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Multi-criteria analysis and network analysis for walkability score in Amphoe Muang, Nonthaburi, Thailand

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Abstract

Aim: This study aims to improve Amphoe Mueang and Nonthaburi's quality of life by identifying the best path forward by examining geographical factors.
Method: The Multi-Criteria Analysis (MCA) used to calculate the walk score is a helpful instrument for examining geographical factors that impact people's social and economic well-being. Network analysis and the Analytic Hierarchy Process (AHP) form the basis of the walkability score. Two groups of nine factors were used. Before anything else, we look at two aspects of connectivity: 1) betweenness and 2) centrality. Second, factors close to the facility include 1) retail. Seven categories are considered: 2) public transportation, 3) landmarks, 4) recreation, 5) the workplace, 6) the home, and 7) security.
Findings: Findings indicated that the east side of the study area contained the majority of the highest scores. As a result of the need for private automobiles rather than walking and purpose to residents only, the low walkability score is located opposite the high score. One method of recognising people who walk around cities is the Walkability Score derived from network analysis. Correct, analyse, score, and prioritise factors with MCA's efficient tools. It can normalise Factor 1 by adding a good factor or removing a bad factor. The disparity in importance demonstrates that society needs to take the path down which its members can find happiness, ease their minds, and engage in more physical activity. That way, they can keep their work, food, and sleep all in one place.
Implications/Novel Contribution: Apartment-seekers and business patrons alike can benefit from the walkability score results by making decisions based on the relative attractiveness of walkable neighbourhoods and the costs of various living arrangements.

Keywords: Walkability Score, AHP and MCA by Network Analysis

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INTRODUCTION

People today tend to separate their lives into private and public spheres. Each time they switch between the two, they use transportation to get from one to the other (Jongkroy, 2009). Different people use different modes of transportation for different reasons; some prefer the convenience of a car, while others prefer to take the speed and reliability of the sky train. Vehicles that travel on lands, such as cars and buses, are the most common form of transportation. Motorbike cab rides and strolling. Getting around on foot is crucial to any city's success. Individually, walking is a great way to boost daily activity and health. Most notably, it doesn't cost anything and is very simple. Economically speaking, walking helps local businesses and can lead to growth on a neighbourhood scale. As a result, it encourages people to treat each other fairly and to build horizontal relationships in society. To encourage people to incorporate exercise into their daily routines, developed nations track their citizens' ability to walk around town. Neighbourhoods While travelling and reading in (World Health Organization, 2017; Osra, 2017; Dewi, Astawa, Siwantara, & Mataram, 2017).

Nonthaburi is a prime residential area of greater Bangkok that next to the metropolis. The government has set up an infrastructure. They develop the project to make the link between Bangkok and Nonthaburi effective. One of the major problems from fast-growing cities cannot manage appropriate transportation. As a result, urban people have to spend more time and travel expenses. Concept of urban development using urban travel without

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car or use public transport instead, it was developed. It is the mainstream in the development of cities around the world (Kantamuanglee, 2017; Kamran & Zhao, 2016; Prasad, 2017). MCA for finding walk score is useful tools to collect the network and facility that support walkability Such as service area or network analysis in Geographic Information System (GIS). The weighting methods such as AHP or Rank Sum can used to compare criteria by less bias and reasonable to real walking in urban. So, this research. It focuses on finding the right footpath in Amphoe Mueang, Nonthaburi by analyzing geographic factors to improve the quality of life, social and economic as well.

METHODOLOGY

Methodology and data for walkability score are including Study area, AHP and MCA by network analysis.

Study Area

Amphoe Muang Nonthaburi is the district of Nonthaburi province. It located in the central part of Thailand that support the metropolitan expansion. The length of border of Nonthaburi and Bangkok is about eight kilometers. Chao Phraya River cuts the central Nonthaburi and results in the flood plain in this area. Amphoe Muang Nonthaburi located between latitude 13.8°-13.9° N and longitude 100.43°-100.56° E. Amphoe Muang Nonthaburi is 1.8 meters above mean sea level and has an area of 73.19 km^2. Road network length about 68 kilometers in main road and more than 600 kilometers in sub-road (Office of National Statistics, 1996) Figure 1.

