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APPLICATION OF GEOGRAPHICAL DATABASES FOR THE DEVELOPMENT OF GEO-PORTALS IN KAZAKHSTAN

Abstract

In the context of Kazakhstan's ongoing digital transformation, the development of geo-portals based on geospatial databases has become a strategic direction for improving the efficiency and transparency of spatial data management. The purpose of this study is to evaluate the effectiveness of using geographical databases in the design and implementation of geo-portals and to propose methodological approaches for building a unified geoinformation environment in the country. The research employed platforms such as QGIS, ArcGIS Pro, PostgreSQL/PostGIS, and Leaflet, enabling the integration and visualization of administrative, hydrographic, agricultural, and infrastructural data layers. Emphasis was placed on adherence to open standards (e.g., OGC WMS/WFS, ISO-compliant metadata), role-based access control, and scalable deployment patterns suitable for multi-departmental use. The proposed geo-portal architecture combines data processing, analysis, and visualization workflows, provides near real-time access to spatial information, and incorporates data-quality assurance (topology checks, schema validation), caching, and logging for performance and auditability. Evaluation included interoperability testing with regional and national GIS systems, response-time benchmarking under load, and user acceptance testing with domain experts. The results demonstrate that the application of geodatabases significantly enhances interoperability across platforms, improves discoverability and reuse of authoritative datasets, and contributes to the digital transformation of land management, environmental monitoring, and spatial planning processes in Kazakhstan. The study concludes with practical recommendations on governance, data lifecycle management, and technology stack selection to support sustainable, secure, and extensible geo-portal implementations.

Keywords: *geographic information systems (GIS), land resources, land monitoring, spatial analysis, QGIS, land management, East Kazakhstan region.*

Introduction

The digital transformation of spatial data infrastructures (SDI) has significantly reshaped approaches to land administration, territorial planning, and environmental monitoring worldwide. In Kazakhstan, the rapid modernization of spatial data systems and increasing demand for open-access geoinformation platforms have intensified the need for reliable, scalable, and interoperable geoportals. These platforms play a key role in supporting transparent land management, providing centralized access to spatial data, and improving coordination between governmental agencies, research institutions, and the public [1].

Over the past decade, Kazakhstan has launched initiatives aimed at integrating geospatial technologies into public administration, including the development of web-based cadastral platforms, remote sensing monitoring systems, and region-level mapping services. Numerous studies indicate that Geographic Information Systems (GIS) and remote sensing (RS) increase the accuracy of spatial data interpretation and support evidence-based governance in sectors such as agriculture, environmental protection, and spatial planning [2-4]. However, existing geoportals in Kazakhstan predominantly focus on visualization and cataloguing, while automated updating of spatial layers, quality assessment, and database-driven geoprocessing remain insufficiently addressed.

International practice demonstrates that geospatial databases form the technological core of sustainable SDI, ensuring positional accuracy, interoperability, and long-term preservation of spatial information [5]. The adoption of open-source solutions—such as PostgreSQL/PostGIS, QGIS, Leaflet, and OpenStreetMap—offers cost-effective and flexible architectures capable of supporting multi-scale data management, automated workflows, and public accessibility [6-7]. Despite ongoing progress, the absence of standardized methods for integrating geodatabases with automated thematic map updating from satellite imagery remains a critical research gap.

The object of the study is the development of a geoportal architecture based on integrated geospatial databases and open-source technologies used for land monitoring and spatial data visualization in Kazakhstan [8-9]. The research focuses on the creation, structuring, and publication of spatial data within a unified geodatabase that serves as the backbone of the proposed geoportal.

The main aim of the study is to develop and experimentally validate a geographic database integrated into a functional geoportal prototype. To achieve this aim, the following research tasks have been defined:

• define test boundaries and prepare reference spatial datasets, including initial object contours and thematic layers [10];

• determine the optimal database structure and configuration;

• develop an open-source geoportal enabling further testing and application for research and practical purposes.

Structurally, the article presents the conceptual framework, the implemented technological architecture, the experimental evaluation of database-driven updates, and the assessment of performance and reproducibility compared to traditional geospatial workflows.

Materials and Research Methods

This study employed a comprehensive, multi-layered methodological framework integrating geographic information systems (GIS), relational spatial databases, web cartographic services, and automated analytical pipelines [11-13]. The methodology aimed to develop reproducible, scalable, and interoperable geoportal prototypes suitable for supporting Kazakhstan's emerging Spatial Data Infrastructure (SDI) [14].

