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Pilot project of the forest information system in the Arkhangelsk region (Russia)

Igor Muraev[1] and *Olga* Sushko[2*]

[1]The Government of the Arkhangelsk region, 163000, Arkhangelsk, Russian Federation
[2]Plekhanov Russian University of Economics, 36, Stremyanny Lane, 109992, Moscow, Russian Federation

Abstract. The article emphasizes the relevance of the research topic related to the digitalization of the forestry complex, the new stage of which was the development and implementation of FGIS LC. The object of the study is the process of implementation of FGIS LK in the Arkhangelsk region. The purpose of the study is to conduct an in-depth analysis and study of the results of the implementation of FSIS LC in the Arkhangelsk region as a pilot project. During the work, analytical materials, reports of specialized institutions and scientific articles on this topic were studied. The study used both qualitative and quantitative methods. Qualitative methods included observation, interviews, professional assessments, and testing. Quantitative methods such as questionnaires and monitoring were used in combination with these. To analyse various sources of information, methods of analysis and synthesis, comparison, as well as an empirical approach were used. The results of the study include an analysis of foreign information systems and services for forest accounting, timber harvesting, as well as an assessment of the architecture, structure and functionality of FGIS LC, as well as an analysis of the implementation process of FGIS LC in the Arkhangelsk region. Expert discussions with professionals on the implementation of FSIS LC in the Arkhangelsk region made it possible to identify a number of main errors and ways to solve them. Testing the functionality of FGIS LC in the Arkhangelsk region is focused on solving key issues that require refinement and improvement of the system. An analysis of the experience of implementing FGIS LC in the Arkhangelsk region revealed the best practices and difficulties of working with this system. Such analysis is necessary, as it helps to optimize processes in the activities of enterprises and government agencies.

1 Introduction

Effective development of the forestry sector is impossible without modern information systems. Digitalization and informatization of the forestry sector means the introduction of innovations and information systems into all business processes. The introduction of full-cycle information systems from cutting to wood sales is not just a technical solution, but an

* Corresponding author: osushko@mail.ru

integrated approach aimed at increasing the transparency and sustainability of the forestry industry (Fig. 1).

Strengthening control over forest use:

- The need to prevent illegal logging, trace the origin of wood and ensure its legality.

Improving forest management:

- Increasing the efficiency of logging, optimizing supply chains, reducing wood losses.

Reducing business risks:

- Ensuring transparency of transactions, protection against counterfeiting and falsification, increasing confidence in products.

Compliance with international standards:

- Implementation of wood tracking systems in accordance with the requirements of FSC, PEFC and other international organizations.

Fig. 1. Triggers of informatization of the forestry sector.

The development of digitalization of the forest complex began with the IS Forest platform, which was created to track the harvesting of wood. However, the development and launch of the platform showed the shortcomings of the functionality and the unwillingness of the forest sector itself to fully launch. The main problem of the LesEGAIS platform manifested itself in the limited functions, since it tracked only the trade in timber. The evolution of digitalization of the forest complex is associated with the transition to the system of the Federal State Information System of the Forest Complex (hereinafter FGIS LC) [1, 2], which has expanded functionality and should take full control over the forest industry. A number of modern trends (Fig.2) conditions the evolutionary transformation of the information system.

Technology development

The introduction of artificial intelligence, machine learning, and big data analysis to automate processes, optimize logistics, and make decisions.

Creating a single digital space Integration of the FGIS LC with other government systems, for example, with the Unified State

Register of Legal Entities, to ensure comprehensive control and transparency. Expansion of functionality

The addition of new modules for tracking the origin, quality and volume of wood, monitoring compliance with forest regulations, managing access to forests and monitoring reforestation.

Strengthening digital tools Development of mobile applications, online platforms, and geographic information systems for user convenience, improving the efficiency and accessibility of information.

Fig. 2. Triggers of digitalization and informatization of the forestry sector.