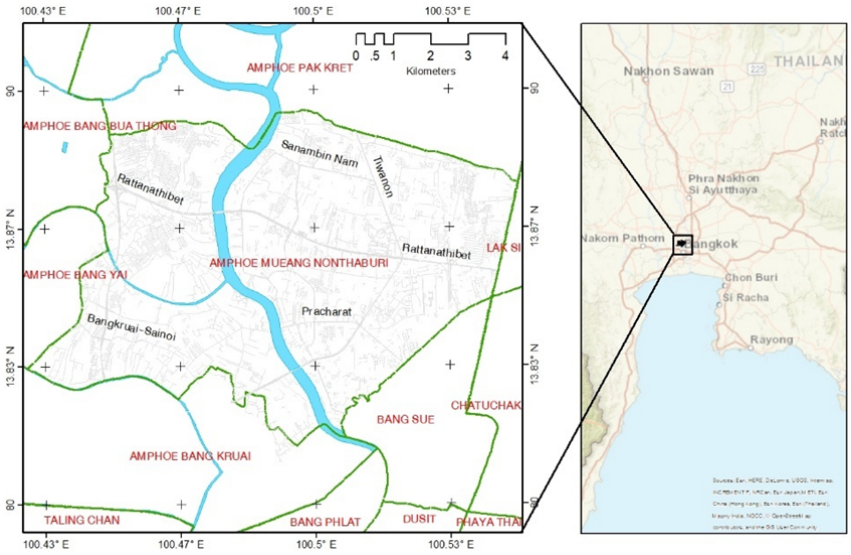

Figure 1. Study area

Walkability Score

Walkability is largely a function of the proximity and connectivity between destinations, or the degree to which we can travel directly between places where we live, work and play (Health and Community Design Lab, 2017). Walkability score combining aspects of the built environment that promote or inhibit walking (Glazier et al., 2012; Frank et al., 2010). Different approaches have been used to quantify the situation of walkability in different areas such as *Z*-score, Sum of deciles, Principal component analysis and Distance decay function (Habibian & Hosseinzadeh, 2018). The score can be used to investigate associations between urban form and a wide range of outcomes, to identify priority areas for transportation enhancements and redevelopment and to monitor changes in urban form over time (Frank et al., 2010).

AHP

The AHP is a powerful tool that was introduced and developed by Saaty (1990). Hierarchical decision-making is one of several methods of decision making. That is the choice decision. When there are several criteria for consideration, the process is a very efficient and convenient process of prioritizing. AHP method can combined and evaluated with a GIS. Expert opinions, together with multi-criteria such as geographical, statistical and historical data (Siddayao, Valdez, & Fernandez, 2014).

Walking Score by MCA

There are many ways to gain GIS, for example potential surface analysis: PSA, MCA and fuzzy logic analysis. The present study uses MCA because it can analyse complex spatial data by configuring the factor scores and weight of each factor by ordering the importance of different factors. Factors involved in a walkability are related with the road network such as betweenness and facility along path way such as commercial zone, transportation link, residential areas and recreations place etc (Cubukcu, Hepguzel, Tumer, & Onder, 2015; Azmi & Ahmad, 2015).

Finding combat scores to reach places. In Izmir, Turkey, to encourage active living by using walking as a journey. To reduce obesity in urban areas. This study aims to introduce and discuss alternative models to measure the ability to walk on the road through geographic information systems. Walking ability rating depends on the relationship between the centrality score obtained from the road network and the land use access score. For each segment of the road is measured by geographic information systems and spatial network analysis (Cubukcu et al., 2015).

Environmental factors of nearby areas that influence the walking ability to promote a sustainable environment for everyone. The study identifies three environmental indicators of three adjacent areas that can lead to improvements in the neighbourhood: 1) residential density 2) land use and 3) road connection Using geographic information systems to take advantage of the neighbourhood environment. The key research findings in this article will show that residential density, road connection and mixed land use will have an effect on walking ability (Azmi & Ahmad, 2015).

Spatial diversity assessment and cross-sectional assessment of road level to assess the ability of the road to walk and to be consistent with the possibilities. The integration of geographic information systems, remote sensing and multi-stakeholder analysis to assess urban walkways is using multiple criteria: 1) Access Route 2) Transportation 3) Land Use 4) Residential Density 5) green area. Weighting of each criterion is determined by the participation process of the residents. The findings suggest that the use of multiple-group analysis to integrate the views of both groups should be a good approach (Taleai & Amiri, 2017). Alexandros Study of Walking and the City The GIS index was calculated and used for weighting. This affects people's travel habits. In the analysis, the weighted values are determined by the factor accessibility, population density, network connection and land use to analyse the hierarchy of the test results (Tsiompras & Photis, 2017). Eva Lesliea using GIS to measure the qualities of an environment that influences the fitness of adults by stratified sampling, 32 households were selected for analysis of community and environmental activities. Leslie et al. (2007) studied the physical characteristics of pedestrian and Walkability Index (WI) of the Asian Development Bank (ADB). such as width of path, height of the corridor and obstacles on the pedestrian. The assessment of the ease of walking was determined by the standardized scoring of the statue (Chaiboonruang & Panyanchan, 2016).

