Decision Support System for Education Development and Analysis of Education Facilities Using GIS

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Abstract

Myanmar's Government is leading the process of national education reform. It is estimated that over one million children are still out of school in Myanmar due to poverty, geographical remoteness, disability, language conflict and other barriers. The purpose of this study is to determine education development in 4 townships of Meiktila District and to illustrate how GIS can be used in addressing the educational planning problems through a case study of educational facilities. In this article, 31 criteria are described to determine the ranking of educational development level of four townships; Meiktila, Mahlaing, Thazi and Wundwin in Mandalay Division, Myanmar. The ranking results are compared by using two methods of AHP and SAW. Ranking results and the most important criteria are generated in GIS environment to show how GIS platform can analyze educational development problems. GIS is well known to the planners, decision makers and other actors of planning as a Decision Support System (DSS) tool. As the future work, the analysis of the regional distribution of educational facilities, evaluation of spatial accessibility to the facilities and demographic data will be used in demand analysis for various educational services within the country.

Keywords: AHP, SAW, MCDM, GIS, DSS, Location-allocation.

1. Introduction

This paper builds a system that supports choosing the best high school. Multi-Criteria Decision Making (MCDM) methods rate and prioritize a set of alternatives that best satisfy a given set of criteria. Criteria are a set of requirements or independent attributes that have to be satisfied by several alternatives. Each criterion may be measured in different units (e.g. years, miles or dollars) but they all have to be normalized to obtain dimensionless classifications, i.e. a common numeric range/scale, to allow aggregation into a final score. Data normalization is an essential part of any decision making process because it transforms the input data into numerical and comparable data, allowing using MCDM methods to rate and rank alternatives. The Analytic Hierarchy Process (AHP) was introduced by Saaty to solve unstructured problems in economics, social sciences, and management. The multi-criteria programming by using the analytic hierarchy process is a technique for decision making in complex environments in which many facts, variables or criteria are considered in the prioritization and choosing of the best alternatives or projects.

A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions. Every day, planners use GIS technology to research, develop, implement, and monitor the progress of their plans. GIS provides planners, surveyors, and engineers with the tools they need to design and map their neighborhoods and cities. Planners use GIS both as a spatial database and as an analysis and modeling tool. The applications of GIS vary according to the different stages, levels, sectors, and functions of planning. GIS helps make the presentation of data more attractive than traditional static maps. Through considering geographical (spatial) factors, the analysis becomes finer and more precise, increasing the likelihood that ensuring strategies will be more prominent. Traditionally, GIS are keys to (spatial) data management, but lack problem domain modeling capability. This means additional processing or analytical capabilities are needed to extend functionality for decision making. In this article, QGIS and ArcGIS are used to analyze and present geographical information.

This article's objectives are:

1. To illustrate the main criteria of decision support system to estimate the most development in education facility in four townships of Meiktila District, Myanmar.
2. To analyze the regional educational developments of BEHS education facilities by using several criteria and collected data.
3. To analyze the siting of school facilities to get more coverage area in four townships.

4. To assist E-Government by providing effective decisions making for planning educational developments in four townships of our Country.

2. Related Works

The authors in paper [1] described one of the decision making model called Simple Additive Weighting (SAW) method for personnel selection. They applied seven criteria that are qualitative and positive for selecting the best one among five personnel and also ranking them. They summed up the total obtained values, the criterion weight, and the highest score was considered as the best alternative.

In paper [2], the author described that importance insight into an area of multi-criteria decision making and the employment of the Analytic Hierarchy Process (AHP) to assess the contributions of management student team members. And then, he demonstrated the results that the student ranking was more likely influenced by the relative importance of teaming, computer skills and management and by sub-criteria, communication, innovation, determination and cooperation.

The authors of paper [3] determined the most appropriate host country among the six alternatives (USA, England, Canada, Australia, New Zealand and Malta) using AHP methodology. In that paper, the AHP model of the problem was structured with the predefined and evaluated criterions; as "Easy Application Procedure", "Expenses for Education and Daily Life", "Security of Life", "Level of Sociocultural Life" and "Easy Travel Connection". The pairwise comparison matrix formed based on the knowledge of an expert group and the customer expectations vector derived from the graduates were used to find the weights of host country options. The authors discovered that, choosing Malta as the host country was the best alternative.