1. Data Acquisition and Preprocessing. Spatial data were sourced from national cadastral repositories, OpenStreetMap (OSM), QGIS basemaps, and Sentinel-2 MSI and Landsat 8/9 satellite products. These datasets represented administrative boundaries, hydrographic networks, transport infrastructure, and agricultural parcels. All datasets underwent preprocessing, including coordinate system harmonization to the national CRS, attribute normalization, metadata assignment following ISO 19115 standards, and topological validation. Tools from QGIS and ArcGIS Pro were applied to ensure spatial accuracy, eliminate duplicate geometries, and validate attribute integrity prior to database integration [15].

2. Database Design and System Architecture. A multi-tier system architecture was developed to support robust spatial data management and web-based dissemination. The structure included:

- **Database layer:** PostgreSQL/PostGIS environment for long-term storage, versioning, indexing, and spatial topology enforcement.
- **Application layer:** GeoServer for service orchestration (WMS, WFS, WMTS), authentication, and interoperability with OGC standards.
- **Client layer:** Web clients (Leaflet), desktop GIS software (ArcGIS Pro, QGIS), and REST API consumers.

The logical database model followed a hybrid relational–topological structure. Entities such as cadastral parcels, administrative units, infrastructure objects, and satellite-derived classes were organized through an Entity-Relationship (ER) model supporting referential integrity, temporal attributes, and hierarchical classification. Indexing strategies (GiST and BRIN) and stored procedures ensured efficient spatial querying and minimized system latency [16].

To provide clearer structural understanding, the core database design was conceptualized through a generalized model (presented as Table 1).

Table 1. Core schema concept for the spatial database

Layer group	Model basis	Key stored elements
Cadastre and administrative units	Parcel-based topology	parcel polygons, boundaries, ownership metadata
Natural resources and land cover	Raster–vector hybrid model	vegetation indices, soil zones, classified imagery
Infrastructure and utilities	Spatial network model	roads, routing networks, utilities

This model enabled modular scalability, reducing redundancy and supporting future integration with national SDI components.

3. System Configuration and Web Integration. Web-mapping functionality was implemented using GeoServer and the Leaflet JavaScript library. Services were published using OGC-compatible formats, and caching mechanisms (GeoWebCache) were configured to improve rendering speed, particularly under limited network conditions. The user interface was developed using HTML5, CSS3, and JavaScript, integrating tools for map navigation, feature identification, spatial querying, and attribute filtering. Browser compatibility was verified across Chrome, Firefox, Safari, and mobile platforms. Security controls included user-role–based access, controlled write operations, and activity logging to ensure data governance compliance [17].

4. Spatial Analysis and Automated Processing. Analytical workflows incorporated geoprocessing operations such as buffering, intersection, overlay analysis, raster–vector fusion, and terrain-based modeling. Python scripts (GDAL, Rasterio, GeoPandas) automated repetitive tasks, ensuring reproducibility. Satellite data analysis included radiometric calibration, cloud masking, reprojection, and spectral index computation (NDVI, NDWI, NDBI). A Random Forest classifier (scikit-learn) was trained using field reference samples and visually interpreted high-resolution imagery. Automated ETL workflows transferred classified outputs into the database, where topology rules were checked directly in PostGIS before publication.

5. User Scenarios and Prototype Testin. Functional testing followed a scenario-based evaluation approach reflecting real-world use cases:

- cadastral parcel identification and verification,
- agricultural monitoring through spectral index time-series,
- thematic spatial analysis for land-use planning and environmental monitoring.

Usability was evaluated according to ISO 9241-11, incorporating expert feedback from land management agencies, GIS specialists, and academic researchers. Performance optimization included tile caching, indexing refinement, and simplification of geometry-heavy layers.

6. Limitations, Risks, and Interoperability Challenges. Despite successful prototype implementation, several constraints were identified. These included heterogeneous legacy datasets, inconsistent metadata practices, limited bandwidth in rural regions, and regulatory barriers to inter-institutional data exchange. Technical risks involved infrastructure scalability, spatial versioning management, and dependency on proprietary environments in mixed software stacks.

These challenges highlight the critical need for centralized governance, standardization frameworks, and streamlined data exchange protocols in future national-scale deployments.

7. Benchmarking Against International SDI Models. To contextualize the methodological approach, the developed system was benchmarked against established SDI implementations in the European Union (INSPIRE), the United States (NSDI), and Australia (ANZLIC). The comparison is summarized in Table 2.

