Brief information about the program

Name of the program	BR21882122 “Sustainable Development of Natural-Industrial and Socio-Economic Systems of the West Kazakhstan Region in the Context of Green Growth: A Comprehensive Analysis, Concept, Forecast Estimates and Scenarios” (0123PK01214)
Relevance	Sustainable development of regions in Kazakhstan is currently one of the priority tasks, as dynamically developing and competitive, they represent a source of population welfare growth, a foundation for implementing national policies to reduce regional disparities, and facilitating a more balanced and sustainable development of the republic. Western Kazakhstan, possessing significant economic potential, risks losing stability in its future ecological-social-economic development due to the existing economic model of irrational natural resource use, ongoing ecological and natural, socio-demographic processes. Key tasks for the region include reducing environmental stress, poverty, increasing the employment level of the working-age population; forming a rational (more uniform) settlement system; preserving biodiversity through the restoration of the region's disturbed water resource balance; and rational use of natural resources. In this context, the main idea of the program is to form a complex of indicators characterizing the sustainability of the ecological-social-economic development of the Western Kazakhstan Region (WKR) and to assess on their basis the demographic potential, economic growth, social well-being, underground and surface water resources, the population's provision with water and biological resources, air basin quality, soil pollution, contamination of underground and surface freshwater and marine waters, the degree of degradation of flora and fauna, desertification level, identifying the tourist potential of WKR, using created geodata bases and digital thematic maps. The bioresource potential of ecosystems is not fully utilized, necessitating in-depth analysis and foresight research to determine paths for long-term development and making informed management decisions. A strategic task is to create a comprehensive methodology and toolkit for the systematic assessment and management of the quality of natural-economic systems, monitoring environmental components of the studied region and their impact on population health based on environmental quality management recommendations and scenario assessments aimed at achieving sustainable development of the region. Within the framework of the program, comprehensive ecological-economic-sociological, hydrogeological studies will be conducted, including the survey of all significant environmental components, as well as studying their impact on the ecosystem. Major pollution sources will be identified, and an analysis of industrial emissions and their impact on environmental quality and population health will be conducted. These data will be used to develop models and methods for pollution assessment and determining the most critical zones. This will allow for a more accurate, high-quality, and systematic basis for risk assessment, applying preventive measures to minimize them, developing effective strategies to counteract environmental degradation, and ensuring the improvement of the environmental situation in the region. Based on the analysis and assessment of environmental challenges and threats in the natural-economic systems of WKR, a comprehensive set of measures for managing their environmental safety will be proposed.
Purpose	Conduct comprehensive studies on ensuring sustainable development of the natural-economic and socio-economic systems of the Western Kazakhstan

	Region (Mangystau, Atyrau, West Kazakhstan, and Aktobe regions) in the context of green growth.
Objectives	***For the Year 2024:*** *Subprogram 1. Assessment of Natural Resource Potential as the Main Factor in the Development of Natural and Economic Systems in the West Kazakhstan Region:* – Conduct a modern assessment of surface water resources in the West Kazakhstan region. – Assess the conditionally natural resources of surface waters by administrative divisions. – Evaluate the anthropogenic load on surface water Assess the current state of surface water resources, considering climate change and anthropogenic impact by administrative divisions. – Develop a unified digital spatially coordinated hydrological database. – Assess the current resource potential of the climate in the West Kazakhstan region by creating a series of informational assessment maps (air temperature). – Assess the current resource potential of the climate in the West Kazakhstan region by creating a series of informational assessment maps (atmospheric precipitation). – Provide a scientifically substantiated assessment of the modern hydrological and hydrochemical regime of the Kazakhstani sector of the Caspian Sea. – Evaluate the current spatial and temporal changes in the Caspian Sea level in its Kazakhstani sector. – Assess the current features of wind-driven surges and recessions in the Kazakhstani sector of the Caspian Sea. – Evaluate the current state and changes in the thermohaline structure of the waters in the Kazakhstani sector of the Caspian Sea. – Assess the modern dynamics of changes in the hydrochemical regime of the Kazakhstani sector of the Caspian Sea. – Assess the pollution of groundwater in the West Kazakhstan region. – Develop methodological foundations for assessing groundwater quality, create an informational database, and populate the database with hydrogeological and environmental information. – Conduct an expeditionary survey of the West Kazakhstan region. – Assess the environmental condition of groundwater with the development of a series of specialized hydrogeological and environmental maps. – Conduct a modern assessment of land resources with the creation of a series of informational assessment maps. – Develop a soil database, collect and enter data from previous research for the Mangystau and Atyrau regions. – Conduct field studies, establish soil profiles, and collect samples to assess the current state of soils in the Mangystau and Atyrau regions. – Develop an agro-industrial land classification for the Mangystau and Atyrau regions. – Create a land degradation map for the Mangystau and Atyrau regions. – Collect and enter data from previous research for the West Kazakhstan and Aktobe regions. – Conduct field studies, establish soil profiles, and collect samples to assess the current state of soils in the West Kazakhstan and Aktobe regions. – Develop an agro-industrial land classification for the West Kazakhstan and Aktobe regions.

