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INVESTIGATING THE LOW-INCOME SETTLEMENT IN AN URBANIZATION AND URBAN FORM A CONSEQUENCES OF BANGKOK GROWING CITY, THAILAND

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ABSTRACT: A rapid urbanization has resulted in more rush transformation of a settlement of low-income migration growth into an urban area. The growth squatter settlement role was influenced through an urban form conflict. Many of these points have been debated over the issue of sustainable urban development plan that has led the way into the urban building density appearance and the phenomenon of its urban area growth effects. The ultimate results depend on an increase in carbon emissions changed over time and its effect on climate change. The real challenged problems are being solved in the developing country, such as Thailand's capital Bangkok. Moreover, an unplanned and low-efficient development projects cause extensive devastating consequences to both urban environment and human beings. Particularly for the low-income people who live in a lowland area are more heavily burdened by environmental risks and unsafe area. Thus, it is imperative for this paper to discover a key issue of low-income migration and settlements on the basis of the measurements which includes: (a) the situation of urbanization driving process forces the low-income settlement growth, and (b) investigate the causes and effects on urbanization in terms of the urban environmental conditions and location system (e.g. sensitivity analysis, risk approaches) using GIS-based Multi-Criteria Decision Analysis (MCA) for calculating the simplify situations of alternative factors and using the Analytical Hierarchy Process (AHP) for weighting the measure of individual participant data. By this approach, it is becoming more feasible to be configured, with the Weighted Linear Combination (WLC) operators. This tool presents the usefulness of the relative important weights for relevant approaches of low-income settlement in consequences of growing cities based on geographic information system (GIS).

Keywords: Low-income settlement, urbanization, Multi-Criteria Decision Analysis (MCA), Analytic Heirarchy Process (AHP), Weighted Linear Combination (WLC).

INTRODUCTION

Urbanization is the one of the most serious problems that has general effects on all elements of environmental causing Climate Change crisis. This is including to habitat destruction, disasters, air pollution, flooding risk, urban climate condition and so on. Recently, the world has experienced a dramatic growth of its urban population for over the last 50 years (United Nation, 2009). In addition, the rate of the urban population growth is more than that of the rural population. United Nation, (2009) reports that most of the world population currently lives in urban areas. The worldwide urban population is estimated to be 3.3 billion and is predicted to almost double by 2050. More importantly, the speed and scale of this growth have usually been concentrated in developing countries that are characterized by larger metropolitan areas and a great number of megacities. Inevitably, prolific population growth leads to a rapid expansion of urban growth, causing changes in land use and land cover in many metropolitan areas around the world. Significant, uncontrollable changes can intensify a large number of social and physical problems; especially in many developing countries have deployed various products, themes and re-sources to compete for a share of tourism and other external capital. Some researchers have focused on qualities such as centers of cultural (Griffiths, 1995) or advantages of site (Barke and Harrop, 1994).

As rapid urbanization, escalating poverty and inadequate institutional capacity that is provided to infrastructure, housing and employment opportunities. Consequently, a growing proportion of urban population

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is living in housing poverty in slum or informal settlements so there was resulted to "low-income housing" growth. Most of the developing world, which are least equipped to deal with rapid urbanization -- 95 % -- and will be absorbed by cities of the developing world (UN-habitat, 2006). The half of the world's population is estimated to live in cities and though to reach of low-income population 889 million by 2020 (UN-habitat, 2010). Urban poverty merits attention in its own right since it presents some issues distinct from those addressed in the typical analysis of poverty (Baker and Schuler 2004). There are three distinctive characteristics along which urban poverty and vulnerability differ from rural poverty: commoditization, environmental hazard, and social fragmentation (Moser, et. al., 1996). Including to insecure land tenure, the lot of many poor urbanites, provides yet another disincentive to invest in environmental improvement that the burden of most environmental problems falls more heavily.

Moreover, the public service of environment may not be suitable even for affluent cities. Most government of developing countries is finding it increasingly difficult to bear the burdens of environmentally heedless urban dwellers. For environmental management, many shifts of urban development proposals have emphasized onto more sustainable path support a move away from centralized service supplying, household activity and community involvement (Gordon, 1993). Moreover, the environmental hazards risks are also higher in urban areas by the climate change crisis. The combination of inadequate access to water and sanitation, poor quality housing, and overcrowding increases the health risks facing urban residents and the urban poor in particular. Thus, low-income dwellers are hardship of being poor health services compared to general households which is residing in non-slum/ low-income settlement area (Rutstein, et. al., 2005).

