Geoportal for the Goals of Sustainable Socio-Demographic Development of Western Kazakhstan

Nyussupova, G.,* **Aidarkhanova, G., Kelinbayeva, R., Kenespaeyeva L. and Zhumagulov, C.**
Al-Farabi Kazakh National University, Kazakhstan, E-mail: gulnaran@mail.ru*
**Corresponding Author*

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Abstract
One of the modern means of implementing the tasks of spatial analysis of socio-demographic processes are geoportals - portals that display and provide researchers with convenient access to geographic information through web services. This article examines the structure and content of the socio-demographic information database of the geoportal of the West Kazakhstan region of the Republic, developed within the framework of the Megagrant Program-targeted financing "Sustainable development of natural-economic and socio-economic systems of the West Kazakhstan region in the context of green growth: comprehensive analysis, concept, forecast estimates and scenarios." The research and content of the database structure is built in accordance with the Sustainable Development Goals. Today, the system of national indicators for monitoring the SDGs includes 262 indicators, of which 29 represent demography and 37 indicators reflecting social systems (key indicators) of sustainable development are highlighted. In addition, to assess the sustainable development of the West Kazakhstan region of the republic, 13 demographic and 17 social indicators were identified for the administrative districts of the four regions under study (Aktobe, Atyrau, West Kazakhstan and Mangystau). The developed information database of the geoportal in integration with GIS systems will provide the ability to visualize and increase the efficiency of monitoring, analysis, assessment and management of socio-demographic processes in the regions of Western Kazakhstan.

Keywords: Database, Geoportal, SDG, Socio-Demographic Development, West Kazakhstan Region

1. Introduction

Geoportals are an important tool for accessing and sharing spatial data, which can be used to address various tasks in the field of sustainable development. They allow users to visualize, analyze, and collaborate on spatial data managed with GIS (Geographic Information Systems). The use of GIS in sustainable development helps public and private organizations to better manage resources and plan long-term projects with minimal environmental impact. For example, GIS can be used to monitor the condition of forests, water resources, biodiversity, and to plan urbanization while taking into account ecological and social factors.

Geoportals not only facilitate access to data but also support interaction between various stakeholders—government agencies, research institutions, the private sector, and the public. These platforms can serve as a tool for feedback and collaborative decision-making [1]. In recent years, the research and development of geoportals has undergone new developments, especially with the emergence of new technologies and approaches in big data processing, cloud computing, and artificial intelligence. Modern geoportals integrate big data and AI to improve spatial data analysis and automate data update processes [2]. Cloud computing and distributed systems can improve the scalability and availability of geoportals [3]. Recent studies highlight successful examples of the implementation of geoportals, atlases within the framework of regional open data programs and initiatives. User interfaces are becoming increasingly intuitive and adaptive, based on distributed online services, extensible, compatible and modifiable, flexibly adapting to located devices [4].

Research and development of geoportals, especially in the context of the Sustainable Development Goals (SDGs), cover a wide range of issues related to spatial analysis, monitoring, and data management. Geoportals have become an important tool for achieving the SDGs due to their ability to collect, process, and visualize the data necessary for monitoring progress in sustainable development [5] and [6]. For example, GeoPlatform is a US government initiative aimed at supporting decision-making related to sustainable development.

The platform provides data for analysis on the topics of ecology, climate change, demography and health (https://www.geoplatform.gov). The European Data Portal provides access to an extensive database of open data from EU countries. The portal includes environmental, social and economic data that support the monitoring of SDGs in areas such as climate change, energy consumption and resource management (https://data.europa.eu). The UN Biodiversity Lab portal provides spatial data to help countries track SDG-related biodiversity targets. The platform helps in natural resource management, protected area planning and ecosystem conservation (https://unbiodiversitylab.org). The UN SDG Data Hub portal provides the data and visualizations needed to monitor progress on all 17 SDGs. It enables Member States to share statistics and data to assess progress on key sustainable development indicators (https://unstats.un.org/sdgs/dataportal).

The study of geoportals as a tool for working with spatial data has been actively evolving since the late 20th century, with many scholars making significant contributions to this field. Their work encompasses various aspects from spatial data infrastructure to the use of geoportals for monitoring and achieving the SDGs. For example, the application of spatial data infrastructure for achieving the Sustainable Development Goals was conducted by [7]. The role of spatial data infrastructure in land and natural resource management has been studied by [8]. The study helped laying the foundation for the development of national and regional geoportals used for land use and resource management.

