A Decision Support System for Placing Shared E-Scooters: A Case Study for Istanbul

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A smart and sustainable city should be an innovative city that uses information and communication technologies to improve the quality of life via its operations. They need to be planned, managed, and regulated by open data collected through different data sources to provide efficient services. Transportation services can be accepted as one of the essential services of a city. In smart cities, intelligent transportation systems help to solve problems such as traffic congestion or the amount of fuel spent in traffic by providing communication between vehicles and devices that build the whole transportation network. In order to achieve the success of intelligent transportation systems, transportation methods should be planned dynamically according to the collected data and the requirements of the city's transportation network. E-scooters are also a part of the transportation system, and since 2017, shared e-scooter systems have been used as a transportation alternative in some cities. However, e-scooters are placed in random locations in cities without relying on a precise algorithm. Thus, users in some locations cannot benefit from the e-scooter sharing system efficiently due to the lack of e-scooter in neighborhoods. In this study, a decision support system for e-scooter sharing systems is suggested, which helps to place e-scooters dynamically in areas that are needed in the city. This system is intended to offer select options by combining the traffic density information of the regions and alternative region data provided by the multi-criteria analysis made using the Analytical Hierarchy Process (AHP) with real-time social media data.

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Keywords: Analytic Hierarchy Process, Decision Support Systems, Shared E-Scooter Systems, Smart and Sustainable Cities, Social Media.

Paylaşımlı E-Scooter Yerleştirmeye Yönelik Bir Karar Destek Sistemi: İstanbul İçin Vaka Çalışması

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Akıllı ve sürdürülebilir bir şehir, sakinlerinin yaşam kalitesini iyileştirmek için bilgi ve iletişim teknolojilerini kullanan, sağladığı hizmetlerde yenilikçi bir şehirdir. Bu şehirler, etkili hizmetler sunabilmek için çeşitli kaynaklardan toplanan açık verilerin kullanılmasıyla geliştirilmeli, yönetilmeli ve kontrol edilmelidir. Ulaşım, kente önemli veriler sağlayan temel hizmetlerinden biridir. Akıllı şehirlerdeki akıllı ulaşım sistemleri, ulaşım ağını oluşturan araç ve cihazların birbirleriyle etkileşime girmesini sağlayarak trafik sıkışıklığı, trafikte tüketilen yakıt miktarı gibi sorunların çözülmesine yardımcı olmaktadır. Ulaşım İstanbul'un önemli sorunlarından biridir ve bu nedenle örnek bir çalışma modeli olarak İstanbul şehri seçilmiştir. Kentlerde sürdürülebilir hareket kabiliyeti, ulaşım temelli problemler için uygun bir çözüm olarak görülmektedir. Elektrikli araçlar da düşük maliyetli ve sürdürülebilir ulaşım yöntemleridir. 2017'den bu yana e-scooter araçlarının da ulaşım sisteminin bir parçası olduğu görülmekte ve birçok şehir ulaşım alternatifi olarak paylaşımlı e-scooter sistemlerini kullanmaktadır. Ancak, e-scooter araçları şehirde rastgele yerlere yerleştirilmekte, yerleşim kararlarında herhangi bir algoritma kullanılmamaktadır. Buna bağlı olarak bazı bölgelerdeki kullanıcılar, bulundukları çevrede e-scooter olmaması nedeniyle paylaşım sisteminden tam olarak yararlanamamaktadır. Sosyal medya, çeşitli karar destek sistemlerinde yararlanılmak üzere değerli bilgiler toplayan yeni araçlardan biridir. Bu çalışmada sosyal medya ağlarından konum etiketlerini gerçek zamanlı toplayarak, Google Haritalar'dan sağlanan araç ve yaya trafiği bilgilerini Analitik Hiyerarşi Yöntemi (AHP) ile belirlenen İstanbul'daki bölge alternatifleriyle birleştiren prototip bir sistem geliştirilmiştir. Böylelikle e-scooter araçlarının konumlandırılma seçenekleri trafik uygulamalarından ve sosyal medyadan gelen verilere göre değişmekte ve oluşturan prototip e-scooter araçlarının şehir içinde ihtiyaç olduğu yerlere zamanında yerleştirilmesine yardımcı olmaktadır.

Anahtar Kelimeler: Akıllı ve Sürdürülebilir Şehirler, Analitik Hiyerarşi Yöntemi, Karar Destek Sistemleri, Paylaşımlı E-Scooter Sistemleri, Sosyal Medya.

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1. INTRODUCTION

As we move from the information age to the digital age, the possibilities of data usage may reshape the decision support systems. Social media is one of the new tools that collects valuable information like geolocation data to be used in various decision support systems for different industries. The location tags that are used in location-based social networks like Instagram and Twitter can have an impact on the studies related to urban design and planning, and also city management. In this study, we present an electric scooter deployment model which can be beneficial for city management agencies to reduce traffic congestion and travel time with the use of real-time data from social media in urban areas with heavy pedestrian and vehicle traffic. Therefore, Istanbul is chosen as a case study to test our proposed model since it is one of the cities with dense population and traffic problems.

