THE RELATIONSHIP BETWEEN POPS AND PUBLIC OPEN SPACE SYSTEM BASED ON SPATIAL POINT PATTERN ANALYSIS IN TAIPEI CITY, TAIWAN

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Abstract

In Taiwan, to achieve the goal of improving urban environment and disaster prevention capacity, some urban renewal development projects could apply for additional floor area bonus and result in part of the private property turn into the privately owned public space (POPS). Certain properties have become a unique existence in the open space system.

From 1980s, Taiwan government have provided incentives in exchange for more public open space through legal system, i.e. Zoning Code, Urban Renewal Act and Land Use Regulation, as a result, 483 POPS had developed from 1983 to 2013. Many local research have explored the effect of the individual POPS to the regular open space and proposed better usage and management of POPS. However, there is lack of debate about private property and the relevance of entire POPS system with open space network. Moreover, in most cases, the lack of proper and flexible design guidelines and review system could also result in poor design and limited usage due to the unwillingness of private owners. Accordingly, POPS could not serve better function to the surrounding built environment and citizens.

Hence, this paper will discuss the relationship between existing POPS and public open space system based on spatial point pattern analysis, choosing Taipei City, Taiwan as a case study area. This paper will expect to provide some information for better policy of public space system in Taipei.

1. Research background

To achieve the goal of improving the urban environment and the capacity for disaster prevention, some building site owners can apply for additional floor area bonuses that results in part of the private property being converted into privately owned public spaces (POPSs). A lot of POPSs started up after the Taipei City government formulated the Regulations on Taipei Land Use Control in 1983. Then, some regulations, the Detail Plan for Keelung River Surrounding Area in 1994 and the Regulations of Bulk Reward for Urban Renewal in 1999, followed. The number of POPSs increased to 483 from 1983 to 2013.

The concept for the POPS regulations is good, but many people have questioned the openness of POPSs in residential zones. In 1997, POPSs became a social issue related to the applicability of their location and management. After that, the Regulations on Taipei Land Use Control were amended to cancel the bulk reward, extra floor area rewards for new building construction project, for residential zones. In 2014, the same issue arose, and it was reported that people wouldn't want to be converted to POPSs. Therefore, it is necessary to review whether the conversion to POPSs was able to achieve the primary goal for such spaces. In addition, the locations of POPSs were chosen on the basis of the laws without considering the entire planning scope. Hence, this paper discusses the relationship between existing POPSs and the public open space system itself.

2. Literature review

2.1 The relationship between POPS and public open space system in Taipei

In high density cities, it is difficult to get extra open spaces. In order to improve the existing open space system, one solution has been to create building lots to provide open spaces. In New York City, since the 1890's, a lot of skyscrapers have emerged in order to gain height and volume, resulting in some problems in the urban environment. As a result, the 1916 zoning resolution created a sense of openness, also known as "light and air," at the street level. Further, the Voorhees draft in 1958 proposed the first concept related to POPSs. "In order to bring more light and air into streets surrounded by tall buildings, as well as to create more usable open space, a bonus device has been established to encourage the setting back of buildings from the street line." (Kayden, J, S., 2000). Likewise, Taipei, as the capital of Taiwan, faces same problems related to the environment in open spaces. In addition, the city cannot expand its borders due to limitations related to basin and range topography. The urban growth is close to a saturation point, so it cannot afford more construction in open space land. That is to say, it is more important to improve open space system by putting in a strategic number of POPSs. The POPS policy has been in operation for 30 years. However, the question remains as to whether it has actually achieved the goal of improving the open space system. The literature review makes it clear that there has been limited discussion of the entire POPS system. Therefore, this paper discusses the contribution of POPS to the open space system. In the next section, we review the legal and planning purposes of POPS.

