

# Building Friendly Environmental Assessment Indicator System by Using Big Data and Grey-ANP

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**Abstract**—This study constructs an assessment index applicable to the vulnerability of the traffic environment population in Taiwan. Apply BIG DATA to analyze the case area with a radius of 500 meters, such as Zhongxiao Fuxing Station (women, children), National Taiwan University Hospital (aged), Yongan Market Station (other) as an empirical case. First, based on five assessment criteria and eighteen assessment indicators, each of which Both the criteria and the indicator weights have grey decision-making flexibility space, such as land use indicators [14.40~17.97], public facilities service indicators [20.64~23.13], pedestrian environmental indicators [29.97~35.03], and huge data indicators [5.98~7.84]. The five assessment facets, such as the traffic environment indicators [17.89~27.14], and the gray weights of the 18 assessment indicators represented in each facet can help the public transport development regions to use the evaluation criteria and indicators for flexibility. Decision-making can also be used as a reference for more efficient resource allocation with the conditions of the mass transit station and surrounding external characteristics.

**Keywords**—transit-oriented development; big data; fuzzy delphi method; grey-ANP

## I. INTRODUCTION

The Taiwanese people are deeply affected by global urbanization and climate change. Under the promotion of the mass transit-oriented development (TOD), the Taipei MRT system has an average daily traffic volume of only about 40,000 people. In 1996, the average daily traffic volume has exceeded 2 million (2016), and the growth rate has increased by 50 times. It can be seen that the MRT system has become an important means of transportation in people's daily life. If we promote the TOD development process from the Taiwanese city, such as the Republic of China's first rapid transit system in the Republic of China in 85 years, the Mucha line, and the MRT Songshan Line to date, its TOD transportation environment planning and design has not followed the past 18 years. With the development and evolution, it can be seen that Taiwan also neglects an important factor, that is, the public's demand for the TOD transportation environment. Therefore, the best way to improve the transportation environment is to understand the user's behavior in depth and to discuss the meaning behind it. To adjust and improve the overall environment to make it more responsive to the needs of use [1]. It can be seen that the traffic environment will greatly affect the willingness of the disadvantaged groups to go out, and also

reduce the opportunities for the disadvantaged groups to contact with the society. It is more likely to move to the use of private transport because of the needs of daily life (such as choosing steam, locomotives to pick up children, seeing doctors, daily routines). The purchase of goods and participation in gatherings, etc., will inevitably have an impact on the overall traffic environment of the city, and the concept of sustainable development of TOD will be disintegrated.

In response to the above issues, the concept of Big Data has been widely used in various fields in recent years. As Viktor Mayer-Schonberger said, the core value of Big Data lies in the repetitive use of data, and can be seen by a large number of messy The data is inferred to be potentially relevant. The key point is that through the analysis of Big Data, it not only helps to understand the relevance of the world, but also improves the decision-making way to reshape the society [2]. For example, the Seoul Metropolitan Government of Korea began to use big data analysis in 2014 for the leisure and welfare facility improvement policy, with commuting population (unit: hour, day), population over 65, resident population, employed population, income, sidewalk and street network, etc. Public facilities, the results found that 89% of the elderly population is mainly using public facilities around 16-17 minutes walking distance around the residential area, of which only 4.5% of the elderly use more than two facilities as an environmental improvement strategy Evaluate the basis and effectively reduce wasteful expenses. Therefore, in order to effectively understand the impact of people's transportation needs and environmental resilience on population vulnerability, this study uses the application of Big Data to understand the potential relevance of the built environment, so that it can fully utilize the conditions and use around the station before planning and configuration. The past behavioral patterns were evaluated to grasp the future traffic demand trends as a benchmark for evaluation, and a series of land use and transportation planning were carried out. It is expected to effectively integrate planning supply with demand and develop towards a more friendly urban environment.

## II. FORECASTING THE POTENTIAL OF TRAFFIC DEMAND WITH BIG DATA TRENDS

At present, Big Data is widely used in various fields for analysis. However, the traffic environmental impact factors have obvious heterogeneity, and these heterogeneous characteristics or conditions affect the consideration of public

behavior, and thus become the determinant of judgment. The study uses Big Data's macro perspective to identify potential correlations from the influencing factors of vulnerable population traffic demand. However, there are many environmental characteristics that Big Data can use. Whether it is internal conditions, external location, environment, or even overall factors, it may affect the environmental trends. It is still necessary to conduct a careful evaluation of the series, such as this study. Use FDM to conduct expert consensus screening to grasp important characteristics that affect the environment.