Table 2. Comparative evaluation of Kazakhstan's SDI characteristics

Dimension	**EU INSPIRE**	**U.S. NSDI**	**Australia ANZLIC**	**Kazakhstan Prototype**
Metadata and governance standards	Strict, mandatory	Flexible, multi-agency	Harmonized and enforced	Partially developed
Interoperability and OGC compliance	High	High	High	Improving
Licensing and access	Open-by-default	Mixed	Mostly open	Restricted
Institutional maturity	Fully developed and legislated	Established since 1990s	Coordinated national model	Fragmented, evolving

This benchmarking demonstrates that Kazakhstan is progressing toward an interoperable SDI ecosystem, yet requires standardization alignment, governance frameworks, and shared infrastructure to match mature international models.

The selected methodology reflects a transition from static GIS environments toward dynamic, service-oriented web geoplatforms supporting multi-user access, analytical automation, and open data dissemination. The resulting geoportal framework operates not only as a visualization environment but as a functional decision-support system contributing to spatial monitoring, agency collaboration, and improved public access to land and environmental information in Kazakhstan.

Results and discussion

As part of this study, a survey among GIS specialists was conducted to identify the most effective approaches to applying geospatial databases in the creation of geoportals in Kazakhstan [18].

The purpose of the survey was to gather expert opinions on database integration, data harmonization, web cartography, and interface design. Respondents included professionals in cartography, remote sensing, and spatial data processing from research institutions and production organizations.

The survey results (Table 3) revealed that experts emphasized three main priorities — automation of data processing, development of multilingual interfaces, and establishment of unified database standards to ensure interoperability among different GIS environments. In addition, specialists highlighted the necessity of regular personnel training and implementation of modern web-based tools to improve data accessibility and usability.

Beyond thematic insights, the questionnaire employed a structured design with closed (5-point Likert scale) and open-ended items, enabling both quantitative aggregation and qualitative coding of expert feedback. Responses were analyzed using descriptive statistics (means, standard deviations, and priority ranking) and inductive thematic analysis to capture nuanced requirements for workflow automation, multilingual UX, and database standardization. To mitigate bias, we anonymized submissions and cross-checked recurring themes across institutional types (research vs. production). The primary limitations concern sample size and potential sectoral overrepresentation, which may affect generalizability. Nevertheless, the findings provide actionable inputs for a phased implementation roadmap—defining interoperability KPIs, training modules, and a governance model for data lifecycle management and continuous interface improvement.

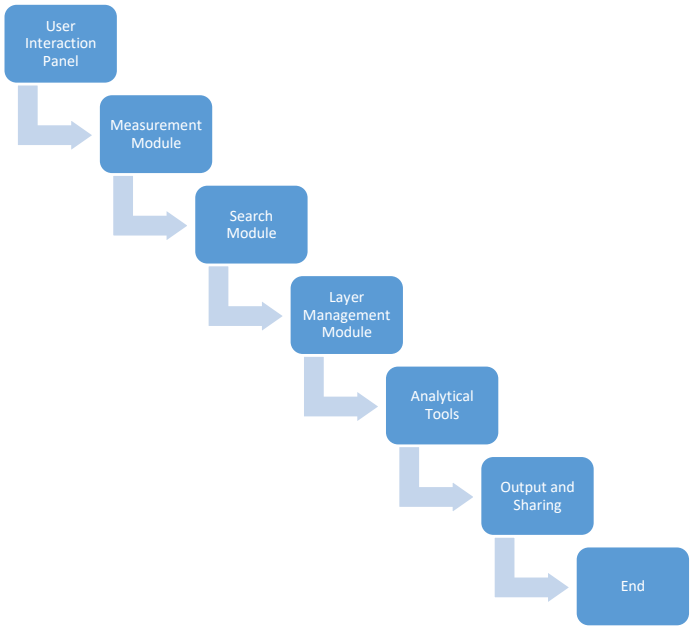
Table 3. Survey of GIS Experts

Category of Input	Synthesized Respondent Feedback	Resulting Implications for the Geoportal Model
Professional Focus and Experience	Respondents demonstrated extensive experience in GIS, cartography, remote sensing, and spatial data processing (ranging from software transition projects to operational remote sensing workflows).	Confirms the relevance and maturity of GIS practices in Kazakhstan and supports the feasibility of implementing an SDI-aligned database model.
Existing Achievements in GIS Practice	Experts reported contributions such as thematic mapping, aerial photo interpretation methodologies, system automation, and localization of GIS products for local language use.	Highlights the need for preserving expert knowledge and integrating proven national workflows into the design of the new geospatial infrastructure.
Observed Challenges	Identified issues included manual processing bottlenecks, fragmented standards, legacy formats, and limited user proficiency with modern tools.	Supports prioritizing standardization, skill development, and automated ETL workflows.
Recommendations for Database Development	Suggested priorities included workflow automation, interoperability standards, multilingual interfaces, and structured data governance.	These recommendations directly informed system architecture choices, including OGC compatibility, PostgreSQL/PostGIS data model governance, and web-based multilingual UX.