Fig. 1 Urbanization as building in; (a) 1994 and (b) 2009 using Landsat TM (Band 7, 4, 3, resolution 30 meters)

In Thailand, the urban population was 31.1 % of total national population in 2000 and is projected to increase to 45.8 % by 2030. Fig. 1 showed the urbanization made the highly build-up area in 1994 and 2009 using Landsat TM (Band 7, 4, 3) in resolution 30 meters. In 2009, there has also resulted in several low-income settlements using Point Pattern Analysis (Fig. 2). Most of the inhabitants are believed to be poor such as; area less than 1,600 sq.m. / 15 units; number of story; type of detached house, flat, and floating house; and also wood and corrugated iron characterize.

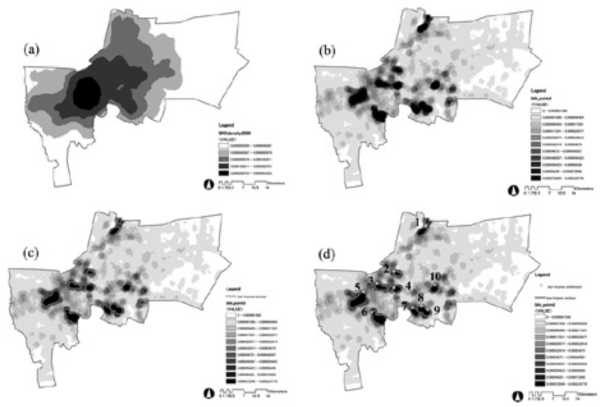

Fig. 2 The investigated of low-income settlements as well as; (a) Build-up area density (Table 1), (b) Density estimation of low-income point, (c) Highest range of contour polygon (z-score = 0.000080435), and (d) Point location of ten special cases.

Table 1 The density of low-income settlements using Point Density Estimation by GIS technique (Fig. 2(a))

Legend	Density Levels	Area (hectare)
	Very high	6,248.03
	High	23,915.97
	Moderately	32,443.90
	Low	33,823.59
	Very low	60,442.21

In particular, there are two posing unprecedented problems for governments and local authorities – rapid urban population growth and urban poverty. However, in Thailand, low-income dwellers account for 3 % of the total population, and of the total low-income population, 84 % live in the Bangkok Metropolitan Region, and the rest live in other municipalities of the country (Pornchokchai, 2003). Moreover, Thai urban planning tends to perform very poorly and has had almost no effect on shaping Thai urban form and land use due to the lack of policy coordination and synchronization in central and provincial level. In Bangkok and its surroundings, urban development has generated many slums. They increased from 50 communities or settlement in 1968 to 1,020 in 1985 (Pornchockchai, 1992) and 1,266 in 2009 (CODI, 2010) that are located around center of Bangkok (Fig.2).

As a result, Thai cities are built up self-organization, the Thai government has been implementing several programs for slum upgrading, e.g., re-blocking (re-design), reconstruction, land sharing and relocation in slum areas (Guerra, 2004). The Thai government was making improvements such as roads and walkways, water supply, and electricity in slum upgrading projects and providing affordable housing through by the National Housing Authority (NHA) and Community Organizations Development Institute (CODI). However, almost low-income dwellers are located nearby CBD, they did not want to improve or remove to other place. Anyways, low-income settlement of Bangkok was still addressing the main problems of comprehensive information and increasing in year by year (Fig. 3). Thus, these highly dynamic areas as a basis for climate change condition plan for Bangkok Thailand and developing country.

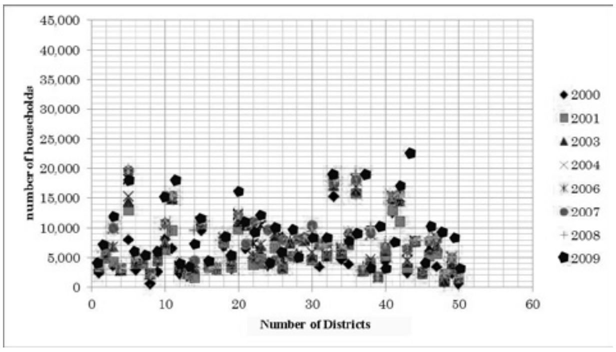

Fig.3 Statistical profile of low-income households in Bangkok since 2000-2009
Source: Strategy and Evaluation Department, Bangkok Metropolitan Administration

