QUBAHAN ACADEMIC JOURNAL
VOL. 4, NO. 1, Feb 2024
https://doi.org/10.58429/qaj.v4n1a269

Road Maintenance Planning of the Fier-Vlore Road Axis, based on the Assessment and Forecast of AADT and Los Service Level

Shkelqim Gjevori [1*] and Arian Lako [2]

[1] Department of Studies and Projects, Institute of Transport Studies of the Ministry of Infrastructure and Energy of Albania, Tirana, Albania.
[2] Department of Construction Structures and Transport Infrastructure, Polytechnic University of Tirana, Tirana, Albania.

Corresponding author: e-mail: shkelqimgjevori1@gmail.com.

ABSTRACT: The relevance of this study lies in the fact that maintaining roads in good condition is an important condition for ensuring the safety and comfort of road traffic, as well as the economic development of the region. The aim of the study is to develop a method for planning road maintenance along the Fier-Vlore axis based on the assessment and forecast of the level of service AADT and LOS in order to improve the quality and safety of road traffic. The AADT and LOS service level estimation and forecast method is used to determine the performance of road networks and identify problem areas. The results of this study indicate that in the next 10 years, the level of service on this section of the road will be satisfactory and will be classified as "C". However, after 2027 until 2032, the service level is expected to decline to category "D" and "E", which could potentially lead to restrictions in manoeuvring and an increase in traffic accidents. In addition to reducing the distance, the construction of this Fier-Vlore Road has a significant impact both in reducing transport costs and in reducing the stress and anxiety caused by the old road. The main goal of the road is to provide comfort, safety, minimum cost and sustainability to the environment. In general, the use of the AADT and LOS Service level estimation and forecast method has significant practical value for planning investments in road maintenance and road infrastructure improvement.

Keywords: Maintenance; Road Infrastructure; Planning Efficiency; Average Daily Number of Vehicles; Service Level.

I. INTRODUCTION

The study of this topic is significant in several aspects. It contributes to road safety by detecting and correcting damage to the road surface, and deficiencies in signs and markings. Such maintenance improves the quality of road infrastructure and extends its service life. In addition, proper maintenance planning allows efficient allocation of resources for road repair and maintenance, which contributes to economic efficiency. Finally, improving the quality of road infrastructure has a direct impact on the quality of life of people who use these roads, increasing the comfort and safety of movement, reducing travel time and reducing the likelihood of accidents and injuries.

Problems associated with road maintenance planning based on AADT (Annual Average Daily Traffic) and LOS (Level of Service) estimates and forecasts may include: Insufficient or unreliable information, Forecasting difficulties, Resource constraints, Difficulty coordinating various organizations and authorities, as well as the difficulty of assessing the effectiveness of the planning process, especially in the long term. In general, this issue is associated with difficulties in obtaining and analysing information, limited resources, and the complexity of coordinating and evaluating the effectiveness of the planning process. In general, the study of this topic allows us to develop an effective road maintenance planning system that improves road safety, improves the quality of road infrastructure, saves budgetary resources and improves the quality of people's lives.

According to G. Tahirai [1], ensuring road safety is a very important aspect that requires constant attention and efforts from governments, road safety authorities, drivers, and pedestrians. As K. Shala and A. Dorry [2] said, improving the quality of road infrastructure is a key aspect for ensuring road safety and efficient use of road networks. I. Jaferai and N. Shkodrani [3] determined that the quality of road infrastructure is of great importance for the quality of life of people who use these roads. Unsuitable road conditions can lead to various problems that negatively affect people's lives.

D. Dalakoglu [4] notes that road maintenance is an important process that allows maintaining the quality of road infrastructure and ensuring road safety. Road maintenance includes a number of activities aimed at improving the condition of roads and preventing their destruction. Referring to the definition of D. Bardi [5], one of the main advantages of regular road maintenance is its ability to prevent the destruction of road infrastructure. Repairing pavement and infrastructure at an early stage avoids major repairs in the future and keeps the road in good condition over a long period of time. E. Hasa et al. [6] report that a preliminary assessment of AADT and LOS can help determine the amount of work needed and budget for road maintenance. This can help public authorities and organizations responsible for road infrastructure in planning and allocating financial resources for road maintenance.