	– Create a land degradation map for the West Kazakhstan and Aktobe regions. – Conduct a modern assessment of forage resources with the creation of a series of informational assessment maps. – Carry out phytocenological classification and a general review of vegetation in grazing lands. Perform practical collection and laboratory processing of materials, assess the reserves of plant-based forage resources of different types of pastures, and determine their level of utilization. – Study the distribution of grazing lands based on remote sensing data and field observations. – Assess the productivity of grazing lands based on the analysis of remote sensing data. Explore ways to develop and increase the productivity of natural grazing lands. – Monitor environmental factors (hydrology, hydrochemistry, toxicology, fish forage base) and create informational assessment maps of the Ural-Caspian water basin within the Atyrau, West Kazakhstan, and Aktobe regions. – Evaluate the anthropogenic load on water bodies and watercourses. – Conduct ecological mapping of the Kazakhstani sector of the Caspian Sea within the Atyrau and Mangystau regions, identifying zones of varying ecological risk (migration corridors, sources, and nature of pollution, etc.). – Assess the natural capital of water bodies (biological resources, water supply, refugia, genetic resources) and the value of ecosystem services (water supply, water regulation, bioregulation, food production, tourism, and recreation). – Publish research results. *Subprogram 2. Assessment of Biodiversity in the West Kazakhstan Region in the Context of Sustainable Development and Green Growth:* – Assess the current state of biodiversity (marine and terrestrial), conduct an inventory of biodiversity objects (flora and fauna) with the creation of a series of informational-analytical maps. – Conduct an analytical assessment of archival, literary, herbarium, collection, and cartographic data. – Prepare and conduct comprehensive field studies for the inventory of biodiversity (flora and fauna). – Perform laboratory processing of collected materials and populate the geodatabase with biodiversity data, preparing cartographic materials. *Subprogram 3. Assessment of Air Quality in the West Kazakhstan Region in the Context of Sustainable Development:* – Assess the current state of air quality and conduct an inventory of air pollution sources with the creation of a series of informational assessment maps. – Study the spatial and temporal patterns of pollutant dispersion in the atmosphere. – Create a series of informational assessment maps of emission sources and atmospheric pollution. – Publish research results. *Subprogram 4. Assessment of Soil Pollution in the West Kazakhstan Region by Toxic Chemical Substances from Industrial Activities:* – Assess the current state of soil contamination by toxic chemical substances with the creation of a series of informational assessment maps. – Conduct a literature review and patent search on the assessment and remediation of soil contaminated by toxic chemical substances.

