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# Modern approach to inventory of urban green spaces using GIS-technologies (in terms of the city of Rostov-on-Don)

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**Summary.** As a result of the survey, a geospatial database was generated – a digital twin of Rostov-on-Don green structure facilities. The work was performed with the use of advanced knowledge-intensive technologies by means of unmanned aircrafts, mobile laser scanning, automation of data recording and transmission. The obtained results allow for estimation of quantitative and qualitative condition of landscaping and greening of the areas of separate districts and the city in broader terms for the given period, and they are the basis for prospective planning both of operating expenses for spaces maintenance and expenditures for new construction and repair of facilities.

## 1. Introduction

Rostov-on-Don is the largest city in the south-west of Russia, and the administrative center of South Federal District and Rostov region. There are 14 parks and 35 public gardens in the city, which in aggregate occupy 1.4 thousand ha. Another 1.2 thousand ha account for shrubs near motor roads. There are also the so-called special greening facilities in Rostov which include the embankment territory, Pushkinskaya street and Fountain square in the October Revolution park. The main dilemma of green construction in Rostov-on-Don is to find a favorable ratio of architecture-planning and environmental functions of green spaces [1, 2].

It is known that environmentally efficient creation and maintenance of urban greening system is impossible without detailed inventory of currently existing spaces, subject to all the figures which reflect their condition. It is necessary to develop recommendations for servicing the existing spaces in order to maintain their performance. However, in this case planning of new greening facilities is also required subject to the territory features, its social, economic and environmental requirements [3, 4].

It is impossible to create new urban spaces without condition analysis of the types which have been springing up for quite a long time under certain conditions of the city microclimate [5].

Therefore, everything begins with acquisition of accurate and comprehensive information about the structure and condition of all the elements, namely trees, shrubs, lawns, and flower gardens.

## 2. Methods and Materials

In 2019 the work on comprehensive inventory of almost all the shrubs growing in the city area was conducted for the purpose of creating a reliable green space database with import of obtained results into digital geoinformation system GIS BIS. The use of GIS-technologies is increasingly evolving in



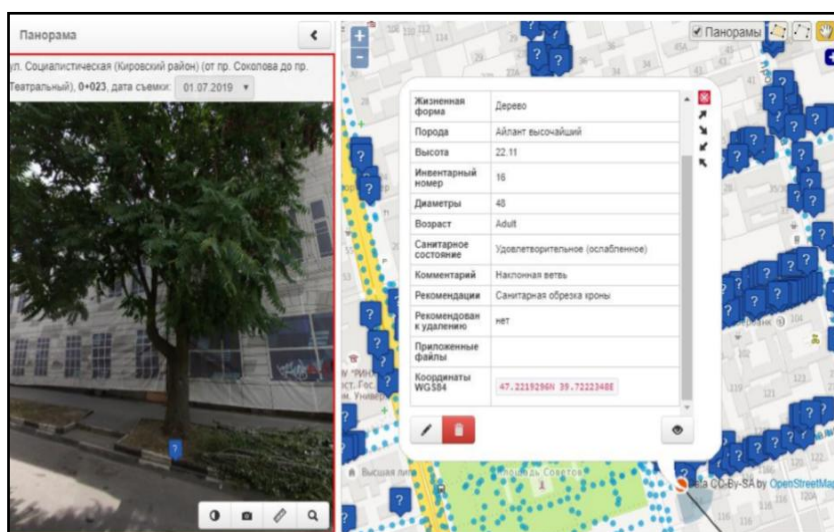
the field of urban environment monitoring [6-8]. The inventory was carried out on the basis of established procedure [9, 10]. Based on information obtained, it is expected to generate programs on maintenance and development of urban green resources in the years to come (table 1).

**Table 1.** The stages of survey.

Stage	Stage content
1 Acquisition of primary information	Panoramic shooting, air-borne survey, land survey and laser scanning to be performed
2 Spatial map creation	Spacing, landscaping facilities and road network to be mapped
3 Full-scale survey	Dendrology experts will inspect the spaces visually, entering information into the program unit with automatic unloading to the server
4 Receipt of the spacing system digital twin	Completion of office analysis and unloading to public access

### 3. Results and Discussion

For the first time in real practice a geoinformation electronic platform was introduced for data processing, into which the items required for survey are loaded, which sealed the timing gap between on-the-field survey performance and processing of obtained results during office analysis. All the spaces formed within various categories of urban development were studied (multi-floored residential development, private low-rise development, recreation areas). The survey resulted in formation of a geospatial database which is a digital twin of green facilities in Rostov-on-Don. For work performance advanced knowledge-intensive technologies were involved, such as unmanned aircrafts, mobile laser scanning, automation of data recording and transmission. All results were generated as part of the digital platform. A vast volume of work was conducted on inventory of green spaces, including entering the obtained results into GIS system GIS BIS (more than 260 thousand spacing facilities with generation of the 21st information layer). Figure 1 shows the example of the survey unit reflection, namely an in-row tree planting.



