

SCENARIOS FOR MOBILITY IMPROVEMENT BASED ON INDIVIDUAL SOCIOECONOMIC FACTORS

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ABSTRACT

This research investigated various factors related to different mobility improvements based on individual socioeconomic variables. In this study, two sustainable mobility scenarios have been suggested to be implemented in the Central Business District (CBD) area, in which the traffic situation is severely congested. These new mobility improvements are vehicle-free zones and congestion pricing. The two options have been studied and investigated using the binary decision tree method. The main aim of the study is to identify which mobility options are preferred by different groups of people in the city. This will reveal public opinion about the future change in mobility in the city. With the help of the Python programming language and the idea of machine-learning represented by the Decision Tree method, several trials were carried out to get the desired and accurate outcome from the public participation. The study findings showed that the "age" and "gender" variables are significant decision-making factors, whereas the number of trips and mode of transport have no effect on the choice set.

KEYWORDS: Public participation; Congestion pricing; Car-free zone; Sustainability;

1. INTRODUCTION

Enhancing public participation in policy-making is a primary prerequisite for improving the effective use of urban transportation resources. The fundamental reasons preventing the effective use of transportation resources are a lack of recognition of mobility development planning and insufficient policy participation. Public participation can improve the productivity of public project management and construction, make construction results conform to public demand, and adapt to the current supply and demand system's development trend. Many scholars have proposed that public projects, particularly those that directly serve the public, such as education, medicine, and transportation, need to consider public participation. (Zhang et al., 2021). The European Landscape Convention (ELC), specifically articles 5 and 6, emphasize public involvement and participation as key factors in developing landscape policies (Santé et al., 2020).

Citizens' participation in transportation planning is typically modeled after a liberal democracy in which people can express their preferences on a project (McAndrews & Marcus, 2015).

Cities all over the world strive to improve their city centers in order to make them more attractive, vibrant, and accessible. This goal is frequently motivated by the following desires: to provide residents with a pleasant city center that they enjoy and use; to facilitate suitable environments for retail, services, and other commercial and non-commercial activities; to attract businesses and residents to the city; and to shift urban mobility toward more sustainable modes (Hagen & Tennøy, 2021). City centers are those parts of a city where most of the city's commerce, politics, culture, and power are concentrated. Since it was typically the first part of the city to be settled, the city center is the place with the most historical significance. Street spaces are reallocated by cities worldwide as part of initiatives to serve cars and other modes of transportation, and numerous studies have

been conducted to make the city center more appealing. By excluding cars from entering the designated area, the pedestrian zone is evolving as a very successful and significant policy goal for cities aiming to increase their performance in "livability" and "walkability" and alleviate traffic congestion in urban centers. Without enough other transportation options, such as buses and light-rail streetcars, it was deemed that a pedestrianized zone could not be implemented properly. Policymakers can establish "transit priority" through dedicated lanes to ensure continuous transit travel options when congestion varies, lessening the impact of traffic congestion on transit and creating a steady demand (Fournier, 2021).

Numerous studies have shown that active mobility measures improve citizens' and city users' opportunities, as well as the perceived safety and attractiveness of historic city centers (Gargiulo & Sgambati, 2022). Green space and neighborhood walkability are important components of a healthy and sustainable city (Hu et al., 2022). Open and green space has been shown to be effective in encouraging people to engage in physical activity, whereas, for older people, health conditions and socioeconomic characteristics have a greater influence on the amount of physical activity undertaken (Xiao et al., 2022).

The area where pedestrians are concentrated prevents the capacity of the road network from being exceeded by traffic flow in the center. The pedestrian zone does not need to be so large that it pushes the capacity of the surrounding highways or extends travel times because of walking. The improvement of pedestrian safety is a top objective for many transportation authorities. Particularly on congested arterials, many pedestrians find it is challenging to cross streets in the middle of blocks. Some crosswalk upgrades are intended to increase crosswalk visibility for vehicles, reduce the distances that pedestrians must cross, or physically separate pedestrians from motorized traffic. (Fournier, 2021).