The technical development of geoportals, particularly in the context of using satellite data to monitor environmental changes was conducted by [9]. The research focuses on integrating data from different sources and developing geoportal architectures to support decision-making related to sustainable development. Additionally, the use of geoportals for monitoring urbanization and its environmental impacts was performed by [10].

Research on the use of geoportals for sustainable socio-demographic development lies at the intersection of disciplines related to geographic information systems (GIS), demography, and sustainable development. Geoportals in this field help analyze and visualize spatial data, enabling the assessment of socio-demographic changes, forecasting population migration, planning infrastructure development, and tracking the implementation of social programs. The examples of using GIS to identify spatial inequalities in cities and plan infrastructure projects with consideration of socio-demographic characteristics were analyzed by [11]. This research contributes to the achievement of SDG 10, SDG 11. Furthermore, the geoportals were used to assess the accessibility of healthcare services in different regions and how spatial analysis can help develop strategies to improve access to these services [12]. This research focused on the application of GIS to SDG 3, SDG 9, SDG 10.

2. Material and Methods

The research is based on scientific and methodological principles and ideas of the general theory of cartography, domestic and international complex mapping and development of geoportals, web platforms of socio-economic phenomena and processes. The research methods included comparative-geographical, geoinformation mapping, spatial analysis, as well as mathematical and statistical methods. In developing the content of the maps and the structure of the portal, special attention was paid to methods for assessing social and demographic development, calculating integral indices of sustainable socio-demographic development.

In compiling the statistical database on demographic, social and economic indicators, official data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (https://stat.gov.kz), the Ministry of Science and Higher Education of the Republic of Kazakhstan (https://www.gov.kz/memleket/entities/edu?lang=en), the Ministry of Health of the Republic of Kazakhstan (https://www.gov.kz/memleket/entities/dsm?lang=en), the national reporting platform for SDGs of the Bureau of National Statistics (https://kazstat.github.io/sdg-site-kazstat/), monographs, articles in scientific journals, and Internet resources were used.

3. Results and Discussion

Kazakhstan, as a country that has committed to implementing the Sustainable Development Goals, is actively working in all areas and contributing to the successful achievement of global goals. The Government of the Republic of Kazakhstan has developed a national SDG reporting platform (https://kazstat.github.io/sdg-site-kazstat/). The purpose of this platform is to provide Kazakhstan with data on both global indicators for achieving the SDGs and national indicators. In addition, it provides the interested public with up-to-date information on the status of Kazakhstan's SDG indicators and detailed information on their calculation methodology. The monitoring data for SDG indicators in Kazakhstan are presented on the website in the form of tables and graphs (Figure 1).

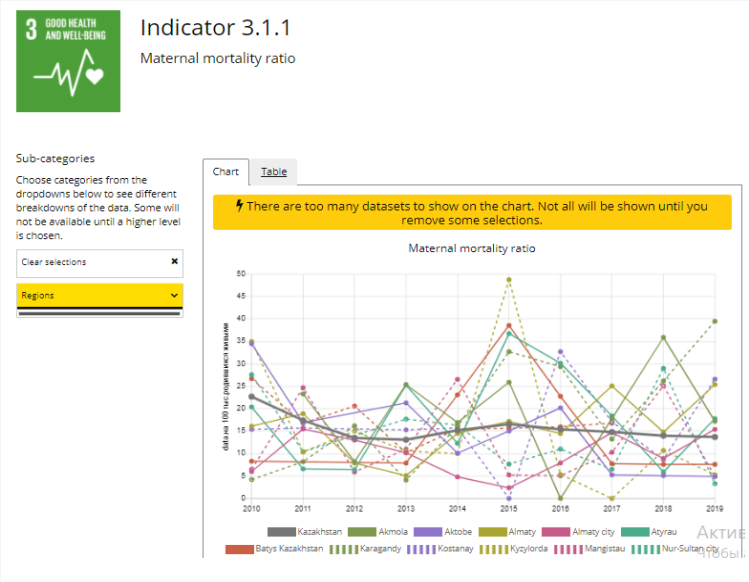

Figure 1: Maternal mortality indicator on the national reporting platform of the SDGs of the Republic of Kazakhstan