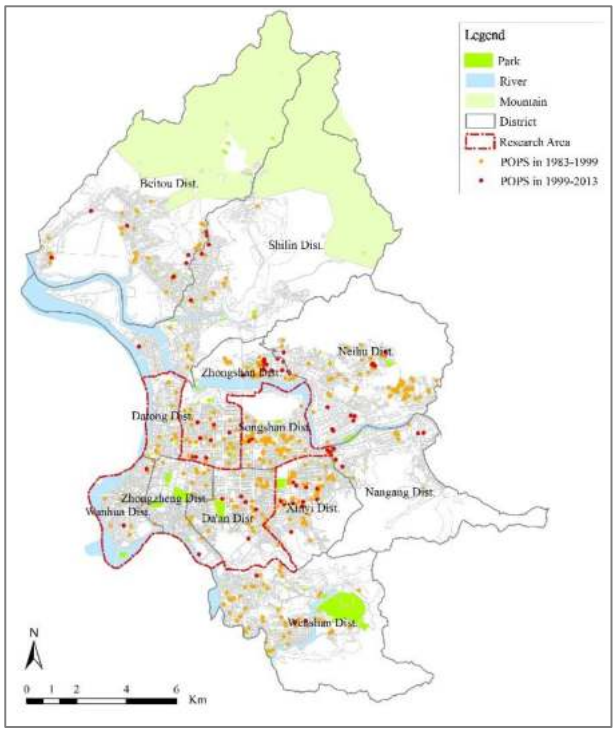


Figure 1. Location of existing open space and POPS in Taipei

2.2 Legal and planning purpose of POPS

The legal ground of POPS with a bulk reward in Taipei includes the Regulations on Taipei Land Use Control, Regulations of Bulk Reward for Urban Renewal and Detail Plan. The purpose of these laws is to improve the urban environment and to shape an open space network.

In 1983, Article 26 of Taipei City's Enforcement Rules of Urban Planning Law, Taipei first executed Land Use Control in Taiwan. In Chapter 11, the Comprehensive Design and Bulk Reward Regulations encouraged small building lots to merge into entire blocks in order to provide centralized open spaces for the public. The government use a carrot-and-stick approach to establish the rules of operation, management and rewards for POPS. In order to prevent budget increases, the urban environment had shared open public spaces (Huang, J. N., 2004). The locations of POPSs were ordered in residential zones, commercial zones and market land. However, POPSs located in residential zones caused many management problems at that time. Hence, residential zones were canceled as reward sites in 1999. After 1994, some planned areas had more design standards for POPSs but were still limited to commercial zones and high density land use as reward areas. Regulations of Bulk Reward for Urban Renewal was published in 1999. Among the rewards for planning and design (△F5), it was encouraged that building lots remain open spaces or plazas. In addition, sites could get bulk rewards by redeveloping urban renewal areas.

According to the policy review, we can classify the POPS policy into two phases. The first phase is the initial period from 1983 to 1999. It delineated general rules for locations and specifications at that time. However, the second phase started after 1999 and incorporated strategic rules. High density land use and urban renewal areas were its bulk reward objects. Table 1 shows the open space type. There are strip-type, plaza-type, pedestrian decks, arcades, sidewalks, etc.

After a review the three legal grounds of POPSs, the role of POPS laws in the entire open space system is discussed. Figure 2 shows the legal hierarchy of open space planning. In the open space system, POPS can remedy the weaknesses of the parks planning and green fields systems in order to improve environmental quality and the capacity for disaster prevention. Lin (1995) defended the open space system. POPS is part of the patch elements of the open space system. In addition, open spaces in building lots can be divided into two types: statutory open spaces and POPSs. Extra bulk rewards can be used to exchange more open spaces for public as POPS (Shie, Y. C., 2006). However, the exchange between public interest and private profit in POPSs has extended the debate on this subject. That is to say, it is necessary to review the contribution of POPS to open space environments from a legal standpoint.

POPS as provided in the form of bulk rewards is one of the tools implemented for open space planning in the legal hierarchy (Huang, J. N., 2004). POPS, as a patch type, increases the completeness of the entire open space network. However, the competition between three legal grounds causes developers to prefer building lots with higher bulk rewards and fewer specifications (Yang, S. Y., 2007). POPS cannot be located in areas with poor environmental quality as a result of the legal specifications. Next, we compare domestic and foreign policy.

Table 1. Legal and planning specification of POPS

Related laws and plans	Purpose	Locations	Open space type (specification)
Regulations on Taipei Land Use Control	• To increase park and sidewalk construction • To connect with existing open space	**1983-1999** - Residential zone, Commercial zone, Market land **After 1999** - Commercial zone, Market land	• Strip-type (50 m^2 minimum area) • Plaza-type(100m^2 minimum area) • Pedestrian deck (4.5m maximum height difference) • The atrium space on the first floor of the building

Related laws and plans		Purpose	Locations	Open space type (specification)
Regulations of Bulk Reward for Urban Renewal		• To improve poor environment • To reward sites with good design	**After 1999** - Urban renewal area	• Plaza (200m^2 minimum area)
Detail Plan	**Keelung River Surrounding Area**	• To fulfill open space demand for increasing resident	**After 1994** - Commercial zone, Entertainment zone (part of residential use is allowed)	• Plaza (200m^2 minimum area)
	Xinyi District	• To shape open space network	**After 2000** - Business facility zone, Special business zone (located in the main road)	• Strip-type (for 10-20m) • Plaza-type (accounting for more than 15% of site) • Plaza at street corner • Arcades and Sidewalk