The analysis of expert opinions served as the foundation for developing a unified geospatial database model that integrates data across all regions of Kazakhstan. This structure enables distributed storage and synchronization of geodata, allowing regional datasets to be combined within a single national framework.

To achieve this, separate geodatabases (.gdb) were created for each administrative region. Each contains standardized thematic layers — administrative boundaries, hydrography, transportation, agricultural land, and settlements — all organized according to national metadata and naming conventions. These datasets form the technological backbone of Kazakhstan's emerging National Spatial Data Infrastructure (NSDI).

Table 4. Workflow of the National Geoportal



This database design ensures data consistency across regions, enabling the integration of geospatial resources into a national geoportal. By maintaining separate yet interconnected regional .gdb files, the system allows for efficient data updates, distributed editing, and scalable synchronization with a central PostgreSQL/PostGIS server.

The developed structure has several advantages:

- uniform metadata standards and attribute naming across regions; simplified integration into web services via GeoServer and Leaflet;
- support for multi-level access control and real-time updates; compatibility with both ArcGIS and QGIS environments.

Building upon this database framework, an open-source Kazakhstan Geoportal was developed to demonstrate the integration of regional geodatabases within a single web platform. Using freely available technologies — including Leaflet, PostgreSQL/PostGIS, GeoServer, and QGIS — the system provides interactive visualization, query capabilities, and analytical tools for specialists and public users.

This approach showcases the potential of open-source solutions for developing scalable and cost-effective national spatial data infrastructures.