Why do we need to find out these important environmental characteristics? Because the traffic environment and the trend of people's transportation behavior will be heterogeneous due to different environments and different use groups, it is generally difficult to quickly measure an environmental factor, and Big Data provides a huge amount of data to find out the potential relevance methods recorded in daily life. In addition, Big Data can be based on the potential relevance of the environment, assuming that factors or indirect data can be used to resolve potential impacts, and to clearly identify these impacts and characteristics, the value contributed by these features can be quantified. The current TOD development issues are more focused on the problems arising from the high degree of urbanization, such as the spread of the city towards the suburbs, the emergence of linear, radial and leapfrog developmental type of derivative industry, traffic congestion and construction costs. And is committed to reducing the use of private transport to reduce carbon dioxide and slow down global warming.

It is more worth noting that the friendly environmental issues arising from the immediate environmental disasters are advocating TOD. Develop immediate effects that are forgotten while generating many benefits. Therefore, based on the TOD urban planning thinking, this study applies the potential impact analysis of Big Data, and then analyzes a series of related issues such as the user's perspective and the environmental level, considering the population vulnerability and the traffic demand trends of the vulnerable groups. Achieve friendly TOD environmental planning. Firstly, the fuzzy stage Delphi method (FDM) is used to conduct the first-stage expert questionnaire survey. The consensus value analysis is used to analyze the expert consensus and screening factors, and the evaluation criteria and indicator structure are completed. Then the gray analysis network program method (Grey-ANP) is used. The second phase of the expert questionnaire survey to calculate the relative weight and priority of the indicators.

### III. RESEARCH DESIGN

#### A. FDM and ANP

This study analyzes them sequentially through two-stage evaluation. Firstly, the first stage of the Fuzzy Delphi method (FDM) is based on FDM to develop the operational basis of various evaluation indicators. The design of the questionnaire survey project is based on the results of the literature review, and summarizes the relevant factors that influence the promotion of through verification and integration. The results

of the expert questionnaire will be used to explore the importance of each indicator. According to the screening of indicators, the factors affecting the evaluation indicators will be developed, and the interdependence between the indicators will be obtained to understand their mutual influence. The second phase uses the basis of the "Analytic Network Process (ANP)" design.

#### B. Data Processing

Since the data of the current environment are different in units, when the weight calculation is carried out, the data standardization process has been carried out first, so that the current situation data of the case site is distributed between 0-1, so after standardization There is no unit problem between the data, in order to facilitate the subsequent weighting calculation, and the simple formula for standardization processing is as follows. Complete Big Data analysis through urban built environmental data.

$$\text{normalization} = \frac{x - \mu}{\sigma}$$

$x$  = Raw scores to be standardized

$\mu$  = Average of the mother

$\sigma$  = Maternal standard deviation.

### IV. INDICATOR WEIGHT OF TRAFFIC ENVIRONMENT POPULATION VULNERABILITY

In this study, the gray weight analysis method uses the Grey-ANP pairwise comparison method to select the priority applicability between the indicators. The statistical analysis method uses the pairwise comparison method to evaluate the factors. First, the five major facets are compared for each other, and then the comparison between the indicators is made. Expert integration preferences will be based on Satty's proposed geometric averaging method [3], followed by analysis using Super-Decisions software to create pairwise comparison matrices, solving eigenvectors and eigenvalues. The devaluation value in the pairwise comparison matrix is the judgment value of the decision makers according to subjective opinions. However, due to the judging hierarchy and the influence, it is difficult for the decision makers to achieve consistency before and after the comparison. Therefore, it is necessary to perform a Consistency Index on the threshold, and check whether the pairwise comparison matrix formed by the decision maker's answer is a consistency matrix.

After the Grey-ANP questionnaire method, after the importance of the comparison indicators of the grey interval, the Super Decision software was used to obtain the upper and lower limits of the relative weight values of the 18 evaluation indicators. In this study, the weight value of the original value of the Limit Matrix is used to further calculate the relative weight of the final upper limit value and the lower limit value by the arithmetic mean  $(A+B+C+\dots)/n$ , and finally the percentage (%) according to the weight. For the conversion, the

gray weight value of the 18 evaluation indicators is obtained; then the weight white value of  $\frac{\bar{g}(x) + \bar{g}(x) + \bar{g}(x) + \bar{g}(x)}{4}$  is calculated

by the gray weight value, and the weight priority is sorted, and the result is summarized as shown in Table 1 below.

