Location Suitability Analysis of Environmental Education Facilities

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ABSTRACT

Environment Education (EE) becomes more and more important in Taiwan ever since the Environmental Education Act (EEA) was implemented in 2011. One of the essential promotion policies is to establish Environmental Education Facilities (EEF). By the end of January 2014, there were 78 facilities certified in Taiwan, nevertheless the current standards of certification are still lack of various aspects for consideration. This study attempts to include the environmental factors such as transportation accessibility and vegetation cover ratio to examine the location suitability with the EEF cases in central Taiwan. The Normalized Difference Vegetation Index (NDVI) were derived from satellite data to represent the vegetation cover ratio. Meanwhile, the transportation accessibility and services range were analyzed by GIS. With the improved criteria of EEF allocation, the facilities are expected to generate more policy effect in the future.

INTRODUCTION

Since the Industrial Revolution, the rapid economic growth has also caused a variety of environmental problems. In recent years, human have perceived these adverse impacts and start to seek for solutions. In order to let people know more about the environment, the Environmental Education(EE) has been promoted for many years. It's an important issue that teaches all civilians to understand the environment and improve their ability to solve the environmental problems with sufficient environmental knowledge. Taiwan's Environmental Protection Administration (EPA) has constantly promoted environmental education. Until the recent, the Environmental Education Act (EEA) was implemented on June 5, 2011.

The EEA claims that agencies, public utilities, elementary school, high schools, and the organizations which receive more than 50% of fund income from the government shall promote EE. And all the government staffs, teachers and students should be required to participate in EE for at least 4 hours every year (EEA, 2010). Since the Act was implemented, the need of EE is growing. Therefore, to set up more Environmental Education Facilities (EEF) becomes an important issue. Moreover, the government also encourages the public or private sectors to reuse abandoned buildings or spaces to become EEF.

To provide diverse EE services with more high-quality EEFs is one of the important issues in Taiwan (Chou,2011). In order to promote environmental education effectively, public and private sectors have already invested a lot of effort and resources. By the end of January 2014, there were 78 EEFs certified in Taiwan, nevertheless the current standards of certification are still lack of various aspects for consideration. The current certification standards did consider the environment (natural or cultural features), environmental education professionals, environmental education programs and management, but not include the location consideration which has caused the uneven distribution of EEFs among counties and obstruct people from taking EE courses.

There are diverse types of EEFs certificated in Taiwan and each type of them develops differently in the future. Therefore, it is an important issue to choose the location for their development. Chou(2011) pointed out that the location is the key factor of the EEF effect.

However, most of the prior studies focused on the sites with commercial activities. Some exceptions like Chou(2011),he indicated several criterions of EEF from the social marketing point of view according to the related EE research. These criterions includes: 1.determine the product and service features; 2. confirm whether consumers are easy to obtain information; 3.confirm the conditions of development. Besides, Chou et al.(2000) also proposed the criteria of EEF's location selection from the economic and environmental points of view. The economic aspects include the competition relationship, development condition, and consumer condition. The competitive relationship depends on whether the existing competitors or potential competitors offer the same products and services. The development condition depends on the services provided which can be supported by policies or laws. And the consumer condition can be determined by the ability to satisfy consumer demand. From the environmental aspects, the criteria include the climatic conditions, land and facilities acquired conditions, the support conditions, the resource conditions, the usage conditions, as well as the transportation conditions. Among all, the climatic conditions indicate the temperature, rainfall and other environmental factors. The land and facilities acquired conditions depend on the land's ownership. And the support conditions depend on the support from the neighboring resources, the basic infrastructures, or the involvement of participated community residents. The resource

conditions depend on the richness of cultural and natural landscape. The usage conditions depend on the base area, parking demand and the whole image. The transportation conditions consider the facilities' transportation accessibility.

Location selection criteria taken in the research are according to the proposed conditions by Chou et al.(2000) but the identical criteria to the current standards are ignored. The GIS data were analyzed to build EEF's locations. The site selection method pointed out by this study is expected to improve the EEF policy effect in the future.

