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Aksaray İli'nde Araç Türüne Göre Dağılım ve Gelecek Tahminleri: İstatistiksel Bir Çalışma

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ÖZ

Bu çalışma nüfus olarak günden güne kalabalıklaşan Aksaray ili için 2014-2024 yılları arasındaki yıllık araç türlerine ait sayılar veri olarak kullanılarak, Doğrusal regresyon analizi yöntemi ile araç türlerine ait büyüme miktarları analiz edilerek, gelecek yıllara yönelik tahminler sunmaktadır. Sonuçlar, Aksaray'da trafik sıkışıklığının artacağını ve yerel ulaşım altyapısının gelecekteki talepleri karşılamak için önemli yatırımlara ihtiyaç duyulacağını göstermektedir. Bu çalışma, beklenen büyüme modelleri ve kentsel planlama ile trafik yönetiminin önümüzdeki yıllarda karşılaşacağı zorluklar hakkında değerli bilgiler sunmaktadır.

Vehicle Distribution by Type in Aksaray Province and Future Predictions: A Statistical Study

Research Article

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ABSTRACT

This study provides estimates for the upcoming years by using the annual vehicle types between 2014-2024 as data for the increasingly crowded Aksaray province, and by analyzing the growth rates of vehicle types with the linear regression analysis method. The results show that traffic congestion will increase in Aksaray and that significant investments will be needed in the local transportation infrastructure to meet future demands. This study provides valuable information about the expected growth patterns and the challenges that urban planning and traffic management will face in the coming years.

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1. Introduction

Transportation is rapidly shaping up as one of the biggest environmental problems of the future. Road traffic is known as the fastest growing source of greenhouse gases. Road construction is one of the biggest causes of wildlife habitat destruction, and both traffic and new roads are causing increased general trespass and problems in the local environment. However, the policies behind these problems are not very solution-oriented. Transportation directly affects people's lives, and pressure for policy change is increasing day by day due to the public's perception of a 'transportation crisis'. In addition to solving transportation problems, this situation also creates the opportunity to propose more environmentally sustainable transportation policies.

Increasing population density around the world has brought about increased vehicle traffic. Due to rising population density, traffic on the roads has increased significantly in the last 20 years, especially in the USA and other countries (Schrank and Lomax, 2007).

Problems in the urban transportation system caused by the increasing number of vehicles in traffic are a common problem in most cities. Especially the city center, long-term problems can be seen in city traffic due to many reasons such as incorrect parking, density of pedestrians and vehicles, lack of good infrastructure of the roads used by vehicles, poor signaling system, and the behavior of vehicle owners in traffic (Çinicioğlu et al., 2013). The increasing number of vehicles in traffic causes many difficulties and problems that affect various aspects of urban life, the environment and general transportation systems. Some key problems with the increasing number of vehicles are:

1. Traffic congestion: As the number of vehicles on the roads increases, traffic congestion becomes an important problem. This causes travel times to increase, fuel consumption to increase and frustration among drivers.
2. Air pollution: The increase in the number of vehicles causes air pollution to increase. Exhaust emissions release pollutants such as carbon monoxide, nitrogen oxides and particulate matter, which can have harmful effects on air quality and public health (KGM, 2008).
3. Environmental Impact: Increased vehicle use contributes to environmental degradation, including habitat loss, deforestation, and increased greenhouse gas emissions. This situation exacerbates climate change and negatively affects ecosystems.
4. Infrastructure Imperative: The increasing number of vehicles may strain the existing transportation infrastructure. Roads, bridges and public transportation systems may become inadequate to meet increasing demand, resulting in maintenance difficulties and the need for costly expansions.
5. Accident Rates: Higher traffic volumes are generally associated with an increased likelihood of accidents. As more vehicles share the road, the risk of collisions and road deaths increases, potentially leading to a greater burden on healthcare systems.
6. Decrease in Quality of Life: Traffic congestion and increased noise levels from vehicular traffic can reduce the overall quality of life in urban areas. Residents may experience stress, decreased mobility, and a decrease in overall well-being.
7. Dependence on Fossil Fuels: The majority of vehicles are still dependent on fossil fuels, contributing to the depletion of non-renewable resources and the release of pollutants. Transitioning to more sustainable and environmentally friendly transport options is crucial to reducing these problems
8. Urban Planning Challenges: Vehicle flow can create challenges for urban planners in designing and managing city spaces. Striking a balance between meeting transportation needs and maintaining livable, walkable urban environments is becoming more complex (KGM, 2013).