	– Analyze soil samples from contaminated sites. – Identify the concentration of toxic chemical substances in the selected region. – Develop a series of informational assessment maps. – Prepare an interim report following GOST 7.32 standards. *Subprogram 5. Assessment of Surface and Groundwater Pollution in the West Kazakhstan Region in the Context of Sustainable Development:* – Assess the ecological state and quality of surface and groundwater with the creation of a series of informational assessment maps. – Compile a register of enterprises in the West Kazakhstan region that discharge pollutants into water bodies and map sampling locations for surface water and monitoring wells for groundwater. – Conduct fieldwork to collect surface water samples and verify the registry of entities discharging treated wastewater in regional departments of Kazhydromet and basin inspections in the Mangystau and Atyrau regions. – Conduct fieldwork to collect surface water samples and verify the registry of entities discharging treated wastewater in regional departments of Kazhydromet and basin inspections in the West Kazakhstan and Aktobe regions. – Conduct laboratory analysis of surface and groundwater samples to evaluate their ecological state and quality. *Subprogram 6. Assessment of Landscape and Ecological Conditions in the West Kazakhstan Region for Sustainable Development:* – Develop a map of modern landscapes, assessing their structural organization and spatial differentiation. – Conduct field surveys and decode satellite images to assess anthropogenic disturbances in the region. – Identify ecological issues in the region caused by economic activities based on field research and remote sensing data. – Publish research results. *Subprogram 7. Assessment of Socio-Economic Development in the West Kazakhstan Region in the Context of Sustainable Development:* – Analyze and assess the socio-economic development of the West Kazakhstan region. – Conduct demographic assessments, analyze labor resources, and evaluate tourism potential. – Publish research results. *Subprogram 8. Scientific and Applied Foundations for Ensuring Sustainability of Natural and Economic Systems in the West Kazakhstan Region:* – Assess regional features of natural and economic systems and model optimal sustainability parameters for the Aktobe and West Kazakhstan regions. – Publish research results.
Expected and achieved results	**For the Year 2024:** *Subprogram 1. Assessment of Natural Resource Potential as the Main Factor in the Development of Natural and Economic Systems in the West Kazakhstan Region:* – A modern assessment of surface water resources in the West Kazakhstan region has been conducted. – An assessment of conditionally-natural surface water resources by administrative divisions has been carried out. – An evaluation of the anthropogenic load on surface water resources by administrative divisions has been conducted.

	– The current state of surface water resources has been assessed, considering climate change and anthropogenic impact by administrative divisions. – A unified digital spatially coordinated hydrological database has been created. – Spatial distribution maps of temperature have been created, including annual averages, seasonal variations, and the vegetation period. – Precipitation distribution maps have been developed for annual totals, seasonal variations, and the vegetation period. – A scientifically substantiated assessment of the modern hydrological and hydrochemical regime of the Kazakhstani sector of the Caspian Sea has been conducted. – An assessment of the spatial and temporal changes in the Caspian Sea level in its Kazakhstani sector has been completed. – An evaluation of wind-driven surges and recessions in the Kazakhstani sector of the Caspian Sea has been carried out. – The current state and changes in the thermohaline structure of waters in the Kazakhstani sector of the Caspian Sea have been analyzed. – The modern dynamics of changes in the hydrochemical regime of the Kazakhstani sector of the Caspian Sea have been assessed. – An assessment of groundwater pollution in the West Kazakhstan region has been conducted. – Methodological foundations for assessing groundwater quality have been developed, and an informational database has been created and populated with hydrogeological and environmental information. – An expeditionary survey of the West Kazakhstan region has been conducted to collect real-time data on groundwater conditions. – A series of specialized hydrogeological and environmental maps has been compiled, including: hydrochemical map; map of the observation network for the state monitoring of groundwater; groundwater pollution map; – Map of anthropogenic load on groundwater. – A modern assessment of land resources has been conducted, resulting in a series of informational assessment maps (soil, agro-industrial land classification, soil degradation). – A soil database has been developed, and historical research data from the Mangystau and Atyrau regions have been collected and entered. – Field studies have been conducted with the establishment of soil profiles and sample collection to assess the current state of soils in the Mangystau and Atyrau regions. – An agro-industrial land classification for the Mangystau and Atyrau regions has been developed, and a corresponding map has been compiled. – A land degradation map for the Mangystau and Atyrau regions has been created. – A soil database has been developed, and historical research data from the West Kazakhstan and Aktobe regions have been collected and entered. – Field studies have been conducted with soil profile establishment and sample collection to assess the current state of soils in the West Kazakhstan and Aktobe regions. – An agri-industrial land classification for the West Kazakhstan and Aktobe regions has been developed, and a corresponding map has been compiled. – A land degradation map for the West Kazakhstan and Aktobe regions has been created.