The purpose of this study is to develop a methodology for planning road maintenance along the Fier-Vlore axis based on the assessment and forecast of the level of service AADT and LOS, taking into account the difficulties associated with obtaining and analysing information, limited resources, the complexity of coordination and evaluation of the effectiveness of the planning process. To achieve this goal, research will be carried out to develop methods for estimating AADT and LOS service levels, analysing data and predicting future values, and developing an optimal road maintenance planning methodology based on the results obtained and taking into account the complexities indicated above.

II. MATERIAL AND METHOD

Road maintenance is an important aspect of keeping them in good condition and ensuring traffic safety on them. At the same time, road maintenance planning should be based on the assessment of the level of service and the forecast of AADT and LOS. This section will describe how the AADT and LOS service levels were assessed and forecasted, and how road maintenance planning along the Fier-Vlore axis was based on these data. To evaluate the level of service, a LOS assessment was carried out based on the HCM (Highway Capacity Guide) method. The Highway Capacity Manual allows estimating LOS based on various parameters such as traffic speed, traffic density, road capacity, and others. For each road section, a LOS estimate was made based on its characteristics and AADT data. The results of the LOS assessment were used to determine the need for road maintenance.

Various methods have been used to predict AADT and LOS, such as trend analysis, regression analysis, and machine learning modelling. In this case, a forecasting technique based on trend analysis and regression analysis was used. For this, data on traffic flow for past years, as well as data on the economic development of the region and social trends, were used. The results of the AADT and LOS forecast were used to determine the need for road maintenance in the future. Given the assessment of the level of service and the forecast of AADT and LOS, road maintenance planning was carried out. For this, a road maintenance program was developed, which determined the necessary work to keep them in good condition. The program included planned work on the repair and renewal of the pavement, the repair, and replacement of road markings, the installation of new signs and traffic lights, and other works. Road maintenance planning also took into account factors such as financial capacity, timing of work and the availability of necessary resources. A road maintenance budget was developed to allow the necessary work to be carried out in line with the level of service and the AADT and LOS forecast.

Various methods can be used to calculate the traffic forecast (AADT) for a 10-year period, including mathematical models and expert judgment. One such method is to use a calculation formula that can be developed based on the analysis of previous traffic data. For example, to calculate the AADT forecast for a 10-year period, it is possible to use the following formula:

$$\text{AADTt+n}=\text{AADTt}(1+r)^{n} \quad (1)$$

Where AADTt is the current value of AADT; r – annual traffic growth rate; n – the number of years for which it is necessary to predict traffic.

It is possible to use AADT percentage change data from previous years to calculate the annual traffic growth rate. For example, if over the past five years the average annual traffic growth was 3%, then r would be 0.03. Thus, using this calculation formula, it is possible to predict the change in traffic on the road over a 10-year period and use the results to plan road maintenance based on forecasting future demand for road infrastructure.

III. DATA ANALYSIS

Important technical data is required to determine the type of maintenance. Among the most important data Figure 1, it contains the technical parameters used to evaluate the effectiveness of maintenance. In the analysis, only one of the technical factors influencing the operation of the road was evaluated, i.e. the second factor, traffic data.

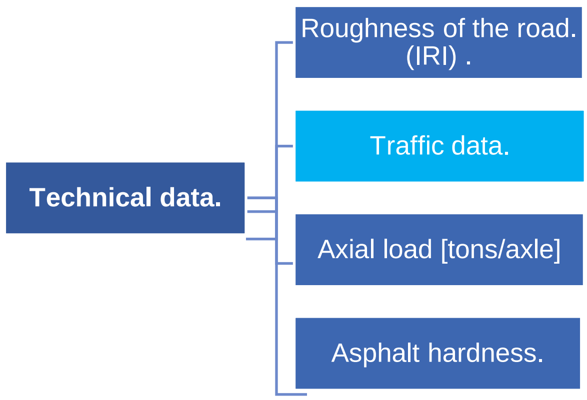

FIGURE 1. Technical data for evaluating the effectiveness of maintenance [7].

The estimation of traffic parameters (ADT, AADT) is very important, because the other three technical data in scheme 1 are evaluated if there is ADT (average daily traffic), AADT data. The remaining three technical data that are needed to determine the type of maintenance include: Road roughness, measured by the amount of transverse and longitudinal inclination of the carriageway, can significantly affect the safety of vehicles and requires an appropriate level of maintenance. Axle load is the weight of vehicles passing on the road, and its value affects the wear and tear of the road surface and the need for its repair. The hardness of asphalt is an indicator that characterizes the resistance of the road surface to deformation and cracks. It can also influence the need for road maintenance and repair. All of this data, including ADT and AADT, helps determine the most efficient and cost-effective level of road maintenance.