Sustainable urban mobility is a feasible solution for future smart cities. Electric scooters, as one of the sustainable transportation alternatives, are cost-effective and acknowledged as a feasible solution in dense metropolitan areas with the use of GPS technology and smartphone (Hosseinzadeh, Algomaiah, Kluger, and Li, 2021). They can reduce the usage of private automobiles, fit easily into small and narrow streets, and help to alleviate parking issues in cities. The use of shared e-scooters is also a novel mode of transportation, particularly among young people (Laa and Leth, 2020).

In the scope of this study, an online survey is conducted to evaluate the possible usage of the e-scooter sharing system in Istanbul in order to provide preliminary data on potential regions for e-scooter placement. However, each region may face different challenges throughout the day, such as traffic density and topographical aspects that may limit the use of e-scooters. As a result, multiple factors must be evaluated to determine shared e-scooter areas, which can be confusing and time intensive for city management. As a result, this study recommends using the Analytical Hierarchy Process (AHP) approach to weigh and rank these location selection factors.

The Analytical Hierarchy Process (AHP), developed by Saaty in 1977, is a multi-criteria decision-making method that allows for the comparison of a large number of alternatives using specified criteria in accordance with a specific purpose, and is widely used by decision makers in solving complex problems (Saaty, 1987). For our case study, a decision hierarchy is built for setting the priorities for e-scooter mobility in an urban environment. SuperDecisions, which is an open-source decision support software that implements the AHP, is used to evaluate decision processes in this study. The methodology is then used to create a prototype for an application that collects pedestrian and vehicle traffic information from several districts in real-time using online maps and location tags from social networks. All traffic data is gathered from Google Maps transactions and cross-checked with the results of an online survey. The short-distance routes with the high pedestrian and vehicle traffic in the city are categorized in the decision process. In that way, the location alternatives to place e-scooters will be changing according to data coming from traffic information applications and social media. We assume that this system will offer the best locations for e-scooter placement and use. Additionally, the proposed approach can reduce commuting time in dense areas while contributing to the reduction of environmental footprint.

2. LITERATURE REVIEW

There have been studies on electric vehicles since the 1800s. Nevertheless, electrical vehicle usage has only been started in the 2000s as a result of the increase in fuel prices and environmental awareness (Situ, 2009; Vynakov, Savolova, and Skrynnyk, 2016; Salmeron-Manzano and Manzano-Agugliaro, 2018). Although it is not certain which company produced the first electric scooter for commercial use, it is claimed that the electric scooters started to be sold in the early 2000s (Razor, 2021).

Vehicle sharing systems have been used in various countries since the 1950s to reach the city center and transportation network from remote areas by car or to save fuel in and around the city. In the 1990s, due to the increase of the population and vehicle density in the cities, car-sharing systems started to be noticed and popularized as a solution to traffic and environmental pollution problems (Shaheen, Sperling, & Wagner, 1998). The first bicycle sharing system was implemented in 1965 in Amsterdam (Shaheen & Guzman, 2011). However, the program has been terminated since most of the bikes were damaged or stolen. Then in Copenhagen, this system was developed and re-applied in 1995 by using the deposit method (European Best Practices in Bike Sharing Systems Report, 2009). Nonetheless, it did not prevent the bike thieves. With the development of communication technologies and personal electronic devices, the use of vehicle sharing systems has been improved, and these enhanced systems are started to be used in bicycle sharing systems, too. GPS and remote locking systems installed on electric bikes stopped the theft of bicycles. Thus, bicycle-sharing systems began to become widespread in the 2000s. According to the research conducted by Plazier, Weitkamp, and van den Berg (2017) e-bike users are seeking for faster rides, simple use, comfortable bike riding experience with electrical power assistance, and freedom from the time schedules of public transit (Kazemzadeh & Ronchi, 2021). Beside these parameters, people may prefer e-bikes in daily use compared to traditional bikes since they do not cause joint pain, sweat, and fatigue of the user.

Following the e-bike sharing systems, electric scooter sharing systems have been implemented in recent years. It is said that the main reasons to prefer electric scooters over electric bikes are the lower maintenance costs and the size of the area they occupy for parking and storage (Tuncer & Brown, 2020; Unagi Scooters, 2020). They can also be preferred by users who have joint problems, different health problems, physical differences, or they can be preferred just because of the characteristics of the users' clothes. Because e-scooter riding does not make users sweat like bike riding, people can ride in business attires comfortably (Tuncer & Brown, 2020). Since 2017, companies such as Bird, Lime, Bolt, and Lyft have been running in many countries (Dickey, 2018). Top cities in Europe that actively use the e-scooter sharing system as of 2021 include Paris, Madrid, Berlin, and Stockholm (Electric Scooter Sharing Market in US and Europe 2021-2026, 2020).

E-Scooter sharing systems are thought to be ideal for short trips due to their advantages over other public vehicles. These advantages can be listed as follows (DeMaio, 2003; Hardt & Bogenberger, 2019).

• It provides private transportation;
• It reaches to the points that most public vehicles cannot reach;
• It requires less infrastructure than other transportation methods;
• Production and maintenance costs are low in comparison to other means of transportation;
• It does not generate traffic jams;
• It does not cause air pollution while operating;
• It reduces personal bicycle and scooter theft.

According to the survey conducted by the US Department of Energy in 2017, the share of vehicle trips by distance was calculated, and it is found out that 60% of the total vehicle density consists of the cars traveling less than 10 km (**Figure 1**). These results support the idea of the implementation of the e-scooter sharing system at short distances, which will have an impact on reducing traffic density. Also, another study in 2016 shows that the use of e-scooters is expected to increase significantly by 2025 compared to other electric vehicles (**Figure 2**).