In recent years, private car acquisition in our country has increased. The number of private cars is increasing rapidly due to the ease of It increases in this way. Vehicle occupation areas of private cars. It is quite a lot compared to minibuses and buses. This situation causes traffic congestion in our cities.

The presence of motor vehicles in cities affects transportation dynamics significantly. Aside from the sheer number of vehicles, the modal distribution of trips is also crucial. Unfortunately, the proportion of trips made using public transportation is declining as urban transportation issues become more prevalent. Many cities are currently grappling with transportation challenges due to insufficient planning and resources.

The literature has defined five basic criteria (Knupter et al., 2018; Litman, 2021) that evaluate the primary factors influencing modal distribution preferences in transportation. These criteria are proximity, modal integration, affordability, inclusiveness, and social status. The first criterion, proximity, determines the distance between urban public spaces and homes and workplaces (Erkip, 1997). It includes the location of the workplace and home in accessibility, the starting point for accessing the squares, the access time to the square, and the time to reach the square by walking (Levinson, 1998). Modal integration refers to the seamless connection between different modes of transportation, ensuring that users can transition efficiently between public transport, cycling, and walking, thereby improving overall accessibility and convenience (Litman, 2021). Affordability is another vital factor in effective urban transportation and transportation type selection, which includes monthly disposable income for transportation and monthly transportation expenses (Knupter et al., 2018; Rivas et al., 2018). Inclusiveness ensures that transportation systems are accessible to all individuals, including those with disabilities, the elderly, and economically disadvantaged populations, by providing equal mobility opportunities (Knupter et al., 2018). Finally, social status plays a significant role in transportation preferences, as individuals may choose specific modes of transport based on perceived prestige, convenience, and societal acceptance (Litman, 2021).The transportation sector aims to eliminate interregional imbalances, support development and their complementary effects. Transportation policies can be used as a tool of economic development. Transport activities and accessibility are most important factors that determine the transportation networks and vehicles.

The study examined the types of transportation used and made future predictions. The discussion includes measures that can be taken to ensure legal balance in the future.

2. Materials and Methods

The linear regression analysis involves fitting a linear trend line to the data, which is then used to predict the number of vehicles for each category from 2025 to 2030. Excel software is utilized to calculate the regression equation and generate forecasts for each vehicle type based on historical growth patterns.

Regression analysis is a statistical technique used to examine the relationship between a dependent variable and one or more independent variables. It allows researchers to model and understand how changes in the independent variables (predictors) influence the dependent variable (outcome). The most common form is linear regression analysis, which assumes a straight-line relationship between the variables. By fitting a regression model to the data, it's possible to make predictions and quantify the strength of the relationship between the variables. Linear Regression analysis is widely used in fields like economics, engineering, and social sciences to analyze trends and forecast future outcomes. Linear Regression analysis is primarily used for predicting outcomes and understanding relationships between variables. For example, it can forecast future sales based on advertising expenditures or analyze how changes in temperature affect energy consumption. By examining historical data, regression offers valuable insights into the behavior of systems and processes, enabling decision-makers to plan more effectively. Additionally, regression helps identify which variables significantly influence outcomes, guiding improvements and optimizations across various sectors, including healthcare, business, and environmental sciences (Chatterjee et al., 2015; Freund et al., 2006; Draper, 1998).

This study analyzes vehicle type data from 2014 to 2024 and uses linear regression analysis to forecast the distribution of vehicles in Aksaray for the period 2025-2030. These predictions will assist local authorities in making informed decisions about future transportation needs. The methodology used in this study is based on linear regression analysis, which is a widely used statistical technique to forecast future trends based on historical data.