Shared spaces have become substantially more popular to increase the level of active travel modes like walking, cycling, and running. A study conducted in the UK from a sustainability perspective, in which, policy-makers argued that shared spaces afford greater opportunity for cycling off-road in areas with busy traffic. It was concluded that collectively sharing mobility spaces in the UK requires long-

term changes in urban infrastructure that can promote a shift away from the political dominance of the private vehicle. (Barr et al., 2021). A study from Brussels examines the impact of pedestrianizing central boulevards as well as changes in public transportation and parking facilities and interventions that have the potential to affect the entire city center. The level of support for car-free boulevards varies depending on the type of user, but overall, supporters outweigh non-supporters (Hagen & Tennøy, 2021). Another study was conducted in Nanjing, China, at DeJa Plaza, which considered people's perceptions, experiences, and emotional needs of the commercial place as a significant dimension for developing the relationship between people and city centers. The study's findings showed that social perceptions have a positive impact on regional identities. Moreover, the study indicated that local individuals' activities have a positive effect on personal identities when they have prominent cultural characteristics. It was determined that the location's good accessibility and nice surroundings attract a larger number of people. (Sun & Yu, 2021).

Congestion pricing is an effective, and demand-oriented approach. It reduces traffic congestion in the pricing zone by encouraging travelers to modify their travel schedules by switching their modes of transportation, departure times, and routes (Chen et al., 2021). Congestion pricing on high-traffic roads aims to influence travelers' route selection, trip timing, mode selection, and destination selection in order to keep vehicles moving and avoid excessive congestion (Clements et al., 2021). Implementing more proper economic policies to reduce congestion, such as congestion pricing and efficient investment plans can frequently result in a significant potential increase in public welfare. Although it is a well-known method of reducing traffic congestion, congestion pricing is rarely used, primarily due to worries about its distributional implications. Due to reduced travel time but increased financial expenditures, pricing may actually make some commuters worse off (Takayama, 2020). The fundamental ideas for the economic design, analysis, and evaluation of such policies are the values that travelers assign to travel time losses (values of time, or VoTs). These values are essential to determining the economic value of travel time gains from infrastructure investments or for determining optimal congestion pricing

(Verhoef, 2020). Without regulation and pricing, users only take into account the direct costs of congestion on their own travel times, which causes the demand-supply equilibrium for road space to be suboptimal (Clements et al., 2021). Each customer decides whether to accept or reject the concept based on a specific threshold value. The objective should be to maximize profit, which is estimated as the difference between route costs and total service revenue (Afsar et al., 2021). Congestion pricing schemes all work by charging cars for entering areas with high vehicle concentrations, but they differ in their implementation. It can help mitigate the negative effects of automobiles by reducing the amount of time people spend stuck in traffic while also increasing their benefits. (Yu et al., 2019). In Stockholm and Singapore, a cordon system governs pricing based on the time of day, with rush hour being the most expensive. Congestion pricing has benefited both health and society. Significant reductions in air pollution, including the most dangerous form, were achieved in London, Stockholm, and Milan. These reductions ranged from minor adjustments to as much as 20%. Using alternative modes of transportation also helps to reduce obesity, heart disease, and cancer. Congestion pricing has not only reduced congestion and air pollution in areas where it has been implemented, but it has also encouraged the use of more active modes of transportation, such as walking, cycling, and public transportation (Yu et al., 2019).

The aim of the congestion pricing is to propose an effective and practical solution for improving transportation performance and efficiency by charging vehicles for driving on specific corridors at specific times of day. By encouraging drivers to choose between using toll lanes or altering their travel schedules, traffic congestion is expected to decrease (Nguyen et al., 2021). The number of cities that have actually implemented congestion pricing is still limited. Public rejection and concerns are some of the critical reasons for their non-implementation. As a result, experts consider public acceptance to be a necessary precondition for the successful implementation of such strategies. Cities such as New York, Manchester, and Edinburgh have reported a lack of public support for congestion pricing policies (Abulibdeh, 2022).

While numerous studies and books have been published emphasizing the potential social, environmental, and economic benefits of

walkability and pedestrian-centric design, these studies frequently lack an objective and quantitative evaluation to support their claims (Fournier, 2021). One of the most essential responsibilities taken on by transportation planning agencies is transportation improvement programming. Lack of public support for transportation projects could lead to global resentment toward the agencies proposing the projects. The use of technology is ideal for implementing public participation, which is a new component in the programming process (Zhong et al., 2008).

In this paper, the concept of congestion pricing and car-free zones is examined. The literature revealed that both approaches have different effects on mobility status and sustainability. A new procedure is developed based on the combination of the two proposed sustainable mobility scenarios, which are congestion pricing and a car-free zone in the city center. The decision tree method is used in a quantitative approach to analyze public preferences in relation to socioeconomic factors of different groups of people in the city.

