A FUZZY-MCDM EVALUATION FRAMEWORK BASED ON HUMANITY-ORIENTED TRANSPORT FOR TRANSFORMING SCHEME OF MAJOR ARTERIAL SPACE IN TAIPEI METROPOLITAN

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Abstract: Based on the concept of designing humanity-oriented, this paper established an evaluation framework, including four dimensions: traffic smoothness, pedestrian friendliness, comfort of landscape, and space complexity, to assess transforming schemes of major arterial roads in the Taipei metropolitan area and to facilitate decision-making process. By conducting fuzzy-MCDM approach and fuzzy-AHP method to integrate opinions of experts with different expertise into the evaluation framework and further determine the optimal transforming scheme. The evaluation result showed that the two optimal schemes both assign the maximum of adjusted roads to pedestrian space, transform the vehicle-oriented arterial roads into a pedestrian-friendly place, focus on greening the streetscape, and encourage mixed land use. The evaluation framework and the research methods applied in this paper are practical for the related municipal departments to utilize in reviewing transforming plans, thus creating a sustainable city.

Key Words*: *Fuzzy-MCDM, Humanity-oriented transport, Arterial road

1. INTRODUCTION

While cities accommodate various civilian activities, transportation modes are merely the means allowing people to engage in and connect with different activities. After World War II, however, urban transport planning has been focused on vehicular traffic, which affects mode choice and results in safety issues, thus indirectly causing suburbanization, urban sprawl, and leapfrog. Transport systems are designed to let people circulate though the systems; arrive their destinations; and achieve their trip purposes. As a result, it is essential to provide with an environment that makes road users feel convenient, secure, comfortable, and healthy when using the transportation system.

To resolve the problems stated above, planners in the 1990s started to propose the concepts of New Urbanism and sustainable development to redefine and redevelop the transport system, generating the new focal point in the field of planning—humanity-oriented transportation, which aims to redevelop the transport system that is environmental-friendly, safe, and efficient to use. The initial network of the Mass Rapid Transit system network in Taipei metropolitan area was established in 2000 and the operation of such a network indeed influence private mode use. Major arterials roads, have been ignored in the series of discussions on the review of urban space within Taipei metropolitan area throughout the 1990s. This paper therefore chooses Zong-Xiao East Road and Roosevelt Road in Taipei as the survey area to review the City's major arterial space and evaluate its transforming schemes, based on the concept of "humanity-oriented transport."

In order to integrate with different perspectives of planning, this paper utilizes fuzzy-MCDM approach to establish the evaluation framework of "the optimal transforming scheme of humanity-oriented major arterial space in Taipei metropolitan area." Furthermore, the fuzzy-AHP method is adopted to realize the preferences of different expertise and then ranks different alternatives. The objective of this paper is to provide an evaluation framework that is practical for the government to assess and review major arterial roads in the decision-making and execution process.

2. LITERATURE REVIEW

Opening a retail store along the street has been the custom of Taiwanese society, and thus major commercial areas are developed by the side of main arterial roads, which consequently encouraged urban growth. Inappropriate street allocations in commercial areas, on the other hand, have negative impacts on urban development (Yang An-Tsai, 2004). Therefore, major arterial roads mentioned in this paper include driveways, surrounding pedestrian space (e.g., sidewalks and arcades), buildings, and public facilities and street trees located within driveways or pedestrian space. Thus, related literature on humanity-oriented transport, urban design, and fuzzy methods are reviewed in order to build the evaluation framework.

2.1 Humanity-Oriented Transport

Hsu (2003) argues that the concept of humanity-oriented transport originates from the attempt to reduce negative impacts resulted from vehicle-oriented transportation planning. He then defines humanity-oriented transport as "the transportation system that is designed for the public and is necessary for pursuing a beautiful and sustainable life." In other words, humanity-oriented transport is based on the idea of sustainability, emphasizes the importance of pursuing a better environment, and regards the improvement in the well-being of the public as its ultimate goal. Based on the perspective of ecological transport, Kuo(2005) asserts that Taiwan's current transportation planning requires more considerations on improving environmental amenity and should integrate transport constructions into people's lives instead of dividing urban space. The reform of road designations in nature can shift travel modes from automobiles to human-powered transportation such as walking and bicycling, thus coordinating the transportation system with the improved living environment. Design concepts such as traffic Calming, pedestrian friendly, TOD and green transport are at the heart of humanity-oriented transport.