The data used in this study was obtained from two main sources: the Aksaray Provincial Traffic Directorate, which provided annual statistics on vehicle registrations categorized by type, and National Transport and Infrastructure Reports, which contained transportation trends at a national level. These national reports were used to cross-check and validate the regional trends observed in Aksaray, ensuring data accuracy. The registered vehicle types were classified into several categories: Automobiles, referring to passenger cars used for personal and commercial purposes; Light Trucks, which are commercial vehicles weighing less than 3.5 tons and mainly used for small-scale freight transport; Tractors, primarily used in agriculture and rural areas for farming operations; Motorcycles, including all two-wheeled motorized vehicles such as scooters and standard motorcycles; Trucks, which are heavy commercial vehicles used for large-scale freight transport; Minibuses, small public transport vehicles typically serving short-distance routes; Buses, larger passenger transport vehicles used for long-distance and high-capacity transit; and Special-purpose vehicles, a category encompassing ambulances, fire trucks, construction vehicles, and other specialized service vehicles. By analyzing these vehicle categories, this study provides a comprehensive understanding of the transportation landscape in Aksaray and its implications for traffic congestion and infrastructure planning.

The general formula for a linear regression model is:

$y=\beta 0+\beta 1x+\epsilon y$

Where:

- y represents the dependent variable (the number of vehicles of a specific type),
- x represents the independent variable (time, or years since the start of the study),
- β0 is the intercept of the line,

- $\beta 1$ is the slope of the line (rate of change),
- ϵ is represents the error term.

For each vehicle type (private cars, buses, trucks, motorcycles, etc.), we fit a linear regression model to historical data, where time (in years) is the independent variable, and the number of vehicles is the dependent variable. By applying this model, vehicles for each type in future years was predicted.

3. Findings and Discussion

Table 1 shows the Vehicle Count data on Aksaray province state roads between 2014 and 2024. The values are given in thousands (x1000) for ease of representation and comparison.

Table 1. Vehicle Count (between 2014 and 2024) (Source: Aksaray Municipality, Traffic Department)

Year	Vehicle Count (piece)
2014	112.500
2015	115.410
2016	118.420
2017	122.130
2018	125.040
2019	128.050
2020	131.060
2021	133.970
2022	137.680
2023	143.391
2024	152.171

The annual average daily traffic data of Aksaray province state roads is examined in Table 2, which shows the breakdown of vehicle types from 2014 to 2024. The total sum of vehicle types should match the values in Table 1 for consistency.

Table 2. Annual Average Daily Vehicle Values (between 2014 and 2024) (Source: Aksaray Municipality, Traffic Department)

Year	Automobiles (piece)	Light Trucks (piece)	Tractors (piece)	Motorcycles (piece)	Trucks (piece)	Minibuses (piece)	Buses (piece)	Special-purpose vehicles (piece)
2014	60.000	20.000	15.000	10.000	5.000	1.000	1.000	500
2015	61.500	20.500	15.200	10.500	5.100	1.050	1.050	510
2016	63.000	21.000	15.500	11.000	5.200	1.100	1.100	520
2017	65.000	21.500	16.000	11.500	5.300	1.150	1.150	530
2018	66.500	22.000	16.200	12.000	5.400	1.200	1.200	540
2019	68.000	22.500	16.500	12.500	5.500	1.250	1.250	550
2020	69.500	23.000	16.800	13.000	5.600	1.300	1300	560
2021	71.000	23.500	17.000	13.500	5.700	1.350	1.350	570
2022	73.000	24.000	17.500	14.000	5.800	1.400	1.400	580
2023	74.092	24.216	17.650	16.786	7.245	1.430	1.367	605
2024	79.918	25.000	18.000	18.000	7.652	1.525	1.427	649

Table 3 presents the predicted vehicle count for Aksaray province from 2025 to 2030. These predictions are based on a linear regression model. The reliability of the regression analysis is measured by statistical indicators such as R-squared and confidence intervals, which should be included to ensure validity.

Table 3. Predicted Vehicle Count (between 2025-2030)

Year	Predicted Vehicle Count(piece)
2025	169.500
2026	174.000
2027	178.500
2028	183.000
2029	187.500
2030	192.000

Figure 1 illustrates the predicted vehicle count trend from 2025 to 2030, generated using linear regression analysis. The x-axis represents the years, while the y-axis represents the vehicle count (in thousands). The figure visually represents the increasing trend and should include confidence intervals to depict the reliability of the predictions. The reason for choosing a 5 year forecast period is to provide more reliable and applicable forecasts in terms of short and medium-term planning. While long-term forecasts (e.g. 10 years or more) increase uncertainties, the 5-year period provides more manageable and reliable results in terms of economic, demographic and infrastructural variables. In addition, since local governments' transportation and infrastructure policies are usually based on 5-year development plans, forecasts made during this period can turn into more directly applicable data.

