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Forest Management System Based on Geospatial Information Resources

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Abstract: The article discusses the development of geospatial information support for addressing forestry issues, implemented in the form of a forest geoinformation system that ensures the resolution of multi-level management problems within the Republic of Uzbekistan.

Keywords: Forest infrastructure, public-private partnership, transport accessibility, efficiency, forestry complex, investments, regional development, logistics, strategic planning, economic assessment.

Introduction: The development of sustainable forestry is one of the main tasks of forest management. Sustainable forest management refers to purposeful, long-term, and economically beneficial relationships between people and forest ecosystems. Nowadays, it is difficult to imagine sustainable forest management without forestry materials and environmental monitoring data. The main goal of forest management is to obtain reliable and comprehensive information about the forest fund, ensure the rational use of forest resources, and develop a system of measures aimed at the efficient expansion, protection, and preservation of forests.

Data obtained in the field of forestry are one of the key sources for shaping information resources about the state of the environment, anthropogenic impacts, and even transboundary transfer of pollutants. These data contribute to more rational use of natural resources and help assess the condition of potentially hazardous facilities for the national economy.

The main task of forest management is to provide forestry professionals, forestry-related activities, and government bodies with information through maps indicating forest resources and their location, and to monitor the activities of organizations operating in forested areas. The goal of the environmental monitoring system is to support and supply information for decision-making processes in environmental protection and environmental safety. Without proper information support, it is impossible to manage forests effectively.

The rapid development of computer technologies and information systems, along with the emergence of GIS as systems enabling the use of spatially distributed multi-temporal data, has fundamentally transformed the entire information supply system of forestry. It has also created a need to develop specialized geographic information systems (GIS) to address forestry-related challenges.

LesGIS offers several methods for updating data:

- Based on field surveys of forest areas using GPS;
- Based on field interpretation of aerial photographs and images;
- Based on satellite imagery.

After a detailed analysis of the functional features of various GIS platforms—including their sets of service applications, ability to work with cartographic materials, user-friendliness, and ease of learning - MapInfo was selected as the base system.

LesGIS possesses computing and modeling functions

for working with integrated databases, allowing for the adoption of various user solutions in forestry:

- Making current updates to existing inventory (information) and cartographic databases using computers, ensuring up-to-date information about the forest fund at all times;
- Retrieving data from the database in both digital and cartographic formats through standard and custom queries (including spatial distribution of query results).