Traffic calming is a traffic management technique specifically designed to reduce vehicle speeds and traffic volumes. It is to protect residents living in the neighborhood, improve the local environment, and increase safety while providing access to motor vehicles (Lockwood, 1977; Lin Jui-Hsien, 2001). Lin and Yeh (2002) suggest that traffic calming measures should be applied not only to residential areas but also other land uses, in response to time.

Pedestrian friendly is now emphasized in the car-free world. Tsao (2003) argues that in the process of modern urban development, people tend to reduce walking because they have been mostly exposed to a motorized environment. In addition, the importance of vehicles' rights of way has been overstated, causing the invasion of automobiles to pedestrian space, and thus, pedestrian planning has been ignored in transportation planning. Lo (2004) emphasizes the role of pedestrian space in a city setting and cities should be primarily made up of human beings and walking is the most essential form of movement chosen by the public. Therefore, improving walkable space, putting emphasis on the level of humanity, and differentiating activities by their characteristics are the three key elements for designing pedestrian space (Li Jin-Lian, 1988).

Jacobs (1961) suggests that planners should design a pedestrian-friendly city that encourages walking and influences the school of new urbanism which stresses the importance of improving the quality of life in planning. Cheng (2001) and Huang (2005) both advocate creating a vibrant, healthy city that encourages people to use public transit and allows residents to engage in diverse entertainment and commercial activities within a five-minute walking distance of communities. Therefore, cities developed by automobile-oriented transportation planning are not safe and it is essential to create a walkable urban environment by implementing humanity-oriented planning (Paumier *et al.* 1988).

Green transport has become a popular measure to solve transportation and environmental pollution problems, in conjunction with the advocacy of sustainable development. Green transport is implemented, by using alternative transportation modes that generate less pollution and are suitable for urban environment, to accomplish social economic activities similar to those achieved by transport modes generating more pollution. Generally, green modes of transport refer to environmental-friendly transportation modes, such as walking, cycling, and public transit. Hsu (2005) believes that green transport is the way to completely reform urban transportation system and urban environment, which will transform urban spatial structure, alter the public's life style, and decrease adverse impacts resulted from traffic pollution.

The idea of **sustainable development** was initiated in 1970s by developed countries when the preservation of natural resources had become a notice. Sustainable city, although based on the concept of sustainable development, highlights the need of integrating development and preservation. Several researchers (Yang An-Tsai, 2004; Lee Yung-jaan, 2002; Robert and Hunter, 1991) indicate that a city aiming to pursue sustainability should be developed according to its local features and limitations and give considerations to environmental, economic, and social issues. Moreover, a city's development plan should reflect its environment capability and multifunctionality to ensure its sustainability. Combining different points of view, Yang(2004) further argues that besides ameliorating its polluted conditions, a sustainable city is the place in which the land is efficiently used and the environment is safe and highly livable.

Li (2003) defines **transit-oriented development (TOD)** as a form of development that emphasizes the role of public transit, which locates retail, entertainment, and office space around transit stops adjacent to residential areas. Calthorpe (1993) proposes the design principal for TOD: areas should be densely developed and be supported by public transit system. Lin and Gau (2003) point out that Taipei City has been mainly developed along the main links, resulting in traffic jam and deteriorating quality of life. They therefore conclude that TOD can resolve congested traffic and the subsequent problems, improve the current environment, and achieve the goal of sustainability.

2.2 Fuzzy Evaluation Theory

(A) Fuzzy-MCDM Approach

Zimmermann (1977) argues that the new trend of decision making is to involve multiple criteria into the management planning process instead of concerning about single criterion. He therefore proposes Multiple-Criteria Decision Making approach (MCDM), which is the systematic method incorporating multiple conflicting criteria into the process, evaluating, comparing, and rating different alternatives. Among numerous MCDM methods, Analysis Hierarchy Process (AHP), presented by Satty (1980) to solve the problems resulting from complicated conditions and incomplete information, is the easiest one and is highly applicable in practice. Several researchers (Tzeng Gwo-Hsiung and Teng Junn-Yuan, 1989; Luo Li-Ren, 2002) indicate that AHP is an approach mainly applied in decision making which includes multiple choice criteria and demonstrates indefinite situations. The goal of AHP is to systemize complex problems by structuring multiple criteria into a hierarchy and determining an overall ranking of the alternatives.