This paper was provided that real developing world problems give rise to multi-criteria decision analysis (MCA) based on geographical information system (GIS). This techniques has assumed the decision making and can be thought of as a process in the sense that offer unique capabilities for automating, managing, and analyzing a variety of spatial data for decision making (Drobne and Lisec, 2009). The thematic map is alternative to the layer approach of GIS oriented objects, which is closely represented the real world elements and very important role in decision-making. Two methods of GIS and multi-criteria decision analysis (MCA) are calculating the simplify situations of alternative factors. It is becoming more feasible to configurated, with using both the analytical hierarchy process (AHP) and the weighted linear combination (WLC). This tool presented the usefulness of relative important weights for investigating the "low-income settlement" in consequences the environmental conditions and location system (e.g. sensitivity analysis, risk approaches) by GIS techniques. Moreover, there was provided of policy management of climate change crisis that highly effected to the low-income communities in case of Bangkok growing city, Thailand.

DESCRIPTION OF STUDY AREA

The study area is Bangkok megalopolis, a capital center of Thailand, which one of the most successful developing countries. Bangkok is a part of fertile floodplain that owes its existence to the Chao Phraya River and Gulf of Thailand. This area is located between 13o45’8”N and 100o29’38”E, covering 1,568.737 sq.km. (606 sq. mi) (Fig. 4) and lies about two meters (6.5 ft) above sea level so the flooding is the main cause of problems for the protection of the city. Bangkok is the one of special administrative area and itself has gained a reputation of having among the most rapidly degraded and severely deteriorated urban environments as an independent, dynamic and influential city such as economic, social, political, population and services, which has resulted in accelerating urbanization. More energy consumption and air pollution from particulates and lead to microbiological contamination, environmental condition and traffic congestion are among Bangkok’s most serious problems.

Fig. 4 Location of study area

In particular, economic of Bangkok (World Bank, 2006) concentrated and expanded more and more slight increase from under 60 % in 1970 to just over 60 % in 1986, reached 70 % by 1996, and increased to 72 % in 2004. While getting a job is easy, wage employment is not only harder to come by, but it is also less well enumerated. So, people, especially among the young (15-40 years old), from outlaying regions leave their villages to seek employment in the service sector in Bangkok. Moreover, in terms of population size, the only outlier is Bangkok, while there are six outliers in terms of GDP per capita, all located in and around Bangkok (Fig. 5).

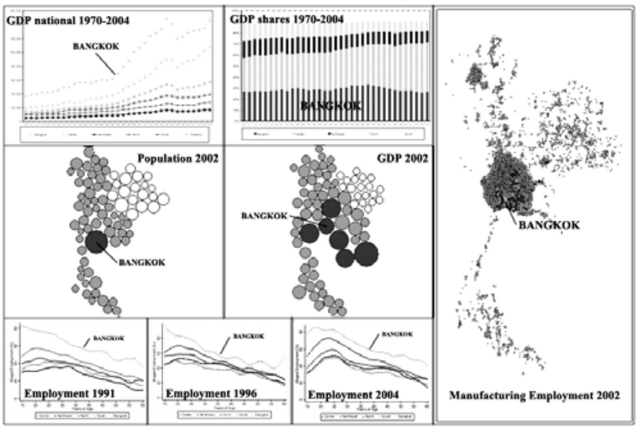

Fig. 5 Economic feature of Bangkok, Thailand
Source: World Bank, 2006.

These challenges was meaning to the population growth into urban area especially low-income settlement and squatter. As a result, much of debates has pointed on an issue of increasing of urban density concerning urban "sprawl" and urbanization conflict which generally caused of high carbon consumption emission and environment quality is one of the basic conditions for quality of life, as well as the main support for the activities of economy and society. Due to the improper and inefficient development projects in developing country have the most extensive devastating consequences to both environment and human beings especially low-income settlement.

Considering the aimed of study, an area was illustrated the causes and effects on urbanization growth processes based on the use of GIS-based Multi-Criteria Decision Analysis (MCA) for calculating the simplify situations of alternative factors using the Analytic Heirarchy Process (AHP) and Weighted Linear Combination (WLC) for quantifying subjective characteristic of low-income settlement, it is simplify complex contributed the approach of sustainable urban form in developing country.