	– A modern assessment of forage resources in the West Kazakhstan region has been conducted, resulting in a series of informational assessment maps. – A detailed classification scheme of grazing land vegetation has been developed, identifying vegetation formations in grazing lands. – A series of maps titled “Distribution of Forage Resources in West Kazakhstan” has been prepared. – A series of maps titled "Assessment of Forage Resource Productivity in West Kazakhstan" has been developed. – A production characterization of hayfields and pastures has been conducted, identifying optimal usage periods and improvement measures. – Environmental factor monitoring (hydrology, hydrochemistry, toxicology, fish forage base) has been conducted, and informational assessment maps of the Ural-Caspian water basin have been created for the Atyrau, West Kazakhstan, and Aktobe regions. – An evaluation of the anthropogenic load on water bodies and watercourses has been conducted. – Ecological mapping of the Kazakhstani sector of the Caspian Sea in the Atyrau and Mangystau regions has been carried out, identifying zones of varying ecological risk (migration corridors, pollution sources, pollution characteristics, etc.). – An assessment of the natural capital of water bodies has been conducted, including biological resources; water supply; refugia; genetic resources; ecosystem service valuation (water supply, water regulation, bioregulation, food production, tourism, and recreation). *Subprogram 2. Assessment of Biodiversity in the West Kazakhstan Region in the Context of Sustainable Development and Green Growth:* – The current state of biodiversity (marine and terrestrial) has been assessed, and an inventory of biodiversity objects (flora and fauna) has been conducted, resulting in the development of a series of informational-analytical maps. – Preliminary floristic and faunal lists, including lists of green spaces in populated areas, have been compiled. An assessment of data completeness has been conducted, identifying territories or taxa requiring clarification during field research. – Primary materials for the inventory of biodiversity (flora and fauna) have been collected. – A comprehensive biodiversity inventory has been conducted. The biodiversity geodatabase has been populated, and a series of informational-analytical maps has been created. *Subprogram 3. Assessment of Air Quality in the West Kazakhstan Region in the Context of Sustainable Development:* – The current state of air quality has been assessed. Results of the inventory of air pollution sources have been presented, and a series of informational assessment maps have been created. – Patterns of the spatial and temporal distribution of major and marker pollutants in the West Kazakhstan region have been studied. Their statistical characteristics have been analyzed. – A database of emission sources for various categories, including automated industrial tracking systems (AITS), has been created. – Spatial and temporal features of pollutant dispersion in the atmosphere have been studied.

	– A GIS platform has been developed, integrating analytical data with the capability to generate reports based on selected parameters. A series of informational assessment maps of emission sources and atmospheric pollution has been created. *Subprogram 4. Assessment of Soil Pollution in the West Kazakhstan Region by Toxic Chemical Substances from Industrial Activities:* – An assessment of the current state of soil pollution by toxic chemical substances has been conducted, resulting in the creation of a series of informational assessment maps. – A literature review and patent search have been carried out to evaluate methods for assessing and remediating soil pollution by toxic chemicals in the selected region. – Soil samples from various contaminated sites have been collected and analyzed. – Concentrations of toxic chemical substances in the selected region have been identified. – A series of informational assessment maps has been developed. – An interim report has been prepared following GOST 7.32. *Subprogram 5. Assessment of Surface and Groundwater Pollution in the West Kazakhstan Region in the Context of Sustainable Development:* – The ecological state and quality of surface and groundwater have been assessed based on field research and calculations of integral ecological target functions using R. Pantle's methodology, resulting in the creation of a series of informational assessment maps for the West Kazakhstan region. – Large-scale maps for each region of West Kazakhstan have been compiled, marking control sections and potential sources of impact on surface and groundwater quality. – Water samples from water bodies in the Mangystau and Atyrau regions have been collected, and the registry of entities discharging treated wastewater into water bodies has been updated. The chemical composition of collected water samples has been analyzed in certified laboratories. – Water samples from water bodies in the West Kazakhstan and Aktobe regions have been collected, and the registry of entities discharging treated wastewater into water bodies has been updated. The chemical composition of collected water samples has been analyzed in certified laboratories. – The ecological state of surface and groundwater has been evaluated using target function modeling, and two regional maps of surface and groundwater quality assessments for 2024 have been developed. *Subprogram 6. Assessment of Landscape and Ecological Conditions in the West Kazakhstan Region for Sustainable Development:* – A map of modern landscapes has been created, assessing their structural organization and spatial differentiation. – Field surveys and satellite image interpretation have been conducted to assess anthropogenic disturbances in the region, resulting in the development of an anthropogenic landscape disturbance map. – A landscape resilience map has been created, and the resilience of landscapes to anthropogenic impact has been assessed. – Based on field research and remote sensing data, ecological problems caused by economic activities in the region have been identified. *Subprogram 7. Assessment of Socio-Economic Development in the West Kazakhstan Region in the Context of Sustainable Development:*