In response to the complicated urban development forms nowadays, AHP method is capable of making decisions regarding urban issues to involve different perspectives in the planning process. Lin (2001), on the other hand, argues that under the influence of complexity and uncertainty about the future, decision makers should give considerations to the characteristics of fuzziness in order to properly estimate the degree of achievement. Many researches (Buckly, 1985; Millet and Haker, 1990; Nien Shu-Hui, 1995; Kao Chih-Hui, 1998) show that it is appropriate to incorporate Fuzzy Sets, proposed by Zadeh (1965), into AHP approach for avoiding a number of shortcomings.

(B)Fuzzy-Delphi Method

The original Delphi method was developed in Rand Corporation by Norman Dalkey and his assistants, which is a technique for obtaining forecasts from selected experts and gaining insights from them. Hwang and Lin (1987) and Lin (2001), however, specify some drawbacks of conducting Delphi method. For instance, experts' opinions may greatly differ from each other due to various issues involved in the research. Moreover, it is costly to obtain a better result by increasing the rounds of questioning. Another drawback of Delphi method is that the statistical result is easily affected by the outliers existing in the collected data. Hence, several researchers (Ishikawa *et al.*, 1993; Chang *et al.*, 1995; Cheng Jao-Hong, 2001; Chan Ya-Chan, 2005) utilize Fuzzy-Delphi method to remedy the above problems, which uses geometric means as the evaluation basis of group's decision-making in calculation.