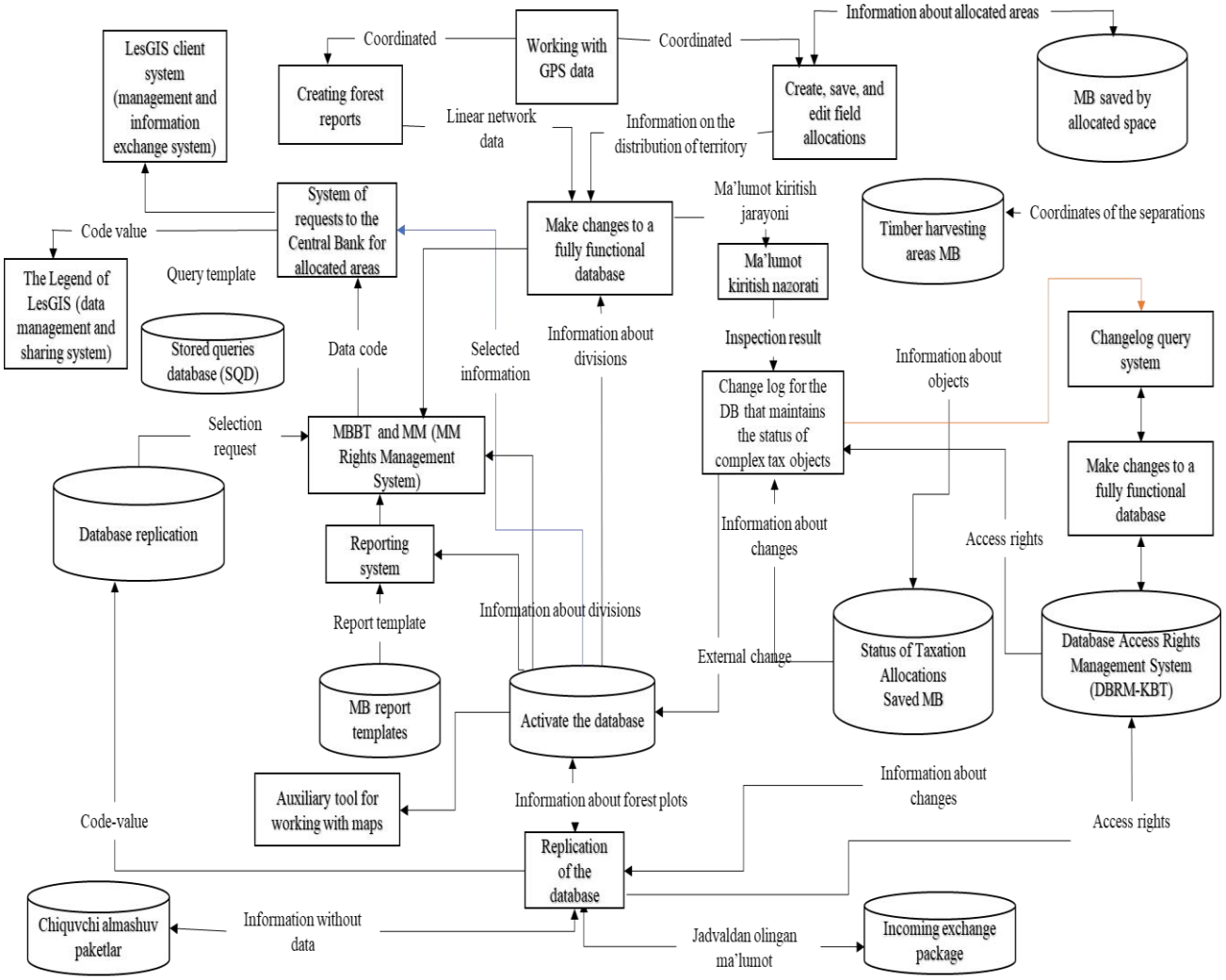

Figure 1 – General Structure of LesGIS

Let's briefly consider the functional capabilities of the complex (system):

1. The information acquisition and query generation block provides the following: obtaining information about each plot of forest fund land; creating queries, obtaining reports on queries and thematic maps; obtaining information about felling sites.

2. Linear and area object cranes block: production of cranes of linear objects (roads, power lines, highways, etc.) and area objects (deviations); allocation of land plots for the construction of industrial and residential facilities; obtaining descriptions of forest fund land plots within the boundaries of the allocation, material and monetary valuation based on forestry data, data for drawing up a declaration by the forest user.

3. GPS working block: using GPS receiver data when making changes to the cartographic database.

4. State Forest Register block: obtaining the main forms of the State Forest Register; report on the assortment composition of forest stands; report on the results of cadastral assessment; report on the results of material and monetary assessment of felling areas.

5. Block "Create queries".

The formation of queries for the selection and grouping of taxation indicators is carried out using the "Query system for the DB unit" module. The standard SQL language for creating queries to databases.

6. "Forest Fund" block:

- obtaining material and monetary assessments based on allocation data;

accounting for actually cut timber, taking into account inspection reports of felling areas and violations of the rules for the removal of standing timber, analysis of the felling fund;

- receiving statistical reports;

- a set of statistical reports, analysis of the use of forest resources at all levels of management.

The information basis of the system is a data bank, the composition and organization of which are determined by the composition of input and output data necessary to solve functional problems. The main component of the information system is a unified relational database containing information on forestry. Additional databases are provided for the operation of the system:

- a database of stored areas;

- a database of timber harvesting areas;

- a database of stored queries;

- a database of access control systems (DBKNKT);

- a database of report templates;

- a database of the status of tax allocations;

- a normative-informational database (MMMB)

- a replication database.