After examining the volume and characteristics of traffic on the Fier-Vlore Road axis, the effectiveness of the road and its ability to accommodate the traffic that takes place on it must be assessed. This will help to find solutions for improving and developing the road in accordance with the future traffic volume and intensity. To do this, it is necessary to determine the capacity of the road, which reflects its ability to perceive traffic in the presence of free flow. This can be done by comparing the volumes of daily traffic on the studied roads with the design capacity, which was determined when designing the cross-section of the road, taking into account the magnitude of the design traffic. The service level for the roads can then be determined. Design road capacity is based on the PCU (Passenger Car Unit) measurement unit, which takes into account the size and characteristics of vehicles and their effect on traffic flow.

In order to obtain transport volumes of equivalent units, it is necessary to transfer all vehicles to PCU in accordance with the Albanian specifications for roads and bridges. Road performance assessment is an important step in its development and modernization, which is necessary to ensure the sustainable development of transport infrastructure and improve the quality of life of people. This requires the attraction of appropriate investments and resources, as well as cooperation between various stakeholders, such as public authorities, private companies and the public. This work will help develop effective strategies to improve road infrastructure and ensure road safety on this axis of the road in the next 10 years.

In both cases, traffic parameter estimation (AADT, VOP, LOS) and prediction can help determine the cause of compression and take action to improve road performance. AADT shows the average daily number of vehicles passing on a given section of the road during the year, which can help determine the current congestion of the road [8]. VOP (Volume Over Capacity) shows the ratio of the current traffic flow to the design capacity of the road, which can also help determine the level of congestion. LOS (Level of Service) evaluates the quality of service to road users based on speed, delay time, comfort, and safety. Predicting future traffic flows and changes in road use can help take action to improve road performance and prevent future compression. In these cases, it is possible to analyse, assess the situation and propose a solution to the situation. Therefore, traffic forecasts (AADT) and maintenance planning based on technical criteria (Figure 2) must be constantly reviewed depending on the dynamics of the territory development [9]. Over time, the more reality deviates from the forecast, the greater will be the need for immediate monitoring efforts to predict road maintenance. The purpose of evaluating service level forecasts is to develop a road maintenance strategy and, if needed, add a traffic lane or a new alternative road. Various methods and tools can be used to estimate and predict traffic parameters on the road over a ten-year period. For example, to determine the current values of AADT and VOP, it is possible to perform a counting observation and analysis of road load. It is possible to use traffic modelling and delay analysis techniques to predict service levels. To improve road performance, it is necessary to analyse the data and determine what actions can be taken. This may include increasing the design capacity of the road, adding new lanes or building alternative roads, and improving the technical condition of the road by repairing or rehabilitating existing roads. Constant monitoring of the state of roads and forecasting their use are important tasks for ensuring the safety and efficiency of traffic. This allows making decisions to optimize the use of roads and solve problems associated with congestion or damage to roads [10].

Given data provided by ARRSH (Albanian Road Authority) in Table 1, there is AADT for the period 2013 to 2022. Table 2 and Figure 3 show the dynamics of AADT, VOP and LOS for the period 2013-2022. This trend indicates that the road section is overloaded and requires optimization. It is necessary to analyse the reasons for the deterioration in performance and develop measures to improve the level of road maintenance. Possible measures could be increasing the design capacity of the road, reconstructing the road, introducing additional speed limits, or to re-route vehicles.

Table 1. Dynamics of AADT [11]

year	AADT
2013	12106
2014	13420
2015	13431
2016	13428
2017	13534
2018	13489
2019	13420
2020	7156
2021	11004
2022	13608