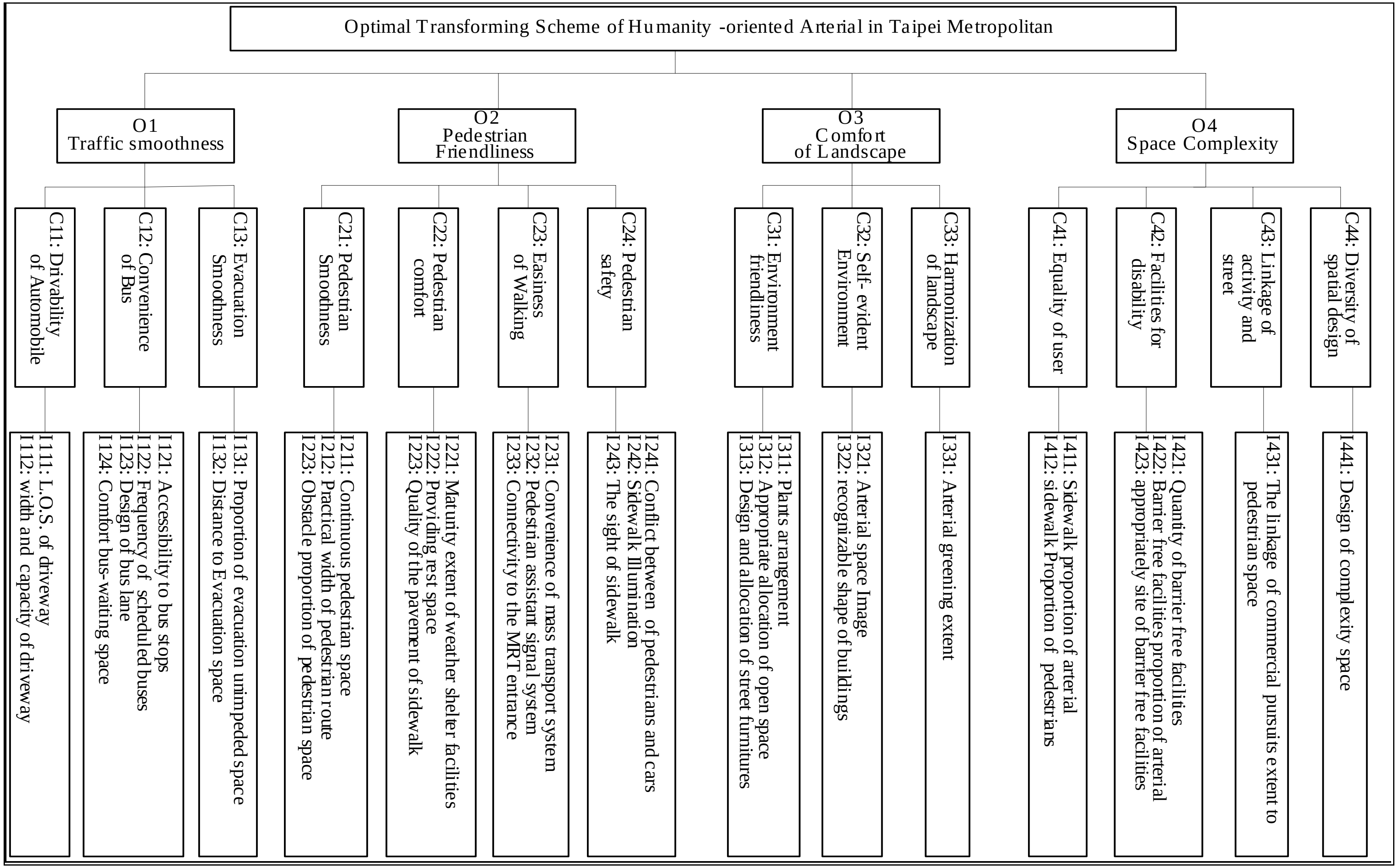
3. ESTABLISHING EVALUATION FRAMEWORK AND PROCEDURE

Fuzzy-Delphi method and Fuzzy-AHP approach are conducted in the research to establish the evaluation framework, and then This paper aims to identify the best scheme among all the transforming alternatives and benefit the practice of evaluating transforming plans in a relatively objective and thorough process.

3.1 Building Evaluation Framework

This paper argues that the proportion of pedestrian space to vehicular space in a metropolis' major arterial space should be balanced. Furthermore, an evaluation framework with considerations of arterial spatial design and environmental sustainability should be build comprehensively. The evaluation framework of "The Optimal Transforming Scheme of Major Arterial Space in Metropolitan Area" is therefore established by adopting the concept of humanity-oriented—emphasizing the role of *people* in transportation and urban planning.

The framework includes four dimensions: traffic smoothness, pedestrian friendliness, comfort of landscape, and spatial complexity. This paper argues that major arterial roads should be



O: Objective, C: Criterion, I: Indicator

Figure 1 The evaluation framework of the optimal transforming scheme in Taipei metropolitan able to provide traffic smoothness, while pedestrian friendliness specifically illustrates the role of pedestrian in the research. Moreover, it is essential to create a comfortable landscape when designing the major arterial space. Spatial complexity, on the other hand, gives careful consideration to social functions and diverse use of different groups. Figure 1 shows the component of this evaluation framework.

The evaluation criteria regarding traffic smoothness, comfort of landscape, and spatial complexity are selected mainly based on the following researches: The Study of Quantified Indicators of Sustainable Transport (Institute of Transportation, MOTC, 2003), Well Measured-Development Indicators for Comprehensive and Sustainable Transport Planning (Todd Litman, 2005), and Guide to Sustainable Community Indicators (Maureen Hart, 1999). In reference to the criteria of pedestrian friendliness, this paper selects the indicators that have been used by Institute of Transportation Engineers, (USA, 2005) and United States Department of Transportation (FHWA, 2006).

3.2 Evaluation Methods

Fuzzy-Delphi method was conducted to select evaluation criteria, thus making up the contents of the evaluation framework (Table 1 illustrates the procedure). And, Fuzzy-AHP approach was used to deal with selected experts' inputs by incorporating into fuzzy values and derive the weight value of each evaluation criterion (see Table 2).

Table1 Evaluation procedure of fuzzy-Delphi

	Procedure	content
Step1	Collect opinions of decision groups	Using expert survey to collect preferences for decision makers. Giving every criterion an interval to compute criteria's evaluation values from experts. Minimum of evaluation values as the conservative quantitative value of criteria；Maximum of evaluation values as the optimistic quantitative value of criteria.
Step2	Build fuzzy trigonometric function	Transforming evaluation values collected form survey to find the triangular fuzzy number of conservative value $C^i = \left(C_L^i, C_M^i, C_U^i\right)$ and the triangular fuzzy number of optimistic value $O^l = \left(O_L^i, O_M^i, O_U^i\right)$。
Step3	Sieve out evaluation criteria	Taking the geometric mean of triangular fuzzy number of each criterion as its membership function value 「Mi」 to represent surveyed experts has consensus, then depend on the goal to decide evaluation threshold vale 「S」. (1) $Mi \geq S$, accept criterion i as evaluation criterion (2) $Mi < S$, delete criterion i.