METHODOLOGY

The methodology was discussed and defined which is a generalised of Multi-Criteria Decision Analysis (MCA) using GIS based spatial decision making procedure and compared of both approaches has been made the environmetal condition and location of low-income settlement and expansion. MCA for calculating the simplify situations of alternative factors based on geographical information system GIS has an important position of decision-making process.

Research Question: How to investigate the low-income settlements in consequences of an urbanization approaches of Bangkok's capital, Thailand ?

Hypothesis working: The low-income settlements were interested the main problem of urbanization crisis and also more heavily burdened by urban environmetal condition in consequence of Bangkok growing city in Thailand such as urban density, flood, pollution, and so on.

By this study, it is necessary to establish a set of

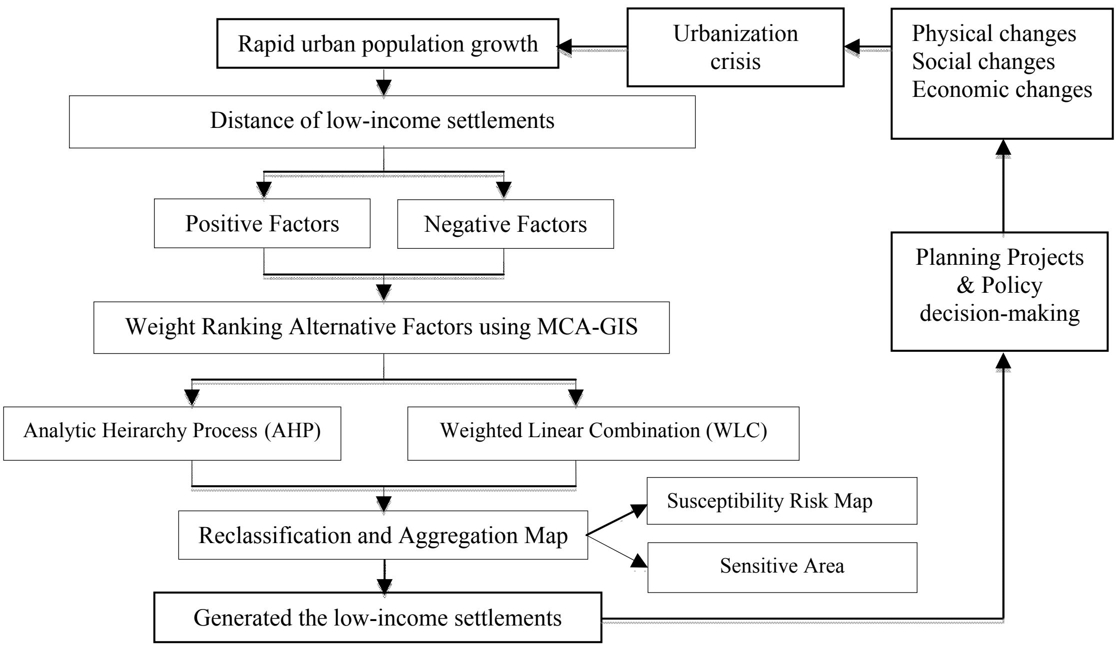

Fig. 6 GIS-based spatial decision making procedures

weights for each factors of objectively using AHP technique with expert knowledge. Finally, there is becoming more feasible to configurated, with WLC operators (Fig. 6).

WEIGHTS CRITERION AND EVALUATION

The Analytical Hierarchy Process (AHP)

In developing weight, Saaty (1977) developed in context of decision-making process known as AHP. A weight of this nature can be derived by taking the principal eigenvector of a square reciprocal matrix of pair-wise comparisons between the criteria and deal with the relative importance of the two criteria involved in determining suitability for an individual or group compares. These methods provide an estimate of the relative weights of the relevant criteria. In addition, an index of consistency can be produced a procedure and a consistency ratio (C.R.). C.R. is defined the probability that the matrix judgments were generated randomly as:

$$CR = CI / RI \qquad (1)$$

where RI is the random index, and CI is the consistency index which provides a measure of departure from consistency.

$$CR = (\lambda_{max} - n) / (n - 1) \qquad (2)$$

where λ_{max} is the average value of the consistency vector, and n is the number of criteria. C.R. is ordered of 0.1 or less is a reasonable level of consistency by Saaty (1977).