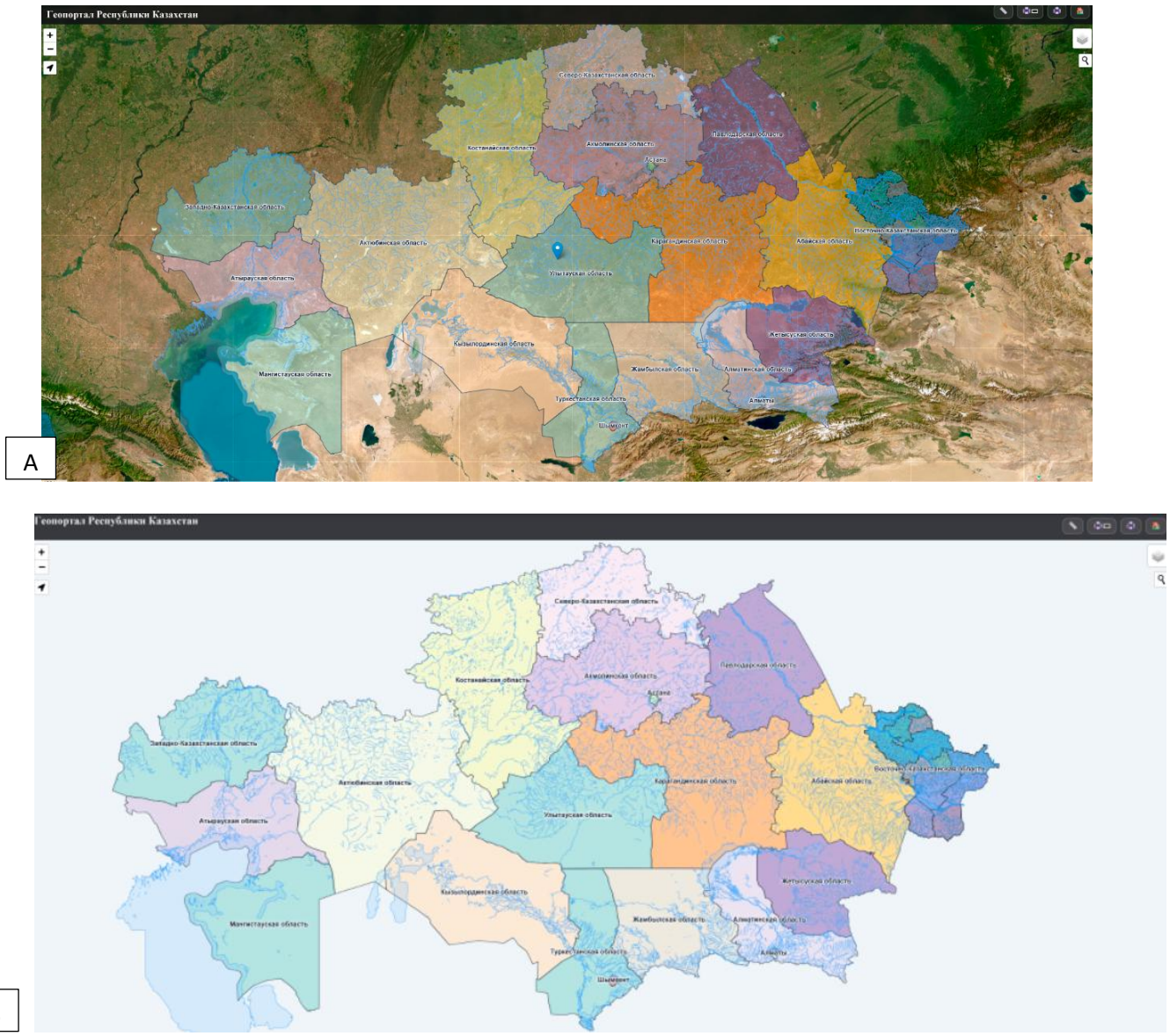


Figure 1. National Geoportal of the Republic of Kazakhstan: A) Geoportal with OpenStreetMap (OSM) basemap; B) Geoportal without basemap, displaying national geodatabase layers of the Republic of Kazakhstan.
**Compiled by the author using open source code*

The geoportal is built on the *Leaflet* framework and integrates multiple geospatial services. It provides a dynamic map interface for displaying regional boundaries, thematic layers, and attribute information in real time. The platform supports functions such as zooming, layer selection, coordinate search, and data export, ensuring accessibility from any device connected to the Internet.

Figure 2. Interactive Tools and Functional Modules of the Geoportal
**The tools are tested and compiled by the author*

The left panel shows the measurement tools, which allow users to calculate distances and areas (in meters, kilometers, hectares, or square kilometers). The right panel demonstrates the search function available in three languages — Kazakh, Russian, and English — enabling multilingual access to geographic data across regions.

The interface includes several key analytical and visualization tools that can be adapted for various applications.

These modules support:

- spatial monitoring of land resources;
- analysis of environmental and agricultural changes;
- visualization of cadastral and infrastructure data;
- integration of external datasets (e.g., remote sensing products or statistical indicators).

As demonstrated in the figures, the Kazakhstan Geoportal represents a practical example of applying a unified geodatabase and open-source web technologies for nationwide geoinformation integration.

The flexibility of the Leaflet and PostGIS ecosystem allows the system to be easily customized for diverse research, monitoring, and management tasks — from agricultural land analysis to environmental assessment and spatial planning.

Conclusions

According to the objectives defined in the introduction, the conducted research has confirmed the effectiveness of using geographical databases and modern GIS technologies for the creation of geoportals in Kazakhstan. The main goal — to design and implement an integrated geospatial database combining administrative, hydrographic, agricultural, and infrastructural datasets — was successfully achieved. The database structure, developed in the PostgreSQL/PostGIS environment, ensures reliable storage, spatial indexing, and accessibility of geodata for national and regional applications.

The second objective, related to the development of the geoportal architecture, was implemented through the integration of open-source platforms including QGIS, GeoServer, and *Leaflet*. This architecture provides interoperability between the database and the web interface, enabling efficient data visualization, analytical processing, and user interaction in real time.

The third objective involved the implementation of interactive analytical and visualization tools, allowing users to view, query, and interpret spatial data directly through the web interface. Using analytical modules built within ArcGIS and QGIS, several geoprocessing functions — such as buffering, overlay analysis, and NDVI visualization — were successfully integrated into the web application. These tools allow specialists to perform thematic mapping, assess land use dynamics, and monitor environmental conditions at multiple spatial levels.

The developed system combines data management, spatial analysis, and visualization functions within a single interactive platform. It adheres to the principles of open spatial data, contributes to the development of a National Spatial Data Infrastructure (NSDI), and supports Kazakhstan's digital transformation strategy in land and environmental management. Through the integration of multilingual interfaces and automated data update mechanisms, the system improves both accessibility and transparency in decision-making processes.