3.3 Panel Design

This paper establishes the framework and determines the weighting system by conducting expert questionnaire. The first round questionnaire was sent to scholars in urban planning and transportation planning fields, governmental departments (i.e., department of transportation

Table 2 Evaluation procedure of fuzzy-AHP

	Procedure	content
Step1	Establish evaluation hierarchy framework	Setting goal, objectives, subjects and criteria of the evaluation framework. Ascertaining evaluation criteria by fuzzy-Delphi method.
Step2	Consistence Test	Using Consistence test to make sure experts' preferences sensible and evaluation outcome drawn on reality. Consistence Index (C.I.) tests the consistence of experts' preferences during the evaluation procedure. When C.I.=0, expert's preferences had consistence; C.I.>0, expert's preferences didn't consist, but C.I.<0.1,as the acceptable error. Consistence Ratio,(C.R.) test the consistence of the evaluation framework .C.R. as the ratio between C.I. and Random Index,(R.I.) in the same matrixes. When C.R.≦0.1, the matrix is acceptable; C.R.>0.1, the matrix didn't consist. $C.I.=\frac{\lambda_{\max}-n}{n-1}$ ……(1) $\lambda_{\max}$ The maximum eigenvalue of pairwise comparison matrix of the framework. $C.R.=\frac{C.I.}{R.I.}$ ……(2)
Step3	Establish fuzzy pairwise comparative matrix	Experts compare the importance of each pair criteria and use triangular fuzzy number M_{ij} to combine their estimate. Furthermore, set fuzzy positive reciprocal matrix M and compute relative weight of criteria from vectors in the pairwise comparison matrix. $M=\lfloor \tilde{M} \rfloor$ ……(3) M: Fuzzy positive reciprocal matrix $M_{ij}=(L_{ij},M_{ij},R_{ij})$ ……(4) $M_{ji}=1/\tilde{M}_{ij}$, $\forall ij=1,2,3,...,n$ ……(5) L_{ij} : The left triangular fuzzy number of the subject i with respect to criteria j M_{ij} : The median triangular fuzzy number e of the subject i with respect to criteria j R_{ij} : The right triangular fuzzy number e of the subject i with respect to criteria j
Step4	Integrate preferences of multiple decision makers	Integrate expert's opinions in fuzzy number by Buckly's average method. $\tilde{m}_{ij}=(1/N)\otimes(\tilde{m}_{ij}^{1}\oplus\tilde{m}_{ij}^{2}\oplus...\oplus\tilde{m}_{ij}^{N})$ ……(6) N : The number pf survey experts $\tilde{m}_{ij}$:The triangular fuzzy number of expert N of the subject i with respect to criteria j $\tilde{m}_{ij}^{N}$:The pairwise comparison value of expert N of the subject i with respect to criteria j
Step5	Compute fuzzy weight system of the framework	Compute the fuzzy weight of each criteria $\tilde{Z}i=(\tilde{a}_{i1}\otimes\tilde{a}_{j2}\otimes...\otimes\tilde{a}_{in})^{\frac{1}{n}},\forall i=1,2,...,n$ ……(7) $\tilde{w}=\tilde{Z}_i\otimes(\tilde{Z}_1\oplus\tilde{Z}_2\oplus...\oplus\tilde{Z}_n)^{-1}$ ……(8) $\tilde{Z}i$: The geometric mean value of triangular fuzzy number $\tilde{a}_{ij}$:The triangular fuzzy number of the row i with respect line j in fuzzy positive reciprocal matrix $\tilde{w}$: The fuzzy weight of each row in fuzzy positive reciprocal matrix
Step6	Compute final weight system of the framework	Using center of gravity method to defuzzfication the criteria fuzziness, then normalize the defuzzfication to a crisp value. Compute the weight of evaluation framework as 1.

and planning departments.), and related engineering consulting companies. The framework structure was revised and criteria were modified according the result of first round Delphi survey. In the second round, AHP expert questionnaires are utilized to take preference of different groups into consideration, leading to a relatively objective weighting system, this paper also sent questionnaires to graduate students in planning programs. Table 3 shows the weighting system derived from the computation of expert questionnaires.