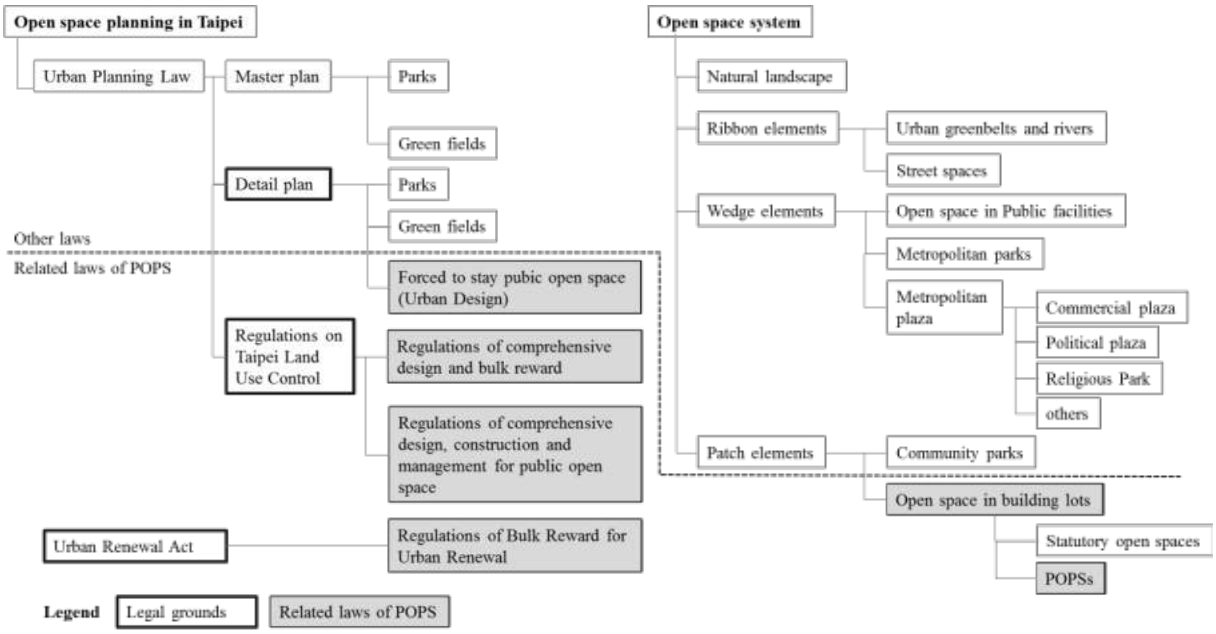


Figure 2. The relationship between POPS regulations and the open space system

2.3 Comparison of domestic and foreign policy

Because the USA was the first to use bulk rewards to encourage the private sector to retain open spaces, the Regulations of Land Use Control became more elastic. Furthermore, urban planning in Taiwan was also influenced by Japan. The regulations from Japan for comprehensive design and bulk reward were studied. Thus, in this section, we introduce the related policies in New York and Tokyo and then compare them with domestic policies.

Since the 1890's, a lot of skyscrapers have emerged in New York to incorporate a larger volume of people and activities, causing some problems in the urban environment. As a result, the 1916 zoning resolution created a sense of openness, also known as "light and air," at the street level. In 1961, New York City published The 1961 Zoning Resolution to establish bulk rewards and to give additional floor

areas a bonus, less than 20% of the original floor area ratio (FAR), for building lots providing plazas or arcades. It was the first case of a POPS bulk reward. Then the period of special purpose district from 1967-1973, the open space type became diversified, i.e. elevated plazas, through block arcades, covered pedestrian spaces, sunken plazas, open air concourses, etc. To achieve a specific goal according to an ideal situation, the New York City government formulated five special purpose districts. After 14 years of experience, in 1975, an "as-of-right" plaza was imposed with higher design standards. Then, in 1977, the "residential plaza" was proposed to differentiate it from urban plazas (Kayden, J, S., 2000). However, New York City Mayor Koch imposed overall laws in 1982. The points of the revised laws are shown as follows (Shou D. G., 1993):

1. The open space type of planning changed from a concept into a definite type with a regional planning system.
2. Forced specifications existed for some welfare facilities, i.e. locations of green fields.
3. The functions of space were required to suit daily life activities.
4. The concept of POPS standards changed from single into multiple, emphasizing functional rewards.

In Japan, the bulk rewards for open space design had two classifications: a Specific Block System and a Comprehensive Design System. In 1968, urban planning laws for land use control formulated the idea of specific blocks, having spatial standards about FAR, height, and building lines. The Building Standard Laws were revised in 1970 to enhance the Comprehensive Design System. If building lots with enough site area retained a certain percent of the area as open space and contributed to the urban environment, they were allowed more liberal specifications for FAR and height (Chen, L. F., 1995). The government of Tokyo formulated Tokyo Comprehensive Design Permission Regulations in 1988. To merge building lots into large-scale areas and keep adequate open space, the regulations liberalize the FAR and building type and ensured the environmental quality of open spaces and urban areas. However, due to the lower standards for site area (Specific Block: 5,000 m2; Comprehensive Design: 1,000-3,000 m2) in the Comprehensive Design System and the fact that it involves a simple process, it has higher usage.