The results of this study demonstrate that the creation of geoportals based on structured geoinformation databases is a scalable and sustainable solution for enhancing the efficiency of spatial data management, monitoring, and analytical decision support in Kazakhstan. The proposed methodological and technological framework can be replicated across various regions and sectors, forming the foundation for a unified, interoperable geospatial infrastructure of the Republic.

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References

1. Rafikov, T., Yerbolkyzy, M., & Zhildikbayeva, A. (2024). Otsenka sostoyaniya rastitel'nosti Vostochno-Kazakhstanskoy oblasti s ispol'zovaniem NDVI. *Izdenister, natigeler, 1(101)*, 183–191. https://doi.org/10.37884/1-2024/18 [in Russian]

2. Zhumataeva, Zh., Serikbayeva, G., Turganaliev, S., Mukaliyev, Zh., & Rafikov, T. (2024). Povyshenie ekologo-ekonomicheskoi effektivnosti ispol'zovaniya zemel'nykh resursov. *Izdenister, natigeler, 2(102)*, 360–369. https://doi.org/10.37884/2-2024/35 [in Russian]

3. Sadenova, M., et al. (2024). Assessing the effectiveness of remote sensing, GIS, and AI data integration for sustainable agriculture: A case study from Kazakhstan. *Sustainable Computing Systems*. https://doi.org/10.1007/s43621-024-00625-4

4. Goodchild, M. F., & Li, W. (2021). GIScience and big data: The challenge of spatial data in the era of machine learning. *Computers, Environment and Urban Systems, 90*, 101687. https://doi.org/10.1016/j.compenvurbsys.2021.101687

5. Goodchild, M. F. (2019). Geography and geographic information science: An evolving relationship. *The Canadian Geographer, 63*(4), 530–539. https://doi.org/10.1111/cag.12554

6. Haklay, M., & Weber, P. (2008). OpenStreetMap: User-generated street maps. *IEEE Pervasive Computing, 7*(4), 12–18. https://doi.org/10.1109/MPRV.2008.80

7. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). *Geographic information science and systems* (4th ed.). Wiley. https://www.wiley.com/en-us/Geographic%2BInformation%2BScience%2Band%2BSystems%2C%2B4th%2BEdition-p-9781119128458

8. Kraak, M.-J., & Ormeling, F. (2020). *Cartography: Visualization of geospatial data* (4th ed.). Routledge. https://www.taylorfrancis.com/books/mono/10.1201/9780429464195

9. Li, S., Dragicevic, S., & Veenendaal, B. (Eds.). (2020). *Advances in web-based GIS, mapping services and applications* (2nd ed.). CRC Press. https://www.routledge.com/Advances-in-Web-based-GIS-Mapping-Services-and-Applications/Li-Dragicevic-Veenendaal/p/book/9781138117815

10. QGIS Development Team. (2025). *QGIS geographic information system* [Computer software]. QGIS Association. https://www.qgis.org

11. Esri. (2023). *Best practices for system architecture — ArcGIS Enterprise*. Environmental Systems Research Institute. https://enterprise.arcgis.com/en/server/11.2/deploy/windows/best-practices-for-system-architecture.htm

12. Esri. (2023). *Work with services — ArcGIS Enterprise* [Documentation]. Environmental Systems Research Institute. https://enterprise.arcgis.com/en/server/11.0/install/windows/services-in-arcgis-enterprise.htm

13. Craglia, M., & Annoni, A. (2020). Digital Earth vision and spatial data infrastructures: Pathways for integration. *International Journal of Digital Earth, 13*(8), 950–971. https://doi.org/10.1080/17538947.2020.1762093

14. Abdrakhmanov, T., Serikbayev, K., & Tuleuov, A. (2023). Implementation of GIS technologies for land monitoring in Kazakhstan. *Bulletin of KazNARU, 2(94)*, 77–84. https://kaznaru-bulletin.kz (journal homepage)

15. Batyrkhanova, D., & Akhmetova, A. (2022). Development of a national geoportal for open spatial data in Kazakhstan. *KazNU Bulletin. Earth Sciences Series, 1(59)*, 41–50. https://bulletin.enu.kz/ (series homepage)

16. Biekša, K. (2016). The evaluation of cereal farms using the ecological footprint method. *Management Theory and Studies for Rural Business and Infrastructure Development, 38*(3), 207–218. https://doi.org/10.15544/mts.2016.16

17. Hurni, L., & Sieber, R. (2023). The evolution of geographic information science: From desktop mapping to cloud-based geoportals. *International Journal of Digital Earth, 16*(1), 1–18. https://doi.org/10.1080/17538947.2023.2172763