Table 3 Weight Value table of evaluation framework

Goal	Objective	Subjective	Criteria
Optimal transforming scheme of Humanity-oriented Arterial in Taipei metropolitan	O_1 (0.320263)	C11(0.089561)	I111(0.064919)、I112(0.024642)
		C12(0.123137)	I121(0.043975) 、 I122(0.039070) 、 I123(0.019663) 、 I124(0.020429)
		C13(0.10788)	I131(0.074899)、I132(0.032981)
	O_2 (0.393204)	C21(0.087353)	I211(0.041363)、I212(0.024707)、I213(0.021283)
		C22(0.072531)	I221(0.023010)、I222(0.020996)、I223(0.028525)
		C23(0.064644)	I231(0.030150)、I232(0.012483)、I233(0.022011)
		C24(0.168677)	I241(0.091537)、I242(0.047575)、I243(0.029565)
	O_3 (0.196642)	C31(0.119067)	I311(0.032689) 、 I312(0.015089) 、 I313(0.044380) 、 I314(0.026908)
		C32(0.0428)	I321(0.032040)、I322(0.010760)
		C33	I331(0.034775)
	O_4 (0.089891)	C41(0.018444)	I411(0.009619)、I412(0.008825)
		C42(0.034497)	I421(0.010700)、I422(0.013919)、I423(0.019853)
		C43	I431(0.023655)
		C44	I441(0.013296)

From Table 3, at the objective level, we can see Pedestrian Friendliness(O_2) with highest weight (0.3932) and next is Traffic Smoothness(O_1), reflecting the social awareness of arterial road shift from car-oriented to human-oriented. As to the subjective level, Pedestrian Safety(C_{24}) is with the highest weight (0.1686), Convenience of Bus(C_{12}), Evacuation Smoothness(C_{13}) and Environmental Friendliness(C_{31}) were all with weight higher above 0.1, indicating the design of transforming scheme should pay more attention on these dimensions.

4. ANALYSIS OF CASE STUDY

Zong-Xiao East Road and Roosevelt Road, as the two major arterial roads in Taipei metropolitan area, are selected as the objects of this study. Zong-Xiao E. Road is the east-west oriented arterial, while Roosevelt Road represents the north-south oriented road; the city's most prosperous commercial areas are therefore developed alongside the two arteries. Furthermore, both two roads are paralleled to the Mass Rapid Transit network (underground constructed) and are designed with exclusive bus lanes (the former is under construction, the later is already built).

4.2 Ranking of the Transforming Scheme

(A) Transforming Scheme of Zong-Xiao E. Road and Roosevelt Road

A spatial design consultant firm was contracted to propose transforming plan by Taipei City Government, a variety plan drafts were principally examined by review group to screen out feasible schemes at initial stage. Three transforming schemes of Zong-Xiao E. Road and two schemes of Roosevelt Road were selected as the alternatives for further evaluation. The primary differences between these schemes are the adjustments in the road types, and the broadening level of sidewalks. Table 4 summarizes the content of each transforming scheme.

(B) Determining the Best Transforming Scheme
This paper compares the transforming schemes of each arterial road, derives the performance values of each plan by referring to the evaluation criterion, in conjunction with the weight values of each criterion obtained from Fuzzy-AHP computation result of expertise, and therefore concludes the final score of each scheme (see Table 5). Among the transforming schemes, the schemes of both roads being ranked with the highest score are the plans that broaden the sidewalks to the greatest degree and transform the reduced driveway space into pedestrian space to cooperate with the design of bus lane.

Table 4 Transforming schemes compare table

	Transforming schemes	content
Zong-Xiao East Road	Scheme1	Median bus lanes, decrease car lane’s width and increase sidewalk 1.5m width in both side of arterial，greening the arterial.
	Scheme2	Curb bus lanes，decrease car lane’s width and increase sidewalk 1.5m width in both side of arterial，greening the arterial.
	Scheme3	Curb bus lanes，decrease car lane’s number width and increase sidewalk 4m width in both side of arterial，greening the arterial.
Roosevelt Road	Scheme1	Median bus lanes，decrease car lane’s number width and increase sidewalk 1.5m width in both side of arterial，greening the arterial.
	Scheme2	Median bus lanes，decrease car lane’s number width and increase sidewalk 3m width in west side of arterial，greening the arterial.