TABLE I. EVALUATE FACET AND INDICATOR ANALYSIS RESULTS

| Evaluation facet          |                       |                 |      | Evaluation index                               |                       |                 |      |
|---------------------------|-----------------------|-----------------|------|--|-----------------------|-----------------|------|
| facet                     | Gray weight value (%) | White value (%) | Sort | index  | Gray weight value (%) | White value (%) | Sort |
| Land use                  | [ 17.97~14.40 ]       | 16.19           | 4    | Land use pattern around the station            | [ 7.52~5.20 ]         | 6.36            | 7    |
|                           |                       |                 |      | Site land use scale                            | [ 6.22~5.20 ]         | 5.71            | 8    |
|                           |                       |                 |      | Volume density of buildings around the station | [ 4.24~4.01 ]         | 4.12            | 12   |
| Public facilities service | [ 23.13~20.64 ]       | 21.89           | 3    | People's livelihood needs service facility     | [ 4.93~3.66 ]         | 4.30            | 11   |
|                           |                       |                 |      | Open space service facility                    | [ 8.00~7.10 ]         | 7.55            | 6    |
|                           |                       |                 |      | Public infrastructure                          | [ 2.49~2.40 ]         | 2.45            | 16   |
| Pedestrian environmental  | [ 35.03~29.97 ]       | 32.50           | 1    | Accessibility service facility                 | [ 7.80~7.39 ]         | 7.59            | 5    |
|                           |                       |                 |      | Greening planting degree                       | [ 11.22~8.28 ]        | 9.75            | 3    |
|                           |                       |                 |      | Pedestrian friendliness                        | [ 14.18~10.98 ]       | 12.58           | 1    |
|                           |                       |                 |      | Environmental quality improvement              | [ 5.45~5.22 ]         | 5.33            | 9    |
| BIG DATA                  | [ 5.98~7.84 ]         | 6.91            | 5    | Evacuation and evacuation space ratio          | [ 5.26~4.41 ]         | 4.84            | 10   |
|                           |                       |                 |      | Local air quality changes                      | [ 3.16~2.61 ]         | 2.88            | 14   |
|                           |                       |                 |      | Local weather temperature changes              | [ 0.48~0.37 ]         | 0.42            | 18   |
|                           |                       |                 |      | Local rainfall changes over the years          | [ 0.91~0.86 ]         | 0.89            | 17   |
| Traffic environment       | [ 17.89~27.14 ]       | 22.51           | 2    | Local calendar population composition          | [ 3.29~2.15 ]         | 2.72            | 15   |
|                           |                       |                 |      | Surrounding population                         | [ 10.85~7.25 ]        | 9.05            | 4    |
|                           |                       |                 |      | Road system connectivity                       | [ 3.78~2.33 ]         | 3.06            | 13   |
|                           |                       |                 |      | Mass transit development                       | [ 12.51~8.30 ]        | 10.40           | 2    |

a. Weighted weighting is calculated by multiplying the normalized data by the indicator weight value

TABLE II. TRAFFIC ENVIRONMENT POPULATION VULNERABILITY ASSESSMENT RESULTS

| Evaluation facet   | Original weight value | Case evaluation          |                         |                        |
|--|-----------------------|--------------------------|-------------------------|------------------------|
|  |                       | Weighted average         |                         |                        |
|  |                       | Zhongxiao Fuxing Station | Taiwan Hospital Station | Yong'an Market Station |
| Land use   | [ 17.97~14.40 ]       | 0.0715                   | 0.0567                  | 0.0478                 |
| Public facilities service                                      | [ 23.13~20.64 ]       | 0.0436                   | 0.2252                  | 0.0096                 |
| Pedestrian environmental                                       | [ 35.03~29.97 ]       | 0.1072                   | 0.0946                  | 0.0331                 |
| BIG DATA   | [ 7.84~5.98 ]         | 0.0323                   | 0.0361                  | 0.0298                 |
| Traffic environment  | [ 27.14~17.89 ]       | 0.0934                   | 0.0673                  | 0.0518                 |
| total  |                       | 0.348                    | 0.4799                  | 0.1721                 |
| Traffic environment population vulnerability and force ranking |                       | 2                        | 1                       | 3                      |

a. Calculation method: After the current situation data is standardized and weighted by various facets, the higher the score = the higher the tolerance, the more friendly.

