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Spatial Characteristic of Tourism Sites on Neighborhood Support Facilities and Proximities in Cultural World Heritage Sites

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***Abstract*—Tourism is continuously developing as a new economic source in Indonesia. Tourism activities extend to the various services, products, and experiences provided in the tourism site's surrounding area. Tourism development requires information on possible related activities with tourism. However, there was a lack of studies that examined the relationship between tourism sites and the simultaneous presence of multiple public facilities, which would reveal the value of proximity. This paper aims to investigate the proximity patterns of tourism sites and the support facilities, to develop a strategy for tourism sites. The average nearest-neighbor results verify that there are clustering tendencies for almost all datasets. The Kernel Density Estimation (KDE)-based raster's were created to visualize the patterns of tourism sites and nearby public facilities, which located near three world cultural heritage sites in Indonesia. Co-location pattern mining was applied to examine the co-location behavior between tourism sites and tourism support facilities using the Participation Index (PI) as the measurement parameter. This study provides knowledge, specifically the existence of co-location rules between tourism sites and tourism support facilities, which consist of food services, accommodations, transportation, shopping, and other tourism support facilities. The network graph shows that the location of tourism support facilities can be affected by the types of tourism sites, providing practical implications for individuals, business owners, and policymakers. Government policies related to planning for tourism destination development that consider the characteristics of spatial interactions are expected to be able to support government targets for increasing lengths of stay and tourist expenditures.**

***Keywords*— tourism; tourism support facilities; spatial analysis; co-location pattern mining; network graph.**

I. INTRODUCTION

Tourism is being developed as a new economic source in Indonesia, as well as the creative economy. Its share of the Gross Domestic Product (GDP) continues to increase significantly [1], [2], and it now occupies the third position after mining and agriculture [3]. Indonesian tourism encourages confidence, credibility, and calibration [4]. This growth in its share of GDP is supported by increased awareness towards tourism on the part of the Indonesian people, which is related primarily to increased spending for travel, vacation, leisure, and recreation [5].

Tourism activities do not occur only at tourism sites but also extend to the various services, products, and experiences provided in the surrounding area [6]. Whether or not cities will grow and provide the various services, products, and experiences that will support the tourism flow of destination, the connection still needs to be studied further. Spatial characteristics influence the relationship between tourism activities, especially in proximity [7], [8]. Based on the experiences of tourists collected from survey results, a study found that there are relationships between attractions at a destination [7].

Infrastructure and identifiable recreation and leisure activity locations could make tourism in a region viable [9]. A tourism board can determine effective strategies for managing and developing a destination area by identifying major attractions or sites in a tourism network format [7]. A study on nature-based tourism showed that tourists can be clustered based on their activities to conduct tourist profiling for destination development strategies [10]. A study recommended that planners not commodify cultural tourism as a mass program [11].

This paper aims to investigate the proximity patterns of tourism sites and support facilities, such as food services, accommodations, transportation, shopping, and other tourism support facilities, to develop a strategy for tourism sites, or, more broadly, for a tourist destination. An average nearest-neighbor analysis is conducted to examine the proximity of tourism sites and public facilities that support tourism. The GIS (Geographical Information System) approach is used to visualize and assess the density of the research objects. The co-location pattern mining approach is then used to examine the types of tourism support facilities and the categories of tourism sites that locate together frequently. The authors describe several studies that have been conducted by other researchers. Besides, the authors explain the data used to analyze spatial patterns.

II. Materials and Method

A. Laws of Geography in Tourism Analysis

GIS provides an opportunity for applied tourism researchers to understand and define interaction models between time, space, and tourism activities [12]. Tourism has many aspects that need to be considered, including the environment (and its conservation), human perception, human mobility, and spatial behavior [13]. Location information is becoming increasingly important economically, along with the development of the Internet of Things [14]. Tobler in 1970 and again in 2004 asserted that "the fact that near things are more related than distant things seems a fundamental property of geography" and called it Tobler's first law of geography [15], [16]. Many studies have been conducted to review and elaborate upon this law [17–20], and many studies have shown the relevance of this law in various problems related to spatial/geographical conditions. One way of quantifying Tobler's first law of geography is to utilize the spatial autocorrelation technique to examine whether clusters are present or a random pattern prevails [21]. Several studies have applied spatial analysis to obtain the location-related characteristics of a tourism destination. However, this study discusses other research that examines the proximity between objects. Vasiliadis and Kobotis identified key locations that are specific to tourist behavior and underlined the linkages between access routes, tourist activities, and the tourist infrastructure using nearest-neighbor analysis [22]. Lee, Choi, Yoo, and Oh used a gravity model to estimate the spatial tourism interactions affecting human movements corresponding to the distance between locations, tourism factors, and human resources [23]. Das and Finne explained that in creating innovations, one of the critical factors is co-location [24].