The Forest Information System (GIS LC) serves a dual purpose: as both a comprehensive information system and a vital instrument for executing national forestry policy and its advancement.

Its implementation signifies more than just a phase in digitalization; it represents a holistic strategy to address crucial strategic objectives at both the federal and regional levels within the Russian Federation. Sustainable resource management is a key area for the development of the forest industry. This involves determining the optimal levels of logging that ensure the conservation of biodiversity, maintain ecological balance and protect forests from forest fires. FGIS LC will ensure the rational use of forest resources, preserve biodiversity, develop the forest industry and make the Russian forest sector sustainable and competitive in the global market. FGIS LC creates conditions for the introduction of innovative technologies in forestry, simplifies the processes of planning and accounting for forest management, provides access to up-to-date information for making optimal decisions.

Thus, the introduction of FGIS LC is an important step towards creating a transparent and sustainable forest sector in Russia, which will serve the interests of both the economy and the environment.

FGIS LC will provide information on the state of forests in real time, allowing you to track changes, plan forestry activities and effectively monitor the use of forest resources. The Federal State Information System Forest Complex (FGIS LC) aims to enhance transparency and accessibility within the forestry sector. By providing a comprehensive platform for data sharing, the system will enable the monitoring of all stakeholders in the industry, from logging companies to government regulatory agencies. This increased oversight is intended to mitigate risks associated with illegal deforestation, corruption, and unsustainable forest management practices. The implementation of FGIS LC was planned for early 2023, but later it was decided to postpone it to 2025. From September 1, 2023, three regions (Moscow, Arkhangelsk and Ulyanovsk) began operating in the system in pilot mode. By the end of 2023, 63 subjects of the Russian Federation had gained access to FGIS LC. Today, three pilot regions, and among them the Arkhangelsk region, have the most work experience, and therefore it is possible, based on the experience of pilot projects, to analyses and summarize the issues and problems of the functioning of FGIS LC.

2 Theoretical overview of the problem

Analytical materials, reports of specialized institutions and scientific articles have been studied on the topic of the study. The article by A.S. Shishlova and L. I. Zagidullina examines the issue of introducing FGIS LC into forestry in order to improve the efficiency of management of the Ulyanovsk region's forest industry [3]. The process of filling the information system, coordinating the input data, maintaining the relevance of information and monitoring these processes is described. An algorithm for optimizing the creation of FGIS subsystems is also proposed. E.A. Nigai, I.A. Nikulin analyzed the results of the digital transformation of forestry management [4]. A.P. Belonozhkina considered the problems of implementing wood monitoring from the cutting site to the buyer, including the export of timber based on the USAIS Forest, and subsequently to the FGIS LC [5]. The author describes the principles of wood accounting information systems. The author's work reflects both the positive aspects of the implementation of these systems and their disadvantages. The author concludes that after the introduction of the LesEGAIS system, illegal logging will decrease. A group of scientists O.V. Zubov, D.E. Novikov and A.S. Martynyuk, in a report at the conference of the St. Petersburg State Forestry University named after S.M. Kirov in 2022, presented a brief analysis of existing problems in timber accounting systems [6]. We also identified the trends in the development of the LesEGAIS digital platform, its transition to the FGIS LC system with advanced functionality. The ways of solving key problems in this area are also proposed using the example of the development of the digital system "Smart Forest". V. Dorofeeva considers FGIS LC to be an important information and analytical tool for ensuring the disclosure and investigation of illegal logging and illegal timber trafficking [7]. D.S. Malygin analyzed the digitalization of wood supplies. The author believes that the problems of supply logistics and wood turnover can be solved through the introduction of information systems [8].