After the case review, POPS foreign policy is compared with domestic policy. Due to different historical backgrounds, the primary subject of POPS development is different in each country. In New York, the USA case, POPSs play the role of improving building environmental quality in commercial zones i.e. CBD. In the case of Tokyo, Japan, the program assists with urban disaster prevention. In Taipei, Taiwan, urban renewal areas are included in reward area specification. Although the objectives are different in each country, the same goal for better open space environments is shared by all of them. However, the regulations specified for the locations of POPSs in Taiwan are generally applicable and result in uncertainty with regard to the sites developed for POPS.

Table 2. Comparison of domestic and foreign policy of POPS

Country/ Area	Purpose	Locations	Open space type (specification)
USA/ New York	**1961** • To improve urban environment	• Commercial zone, Business zone • Special purpose district	• Plazas, Arcades, Urban plazas, Residential plazas, Sidewalk widening, Open air concourses, Covered pedestrian spaces, Through block arcades, Through block gallerias, Elevated plazas, Sunken plazas

Country/ Area	Purpose	Locations	Open space type (specification)
Japan/ Tokyo	**1968** • To improve urban environment • Development of merged building lots • Urban disaster prevention	• Commercial district, Business zone, Residential zone, Industrial zone • 1,000m^2 minimum area and open space should more than 65% of site	• Plazas, Green field, Sidewalk (100-300 m^2 minimum area)
Taiwan/ Taipei	**1983** • To improve urban environment • To shape open space network	• Commercial zone, Market land • High density land use in detail plan • Urban renewal area	• Strip-type (50 m^2 minimum area) • Plaza-type (100m^2 minimum area) • Pedestrian deck (4.5m maximum height difference) • The atrium space on the first floor of the building • Plaza at street corner • Arcades and Sidewalk

2.4 Related research

Many local researchers have explored the effect of individual POPSs on regular open spaces and have as a result proposed better usage and management of POPSs. However, there is less debate about private property and the relevance of the entire POPS system in the open space network. Most methodology use questionnaires or observed phenomena for such studies, and therefore, using quantitative analysis for the study of POPSs is unusual.

From a design and management perspective, law reviews and case studies are usually the research methods (He, S. B., 1988; Lu, G. B., 1989; CPAM, 1991). From the user behavior perspective, policy advice is provided by establishing evaluation subjects and surveying properties to investigate user behavior (Chiang, W. C., 1993; Chang, W. Z., 1994; Chiu, H. Y., 1995). From the effect of openness perspective, some researchers have conducted analysis by describing phenomena, comparing cases, or by doing law reviews and case studies in order to propose improvements (Tung, Y. Y., 1999; Rou, R. H., 2003).

In the past, the main discussion of POPS-related research in Taiwan was individual spaces; nevertheless, the debate on site locations and the influence of open space systems are rare. Moreover, a successful reward system should have systemic feedback instead of patch feedback. Depending on the complete plan and management system, a carrot-and-stick approach should work (Marcus & Carolyn, 1990: 13-15).

2.5 Open space system review in Taipei City

Table 3 reviews the developed ratio of open spaces in Taipei. Over the past decade, the developed ratio increased by 7.9%, from 43.0% to 50.9%, but half of the areas planned for open spaces have not been developed. That is to say, planning areas in open space systems cannot provide expected effect, and the differences are shown in Figure 3. Furthermore, each district is compared according to its green resources per capita in Taipei. The green resources per capita in the five districts, Wanhua, Zhongzheng, Songshan, Da'an, and Datong, are lower than 10 m2. These districts are mostly located in the western area, the old developed area, which lacks public facilities. In a situation where no open spaces can be developed, it is important to increase and connect the open space network efficiently.