Memon and Kinder described co-location as a sharing of physical space and services by formerly distributed services [25]. However, more specifically, co-location is an important factor in providing public services [25], as well as in the relationships between domestic and foreign companies [26], since it benefits both users and providers. Many studies have examined various co-location pattern mining frameworks, although there are still not many studies that apply these various frameworks. Hotels, restaurants, and highways are a few of the spatial objects that have been studied using the co-location pattern mining framework [27, 28]. The co-location pattern mining provides the co-location rule information between objects that can be used for location determination.

B. Laws of Geography in Tourism Analysis

This research examines tourism sites around three world cultural heritage sites in Central Java Province and Yogyakarta Province, namely the Borobudur Temple Compound, Prambanan Temple Compound, and Sangiran Early Man Site. The spatial data consist of area boundaries obtained from the Indonesian Geospatial Information Agency. The locations of support facilities for the tourism sites were obtained from OpenStreetMap Indonesia. QGIS Desktop ver. 2.18.14 software was used to collect, manage, process, and visualize the spatial data.

The density of the tourism sites and tourism support facility distributions were estimated using the KDE (Kernel Density Estimation) method, which determines the number of tourism sites or support facilities per unit area using search radius parameters [29]. The heatmap plugin feature in QGIS was used to create the density raster. These density rasters visualize the objects' location patterns, i.e., whether they are scattered randomly or tend to cluster. Average nearest-neighbor was conducted to verify the clustering tendencies of the spatial dataset on specific feature classes.

The PostGIS Shapefile Import/ Export Manager was used to export the spatial data in a PostgreSQL format. Instances of feature classes were generated using the ST_Distance function on PostgreSQL. The participation index (PI) was calculated to determine the prevalence of co-location [30]. In this study, two feature classes are co-located if they are within a set threshold distance of each other.

III. Results and Discussion

Indonesia has nine tourism sites that are registered on the World Heritage List (WHL), including four natural World Heritage Sites (WHSs) and five cultural WHSs. One cultural WHS is on Bali Province/Island, another one is on Sawahlunto, Sumatera Province/Island, and the other three cultural WHSs used in this study are located nearby. The cultural WHSs at Borobudur and Prambanan were listed in 1991, and the site at Sangiran was listed in 1996. Borobudur is located in the city of Magelang in Central Java Province, which is adjacent to Prambanan in the Sleman Regency of Yogyakarta Province. Meanwhile, Sangiran is located in the Sragen Regency of Central Java Province. These three cultural WHSs determine the scope of the area specified in this study.

There are 26 cities/regencies covered in this study. The cultural WHSs are in Sleman, Magelang, and Sragen. Other cities/regencies are located around these three cities. There are 439 tourism sites (including the three cultural WHSs) in these 26 cities/regencies. This data was obtained from the Tourism Statistics Book from the Provincial Tourism Office. The Tourism Offices categorize these tourist locations into three types of tourist destinations, namely cultural tourism, natural tourism, and other tourism. Table I shows that cultural tourism sites dominate the tourist destinations in the data collection area. Tourist villages dominate the cultural tourism destinations, while beaches and other water recreation (such as waterfalls, dams/reservoirs, lakes) dominate the natural tourism destinations.

The five cities/regencies with the highest number of destinations are in the Province of Yogyakarta. Gunung Kidul Regency has the highest number of natural tourism destinations compared to the other cities/regencies. Gunung Kidul Regency is located on the southern side of Java Island and has a stretch of beach along the southern boundary of its administrative region. One of the four Indonesian geoparks registered on the list of UNESCO Global Geoparks (UGGp) is also in the Gunung Kidul region (intersecting with two other cities in the southern part of Java). Its landscape of karst and past cultures have allowed Gunung Kidul to develop several tourist destinations. Sleman, Bantul, and Yogyakarta have many more cultural tourism destinations than natural tourism destinations.

TABLE I
TOURISM DESTINATION CATEGORY

Cultural Tourism	**Σ**	**Natural Tourism**	**Σ**	**Other Tourism**	**Σ**
tourist village	72	beach	54	water park	17
museum	43	water recreation	50	plaza/ stadium	5
religious tourism	33	landscape	26	theme park	4
temple	25	cave	17	edu park	3
landmark	22	forest	15	park	3
attraction	11	agro-tourism	10	zoo	2
craft	6	mountain	8	theater	1
palace	4	conservation	1		**35**
monument	3		**181**		
archaeology site	2				
gallery	2				
	223				

The cities/regencies in Central Java Province have fewer tourism sites compared to Yogyakarta Province. Semarang Regency, which is located on the southern side of Semarang city, has an exciting landscape that can be developed into a natural tourism site. We will study whether status as a city with complete infrastructure will further support the development of cultural tourism sites. The Borobudur Temple Compound is located in Magelang City, while the Sangiran Purba Site's location is in the Sragen Regency. Only a few tourism sites are around Borobudur and Sangiran; therefore, whether or not the available tourism support facilities will support these two WHSs will be further studied. The average nearest-neighbor analysis was conducted to examine the proximity of tourism sites. This analysis also examined various public facilities that support tourism. These various types of public facilities are one of 14 factors that affect the properties of cultural heritage, namely, the major visitor accommodations and associated infrastructure factors [31].

