COMPARATIVE ANALYSIS OF TRADITIONAL AND HIGH-PRECISION GNSS METHODS IN TREE INVENTORY

Nafisa Abduraximova[1],
O‘rol Bo‘tayev[1],
Obidjon Abdirazzaqov[1]
[1]Central Asian University of Environmental and Climate Change, Tashkent, Uzbekistan
E-mail: obidjonabc@gmail.com

Abstract

This paper presents a comparative analysis between traditional methods and high-precision GNSS (Global Navigation Satellite System) technologies in the process of tree inventory and registration. The study examines the advantages and limitations of both approaches in managing urban ecological infrastructure, accounting for urban greenery, and determining tree locations. Using Tashkent city as a case study, special attention is given to the accuracy, efficiency, and reliability of GNSS-based measurements.

The findings demonstrate that GNSS technologies enable centimeter-level accuracy in determining tree coordinates, provide automatic data integration into digital maps, and facilitate effective environmental monitoring. The paper also highlights the practical benefits and recommendations for transitioning from conventional survey techniques to GNSS-based digital inventory systems.

Keywords: tree inventory, GNSS technology, traditional methods, digital mapping, environmental monitoring, GIS, Tashkent city, accuracy, RTK, geoinformation systems

Introduction

In the modern era, the use of digital technologies in ensuring environmental sustainability, controlling urbanization, and managing urban infrastructure is rapidly increasing. Particularly in large cities like Tashkent, managing green areas and maintaining accurate data on urban trees has become a national priority.

Precise identification of the number, condition, species, and spatial distribution of trees plays a crucial role in maintaining ecological balance, assessing urban ecology, and implementing effective greening policies. Therefore, studying the advantages of traditional and modern — GNSS-based — methods in tree registration is a timely and practically significant task.

Literature Review

In recent years, geoinformation technologies — especially GNSS systems — have expanded beyond geodesy and cartography, finding wide application in ecology and natural resource management.

Karimov and Abdurakhmonova (2022) highlighted the practical benefits of GNSS technology in urban development, emphasizing its ability to automate ecological monitoring in urban areas.

Abbasov (2023) noted that geoinformation systems are key tools for promptly updating tree inventory data and integrating them into digital maps.

International practices (Trimble Inc., 2021; Emlid, 2022) have shown that RTK (Real-Time Kinematic) GNSS technology can achieve centimeter-level precision, ensuring reliable data collection and real-time monitoring capabilities.

Traditional Methods of Tree Inventory

For many years, tree inventory processes relied on traditional techniques such as manual measurement, sketching, estimation based on topographic maps, or using basic GPS receivers. The main drawbacks of traditional methods include:

- Low positional accuracy (5–15 meters);
- Manual data entry requirements;
- High dependency on human error;
- Limited integration with GIS systems;
- Slow data updating process.

While traditional methods may suffice for small-scale studies, they are inefficient for large urban areas, leading to inaccuracies and outdated data in ecological databases.

High-Precision GNSS Technologies

GNSS technologies determine spatial coordinates through satellite systems such as GPS, GLONASS, Galileo, and BeiDou. Using RTK (Real-Time Kinematic) and PPK (Post-Processing Kinematic) modes, location accuracy can reach 2–5 centimeters.

Key advantages of GNSS technologies include:

- High accuracy and reliability;
- Full integration with digital mapping and GIS systems;
- Rapid data collection and analysis;
- Real-time monitoring through cloud-based systems;
- Improved environmental accountability and control.

These features make GNSS-based tree inventory a strategic necessity for modern urban ecosystem management.

Comparative Analysis of Traditional and GNSS Methods

Criteria	Traditional Methods	GNSS Methods
Accuracy	5–15 m	2–5 cm
Data collection speed	Low	High
GIS integration	Limited	Full
Human error probability	High	Minimal
Data updating	Manual	Automatic
Cost efficiency	Low initial, high long-term cost	Higher initial, cost-effective long-term

The comparative results indicate that GNSS technologies outperform traditional methods in terms of accuracy, speed, and operational reliability.

Practical Implementation in Tashkent City

In recent years, under the "Green Tashkent" initiative, the use of GNSS technologies for tree inventory has significantly expanded.

The State Committee for Ecology conducted pilot projects using Trimble and Emlid Reach RS2 devices for tree registration.

Results showed that GNSS-based measurements provided **tenfold higher accuracy** and required **four times less time** compared to traditional approaches.

Collected data were integrated into a digital map using QGIS software and uploaded to a unified environmental monitoring database.

Discussion and Results

Analysis revealed that although traditional methods have historical value, they no longer meet the accuracy and efficiency requirements of modern urban management. GNSS technologies not only improve precision but also enable automation of environmental monitoring, real-time supervision, and efficient resource management. Integrating GNSS-based tree registration into digital governance systems is a vital step toward smart urban ecology.

Conclusion and Recommendations

High-precision GNSS technologies demonstrate clear advantages over traditional methods in tree inventory processes.

The wide implementation of such technologies in Tashkent would allow:

- Complete digital mapping of urban trees;
- Real-time data updating;
- Establishment of a transparent and reliable environmental monitoring system.

Future prospects include developing mobile applications based on GNSS for automated field data collection and using artificial intelligence to assess tree health and urban vegetation dynamics.

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