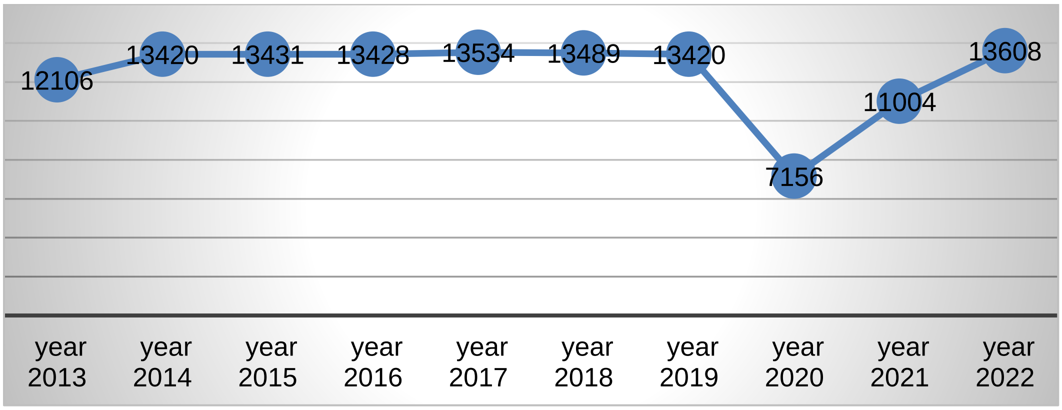

FIGURE 2. ADDT dynamics for the period 2013-2022 [11].

Table 2. AADT, VOP and LOS for the period 2013-2022 [11].

Year	AADT	VOP	LOS
2013	12106	1211	0.55
2014	13420	1343	0.61
2015	13431	1343	0.61
2016	13428	1343	0.61
2017	13534	1353	0.62
2018	13489	1349	0.61
2019	13420	1342	0.61
2020	7156	716	0.33
2021	11004	1200	0.55
2022	13608	1231	0.56

Estimated capacity of this road c=1100 [auto hour/lane] or 2200 [auto hour/direction] according to the "Technical Rules for the Design and Construction of Highways". Given the calculated capacity, it can be determined that the current AADT on this road exceeds the design capacity. Given that VOP and LOS also show a low level of productivity, it can be concluded that options should be considered to increase the capacity of the road, for example, by adding a lane or building an alternative road (Figure 3).

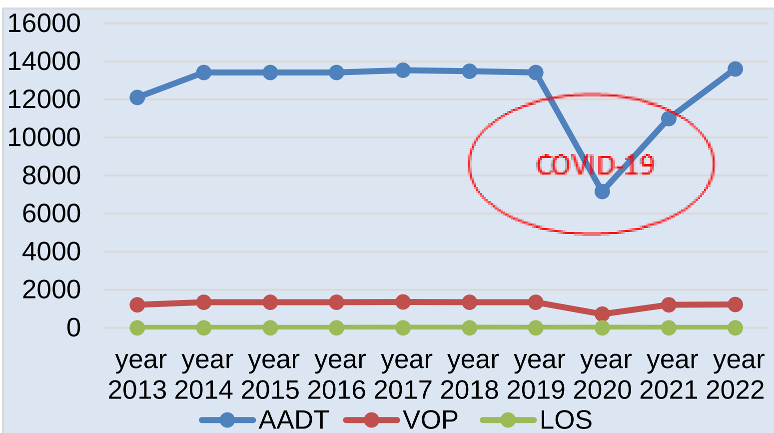

FIGURE 3. AADT Dynamics, VOP, LOS (2013-2022) [12].

Annual growth (p) was assumed to be 1.025% based on estimates for the period 2013-2022 based on economic growth factors. It is worth emphasizing that 2020 and 2021 were unstable due to COVID-19 (coronavirus disease 2019). Table 3, Figure 4 and 5 show the dynamics of AADT, VOP and LOS for the period 2023-2032.

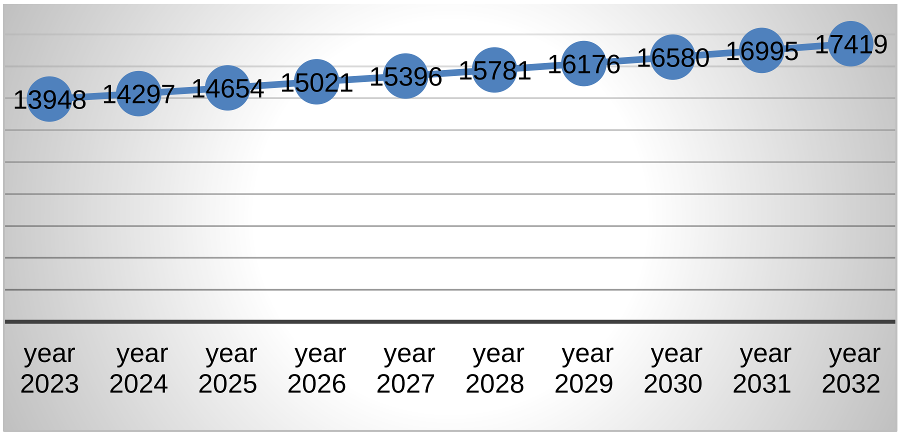

FIGURE 4. AADT forecast for the period 2023-2032 [12].