The statistical analysis results of QGIS are presented in Table II. Clustering tendencies are indicated by nearest neighbor index values below 1 (the airport's index value is greater than 1, indicating more dispersed than hypothetical random data). The z-scores for all categories except airport and campsite are below -1.96, clarifying that sufficient data determine the specific data patterns. The following stages of this study will focus on the clustering patterns occurring in the combined locations of tourism support facilities. The statistical results support the interpretation of the KDE visualization results.

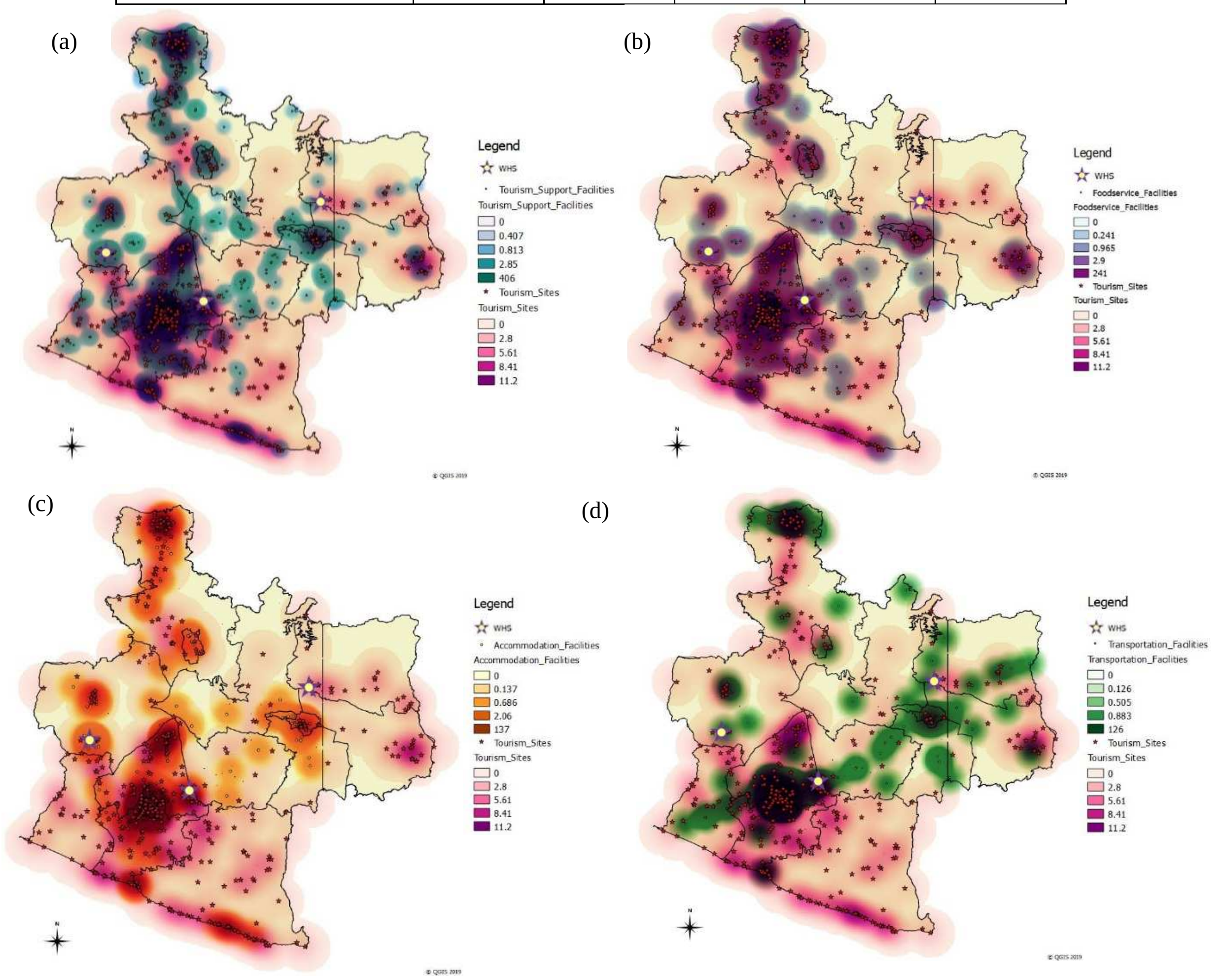
The location distributions of the tourism sites and tourism support facilities are estimated based on the kernel density. The closeness between tourism sites and tourism support facilities is presented by overlaying the density of tourism sites with the density of the tourism support facilities. In Fig. 1, it can be seen that not all tourism sites have tourism support facilities in the vicinity. However, from the six overlay maps that are displayed, it can be seen that each category of tourism support facilities that are densely distributed is located in a region where the distribution of tourism sites is also dense. The distribution of tourism support facilities is denser in areas with city administrative status compared to districts, namely the cities of Jogjakarta, Semarang, Magelang, and Surakarta. Provincial governments in the City of Jogjakarta for the Province of Jogjakarta, as well as in the City of Semarang for the Province of Central Java, must collaborate in managing tourism destinations in general, and cultural WHS, in particular.