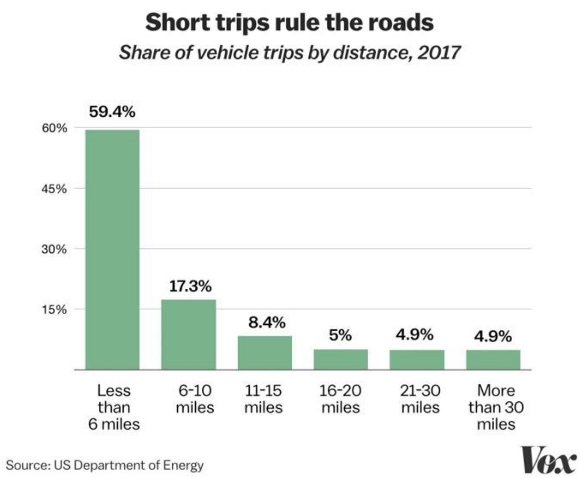

Figure 1: Share of vehicle trips by distance (Irfan, 2018).

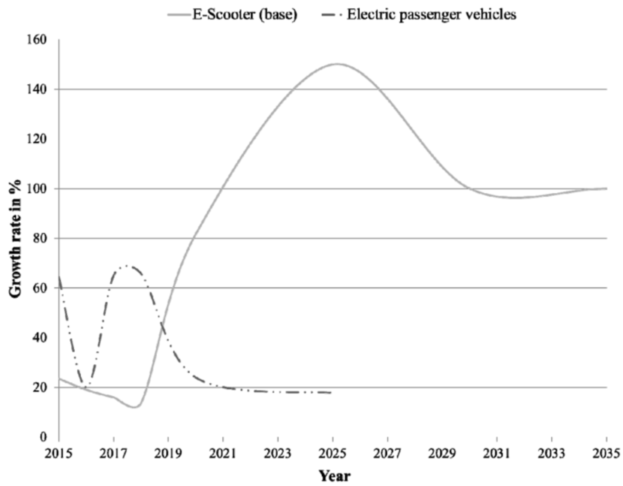

Figure 2: The Estimated growth rate of e-scooter usage over other electric vehicles by years (Sachs, Burandt, Mandelj, and Mutter, 2016).

In Istanbul, the bicycle sharing system "İsbike" which has been launched by Istanbul Metropolitan Municipality in 2009, has been used in various districts. According to the data published on their official website, as of 2021, 2700 bicycles are used in 261 stations in total (İSPARK). The electric bike-sharing system in İstanbul was first used in the Bogazici University campus as a result of a pilot study conducted in the same university in 2018 (Çevreciyiz, 2017). In 2019, it was claimed that a total of 250 bicycles are used actively in all campuses of Bogazici University in Istanbul, Maslak Campus of Istanbul Technical University, and Yildiz Campus of Yildiz Technical University. However, as of 2021, the company does not provide electric bike service but the traditional bike and e-scooter sharing (Bizero). Despite the fact that research on vehicle sharing systems has grown in popularity in recent years, there have been few studies on e-scooter sharing systems and very few initiatives in Turkey. Nevertheless, an initiative started in March 2019 under the name of "Martı" in Istanbul. The company "Martı", which says that they support micro-mobility in cities, is currently active in some regions of Istanbul. Around the same time as Martı, two other shared e-scooter startups named Mobi and Palm were established in Istanbul. Palm E-scooters first appeared on university campuses in 2019, but now in 2021, they are available not on university campuses but also in some regions of Istanbul and Mersin. From 2020, Mobi is also available in some areas of Istanbul. However, right now, Martı is currently active in the majority of locations in Istanbul. Hop! is another company that started in Ankara but is also available in other cities of Turkey and some regions of Istanbul on the Anatolian side.

When we look at studies on the e-scooter sharing system in the world, we find studies mostly on e-scooters' technical features, charging stations, or safety issues (Bishop et al., 2011; Seebauer, 2015; Nocerino et al., 2016; Chen et al., 2018; Genikomsakis et al., 2018; Degele et al., 2018; Allem & Majmundar, 2019). However, there have not been found any studies related to the operations on distribution through different locations of dockless e-scooters in a city. With the development of autonomous systems, it is thought that e-scooters will be able to move automatically and return to charging stations in the coming years (Dickey, 2019). For this reason, e-scooters' movements and locations during the day will be valuable in terms of reaching the places where the people need them. In this study, a decision support system that provides real-time location options is proposed following the criteria determined by the AHP method with the location and traffic densities information provided from social media and map applications during the day. When the demographic characteristics of the users of e-scooter sharing systems are examined, it is seen that the users are mostly between the ages of 18-34 (Huddleston, 2018). This data intersects with the age range of social media users in the world by Statista (Distribution of Instagram users worldwide as of April 2021, by age group) For this reason, it is foreseen that active social media users may prefer the e-scooter sharing system, and e-scooters are expected to offer the options according to these users` popular routes within the city.

3. METHODOLOGY

In this study, a multiple-stage method is used to establish a system to assist in the determination of e-scooter locations (Figure 3). We developed a multi-criteria system in the SuperDecisions program by using the AHP method since these settlements cannot be determined precisely, and the determination of these points is a complex decision problem. AHP method aims to select alternatives, in a process that considers different criteria of evaluation.