Table 3. AADT, VOP and LOS forecast up to 2032 [12].

Year	AADT	VOP	LOS
2023	13948	1395	0.63
2024	14297	1430	0.65
2025	14654	1465	0.67
2026	15021	1502	0.68
2027	15396	1540	0.70
2028	15781	1578	0.72
2029	16176	1618	0.74
2030	16580	1658	0.75
2031	16995	1699	0.77
2032	17419	1742	0.79

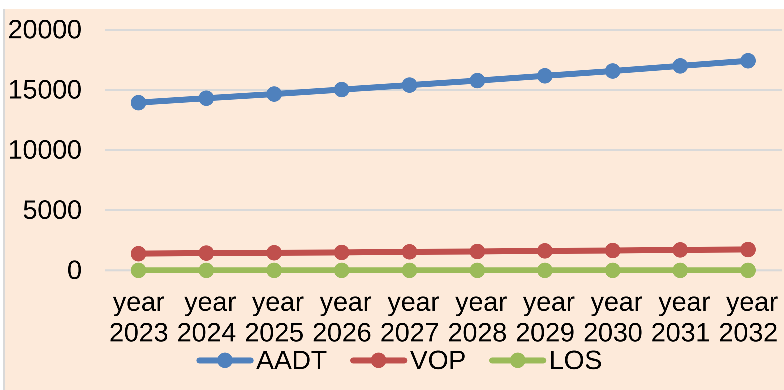

FIGURE 5. AADT, VOP and LOS forecast for the period 2023-2032 [12].

Referring to the results from Table 3, the Service Level for 2032 would be 0.79, or referring to Table 1, the Service Level is in Service Level (LOS) D conditions, which stands for "Long Manoeuvring Restrictions". If reconstruction is not possible, then when a service level in category E or in numerical values above 0.9 is reached, it should be possible to widen the road or another alternative road. Thus, in order to improve the level of service on this section of the road, it is necessary to consider the possibility of reconstructing or building an alternative road. Otherwise, when reaching service levels in categories E or above 0.9, there may be serious restrictions on the manoeuvring and movement of vehicles. Therefore, in order to ensure road safety and the convenience of traffic flows, it is necessary to provide for measures to widen the road or create alternative routes Table 4.

Table 4. LOS dynamics for 2023-2032

LOS Trend for 10 years.						
Viti	A	B	C	D	E	F
	0÷0.25	0.25÷0.5	0.5÷0.7	0.7÷0.9	0.9÷1	1
22023						
22024						
22025						
22026						
22027						
22028						
22029						
22030						
22031						
22032						

The most common way to plan road maintenance work is considered to be a planning method based on defect lists, which determine the types and volumes of work on each road section [13]. Lists of defects are compiled during periodic inspection and assessment of the quality of road maintenance. To determine the annual volume of road maintenance work in the current year and in the future, a methodology based on a cyclic system of road maintenance work is often used. Its essence lies in the fact that each type of road maintenance work is periodically repeated on each section of the road after a certain period of time, which is called the cycle duration and is measured in years, and the number of such intervals during the year is called the cycle coefficient. The cycle duration characterizes the period of time after which this work must be repeated on the same road section, and the cycle coefficient shows how many times the road section needs to be repaired per year. The cycle factor and cycle time are used to determine annual road maintenance volumes based on the prediction of defects on each road section [14]. For example, if the cycle time for pavement repair is 3 years and the cycle factor is 2, then this means that each section of the road must be repaired twice a year, and each repair must be carried out every 3 years. This method allows setting the approximate number of works on each section of the road, which helps to estimate the budget and resources needed to carry out these works. It also allows the development of a long-term road maintenance plan that can be used in the preparation of a state road maintenance and repair program.

IV. DISCUSSION

All economic and social activities of society need transport support. All support for this development is carried out through the transport system, which means that the level of development of the components of this system is the main indicator of the country's development. The transport system, through its constituent links, implements the movement of goods and passengers from one area of the interactive space to another. Transport, as an important element of people's life, has a very large weight and a very important role in their daily activities.