Co-location pattern mining is conducted to test the closeness between two or more data sets. In this study, the test data set consisted of tourism sites and tourism support facilities, including accommodations, food services, shopping facilities, transportation facilities, and other tourism support facilities. At the initial stage, the Participation Index (PI) value was calculated for every two data sets. Proximity is calculated for distances of 1 km to 10 km. At 5 km distances, all combinations have PI values higher than 50%, as shown in Fig. 2. At 7 km distances, 13 of 15 combinations have PI values higher than 70%; while, at 9 km distances, all combinations have PI values higher than 70%. Furthermore, the prevalence value was set at 50%, and the distance threshold was set at 5 km. There are six combinations out of 20 combinations consisting of three-item sets with PI values less than 50%, as shown in Fig. 3.

Among these six combinations, the set of tourism sites is always one of the items set in the combination. Due to the pruning process, six combinations of four-item sets are produced, and only three of these combinations have PI values of more than 50%. These three combinations do not contain tourism sites as part of the combination. Thus, the pruning process stops at the four-item combinations. Fig. 4 shows the PI values for the four-item set combinations. There is only one combination that contains tourism sites as part of its combination, and this combination has a PI value of 46%. The other three members of the combination are food services, accommodation facilities, and other tourism support facilities. There are four combinations in the three-item set combinations with tourism sites as one of the members that have PI values higher than 50%. These combinations include food service facilities, accommodation facilities, other tourism support facilities, and shopping facilities. Transportation facilities have a co-location pattern, with the highest PI value being 76% for a combination of four-item sets. The other three members in this combination are food service facilities, accommodation facilities, and shopping facilities.

TABLE II
STATISTICAL RESULTS OF THE AVERAGE NEAREST-NEIGHBOR ANALYSIS

Point Data	Observed mean distance	Expected mean distance	Nearest neighbor index	Number of points	Z-Score
Tourism Sites	0.0145	0.0289	0.5040	436	-19.8117
Tourism Support Facilities	0.0026	0.0120	0.2186	2290	-71.5322
Transportation Facilities	0.0101	0.0287	0.3512	328	-22.4791
Airport	0.5046	0.1614	3.1262	3	7.0453
Railway Station	0	0.0755	0	42	-12.3981
Bus Station	0	6924.2960	0	58	-14.5695
Bus Stop	0	0.0229	0	225	-28.6961
Accommodation Facilities	0.0052	0.0208	0.2523	476	-31.2077
Hotel	0.0067	0.0263	0.2537	261	-12.0667
Motel	0.0469	0.0838	0.5599	13	-3.0357
Hostel	0.0260	0.0649	0.4005	45	-7.6932
Guest House	0.0096	0.3257	0.2932	157	-16.9414
Food Service Facilities	0.0029	0.0181	0.1616	972	-50.0039
Bakery	0.0214	0.0567	0.3779	41	-7.6204
Café & Bar	0.0099	0.0327	0.3027	162	-16.9801
Fast Food	0.0189	0.0453	0.4162	78	-9.9264
Restaurant & Foodcourt	0.0036	0.0215	0.1686	690	-41.7817
Shopping Facilities	0.0072	0.0239	0.3004	372	-25.8152
Convenience Store	0.0081	0.0297	0.2731	168	-18.0252
Supermarket	0.0149	0.0384	0.3870	141	-13.9244
Apparel & Gift Shop	0.0099	0.0482	0.2059	63	-12.0580
Other Tourism Support	0.0180	0.0397	0.4526	142	-12.4796
Artwork Centre	0.0308	0.0598	0.5142	37	-5.6535
Camp Site	0.0511	0.0558	0.9156	20	-0.7229
Travel Agent	0.0244	0.0513	0.4756	30	-5.4953
View Point	0.0326	0.0614	0.5310	55	-6.6533