The main element of the geographic information system is the forest inventory database, which is a set of interrelated template tables, the content of which describes various aspects of the state of forests. The fields of the layout tables contain numerical data and coded data on the taken-into-use taxation indicators, quality characteristics and planned activities. The data encoding complies with the SOLI (Forestry Information Processing System) standards and is accompanied by the corresponding references, which are part of the MM (normative-informational) database specially provided in the system. The structure of the database is an example of a sample form of a tax card filled out in the forestry process. The thesis describes the technology of the state forest inventory, developed using the LesGIS geoinformation system and aerospace research materials.

Defined the concept of organization of monitoring of forest fund lands (forest monitoring), which is based on a system of complex monitoring of the state of the forest fund using remote sensing methods throughout the territory and a system of ground control with selective placement of permanent observation points, taking into account the natural conditions of forests, influencing factors and the ecological and economic significance of forests; and also with the use of space images. The characteristics of the tax and the stock of fallen harvests can be determined on the basis of large-scale aerial photographic materials or during ground inspection of felling areas.

To predict the success of subsequent restoration work on felled areas, aerospace images are used to record preserved seed fragments and lines, determine the sizes and distances between them, and compare the obtained data with the materials of the delimitation of felling areas. In logging areas, the timber reserves cut as a result of cutting seed strips or strips are determined based on their area and reserves indicated in the logging area allocation materials or forestry materials. In order to determine the degree of damage to the soil and the degree of mineralization of its surface from the impact of logging equipment during clearing, the total area of skid tracks, timber storage areas and other production facilities is determined from photographs. In clearings in mountain forests, the degree of development of erosion processes in the form of linear forms of erosion or layered soil washing is also determined.

The area of forestry monitoring is shown in Figure 2. In the statistical inventory of forests, a network of sample plots is created throughout the studied area, located in a certain order and statistically representative in terms of their totality. When conducting a state forest inventory (GIL), it is necessary to determine the density and placement method of the sample plot network at the GIL work site.