A good transport infrastructure network plays a vital role in achieving economic success in any country. On the other hand, the maintenance of these roads requires significant financial resources. This requires the right economic decision to plan funds by prioritizing roads for improvement and maintenance depending on their importance. Roads are designed for a certain amount of traffic according to the technical criteria approved in the legal regulations of each country. So, in addition to the pace of construction of new roads, care should also be taken to maintain this road network, as traffic flows or even atmospheric agents will damage the infrastructure, reducing its level of maintenance depending on the degree of damage over time.

In order to constantly maintain the performance of the infrastructure, it is necessary to constantly maintain them. The performance of the road network depends on traffic volume (ADT, AADT), traffic composition (zk), type of road surface (asphalt) and strength, environment (E) and service standards. In order to keep the road in good condition during use or predict the level of service in the medium or long term, it is necessary to conduct studies, analyses, and conclusions to take measures to maintain the level of road service. There is a correlation between traffic volume and road damage that affects the level of service. Ultimately, the cost of maintaining the road must be justified by the benefits it brings. These can be both direct financial benefits in the form of minimizing transport costs, and gratuitous social benefits.

According to the results of M. Hatamzad et al. [15], the transport system is a key element in the development of the economy and social activity of society. Without it, it would be very difficult to ensure the free movement of people and goods from one point to another. The level of development of the transport system directly affects many aspects of society. For example, on the level of economic development of the country, on the level of accessibility of medical and educational services, as well as on the standard of living of the population as a whole. The transport system is one of the costliest elements for the state and for society as a whole. Therefore, it is important to ensure its effectiveness and efficient use of existing resources. This may include the use of new technologies, infrastructure improvement, route optimization.

In addition, the transport system can also have a negative impact on the environment, including emissions of harmful substances and air pollution. Therefore, it is also important to ensure the environmental sustainability of the transport system, including the development of environmentally friendly technologies and means of transport. In general, the development of the transport system is an important component of social development, which must be taken into account when developing economic and social strategies for the development of the country.

Referring to the definition of M. Buraim et al. [16], good transport infrastructure is a key factor in achieving economic success in any country. Transport infrastructure enables the free movement of people and goods, which contributes to the acceleration of economic growth and development. However, the maintenance of transport infrastructure requires significant financial resources, and the effective use of these resources requires proper economic planning and decision-making. An important aspect of this planning is the prioritization of road improvements and maintenance based on their importance. At the same time, a proactive approach to addressing the consequences of traffic is a cost-effective approach to maintaining the transport infrastructure. This means that possible problems and damage on the roads must be prevented through regular maintenance and repair. This approach can significantly reduce the cost of maintaining and improving roads in the future, as well as improve road safety [17-19].

But, in addition to a proactive approach, it is also important to take into account changes in the transport environment and social trends in order to correctly plan improvements and changes in transport infrastructure. Research and experience can help with this by allowing analysing data and identifying trends that will help to make more informed decisions when planning transport infrastructure.

The right economic decision in the planning and maintenance of transport infrastructure can help ensure the efficient use of resources and economic success in any country. Researcher P. Gertler et al. [20] determined that roads are built taking into account a certain amount of traffic, and this volume can change depending on various factors, such as population, economic growth, changes in transportation routes, and the development of new technologies. It is equally important to pay attention to the maintenance of the road network so that it can remain in good condition and provide safety and comfort for all users. Regular road maintenance and repair is also important to prevent damage to infrastructure [20]. However, in addition to investing in road maintenance, it is also important to look for alternative solutions to reduce the volume of traffic, such as the development of public transport, bicycle paths and pedestrian zones [21-23]. This can reduce pressure on roads and reduce the need for continuous expansion and repair of the road network.

L. Fang et al. [24] determined that the estimation and forecasting of Annual Average Daily Traffic (AADT) and Level of Service (LOS) is an important step in planning investments in road maintenance. These two indicators are key in determining the level of road use and its effectiveness in servicing traffic flows [24, 25]. Using AADT and LOS data can help governments and road maintenance organizations to prioritize financial resources for road maintenance and repairs. They can also be used to make decisions about planning new road projects and upgrading existing ones.

R. Mukerji et al. [26] have shown through his work that regular maintenance of the road infrastructure is an important aspect of maintaining its performance and productivity. During the operation of the road, it is significantly affected in the form of traffic flows, weather conditions and other factors. As a result, roads are subject to wear, damage and degradation. In order to maintain the performance of the road infrastructure, it is important to conduct regular studies and analyses that will help determine the current state of the road and predict its level of service in the medium and long term [27-29]. These studies include the evaluation of AADT, LOS, traffic composition, road surface type and other factors that affect road performance.