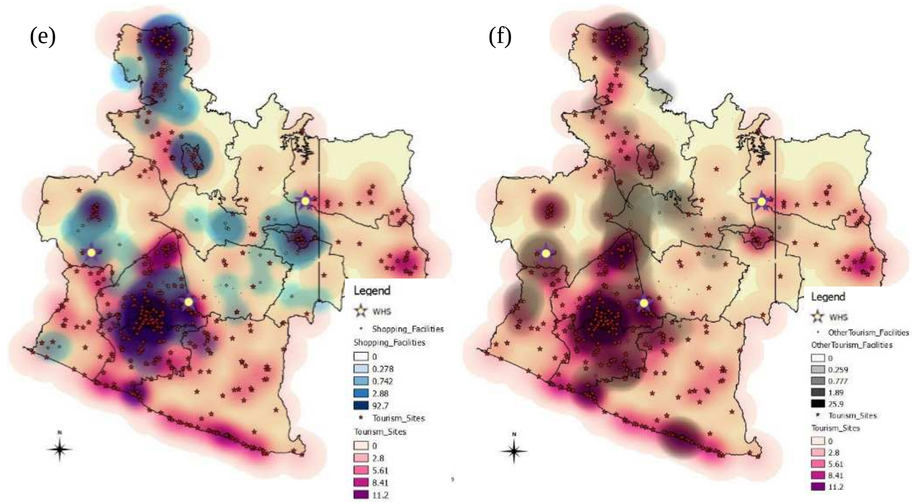


Fig. 1 KDE of Tourism Sites and : (a) Tourism Support Facilities; (b) Food Service Facilities; (c) Accommodation Facilities; (d) Transportation Facilities; (e) Shopping Facilities; (f) Other Tourism Support Facilities

The co-location index between tourism sites and each category of tourism support facilities is high for two co-locations but weakens for three co-locations. Increasing the size to four co-location candidates with tourism sites as one feature results in PI values of less than 50%. In other words, tourism sites have high closeness values for each category of tourism support facilities. However, not all categories of tourism support facilities are always in tourism locations. The co-location mining pattern is applied to both the category and sub-category of tourism support facilities. The list of categories and sub-categories can be seen in Table II. In the range of 1 km between objects, no co-location rule emerges between tourism sites and tourism support facilities (based on a prevalence value of more than 50%). In the range of 3 km between objects, there is a co-location rule between cultural tourism sites and restaurants/food courts, hotels, supermarkets, and fast food as well as co-location rules between other tourism sites and restaurants/food courts, hotels, café/bars, fast food, and convenience stores (listed sequentially by PI value). In the range of 5 km between objects, co-location rules occur in various categories from tourism support facilities to tourism sites. In particular, a co-location rule occurs between cultural tourism sites and restaurants/food courts, supermarkets, hotels, fast food, guesthouses, convenience stores, artwork centers, railway stations, café/bars as well as between natural tourism sites and restaurants/food courts. Also, a rule occurs between other tourism sites and apparel/giftshops, artwork centers, bakeries, bus stops, café/bars, convenience stores, fast food, hotels, restaurants/food courts, and supermarkets. This study provides specific knowledge of the patterns of the co-location rules that occur between categories of tourism sites and subcategories of tourism support facilities.