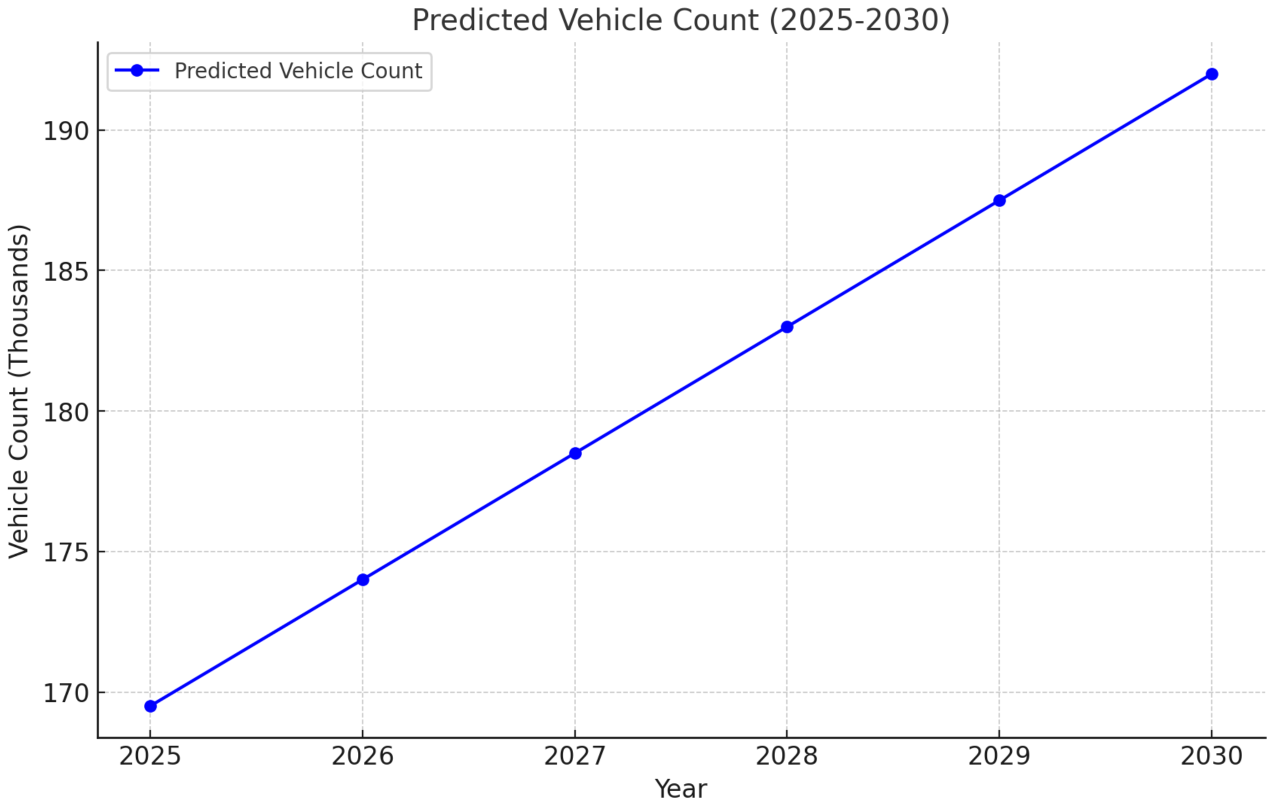

Figure 1. Predicted Vehicle Count

Table 4 provides the forecast for annual average daily vehicle values from 2025 to 2030. These values are derived using a linear regression model and align with the predicted vehicle count trends.

According to the regression analysis results:

R-squared (R^2): 0.977 → The model explains 97.7% of the dependent variable.

F-statistic: 641.1 and p-value: 1.01e-13 → It shows that the model is significant.

Year coefficient: 1.6515 → Annual average increase amount.

P>|t| values: 0.000 → Regression coefficients are statistically significant.

Figure 2 presents the forecast of annual average daily vehicle traffic values from 2025 to 2030. The vertical scale should be adjusted to clearly show the variation over the years. The increasing trends in different vehicle types should be highlighted and interpreted in detail.