Researchers from Southwestern State University (Yu.V. Vertakova, O.A. Kryzhanovskaya, A.V. Evchenko) believed that it was extremely important for the Russian forestry sector to develop a comprehensive and effective legal framework. This framework should be developed to support large-scale programs and strategies aimed at attracting significant investments in the timber industry and related sectors of the economy. This includes the development of contemporary regional forest management plans to bolster the national economy [9]. The authors assert that while the Russian Federation possesses individual strategic plans guiding forest sector development and regulations concerning digital technology implementation within this domain, a cohesive framework is lacking. The authors suggest combining and standardizing current forestry documentation with the requirements of a new digitalization initiative planned for the Russian forestry sector. This unification process should leverage both Russian knowledge and globally accepted best practices.

The article by A.V. Chuprov examines the process of digitalization of forestry management in the Arkhangelsk region, forest management in accordance with the federal forest management plan [10]. The main directions of the implementation of the federal state information system of the forest complex are highlighted. In the article S. N. Bareyko, T. S. Bazhaeva, E. V. Ivanova, K. A. Kozukhina consider the question of the possibilities of using digital technologies, define the tasks of digitalization of forestry [11]. The authors posit that investments in information technology yield multiple benefits for businesses, including reductions in operational expenses, mitigation of risks, and enhancements to process efficiency. Furthermore, they assert that information technology plays a crucial role in strategic planning by enabling better decision-making. In the context of forestry, they emphasize that the implementation of sustainable practices hinges upon access to accurate, comprehensive, and readily available data on forest resources. Modern information technologies are identified as key enablers for achieving this level of data accessibility. Scientists D. Yu and Z. He analyze the demand for information systems for disaster prevention [12]. In numerous studies, intelligent technologies demonstrate their potential in solving fundamental infrastructure-related problems. These include the design and construction of facilities, forecasting and prevention of emergencies, minimizing their consequences, conducting rescue operations and restoring damaged systems. [13 - 19].

Consequently, a review of analytical materials and scientific research, an analysis of practical work in the field of FGIS implementation shows that the degree of theoretical and practical study of the topic is not very high. An important area of research is to ensure open access of scientists to information resources, as well as the development of interdisciplinary cooperation between scientists from various fields of knowledge.This is the only way to ensure the progressive development of science and the achievement of new scientific discoveries in the forest business and in the management of the forest complex.

3 Methods and object of research

The object of the study is the process of implementing FGIS LC in the Arkhangelsk region. The purpose of the study is to analyze the results of the implementation of FGIS LC in the Arkhangelsk region as a pilot project, summarize its experience, and identify problems and trends. The purpose of the study is related to the fact that the results of the implementation of FGIS LC in the Arkhangelsk region as a pilot project are subject to in-depth analysis and study. It is important to identify positive changes in the implementation of this system. The identification of trends identified during the work of the pilot project will allow us to anticipate possible problems and shortcomings that may arise when FGIS LC is distributed to other territories. The experience of the Arkhangelsk region in the implementation of FGIS LC can serve as an example for other subjects of the Russian Federation. Analytical materials, scientific articles and reports of specialized institutions were used in the study. Qualitative and quantitative methods were used to obtain primary and adjust secondary data. Among the main qualitative methods, we used observation, interviews, and testing. Together with qualitative methods, quantitative methods such as mass survey (questionnaire) and monitoring were used. This research employed a multi-faceted methodological approach. It utilized techniques of analysis and synthesis, comparative analysis, and empirical investigation to examine data from diverse sources. By applying comparative and system analysis methods, we have discovered the main patterns of digitalization and informatization of the forest sector during the implementation of FGIS LC. The methods of expert questioning and brainstorming with forestry specialists and experts, employees involved in the implementation of information systems, public authorities, identified trends and problems of business processes in the implementation of FGIS LC. This helped us gain a deep understanding of their structure and changes over time, as well as identify the most important factors influencing the implementation of FGIS LC.