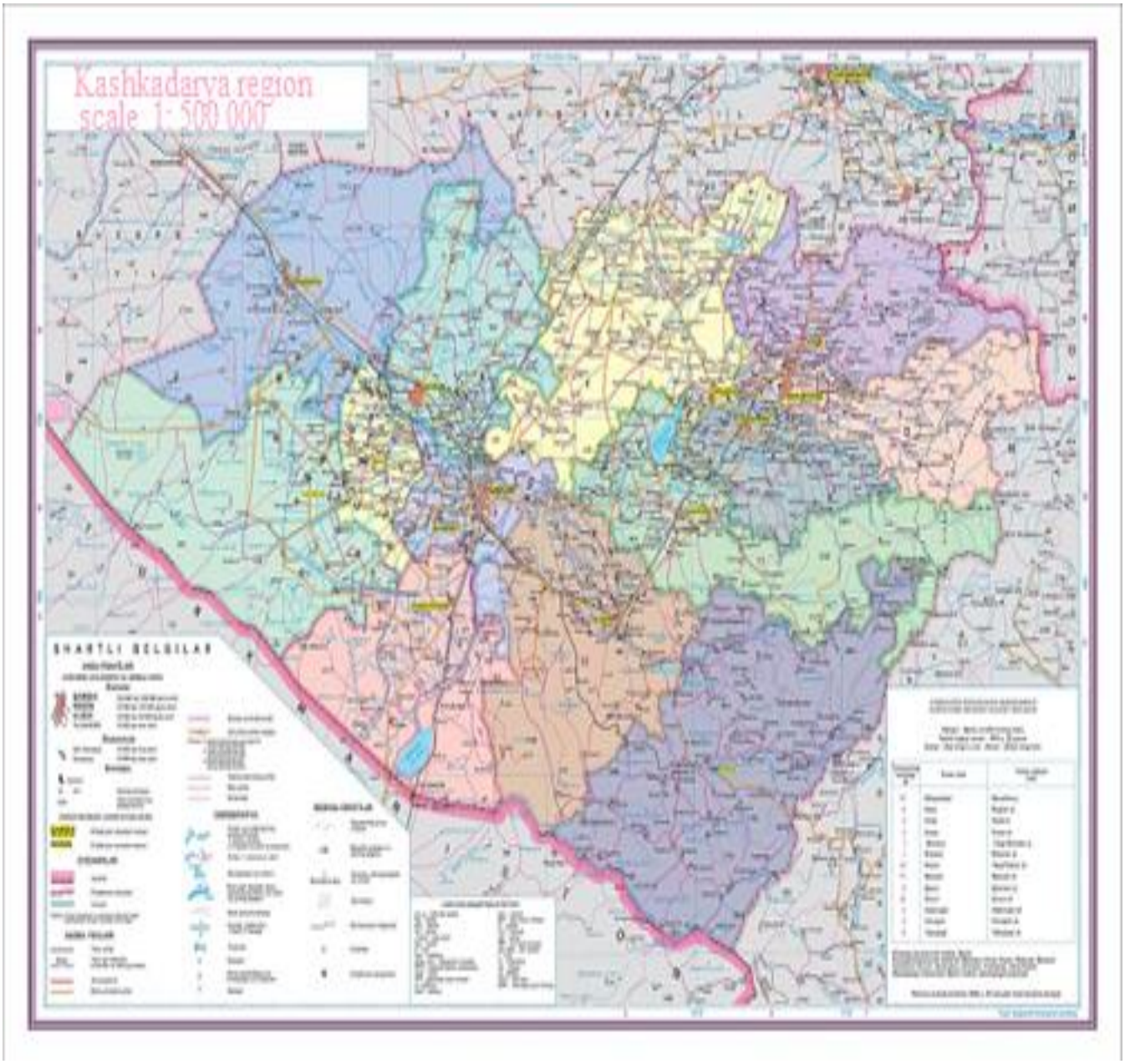

Fig. 2. Kashkadarya region forestry monitoring workspace

The above-mentioned GIL tasks are solved using LesGIS. LesGIS is used to create digital maps of the distribution of the GIL work object area by layers (stratification) and to determine the number of sample plots. The scheme for implementing the complex of works on maintaining the state forest fund is shown in Fig. 3.

Since digital databases have been created for only a third of the district forestry enterprises in Kashkadarya, the issue of creating a digital information base for forest inventory through the processing of paper-based forestry materials is becoming especially relevant.