Integration of MCA and Network Analysis

This study we used network analysis in two main groups criteria. First, connectivity such as centrality and betweenness by Spatial Design Network Analysis (SDNA) and proximity by service area function that more reality than buffer analysis.

SDNA programme can 1) standardize on link-node format 2) unifying the disciplines of spatial network analysis and transport modelling, learning lessons from both fields and 3) prioritizing the testing and validation of outputs against real data (Cardiff University, n.d). Proximity describes the number and variety of destinations within a specified distance of any location. This measure was calculated by seven interest points 1) commercial 2)

public transportation 3) landmarks 4) recreation 5) workplace 6) residential and 7) safety and determination range of distance for walking score is 200 800 meters. The distance that most of Thai people appreciate to walk is 200 meters. Distance increased every 200 meters and finished at 800 meters that is maximum distance for walk of Thai people. The score of walk distance for each criteria is 100, 80, 60 and 40 respectively.

Case Study

MCA and network analysis for walkability score in Amphoe Muang, Nonthaburi is used nine factors from two sets. First, connectivity factors: 1) betweenness and 2) centrality. Second, proximity from facility factors: 1) commercial 2) public transportation 3) landmarks 4) recreation 5) workplace 6) residential and 7) safety. All factors have score from zero to hundred from less to more importance. Weighting used AHP from four specialists that involve in walking management. They compare the criteria by pair-wise and finalise weighting by GAHP. The service area function is used to allocation distance from proximity factors in four range: 0-200, 200-400, 400-600 and 600-800 meters.

RESULTS AND DISCUSSION

Walkability score from multi-criteria are set up with two group of criteria. First, the connectivity that shown the physical of road network. Second, group of criteria are the set of proximity distance that represent the facility or safety for walk. All of these criteria Shown in the Figures and Tables below.

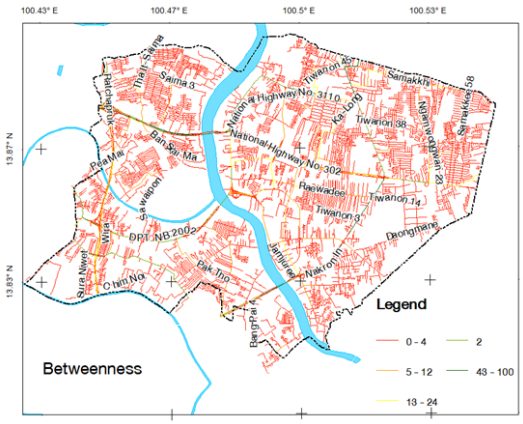

Figure 2. Betweenness

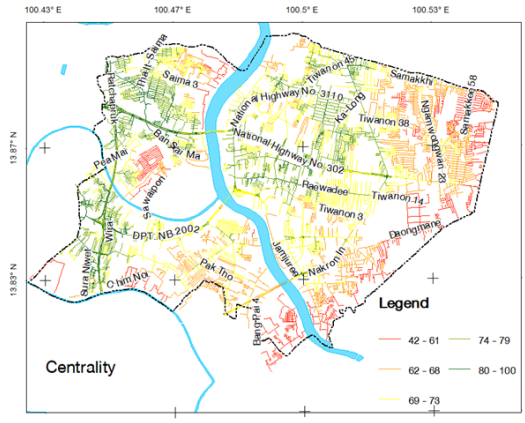

Figure 3. Centrality

Betweenness criteria (left) shown the connectivity of road. The red color is less connectivity. In contrast, the green line represents more connectivity. The score is decrease from 100 to 0. Centrality (right) shown the centroid

of road network that more access to another. The high centrality is separate into two sides by the river. The score of dark green have 100 points and red equal to 42 points. Both of them used the SDNA which originated at Cardiff School of Planning & Geography and the Sustainable Places Research Institute.

