant lands in urban areas. Urban Forestry & Urban Greening, 2016, 19, 128–139.

[10] Piaggio, M. The value of public urban green spaces: Measuring the effects of proximity to and size of urban green spaces on housing market values in San Jos'e, Costa Rica. Land Use Policy, 2021, 109, 105656.

[11] Zhou, H., Liu, Y., He, M. The spatial interaction effect of green spaces on urban economic growth: Empirical evidence from China. International Journal of Environmental Research and Public Health, 2022, 19(16), 10360.

[12] Jennings, V., Bamkole, O. The relationship between social cohesion and urban green space: An avenue for health promotion. International Journal of Environmental Research and Public Health, 2019, 16(3), 452.

[13] Giorgio, F., Angelo, B., Maria Vittoria, M. Green space for health promotion. Journal of Advanced Health Care, 2020, 4, 5–12.

[14] Douglas, O., Lennon, M., Scott, M. Green space benefits for health and well-being: A life-course approach for urban planning, design and management. Cities, 2017, 66, 53–62.

[15] Hunter, R.F., Cleland, C., Cleary, A., Droomers, M., Wheeler, B. W., Sinnett, D., …, Braubach, M.

Environmental, health, wellbeing, social and equity effects of urban green space interventions: A meta-narrative evidence synthesis. Environment International, 2019, 130, 104923.

[16] Jabbar, M., Yusoff, M.M., Shafie, A. Assessing the role of urban green spaces for human well-being: A systematic review. GeoJournal, 2022, 87, 4405–4423.

[17] Alcock, I., White, M.P., Wheeler, B.W., Fleming, L.E., Depledge, M.H. Longitudinal effects on mental health of moving to greener and less green urban areas. Environmental Science and Technology, 2014, 48, 1247–1255.

[18] Astell-Burt, T., Hartig, T., Eckermann, S., Nieuwenhuijsen, M., McMunn, A., Frumkin, H., Feng, X. More green, less lonely? A longitudinal cohort study. International Journal of Epidemiology, 2022, 51, 99–110.

[19] Yang, T., Barnett, R., Fan, Y., Li, L. The effect of urban green space on uncertainty stress and life stress: A nationwide study of university students in China. Health and Place, 2019, 59, 102199.

[20] Zhan, D., Zhang, Q., Kwan, M. P., Liu, J., Zhan, B., Zhang, W. Impact of urban green space on self-rated health: Evidence from Beijing. Frontiers in Public Health, 2022, 10, 999970.

[21] Zhang, Z., Jia, Z., Zhou, Z. Can urban green space cure homesickness? Case study on China poverty alleviation migrants in Anshun, Guizhou. Urban Forestry and Urban Greening, 2022, 68, 127478.

[22] Gong, Y., Palmer, S., Gallacher, J., Marsden, T., Fone, D. A systematic review of the relationship between objective measurements of the urban environment and psychological distress. Environment International, 2016, 96, 48–57.

[23] Weerasuriya, R., Henderson-Wilson, C., Townsend, M. A systematic review of access to green spaces in healthcare facilities. Urban Forestry & Urban Greening, 2019, 40, 125–132.

[24] Astell-Burt, T., Feng, X., Kolt, G.S. Does access to neighborhood green space promote a healthy duration of sleep? Novel findings from a cross-sectional study of 259 319 Australians. BMJ Open, 2013, 3, e003094.

[25] Shin, J.C., Parab, K.V., An, R., Grigsby-Toussaint, D.S. Greenspace exposure and sleep: A systematic review. Environmental Research, 2020, 182, 109081.

[26] Ali, O., Nardo, F. Di, Harrison, A., Verma, A. The link between perceived characteristics of neighbourhood green spaces and adults' physical activity in UK cities: analysis of the EURO-URHIS 2 Study. European Journal of Public Health, 2017, 27(4), 761–765.

[27] Gong, Y., Gallacher, J., Palmer, S., Fone, D. Neighbourhood green space, physical function and participation in physical activities among elderly men: the Caerphilly Prospective study. International Journal of Behavioral Nutrition and Physical Activity, 2014, 11(40).

[28] Hong, A., Sallis, J.F., King, A.C., Conway, T.L., Saelens, B., Cain, K.L., …, Frank, L.D. Linking green space to neighborhood social capital in older adults: The role of perceived safety. Social Science and Medicine, 2018, 207, 38–45.

[29] Haas, W. De, Hassink, J., Stuiver, M. The role of urban green space in promoting inclusion: Experiences from the Netherlands. Frontiers in Environmental Science, 2021, 9.

[30] Jennings, V., Larson, L., Yun, J. Advancing sustainability through urban green space: Cultural ecosystem services, equity, and social determinants of Health. International Journal of Environmental Research and Public Health, 2016, 13(2), 196.