4 Analysis and results research

4.1 Analysis of global and foreign information systems and services for forest accounting, timber harvesting

Forest accounting and timber harvesting information systems and services are utilized internationally. The underlying principles for developing such systems and services are consistent globally, mirroring those employed in Russia: preserving the existing forest and increasing its productivity, ensuring the accessibility of stakeholders and the multi-purpose use of resources. A characteristic difference is the bias towards informing about open economic indicators, the climate agenda and compliance with the carbon balance, conservation of biodiversity and promotion of public activities. The establishment of the Global Forest Information Service (GFIS) marked a significant milestone in the digitization of global forestry practices. It served as a pioneering model for information systems designed to manage and analyze data within the forestry sector. The project originated in the late 2000s as a joint initiative undertaken by several influential international organizations. These included the International Union of Forest Research Organizations, the Food and Agriculture Organization of the United Nations, and the secretariat of the United Nations Forum on Forests. This phrasing emphasizes the collaborative nature of the project's beginnings and highlights the involvement of key international players. The mission of GFIS is to share and disseminate information about the state of forests. But in 2021 After more than two decades of dissemination of forest information, GFIS suspended operations as a separate unit.

Finland has a Forest Center accounting system, which provides open information about forests, as well as an independent service to support decision-making by forest owners and the use of the forest sector of enterprises from obtaining harvesting rights to reporting on the use of forest resources. In the USA, the forest accounting system is somewhat different. The United States exhibits a diverse landscape of private forest ownership. A wide range of ownership structures exists, and there is no centralized authority overseeing forest management practices. Furthermore, forest landscapes are highly fragmented, and forest management practices exhibit significant variation across different departmental jurisdictions. This fragmentation is compounded by discrepancies in forestry regulations and legislation from one state to another. The Forest Inventory and Analysis Program (FIA) operates as an impartial evaluator. Its collected data is freely accessible to the public through designated online platforms. The United States also has a unified forest fire center. There is little information about information systems and accounting resources in the United States in open sources. However, among the main resources, the "National Resource Use Monitoring" (NRUM) is used, which allows forest users to report on their activities and generates statistics. An analysis of the collected data on swelling has been conducted for each state and land category, leading to specific conclusions for each. The Forest Information System for Europe (FISE) is used as a unifying information hub containing information about forests. The monitoring network in Europe "ICP forest" monitors the state of the forest and atmospheric emissions and includes obtaining information about the state of the forest and its impact. Spain, like many European countries, provides services to inform forest users and the public, but without detailed information about the location of the infrastructure of current forestry activities.

Thus, there are a number of information systems dealing with the global study, accounting and assessment of the state of the planet's forests. Each of them is designed to cover only a certain range of tasks, and largely they are limited by territorial and departmental characteristics. At the moment, open data on the functioning of a unified forest accounting and management system in any of the countries, which would provide all the necessary functions for forest users and employees of departments, is not yet known or such a system does not exist.

4.2 Architecture, structure and functionality of FGIS LC

FGIS LC is a system based on processes that provide end-to-end automatic and user tasks. The system supports a registry model for processing documents and data from them, fixing those responsible for the provision of public services and the implementation of public functions, and provides for "continuous forest management" based on the results of accepted documents and changes. The areas of activity supported by FGIS LC are multidimensional and include support for land and forest relations in the use of resources, protection of forest resources and financial activities (Fig. 3).