To ensure statistical reliability, the regression analysis results should include confidence intervals, R-squared values, and significance levels. This will provide a clearer understanding of the stability of the annual growth rate and potential uncertainties in predictions.

Table 4. Forecast Annual Average Daily Vehicle Values (between 2025-2030)

Year	Automobiles (piece)	Light Trucks (piece)	Tractors (piece)	Motorcycles (piece)	Trucks (piece)	Mini-buses (piece)	Buses (piece)	Special-purpose vehicles (piece)
2014	60.000	20.000	15.000	10.000	5.000	1.000	1.000	500
2015	61.500	20.500	15.200	10.500	5.100			510
2016	63.000	21.000	15.500	11.000	5.200	1.100	1.100	520
2017	65.000	21.500	16.000	11.500	5.300	1.100	1.100	530
2018	66.500	22.000	16.200	12.000	5.400	1.200	1.200	540
2019	68.000	22.500	16.500	12.500	5.500	1.250	1.000	550
2020	69.500	23.000	16.800	13.000	5.600	1.300	1.300	560
2021	71.000	23.500	17.000	13.500	5.700	1.000	1.000	570
2022	73.000	24.000	17.500	14.000	5.800	1.400	1.400	580
2023	74.000	24.200	17.600	16.700	7.200	1.400	1.300	605
2024	79.900	25.000	18.000	18.000	7.600	1.500	1.400	649
2025	80.500	25.500	18.200	18.200	7.700	1.000	1.400	660
2026	81.200	26.000	18.500	18.500	7.800	1.600	1.400	670
2027	82.000	26.500	18.800	18.800	7.900	1.600	1.500	680
2028	82.800	27.000	19.100	19.100	8.000	1.700	1.500	690
2029	83.600	27.500	19.400	19.400	8.100	1.000	1.500	700
2030	84.400	28.000	19.700	19.700	8.200	1.800	1.500	710

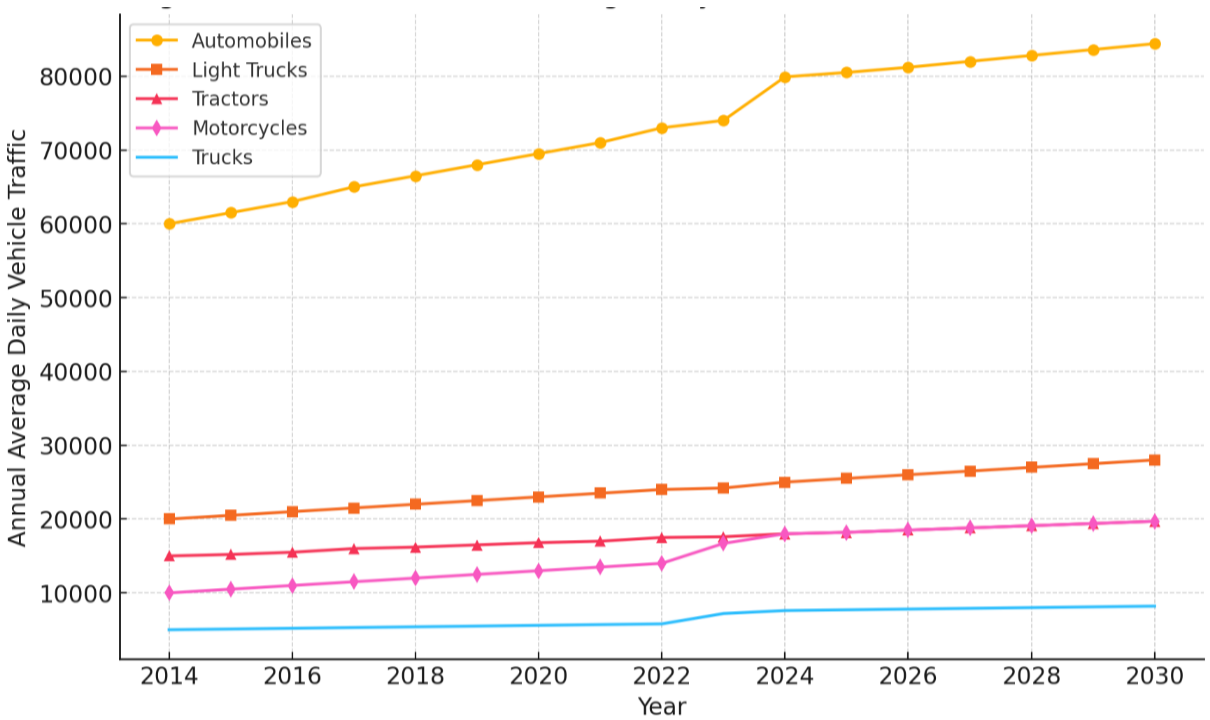

Figure 2. Forecast annual average daily vehicle traffic values (between 2025-2030)