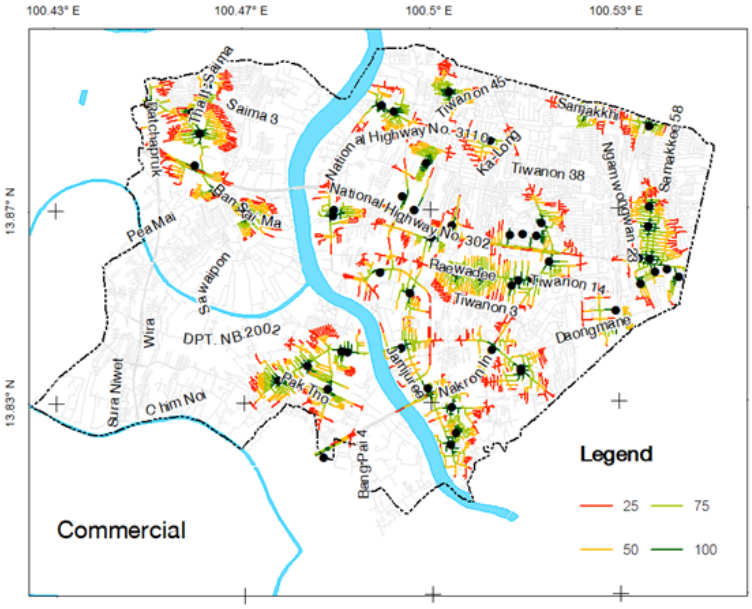

Figure 4. Commercial

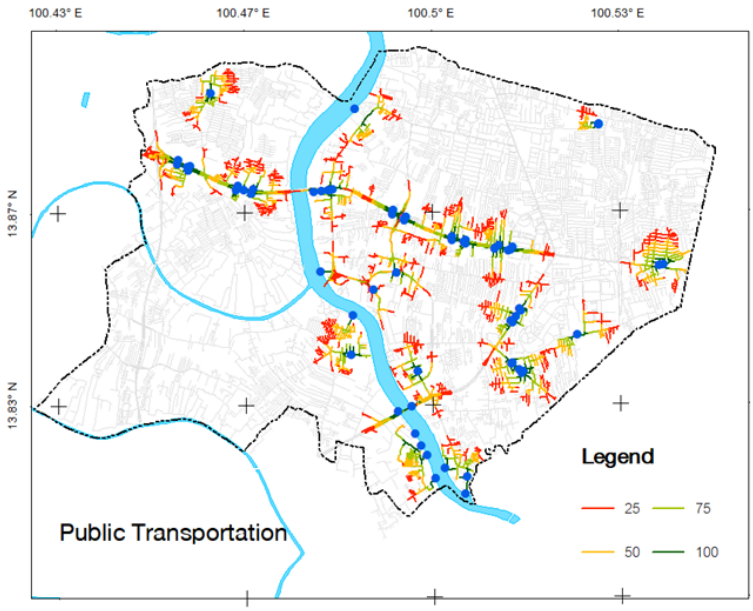

Figure 5. Public transportation

Commercial (left) shown the proximity or service area by network analysis. Distance from commercial point such as department store or super market are determination to four groups. The nearest line around the point (200 m.) have 100 points and 25 points for area in distance 600-800 m. The point and distance range of public transport is same to the commercial area. The public transportation included MRT, bus stop and pier.