RESEARCH METHODS

Study Area

The central area of Taiwan including Taichung City, Changhua County, Nantou County, Yunlin County were selected as the study area to analyze the EEF's location condition (Figure1). The total area is approximately 8767.25km^2. There were 15 facilities certified in this area by the end of January 2014. The EEF were coded to simplify the description (Table1). Because the distribution of certified EEF is uneven, the services areas of EEF were divided into 15 regions by the perpendicular lines through the midpoint between each EEF.
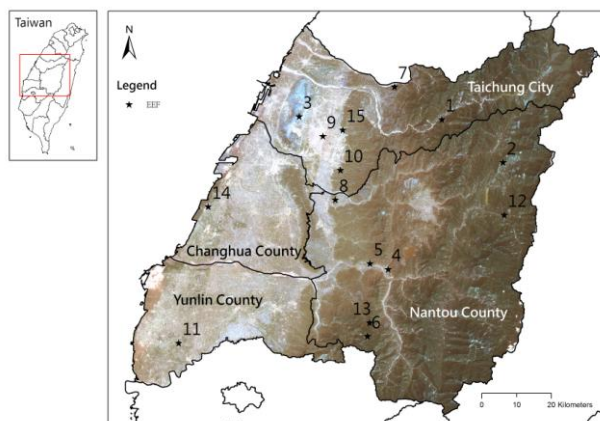

Figure1: Study Area

Table1:

code	name	country
001	Basianshan Nature Center	Taichung city
002	Highland Experimental Farm , NTU	Nantou country
003	Taichung Metropolitan Park	Taichung city
004	Tataka Recreation Area, Yushan National Park	Nantou country
005	Endemic Species Research Institute	Nantou country
006	Sunlinksea	Nantou country
007	Dongshi Forest Garden	Taichung city
008	Ke Lao Shan environmental and ecological park	Nantou country
009	National Museum of Natural Science	Taichung city
010	Chaoyang University of Technology	Taichung city
011	The Formosan golden bat's home	Yunlin country
012	Aowanda Nature Center	Nantou country
013	Xitou Nature Education Area	Nantou country
014	Oyster Printing Life	Changhua country
015	Po Lin discarded furniture Regeneration Center	Taichung city

Research Resources

Formosat-2 Imagery with 8m resolution provided by CSRSR was used in the study to evaluate the vegetation condition. Transportation and school datasets such as roads distribution, train station and school location were

extracted from 2013 Taiwan electronic map. EEF and competing facilities dataset was converted from address by free geocoding tool.

Methodology

Based on the reference proposed by Chou (2000) and the standard criteria of EEF, the factors related with the EEF site evaluation are selected as the following:
(1) Consumer factor is determined by the ability to satisfy consumer demand.
(2) Competition factor depends on whether the existing competitors or potential competitors offer the same products and services.
(3) Resource factor contains the richness of cultural and natural landscape which is evaluated by the vegetation cover ratio in this study.
(4) Transportation factor considers the facilities' transportation accessibility which are represented by the train station services and the road density.

All of the certified EEFs in Central Taiwan were analyzed by GIS to evaluate the strengths and weaknesses according to the 4 selected factors. The factors in this study are classified into 5 levels according to Chou (2011). Then the suitability of EEFs is evaluated to propose the suggested sites in the future.

Consumer Factor

Consumer condition was used to understand the consumers' demand in the region. In this study, the number of schools in the region is considered to be a consumer factor because the school students are the main customers who would take the environmental education according to the Act. Thus, it's important to know the number of schools at all levels in the service region before an EEF was set up. The more schools in the service region the more EEFs are needed.

Competition Factor

Jung et al. (2005) analyzed the location of convenient stores in Taipei and mentioned that the market will be divided by industry competition. Thus, the competition facilities in the neighborhood must be considered in location analysis. The competitive relationship indicates whether the facilities are in competition or cooperation among EEFs. The number of the potential competition or cooperation facilities in the regions (including public and private museums, tourism factory, farm, National Forest Recreation Area, etc.) were calculated to get the competition factor in this study. The more potential certified facilities in the service region, the higher score it is. A higher score means the higher possibility to generate the competition relationship in the future.

Resource Factor

The normalized difference vegetation index (NDVI) derived from red(R) and near-infrared (NIR) is currently the most widely used method to analyze the ratio of surface vegetation distribution (Xiao et al., 2002). It can calculate as following formula:

$$NDVI = \frac{NIR - R}{NIR + R}$$

The range of NDVI is between -1 to 1 where 1 represents the highest plant biomass, and the value less than zero represents a non-vegetation habitat. The image was classified into vegetation and non-vegetation area by setting the NDVI threshold (Lin, 2011), and vegetation cover ratio (representing the EEF's resource conditions) is calculated by the services area.

