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INTEGRATED AND SUSTAINABLE SPATIAL SYSTEM OF PRIMARY EDUCATION FACILITIES WITH HIERARCHICAL LOCATION-ALLOCATION ANALYSIS IN YOGYAKARTA CITY

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ABSTRACT
Yogyakarta City, which is known as the 'City of Education' in Indonesia, still have problem on children access to primary education. The number of junior high school is unable to accommodate all of elementary school graduates. This condition obstructs student's access to continue their education to a higher level. School site planning is very pivotal for equitable access to quality education. This research aims to guarantee integrated and sustainable education by analyzing primary education in a hierarchical location-allocation analysis with Geographic Information Systems (GIS). Hierarchical analysis is used to solve the problem of school spatial coverage and continuation. Educational facilities flow from low-level (elementary schools) to high-level (junior high schools). The different schools locations are tiered, interrelated, and interact significantly where each level of the hierarchy will have different criteria of capacity and spatial range. This research indicates that it is very necessary to add number of elementary school and junior high school in certain area of Yogyakarta City so that the hierarchical flow of educational facilities runs more effective. The appropriate hierarchy will be able to optimize primary education facilities services. Further research is needed to optimize primary education services with site location analysis.

KEY WORDS
Hierarchy, school, location.

Education is an important sector for the country to ensure the quality of human resources. Education is an essential entity in the society [1] which is able to give a big impact on individual life [2]. Every citizen has the right for access to quality education. The government, as state administrator, has an obligation to fulfill this right by equalizing access to education. All residents of school age, without exception, are obliged to have the same educational opportunities [3]. The principle of equity in regional development is that educational planning should be designed to expand the range of education services [4]. Provision of public services primarily based on the ease of access, which means that the facility is easy to access for all of citizen [5]. But in fact, education in Indonesia is still not able to reach the entire population, even though the general condition has increased year after year.

The factual condition of education in Indonesia indicated that there is still limited access of the population to quality education which should be facilitated by the government. It means that Indonesian government still unable to guarantee the equal rights to quality education [6] for all people. In fact, it should be noted that most people still have a tendency to choose public schools over private schools as the main choice in accessing education on the rationale that school fees are free and of good quality and facilities [7]. Community, in general, will choose public facilities location that are considered as the most accessible [8] due to the various considerations, such as convenience, cost, and time. Mileage is the main factor that underlies the selection of the ideal school location [9] because education accessibility is determined by distance and time constraints to school [10].

Location problem decision variables are limited to the placement of facilities and the coverage area of demand [11]. Coverage plays an important role in facility placement because the demand for services in general has a maximum range [12]. The range concept is a symbol of ease of access to public services [5] [13]. Distance is the main factor in measuring service coverage which can be interpreted through mathematical measures (absolute distance, meter), time (in minutes, hours), and costs (in terms of currency, Rupiah-Indonesian currency).

The education system developed by the Indonesian government should be able to meet the needs of a large, diverse, developing, and dispersed population with differences between regions [14]. However, there are educational facilities standard criteria of government agency or ministry that contradict with the concept of service hierarchy in location theory. In a hierarchical system, different facility locations interact significantly with the flow between facilities [15]. In the context of primary education in Indonesia (that is elementary school and junior high school), the education pattern flows gradually from elementary school level to junior high school where each level will have different capacity criteria and coverage distances [16]. Elementary school service coverage will be smaller than junior high school. Infrastructure with a higher function must be located in a wider service area, which is not in the villages but in the sub-districts.

The decision to place the location of public facilities is one of the most crucial strategic decisions [17]. The location factor considered as an important element for the public services success. The right location will lead to a more efficient and good quality of service. Public facilities are generally formed as several points of availability that serve a large number of spatially dispersed points of demand [18]. Location-allocation analysis plays an important role in locating facilities and allocating demand points to those facilities. The spatial allocation model is closely related to the concept of optimality, which is trying to answer the question about "what is the best or optimum".