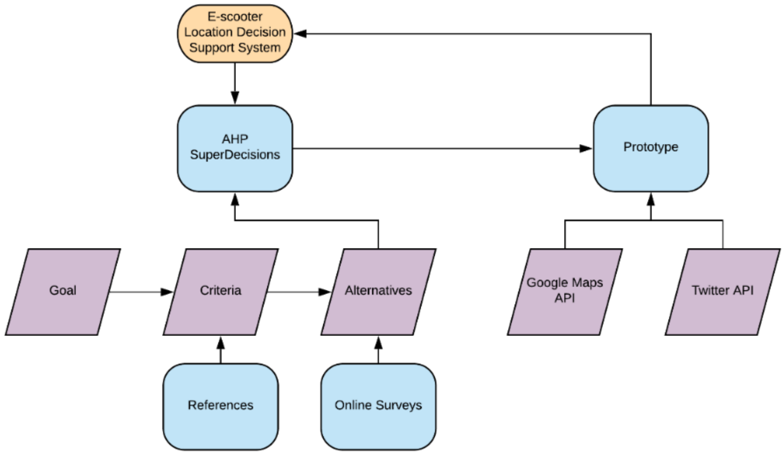

Figure 3: Flow diagram of the system.

In order to implement AHP Sensitivity Analysis in the SuperDecisions program, it is necessary to create three clusters: a goal, the criteria for achieving this goal, and alternatives to be evaluated in line with these criteria. After these clusters are formed, the links between them will be established, and the weights of the alternatives will be evaluated according to the criteria determined in the direction of reaching the goal (**Figure 4**). Thus, in the first phase of the study, it is necessary to decide on the criteria that e-scooter locations must meet for AHP Sensitivity Analysis and suitable regional alternatives for e-scooter placement. Our criteria are based on existing e-scooter firms' research and reports, city governments' studies, and shared e-scooter studies. (City of Chicago, 2021; Zhang & Guo, 2020; Tuncer & Brown, 2020; Lime, 2020; Hardt and Bogenberger, 2019; City of Portland Bureau of Transportation, 2019; Degele et. al., 2018; Bishop et. al., 2011). Local options are created based on the findings of an online survey conducted for this study (İstanbul'daki Ayak İzleri, 2021).

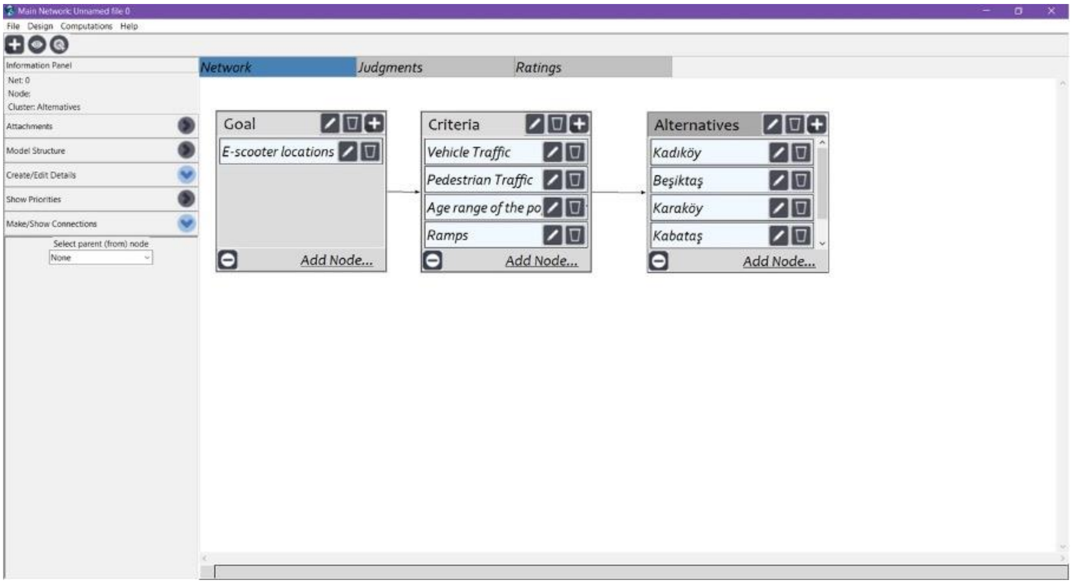

Figure 4: Network of the study in SuperDecisions.

In the second phase of the study, the traffic layer, including pedestrian and vehicle density, is integrated into the Ruby on Rails system using the Google Maps JavaScript API. In this way, a customizable real-time map of the desired region connected to Google data is created. Then, the data obtained in the first stage is transferred to Microsoft Excel, and the data list with a CSV extension is created and uploaded to the map. These data can be displayed on the map as static marked points. In the last stage, the Twitter API is linked to the system, and popular area and place names in Istanbul are filtered from tweets to the developed system's real-time data flow. Thus, a real-time decision support system is created to help identify e-scooter location alternatives based on more than one factor. This system is developed as a prototype for the chosen city.

4. REAL-TIME E-SCOOTER LOCATION RECOMMENDATION SYSTEM

4.1 Data Collection

In the first phase of the study, data needed for the SuperDecisions program was obtained from the online questionnaire answered by 164 residents of Istanbul. Most of the participants are in the 18-36 age group, which is expected to prefer using e-scooters (**Figure 5**).