2. MATERIALS AND METHODS

The data is collected by the author through practical fieldwork served as the primary data source for the analysis in this study. The study area is Duhok, one of the cities in Iraq's Kurdistan Region. The study's focus is on the Central Business District (CBD). It is the heart of Duhok City, where most commercial, social, retail, and recreational activities are carried out on a daily basis. The research dataset was gathered through the distribution of questionnaires to the residents of Duhok city. The questionnaire form has been prepared in hardcopy and as a Google Form link and has been distributed all over the city via an online messages and manually as a hardcopy. Randomly selected individuals from various groups have been targeted in all of the city's districts. Diverse groups of different ages and backgrounds are incorporated into the public participation process. This validates both public participation process and the method used to analyze the results obtained (Santé et al., 2020). The formulation and implementation of public project plans require the participation and interaction of various groups, particularly, the response and feedback of target participants to decision-making, which is a fundamental

requirement for effective public project promotion (Zhang et al., 2021). The items of this questionnaire asked about the installation of possible solutions, which are: applying congestion pricing or creating a car-free zone. The number of people interviewed in this study was 1161. Public participation in the programming step may increase the public's sense that the process is transparent and that their opinions are being heard (Zhong et al., 2008). Python and Excel spreadsheets were the application tools utilized in this study to perform the analysis and create the graphs. Python is data analysis software that tests and estimates various variables based on the function that a user runs. Group decision support systems have become a research hotspot as computer technology has advanced. Currently, research on multi-attribute groups mostly focuses on attribute weights, group consistency, group aggregation methods, and group decision-making plan ranking. (Zhang et al., 2021). The dataset in this study was analyzed using the Decision Tree (DT) algorithm. The primary justification for the use of DT in this study is that the target variable that needs to be examined has a binary property, i.e., the proposed scenarios ("congestion pricing" and "car-free zones"), which is considered to be adequate for these kinds of methods (Abdullah

& Sipos, 2022). In general, DT is a supervised classification with the following procedure: Given an observation dataset called a "training set," different sets of observations are used; this set is known as the "test set." The variable to be predicted (classified) is referred to as the class variable, and the variables in the dataset are referred to as predictive attributes or features (Abdullah & Sipos, 2022).

3. RESULT AND ANALYSIS

3.1. Daily mobility and number of trips.

Figure 1 depicts how frequently respondents in the study area use the various modes of transportation available. Private cars are the most commonly used mode of transportation in Duhok City, indicating that people drive their own cars on a daily basis. As a result, it was chosen by 54.4 percent of respondents. Furthermore, according to the survey results in Figure 2, more than two-thirds of local city respondents made at least two trips per day, with nearly half making three to more than five trips per day. A trip is defined as a journey made by a person between two locations for a specific reason. People travel for a variety of reasons, including meeting daily needs, traveling, jobs, school, or college.

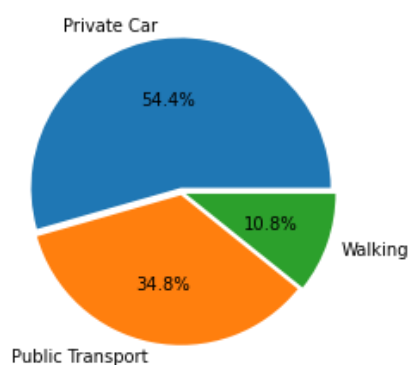


Fig. (1): Frequency of transport modes used daily

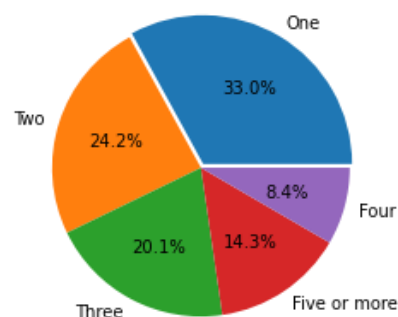


Fig. (2): Number of trips per day by respondents

3.2. Parking lots situation

According to the questionnaire results gathered from Duhok city's residents, a large number of people pointed out that they waste a lot of valuable time looking for a parking spot when they go to the CBD. It is due to the

excessive number of cars, as most people drive their own cars, which causes traffic congestion in the CBD. About 75 percent of people said they were having difficulties in finding a parking spot, while 25 percent said they could easily find one. Figure 3 displays the results.