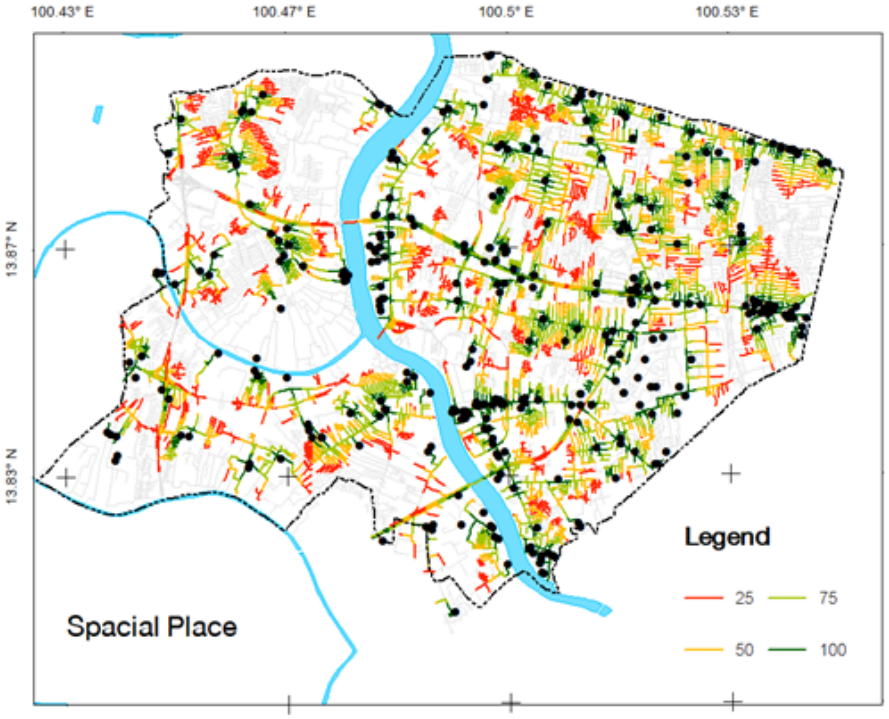

Figure 6. Special place

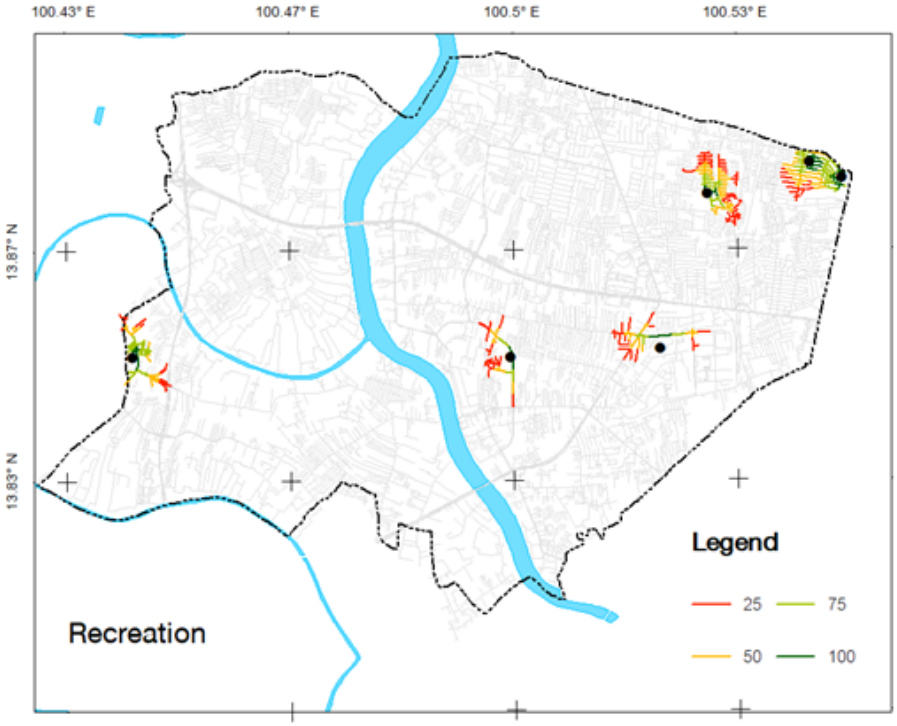

Figure 7. Recreation

Special place (left) is the favorite place for people such as government officer, school, hospital and bank. Recreation area (right) shown urban park or neighborhood park. Amphoe muang has 6 parks that not enough for urban people. Both of criteria used the same previous distance and score.