[31] Krellenberg, K., Artmann, M., Stanley, C., Hecht, R. What to do in, and what to expect from, urban green spaces – Indicator-based approach to assess cultural ecosystem services. Urban Forestry & Urban Greening, 2021, 59, 126986.

[32] Comstock, N., Dickinson, L.M., Marshall, J.A., Soobader, M.J., Turbin, M.S., Buchenau, M., Litt, J.S. Neighborhood attachment and its correlates: Exploring neighborhood conditions, collective efficacy, and gardening. Journal of Environmental Psychology, 2010, 30(4), 435–442.

[33] Hosseini, F., Sajadzadeh, H., Aram, F., Mosavi, A. The impact of local green spaces of historically and culturally valuable residential areas on place attachment. Land, 2021, 10(4), 351.

[34] Yang, Y., Ji, X., Deng, L., Ma, R. How does a good environment affect firms' productivity? evidence from urban public green spaces in China. Frontiers in Energy Research, 2022, 10.

[35] Wellbeing, C. How green spaces can influence employees' productivity and happiness. The Urban Media Lab, 2020.

[36] Sakhvidi, M.J.Z., Knobel, P., Bauwelinck, M., Keijzer, C. de, Boll, L.M., Spano, G., …, Dadvand, P. Greenspace exposure and children behavior: A systematic review. Science of the Total Environment, 2022, 824, 153608.

[37] Foellmer, J., Kistemann, T., Anthonj, C. Academic greenspace and well-being — Can campus landscape be therapeutic? Evidence from

a German University. Wellbeing, Space and Society, 2021, 2, 100003.

[38] Baycan, T., Girard, L.F., Nijkamp, P. Chapter 1: Creative and sustainable cities: A new perspective. In Sustainable city and creativity. Ashgate: Surrey, UK, 2012.

[39] Walsh, L.E., Mead, B.R., Hardman, C.A., Evans, D., Liu, L., Falagan, N., …, Davies, J. Potential of urban green spaces for supporting horticultural production: A national scale analysis. Environmental Research Letters, 2022, 17, 014052.

[40] Castelli, K.R., Silva, A.M., Dunning Jr, J.B. Improving the biodiversity in urban green spaces: A nature based approach. Ecological Engineering, 2021, 173, 106398.

[41] Martens, D., Oztьrk, O., Rindt, L., Twarok, J., Steinhardt, U., Molitor, H. Supporting biodiversity: Structures of participatory actions in urban green spaces. Frontiers in Sustainable Cities, 2022, 4.

[42] Dadvand, P., de Nazelle, A., Triguero-Mas, M., Schembari, A., Cirach, M., Amoly, E., …, Nieuwenhuijsen, M. Surrounding greenness and exposure to air pollution during pregnancy: An analysis of personal monitoring data. Environmental Health Perspectives, 2012, 120(9), 1286–1290.

[43] Fong, K., Hart, J.E., James, P. A review of epidemiologic studies on greenness and health: Updated literature through 2017. Current Environmental Health Reports, 2018, 5(1), 77–87.

[44] Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A.M., …, Fuertes, E. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. Environmental Research, 2017, 158, 301–317.

[45] Takebayashi, H. Influence of urban green area on air temperature of surrounding built-up area. Climate, 2017, 5(3).

[46] Twohig-Bennett, C., Jones, A. The health benefits of the great outdoors: A systematic review and meta- analysis of greenspace exposure and health outcomes. Environmental Research, 2018, 166, 628–637.

[47] Strohbach, M.W., Arnold, E., Haase, D. The carbon footprint of urban green space—A life cycle approach. Landscape and Urban Planning, 2012, 104(2), 220–229.

[48] Sahoo, G., Sharma, A., Dash, A.C. Biomass from trees for bioenergy and biofuels – A briefing paper. Materials Today Proceedings, 2022, 65(10), 461–467.

[49] World Bank. Urbanization in Thailand is dominated by the Bangkok urban area. 2015. [Online] Available from: https://www.worldbank.org/en/news/feature/2015/01/26/urbanization-in-thailand-is-dominated-by-the-bangkok-urban-area [Accessed 30 July 2023].

[50] World Population Review. Thailand Population 2021. 2021. [Online] Available from: https://worldpopulationreview.com/countries/thailand-population [Accessed 29 July 2022].

[51] Office of Natural Resources and Environmental Policy and Planning (Thailand). Environmental quality management plan 2023–2027, 2022. (in Thai)

[52] Office of Natural Resources and Environmental Policy and Planning (Thailand). Quantitative green space data at municipal level, 2019. (in Thai)

[53] World Health Organization. Urban planning and human health in the European City, Report to the World Health Organisation, International Society of City and Regional Planners (ISOCARP), 2009.