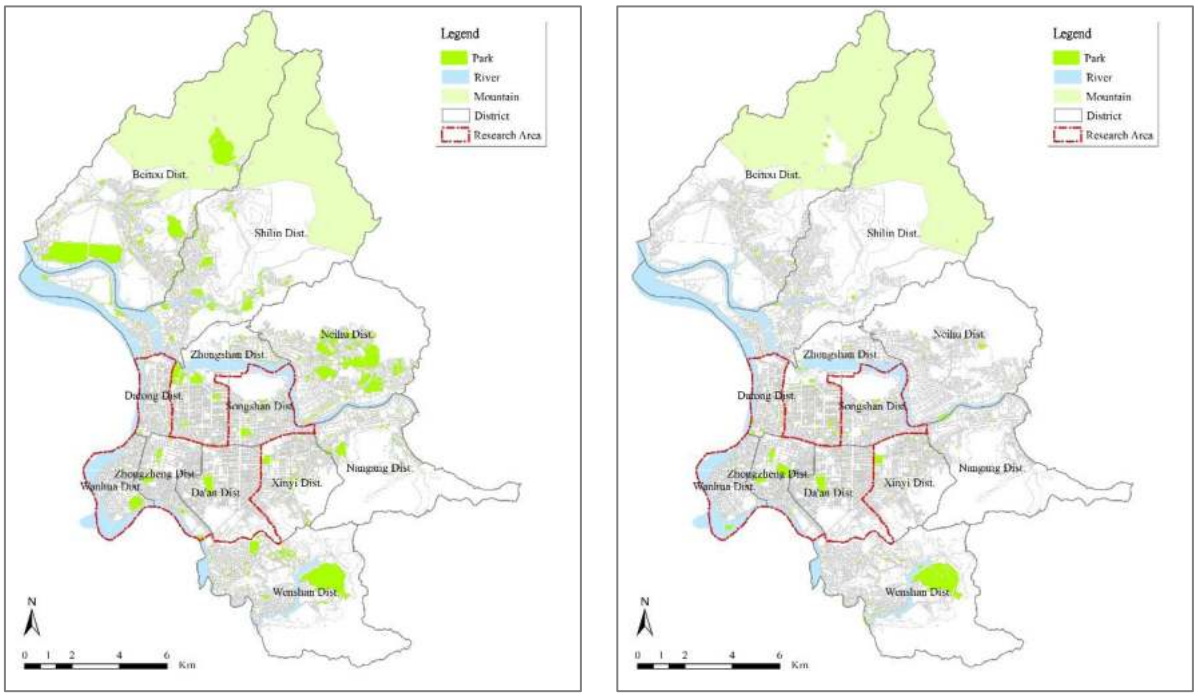
Current policies encourage building lots to remain as open spaces through the use of bulk rewards, but the contribution of POPS in areas with poor environments is still a question. Subsequent analysis will take these five districts as the research area to allow discussion of this point.

Table 3. The developed ratio of land use of open spaces in Taipei City

	Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Open space*	Planning area (ha)	1,425	1,425	1,429	1,443	1,444	1,435	1,315	1,324	1,326	1,333	1,335
	Existing area (ha)	612	617	635	630	646	664	669	669	671	677	680
Developed ratio (%)		**43.0**	**43.3**	**44.4**	**43.7**	**44.8**	**46.3**	**50.9**	**50.5**	**50.6**	**50.8**	**50.9**

* Open spaces include parks, green fields, plazas, and playgrounds

Reference: Statistical abstract of Taipei City



Open space planning system

Existing open space system

Figure 3. Comparison of planning and existing open space system

Table 4. Green resources per capita in Taipei

2013	Green resources* (ha)	Green resources per capita (m^2)	Park(m^2)	Green field (m^2)	Playground (m^2)	Riverside park (m^2)	Plaza (m^2)
Beitou Dist.	3,599	140.9	1,024,010	244,289	777	81,900	11,673
Shilin Dist.	3,998	138.0	752,103	139,083	908	523,789	10,570
Nangang Dist.	1,278	106.8	404,055	74,076	11,927	88,000	3,941
Neihu Dist.	1,727	61.1	767,550	58,732	-	477,702	5,489
Wenshan Distr.	1,580	58.2	2,059,587	22,888	-	512,853	-
Xinyi Dist.	672	29.4	406,421	45,598	-	-	87,062
Zhongshan Dist.	377	16.5	797,926	32,235	-	895,533	4,246
Wanhua Dist.	177	9.2	298,325	200	1,000	1,077,680	14,671
Zhongzheng Dist.	126	7.7	567,224	20,720	-	233,506	46,502
Songshan Dist.	122	5.8	178,742	4,860	468	872,161	-
Da'an Dist.	133	4.2	585,450	7,076	-	-	-
Datong Dist.	30	2.3	113,609	16,418	-	94,350	9,846
Total	**13,819**	**51.4**	**7,955,002**	**666,175**	**15,080**	**4,857,474**	**194,000**

* Green resources include parks, green fields, plazas, playgrounds, stadiums, educational parks, riverside parks, scenic spots, protected areas and national parks.