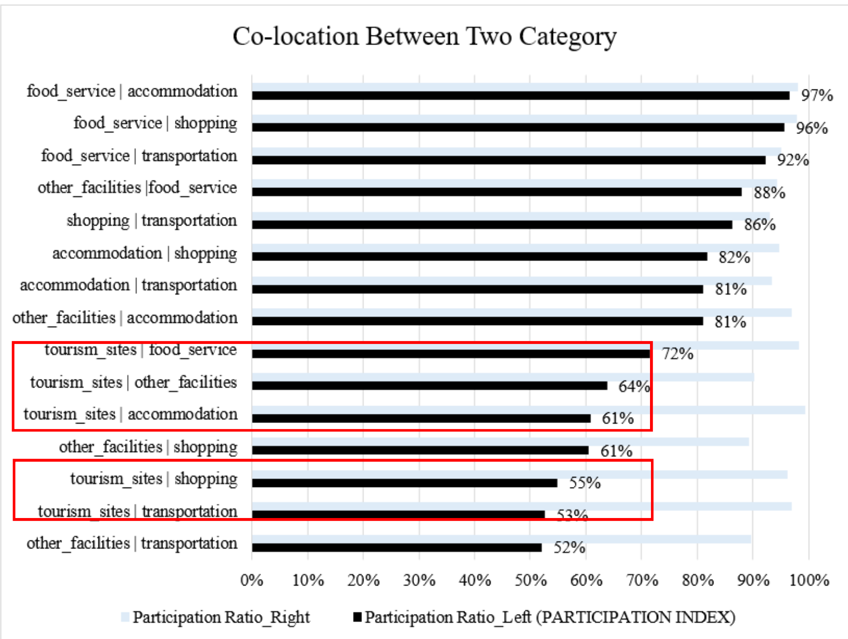


Fig. 1 Co-location between 2 categories; 5 km buffer distance

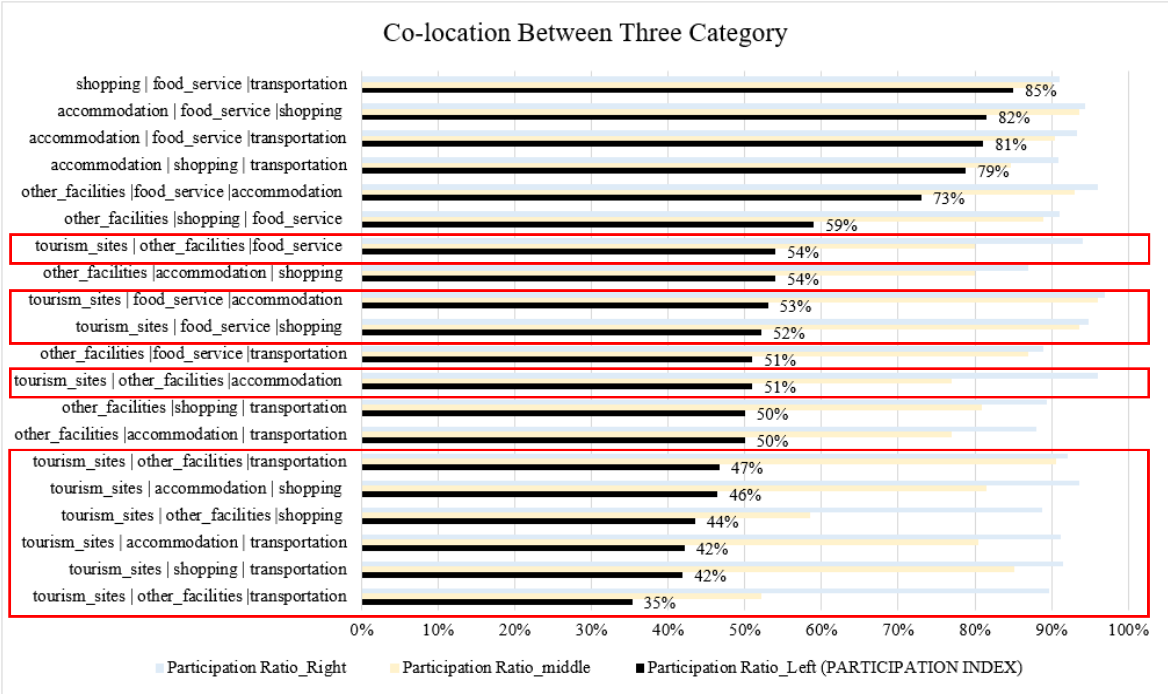


Fig. 3 Co-location between 3 categories; 5 km buffer distance

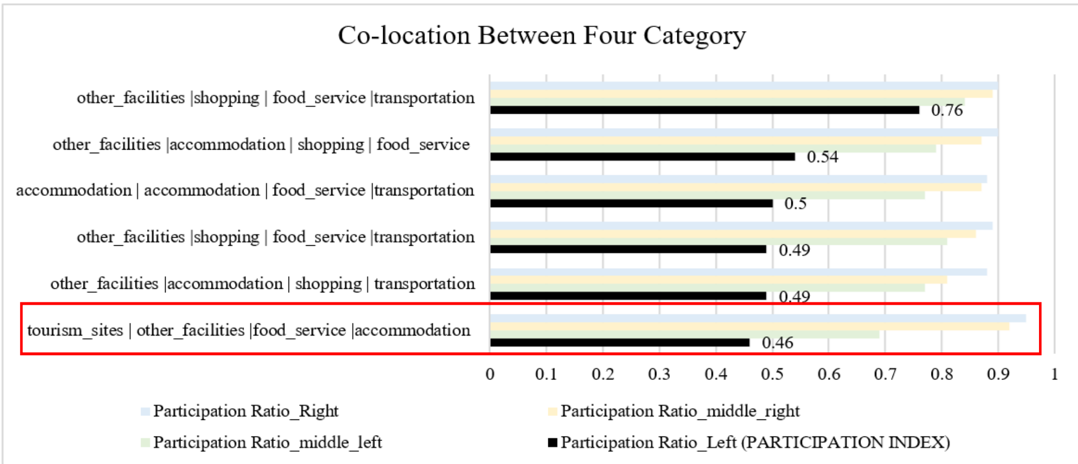


Fig. 4 Co-location between 4 categories; 5 km buffer distance

TABLE III

TOURISM SUPPORT FACILITIES – SUBCATEGORY FOR EACH TOURISM TYPE FOR 3 KM THRESHOLD AND MINIMUM 50% PARTICIPATION INDEX

Tourism Support Facility	Cultural Tourism Sites	Natural Tourism Sites	Other Tourism Sites
Foodservice facility	Restaurant/foodcourt; fastfood		Restaurant/foodcourt; fastfood; café/bar
Accommodation facility	Hotel		Hotel
Transportation facility	Railway station		
Shopping facility	Supermarket		Convenience store

TABLE IV

TOURISM SUPPORT FACILITIES – SUBCATEGORY FOR EACH TOURISM TYPE FOR 5 KM THRESHOLD AND MINIMUM 50% PARTICIPATION INDEX

Tourism Support Facility	Cultural Tourism Sites	Natural Tourism Sites	Other Tourism Sites
Food service facility	Restaurant/foodcourt; fastfood; café/bar	Restaurant/foodcourt	Restaurant/foodcourt; fastfood; café/bar; bakery
Accommodation facility	Hotel; guesthouse		Hotel
Transportation facility	Railway station		Bus stop
Shopping facility	Supermarket; convenience store		Convenience store; apparel/gift shop; supermarket

Other tourism facilities	Artwork center		Artwork center

TABLE V
TOURISM SUPPORT FACILITIES – SUBCATEGORY FOR EACH TOURISM TYPE FOR 10 KM THRESHOLD AND MINIMUM 50% PARTICIPATION INDEX

Tourism Support Facility	Cultural Tourism Sites	Natural Tourism Sites	Other Tourism Sites
Food service facility	Restaurant/foodcourt; fastfood; café/bar; bakery	Restaurant/foodcourt	Restaurant/foodcourt; fastfood; café/bar; bakery
Accommodation facility	Hotel; guesthouse; hostel; motel	Guesthouse	Hotel; guesthouse; hostel; motel
Transportation facility	Railway station; bus stop		Railway station; bus stop
Shopping facility	Supermarket; convenience store; apparel/gift shop	Supermarket	Supermarket; convenience store; apparel/gift shop; supermarket
Other tourism facilities	Artwork center; viewpoint; travel agent	viewpoint	Artwork center; viewpoint; travel agent