Most of the location-allocation models fail to account the hierarchical factors, multi-level structure, which is serves as an important fundamental for the coordinated provision of related services [19]. In general, location-allocation modeling focuses on the interaction between demand and facilities at one level only, it neglect the interactions between facilities. The comprehensive location-allocation model is established according to the different object locations and attributes of the facility hierarchy [20]. Public facilities are provided at a hierarchical level for different locations in the context of object efficiency by taking into account fairness of provision for services equal distribution [11]. The primary and secondary education systems are the clearest example of a hierarchical service system [21].

In educational facilities, schools have tiered and interrelated characteristics. The example is primary education; in Indonesia are Elementary School (ES) and Junior High School (JHS). Elementary school graduates become input for the admission of new students at the junior high school level. Elementary school and junior high school spatial distribution will certainly determine the effectiveness of basic education services in a region. The issue of educational facilities location-allocation from a hierarchical point of view is very important to do in order to support the sustainable education services for the community.

LITERATURE REVIEW

Location problems in public facilities using location-allocation analysis seeks to optimize the location of facilities and the allocation of demands (requirement) to these facilities. The objectives, among others, are to minimize or maximize the function of certain objectives, such as minimizing distance to save transportation costs or maximize service coverage. Daskin and Stern (1981) saw the characteristics of this hierarchy by developing a hierarchical objective set of covering problems [17], while Moore and ReVelle [21] developed a hierarchical service location problem.

Research on how the problem of maximum site coverage can be modified and expanded to account the hierarchy of service systems is still needed. Research on the hierarchy of location-allocation concept are mostly done in the health sector. Smith et al [11] illustrated equity hierarchical location models in Vikasnagar Village, a rural area in northern India. Zhu et al [20] observed the location optimization of Trauma Centers in Shenzen, China using a hierarchical location-allocation model with high-low level category. Hodgson [22] investigated a hierarchical model of primary health care in developing countries, targeting analysis for the Salcette Taluka area, Goa, India. Baray and Cliquet [23] present a hierarchical location-allocation model that combines the maximum-covering and P-center models to determine the optimum location for three levels of maternity hospitals in France through computational mathematical calculation results. Meanwhile, Rashtagi et al [24] investigated a multi-objective hierarchical location-allocation model for a network of various health facilities in Iran.

The theoretical problems of spatial research in education related to dynamics and hierarchical models deserve further attention [18]. Asmanto et al [25] suggested to make research integrated with the concept of spatially inter-level education system sustainability. Empirical studies of hierarchical concept based on location-allocation analysis in education have never been implemented, including in Indonesia.

School facilities have geographic spatial relationships that can be expressed through a spatial analysis tool that is Geographic Information System (GIS) [26]. GIS is the most suitable tool for studying educational inequality problems and should be of wider use in educational research. GIS has the ability to solve spatial problems faster and to help the stakeholders to make the right decisions [27]. GIS has many characteristic features which is unable to be done by mathematical formulation. Integration of GIS with location-allocation concept can act as a public facility planning tool to develop a spatial decision support system [28]. This research will apply the location-allocation analysis function contained in the network analyst of the ArcGIS program to assist in the hierarchical analysis of primary education (elementary school and junior high school) in Yogyakarta City.

MATERIALS AND METHODS OF RESEARCH

The research was conducted in the Yogyakarta City, known as the City of Students or the City of Education in Indonesia. Yogyakarta City has an area of 32,5 km², divided into 14 districts and has a total population of 414.055 people with an average population density of 12.740 people/km² [29]. Yogyakarta City is known to have 105 primary education facilities, that is 89 Public Elementary Schools (PES) and 16 Public Junior High Schools (PJHS). The general conditions per district in Yogyakarta City can be seen in Table 1. The number of public schools in Yogyakarta City, for both elementary schools and junior high schools, is generally not proportional and not evenly distributed in each district.