[54] Rujivanarom, P., Wancharoen, S. Solving the city's lack of green space. [Online] Available from: https://www.bangkokpost.com/thailand/general/2303294/solving-the-citys-lack-of-green-space [Accessed 31 July 2023].

[55] Chaichumkhun, J. Behind the problems of green space in the city that the BMA did not tell (in Thai). 2022. [Online] Available from: https://thematter.co/bkk65/problem-of-green-space-in-bkk/174780 [Accessed 31 July 2023].

[56] Adopted from Alicia Biasotti. The challenges of urban green spaces and how they might be resolved. [Online] Available from: https://www.acbconsultingservices.com/sustainable-construction-project-management/the-challenges-of-urban-green-spaces-and-how-they-might-be-resolved/ [Accessed 1 August 2023].

[57] Orr, S., Paskins, J., Chaytor, S. Valuing Urban green space: Challenges and opportunities. In UCL Policy Briefing, 2014.

[58] Costa, C.S., Erjavec, I.S., Mathey, J. Green spaces – a key resources for urban sustainability The green keys approach for developing green spaces. Urbani Izziv, 2008, 19(2), 199–211.

[59] Haaland, C., van den Bosch, C.K. Challenges and strategies for urban green-space planning in cities undergoing densification: A review. Urban Forestry and Urban Greening, 2015, 14, 760–771.

[60] Wang, D., Brown, G., Liu, Y. The physical and non-physical factors that influence perceived access to urban parks. Landscape and Urban Planning, 2015, 133, 53–66.

[61] Perez-Tejera, F., Anguera, M.T., Guardia-Olmos, J., Dalmau-Bueno, A., Valera, S. Examining perceived

safety and park use in public open spaces: The case of Barcelona. Journal of Environmental Psychology, 2022, 81, 101823.

[62] Sittipunt, C. Plant a million trees to create green spaces and dust filter walls throughout Bangkok. 2022. [Online] Available from: https:// www.chadchart.com/policy/6215eef94e43cd8b4760bc16/ [Accessed 2 August 2023]. (in Thai)

[63] iGreen. Draft Green Area Regulations. 2023. [Online] Available from: https://www.igreenstory.co/bangkok-council-green-space/amp/ [Accessed 2 August 2023]. (in Thai)

[64] Sittipunt, C. 15-minute park in Bangkok. 2022. [Online] Available from: https://www.chadchart.com/policy/6217294d4e43cd8b4760bc6c/ [Accessed 2 August 2023]. (in Thai)

[65] Nanta, P. Guidelines for increasing green space and assessing the potential of green space in Vadhana District, Bangkok. 2020. [Online] Available from: https://so05.tci-thaijo.org/index.php/sarasatr/article/view/242258 [Accessed 6 August 2023]. (in Thai)

[66] Adopted from Essex Planning Officers Association (EPOA)'s 'Successful criteria for public open spaces'. [Online] Available from: https://www.essexdesignguide.co.uk/design-details/landscape-and-greenspaces/successful-criteria-for-public-open-spaces/ [Accessed 6 August 2023].

[67] Stessens, P., Canters, F., Huysmans, M., Khan, A. Z. Urban green space qualities: An integrated approach towards GIS-based assessment reflecting user perception. Land Use Policy, 2020, 91, 104319.

[68] Senik, B., Uzun, O. A process approach to the open green space system planning. Landscape and Ecological Engineering, 2022, 18, 203–219.

[69] Gelan, E. GIS-based multi-criteria analysis for sustainable urban green spaces planning in emerging towns of Ethiopia: The case of Sululta town. Environmental Systems Research, 2021, 10(13).

[70] Urban Creature. Explore 10 cities with the greenest areas in the world. 2020. [Online] Available from: https://urbancreature.co/greenspace-trees/ [Accessed 7 August 2023]. (in Thai)

[71] Adopted from A Singapore Government Agency Website's 'A City of Green Possibilities'. [Online] Available from: https://www.greenplan.gov.sg/ [Accessed 7 August 2023].

[72] The Citizenplus Thai PBS. Green space and the city of St. Louis, Missouri. 2022. [Online] Available from: https://thecitizen.plus/node/62707 [Accessed 7 August 2023]. (in Thai)

[73] Tana. Green Society and "5 Green Cities" that you must visit once in your life. 2019. [Online] Available from: https://homedeedee.com/green-society-กับ-5-เมืองสีเขียว-ที่ในชีวิตต้องไปให้ได้สักครั้ง/ [Accessed 7 August 2023]. (in Thai)

[74] TNN Online. Green policy "Berlin", the capital city of Germany. 2022. [Online] Available from: https://www.tnnthailand.com/news/earth/114386/ [Accessed 7 August 2023]. (in Thai)

[75] Adopted from Hisour's 'Urban environment and green spaces of Geneva, Switzerland'. [On;ine] Available from: https://www.hisour.com/urban-environment-and-green-spaces-of-geneva-switzerland-58240/ [Accessed 8 August 2023].