Transportation Factor

Transportation accessibility indicates the transportation convenience. According to previous study, there are many methods to evaluate the transport accessibility. For example, the number of facilities within a specific range, the shortest distance, the least cost transportation method, road density and the space syntax are often used to measure the accessibility(Xie, 2008; Tsou, 2009). In this study, the road density was counted as one factor where more intensive road density in the surrounding is with higher accessibility. Meanwhile, some of the consumers may go to the EEFs by public transportation system, the train stations' services area was used as another factor because there is no MRT in the middle of Taiwan. These two factors were combined to compute the transportation accessibility in the study area.

RESULTS AND DISCUSSION

Consumer factor

The EEFs coded as 011,008,003 have larger consumer groups and are mostly from the elementary schools. The 005 service area has only 53 schools, but with the most amount of junior high schools while the 009 area has

the most number of senior high schools (Table2). The total number of schools in this study is classified as 5 level and the scores is given. The schools clumped along the coast area have darker color (Figure2), which might be due to the plain topographic. That is, the schools distribution is highly related with human population in Taiwan. Therefore, the more schools there is, the more EEF is needed.

Table2: Consumer groups

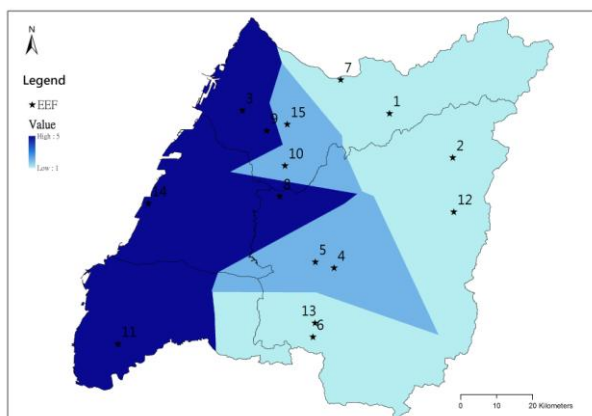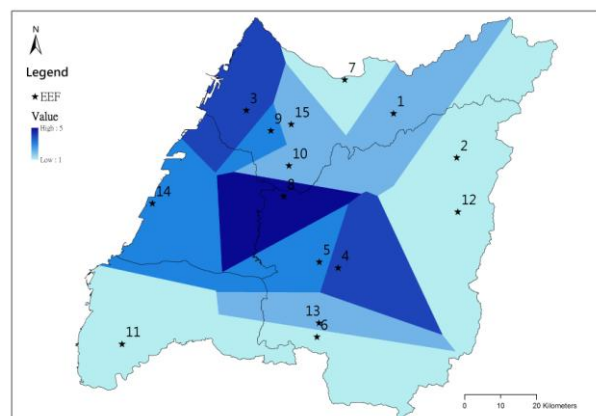| code	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015
elementary school	10	11	90	4	3	22	3	92	73	32	118	9	29	101	44
junior high school	1	2	29	32	39	4	25	20	28	7	23	1	5	17	12
senior high school	0	1	12	7	11	1	5	16	26	8	13	1	3	8	8
total	11	14	131	43	53	27	33	128	127	47	154	11	37	126	64

Figure2:　Consumer groups

Figure3: Competing sites

Competition Factor

There are 8 EEFs with more than 10 competitive facilities (including code 003,004,005,008,009,013,014, and 015). Most of them are located in the downtown area or near coastal zone (Figure3). The code 008 located among three countries and cites has the most amount of competitive facilities. If the EEFs are varied in different types, the competition relationship between the EEFs can become insignificant. The relationship may convert from competition to cooperation and will be helpful to promote EE in the future.

Table3: Competitive sites

code	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015
competitive sites	8	1	20	19	15	5	4	26	13	9	5	4	10	12	11

Vegetation Factor

The vegetation cover ratio is higher in the EEF service regions of 002,012,004,006(Table4).This is mainly because these EEFs are located in Nantou's mountain area where is rich with forest resources (Figure4). The vegetation cover ratio is lower along the coast where the city buildings and crops are the major land use types. Meanwhile, there is an observable transition region between them in the middle zone.
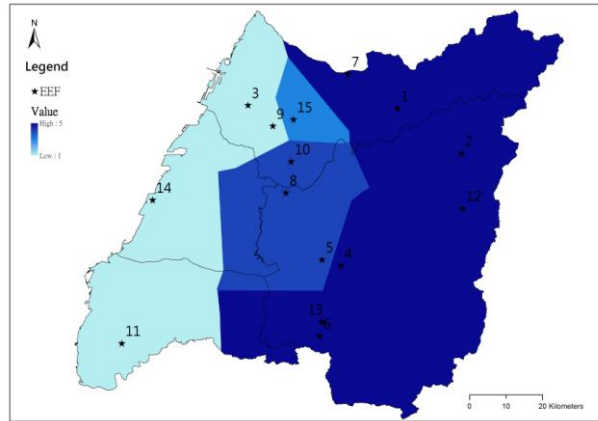
Figure4: The ratio of vegetation cover