Table 1 – General Condition of Yogyakarta City per District

District	Population	Number of Children		Number of School	
		Elementary School Age (6-12 years)	Junior High School Age (13-15 years)	Public Elementary School	Public Junior High School
Mantrijeron	35.433	3.701	1.589	6	1
Kraton	21.831	2.046	962	5	1
Mergangsan	32.043	3.367	1.432	7	0
Umbulharjo	69.887	7.667	3.347	13	1
Kotagede	34.311	3.767	1.651	12	1
Gondokusuman	42.818	4.330	2.113	8	3
Danurejan	21.335	2.211	1.070	4	2
Pakualaman	10.810	1.096	495	3	0
Gondomanan	14.982	1.430	621	2	1
Ngampilan	18.550	1.855	893	2	0
Wirobrajan	27.868	2.930	1.401	5	0
Gedongtengen	19.891	1.938	943	2	1
Jetis	27.132	2.873	1.285	9	3
Tegalrejo	37.164	3.935	1.798	11	2
Total	414.055	43.146	19.600	89	16

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Figure 1 – Distribution Map of Primary School (A) and Distribution Map of Demand (B)

Yogyakarta City is known to deliver more than 6 thousand elementary school graduates each year, while the capacity of public junior high schools is only for 3.487 students [30]. Therefore, not all junior high school age children can be accommodated in public schools. This causes the children to access public schools outside the administrative area of Yogyakarta City or to enroll in a private school in Yogyakarta City. This has an impact on the large amount of household expenditure for education purposes. In low economic conditions households, this situation causes the children not continuing to school (higher level).

There are four sub-districts that don't have PJHS facilities, that is District of Mergangsan, Pakualaman, Ngampilan, and Wirobrajan. This means that junior high school aged children (13-15 years) in this area will not have access to junior high school level of education. The number of PES is noted to be more evenly distributed than the number of PJHS, but it still considered spatially uneven related to actual requirements. Spatial distribution of ES and JHS in Yogyakarta City described in Figure 1 (A).

Spatial distribution for educational facilities requirement can be seen through a map depicted with points of demand according to the existence of settlements. One point of demand represents a block of settlements (Figure 1-B). Public access to primary education (ES and JHS) is greatly influenced by the distribution of educational facilities. Spatial distribution of demand points will describe the actual needs spatially.

This study analyzes the condition of primary education, that is Elementary School (ES) and Junior High School (JHS), in Yogyakarta City. These two educational facilities are tiered and related, elementary school graduates in this region will become an input for the enrolling process of new students, known as the "Penerimaan Peserta Didik Baru" (PPDB) for junior high school. There is a flow of students from ES to JHS where its effectiveness will be influenced by the number and distribution of educational facilities available in the area.

The location-allocation model is a method used in general to determine the optimal location of a facility and allocate it spatially based on demand. The demand referred to, in this case, is the number of school-age children, both at the ES and JHS levels. This flow planning needs to be considered in planning school placement in order to provide optimal and sustainable educational services. In the sense of being able to guarantee the students continuity, the ability to continue their education to a higher level. This integrated and sustainable spatial planning is important to avoid cases of children dropping out of school.

The personalized location-allocation analysis at each facility level is a hierarchical location-allocation [31].

Hierarchical facility systems can generally be divided into two types, that is nested and non-nested hierarchical systems [20]. In a nested hierarchy system, high-level facilities offer all services for both high and low level criteria. In a non-nested hierarchical system, each facility level offers a different service. Thus, primary education facilities (ES and JHS) are included in the criteria for non-nested hierarchical systems. In addition, schools have service characteristics where the consumers come to the service location. So that the concept of distance consider as a very important factor that needs attention. Especially after the implementation school zoning system as the education policy which requires children to choose the closest school to their place of residence.

Figure 2 illustrate the outline of the research. This research fills a research gap regarding the analysis of the hierarchical location-allocation system in education sector. The hierarchy of primary education (Elementary School-ES and Junior High School Levels) is determined by the criteria in which ES is considered to be the low-level and JHS as the high-level. Hierarchical analysis will allocate continuity of flow between these primary educational facilities. ES location will be allocated to certain JHS facilities based on the P-Median problem concept, the concept of minimizing the average distance of each point demand to the facility. The analysis process is carried out using the network analyst feature in the ArcGIS program.