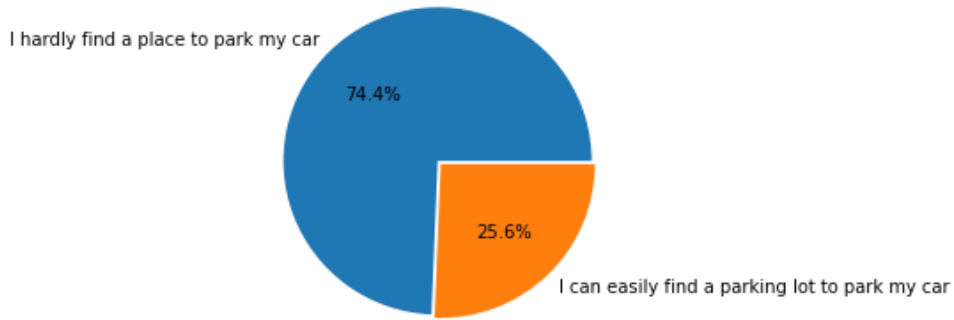


Fig. (3): Parking lots concerns in the CBD area

3.3 Decision Tree Analysis

The output of the DT procedure in Python is displayed in Figure 4. The graph in the tree depicts the key factors that contribute to the decision factors. The secondary factors are located lower on the tree hierarchy scheme, whereas the significant element is at the top. Both of the proposed options are displayed by the elements of the value array. A car-free zone is represented by the first value, while a congestion pricing development scenario is represented by the second. From the gathered

information, the root node implies that out of 1161 respondents, 672 chose the first option, whereas 489 picked the second. Entropy is a unit of measurement for noise in a decision. Uncertainty is a way to describe noise. As an illustration, the entropy is at its highest value, or 1.0, in nodes where the decision results are equal. This indicates that the categorization decision made by the model based on the input variables was not able to be marked clearly. When entropy was extremely low, the choice was considerably easier to make.

Table (1): The dataset names and their numerical description

Variable	Description
Age	Age groups (1 = 18 - 25; 2 = 26 - 39; 3 = 40 - 64; 4 = 65 or older)
Gender	Male = 1; Female =2
Parking	Easily find a parking lot = 1; hardly = 2
Owning_car	(0 = No; 1 = Yes)
Trips	Trips/day (one = 1; two=2 ... more than 4 = 5)
Daily_Mobility	Private Car = 1; Public Transport = 2; Walking = 3
PreferedFutureImprovement	Car-free-zone = 1; Congestion Pricing = 2

