ENGINEER

international scientific journal

ISSUE 3, 2025 Vol. 3
E-ISSN
3030-3893
ISSN
3060-5172

SLIB.UZ
Scientific library of Uzbekistan

A bridge between science and innovation

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

ENGINEER

A bridge between science and innovation

E-ISSN: 3030-3893

ISSN: 3060-5172

VOLUME 3, ISSUE 3

SEPTEMBER, 2025

engineer.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY

ENGINEER

INTERNATIONAL SCIENTIFIC JOURNAL
VOLUME 3, ISSUE 3 SEPTEMBER, 2025

Founder of the international scientific journal "Engineer" – Tashkent State Transport University, 100167, Republic of Uzbekistan, Tashkent, Temiryo'lchilar str., 1, office: 465, e-mail: publication@tstu.uz.

The "Engineer" publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

- Engineering;
- General Engineering;
- Aerospace Engineering;
- Automotive Engineering;
- Civil and Structural Engineering;
- Computational Mechanics;
- Control and Systems Engineering;
- Electrical and Electronic Engineering;
- Industrial and Manufacturing Engineering;
- Mechanical Engineering;
- Mechanics of Materials;
- Safety, Risk, Reliability and Quality;
- Media Technology;
- Building and Construction;
- Architecture.

Tashkent State Transport University had the opportunity to publish the international scientific journal "Engineer" based on the **Certificate No. 1183** of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. **E-ISSN: 3030-3893, ISSN: 3060-5172.** Articles in the journal are published in English language.

Automation of green space maintenance along road infrastructure

N.U. Jurakulova[1][a], Sh.R. Khalimova[1][b]
[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: The study comprehensively examined the efficiency of automated irrigation systems applied to green areas along the Tashkent–Chirchik highway. Within the research framework, soil moisture sensors were utilized to continuously monitor environmental conditions and to optimize the allocation of water resources. This methodological approach enabled the collection of precise data on soil humidity levels, making it possible to design irrigation schedules that respond directly to the actual needs of the vegetation. The findings revealed a range of important outcomes. First, automation led to a reduction in water use by approximately 25–30%, which is a crucial achievement considering the growing problem of water scarcity in Central Asia. Second, labor requirements decreased by nearly 40%, thereby reducing the dependence on manual maintenance and significantly lowering operational costs. Third, plant resilience during the vegetation period was noticeably improved, as indicated by healthier leaf coloration, higher photosynthetic activity, and greater tolerance to drought stress.

In addition, system management through IoT-based technologies allowed for real-time monitoring and rapid response to changing conditions, which significantly improved the speed and quality of maintenance services. This ensured more efficient allocation of limited resources, minimized the risks associated with over- or under-irrigation, and contributed to more stable plant growth. Overall, the adoption of automated irrigation and monitoring systems represents not only a technological advancement but also an important step toward achieving environmental sustainability, energy efficiency, and long-term landscape resilience. These results highlight the potential for wider application of such technologies along highways and in other urban green zones, where resource savings and ecological balance are of strategic importance.

Keywords: Automated irrigation system, IoT technologies, green areas/landscaping, soil moisture monitoring, water resource saving, ecological sustainability, remote control, vegetation stability, highway landscape, innovative maintenance methods

1. Introduction

In recent years, along with transport infrastructure, considerable attention has been paid to issues of environmental sustainability. Green areas along roads are not only elements that enhance the aesthetic appearance but also important ecological systems that reduce the amount of dust and gases in the atmosphere and absorb noise [1, 11]. For example, green zones created along the Tashkent–Samarkand highway play a significant role not only in reducing harmful gases emitted by vehicles but also in improving the aesthetic appearance of the road and ensuring psychological comfort for drivers and passengers. Such green zones contribute to maintaining ecological balance by absorbing carbon monoxide, nitrogen oxides, and other harmful substances released into the atmosphere by moving vehicles. In addition, the placement of trees and shrubs along roads regulates wind speed, reduces noise levels, and positively influences the surrounding environment.