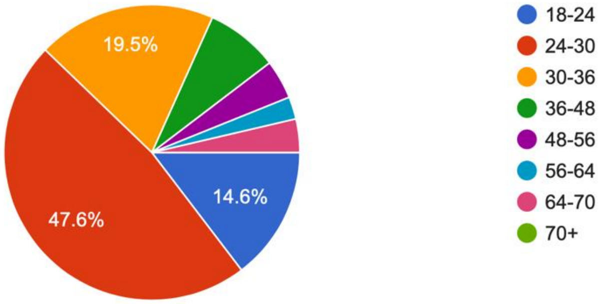

Figure 5: Age range of the survey respondents.

An online survey was conducted and seven questions were asked to the participants. In the first two questions, the age information of the participants and the district of their residence were asked. According to the survey results, the majority of participants live in the districts Kadıköy, Şişli, Beşiktaş, Sarıyer, and Maltepe (**Figure 6**).

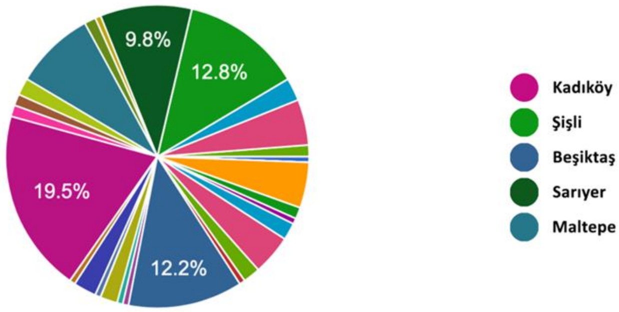

Figure 6: The districts where the survey respondents are living in the city.

In the third question, participants were asked to choose the district or districts which they regularly visit to go to work or school. As a result, Beyoğlu (35.4%), Beşiktaş (31.7%), Kadıköy (24.4%), and Şişli (23.2%) appear to be the most chosen four districts. Following these first four highest rates, 14.6% of the participants marked the option of saying they travel within the district where they live. In the fourth question, we asked participants to mark the transfer stations they use while traveling to work or school. Accordingly, 43.5% of the participants stated that they did not transfer during their daily travel. Nevertheless, the most frequently used transfer stations are as follows: Beşiktaş (19%), Kadıköy (17%), Yenikapı (16.3%), Ayrılık Cesmesi (12.2%) and Taksim (9.5%). When the participants were asked if there were long walking distances at the transfer stations they use, the majority responded as "sometimes" and "yes" (65%). As a result of these questions, we obtained the data on the daily routes of the participants, especially on weekdays.

In the next part of the questionnaire, participants were asked to select the districts they frequently visit for activity, sightseeing, or shopping. In this way, we collected the data on the regular routes of the participants, mostly during weekends. Accordingly, Beşiktaş (68.3%), Kadıköy (67.1%) and Beyoğlu (41.5%) are the first three with a superior advantage over other regions.

Finally, since we foresee that the locations people enjoy walking will be the locations, they will not prefer using e-scooters, we asked participants to mark the place or places where they enjoy walking. Accordingly, the most preferred areas for walking are the following: Kadıköy Moda (37.8%), Caddebostan Sahil (32.9%), Bebek (22%), Bağdat Street (21.3) and Kadıköy Bahariye Street (20.7%).

As a result of the survey, nine alternative regions were obtained for processing in The SuperDecisions program. These alternative regions are Kadıköy, Şişli, Beşiktaş, Sarıyer, and Maltepe, where the participants mostly reside; Beyoğlu, one of the regions frequently visited by participants; Yenikapı, Ayrılık Çeşmesi, and Taksim, where the participants use transfer stations mostly. In case one of these nine alternative regions enclose any regions that are preferred for walking, these areas are marked separately. So, the system we develop will not offer any e-scooter placement for these locations.

4.2 Determination of Regional Alternatives with the AHP Method

In order to implement AHP Sensitivity Analysis in the SuperDecisions program, it is necessary to create a goal, the criteria for achieving this goal and alternatives to be evaluated in line with these criteria. After these clusters are formed, the links between them are established, and the weights of the alternatives are evaluated according to the criteria determined in the direction of reaching the goal. Within the scope of the project, the goal has been determined as the locations for e-scooter placements (Figure 7).

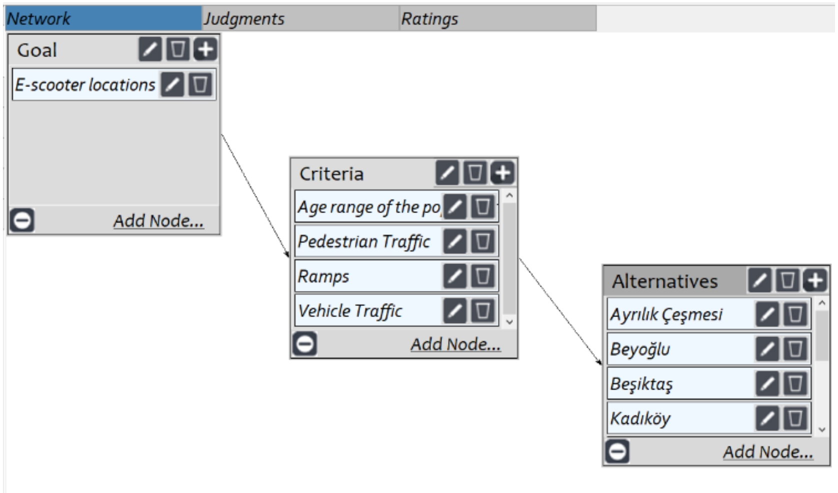

Figure 7: The project model in SuperDecisions.