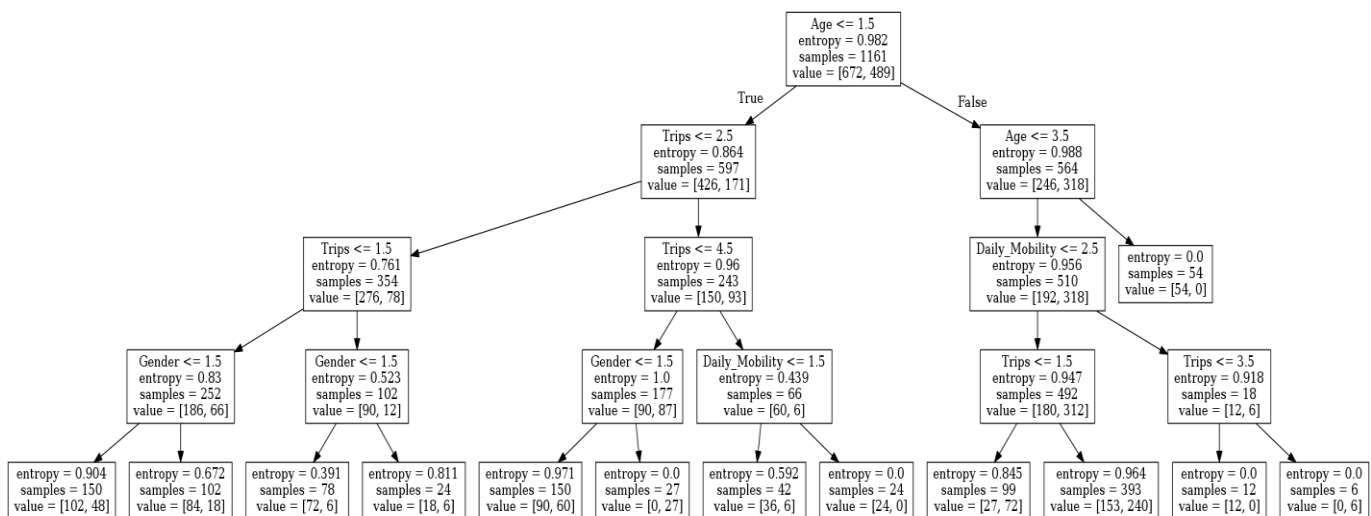


Fig. (4): Output by Python illustrating the results of the Decision Tree Method

4. DISCUSSION

The decision-making variables for future development are examined in the current research. Table 1 lists the variables that were included in the dataset collection. The data transformed into digits were used to generate the decision tree that served as the basis for the evaluation. The variable "Age," the tree's root, is listed first at the top, showing that it is the most significant factor in identifying patterns. The decision factor indicates that the younger people go with the branches on the left. The decision factor, the entropy, and the number of respondents who met the requirement at that node in the tree are all contained in each root and intermediate node. The root node, for instance, shows that the learning data set consists of 1161 observations. On the following level, to the right, it can be seen that the older group of 564 individuals, who are between the ages of 26 and 64, prefer the option of congestion charging, which is 318. In addition, it is clear that this group is making fewer daily trips. Furthermore, the entire group of 65-year-olds and older chose the car-free zone scenario, which had zero entropy with 54 samples, but they made the fewest number of trips. On the other hand, to the left, it can be observed that 579 of the younger people who make more daily trips—and a majority of them are men—prefer the first development option, which is a car-free zone. All young women who make 3 to 4 daily trips seem to favor the second alternative, while young people of both genders who make 1 or 2 daily trips favor car-free zones. On the third level, it is also discovered that young people between the ages of 18 and 25, who make 5 or more daily trips, and use private car, public transportation or walking, prefer the first option—a car-free zone—while the older people support the congestion pricing option.

5. CONCLUSION AND RECOMMENDATIONS

A majority of urban residents of Duhok city rely on private vehicles for their mobility needs, as shown by the study's findings that more than half of respondents use their own private cars for daily travels. Concerning possible future development in the CBD zone, surveyed residents favored both congestion pricing and a car-free zone based on different socioeconomic factors. Age is the key socioeconomic

component that determines this classification. Younger residents favor car-free zones, whereas older residents favor congestion pricing. These results implied that older people might require a higher level of accessibility to attain their destinations. As for the car-free zone development option, it would be wise to consider providing modes of public transport in the CBD area and a convent streetscape level in the designated area. The decision tree also included gender, number of daily trips, and mode of transport as other important considerations. According to the results, most young men and women in Duhok want car-free zones, while young women, specifically, who make 3–4 daily trips, favor congestion pricing. This is because it is culturally accepted in the city that women often dislike walking long distances, especially if they are alone. To sum up, according to the study's findings, it reveals that "age" and "gender" variables have been shown to be significant factors in making the decision, while the number of trips and mode of transport do not affect the choice set. The findings mentioned above might help implement a future development in the study area. The successful implementation of the proposed plans will significantly reduce the use of private cars and enhance sustainable mobility in the city center.

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REFERENCES

- Abdullah, P., & Sipos, T. (2022). Drivers' Behavior and Traffic Accident Analysis Using Decision Tree Method. *Sustainability*, 14(18), 11339. <https://doi.org/10.3390/su141811339>
- Abulibdeh, A. (2022). Planning for Congestion Pricing Policies in the Middle East: Public Acceptability and Revenue Distribution. *Transportation Letters*, 14(3), 282–297. <https://doi.org/10.1080/19427867.2020.1857908>
- Afsar, H. M., Afsar, S., & Palacios, J. J. (2021). Vehicle routing problem with zone-based pricing. *Transportation Research Part E: Logistics and Transportation Review*, 152, 102383. <https://doi.org/10.1016/j.tre.2021.102383>
- Barr, S., Lampkin, S., Dawkins, L., & Williamson, D. (2021). Shared space: Negotiating sites of