18. Zhang, C., & Li, W. (2021). *Web GIS: Principles and applications*. Springer. https://link.springer.com/book/ (publisher portal)

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ҚАЗАҚСТАНДА ГЕОПОРТАЛДАРДЫ ДАМЫТУ ҮШІН ГЕОГРАФИЯЛЫҚ ДЕРЕККӨРЛАРДЫ ҚОЛДАНУ

Аңдатпа

Қазақстандағы цифрлық трансформацияның жүріп жатқан жағдайында геокеңістіктік деректерге негізделген геопорталдарды әзірлеу кеңістіктік деректерді басқарудың тиімділігі мен ашықтығын арттырудың стратегиялық бағытына айналуда. Зерттеудің мақсаты — геопорталдарды жобалау мен енгізуде географиялық деректерді пайдаланудың тиімділігін бағалау және елде бірыңғай геоақпараттық ортаны құруға арналған әдістемелік тәсілдер ұсыну. Жұмыста QGIS, ArcGIS Pro, PostgreSQL/PostGIS және Leaflet платформалары қолданылып, әкімшілік, гидрографиялық, ауыл шаруашылығы және инфрақұрылымдық деректер қабаттарын біріктіру мен визуализациялау қамтамасыз етілді. Ашық стандарттарды (OGC WMS/WFS, ISO талаптарына сай метадеректер) сақтау, рөлге негізделген қолжетімділікті басқару және ведомствоаралық пайдалануға лайық ауқымдалатын орналастыру үлгілеріне ерекше көңіл бөлінді. Ұсынылған геопортал архитектурасы деректерді өңдеу, талдау және визуализациялау үдерістерін біріктіреді, кеңістіктік ақпаратқа дерлік нақты уақыт режимінде қолжетімділік береді, сондай-ақ деректер сапасын қамтамасыз ету (топологияны тексеру, схема/құрылымды валиддеу), кэштеу және журналдау тетіктерін қамтиды, бұл өнімділік пен аудитке жарамдылықты арттырады. Бағалау өңірлік және ұлттық ГИС жүйелерімен өзара үйлесімділікті сынау, жүктеме кезіндегі жауап беру уақытын бенчмаркингтеу және салалық сарапшылардың қатысуымен пайдаланушылық қабылдау сынақтары арқылы жүргізілді. Нәтижелер геодерекқорларды қолдану платформалар арасындағы өзара үйлесімділікті айтарлықтай жақсартатынын, беделді деректер жиынтықтарын табу мен қайта пайдалануды жеңілдететінін және Қазақстандағы жер ресурстарын басқару, экологиялық мониторинг және кеңістіктік жоспарлау үдерістерінің цифрлық трансформациясына үлес қосатынын көрсетеді. Зерттеу деректерді басқару, деректердің өмірлік циклін ұйымдастыру және технологиялық стекті таңдау бойынша

орнықты, қауіпсіз және кеңейтілетін геопортал енгізілімдерін қолдайтын практикалық ұсынымдармен аяқталады.

Кілт сөздер: географиялық ақпараттық жүйелер (ГАЖ), жер ресурстары, жер мониторингі, кеңістіктік талдау, QGIS, жер ресурстарын басқару, Шығыс Қазақстан облысы.

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ПРИМЕНЕНИЕ ГЕОГРАФИЧЕСКИХ БАЗ ДАННЫХ ДЛЯ РАЗВИТИЯ ГЕОПОРТАЛОВ В КАЗАХСТАНЕ

Аннотация

В контексте продолжающейся цифровой трансформации Казахстана разработка геопорталов на основе геопространственных баз данных становится стратегическим направлением повышения эффективности и прозрачности управления пространственными данными. Цель данного исследования — оценить эффективность использования географических баз данных при проектировании и внедрении геопорталов и предложить методические подходы к построению единой геоинформационной среды в стране. В работе использовались такие платформы, как QGIS, ArcGIS Pro, PostgreSQL/PostGIS и Leaflet, что обеспечило интеграцию и визуализацию административных, гидрографических, сельскохозяйственных и инфраструктурных слоёв данных. Особое внимание уделено соблюдению открытых стандартов (OGC WMS/WFS, ISO-совместимые метаданные), ролевой модели управления доступом и масштабируемым схемам развертывания для межведомственного использования. Предложенная архитектура геопортала объединяет процессы обработки, анализа и визуализации данных, предоставляет доступ к пространственной информации в режиме, близком к реальному времени, а также включает механизмы обеспечения качества данных (проверки топологии, валидация схем), кэширование и журналирование для повышения производительности и аудируемости. Оценка проводилась через тестирование совместимости с региональными и национальными ГИС, бенчмаркинг времени отклика под нагрузкой и пользовательские приёмочные испытания с участием отраслевых экспертов. Результаты показывают, что применение баз данных существенно повышает интероперабельность между платформами, улучшает обнаруживаемость и повторное использование авторитетных наборов данных и способствует цифровой трансформации процессов управления земельными ресурсами, экологического мониторинга и пространственного планирования в Казахстане. Исследование завершается практическими рекомендациями по вопросам управления данными, менеджмента жизненного цикла данных и выбора технологического стека для устойчивых, безопасных и расширяемых внедрений геопорталов.