The paper [4] demonstrated the use of GIS in analyzing positional related data and its enormous potential in solving educational planning problems of disparity and lack of balance between demand and supply of educational facilities to aid decision making on what action to take.

Paper [5] showed the applicability of GIS in education facilities, where each educational unit has easy access to the common database. The system was constructed for schools in Old Tbilisi District, in Tbilisi, Georgia and different analyses related to education were performed.

3. The Study Area

Meiktila district is located in the Mandalay Division, Myanmar. It is located at 20˙ 0' 0"N and 96˙ 0' 0"E and its area is 1,231.2 3 Km². It lies between Wundwin, Myingyan, Yamethin, and touches Shan State on the east. It consists of four townships namely: Meiktila (379 villages), Mahlaing (247 villages), Wundwin (218 villages), and Thazi(249 villages). The district's population is 309,663 based from the 2014 Myanmar Population and Housing Census. Population density (per Km²) is 251.5 persons.

Several GIS data layers of Meiktila district are made available for assessment of quality and suitability for use in GIS analysis. Locations, schools' age, no of students, no of teachers, Buffer area of BEHS in 4 townships, etc, are represented as points and areas. Data for all schools are received from Meiktila District Education Office for 2016-2017.

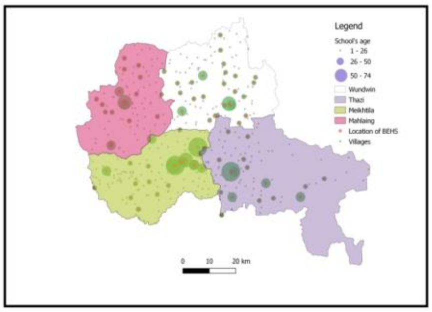

Figure 1:School's Age of BEHS in 4 Townships of Meiktila District

Figure 1 and 2 indicate that school's age and pass rates of BEHS in 4 townships. The school's age is defined as the main criterion. Passing rate is also important and it can be determined the success of that school.

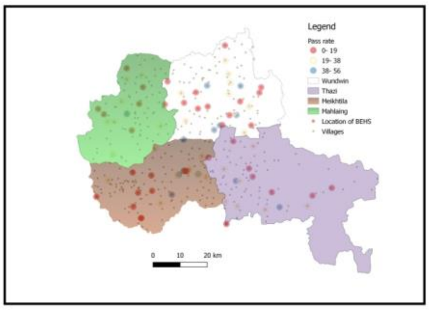

Figure 2: Pass Rates of BEHS in 4 Townships of Meiktila District

Figure 3 and 4 illustrate the data for the number of students and teachers in the 4 townships of Meiktila district as the Criteria C4 and C5 used in the multi crieria decision making process. The number of students and teachers are 25573 and 948 in Meiktila township, 12332 and 480 in Mahlaing township, 19188 and 671 in Wundwin township and 16759 and 625 in Thazi township. The student to teacher ratio is 29:1 in Wundwin, 27:1 in Meikhtila and Thazi and 26:1 in Mahlaing township. Student and teacher density in Meikhtila township is more heigher than the other three townships.