Table 5 Transforming schemes evaluation score table

	Zong-Xiao East Road			Roosevelt Road	
	Scheme1	Scheme2	Scheme3	Scheme1	Scheme2
Score	3.9042	4.0574	4.5612	4.0232	4.4732

5. ANALYSIS OF DECISION MAKING PREFERENCE AMONG GROUPS

Recognizing that urban spatial planning involves various professional domains and each domain may have different ideology and different conception towards space, this paper categorizes selected experts into four groups: graduate students, scholars, governmental urban planning departments, and governmental transport departments. The weights assigned to each criterion within evaluation framework are sorted to understand the preference of each group in decision making.

5.1Analysis of Different Weights among Groups

(A) Graduate Students
Graduate Students in planning-related programs view traffic smoothness as the most important element in the study, followed by pedestrian friendliness. Moreover, the weight given to traffic smoothness is nearly 50%, which shows that the student groups pay much attention to the functionality of arterial space. The dominant preference for traffic smoothness can be explained by the fact that students, although have learned the theories mentioned before, tend to shift their roles from professional evaluators to road users when the transforming schemes take place in reality, within actual urban space. Because of the current

street use habit, the public is more tolerant of unfair pedestrian space as long as it will not affect their safety. Pedestrian safety and comfort of landscape are, however, being ranked after pedestrian smoothness, which indicates that people have been concerned about living environment nowadays.

(B) Scholars
Unlike graduate students, scholars in the urban planning domain pay more attention on pedestrian friendliness than traffic smoothness. From the 1990s, scholars have noticed that the unlimited construction of road and the overuse of motorized vehicles have caused unbalanced development of urban space. In addition, scholars, influenced by the trend of sustainable development, begin to review the spatial allocation of the city and expect to transform streets into a locus which is pedestrian friendly with mixed land use. It is therefore not surprising that the scholar group favor pedestrian friendliness over other factors.

(C) Governmental Urban Planning Departments
Urban planning departments consider pedestrian friendliness as the most important factor in evaluating a transforming scheme and rate traffic smoothness as the second one. The preference of planning departments indicates that planning departments make their design principals move in the same direction as planning theories. In other words, improving quality of life, focusing on the convenience provided by public transit, and creating an enjoyable landscape by greening streets and designing open space, are the recent concerns of urban planning departments.

(D) Governmental Transport Departments
Traffic smoothness ranks first in questionnaires collected from transport departments. This group preference clearly shows that transport departments, based on their expertise, still give emphasis to the functionality of urban streets. It does, however, merit notice that the difference between the weight of traffic smoothness and that of pedestrian friendliness is not distinct. This evidence indicates that the function of walking in major roads is not ignored by transport departments; instead, they conceive major arterial roads the locality to provide convenient traffic and ensure pedestrian safety at the same time. In the overall ranking, pedestrian safety, convenience of bus, and environment accessibility are the top three emphases of transport departments. The preference reflects that transportation departments are inclined to promote the use of public transit rather than provide more services to private vehicles.

5.2 Analysis of Different Preference
To further understand the difference in decision making between four groups, this paper compares each group's preference and summarizes the following observations.

1) Although each group has different preference in decision making, these two variables—environment accessibility and convenience of bus—are treated as the relatively important element among groups (see Figure2).