Reference: Statistical abstract of Taipei City

3. Methodology

The research process uses four scenarios and then compares the results of the scenario analysis. Average nearest neighbor and kernel density estimation are used as the research methods due to the spatial data type of point pattern. Through a global analysis, we can determine the intensity of clusters with POPS and open spaces in Taipei. In the average nearest neighbor analysis, the distribution of POPS and open spaces will show as clustered, random or dispersed. If the average nearest neighbor ratio is clustered, then hot spots are analyzed using a kernel density estimation in order to determine the differences among the districts. The result will show that the open space environment is improved whether or not through formulating the POPS policy, especially Wanhua, Zhongzheng, Songshan, Da'an, and Datong district.

3.1 Scenario Analysis

The literature review clarifies the planning and development of open spaces through the two phases of POPS policy. Therefore, the open space system is classified into four scenarios and shown as below. Subsequent analysis will involve a spatial point pattern analysis for four scenarios in order to compare the differences among the different scenarios and to verify whether the environment improved after executing the two phases of POPS policy.

- Scenario 1: Open space planning system (a total of 1,165; an area of 1,510.02 ha)
- Scenario 2: Existing open space system (a total of 253; an area of 397.63 ha)
- Scenario 3: Scenario 2 adds the first phase of POPS from 1983-1999 (a total of 634; an area of 466.41 ha)
- Scenario 4: Scenario 2 adds the existing POPS from 1983-2013 (a total of 736; an area of 481.11 ha)

3.2 Average Nearest Neighbor (ANN)

The null hypothesis of average nearest neighbor in hypothesis testing states that "the events are randomly distribution without clustering." The Nearest Neighbor Index is a distance statistic for point pattern data sets that gives the analyst an indication of the degree of the clustering of points (Chainey & Ratcliffe, 2005). In Average Nearest Neighbor, $\overline{D}_O$ is the average nearest neighbor distance; d is the nearest distance of dot i to dot j; n is the number of event points in study area. R is s nearest neighbor index; D¯_E is the average distance between the nearest neighbor and point.

$$\overline{D}_O = \frac{\sum d_{ij}}{n} \qquad R = \frac{\overline{D}_O}{\overline{D}_E} \tag{1}$$

The Average Nearest Neighbor is an index for evaluating point pattern distribution. If the index (Average Nearest Neighbor ratio) is less than 1, the pattern exhibits clustering. If the index is greater than 1, the trend is toward dispersion (Mitchell, A., 2005). If the index is near 1, the pattern is random.

3.3 Kernel Density Estimation (KDE)

Kernel Density is used to estimate the intensity of a spatial point pattern. Kernel Density Estimation represents the core area of design k1, k2, and uses points s1, s2 for the number of events within a core computing radius. The majority of events are assigned to different event groups, and then the density surface, the core area with a radius length τ1, τ2, will affect the accuracy of the estimates. Conceptually, a smooth, curved surface is fitted over each point. The surface value is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the search radius distance from the point (Silverman, B. W., 1986). If s represents a general location in R, and s1,…, sn are the locations of the n observed events, then density, λ(S), at s is estimated by (Bailey & Gatrell, 1995):

$$\hat{\lambda}_\tau(s) = \frac{1}{\delta_\tau(s)} \sum_{i=1}^{n} \frac{1}{\tau^2} k\left(\frac{s-s_i}{\tau}\right) \tag{2}$$

* $k()$ is a suitably chosen bivariate probability density function, known as the *kernel.*
* The parameter $\tau > 0$ is known as the *bandwidth* and determines the amount of smoothing.

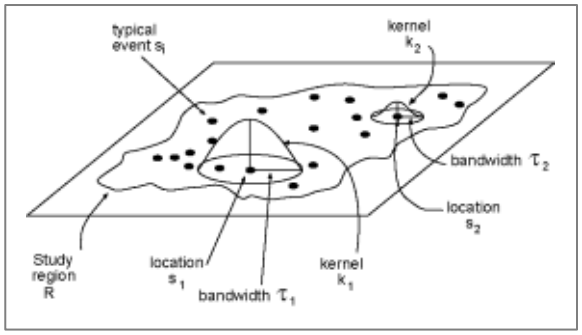


Figure 4. Kernel estimation of a point pattern
Reference: Bailey & Gatrell, 1995

4. Analysis

4.1 Average Nearest Neighbor Analysis

Table 5 shows that all of the average nearest neighbor ratios are less than 1 and that the Z-Score is less than -2.58 (P-Vale= 0.0000). That is to say, the point is a clustered distribution and allows the kernel estimation of the open space. In addition, reviewing the value of the four scenarios, the ratio of scenario 1, open space planning system, is 0.6155 more than the other scenarios. The case of scenario 1 shows that open space ideally tends toward an average distribution. In scenarios 2 to 4, the ratio become gradually smaller (from 0.6784 to 0.5541). The entire open space become more clustered after executing the different phases of POPS policy.