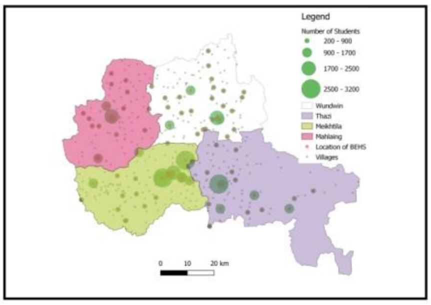

Figure 3: Number of Students in 4 Townships of Meiktila District

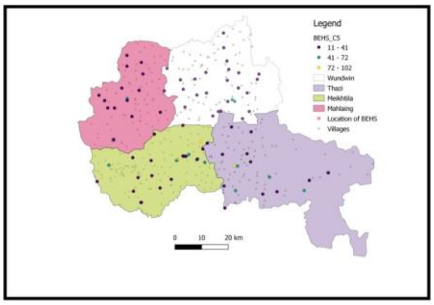

Figure 4: Number of Teachers in 4 Townships of Meiktila District

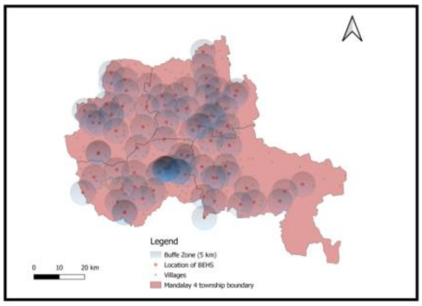

Figure 5: 5 Kilometer Buffers around BEHS

Figure 5 is showing that the 5 km coverage buffer area around the schools in four townships of Meiktila District. The 5 km is suitable distance for childrens to go to school. Buffer zone are indicating that all villages in four townships are not covered in 5 km distance form schools. To get the best coverage zone we can build and site the new school in this area.

4. Methodology

In this article, the ranking of the regional education developments are described by performing the following steps:

1. Define the problem and determine various types of criteria show in Table 2.
2. Structure the decision hierarchy taking into account the goal of the decision as shown in Figure 1.
3. Construct comparison matrix by using the fundamental scale of pair-wise comparison shown in Table 1.
4. Calculate the weighted values vector (W_j) for weighting process by measuring consistency ratio (CR). Accept the estimate weighted values if the consistency ratio is significant small. If CR is not less than 0.1, revise the judgments.
5. Determine multi decision matrix for ranking m alternatives (A_1, A_2, …, A_m) by n criteria (C_1,C_2, …,C_n) as presented in Table 3.
6. Presenting results in GIS map as approach of research framework procedure shown in Figure 7.

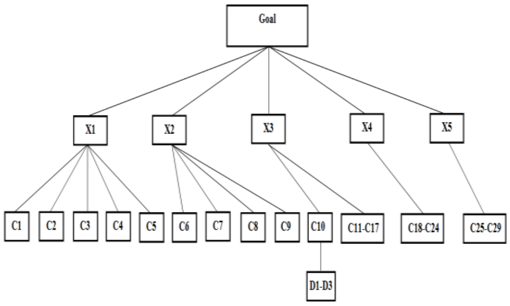

Figure 6: AHP example of approaching goal for ranking best school in Myanmar

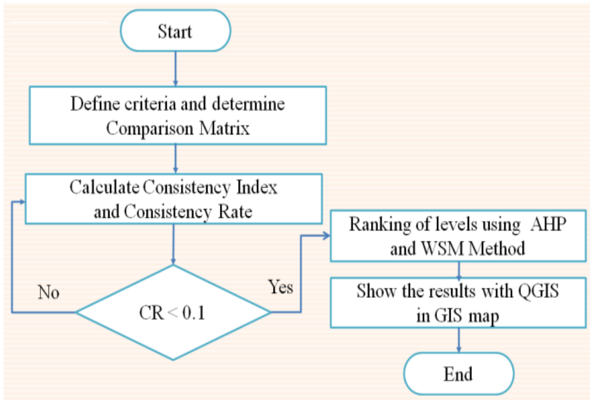

Figure 7: Research Framework

Table 1: Numerical relation scales

Intensity of importance	Definition
1	Equal importance
3	More importance
5	Much more importance
7	Very much more importance
9	Extremely more importance
2,4,6,8	Intermediate values