Ключевые слова: географические информационные системы (ГИС), земельные ресурсы, мониторинг земель, пространственный анализ, QGIS, управление земельными ресурсами, Восточно-Казахстанская область.

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Rafikov Timur – Resources; Investigation; Data curation; Visualization; Verification.

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ШАРДАРА МАССИВІНІҢ СУАРМАЛЫ ЖЕРЛЕРІНІҢ ЭКОЛОГИЯЛЫҚ-МЕЛИОРАЦИЯЛЫҚ ЖАҒДАЙЫН БАҒАЛАУ

Аңдатпа

Мақалада Қазақстанның оңтүстік өңірлеріндегі, әсіресе Шардара массивіндегі суармалы жерлердің экологиялық-мелиорациялық жағдайы қарастырылады. Ирригациялық жүйелердің тозуы, суару суларының сапасының нашарлауы, жер асты сулары деңгейінің көтерілуі және топырақтың екінші реттік тұздану процестері талданды. Гидромелиорациялық жүйелердің жағдайын бағалаудың әдіснамалық негізі М.Ф.Натальчуктың жіктеуіне негізделді. Бұл әдіс ирригациялық желілердің техникалық жағдайын және олардың функционалдық жарамдылық деңгейін объективті түрде анықтауға мүмкіндік берді. Аталған жіктеу мелиорациялық жүйелердің жағдайын және ирригациялық инфрақұрылымның тиімділігін сипаттайтын негізгі параметрлердің кешенді талдауына сүйенеді. М.Ф.Натальчук әдісі негізінде жүргізілген зерттеу нәтижелері гидромелиоративтік жүйелердің қазіргі жағдайының сын көтермейтінін көрсетті. Яғни, аймақтағы суару жүйелерінің басым көпшілігі IV разрядқа жататыны анықталды. Бұл жағдай суару инфрақұрылымының аса күрделі жағдайда екенін көрсетіп, оның толықтай жаңғыртылуын қажет ететінін айқындайды. Сонымен қатар, суару жүйелерін жаңғырту және қалпына келтіру бойынша бірқатар шаралар ұсынылған, соның ішінде каналдардың пайдалы әсер коэффициентін (ПӘК) арттыру, заманауи агротехнологияларды енгізу және коллекторлы-дренаждық сулардың сапасын жақсарту. Суармалы жерлердің тұрақты дамуын қамтамасыз ету үшін экологиялық, экономикалық және әлеуметтік аспектілерді қамтитын кешенді көзқарас қажеттілігі атап өтілді.

Кілт сөздер: *суармалы жерлер, тұздану, топырақтың деградациясы, ирригация, мелиорация, су ресурстары, гидромелиоративтік жүйелер.*

Кіріспе

Суармалы жерлерді сақтау және оларды ұтымды пайдалану Қазақстанның ауыл шаруашылығының тұрақты дамуын қамтамасыз етудегі басты міндеттердің бірі. Елдің оңтүстік аймақтарында, атап айтқанда Түркістан, Жетісу, Жамбыл, Алматы және Қызылорда облыстарында барлық суармалы жерлердің 90%-дан астамы шоғырланған. Алайда соңғы онжылдықтарда ирригациялық жүйелердің тозуы, топырақтың тұздануы және жер асты сулары деңгейінің көтерілуі салдарынан олардың мелиорациялық жағдайы нашарлауда. Суармалы егіншіліктің ең кең таралған аймағы Сырдария өзені бассейні болып табылады, онда ірі ирригациялық массивтер орналасқан [1-3]:

- Мақтаарал массиві – шамамен 136 мың га,
- Жетісай массиві – 80 мың га астам,
- Сарыағаш массиві – шамамен 60 мың га,
- Шардара массиві – шамамен 50 мың га.