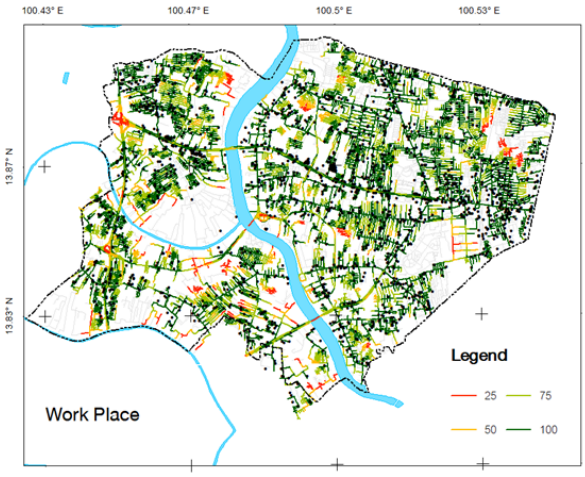

Figure 8. Work place

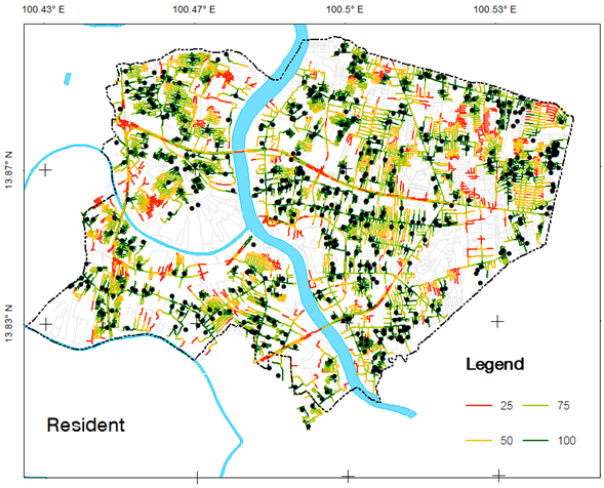

Figure 9. Resident

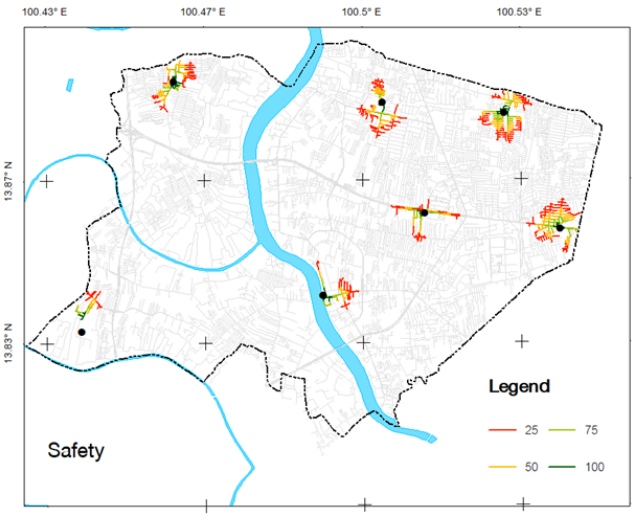

Figure 10. Safety

Work place, Resident and safety have the sane process to make multiple service areas (200, 400, 600 and 800 meters) by network analysis. Resident and work place are generated from point of building such as office, condominium, apartment and village. Safety criteria is setting up from police station and police stop points in study area.

Nine factors from connectivity group and proximity group are compare together by AHP. Four specialists compare each pair of criteria by own. Each weighting are compare together again by group AHP to calculate last weighting that show in Table 1.

Table 1: Recalculate weighting from four specialist by GAHP

	1	2	3	4	5	6	7	8	9
Weighting	0.133	0.156	0.178	0.200	0.111	0.022	0.044	0.067	0.089

Remark: 1 = betweenness, 2 = centrality, 3 = commercial, 4 = transportation, 5 = special place, 6 = recreation, 7 = work place, 8 = resident and 9 = safety

The results of GAHP are the most importance criteria are public transportation (0.200), commercial (0.178) and centrality (0.156) respectively. Public transportation including Sky train, rapid boat and bus is the first priority for people to make decision to walk. Urban citizen always used public transportation to travel, work, shopping, eat, recreation and go back to home. They connect those transportation by walk because of they don't want traffic jam or need least travel time. The medium importance criteria are betweenness (0.133), special place (0.111) and safety (0.089) respectively. The low importance criteria are resident, workplace and recreation area by 0.067, 0.044 and 0.022. People in urban don't have many time after work to go to recreation area because the urban park is not enough for them and hard to access by walk. So, the weighting of recreation to be least. All criteria's score multiplied with each weighting criteria by multi criteria analysis. (Equation 1.)

$$WAS = \sum_{i=1}^{9} C_i W_i \tag{1}$$

When WAS = Walkability Score C_i = Criteria 1-8 W_i = Weight 1-8 1 = betweenness 2 = centrality 3 = commercial 4 = transportation 5 = special place 6 = recreation 7 = work place 8 = resident 9 = safety. The total score shown in Table 2 and Figure 11.