Table 2: Definitions of Criteria

Criteria	Definitions	Sub-Criteria	Definitions
X_1	School's Profile	C_1	School Age
		C_2	Pass Rate
		C_3	Distance from Office
		C_4	Number of Students
		C_5	Number of Teachers
X_2	Teaching	C_6	Computer Training
		C_7	Language Lab Training
		C_8	Laboratory
		C_9	Completion of Teachers' Training
X_3	Infrastructure	C_{10}	Class Rooms
		C_{11}	No. of Science Labs
		C_{12}	No. of Toilets
		C_{13}	Teachers' Recreation Rooms
		C_{14}	No. of Multimedia Rooms
		C_{15}	Library
		C_{16}	Stadiums
		C_{17}	Hazard Buildings
X_4	School's Facility	C_{18}	Sport Goods
		C_{19}	No. of Books in Library
		C_{20}	Electricity Availability
		C_{21}	Musical Instruments
		C_{22}	Water Availability
		C_{23}	Scholarship
		C_{24}	Fund
X_5	School's Staff	C_{25}	Lower Clerk
		C_{26}	Office Helper
		C_{27}	Laboratory (Specialist)
		C_{28}	Upper Clerk
		C_{29}	Security

5. Educational Development by Using AHP and WSM Methods

The first level of the AHP model involved five major criteria: School's Profile criteria, Teaching criteria, Infrastructure criteria, School's Facility criteria and School's Staff criteria. The main criteria are decomposed into 29 sub-criteria: C_1 to C_{29}. C_{10} is also decomposed by 3 criteria (No. of classrooms, No. of blackboards and No. of Tables, Seats and Benches). First level five criteria and second level 29 sub-criteria are given in Table 2.

After the hierarchy has been established, the main five criteria must be evaluated in pairs so as to determine the relative importance between them and their relative weighted values to approach the goal. The evaluation begins by determining the relative weighted values of the initial five criteria groups shown in Figure 7.

Table 3: Normalization values of comparison matrix and weight vector (CR=0.0053)

Normalization	X_1	X_2	X_3	X_4	X_5	Eigen Vector
X_1	0.4380	0.4186	0.4545	0.4364	0.4167	**0.4328**
X_2	0.1460	0.1395	0.1136	0.1636	0.1667	**0.1459**
X_3	0.2190	0.2791	0.2273	0.2182	0.2083	**0.2304**
X_4	0.1095	0.0930	0.1136	0.1091	0.1250	**0.1100**
X_5	0.0876	0.0698	0.0909	0.0727	0.0833	**0.0809**

Table 3 shows the normalization values between the criteria that have been determined by collecting data about the government BEHS schools. The contribution of each criterion is determined by calculations made using the priority weight vector (or Eigenvector). The Eigenvector shows the relative weights between each criterion; it is obtained in an approximate manner by calculating the mathematical average of all criteria, as depicted in Table 3. The contribution of each criterion is determined by calculations made using the priority weight vector (or Eigenvector). We can observe that the sum of all values from the vector is always equal to one (1). The exact calculation of the Eigenvector is determined by ensuring CR (in this case CR=0.0053). The results from Table 3 show that the schools' profile of government BEHS school is more important than others criteria. The second importance is infrastructure criteria to select the best government school.

Table 4: Comparison matrix for School Profile Criteria (CR=0.0053)

School Profile	C_1	C_2	C_3	C_4	C_5
C_1	1	0.5	0.5	0.333333	1
C_2	2	1	1	0.5	2
C_3	2	1	1	0.5	2
C_4	3	2	2	1	3
C_5	1	0.5	0.5	0.333333	1
SUM	9	5	5	2.666667	9

After defining Eigen vector of first level main criteria, pair-wise comparison matrix is defined for all level 2 sub-criteria as shown in Table 4 and computes the Eigen values by ensuring CR values. For SAW method, the weight sum vector is computed by ensuring CR.

Table 5 shows the Eigen values of comparison matrices for all criteria with the pair-wise comparisons already taken by the decision makers.