However, the effective functioning of these zones directly depends on their regular maintenance, irrigation, and monitoring. At present, a significant part of these processes is carried out manually using traditional methods. As a result, large amounts of water and labor resources are consumed, while efficiency remains low. For instance, due to uneven distribution of water, some trees do not receive sufficient moisture, while others are overwatered. This not only leads to inefficient use of water resources but also negatively affects plant growth.

Therefore, under modern conditions, it is necessary to introduce innovative solutions for maintaining green zones along highways, such as automated irrigation systems, remote monitoring using IoT (Internet of Things) technologies, and soil moisture control with sensors. Such an approach makes it possible to use resources efficiently, enhances the ecological effectiveness of green zones, and ensures the long-term sustainability of the landscape created along roads [2]. In this regard, the issue of increasing efficiency through the use of modern automated systems is highly relevant [3, 4].

2. Research methodology

In the course of this study, in accordance with the aim and objectives of the research, the following methodological approaches and methods of analysis were applied:

Literature analysis — international experience (USA, Germany, Japan) in automated irrigation and maintenance systems was studied [5, 6].

Technological modeling — a scheme of the automated process for maintaining green zones was developed [7].

Experimental observation — on a test section along the Tashkent–Chirchik highway, soil moisture was monitored using sensors and water consumption was optimized [8].

Comparative method — the efficiency of traditional maintenance and automated systems was compared [9].

[a] https://orcid.org/0009-0003-4565-0699
[b] https://orcid.org/000-0002-4753-390X

3. Results and Discussion

The analysis of the research results made it possible to draw the following scientifically substantiated conclusions:

When using soil moisture sensor systems, water consumption was reduced by an average of 25–30% [2, 9]. For example, on the Tashkent–Chirchik highway section during the summer period, a significant decrease in water usage was observed due to automated irrigation.

Thanks to automated systems, labor costs for maintenance were reduced by 40% [3]. This was particularly evident on the Tashkent–Samarkand highway, where previously the maintenance of green zones required a large workforce.

Plant resilience during the vegetation period proved to be higher: leaf greenness, photosynthetic activity, and drought resistance showed better results compared to traditional methods [1, 7].

The possibility of remote control based on IoT (Internet of Things) increased the speed of maintenance [2, 8].

Table 1

Table of Results

Indicator	Traditional Method	Automated Method
Water consumption	100%	70–75%
Labor costs	100%	60%
Plant resilience	Medium	High

The obtained results show that traditional methods of maintaining green zones along highways, based on manual labor, lead to inefficient use of significant resources. In particular, during irrigation, uneven distribution of water resources, increased labor costs, and insufficient efficiency of control mechanisms are observed. Moreover, existing systems do not provide adequate results in maintaining stable plant growth.

Addressing these problems has demonstrated the effectiveness of applying automated maintenance systems. According to the research results, the introduction of automated irrigation systems and sensor-based monitoring technologies makes it possible to significantly reduce water consumption, save energy and labor resources, and ensure continuous control over the maintenance process. As a result, conditions are created for the rational use of resources, ecological sustainability of green zones is ensured, and the quality of roadside maintenance is significantly improved.

Thus, it can be stated that the use of automated systems not only increases economic efficiency but also serves as an important factor in strengthening environmental safety, improving road aesthetics, and creating a comfortable environment for drivers [4, 10]. In Uzbekistan, this process is being implemented gradually: for example, along the Tashkent Ring Road, automatic drip irrigation systems have been introduced, operating on the basis of energy-saving pumps and solar panels.

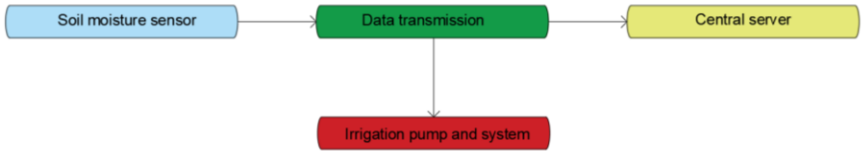

Fig. 1. Block Diagram of the Irrigation System

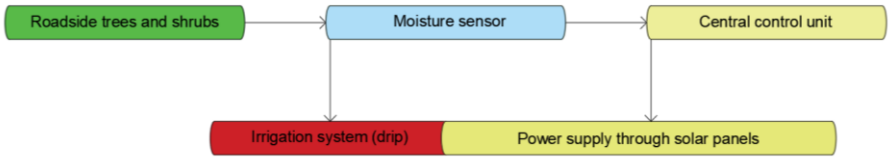

Fig. 2. Operating Principle of the Automated Landscaping System along the Tashkent–Samarkand Highway