	– An analysis and evaluation of socio-demographic and economic sustainability, tourism infrastructure, and tourism potential mapping have been conducted, along with recommendations for regional policy. – Demographic assessments have been performed at the regional, city, and district levels, identifying trends in population dynamics, growth rates, structure, birth and death rates, and internal, intra-regional, and external migration patterns. – The impact of migration policies on regional migration activity has been studied. – Labor resources and employment trends in the region have been assessed. A forecast for labor demand by industry has been developed. – Social issues, social infrastructure, and the standard of living in the West Kazakhstan region have been analyzed. A social survey of the population in the Mangystau, Atyrau, West Kazakhstan, and Aktobe regions has been conducted. – Social sustainability criteria fотr the region have been developed, with recommendations to improve the efficiency of key social sectors. – The tourism potential of natural-recreational resources in the project area has been assessed as a foundation for sustainable tourism development at the regional level. – The tourism potential of cultural and historical resources in West Kazakhstan has been evaluated as a key factor in attracting tourists. – Current tourism infrastructure data has been collected and analyzed, including qualitative and quantitative assessments. – Tourism potential mapping using modern cartographic methods has been conducted to facilitate strategic planning and sustainable territorial tourism development. – The economic potential, industry structure, and development trends in the West Kazakhstan region have been evaluated. – Challenges in regional economic decarbonization have been examined. – Economic criteria for sustainable development and green growth have been developed. – An assessment of the existing regional policies in the West Kazakhstan region has been conducted in the context of sustainable development and the green economy. – Methodological approaches to assessing regional resource potential have been developed, leading to evaluations of the development characteristics of natural-economic systems in West Kazakhstan. *Subprogram 8. Scientific and Applied Foundations for Ensuring the Sustainability of Natural and Economic Systems and Socio-Economic Development in the West Kazakhstan Region in the Context of Sustainable Development and Green Growth:* – An assessment of the regional characteristics of natural and economic systems has been conducted, and optimal parameters for sustainable development of the Aktobe and West Kazakhstan regions have been modeled. – The regional characteristics of natural and economic systems in the Aktobe region have been evaluated, and optimal parameters for sustainable development have been modeled. – The regional characteristics of natural and economic systems in the West Kazakhstan region have been assessed, and optimal parameters for sustainable development have been modeled.

Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	Separate file
Usage	*Fields of Application:* –Ecology and Environmental Management – monitoring the state of the environment, developing measures to reduce anthropogenic pressure, and preventing ecosystem degradation. –Public Administration and Regional Planning – decision-making on sustainable development of the West Kazakhstan Region (WKR) based on forecast assessments and scenarios. –Socio-Economic Development – improving the quality of life by optimizing the use of natural resources and promoting the green economy. –Agro-Industrial Sector – rational use of land and water resources, preventing soil degradation, and ensuring agricultural sustainability. –Tourism and Recreation – identifying and developing the region's tourism potential, and creating sustainable tourism strategies. *Practical Implementation:* –Conducting environmental monitoring of air, water, and soil quality, considering climate change factors. –Developing informational and forecast maps that reflect the current state of natural resources and potential changes. –Identifying critical pollution zones and implementing remedial measures. –Developing and implementing a biodiversity management system to preserve rare and endangered species. –Creating a database of natural resources and biodiversity, accessible to government agencies and research institutions. –Developing a regional sustainable socio-economic development plan, including mechanisms to support small and medium-sized businesses, expand green infrastructure, and enhance the quality of life. –Optimizing the region’s tourism and recreational potential while ensuring environmental safety. –Developing climate adaptation tools for sustainable environmental management. *Expected Benefits:* – Enhancing the region’s ecological sustainability by establishing monitoring systems and pollution reduction strategies. – Improving the quality of life through the conservation of natural resources and the introduction of green technologies. – Advancing government policies in ecology and sustainability, based on scientifically grounded data. – Creating economic prerequisites for the implementation of green growth technologies.