Table 5: Comparison of Eigen vector by AHP and WSM

Criteria	AHP	WSM	Criteria	AHP	WSM
C_1	0.04737	0.04109	C_{15}	0.05277	0.03656
C_2	0.08933	0.06671	C_{16}	0.01462	0.01037
C_3	0.08933	0.04379	C_{17}	0.01017	0.00803
C_4	0.15942	0.06279	C_{18}	0.00673	0.01131
C_5	0.04737	0.06336	C_{19}	0.00754	0.02980
C_6	0.05114	0.02657	C_{20}	0.01382	0.02318
C_7	0.01590	0.01934	C_{21}	0.00439	0.01432
C_8	0.02759	0.03905	C_{22}	0.02648	0.03091
C_9	0.05126	0.03410	C_{23}	0.02536	0.04133
D_1	0.03605	0.06559	C_{24}	0.02572	0.04544
D_2	0.01408	0.04215	C_{25}	0.00564	0.01679
D_3	0.01610	0.03543	C_{26}	0.02426	0.01743
C_{11}	0.02924	0.03991	C_{27}	0.01329	0.02133
C_{12}	0.01429	0.02307	C_{28}	0.01126	0.01903
C_{13}	0.01528	0.01917	C_{29}	0.02642	0.01943
C_{14}	0.027777	0.032623			

In order to apply AHP and SAW, the decision makers compared 87 BEHS schools: MTLA1 to MTLA25 for Meiktila Township, MH1 to MH18 for Mahlaing Township, WD1 to WD26 for Wundwin Township and TZ1 to TZ18 for Thazi Township, taking into consideration every one of the total 31 established criteria.

Decision Matrix (a_{ij}) model is presented in Table 6.

Table 6: Decision Matrix

	C_1	C_2	…..	C_n
A_1	a_{11}	a_{12}	…..	a_{1n}
A_2	a_{21}	a_{22}		a_{2n}
.	.	.	…..	.
A_m	a_{m1}	a_{11}		A_{mn}

$$A_i = \sum_{j=1}^{n} w_j a_{ij} \qquad (1)$$

6. Ranking Results for Education Development in Four Townships

The overall priorities to each individual school can fine after completed all pair-wise comparisons from main 5 criteria to the alternative level of hierarchy. The study results of choosing the most developing in education show that BEHS MTLA1 has highest priority than other schools. The final top ten priority results by two methods are shown in Table [7].

Table 7: Final Priority Results

No.	METHOD1		METHOD2	
1	MTLA1	0.83788	MTLA1	0.79813
2	TZ1	0.83401	TZ1	0.77053
3	MTLA5	0.78102	MTLA5	0.76065
4	MH1	0.73916	MTLA2	0.71083
5	WD1	0.71618	MH1	0.69064
6	MTLA2	0.7096	WD1	0.67046
7	MTLA3	0.66775	MTLA3	0.65493
8	WD2	0.6539	TZ4	0.60629
9	TZ2	0.64598	TZ2	0.6056
10	MTLA4	0.62771	WD2	0.59597

Table 8: Ranking priority of education level in 4 townships

Township	METHOD1	METHOD2	RANK
MTLA	30.05	30.29	1
MH	17.62	17.67	4
TZ	24.28	25.04	3
WD	28.05	27.01	2

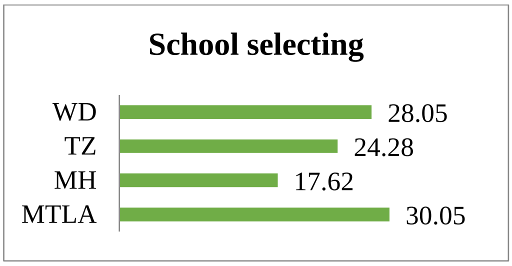

Figure 8: Overall priorities of education level in 4 townships.

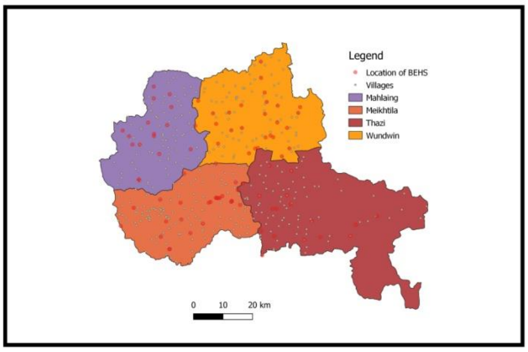

Figure 9: Distributions of BEHS in 4 Townships of Meiktila District

Figure 8, 9 and Table 8 show that the priority of education development for four townships. These results show that "Meiktila Township" is the most developing township in this district and it contributes with 30.05% (0.30). In order to better illustrate the importance of the difference between the weights and priorities of each township, this contributes with about 13% more than "Mahling Township", which contributes with only 17.62% (0.176). Figure 8 shows that Meiktila Township takes the highest priority [0.30], Wundwin Township and Thazi Township has gotten [0.28] and [0.24], while Mahlaing Township gets the lowest priority [0.176]. That's why; we can determine that Meiktila Township deserves the most developing in education to compare to other three townships.