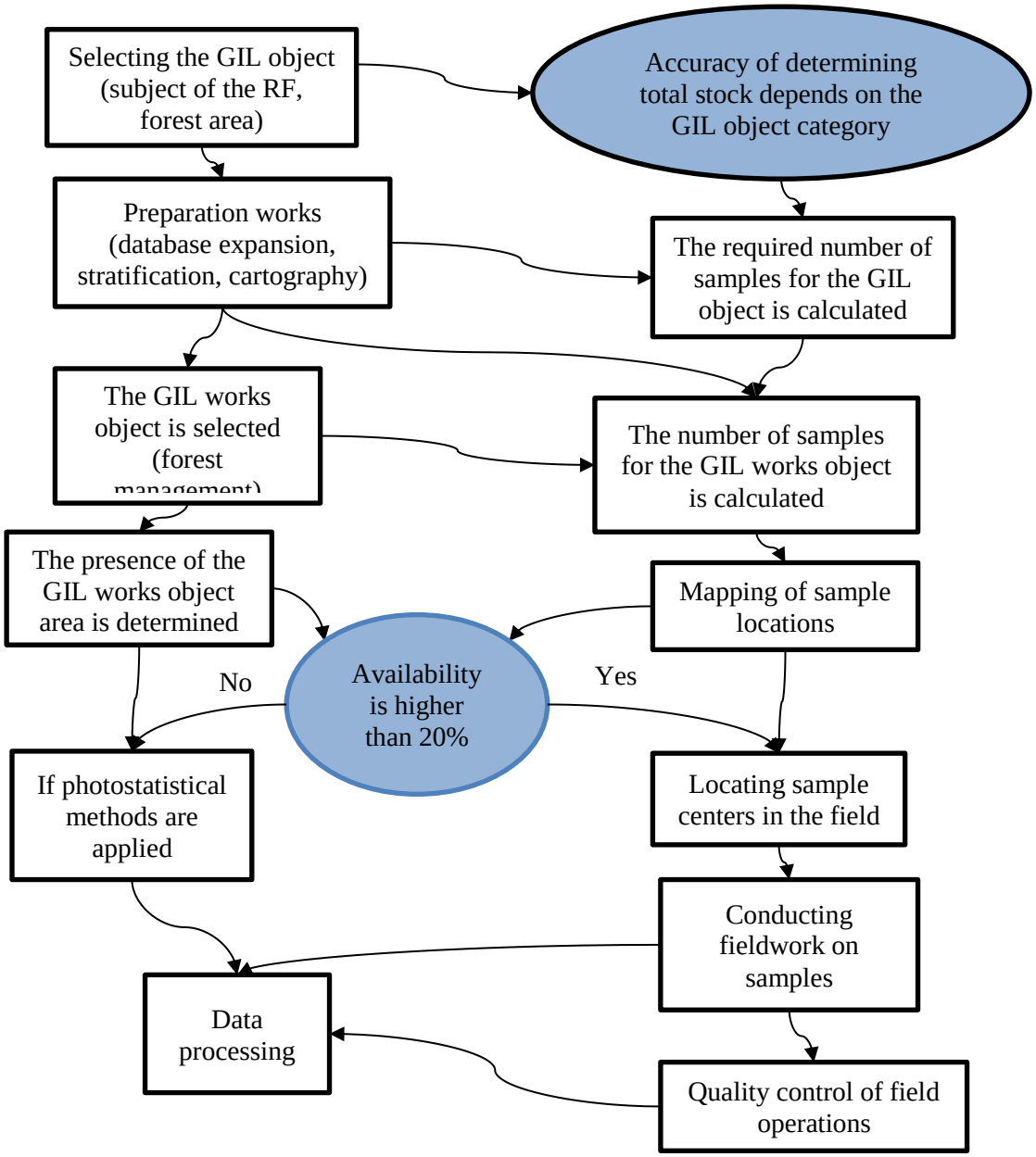

Figure 3 - Scheme of the complex of works on the State Forest Fund

The document proposes the following scheme for preparing an information base for the state forest inventory:

- collection of the latest forestry materials in forestry enterprises (former forestry enterprises): tablets, forest plantation plans, tax descriptions;

- obtaining topographic maps (scales from 1:10,000 to 1:50,000, depending on the scale of forestry plans and the availability of topographic maps for a given area);

- scanning of forestry planning and cartographic materials and topographic maps;

- input of main indicators from the tax description: forestry, district forestry, quarter number, allotment number, allocated area, land category, dominant species, quality class, FT (forest type), dry tree trunks, litter, density, reserve in the allotment; characteristics

For areas used to obtain general information on Uzbekistan (periodic inventory), it is necessary to additionally enter the full tax characteristics of planting;

- linking forestry materials with topographic maps, their vectorization, creation of digital maps of the forest and forest GIS for forestry objects;

- obtaining materials of space photography (aerial photography) with their subsequent processing to introduce changes occurring under the influence of economic activity and natural factors (deforestation, burns);

- taxation (at the level of land categories) and correction of cartographic databases using forestry GIS.

The LesGIS geoinformation system plays a special role in updating forestry data. This is due to the fact that the

functional capabilities of the system allow loading remote sensing materials (raster of aerial photographs and space images) into cartographic and taxonomic databases created on the basis of the proposed technology and making changes to these databases based on image analysis. In addition, the age of forestry materials predetermines the need to update forest taxation indicators (changes in height and diameter, density and stock). All this can also be done using the LesGIS geographic information system. Thus, the final result of the actions is the update of cartographic and taxonomic databases used to plan GIL work. The following characteristics are accepted for the forest: species group (main species), age group, areas not covered by forest vegetation (burnt areas, gaps, etc.), vertical zonality. As one of the specific features when determining layers in mountainous areas, the author also suggests taking into account vertical zonality, so the height above sea level is related to the productivity of forest plantations.