The SuperDecisions program generates weights between 0 and 1 according to the data entered for each alternative. Four criteria with varying weights are chosen for the criterion cluster based on usage reports from e-scooter firms, governments, and related studies. These are vehicle traffic density (0.35), uphill rate (0.30), young age population ratio of the region residents (0.20), and pedestrian traffic density (0.15). The effects of different criteria priorities on the results can be observed by changing the weights in AHP sensitivity analysis. In the alternatives section, nine region alternatives retrieved from the online surveys are entered. Within the program, these three sections were connected, and weight values were entered also for alternative regions according to the data from the online surveys and traffic density data from Google Maps. As a result of the comparison of all weights coming from the criteria section, we have the total weights for the nine alternative regions. The SuperDecisions program creates weights between the alternatives according to the data entered for each alternative (**Figure 8**). After the AHP analysis is completed, which alternatives weigh more in different scenarios can be seen in **Figure 9**.

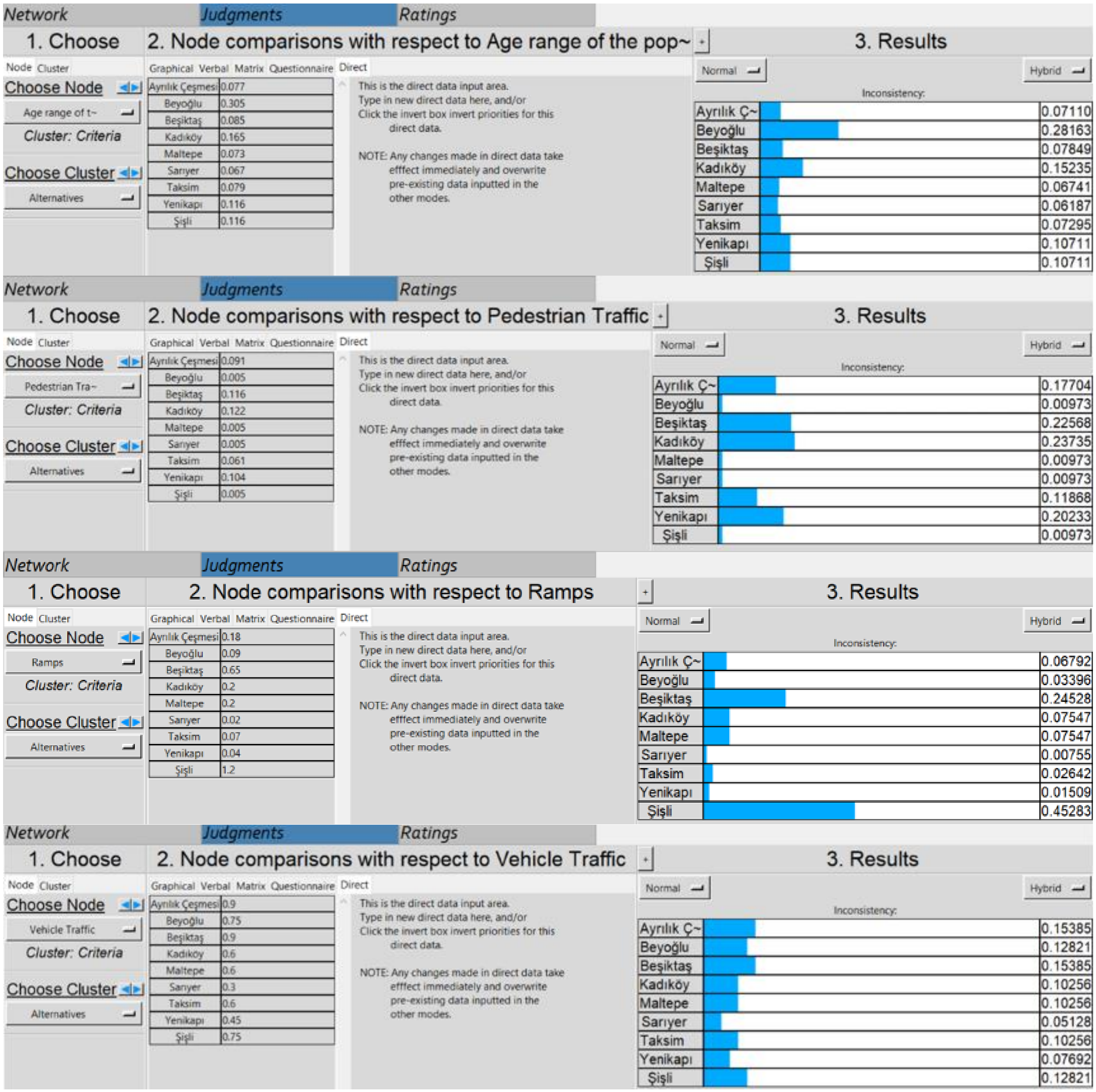

Figure 8: The survey results on the age range, transfer stations, altitude difference in the 1km route for each district, and average traffic density for each district at different times of the week.