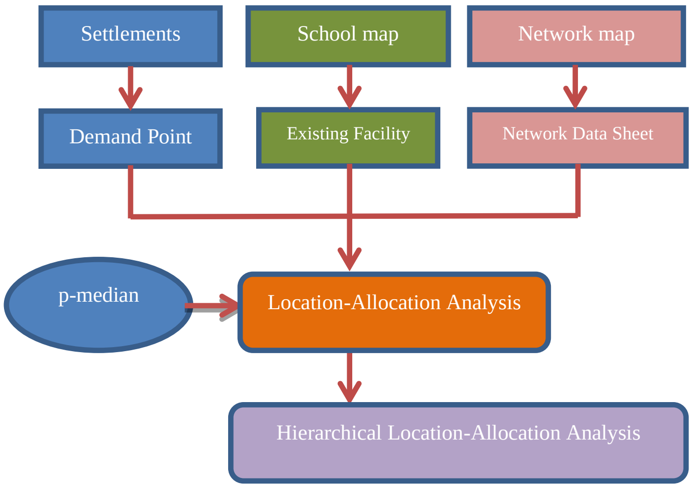

Figure 2 – Research Flowchart

This research uses public school data, with consideration that primary education are entirely become the government responsibilities and not all residents afford private schools. This research also uses the assumption that the children are placed in the nearest school according to the school zone policy.

RESULTS AND DISCUSSION

Yogyakarta City is known to have 89 Public Elementary Schools (PES) scattered in each district. The location-allocation analysis of the P-Median model is used to determine the problem of allocating demand for PES facilities. Demand data illustrate in the form of points where each point represents one residential block. Figure 3 is the result of the p-median location-allocation analysis from ArcGIS network analyst toolbox, without impendence. Each PES has its own range of demand points, with varying amounts.

The results of the distance from one point demand to the PES facility indicated that the closest distance is 1,39 meters while the farthest distance is 1.895 meters. The farthest distance which illustrate the distance from children resident to the PES facility still does not meet the criteria for the Indonesian national standard according to the National Standard Agency, known as “Badan Standar Nasional” (BSN) which determines that the service distance for the elementary school facility is 1.000 meters.

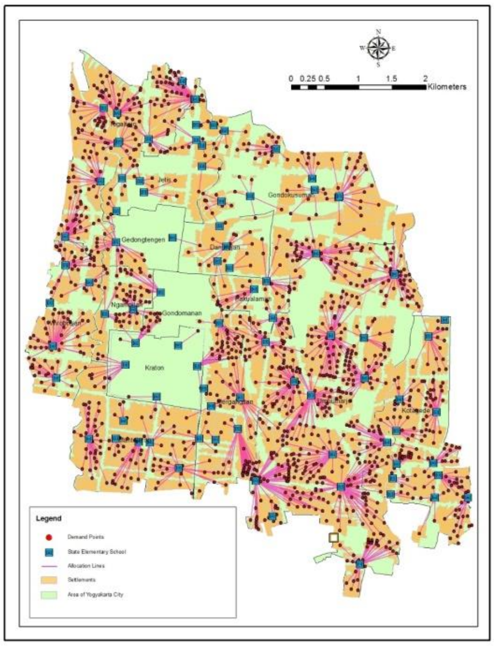

Figure 3 – Map of P-Median Models for Public Elementary Schools

The number of PES is distributed in all districts, but the circumstances of the spatial distribution are not in accordance with the existing residential conditions. In addition, the number of 89 PES has to serve 43.146 elementary school age children in Yogyakarta City (table 1), which is describes as a not ideal condition. If referring to the BSN standard which requires a supporting population of 1.600 for one elementary school, there should be 258 elementary schools.

There are 16 Public Junior High Schools (PJHS) in Yogyakarta City scattered in 10 sub-districts of the 14 existing sub-districts. The location of PJHS in Yogyakarta City is known to be spread unevenly, where there are 4 sub-districts that do not have PJHS facilities. In addition, the spatial distribution is still not in accordance with the existing residential conditions. The locations of PJHS mostly in north and west area, while the distribution of settlements mostly in the south. This circumstances causes education inequality of access for the community.