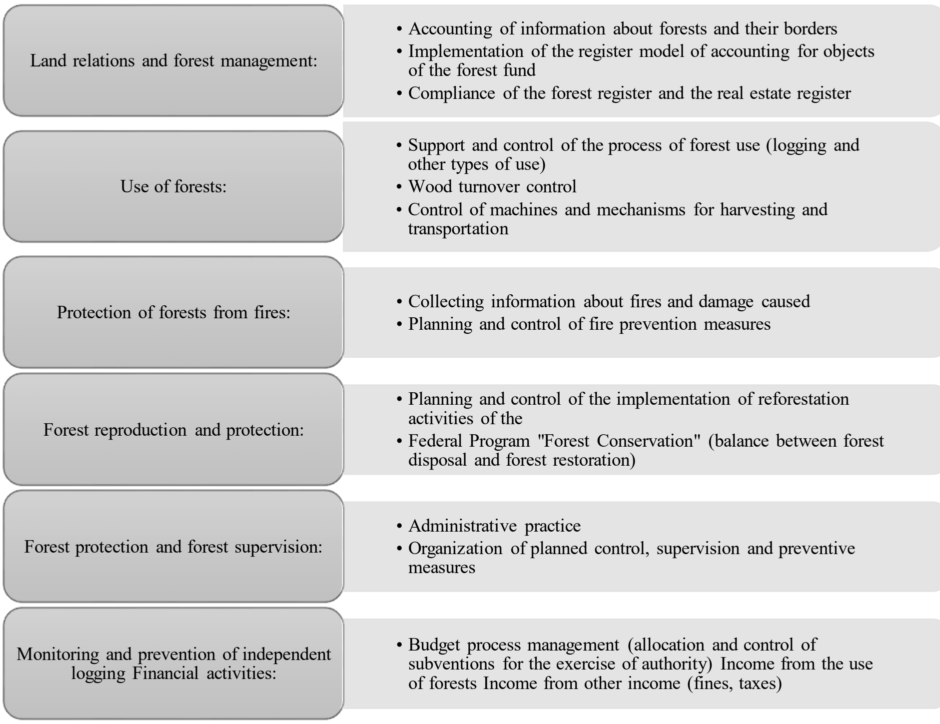

Fig. 3. Areas of activity supported by FGIS LC.

The architecture of FGIS LC includes three segments that logically combine all the functions of the system: – industry segment – provides a solution to the task of conducting GLR; Integration segment – ensures the functioning of the system as a whole; Public segment – provides external users with access to System functions. All these segments and components interact with each other and ensure the functioning of the FGIS LC as a whole (Fig. 4).

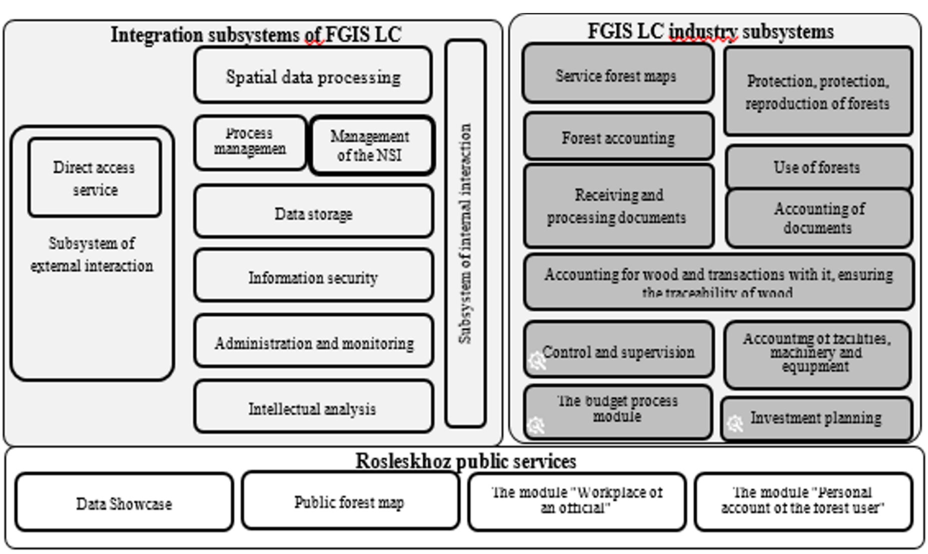

Fig. 4. Architecture of FGIS LC.

Thus, the analysis of the architecture and structure of the FGIS LC shows that the system integrates the necessary functions for the management and control of forestry activities.