- (un)sustainable mobility. *Geoforum*, 127, 283–292.
<https://doi.org/10.1016/j.geoforum.2021.11.012>
- Chen, Y., Zheng, N., & Vu, H. L. (2021). A novel urban congestion pricing scheme considering travel cost perception and level of service. *Transportation Research Part C: Emerging Technologies*, 125, 103042.
<https://doi.org/10.1016/j.trc.2021.103042>
- Clements, L. M., Kockelman, K. M., & Alexander, W. (2021). Technologies for congestion pricing. *Research in Transportation Economics*, 90, 100863.
<https://doi.org/10.1016/j.retrec.2020.100863>
- Fournier, N. (2021). Hybrid pedestrian and transit priority zoning policies in an urban street network: Evaluating network traffic flow impacts with analytical approximation. *Transportation Research Part A: Policy and Practice*, 152, 254–274.
<https://doi.org/10.1016/j.tra.2021.08.009>
- Gargiulo, C., & Sgambati, S. (2022). Active mobility in historical centres: Towards an accessible and competitive city. *Transportation Research Procedia*, 60, 552–559.
<https://doi.org/10.1016/j.trpro.2021.12.071>
- Hagen, O. H., & Tennøy, A. (2021). Street-space reallocation in the Oslo city center: Adaptations, effects, and consequences. *Transportation Research Part D: Transport and Environment*, 97, 102944.
<https://doi.org/10.1016/j.trd.2021.102944>
- Hu, H.-B., Hou, Z.-H., Huang, C.-H., LaMonte, M. J., Wang, M., & Lu, B. (2022). Associations of exposure to residential green space and neighborhood walkability with coronary atherosclerosis in Chinese adults. *Environmental Pollution*, 292, 118347.
<https://doi.org/10.1016/j.envpol.2021.118347>
- McAndrews, C., & Marcus, J. (2015). The politics of collective public participation in transportation decision-making. *Transportation Research Part A: Policy and Practice*, 78, 537–550.
<https://doi.org/10.1016/j.tra.2015.06.014>
- Nguyen, T., Gao, W., Zhong, X., & Agarwal, S. (2021). Reinforcement Learning and Adaptive Optimal Control of Congestion Pricing. *IFAC-PapersOnLine*, 54(2), 221–226.
<https://doi.org/10.1016/j.ifacol.2021.06.026>
- Santé, I., Tubío, J. M., & Miranda, D. (2020). Public participation in defining landscape planning scenarios and landscape quality objectives (LQO): Landscape Guidelines for Galicia (NW Spain) case study. *Land Use Policy*, 94, 104559.
<https://doi.org/10.1016/j.landusepol.2020.104559>
- Sun, S., & Yu, Y. (2021). Dimension and formation of placeness of commercial public space in city center: A case study of Deji Plaza in Nanjing. *Frontiers of Architectural Research*, 10(2), 229–239.
<https://doi.org/10.1016/j.foar.2020.08.001>
- Takayama, Y. (2020). Who gains and who loses from congestion pricing in a monocentric city with a bottleneck? *Economics of Transportation*, 24, 100189.
<https://doi.org/10.1016/j.ecotra.2020.100189>
- Verhoef, E. T. (2020). Optimal congestion pricing with diverging long-run and short-run scheduling preferences. *Transportation Research Part B: Methodological*, 134, 191–209.
<https://doi.org/10.1016/j.trb.2020.02.009>
- Xiao, Y., Miao, S., Zhang, Y., Xie, B., & Wu, W. (2022). Exploring the associations between neighborhood greenness and level of physical activity of older adults in shanghai. *Journal of Transport & Health*, 24, 101312.
<https://doi.org/10.1016/j.jth.2021.101312>
- Yu, W., Suh, D., Song, S., Jiao, B., Zhang, L., & Muennig, P. (2019). The cost-effectiveness of competing congestion pricing plans in New York city. *Journal of Transport & Health*, 14, 100586.
<https://doi.org/10.1016/j.jth.2019.100586>
- Zhang, L., Yuan, J., Gao, X., & Jiang, D. (2021). Public transportation development decision-making under public participation: A large-scale group decision-making method based on fuzzy preference relations. *Technological Forecasting and Social Change*, 172, 121020.
<https://doi.org/10.1016/j.techfore.2021.121020>
- Zhong, T., Young, R. K., Lowry, M., & Rutherford, G. S. (2008). A model for public involvement in transportation improvement programming using participatory Geographic Information Systems. *Computers, Environment and Urban Systems*, 32(2), 123–133.
<https://doi.org/10.1016/j.compenvurbsys.2007.08.010>