By constructing surveys taking into account the criteria for determining layers, digital maps of the distribution of the territory of the GIL work object by layers are created using the GIS “Forestry”. Figure 4 shows a part of such a map.

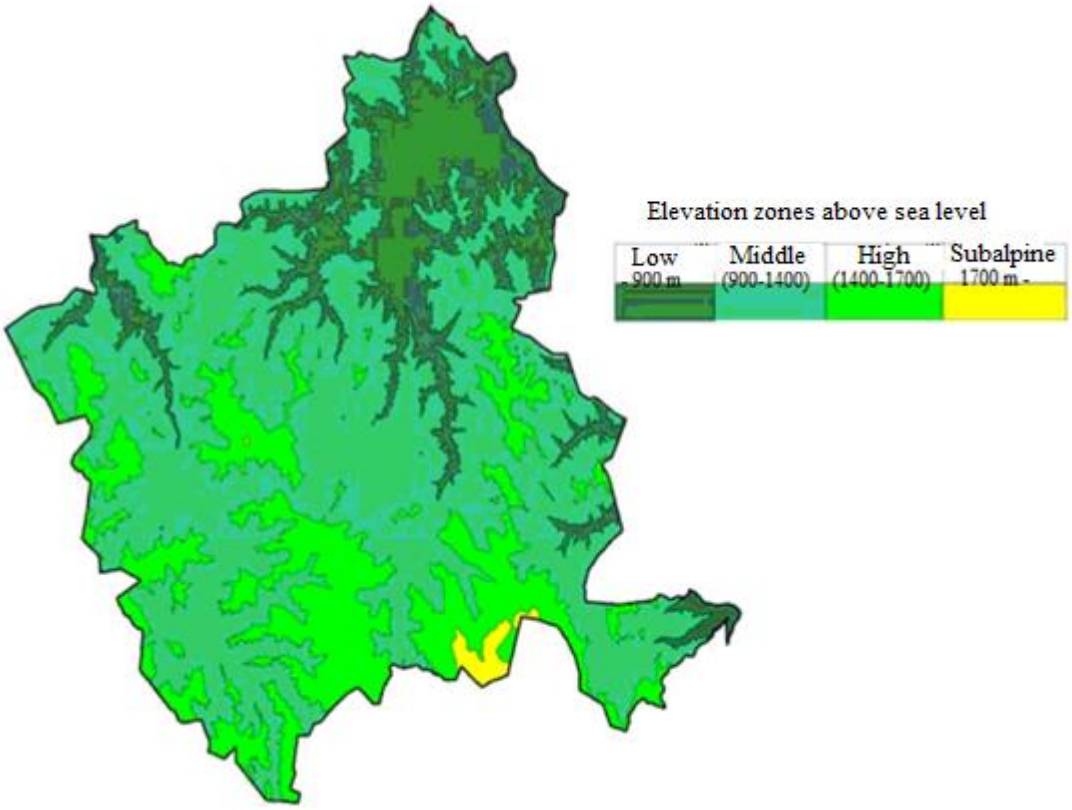

Figure 4 - Example of polygon distribution of elevation zones using LesGIS

The polygon design diagram is shown in Figure 5. Each polygon has an elevation attribute.