Table 5. Average Nearest Neighbor Analysis

Scenario	Ratio	Z-Score	P-Value	Expected Distance	Observed Distance
1	0.6155	-25.1049	0.0000	243.1777	149.6825
2	0.6784	-9.7868	0.0000	513.1923	348.1369
3	0.5585	-21.2525	0.0000	331.9157	185.3595
4	0.5541	-22.8559	0.0000	312.4617	173.1455

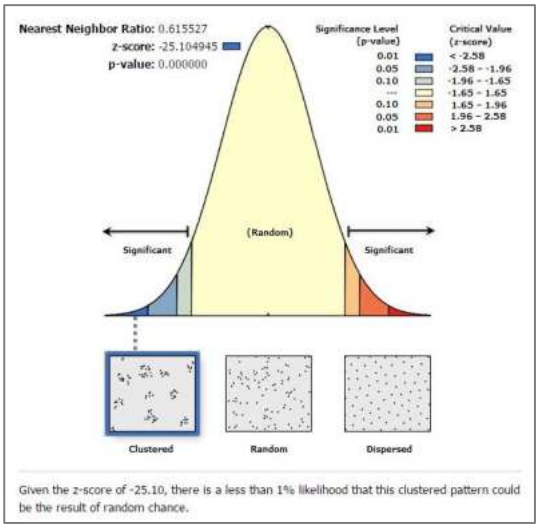


Figure 5. Scenario 1: average nearest neighbor analysis

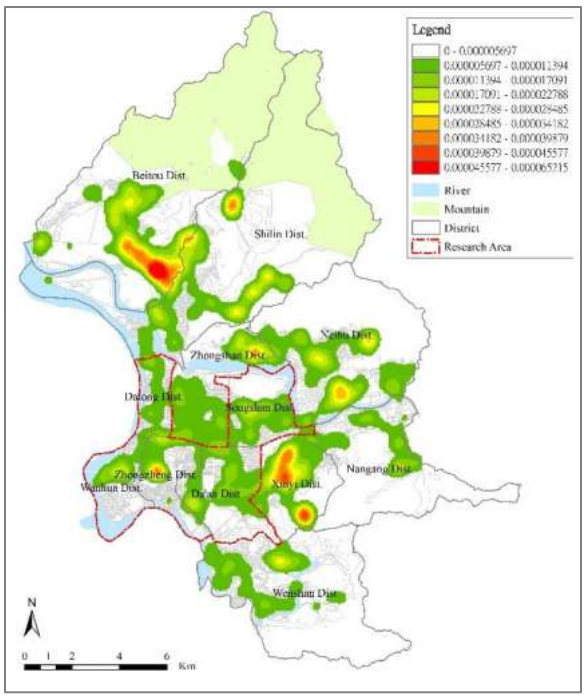
4.2 Kernel Density Estimation

Analyzing the point pattern using kernel density estimation can determine open space hot spots. Furthermore, the change tendencies for open spaces can illustrate the differences in open spaces in each district. Figure 6 shows the intensity of density. Red represents a high density open space area. White represents a low density open space area. The parameter setting is that the center of each open space is the kernel, the value of τ (bandwidth) is 600m, and grid size is $60m^2$. In the different scenarios, the open space is used for hotspot maps.

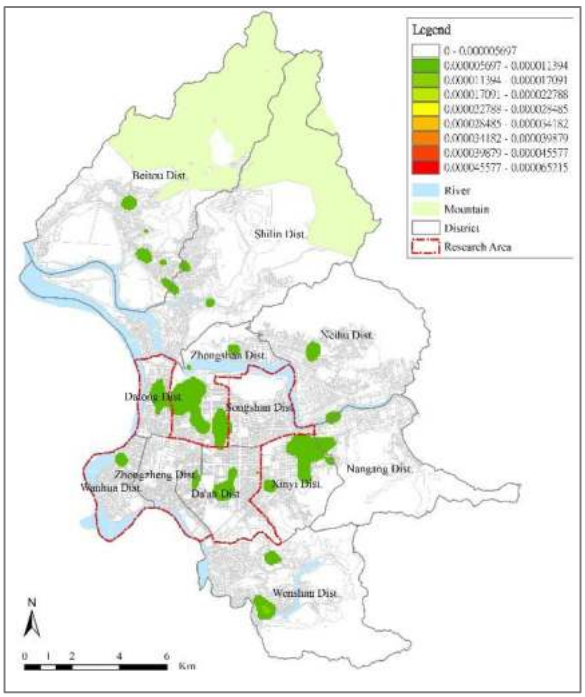
To compare the different open space scenarios, the ranking in the kernel density estimation is revised

as the same in each scenario. From the overall perspective of open space service density in Taipei, the service density of scenario 1 distributes even locations according to population density close to ideal conditions. The policy of POPS is to effectively increase the service density of open spaces because of changes in the different phases from scenario 2 to 4. Although, the POPS policy of has more strategic standard, the POPS tends to be developed in certain area with either higher bulk reward or less rigid requirements due to the different policies. Even though increasing the POPSs amount of 100, the area of 25 ha, from scenario 3 to 4, the entire open space system cannot be improve. Ideal planning cannot be realized in the case of some old community.