Using regression analysis, predictions for vehicle numbers in Aksaray from 2025 to 2030 were made. The results indicate that vehicle numbers across all categories will continue to rise, with a stable annual growth rate. For instance:

- Automobiles are predicted to increase from 79,918 in 2024 to 84,400 by 2030, adding about 5,000 vehicles in the next six years.
- Light Trucks will increase from 25,000 in 2024 to 28,000 by 2030, showing a steady growth of 3,000 vehicles.
- Tractors are expected to grow from 18,000 in 2024 to 19,700 by 2030, an increase of 1,700 vehicles.
- Motorcycles will rise from 18,000 in 2024 to 19,700 by 2030, adding 1,700 vehicles over six years.
- Trucks will increase from 7,600 in 2024 to 8,200 by 2030, growing by 600 vehicles.
- Minibuses are expected to increase from 1,500 in 2024 to 1,800 by 2030, reflecting a moderate growth of 300 vehicles.
- Buses will remain stable at 1,500 vehicles from 2024 to 2030, showing no significant change.
- Special-purpose vehicles will increase from 649 in 2024 to 710 by 2030, adding 61 vehicles in six years.

The rise in vehicle numbers in Aksaray mirrors the overall development of infrastructure, commerce, and urbanization in the province. The rapid increase in automobiles and motorcycles indicates growing personal mobility, which is likely to lead to greater traffic congestion and challenges related to parking spaces.

Moreover, the rise in light trucks and tractors reflects the continued expansion of agricultural and transportation sectors. The increasing number of minibuses and buses indicates a rising demand for public transportation, highlighting the need for enhanced public transit systems.

Local authorities should consider these trends and plan for improved road infrastructure, expanded public transportation services, and increased parking facilities. Implementing smart transportation systems and traffic management strategies could help mitigate the negative effects of rising vehicle numbers.

These predictions suggest a consistent rise in vehicle numbers across all types, which will likely result in increased traffic congestion and higher demand for transportation infrastructure.

4. Conclusion

The results of the linear regression analysis indicate that private cars will continue to dominate the vehicle landscape in Aksaray, with a projected annual increase of approximately 1000 vehicles per year. This steady rise in private car ownership underscores the growing affluence and urbanization within the province, as more individuals seek personal vehicles for convenience and mobility. However, this growth also brings about pressing challenges, particularly in terms of traffic congestion, parking shortages, and environmental impact.

On the other hand, while the number of buses, trucks, and motorcycles are expected to grow as well, the growth rates are comparatively slower. Buses, although a key component of public transport, will require substantial investments to improve service efficiency and accessibility. The moderate increase in trucks indicates a steady need for freight transportation, but infrastructure for heavy vehicles should be carefully planned to avoid strain on road networks. Similarly, motorcycles, while beneficial for their efficiency in crowded cities, also pose safety risks that need to be addressed through proper regulation and infrastructure.

In conclusion, the study underscores the importance of forward-thinking policies and infrastructure planning to accommodate the expected growth in vehicle ownership in Aksaray. While the trends analyzed point to continued growth in private car ownership, with corresponding increases in buses, trucks, and motorcycles, the province has an opportunity to shape its future transportation system in a way that balances mobility, sustainability, and safety.

By embracing a multi-modal transportation approach, focusing on environmental sustainability, and planning for future technological changes, Aksaray can ensure that its transportation system meets the needs of its growing population while addressing key challenges such as congestion, pollution, and road safety. The findings and recommendations provided by this study can serve as a foundation for policymakers, urban planners, and stakeholders to develop a cohesive and sustainable strategy for Aksaray's transportation future.

Conflict of Interest Declaration

The author of the article do not have any conflict of interest.

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