**Figure 1.** Example of the tree data display in inventory materials.

All in all, about 210 thousand copies of trees and shrubs were described, 71.4% of which belong to the trees and 28.6% to the shrubs. This is a feature of Rostov-on-Don urban greening. It has been established that around 100 types of trees are presented broadly enough in the city (over 1000 copies and more). In the city flora representation predominant species are apricots, cultivated sweet cherries and walnuts, the percentage of which reaches 14 % of total number of the trees. This results from a good deal of private low-size development where, above all, residents were interested in growing of edibles. Approximately 100 types of trees can rarely be seen, but still, they increase the figure of species diversity, for example, certain oaks, or ginkgo biloba.

As for the shrubs, the situation is quite different. Only about 30 types are broadly presented around the city. Fruit and berry shrubs are not so many. Those which have the content percentage up to 5% are only black currants, being also predominant in the private low-rise sector. Lilac grows everywhere. It is used both for row and single planting. Feeling perfectly in the city streets, it forms large dense shrubs. Staff trees are widely used for hedgerows, since their percentage is also large. All types of roses - both species and hybrids - are prevalent in view of their decorative qualities, being part of ornamental designs. Mass introduction of ornamental shrubs into the urban flora is obvious.

Sanitary condition of the spaces in Rostov-on-Don represents a major challenge, since only 10% are in good condition and do not require human intervention for life support. Almost half of the trees require replacement, being in unsatisfactory condition and posing a threat to the residents. Primarily these include time-worn planting of black poplars. It is noted that maintenance operations are insufficient and more than 20% require sanitation and tree pruning. One of the main reasons is planting age. In low-rise part of the city fruit trees can frequently be seen at senile stage.

Based on the analysis of the presented data, it is fair to say that condition of weakened and severely weakened trees is prevalent among predominant species. The most frequently encountered reason is abundance of dry branches in the crown which often have emergency slant, in combination with presence of stem rots and kames. Vermin inflict a great deal of damage to the vital condition of trees, for which reason up to 12% are recommended for felling. A separate group, approximately 6%, includes trees with emergency trunk slant which are dangerous to people passing by. Despite the city climate unfavorable for a number of tree species for their growing, almost 3% have significant frost splits on the trunks with stem rot evolving to the extent that these trees are recommended for removal. A large number of introduced species from Central Asia is observed in Rostov-on-Don [11]. Trees with severe mechanical damage and trees with large hollows and actively flowing processes of fruit bodies growing on the trunks amount to 2-3%.

The green spacing system also includes lawns. Almost all of them are related to the common category (99.43%). The grassy ones can be seen in the downtown, while the meadow ones are mostly located along the roads. Half of the facilities areas are in unsatisfactory condition, which is due to abundance of weed vegetation, trampling and different grass turf damage.

#### **4. Conclusion**

In light of all of the above, it is arguable that the procedure developed by “Road Consulting” LLC in cooperation with the Landscape Construction Department of the Ural State Forest Engineering University is innovative. The lessons learned from performance of the dendrological survey are worth being implemented into a good practice.

The deliverable is an electronic base of green spaces in the city, including their composition, morphology and sanitary condition, which, in essence, is formed by digital twin of the city. Based on the received digital twin, the following trends can be developed:

- Systemization of urban green resources with division into possession categories;
- Planning of work on greening of urban territories: all economic entities with access to the system can see where exactly and what operations are conducted;
- Adjustment of the current situation based on quick entering of data and possible unloading of required information by preset parameters with a single click (sampling by certain areas, types of facilities, sanitary condition, etc.);

- The work process performance improvement of green economy experts by means of a user-friendly interface and access to large scopes of information;
- Recording of facts of administrative violations in the field of green economy by assigning an identification number (ID) to each facility;
- Adaptation to certain conditions and operational requirements for territories, for example, planning of spaces reconstruction of separate urban districts;
- Development of urban greening planning strategy.

The obtained results allow for estimation of quantitative and qualitative condition of landscaping and greening of the areas in separate districts and the city at large for the given period, and they serve as the basis for prospective planning of both operating expenses for spaces maintenance and expenditures for new construction and repairing of facilities of the city.

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