The random index is the consistency index of the randomly generated pairwise comparison matrix and depends on the number of elements being compared. The comparisons deal with two criteria involved in a pairwise comparison scale (Table 2) and random inconsistency indices (R.I.) for number of criteria (Table 3).

Table 2 The pairwise comparison scale

Intensity of Importance	Definition
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme important

Source: Saaty, 1977.

For example when the WLC adopted some similarities with the type of spatial AHP (analytic hierarchy process) used by Anagostopoulos et. al. (2009), Samo and Anka (2009). The Analytical hierarchical process (AHP), an adoption of WLC, can be used in two distinctive ways within the GIS environment: first, it can be employed to derive the weights associated with criteria map layers, and second, the AHP principle can be used to aggregate the priority for all hierarchical levels including the level representing alternatives (Samo and Anka (2009), Saaty (1977)).

Table 3 Random inconsistency indices (R.I.) for different numbers of criteria

n	1	2	3	4	5
RI	0.00	0.00	0.58	0.90	1.12
n	6	7	8	9	10
RI	1.24	1.32	1.41	1.45	1.49

Source: Saaty, 1977.

Moreover, the pairwise comparison method employs an underlying continuous scale with values from 1 to 9 rates the relative preferences for criteria between "equally" important and "extremely" important. With different sets of order weights, one can generate a wide range of decision strategies in terms of risk and trade-off. The order weights are assigned on the basis of the triangular decision strategy space will determine the position in the risk dimension. As a result, the size of areas that could be recommended for prioritization becomes gradually larger (Malczewski, 1999).

The Weighted Linear Combination (WLC)

WLC is one of the most common methods in local MCA and a concept where event-controlling parameters can be combined by three levels evaluation. Frist, the importance of each criterion or factors is evaluated against other criteria. Second, data for each criterion are standardized. Third, the index value is calculated for each unit area values and dividing the sum by the total of the weights. WLC and its variants require summation of the weighted criteria. WCL is the most frequently referred method that is popularity lie and easy to understand for obtaining attributes weights or adopted standardization process based on GIS technical analysis.

The first step is developed a digital GIS database of spatial information. The criteria are measured on different scales, it is necessary that factors be standardized before combination, and that they be transformed, if necessary, so that all factor maps are positively correlated with suitability. A linear scaling method has applied typically using the minimum and maximum values as scaling point for standardization that the simplest is following as:

$$X_i = \frac{(R_i - R_{min})}{(R_{max} - R_{min})} * SR \quad (3)$$

where R_i is the raw score of factor *i*, R_{min} is the minimum score, R_{max} the maximum score, and SR is the standardized range.

With the weighted linear combination, factors are combined a weight to each followed by a summation of the results to yield a suitability map:

$$S = \Sigma W_i X_i \quad (4)$$

where S is suitability, W_i is weight of factor *i* (the weights are then usually normalized that sum to 1 ($\Sigma W_i = 1$), and X_i is the criterion score of factor *i* .

The importance weights is expressed the relative importance of each criterion in the set of criteria under consideration. Thus, the evaluation criteria are incorporated and respected to the decision process. The criterion values are associated on a location-by-location (object-by-object), and assigned to a location's attribute values in decreasing order without considering which attribute the value comes from (Malczewski, 2004).

In the other hand, there are some limitations of WLC procedures in decision-making process of the weighted and the procedures for deriving commensurate attribute maps (Malczewski, 1999). In particular case, they suggested that the Boolean criteria analysis (Al-Adamat, R., et al., 2010) or Ordered Weighted Aggregation (OWA) (Jiang and Eastmann, 2000; Malczewski, 2006; Drobne and Lisec, 2009) that GIS made a consistent logic could be solved and considered this MCA features of decision-making as a set problem and through the criteria measurement in ArcGIS. However, this study found the best result of susceptibility risk map using by WLC technique based on GIS. Furthermore, the result can be described the risk levels of low-income settlement in consequence of Bangkok lowland and growing city, Thailand as well.

RESULTS AND DISCUSSION

An urbanization and lowland site selection process requires and creates consideration of urban susceptibility environment criteria to evaluate the sensitive area and to eliminate long-term effects of the low-income settlement.

Table 4 classified six factors, which are affected for urban environment in consequence of Bangkok such as flooding, air pollution, water pollution, noise, global warming, biodiversity, energy, waste, damage, etc. Each factor, which represented in the environmental impact of inefficiency urbanization projects based on MCA-GIS, including AHP and WLC that are technical for analyst and evaluates between difference methods.