Table4: The ratio of vegetation cover

code	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015
vegetation cover (%)	87.25	92.97	23.46	87.38	75.37	89.11	81.53	65.34	23.87	78.41	31.34	90.04	85.86	33.13	64.20

Transportation Factor

Train Station Services Area

It takes less than 15 minutes from the train station to some of the EEFs (003,004,005,009,015) with 50 km/hr driving speed. The 008 and 010 areas take 30 minutes to reach from the station with the same speed while more than 1 hour should be taken to reach the areas coded 001,006,007,011,013. The other EEFs even require much more time to reach. The higher scores are given to the EEFs which require less time to arrive. On the other hand, the lower scores are given to the otherwise. (Figure5).
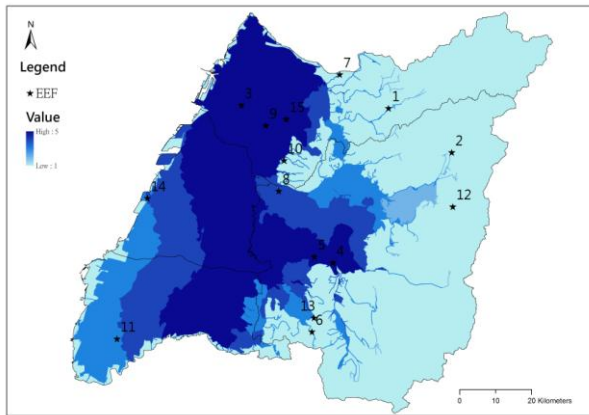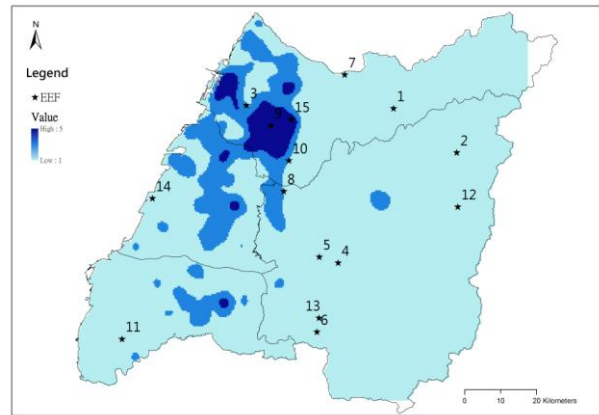

Figure5:Train station services area

Figure6:Road density

Road Density

The areas with high road density are located in the central region of each county (Figure6), where 009areais the highest density region and 015&003 areas are the second. Road density can represent the transportation convenience. Therefore, the higher road density should be given a higher score.

CONCLUSIONS

The EEFs coded 003,004,008,009,015 have the higher scores in the economic and transportation accessibility aspects, although the vegetation cover ratio is lower. The EEFs coded 001,002,006,007,012 have the lower scores indicating that the surrounding area maybe haven't enough consumer groups, competitive facilities, and lower traffic accessibility, although they have larger vegetation cover ratios because most of them are located in the mountain area.
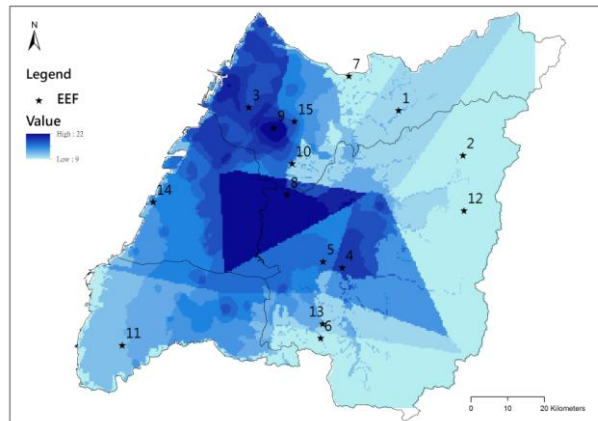
Figure7: Location suitability of EEFs

The location suitability showed in Figure7 indicate that the EEFs near the boundary of Taichung, Changhua and Nantou have enough consumer groups, many existing facilities with competition and cooperation, and convenient transportation accessibility. Therefore, these areas with higher scores can be suggested to promote EE and the facilities certification in the future.

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