Studies and analyses make it possible to identify the most critical sections of the road and take measures for their repair and maintenance. Properly planned road infrastructure maintenance can increase its lifespan, improve traffic safety and reduce future repair and maintenance costs. As J. Schmidt et al. [30] note, there is a close relationship between traffic intensity on the road and its condition. Higher traffic means more traffic on the road, which in turn leads to more wear and tear on the road surface and an increased likelihood of defects and damage. This, in turn, can lead to a deterioration in the level of road maintenance and an increase in the cost of its maintenance [31-32].

It is important to understand that roads play an important role in the economy and social life, providing not only transport links, but also creating jobs, facilitating access to goods and services, increasing productivity and economic growth. Therefore, the cost of maintaining roads should be justified not only financially, but also socio-economically.

V. CONCLUSION

Given the results of engineering analysis of the growth trend of AADT and LOS over a period of 10 years, it is possible to draw the following conclusions. The level of service until 2027, if it is going about the results, will be satisfactory and belongs to category C. At this level, it is worth working with free flow and there is the possibility of calm and safe movement. After 2027 until 2032 there will be a decrease in the level of service from category “C” to category “D” and a trend in category E, values at which concerns begin to appear in the operation of traffic, so there will be visible restrictions in manoeuvring when operating on this road. The situation needs to be taken into account by daily monitoring of traffic management, routine maintenance and planning for periodic maintenance on an ongoing basis. After 2032, there will be traffic delays on this section of the road, which will cause an increase in fares, as well as the possibility of an increase in the number of traffic accidents. Therefore, after 2027, it is recommended to strengthen traffic management measures by installing intelligent ITS systems and increasing measures to maintain the infrastructure of this section of the road. This will help improve service levels and ensure safety for all road users. These practices can also help improve traffic management, reduce travel time and reduce road accidents. These methods may also take into account the influence of factors such as changes in urban planning, the expansion of city limits and the development of transport infrastructure. This will make it possible to more accurately determine the requirements for road maintenance and take effective measures to ensure the safety and comfort of traffic on the roads. These methods can be applied not only on municipal and state roads, but also on private roads, including industrial and forestry roads.

REFERENCES

1. Tahirai, G. Trends in the formation and development of a transport interchange hub in the infrastructure of large cities in Albania. *Archit Mod Inf Technol* **2022**, *Volume 1*, no. 58, pp. 125-135.
2. Shala, K. and Dorri, A. (2021). Identification of the accidents causes and their engineering analysis: The case of Albania. *International Journal of Innovative Technology and Interdisciplinary Sciences*, *4*(2), 706-715.
3. Jaferaj, I. and Shkodrani, N. Road safety visibility distance according to the Albanian code. *J Acad Platform Disasters Disaster Manag* **2020**, *Volume 1*, no. 2, pp. 89-95.