Table 4 List of environmental factors

Date	Factors	Constraint factors	Scale
2009	Urban Area	Point Density Estimation	1:250,000
2009	Roads	Buffer zone	1:250,000
2009	Highways	Buffer zone	1:250,000
2009	Railways	Buffer zone	1:250,000
2009	Canals	Buffer zone	1:250,000
2009	River	Buffer zone	1:250,000

A pairwise comparison matrix scale was derived and related importance on analysis of the AHP techniques with expert knowledge (Table 5). The calculation preferred the important levels weights of the synthesizing judgment matrix, as well as the eigenvector corresponding components weighted that factors was indicated the standardized fuzzy value of each criterion for each alternative. It is also pointed out of the consistency degree that has been improving the ratings.

In AHP, the consistency index, the procedure of consistency ratio was generated to 0.023 that ordered of 0.10 or less and also acceptable (Saaty, 1997). A comparison of this approach has been made, based on result of land suitability and urbanization research factors.

The procedure rule evaluated the weights criteria, risk, and trade-off methods for investigate the factors and combined the actual environmental impact lies on low-income settlement using WLC technique modules in the GIS program to be used for sustainability monitoring of data storage. Thus, the integration of WLC into GIS enhances not only for evaluation but the GIS also become a useful for spatial decision support system in ArcGIS processing tools.

WLC Approach

The aggregation of WLC method is ability related the weighted criteria of urban environmental for Bangkok Metropolitan Region. There were identified six factors as the most important in searching for suitable area by expert and standard of its efficiency services in Bangkok (Table 5).

Table 5 Pairwise (ratio) comparison matrix of all criteria (AHP-weight)

Factors	Urban distance	Roads	Highways	Railways	Canals	River	Eigenvector (weight)
Urban distance	1						0.236543
Roads	1/4	1					0.062424
Highways	1/2	3	1				0.145219
Railways	1/2	3	1	1			0.145219
Canals	1/5	1/2	1/4	1/4	1		0.042071
River	2	5	3	3	4	1	0.368524

Consistency Index (C.I) / Inconsistency Ratio = 0.02885

Random Inconsistency (R.I) (Table 2) = 1.24

Consistency Ratio (C.R.) = 0.023 (Acceptable)

Table 6 Urbanization susceptibility evaluation criteria for weights, ratings and justifications

Factors	First level weights	Rating	Second level weights
Urban distance	0.236543	0.00000011-0.000041161	5
		0.000041161-0.000099804	4
		0.000099804-0.000172132	3
		0.000172132-0.000289419	2
		0.000289419-0.000498581	1
Roads	0.062424	0- 200 m.	5
		200-300 m.	4
		300-400 m.	3
		400-500 m.	2
		> 500 m.	1
Highways	0.145219	0-150 m.	5
		150-500 m.	4
		500-1000 m.	3
		1000-1500 m.	2
		> 1500 m.	1
Railways	0.145219	0-60 m.	5
		60-500 m.	4
		500-1000 m.	3
		1000-1500 m.	2
		> 1500 m.	1
Canals	0.042071	0-100 m.	3
		> 100 m.	1
River	0.368524	0-2000 m.	5
		2000-3000 m.	4
		3000-4000 m.	3
		4000-5000 m.	2
		> 5000 m.	1

Table 6 summarizes the findings of the six criteria studies for weights in respect of ratings of urban facilities justifications.

- Urban distance was created the Kernel Density Estimation, generalization of smoothing technique within the geographically referenced point pattern analysis, estimating their spatial intensity map (Gatrell, et al., 1996). This factor is interested in air pollution, noise, energy consumption, bio-diversity, and climate zone.
- Roads were according to Javadian, et al., (2011), they studied the sustainable urban application and air quality from road, a maximum distance of approximately 100-500 meters and more conservative level is 200-500 meters.
- Highways were according to Javadian, et al., (2011), they studied the sustainable urban application and air quality from freeway/highway, a maximum distance of approximately 150 meters and concentration decreased level after 300 meters. This factor is interested in air pollution, noise, energy consumption and climate.
- Railways were according to Glegg, (2007), he studied the railway noise environmental controls, and definite limits will be suitable interval for general use on flat ground 45-60 meters. This factor is interested in air pollution, noise, and energy consumption.
- Canals were according to Sliva, and Williams, (2001), they studied the land use impact on river quality that should slightly greater influence than 100 meters buffer. This factor is interested in water pollution, waste, damage and bio-diversity.
- River was according to many researchers, they were considered the river buffer zone for interested in water quality, conservation, bio-diversity, and hazards stronger than 2-5 kilometers. This factor is interested in The Chao Phraya River which is the main river of Bangkok.