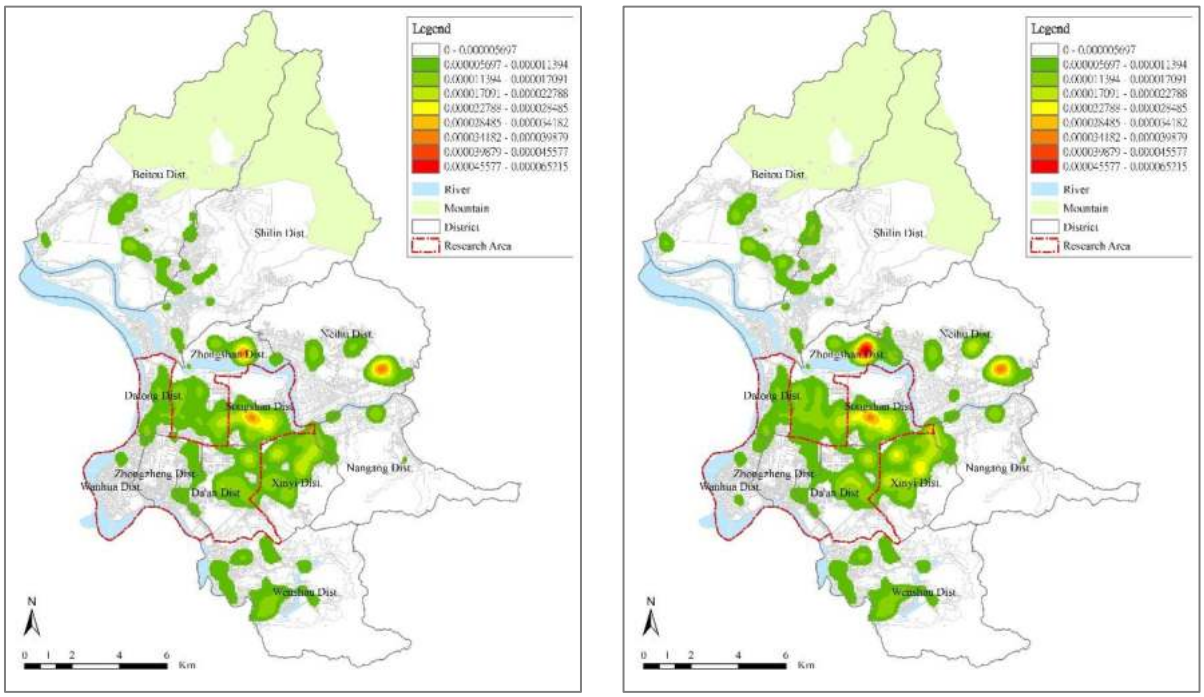
Moreover, the poor green resources districts, Wanhua, Zhongzheng, Songshan, Da'an, and Datong, are the research areas. In planning open space in scenario 1, there is a lack of open space facilities in the Wanhua and Zhongzheng districts. Some districts, Songshan, Da'an, and Datong, improved when moving from scenario 2 to scenario 4, but this was not the case in the Wanhua and Zhongzheng districts. The goal of a better urban environment was not met. Although the result of the POPS development did not fulfill original expectations, but from scenario 2 to 4 the POPS did contribute a bit to those areas need open space most. Still, if we want the POPS to contribute more to the entire open space network, then the open space type and development specifications should be made in order to attract private developers more.



Scenario 1



Scenario 2



Scenario 3 Scenario 4

Figure 6. Kernel density estimation hotspot maps in different scenarios

5. Conclusions

In high density cities, it is hard to create open spaces. This is why governments consider offering bulk rewards for creating open spaces. By developing strategic points for open spaces, urban environments will ideally be improved. According to the literature review, the policy at the first phase was generally about setting locations, but the policy became guiding principles in the second phase. However, different POPS specifications in regulations caused competition between regulations. Based on the analysis conducted in this study, the POPS policy actually improved urban environments according to the average nearest neighbor analysis. However, there have been little effects if the policy in the case of some districts with poor environment according to the kernel density estimation. In order to create better policies, it is necessary to increase rewards for areas with poor environments. On the other hand, rewards should be decreased for other areas. It is therefore possible to guide the development of POPS and achieve the goal of improving environmental quality.

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