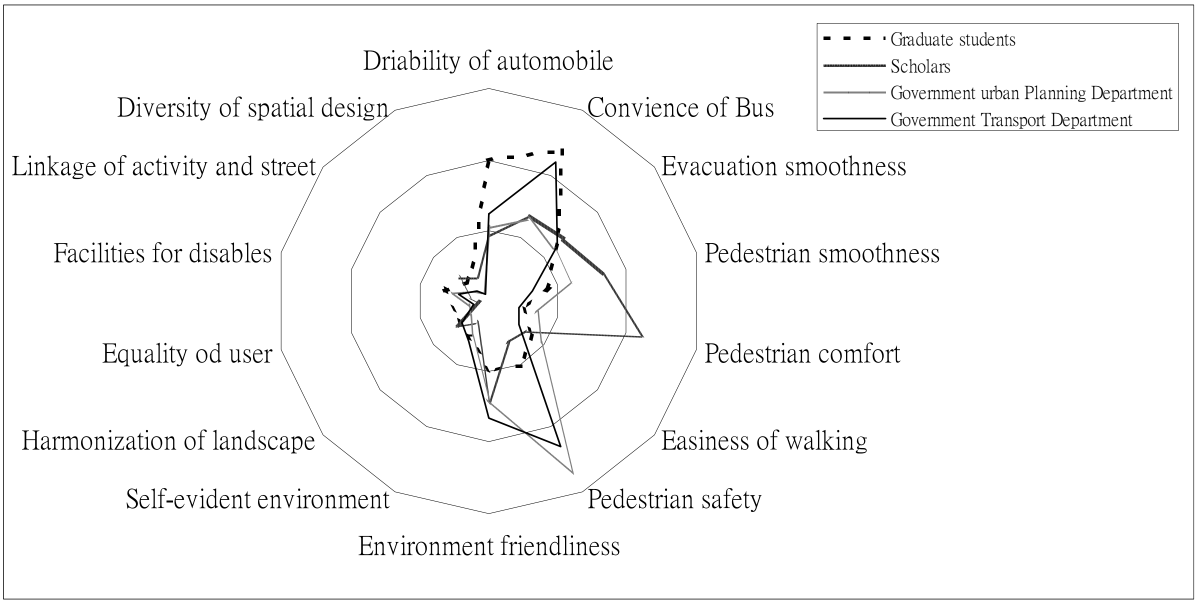


Figure 2 Different groups' preference structure analysis

2) Scholars and governmental departments both emphasize the role of pedestrian environment, while governmental urban planning departments and transport departments pay attention to pedestrian safety. Scholars, on the other hand, are the only group that stresses the importance of the comfort of pedestrian space. From Figure 4, it is evident that space complexity is not viewed as important as other factors by all groups.

3) Scholars and urban planning departments tend to focus on creating humanity-oriented major arterials in the metropolitan area. The concerns of scholars are, however, more comprehensive than that of urban planning departments, because the weights assigned to different elements by scholars are equally distributed.

6. CONCLUSION AND SUGGESTION

The design of streets and roads exclusively providing space to motorized vehicles has overlooked its own role in representing the public space. This paper therefore aims to build a metropolis' major arterial space based on humanity-oriented which includes the functions of traffic and open space by establishing an evaluation framework, utilizing Fuzzy-MCDM approach, and selecting the best transforming scheme. Following are the conclusion and suggestion of this study.

1) The evaluation framework established by this paper includes traffic smoothness, pedestrian friendliness, comfort of landscape, and space complexity these four dimensions. Various criterions relevant to these four dimensions are weighted by different groups and integrated by conducting Fuzzy-MCDM method. This study gives consideration to different professional domains, leading to an effective and practical evaluation result, thus allowing this paper to shed lights to the field of planning.

2) The decision making of the best transforming scheme requires the concerns about uncertain indicators, including quantitative and qualitative evaluation criteria. To avoid the above issue, this paper utilizes Fuzzy-AHP approach and therefore the computation of the weighting system is relatively reasonable and the evaluation criterion is independent from each other.

3) Through the analysis of different preference of several groups, this paper argues that scholars and urban planning departments both focus on the services provided for pedestrians, while governmental transport departments pay much attention to creating the space which ensures the coexistence of pedestrians and vehicles and promoting the use of public transit. The argument implies that the evaluation framework is able to incorporate different viewpoints, thus effectively determining the best transforming scheme.

4) The evaluation result shows that the two best schemes simultaneously place emphases on maximizing pedestrian space and adjusting the alignment of arterial roads. As a result, it is critical for the city government, when making decisions on executing transforming schemes in the future; to cooperate with public transit such as improving mass rapid transit network and designing exclusive bus lanes and transform the selected roads into a place in which pedestrians and vehicles can harmoniously coexist.

5) In order to realize the criterion performance and evaluation result in practice, this paper suggests that the subsequent studies can quantify the pedestrian flow and simulate pedestrian movement. Furthermore, when implementing the transforming scheme in the future, it is recommended to assess and review the effect resulted from the execution of the plan so that other transforming schemes can learn from such feedback.

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