As a result of WLC, the integrated hierarchical structure of the criteria considered which consists of five levels for contamination all maps approach of the urban environment condition and flooding risk of low area. In this model, there are determinate the important assessment factor of urban environment impact using the AHP before integration of all factors in the evaluation process as shown in Fig. 7.

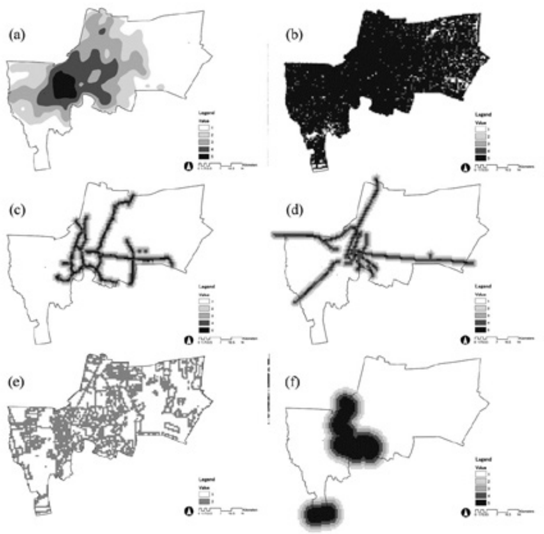

Fig. 7 Aggregation map of WLC criteria analysis; (a) urban distance, (b) roads distance, (c) highways, (d) railways, (e) canals, (f) river

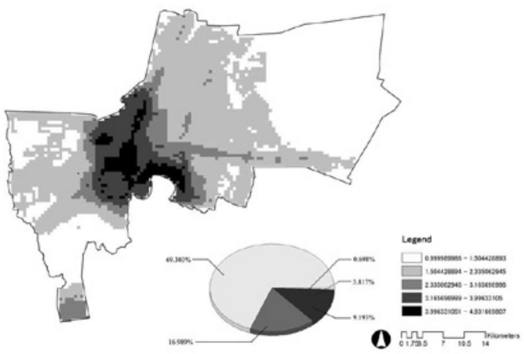

Fig. 8 The result of WLC criteria analysis based on standard deviation map

Table 7 The result of susceptibility risk map using WLC technique.

Susceptibility Levels	Area	
	Hectare	Percentage
Very high	5,987.546	3.817
High	14,421.068	9.193
Moderately	26,650.949	16.989
Low	108,718.544	69.303
Very low	1,095.593	0.698
Total	156,873.700	100.000

Regarding the map resulted of WLC criteria calculation shown in Fig. 8, which is generated the eigenvector directly. The pairwise comparison technique of weight utilizes are set of 1.0 sum factor weights and importantly a consistency ratio. WLC method was multiplied each standardized factor (Samo and Anka, 2009) and compensatory combination rules (Malczewski, 2000) by its corresponding weight. The aggregation map allowed the standard deviation lies on mean value, retaining important information of urban intensity sensitive elements. The final map found the principle of standard deviation method for the best result that provided into five land-use intensity classifications (Fig. 8 and Table 7). The extreme important area will be divided into the most highly impact of urban environmental factors in Bangkok. It was contained 5,987.546 hectare that is nearly the main river or center of Bangkok (3.817% of the total area). While the equal importance or less impact was remained 1,095.593 hectare (0.698 % of the total area) that had still remanded on some area as far from center of Bangkok city. In addition to the areas under moderate or strong importance was distributed 26,650.949 hectare (16.989% of the total area) widely in the eastern and western part of area study.

The WLC method within GIS environment analysis resulted into five classes that are emphasized the urban environmental impact assessment flexibility of site selection of low-income settlement point on several spatial map.