Table 2: Total score calculation for Walkability score

Criteria	Score				Weight	Total				
Connectivity Group										
1. Betwee-nness	(Low) 0			100 (High)	0.133	0 - 13.3				
2. Centrality	(Low) 0			100 (High)	0.156	0 - 15.6				
Proximity Group	800 m				600 m	400 m	200 m			
3. Commercial	25				50	75	100	0.178	4.45	8.90	13.35	17.80
4. Transporta-tion	25				50	75	100	0.200	5.00	10.00	15.00	20.00
5. Special place	25				50	75	100	0.111	2.78	5.55	8.33	11.10
6. Recreation	25				50	75	100	0.022	0.55	1.10	1.65	2.20
7. Work place	25				50	75	100	0.044	1.10	2.20	3.30	4.40
8. Resident	25				50	75	100	0.067	1.68	3.35	5.03	6.70
9. Safety	25				50	75	100	0.089	2.23	4.45	6.68	8.90
Sum						-		1.000		0 - 100		

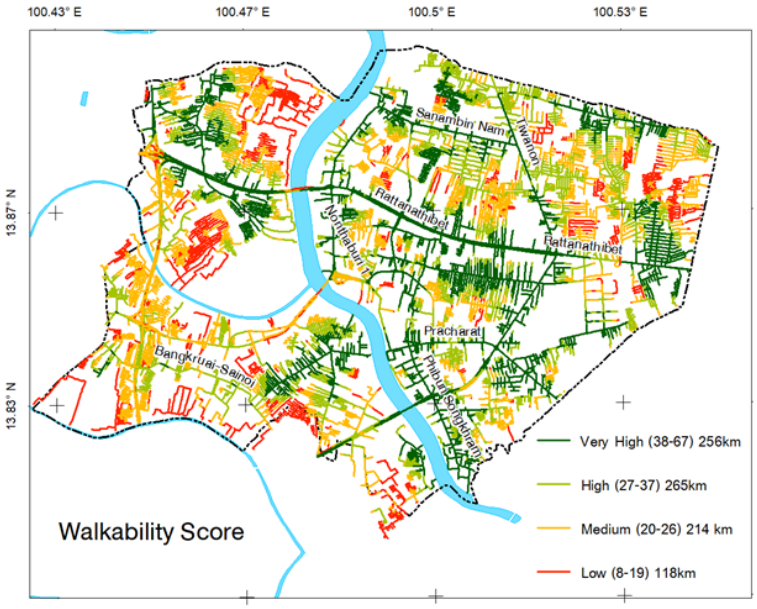

Figure 11. Total walkability Score from network analysis

Walkability score of Amphoe Muang Nonthaburi is classified to four classes: 1) Very high score is 38-67 length 256 km. 2) High score is 27-37 length 265 km. 3) Medium score is 20-26 length 214 km. and 4) Low score is 8-19 length 118 km. The score classification is used equal interval. Most of the high score are located on the east side of study area because of there are close up the Bangkok and they have MRT. In contrast, The low walkability score are located opposite the high score because of they are in the sub urban area that people need private car than walk and purpose to resident only.

CONCLUSION, RECOMMENDATIONS AND IMPLICATIONS

Walkability Score from network analysis are one of many techniques to identify the score for walking in urban area. MCA is the efficiency tools for correct, analyze, scoring and prioritized factors together. It can add good factor or eject weak factor and normalized weight of factor to 1. The difference of weighting are shown that people need to walk on the road that they should have happy, relax and take more activity if they can. So, they can work, eat and sleep in the same area. The result of these research relative to the theory of Transportation Oriented Development (TOD). TOD is supported urban expand that control high density from CBD to another zones. Those zones are prepared facility that support city life and must use walk to transit. Related to the transportation weighting in this research that have the higher weighting.

The result of walkability score can used to suggest people who want to find the accommodation or job that can make decision based on good score or reasonable price of apartment with high walkability. They can walk from office to home or used public transportation to shopping or recreation. In study areas the best road for walk is Rattanatibet Rd. that have MRT, bus and near the rapid boat. It has many of hospital, supper market, office building, government office and condominium. This road has more connectivity to another main road such as Ngang Wong Wan Rd. and Piboon songkram Rd. that not far away from Bangkok.

This research used the network analysis technic to approximated the distance from many landmarks that has the reliable than buffer process in LSA. Service area is shown the exactly distance because of these technic selected only distance from line just not from polygon. The result of walking score is more accuracy than traditional method. It's easy to used this technic to improved the walkability research or another research that related to the route such as logistic etc.

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