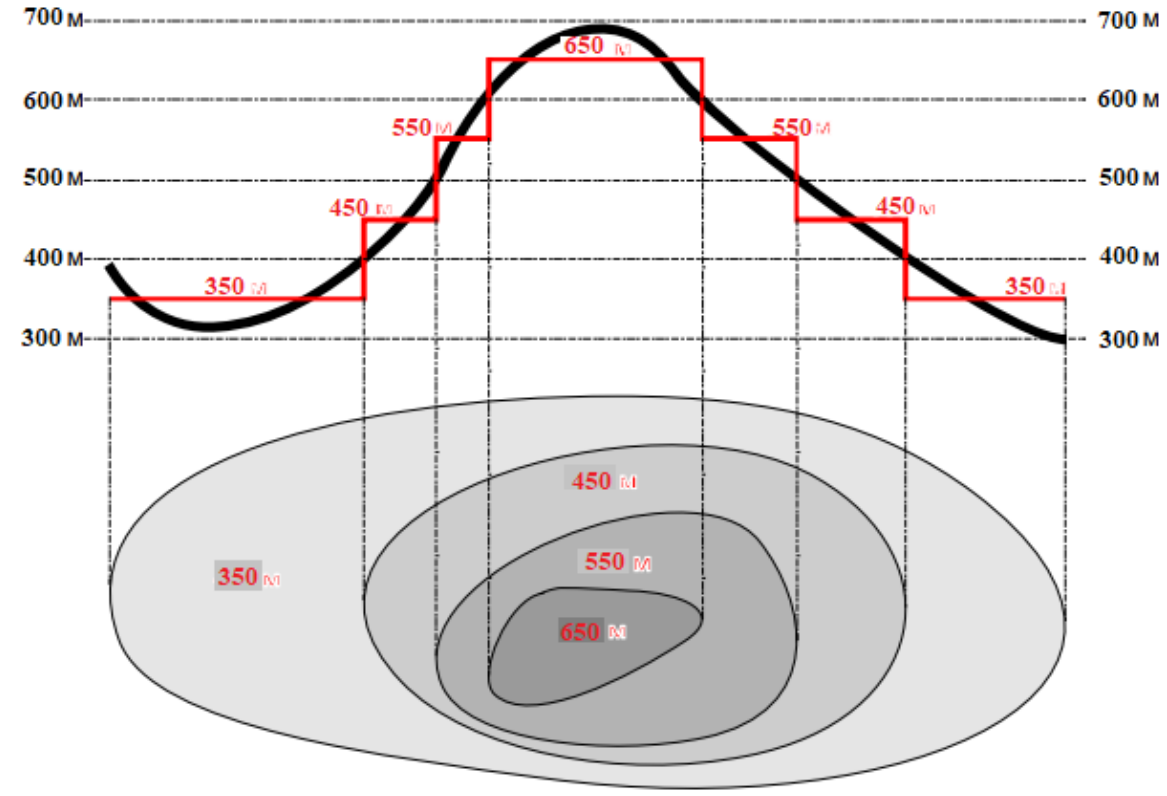

Figure 5 - Polygon distribution scheme by elevation classes

The article proposes a methodology for monitoring forest management practices using space imagery, digital aerial photography, and ground surveys. The work on identifying illegal logging sites was carried out both interactively and automatically using multi-zone satellite imagery by comparing space imagery acquired at different times.

CONCLUSION

As a result of the conducted research, the following main results were achieved: The tasks of forest planning and forestry management were analyzed, the prospects for the development of forest planning based on new methods of data collection and processing were considered, and methods for making management decisions using geographic information systems (GIS) were analyzed. To ensure the solution of forestry problems at various management levels, the architecture of a geographic information system was developed: district forestry - a forestry body of a subject of the Republic of Uzbekistan; and the logical structure of databases necessary for solving these problems. It is proposed to use a territorial database as the basis for forming an interconnection of geographic information system databases to ensure forestry management. The architecture, database structure, query system and necessary functional modules are proposed to provide data analysis for making management decisions at various levels of forestry management in the subject of the Republic of Uzbekistan. The technology of state forest inventory based on high and medium-resolution satellite imagery and stratification using the LesGIS geoinformation system has been developed. The tasks of ecological monitoring of forests have been formulated and the technology for implementing monitoring has been developed. This technology is built on the basis of medium and high-resolution satellite imagery, digital aerial photography and the LesGIS geographic information system. Monitoring serves to solve the following tasks:

- detection of illegal logging;

- monitoring of compliance by forest users with the basic rules and regulations of forestry management;

- assessment of the condition of clearing areas after logging (inspection of clearing areas).

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