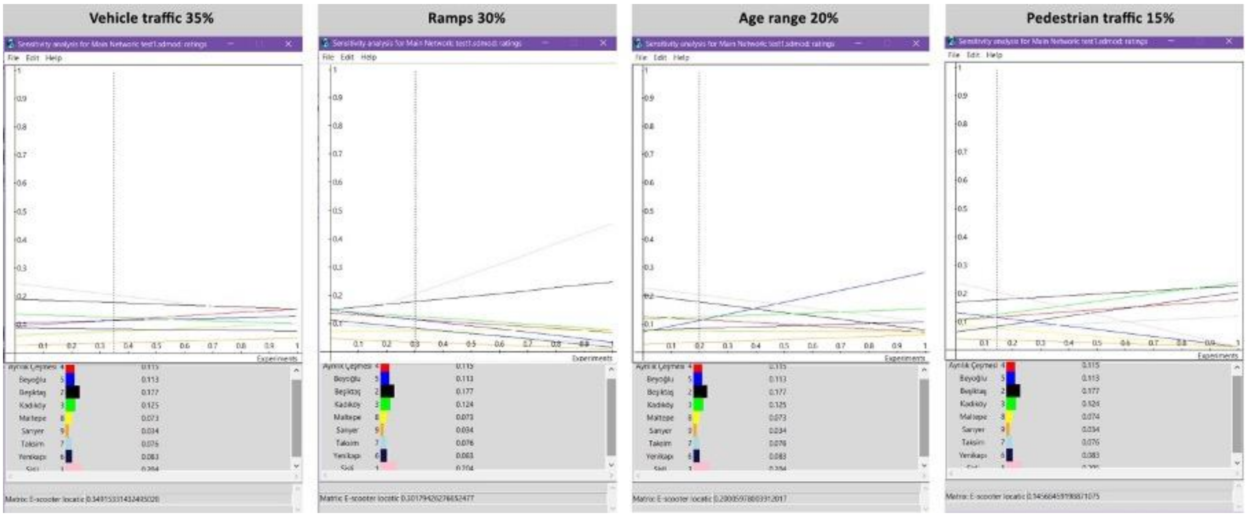

Figure 9: Different scenarios in AHP analysis.

Now, we have the regional alternatives, the data is ready to be processed in the decision support system that is developed to show e-scooter placement suggestions to the user. As a result of the analysis, the weight order of the regions is as follows: Şişli, Beşiktaş, Kadıköy, Ayrılık Çeşmesi, Beyoğlu, Yenikapı, Taksim, Maltepe, Sarıyer.

4.3 Developing a Decision Support System Using Google Maps and Social Media

In the second phase of the study, a software prototype has been developed which provides real-time data flow to determine the areas to place e-scooters (**Figure 10**). Since this software is intended to pull data from social media in real-time, it has been decided to be run on the internet. Considering the Twitter API is available for use among social media platforms, Twitter is chosen as the primary platform for the prototype. Moreover, because Twitter is working on Ruby on Rails application template, the prototype was also developed to work on the same template.

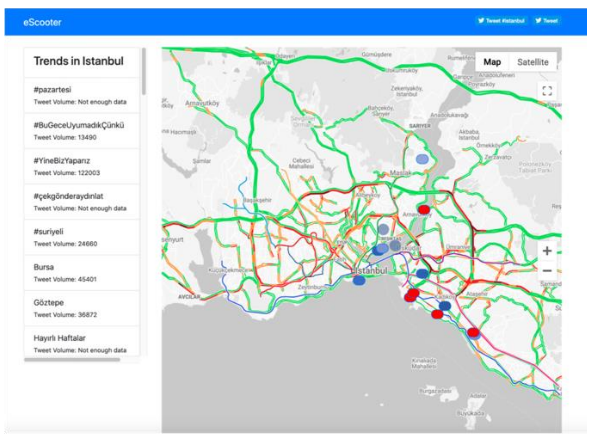

Figure 10: The interface of the prototype.

In order to connect Google API to the Ruby on Rails system, a Ruby library called “gmaps gem”, was used first. However, since the “gmaps gem” is not up to date, and the Google Maps layers cannot be appropriately used, this gem is not used for the prototype. After that, “node.js” JavaScript library, where the most examples are created for Google Maps, has been selected to use for this project. In order to link this library to the Ruby on Rails template, “webpacker” gem is used. Afterward, “React”, a JavaScript library, is installed on node.js to develop the prototype’s interface. In the end, the “Bootstrap” interface library for React is used for user interaction.

After the system template and interface of the prototype are established, the Google Maps React library is connected, and the coordinate information of the Istanbul province is entered into the system. Thus, a map image showing the province of Istanbul is created in the interface. Then, the region alternatives from AHP analysis in The SuperDecisions program are entered into the map as “markers”. Moreover, interactive round marks are added using the Bootstrap library. Information boxes are created using the “Tooltip” interface element so that users can get information about the region when they click on these signs. The traffic layer is activated from the Google Maps React library to show real-time traffic information about Istanbul on the map.