Unfortunately, geospatial data is not yet presented in the national platform of the SDGs of the Republic of Kazakhstan, and statistical data is presented only by regions. This complicates a more detailed study at the district level. The continuous flow of information for adapting management methods to the changing situation during the implementation of the SDGs emphasizes the importance and feasibility of introducing a geographic information system to study territorial aspects and address SDG issues. In this regard, work is underway in Kazakhstan to create a geospatial database on SDG indicators. A scientific study is being conducted at Al-Farabi KazNU within the framework of the project "Sustainable Development of Natural-Economic and Socio-Economic Systems of the West Kazakhstan Region in the Context of Green Growth: Comprehensive Analysis, Concept, Forecasts and Scenarios", where an analysis and assessment of the sustainable development of the Western subregion of Kazakhstan is carried out. During the work, a geodatabase on SDG indicators, ready thematic maps were created.

The geoportal being developed is a geoinformation web system for multi-scale data organization, mapping the situation in the field of research of SDG indicators (economic, social, demographic and natural-ecological). The data will help for further forecasting and modeling of demographic processes. The main feature of the geoportal is the advanced capabilities of cartographic presentation of spatial data. Geoportals are a relatively new topic in the cartographic and geoinformation literature and represent a synthesis of advances in geoinformation technologies, cartography and multimedia. They have advanced functionality, including zooming, navigation, address search, cartometric functions and access to more complex analytical functions inherent in GIS.

The geoportal of the Western region of the Republic of Kazakhstan under development is a multi-purpose geoinformation and reference web system that allows integrating data from various sources, forming and maintaining them in the form of a single geoinformation base, searching and issuing the user the required materials in text, graphic and cartographic form. The geoportal is a shell in the form of a web-cartographic information system – https://ecokazwest.kz/. The data are provided in three languages (Kazakh, Russian and English) (Figure 2). The geoportal will be a systematic collection of geographic maps, organically linked and complementary to each other. Access to cartographic documents is provided through a user interface with interactive functions, geographic and thematic navigation. The geoportal allows making queries, conducting spatial analysis and visualizing in 2-dimensional form. Unlike GIS, the geoportal is primarily a cartographic work with user-oriented maps, as well as an adaptation of complex analytical functions of GIS to solve specific problems. The web portal has a multimedia component in the form of diagrams and text.

Figure 2: Sustainable Development of Natural-Industrial and Socio-Economic Systems of the West Kazakhstan Region» web portal

The geoportal as a kind of database unites information, diverse in detail, time coverage and territory, methods of obtaining, set of indicators and indicators, types of presentation. The web portal being developed is based on geoinformation and telecommunication technologies and provides access to such developments for a wide range of users such as researchers, GIS specialists, government agencies, students, etc. These technologies allow for the prompt compilation and updating of information as territories develop, provide sufficient functions for analysis, forecasting and scenario modeling of various socio-economic and natural-ecological phenomena in general. Table 1 provides a list of the main functions of the geoportal, based on data from Khurni (Encyclopedia of GIS, 2008).

The creation of the web portal "*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*" is based on a number of methodological prerequisites:

1. The geoportal is an example of a user-system, since all its components are socially oriented and take into account the relationship between the population and the living environment.

2. The geoportal has a complex, multi-tiered structure, represented by a hierarchical system of blocks and components.

3. The geoportal has the ability to build spatio-temporal models that reflect changes in economic, social, demographic and natural-ecological parameters, which creates the prerequisites for developing forecasts and scenarios for the development of the Western region of Kazakhstan.

4. An important characteristic of the geoportal is the ability to build integrated models of the territory, reflecting the unity of its economic, social, demographic and natural-ecological components.

5. The adequacy of indicators to various territorial levels is taken into account; a change in the spatial scale of the model is accompanied by a change in the set of indicators and their weighting coefficients.