4.3 The process of implementing FGIS LC in the Arkhangelsk region

In accordance with Federal Law No. 3-FZ dated 02/04/2021 "On Amendments to the Forest Code of the Russian Federation and Certain Legislative Acts of the Russian Federation in Terms of Improving the Legal Regulation of Forest Relations", the launch of FGIS LC should take place no later than 01.01.2025. From now on, all forestry relations must be executed exclusively in electronic form: for both executive authorities and forest users. At the same time, in order to ensure the launch of the FGIS LC in all subjects of the Russian Federation on time, it is necessary to fill the system with primary data. In accordance with the order of the Federal Forestry Agency dated 09/20/2023 No. 922, the schedule for granting subjects' access to the FGIS LC was approved. The Arkhangelsk Region gained access to the system in September 2023. At the beginning of the work, employees of forestry departments and ministries were trained to work with the system. On the part of forest users, large forest users such as JSC "Ilim Group", LLC "PKP TITAN", GC "Region-Les", LLC "GC ULK" are directly involved in the implementation. Since September 2023, work has been underway to fill the FGIS LC with data on forests in the Arkhangelsk region. As of 05/15/2024, the process of filling the system with primary data was completed in the Arkhangelsk region (Table 1).

Table 1. Primary data of the FGIS LC of the Arkhangelsk region.

Name	Quantity (%)
Lease agreements for forest plots	1006
Contracts of gratuitous use	17
Purchase and sale agreements	14 344
Agreements on the establishment of a public easement	37
Quarterly network	39 079 (100 %)
Dedicated network	1 431 612 (93 %)*
Forestry	29 (100 %)
District forestry	211 (100 %)
Forest areas	4 479 (54 %)
Forest declarations	10608
Tax description of the cutting area	2182
Logging areas	4194

Filling the FGIS LC database with primary data made it possible to start providing some services and at the end of July interim results were summed up, which are growing significantly every month. The full number of 14 services in the forestry sector of FGIS LC will be available to users on the EPSU and in their personal account.

In May 2024, work began on verifying forest users' documents previously accepted outside the FGIS LC using the "Download retrospective information" tool. This direction identifies errors in documents that were not previously visible to the region due to the lack of appropriate verification tools among employees. Uploading retrospective information also allows you to fill the FGIS LC with up-to-date information about logging areas. Since June 2024, work begins on testing the FGIS LC mobile application for photo fixation. JSC "Ilim Group", LLC GC "Region-les", GAU JSC "ELTS" take part. In addition, since June 2024, piloting of the functionality for accounting for wood, its processed products and transactions with it begins. In July 2024, the FGIS LC began to be actively filled with vector information about specially protected forest areas and the intended purpose of forests. At the moment, data on three forest areas are being checked in the retrospective data migration system and two more forest areas are ready to migrate. The use of FGIS LC in the Arkhangelsk region made it possible to carry out effective and operational control of forestry activities in the region by uploading primary documents to the system-the bases of forest users, displaying the created objects on a single map, the possibility of automated quality control of information submitted by forest users within the framework of public services. In the process of providing public services to forest users, employees of the region have convenient access to all documents necessary for making a decision on a public service, automated verification tools are also available (formal in terms of the submitted information, spatial in terms of the implementation of legislation on the mutual location of newly created and previously existing facilities, and others), which increases the productivity of employees and the quality of services provided to forest users.

4.4 Problems of FGIS LC implementation

At the initial stage of the start of the provision of services, based on the statistics of refusals to provide public services, it is possible to compile a rating of the most popular mistakes made by forest users. There are two types of failures in FGIS LC: automatic and manual. An automatic failure is when the system records the reason for the refusal of acceptance in the download protocol. When all automatic checks of the application have been successfully completed, the application is taken into work by an employee of a public authority, who, if there are grounds, decides on a manual refusal (Table 2).

Table 2. Grounds for refusals in the FGIS LC of the Arkhangelsk region.

Grounds for automatic refusal	Grounds for manual failure
the number of the forest taxing allocation is not specified, or unstructured data is entered; the main attachment file is not an XML document (an Excel file is attached, for example); the FGIS LC does not support the xsd schema version; – when applying for the EPSU , the user does not specify his region; a document is attached that does not correspond to the service (LD instead of TOL and vice versa).	absence of a foundation document for a forest plot; there is no allocation data in the system; the allocation number is not specified, or unstructured data is specified.