[76] Isranews. 'Green space', an index measuring happiness for Bangkokians, while Bangkok is still far from 'green space'. 'Environmental city'. 2022. [Online] Available from: https://www.isranews.org/article/isranews-scoop/107414-isranews-246.html [Accessed 12 November 2023]. (in Thai)

[77] Fr ckiewicz, M. Can drones be used for monitoring and mapping of changes in urban green spaces?. 2020. [Online] Available from: https://ts2.space/en/can-drones-be-used-for-monitoring-and-mapping-of-changes-in-urban-green-spaces/#gsc.tab=0 [Accessed 17 November 2023].

[78] Adopted from Drone Survey Services's 'Disadvantages of Drone Surveying: Understanding the Cons'. [Online] Available from: https://dronesurveyservices.com/drawbacks-of-drone-surveying/ [Accessed 26 November 2023].

[79] Shahtahmassebi, A.R., Li, C., Fan, Y., Wu, Y., Lin, Y., Gan, M., …, Blackburn, G.A. Remote sensing of urban green spaces: A review. Urban Forestry & Urban Greening, 2021, 57, 126946.

[80] Parmehr, E.G., Amati, M., Taylor, E.J., Livesley, S.J. Estimation of urban tree canopy cover using random point sampling and remote sensing methods. Urban Forestry & Urban Greening, 2016, 20, 160–171.

[81] Shojanoori, R., Shafri, H.Z.M., Mansor, S., Ismail, M.H. Generic rule-sets for automated detection of urban tree species from very high-resolution satellite data. Geocarto International, 2018, 33(4).

[82] Chance, C.M., Coops, N.C., Plowright, A.A., Tooke, T.R., Christen, A., Aven, N. Invasive shrub mapping in an urban environment from hyperspectral and LiDAR-derived attributes. Frontiers in Plant Science, 2016, 7.

[83] Nasi, R., Honkavaara, E., Blomqvist, M., Lyytikainen-Saarenmaa, P., Hakala, T., Viljanen, N., …,

Holopainen, M. Remote sensing of bark beetle damage in urban forests at individual tree level using a novel hyperspectral camera from UAV and aircraft. Urban Forestry & Urban Greening, 2018, 30, 72–83.

[84] Spatial Post. Exploring the pros and cons: Advantages and disadvantages of remote sensing. 2023. [Online] Available from: https://www.spatialpost.com/advantages-and-disadvantages-of-remote-sensing/ [Accessed 26 November 2023].

[85] Utilities One. Applications of satellite imagery in urban green spaces planning and design. 2023. [Online] Available from: https://utilitiesone.com/applications-of-satellite-imagery-in-urban-green-spaces-planning-and-design [Accessed 18 November 2023].

[86] Frackiewicz, M. An analysis of the limitations and challenges of satellite imagery. 2023. [Online] Available from: https://ts2.space/en/an-analysis-of-the-limitations-and-challenges-of-satellite-imagery/#gsc.tab=0 [Accessed 18 November 2023].

[87] Chandrasiri, O. Green area: The heart of a sustainable city. 2022. [Online] Available from: https://www.sdgmove.com/2022/10/22/greenfield-sustainable-city/ [Accessed 3 August 2023]. (in Thai)

[88] Chuang, I.T., Benita, F., Tunзer, B. Effects of urban park spatial characteristics on visitor density and diversity: A geolocated social media approach. Landscape and Urban Planning, 2022, 226, 104514.

[89] Perry, M.A., Devan, H., B.Phty, H.F., B.Phty, K. H., B.Phty, L.-T.L., B.Phty, J.R. Accessibility and usability of parks and playgrounds. Disability and Health Journal, 2018, 11(2), 221–229.

[90] Zhang, S., Zhou, W. Recreational visits to urban parks and factors affecting park visits: Evidence from geotagged social media data. Landscape and Urban Planning, 2018, 180, 27–35.

[91] Wang, H., Dai, X., Wu, J., Wu, X., Nie, X. Influence of urban green open space on residents' physical activity in China. BMC Public Health, 2019, 19, 1093.

[92] Isranews. The community participated in creating 'Green Space', the way to 'Environmentally Sustainable City'. 2022. [Online] Available from: https://isranews.org/article/isranews-scoop/107431-isranews-247.html [Accessed 3 August 2023]. (in Thai)

[93] The Active. Design a 'policy proposal' to create a new green area. 2022. [Online] Available from: https://theactive.net/news/urban-20220919/ [Accessed 3 August 2023]. (in Thai)