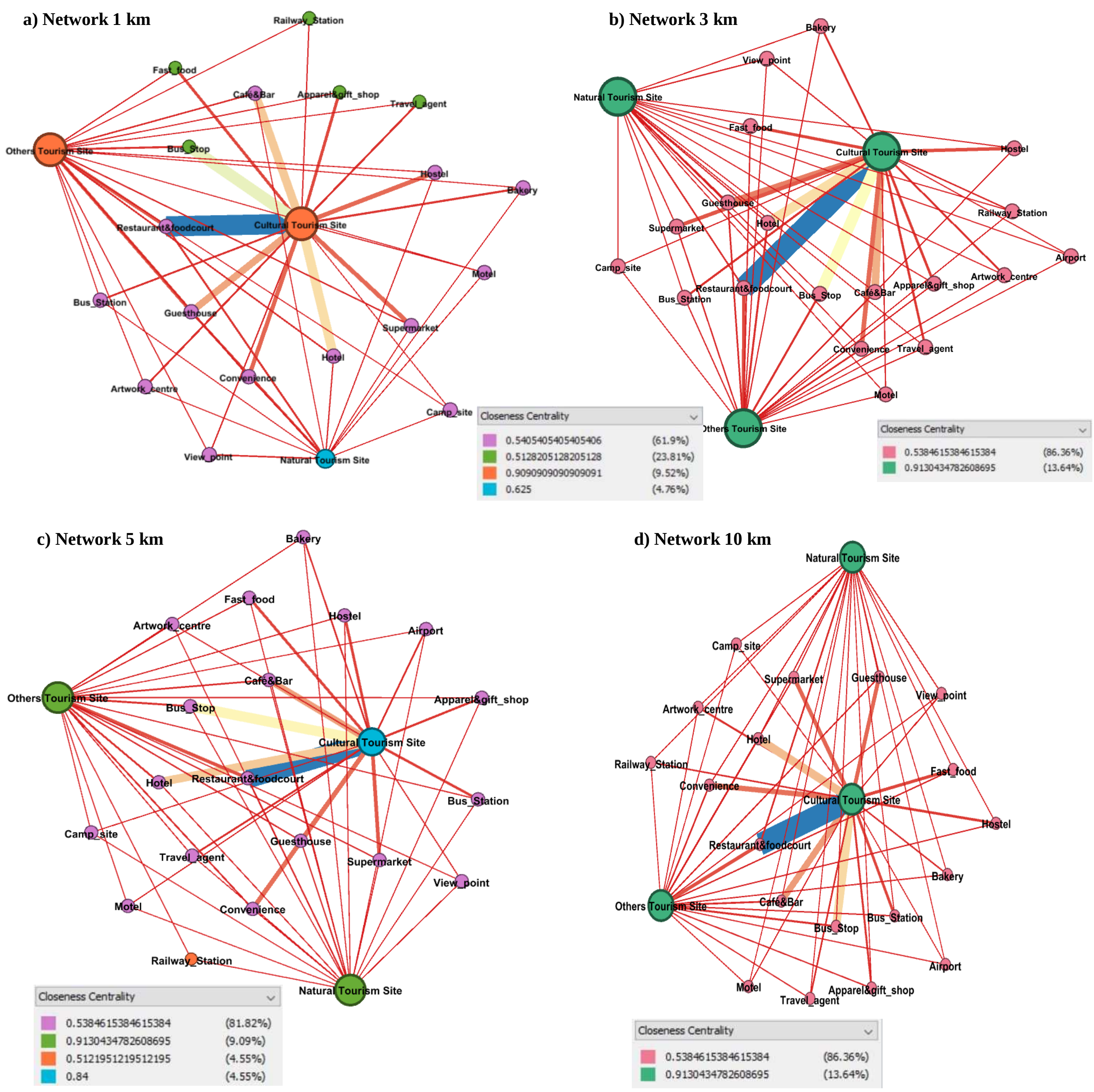


Fig. 5 Closeness Centrality – Network Graph

This study used Gephi (Gephi.org) for network depiction from data networks [32]. The network graph uses closeness centrality values, as a global measure of centrality, based on the weight of the paths from a node to all other nodes in the network [33]. A node in the network with a high in closeness centrality has a closer distance to other nodes, so it has an appropriate alternative to spread information within a network [34]. The network graph shows that the location of tourism support facilities, such as accommodation, food service, transportation, and shopping, can be affected by the types of tourism sites, providing practical implications for individuals, business owners, and policymakers.

The results of co-location pattern mining in a more detailed category, show that at a threshold distance of 1 km there are no co-location rules between tourism sites and tourism support facilities in a more detailed category. This finding means that at a distance of 1 km, tourism sites are not associated with the types of tourism support facilities studied in the study. At some tourist sites, we might find several types of facilities, such as food services or accommodation facilities. But not generally.

Table III shows the co-location rules at the threshold distance of 3 km, with a minimum PI value of 50%. Cultural tourism sites have similarities with other tourism sites. Likewise at a distance of 5 km (Table IV) and 10 km (Table V). Natural tourism sites do not have co-location rules at a distance of 3 km. At a distance of 5 km, this type of tourism has co-location rules with restaurants/food courts. While at a distance of 10 km, it has co-location rules with guest houses, supermarkets, and viewpoints.

The co-location rules between each type of tourism sites and the tourism support facilities provide insight and guidance for service providers to determine potentially good facilities to be developed around tourism sites at a certain distance. This study can be a benchmark for other tourism destinations by adjusting the type of tourism sites.

IV. CONCLUSIONS

This study describes the neighborhood relationships between tourism sites around three world cultural heritage sites and nearby public facilities in Indonesia. This study was feasible due to the development of spatial database systems and geographic information systems that can manage, analyze, and visualize large amounts of spatial data. The statistical results of the average nearest-neighbor analysis show that the distributions of tourism sites and the categories and subcategories of tourism support facilities (except airports and campsites, due to insufficient data) tend to cluster. However, visualizations of the overlays show that the distribution of tourism sites is not always in the same area as the distribution of tourism support facilities. This pattern is explained by the co-location pattern mining approach, i.e., at a buffer distance of 1 km with a prevalence value of 50%, there is no co-location rule between tourism sites and the categories and subcategories of tourism support facilities. Co-location rules are found between tourism sites and each category of tourism support facilities at a distance of 5 km, as are co-location rules between categories of tourism sites and subcategories of tourism support facilities.

The co-location rule patterns obtained show the interaction between the existence of tourism sites, the behavior of tourists in their tourism activities, and the response of providers in the development of supporting tourism facilities in the vicinity. Spatial analysis shows the interactions that have occurred as a result of the provision of public facilities. However, there could be tourism behaviors associated with the tourism activities that have yet to receive a response from providers. Therefore, another approach is needed to explore tourism activities to enable providers to support tourism performances in terms of increasing lengths of stay and expenditures.

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