An extensive analysis was carried out through consultations with experts and specialists in testing system errors, focusing on the implementation of the FGIS LC system in the Arkhangelsk region. This collaboration has made it possible to identify key errors and develop effective solutions to fix these problems.

Conducting expert debates with specialists on the implementation of FGIS LC in the Arkhangelsk region, focusing on solving the main issues that require elaboration and improvement of the system:

- invalid data;
- a lot of source data;
- formats are frankly outdated data;
- the opacity of many processes;
- contradictory and insufficient NPAs;
- different structures of management bodies in the subjects;
- different scheme of forest accounting in different subjects;
- the absence of a single NSI of the forest complex

4.5 Prospects for the development of forestry from the introduction of FGIS LC of the Arkhangelsk region

The implementation of the FGIS LC of the Arkhangelsk region will not only improve the monitoring and management of forest resources, but also significantly simplify the interaction between various public and private structures. In particular, forest users will be able to quickly upload all necessary documents to the system, such as declarations, lease agreements, acts of completed works and other primary documents. This, in turn, allows the regulatory authorities to quickly and accurately verify the legitimacy of the operations being carried out. One of the key advantages of FGIS LC was the creation of a single digital map that displays all objects of the forest fund.

The use of FGIS ensures transparency and accessibility of information, which will make the process of renting forest plots more understandable and predictable for potential tenants. They will be able to be acquainted with the characteristics of the sites they are interested in in advance, check their status and the presence of encumbrances, which will reduce risks and promote more active business involvement in forest management. An important aspect will also be the improvement of interaction between various government agencies. Thus, forest supervision authorities, law enforcement agencies and judicial authorities will have access to a single database, which will allow for more coordination that is effective and exchange of information, which will facilitate quick and accurate decision-making. This is especially important in the context of combating illegal logging and other violations of forest legislation. Uploading primary documents of forest users to the FGIS LC and displaying the created objects on a single map will allow for more accurate and prompt detection of violations. An important result of the launch of FGIS LC are new opportunities for analysis and forecasting. Based on accurate and operational data of the FGIS LC, analytical studies can be carried out, trends can be identified and the development of the situation in forestry can be predicted, which would make it possible to make more informed management decisions aimed at the sustainable use of forest resources and the preservation of the ecosystem.

5 Conclusion

Thus, the generalization of the experience of implementing FGIS LC in the Arkhangelsk region made it possible to identify the best practices and difficulties of working with this system. Such an analysis is necessary, as it helps to optimize the processes in the work of enterprises and government agencies. The FGIS LC system offers significant advantages for the development of forestry based on the principles of transparency, efficiency and control. Firstly, the system provides open access to information about the movement of wood at all stages - from the moment of harvesting to implementation. The data is updated in real time, which guarantees full transparency of the processes. Secondly, FGIS LC allows you to effectively manage the risks associated with illegal logging and trade in timber. The system is equipped with tools for detecting and preventing violations, as well as tracking the origin of wood materials. Thirdly, the automation of processes, optimization of logistics and increase in labor productivity implemented in the system contribute to a significant increase in the efficiency of forestry, reducing costs and increasing profitability. Improvement of product quality because of: comprehensive control over the quality of wood at all stages of harvesting and processing. Promoting sustainable forest management: ensuring reforestation, rational use of resources, and conservation of biodiversity. The development of FGIS LC opens up promising opportunities for the forest sector: Creating conditions for attracting investments: increasing transparency and trust in the forest sector helps attract new investments. Stimulating innovation: Intelligent wood tracking systems contribute to the introduction of advanced technologies, improving the efficiency and competitiveness of the logging industry. Creating jobs and improving the competencies of personnel: the development of FGIS LC will require highly qualified specialists in the field of information technology, which will create new jobs. The introduction of FGIS LC is a timely and necessary step towards building a sustainable and transparent forest industry. In general, the study provides a more complete understanding of the current state of digitalization and informatization in forestry, identify existing problems and develop effective measures to overcome them. The results of the study can be used in the development of forest management policy and decision-making at the state level.