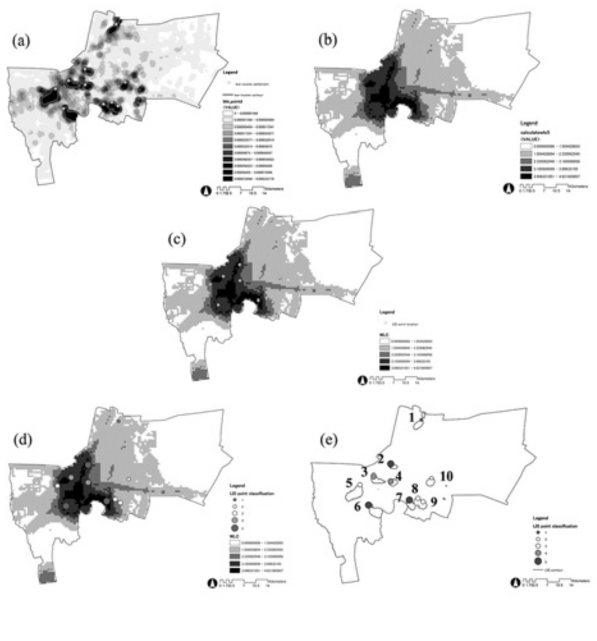

Fig. 9 The adaptation of low-income settlement point followed as; (a) Contour of low-income point pattern analysis (Fig. 2), (b) WCL result of susceptibility risk map, (c) Overlay analysis with WLC method, (d) Generated the levels of low-income point pattern analysis, and (e) Approaches of low-income settlement using GIS technique (Table 8).

Table 8 Classes of Special low-income settlement cases onto susceptibility risk map using MCA-GIS technique

Area no.	Geographic Coordinates Location		Class
	X	Y	
1	2218080.00	5050309.36	Very Low
2	2187441.07	5005755.92	Very High
3	2171454.06	4995255.57	High
4	2187780.31	4991038.32	High
5	2158592.55	4987036.94	Moderately
6	2166491.23	4987548.86	Very High
7	2205752.36	4971971.93	Very High
8	2213905.57	4973702.86	Moderately
9	2219912.07	4970094.13	Moderately
10	2228924.22	4993586.98	Low

As the explained above, discussion of low-income settlement approaches, the aggregation method used AHP and WLC, allowed compensatory combination rules between spatial intensity of auto-correlation map and fully trade-off with each other of urban environmental impact factors shown in Fig. 7. The map also contained the geographic location of susceptibility risk map and sensitive area used in the MCA method in ArcGIS 10.0. In this section, both of AHP and WLC generated between the result of WLC technique (Fig. 8) and the low-income settlement that is the special case of Bangkok approaches (Fig. 2).

The WLC inventory map was estimated the low-income settlement point using highest range of contour value corresponded. Generally, the calculated result was identified the instability levels of ten special cases of low-income settlement which had significantly effected on urbanization crisis based on standard deviation equation method. As a result in Fig. 9(e) shown in, the ten cases were distinguished due to five susceptibility risk map ranging from 0.99998986 to 4.831669807 into five class values. There were three settlements of very high, two settlements of high, two settlements of moderately, one settlement of low, and one settlement of very low lie on unplanned and unsafe area conditions as shown in Table 8.

CONCLUSION

Aggregation maps of output factors proved to be flexible and practical tool for selecting sensitive area using MCA based on GIS technique (Fig. 8). This methodology was developed the successful use of WCL analysis to address their needs. This technique can be found that the susceptibility risk map of urban environmental impact assessment and priorities of site selection into low-income area settlements.

Finally, the special low-income settlement cases are located by the contours of point pattern analysis using point density estimation using GIS technique, which is investigated the relationship between the low-income settlement and the susceptibility risk map (Fig. 9). A number of preparation steps evaluated and ranked the degree of risk situations on several factors that are combined effect of human life and land security (e.g. unplanning, low-efficient development projects and disaster risk conditions).

Almost of special low-income area cases were selected under high and very high level of susceptibility risk map even though the urban environmental condition was generated the extremely important of urban impact assessment such as crowded, polluted, noise, flooding, climate change and so on (Table 8). Thus, the modeling in this study identified hot-spot area that required the degree of low-income settlement lie on urgent intervention. Therefore, on the low-income characteristics and living condition, there were approached and relevant to many conditions of risk levels for low-income settlement self-help projects in Bangkok, Thailand.

Moreover, the resulted could be demonstrated to the strategies for urban environmental protection and management provided the ten special cases of low-income settlement, which is the main problem of growing city as well (Fig. 9). Thus, the predicted results are related to general low-income settlement perception on application of urban environmental impact factors to be more complicated the further planning projects and policy decision-making.

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