The location-allocation analysis of P-Median model is also used to determine the demand allocation for PJHS facilities (figure 4). The analysis results indicated that the farthest distance for the PJHS facilities is 3.745 meters. This condition is very different from the criteria of the BSN which stipulates that the service distance for JHS is not more than 1.000 meters. When referring to the 1.000 meters impendence for PJHS then it can only cover around 37 percent of demand points.

The condition of the PJHS number of 16 schools is known to be very far from ideal because it has to serve 19.600 children (junior high school age, 13-15 years) in Yogyakarta City (table 1). Referring to the BSN standard which requires a supporting population of 4.800 for one JHS, there should be 86 JHS. Yogyakarta city really need additional PJHS in order to ensure all the JHS-age children served equally.

Further analysis with more complex research data is needed to be able to solve the spatial problem of the number of schools that are far from ideal, for both elementary schools and junior high schools. Additional schools are clearly needed in this condition considering that primary education is the government's obligation. Private schools can indeed help the government overcome this, but not all families have the economic ability. More analysis, such as site location, that can help the government to locate school facilities in a particular place to maximize the potential of educational services is needed.

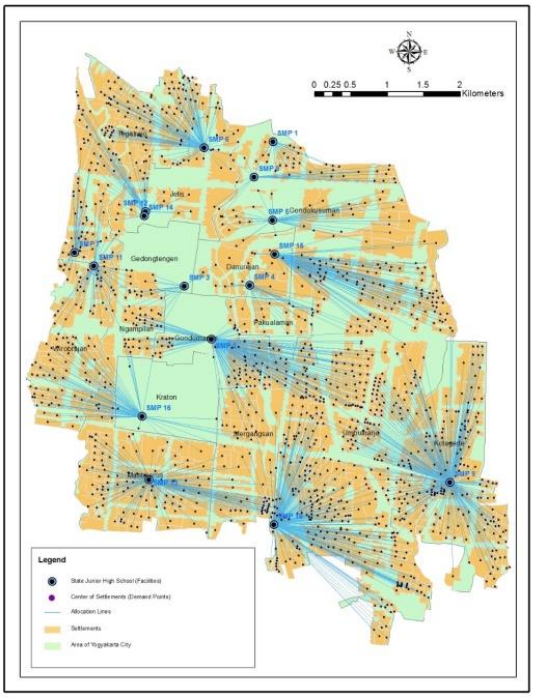

Figure 4 – Map of P-Median Models for Public Junior High Schools

The concept of school sustainability planning in the context of the service hierarchy is the basis for determining this research analysis. The demand point in this analysis is the PES location in Yogyakarta City. Each PES will be allocated to certain PJHS facilities through a network analyst toolbox, location-allocation analysis of the P-median model. This analysis emphasizes the distance proximity of PES and PJHS based on the road network conditions.

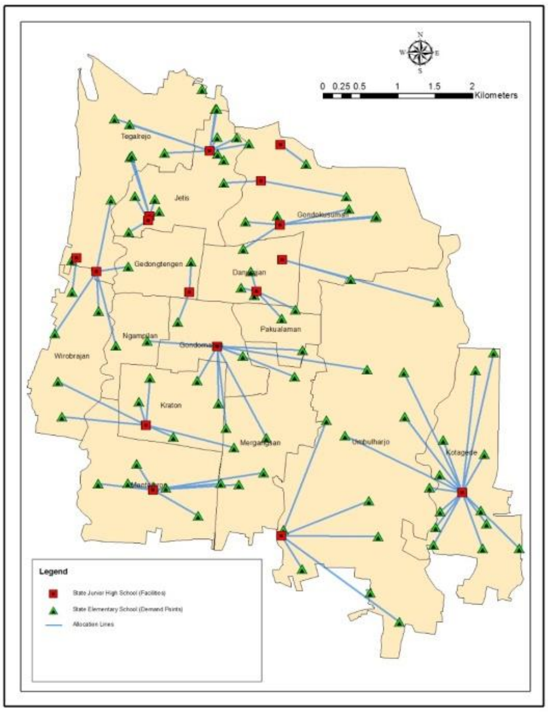

Figure 5 – Hierarchical Analysis of Primary Education (High-Low Level)