References

1. Unified state automated information system for accounting of wood and transactions with it. URL: https://lesegais.ru (date of application: 07/29/2024)
2. FGIS LC is all about digitalization of the forest industry. URL: https://egaislesuchet.ru/fgis-lk (date of application: 07/29/2024)
3. A.S. Shishlova, L.I. Zagidullina, Materials of the All-Russian scientific and practical conference of graduate students and young scientists dedicated to the Day of graduate Students, 311-315 (2024)
4. E.A. Nigai, I.A. Nikulin, Digital transformation of forestry management: a platform approach, STAGE: economic theory, analysis, practice, 109-131 (2023)
5. A. P. Belonozhkina, Sustainability management of strategic development of international transport systems: Proceedings of the III International Scientific and Practical Conference, 37-44 (2023).
6. O.V. Zubova, D.E. Novikov, A.S. Martynyuk, Collection of articles based on the materials of the scientific and technical conference of the Institute of Technological Machines and Transport of Forests based on the results of research work 2021: Materials of the conference reports, St. Petersburg State Forestry Engineering University named after S.M. Kirov, 50-54 (2022)
7. V. A. Dorofeeva, Technical and forensic support for the disclosure and investigation of crimes: A collection of scientific papers of the All-Russian Scientific and Practical Conference held within the framework of the XXVII International Exhibition of State Security Tools "Interpolitech-2023", 87-93 (2023)
8. D. S. Malygin, Proceedings of the XXI International Scientific and Practical Conference, St. Petersburg, Admiral S.O. Makarov State University of Marine and River Fleet, 3-9 (2022)
9. Yu. V. Vertakova, O. A. Kryzhanovskaya, A.V. Shevchenko, Izvestiya Yugo-Zapadnogo gosudarstvennogo universiteta. Series: Economics. Sociology. Management **10(2)**, 46-62 (2020)
10. A.V. Chuprov, The process of digitalization of forestry in the Arkhangelsk region, Topical issues of taiga and tundra forestry in the European North of Russia : materials of the scientific and practical conference, T8 Publishing Technologies, 224-228 (2023)
11. S.N. Bareyko, T.S. Bazhaeva, E.V. Ivanova et al, Proceedings of the 5th International Scientific Conference on Digital Economy and Finances, Saint-Petersburg, 339-349 (2022)
12. D. Yu, Z. He, Natural Hazards (2022) DOI: 10.1007/s11069-021-05190-x
13. I.L. Bachilo, Digitalization of management and economy is a national task, State and Law **2**, 59-69 (2018)

14. J. Qin, Y. Liu, R. Grosvenor, Procedia CIRP **52**, 173-178 (2016)
15. W. Li, M. Wang, X. Zhang, Countermeasures for the integration and development of ecological agricultural industrial chain between China and Russian Far East, 122-143 (2023)
16. M.H. Ismail, M. Khater, M. Zaki, *Digital Business Transformation and Strategy: What Do We Know So Far?* (Cambridge Service Alliance, 2017)
17. R. Valentini, B.L. Marchesini, D. Gianelle, G. Sala, A. Yarovslavtsev, V. Vasenev, S. Castaldi, Annals of Silvicutural Researches **43(2)** (2019)
18. Su-li Wu, Quan-sheng Lou, Zhi-jie Quan, Xiao-jun Li, Chinese Geographical Science **13(1)**, 56-61 (2003) DOI:10.1007/s11769-003-0085-5
19. Ch. Wudel, R. Schlicht, U. Berger, Methods in Ecology and Evolution **14(10)**, 2668-2679 (2023) DOI 10.1111/2041-210x.14206