	– Strengthening ecological tourism and increasing the region's investment attractiveness.
Priority Compared to Existing Analogues	– The program covers all key aspects of sustainable development, including ecological, socio-economic, and natural resource management components. While most studies focus on isolated factors (e.g., air or water quality), this program conducts a comprehensive analysis of all influencing factors. – The program is based on remote sensing (RS) data, GIS technologies, and digital models, allowing for accurate predictive assessments. – Unlike existing natural resource assessment methodologies, this program develops predictive models of environmental changes, enabling long-term sustainable development strategies. – Many similar studies focus only on ecosystem monitoring, whereas this program proposes concrete mechanisms for the restoration and conservation of natural resources. – The program integrates digital thematic maps and a natural resource database, ensuring accessibility for government agencies, researchers, and businesses. – The program is implemented in collaboration with leading scientific centers and governmental institutions, ensuring practical execution. A consortium of nine organizations has been established to develop and implement sustainable solutions.
List of publications with links to them	*Published Articles in Scientific Journals Indexed in Scopus/Web of Science:* – Tokbergenova A., Skorintseva I., Ryskeldiyeva A., Kaliyeva D., Salmurzauly R., Mussagaliyeva A. Assessment of Anthropogenic Disturbances of Landscapes: West Kazakhstan Region // Sustainability. – 2025. – No. 17(2), 573. https://doi.org/10.3390/su17020573 – Kulebayev K., Alimkulov S., Tursunova A., Makhmudova L., Talipova E., Saparova A., Rodrigo-Clavero M., Rodrigo-Ilarri J. Assessing the Vulnerability of Lakes in Western Kazakhstan to Climate Change and Anthropogenic Stressors // Water. – 2024. – 16(24), 3709. https://doi.org/10.3390/w16243709 – Birimbayeva L., Makhmudova L., Alimkulov S., Tursunova A., Mussina A., Tigkas D., Beksultanova Z., Rodrigo-Clavero M.-E., Rodrigo-Ilarri J. Analysis of the Spatiotemporal Variability of Hydrological Drought Regimes in the Lowland Rivers of Kazakhstan // Water. – 2024. – No. 16, 2316. https://doi.org/10.3390/w16162316 – Tleuberdinova A.T., Nurlanova N.K., Alzhanova F.G., Kalmenov B.T. Three Facets of Urban Metabolism (Case of Kazakhstan) // International Journal of Urban Sustainable Development. – 2024. – No. 16(1). – P. 182–198. https://doi.org/10.1080/19463138.2024.236263 – Ginzburg A.I., Kostianoy A.G., Gholamalifard M., Koibakova S.E., Syrlybekkyzy S. Ecologically and Biologically Significant Marine Protected Areas in the Caspian Sea: A Review // Ecologica Montenegrina. – 2024. – No. 76. – P. 85–115. https://doi.org/10.37828/em.2024.76.6 – Yerezhepova N., Kurmanbayeva M., Terletskaya N., Zhumagul M., Kebert M., Rašeta M., Gafforov Y., Jalmakhanbetova R., Razhanov M. New Data on Phytochemical and Morphophysiological Characteristics of Platycladus orientalis L. Franco and Thuja occidentalis L. Conifer Trees in Polluted Urban Areas of Kazakhstan // Forests. – 2024. – No. 15, 790. https://doi.org/10.3390/f15050790 – Bazargaliyeva A., Kurmanbayeva M., Admanova G., Sarzhigitova A., Koblanova S., Utaubayeva A., Gataulina G., Kaisagaliyeva G., Bissenov U., Alzhanova B. Geobotanical Characteristics of Plant Communities with

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Patents	*Obtained Intellectual Property Protection Documents (Patents and Copyright Certificates) Registered in the National Institute of Intellectual Property of the Republic of Kazakhstan (NIIP RK)* *Patents:* – Asylbekova S.Zh., Isbekov K.B., Kulikov E.V., Kim A.I., Tumenov A.N., Bulekhov N.U. Device for Fish Processing in Natural Conditions: Utility Model Patent of the Republic of Kazakhstan No. 9111. IPC A01K 61/10. TOO "NPC RH". Application No. 2024/0090.2; filed on January 22, 2024; published on May 10, 2024, Bulletin No. 19. *(In Russian)* – Ibraimov A.S., Akhmetov Zh.U., Aktymbayeva A.S., Tokanbayev A.E. Multifunctional Autonomous Unmanned Aerial Vehicle: Utility Model Patent of the Republic of Kazakhstan No. 9053. IPC B64C 39/02. Application No. 2024/0156.2, filed on February 2, 2024; published on April 26, 2024, Bulletin No. 17. *(In Russian)* – Ibraimov A.S., Serikbayev S.S., Zhakpayev K.R., Aktymbayeva A.S. Autonomous Unmanned Aerial Vehicle in Security Systems: Utility Model Patent of the Republic of Kazakhstan No. 9026. IPC B64C 39/02 (2006.01).

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