4. Dalakoglou, D. (2010). The road: An ethnography of the Albanian–Greek cross-border motorway. *American Ethnologist*, *37*(1), 132-149.
5. Bardhi, D. (2022). Road Asset Management Assessment. *European Journal of Engineering and Formal Sciences*, *5*(1), 25-36.
6. Hasa, E., Hisa, A., and Tekja, Z. Quantitative landscape fragmentation by the indicator of the effective size of the landscape metric grid: the example of Albania. *Agric For Field Damage Madness* **2021**, *Volume 67*, no. 1, pp. 215-230.
7. Blouin, F., Audy, J. F. and Lamghari, A. (2022). Circular Economy in Winter Road Maintenance: A Simulation Study. *Sustainability*, *14*(23), 15635.
8. Onyshchuk, O. Optimized Calculation of Adsorption Process Through the Nozzle Adsorber by the Cell Model Method. *Bull Cherkasy State Technol Univ* **2022**, no. 1, pp. 37-46.
9. Levchenko, V., Pogosov, O. and Kravchenko, V. (2023). Cobalt application in repair tools for maintenance and modernisation of NPP equipment. *Scientific Herald of Uzhhorod University. Series" Physics*, *53*, 31-41.
10. Bieliatynskyi, A., He, Y., Pershakov, V., Akmaldinova, O. and Krayushkina, K. (2022). The study of the effectiveness of the use of ash and slag in the construction of road pavement during maintenance.
11. Majstorovich, A. and Jayats, N. A model for managing the maintenance of a suburban road network. *Infrastructures* **2022**, *Volume 7*, no. 6, pp. 80.
12. de Bortoli, A., Féraille, A. and Leurent, F. (2022). Towards road sustainability—Part I: principles and holistic assessment method for pavement maintenance policies. *Sustainability*, *14*(3), 1513.
13. Hrechko, Y., Sereda, I., Babenko, I. and Azarenkov, M. (2023). Thermionic coating method with preliminary bombardment of the substrate surface with a stream of low energy ions. *Scientific Herald of Uzhhorod University. Series Physics*, *53*, 9-18.
14. Aghbalyan, S. and Simonyan, V. (2022). Study of hardening and structure of maraging powder steel grade PSH18K9M5TR (18% Ni+ 9% Co+ 5% Mo+ 1% Ti+ 1% Re+ 66% Fe). *Scientific Herald of Uzhhorod University. Series" Physics*, (52), 46-55.
15. Hatamzad, M., Pineres, G. K. P. and Kasselgren, J. Intelligent economical maintenance of winter roads by predicting the temperature of the pavement using machine learning methods. *Knowl Based Syst* **2022**, *Volume 247*, 108682.
16. Bouraima, M. B., Qiu, Y., Kiptum, C. K. and Ndiema, K. M. (2022). Evaluation of factors affecting road maintenance in Kenyan counties using the ordinal priority approach. *Journal of Computational and Cognitive Engineering*.
17. Kosogina, I. Transport Properties of Ceramic Matrices Based on Al2O3. *Bull Cherkasy State Technol Univ* **2023**, no. 2, pp. 135-145.
18. Orozonova, A., Gapurbaeva, S., Kydykov, A., Prokopenko, O., Prause, G. and Lytvynenko, S. (2022). Application of smart logistics technologies in the organization of multimodal cargo delivery. *Transportation Research Procedia*, *63*, 1192-1198.
19. Gertler, P. J., Gonzalez-Navarro, M., Gracner, T. and Rothenberg, A. Road Maintenance and Local Economic Development. *Available at SSRN 4447393*.
20. Nussupbek, Z. T., Bekenov, T. N., Sattinova, Z. K., Beisenbi, M. A. and Tassybekov, Z. T. (2023). Substantiation of methods for calculation of traction forces redistribution indicators on modular front and rear wheels of the vehicle (4X4). *Transportation Engineering*, *13*, 100193.
21. Petruccelli, U. (2011). The perceived quality of the local public transit: A multi-criteria model to select improvement scenarios [La qualità percepita nel trasporto pubblico locale: Un modello multicriteri per la selezione di scenari migliorativi]. *Ingegneria Ferroviaria*, *66*(9), 717-744.
22. Leshchev, V., Maslov, I., Palagin, O. and Naydyonov, A. (2023). Transfer Function for a Controllable Pitch Propeller with Added Water Mass. *Polish Maritime Research*, *30*(4), 74-80.
23. Fan, L., Cao, D., Zeng, C., Li, B., Li, Y. and Wang, F. Y. (2022). Cognitive-Based Crack Detection for Road Maintenance: An Integrated System in Cyber-Physical-Social Systems. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*.
24. Danchuk, V., Bakulich, O., Taraban, S. and Bieliatynskyi, A. (2019). Simulation of traffic flows optimization in road networks using electrical analogue model. In *Energy Management of Municipal Transportation Facilities and Transport* (pp. 238-254). Cham: Springer International Publishing.
25. Chatterjee, S., Saeedfar, P., Tofangchi, S. and Kolbe, L. M. (2018, June). Intelligent Road Maintenance: a Machine Learning Approach for surface Defect Detection. In *ECIS* (p. 194).
26. Berestovoi, A. M., Zinchenko, S. G., Berestovoi, I. O., Khliestova, O. A. and Senatosenko, V. A. (2020). Effectometrics of Transport Technological System. *structure*, *1*, 135-157.
27. Danchuk, V., Bakulich, O. and Svatko, V. (2019). Identifying optimal location and necessary quantity of warehouses in logistic system using a radiation therapy method. *Transport*, *34*(2), 175-186.
28. Petruccelli, U. and Racina, A. (2021). Feeder-trunk and direct-link schemes for public transit: a model to evaluate the produced accessibility. *Public Transport*, *13*(2), 301-323.
29. Schmidt, J., Tietze, N., Gerhold, L. and Kox, T. (2022). Requirements for the use of impact-based forecasts and warnings by road maintenance services in Germany. *Advances in Science and Research*, *19*, 97-103.