The primary education system in Yogyakarta City involves 89 low-level education facilities and 16 high-level education facilities. Each high level will be allocated in the range 1-16 low-level. This condition is not ideal because there is a wide gap of service between low-level coverage due to the uneven spatial distribution of facilities at low and high levels. Equity reffered in this research is that the location of both high and low level criteria must be based on demand conditions (school-age children). The unequal distribution creates access disparities between regions (sub-districts).

Additional education facilities, both in the low and high level criteria, are needed to maximize education services in Yogyakarta city. The spatial distribution of educational facilities is an important factor in ensuring service effectiveness. Additional education facilities will ensure that the range for high level (JHS) and low level (ES) can be adjusted to BSN standard criteria. In addition, Yogyakarta City is known as an area with a high population density (12.740 people per km2). Areas with high population density should place schools in a maximum walking distance [32] where the ideal standard distance for elementary school is 400-800 meters and for junior high school is 800-1.200 meters.

Analysis of additional school needs according to the BSN criteria can be seen on Table 2. Additional schools should be adjusted according to the needs, based on the number of school-age children in each sub-district so that the number of schools required is more actual when compared to the standard number of residents supporting the facilities. The priority for adding JHS (high level) is carried out in sub-districts that do not yet have JHS facilities, that is District of Mergangsan Pakualaman, Ngampilan, and Wirobrajan. According to the Ministry of Education regulations, it is mandatory for each sub-district to have at least one JHS facility. To adjust it spatially, it can be seen from the analysis of the location-allocation network P-median model.

Table 2 – School Requirement According to BSN (Indonesia)

School Type	Elementary School		Junior High School	
	Capacity	Ideal Number	Capacity	Ideal Number
Type A	480	90	1.080	19
Type B	360	120	720	27
Type C	240	180	360	54

New school locations can be added through further analysis, such as site location analysis in GIS, which is able to place the school location according to the standard of selecting the right location for the category of educational facilities. It is highly recommended that additional schools use the criteria for school types B or C, given the potential for population growth in the future. Type A schools no longer allow modification of adding students because they have exceeded the maximum capacity limit. Meanwhile, type B and type C will be able to adjust to the increase in population by manipulating the capacity (adding classes or study groups).

Additional schools considered capable to reduce the farthest distance from the position of demand to the location of educational facilities so that services will be maximized. Especially considering that Yogyakarta City is an area with a high population density, it is highly recommended that school locations be within a walking distance area according to applicable standards.

CONCLUSION

The spatial distribution of primary school (public elementary school and public junior high school) in Yogyakarta City still unable to meet the needs of demand (primary school age children, 7-15years). There is a gap between the number of PES and PJHS, where the number of PJHS is unable to accommodate all of elementary school graduates. This raises problems for the sustainability of the child education. There is a need to add the number of school (PES and PJHS) and distribute schools evenly in every sub district according to population of school age children.

This research contribution is the proposition of the concept of a location-allocation hierarchy using the P-median model approach for public educational facilities, particularly primary education (elementary school and junior high school) by considering the proximity factor of distance. The concept of a hierarchy of locations provides an overview of the sustainability of basic education through the concept of high level facilities (for JHS) and low level (for ES). The P-median model has advantages in the context of the closest distance to being able to allocate low level facilities at high level to determine the integration of basic education.

This research is able to provide an overview of the integration and sustainability of primary education in the spatial system. Additional primary education facilities are needed to optimize education services. The government should pay attention to the spatial integration of primary education in the context of equitable education to ensure that every child has equal access to quality education.

This research has limited road network attribute data which might contribute weaknesses in the analysis results. Further research is needed to optimize primary education services with site location analysis to add the location of educational facilities. The main consideration in selecting ES and JHS locations in the high and low level criteria is spatial distribution.

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