7. Future Work

Buffer (5 km) zone are not enough coverage area in this study area. We need to allocate new BEHS in suitable place to get more coverage area in four townships.

Optimal location of facilities and allocation of demands to them are important issues, since the costs of construction are considerable. Location is often considered the most important factor leading to the success of a private- or public-sector organization. Public-sector facilities, such as schools, hospitals, libraries, fire stations, and emergency response services (ERS) centers, can provide high-quality service to the community with a low cost when a good location is chosen.

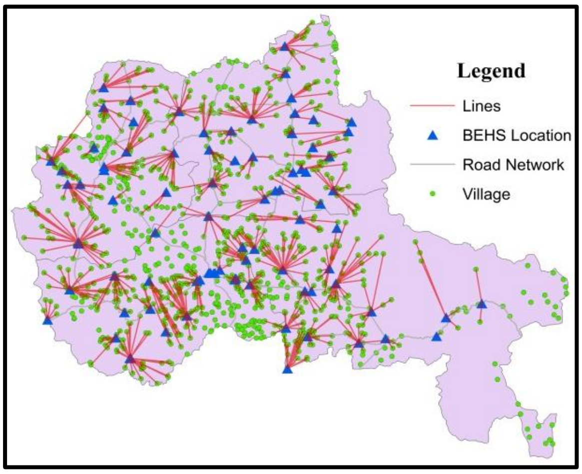

Figure 10: Coverage area of school facilities in 4 townships (No. of schools: 87, villages: 837)

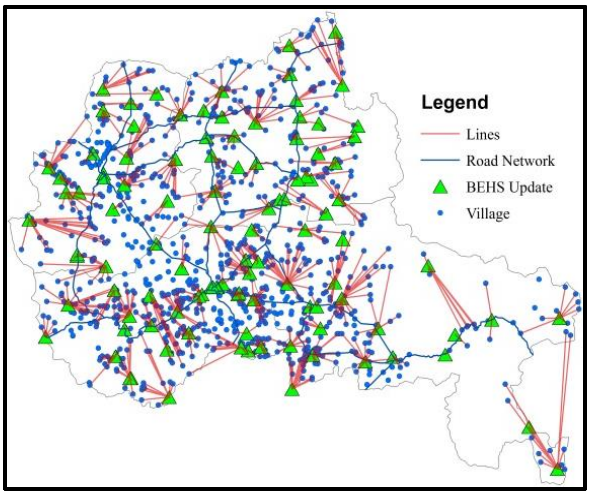

Figure 11: Coverage area of school facilities in 4 townships (No. of schools: 110, villages: 918)

The analysis reveals that the siting new schools can get more coverage in education development with intent of its maximal coverage within the cutoff impedance of 8 km. Figure 10 and 11 show the siting school results. In Figure 10, 87 of BEHS facilities cover 837 demand villages by using 8 km impedance cutoff. 230 villages are located in out of facility. Figure 11 is showing that 110 of BEHS facilities cover for 918 demand villages by using same impedance cutoff. 149 villages are located in out of facility. 81 villages can get education facility when siting 23 news BEHS.

8. Conclusion

The main conclusions in this article are:

1. Select best BEHS in four townships using MCDM methods and estimate the regional educational development level of the four townships. The proposed system not only supports to decision makers and qualifies the decisions, but also enables to justify their choices, as well as simulate possible results.

2. In this paper, some collected data are presenting in GIS as the main criteria of AHP method.

3. The results are showing that Meiktila township is the most developed township in education facility.

4. As the future work, this paper proposed a method of optimization of siting school based on GIS location allocation model.

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