4. Conclusion

The study confirms that the implementation of automated systems for maintaining green zones along highways provides significant ecological, economic, and social benefits. Practical evidence from the Tashkent–Samarkand highway, the Tashkent–Chirchik route, and the Tashkent Ring Road highlights the effectiveness of such solutions in real-world conditions. Automation contributes to the rational use of water and labor resources, enhances plant resilience, and streamlines maintenance operations. Looking ahead, the integration of these technologies is expected to become an essential component of the "smart road" concept, fostering the development of a more sustainable, efficient, and innovative transport infrastructure.

References

[1] Al-Kaabi, K., & Al-Bastaki, N. (2021). Smart Irrigation Systems for Sustainable Urban Landscapes. Journal of Environmental Management, 288, 112125. https://doi.org/10.1016/j.jenvman.2021.112125

[2] Gupta, R., & Yadav, A. (2019). IoT based Automated Irrigation System for Roadside Green Belts. International Journal of Advanced Research in Computer Science, 10(5), 56–62. http://dx.doi.org/10.26483/ijarcs.v10i5.6462

[3] Li, J., Wang, P., & Zhao, X. (2020). Application of Telemetry and Sensor Networks in Urban Greenery Maintenance. Sustainability, 12(7), 2884. https://doi.org/10.3390/su12072884

[4] Food and Agriculture Organization (FAO). (2017). The Future of Food and Agriculture: Trends and Challenges. Rome: FAO. https://www.fao.org/3/i6583e/i6583e.pdf

[5] Khannanova, G. T. (2009). Минеральный порошок на основе пиритных огарков и его использование в асфальтобетонных смесях. Диссертация, Уфа. https://tekhnosfera.com/mineralnyy-poroshok-na-osnove-piritnyh-ogarkov-i-ego-ispolzovanie-v-asfaltobetonnyh-smesyah

[6] Rybiev, I. A. (2012). Bitumen-Mineral Interactions and Road Pavement Durability. Moscow: Transport Publishing. https://search.rsl.ru

[7] Qodirov, B., & To‘rayev, M. (2022). Shaharsozlikda avtomatlashtirilgan sug‘orish tizimlarining qo‘llanilishi. O‘zbekiston Milliy Universiteti Ilmiy Xabarlari, 2(4), 77–85. https://uzjournals.edu.uz/natlib/vol2/iss4/12

[8] World Bank. (2020). Transforming Urban Transport: Pathways to Sustainability. Washington, DC. https://openknowledge.worldbank.org/handle/10986/34127

[9] Zhou, Y., & Chen, L. (2018). Energy-Efficient Smart Irrigation with Solar Power in Urban Roadside Areas. Renewable Energy, 126, 509–518. https://doi.org/10.1016/j.renene.2018.03.056

[10] Karimov, Sh., & Jalilov, O. (2023). Yo‘l bo‘yidagi ko‘kalamzorlashtirishning ekologik samaradorligini oshirishda avtomatlashtirishning o‘rni. TIIAME Ilmiy Jurnali, 3(1), 45–52. https://tiiame.uz/journal/articles/eco-green-automation.

[11] Ergashova M. Z., Bobonazarov T. S. Greening City Streets and Roads in Modern Urban Conditions //Sustainable Development of Transport. – C. 3.

Information about the author

Jurakulova Navbakhor	Tashkent State Transport University, Teacher of the Department of Urban Roads and Streets, Email: navbahor.1011@gmail.com https://orcid.org/0009-0003-4565-0699
Khalimova Shakhnoza	Tashkent state transport university, Docent of the Department of Urban Roads and Streets, Email: xalimova_sh@tstu.uz https://orcid.org/0000-0002-4753-390X

CONTEXT / MUNDARIJA