The Twitter gem has been linked to the prototype draft to include social media data in the system. In order to connect this gem, "private API secret" and "key" are created from the Twitter developer account and added to the prototype. "GET geo / reverse_geocode" and "GET geo / search" APIs have been studied to get information about the regions in the chosen city. However, it has been observed that these APIs only provide geographic information about the location. Therefore, "hashtag" density information about the regions is tried to be connected. However, since Twitter provides this information only to companies, it could not be used within the scope of this research project. Finally, the "GET trends / place" API, which finds trends according to the locations on Twitter, is connected to the prototype. Within this API, hashtag data by districts is currently not available in the case study location, but only data by cities is provided. For this reason, trends in the case study location are added to the prototype as a placeholder to show further development possibilities.

5. ANALYSIS

Within the scope of this research, it is aimed to develop a decision support system that provides options for placing e-scooters in the dense regions where they are needed.

The blue circles in **Figure 11** show the most likely areas to place e-scooters in the case study location. The intensity of the color indicates the ranking of the districts as the result of the AHP analysis (**Figure 11**). This helps users to recognize the most convenient areas at a glance. Also, the red circles show the walking paths that are mostly preferred by the residents (**Figure 11**). So, it is unlikely that e-scooters will be used in those areas. The map in the interface is displayed in grayscale to have a contrast between the data and the background. The colors of the map can be changed any time via the Google Maps API regarding the requests of users.

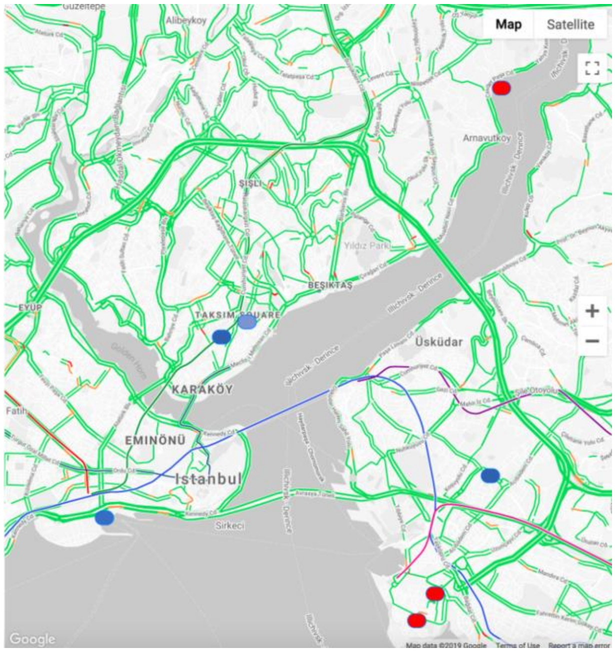

Figure 11: The blue and red circles on the map.

Real-time traffic information displayed on the map also helps users to compare the district alternatives in terms of traffic density. The prototype shows these regions as marked on the map interface, but they are not dynamic. The nine alternative regions from AHP analysis are entered into the system manually. Therefore, in future work, integration of the AHP analysis from the SuperDecisions program to our proposed model might accomplish a real-time decision support system with regional data. Within the scope of smart city studies, this system should be developed with an algorithm that changes according to the dynamics of the city.

Currently, the prototype works with Twitter data. In order to use social media data effectively, other social media platforms such as Facebook and Instagram, as well as Twitter, can be included in the future. If more social media platforms are integrated into the system, they can provide instant data flow according to popular events in the regions on a daily and hourly basis. Thus, the location options for e-scooters can be improved according to this data. Popular hashtags in Istanbul are shown next to the map in real-time. In this way, ongoing events or important news that may affect transportation in the city can be seen. This prototype should be considered as the first step for a smart system that can suggest real-time e-scooter placement options.

6. CONCLUSION

The use of technological facilities and interactive feedback mechanisms can provide better solutions to the problems of the cities. This study aims to support the use of e-scooter sharing systems in order to ease transportation in cities with high pedestrian and vehicle traffic and to make use of e-scooters at the ideal level by solving the random e-scooter placement problem. The developed system collects and presents various data in a single interface to help users determine e-scooter locations.

This paper proposes the use of the AHP method for application in the smart and sustainable city context. Thus, a decision hierarchy is built for setting the priorities for e-scooter mobility in an urban environment. Then, a prototype is developed to collect traffic information from different districts and trending locations from social media platforms in real-time. All data is made available to the user on a single interface to support the decision process.

This study may have potential for diverse industries, from urban planning studies to industrial management operations. It is evident that with rapidly developing technologies, smart cities can benefit from interdisciplinary studies. This integrated solution created from social media data and GPS data with the AHP method may be a trigger for further research to go beyond the traditional techniques and discover innovative approaches for better and livable cities.

The recent global pandemics also affected public transportation in the cities. In the post-pandemic world, city dwellers may seek out other forms of transportation that require less encounters with strangers, given continued concerns about the disease and social distancing.

In the near future, it is possible that e-scooters will become autonomous and will be able to move to different places by themselves. In this case, the developed system can connect with e-scooters via Internet-of-Things (IoT) systems remotely and provide the information for e-scooters to move to the regions where they are needed. For this reason, e-scooters' movements and locations during the day will be valuable in terms of reaching the places where the people need them. The proposed framework of the prototype is ready with all API connected to the map system, and the prototype is available to be reviewed via the link http://82np.hatchboxapp.com/.

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