The highest weight value is "Pedestrian Friendly (12.58%)", and the lowest weight value is "Local Weather Temperature Change (0.42%)". Through the application of a series of

scientific analysis tools, a set of evaluation index system suitable for the vulnerable population of traffic environment is established, which can not only effectively evaluate the mass

transit station, but also make traffic demand trends and friendly environmental strategies. The principle reference.

## V. CASE ANALYSIS

### A. Evaluation of Facet Analysis of Stations

According to the analysis results (Table 2), the weighted calculation of Zhongxiao Fuxing Station has a weight of 0.348, a Taiwan Hospital Station of NTD 0.4799 and a market of Yong'an Market of 0.1721. The rankings are "Taiwan Hospital Station (Best)" and "Zhongxiao Fuxing Station (medium)". is larger than "Yong'an Market Station (second best)". In addition, the results of the five evaluations are separately observed. The Zhongxiao Fuxing Station is located in the prosperous business district, and there are many office and commercial buildings around it. It is also in the core development zone of Taipei's eastern district. The conditions of the pedestrian environment are better. The land use and pedestrian environment have the highest scores, but they are also ranked second in the three case areas (0.348) because of the crowded population and the saturation of development, and the scores on the representative disaster potential are slightly lower (0.348). The current situation around the hospital station is on average above land use, disaster potential, traffic environment, etc., and is adjacent to large-scale park green space (228 Park) and major medical facilities (Taiwan University Hospital), and in the pedestrian environment. It also has a good performance, so it ranks first in the three case areas (0.4799); while the Yong'an market is far from the city center, it is low in the surface environment table, especially in public facilities services. The barrier-free facilities involved were even less effective and the indicators were highly weighted, so they ranked third (0.1721) in the three case areas and were significantly behind.

### B. Evaluation of Index Analysis of Stations

Further weighted analysis is carried out based on the current situation and environmental data of the case area, and the empirical results of each indicator are obtained. Among the highest ranked Taiwan University Hospital stations, the indicators are characterized by open space (0.0328), barrier-free facilities (0.0527), pedestrian friendliness (0.327), and open space services (0.0328). Only the land use type (0.0213) and the surrounding building volume density (0.0219) are slightly different. This part can be appropriately adjusted by using the Grey-ANP gray weights in this study. Zhongxiao Fuxing Station ranks second in the performance of various indicators, which is in terms of land use, such as land use type (0.341), building density around the station (0.353), and good performance in traffic environment projects. The development of mass transit (0.0502) and the surrounding population (0.0346) have better performance. The crowded and convenient mass transit is also in line with the local development. Only the performance of the disaster potential is low due to timely adjustment. In response.

As for the performance of the indicators of Yong'an Market Station, it is obviously worse than the areas of the first two cases. The reason is that the station is in a residential area that

has not been properly planned, and the traffic environment is congested and the environment is messy and only close to the county road. Looking at the surrounding pedestrian environment, there are no pedestrian lanes, flyovers, underground tunnels, etc., and the station body is only used in the access type, and it is not integrated with the environment. Therefore, the land use scale (0.0041) and open space (0.0015) are also seriously inadequate, but the barrier-free service facilities (0.0027), greening planting degree (0.0011) and pedestrian friendliness (0.0037), which are related to traffic behavior and demand, are almost insignificant. Therefore, the current situation of the environment still needs to be improved and adjusted.

## VI. CONCLUSION AND SUGGESTIONS

In this study, FDM was used to screen the index factors. From the five evaluation facets and 25 evaluation indicators, 18 representative key factors were selected, and BIG DATA was used to avoid the previous research methods lacking scientific analysis, and ANP was adopted. The use of the two-to-two comparison of importance shows that the relationship between the indicator factors is very complicated. The gray weight obtained not only has the traditional ANP intuitive decision-making characteristics (white value), but also the elastic interval feature (gray value) of the gray weight, which can provide decision makers to consider the local environmental conditions and allow appropriate adjustment. In view of the development of mass transit, it is recommended that the "Pedestrian Friendly", which is based on the results of this research, be actively pursued, and that the current situation of the built environment should be used in conjunction with the traffic demand as the main considerations, such as daily shopping, general education, family visits, social communication, and medical care. With long-distance travel, community activities and other multi-purpose vehicles, the traffic demand of the disadvantaged groups is the minimum planning and configuration, so as to improve the traffic environment and the walking environment, which not only benefits the general public, but also contributes to the TOD as a whole. The environment is oriented towards sustainable development, which in turn affects the general public's emphasis and respect for the disadvantaged groups, thereby improving the social atmosphere and creating a harmonious atmosphere.

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