6. Implementation is carried out through the analysis of objective data characterizing the territory.

The process of developing the web portal "Sustainable Development of Natural-Industrial and Socio-Economic Systems of the West Kazakhstan Region" consists of several stages:

- Collection, preparation and pre-processing of spatial and statistical data
- Development of geo-analysis tools based on geo-information software
- Development of cartographic design of the project
- Publication of GIS web services
- Creation of web apps
- Web design of the geoportal
- Testing the geoportal

Table 1: Main functions of web portal

Function group	Subgroup of functions	Function
Main		Select view mode, select language, import/export files, print, bookmarks, undo/redo, tips, settings, help, system status, minimize, exit
Navigation	Spatial navigation	Select area, address search, zoom, scroll, move, rotate, determine position by coordinates, select line/angle of observation, route planning
	Thematic navigation	Selecting a topic, indexing pages by topic, navigating by topic
	Navigation in time	Selecting a time period, position on the timeline, retrospective, animation of changes in a phenomenon over time
Cognitive	Explanation	Explanatory texts, graphics, hyperlinks to Internet sources
Cartographic	Map management	Enable/disable map layers, enable/disable categories in map legend, change displays
	Data Analysis	Changing the classification method, modifying the state parameters (lighting, brightness), comparing maps, selecting data
Geoinformation	Spatial and object-oriented queries	Spatial query by coordinates, area, distance, query by intersections and other topology elements
	Thematic queries	Query by attributes, access to statistical database

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The main interface of the website is a user-friendly means of interaction and work with the site and consists of two parts. The first part of the interface is responsible for working with the web portal in the administrator and editor mode. It provides the functionality for creating categories, tables and maps of SDG indicators, and it is possible to delete and modify existing data. The second part of the website interface is implemented for regular users in reading mode, with the ability to work with publicly available functionality.

All information on the website "Sustainable Development of Natural-Industrial and Socio-Economic Systems of the West Kazakhstan Region" is grouped into several menus.

The "About the Project" menu is a ‘Welcome’ block with overview information about this project. The "Indicators" menu will present all indicators in the form of expanded tabular data, where users can view and download data in tabular form. The "Map" menu allows to view a list of all thematic maps, as well as open a specific map. In the "Graphs" menu, users can view statistical data on all SDG indicators in the form of diagrams for each district of the West Kazakhstan region and in dynamics by year. The "Administration" menu provides full access to all elements of the geoportal. This entry is intended for site administrators and editors, and analysts manually entering queries to the database via SQL language, upload, enter and edit data.

The main functionality of the web portal consists of data entry and storage functions, visualization, and geoanalysis. The data entry and storage function support loading statistical and geographic data and database management, and manipulations with them are also possible on the server, including copying, deleting, exporting, importing, and other operations to solve specialized tasks. To ensure the functioning of the geoportal, a structure was developed and a geodatabase (DB) was formed for SDG indicators. The DB consists of two types of information: statistical and spatial. The spatial components consist of vector layers, previously created and processed in a GIS and corresponding to the basic requirements of vector information (the necessary detail, reliability,

accuracy, compliance with the requirements for the coordinate system and cartographic projection, data exchange format, etc.) They are loaded into the DB as a cartographic base for all future thematic maps of the geoportal and contain information on the boundaries and settlements of administrative-territorial entities.

The statistical data of the database of the web-portal "Sustainable Development of Natural-Industrial and Socio-Economic Systems of the West Kazakhstan Region" represent primary and integral indicators of sustainable development in four topical chapters economic, social, demographic, natural/ ecological) for the 4 regions of Western Kazakhstan (Aktobe, Atyrau, West Kazakhstan and Mangystau regions) showing the dynamics for the period from 2000 to 2022.

Within the framework of subprogram 7 "Analysis and assessment of the socio-economic development of the West Kazakhstan region in the context of sustainable development", 14 demographic and 17 social key indicators were selected for the assessment of the sustainable development of the Western region of Kazakhstan by administrative districts of these four study regions, which, in our opinion, characterize the sustainable (or unsustainable) development of the regions and for which there are available statistics. The system of indicators was formed on the basis of the analysis of the compliance of the SDG indicators with the system of regional economic and statistical indicators of the Republic of Kazakhstan in the database of the Bureau of National Statistics (https://stat.gov.kz) (Figure 3). A total of 130 tables with indicators were uploaded to the site. For the economic component, 48 tables were uploaded to the site, for the social component, 30 tables were uploaded, and for the demographic component, 52 tables were uploaded. For ease of use, the site has developed a function for filtering indicators by components. The geoportal data visualization function is a presentation of data on SDG indicators in the form of maps, tables, texts and graphs and is the result of geoanalysis in the most understandable and convenient form for monitoring SDG indicators in the Western region of the Republic of Kazakhstan. The web portal allows users to make requests, conduct spatial analysis and visualize objects.

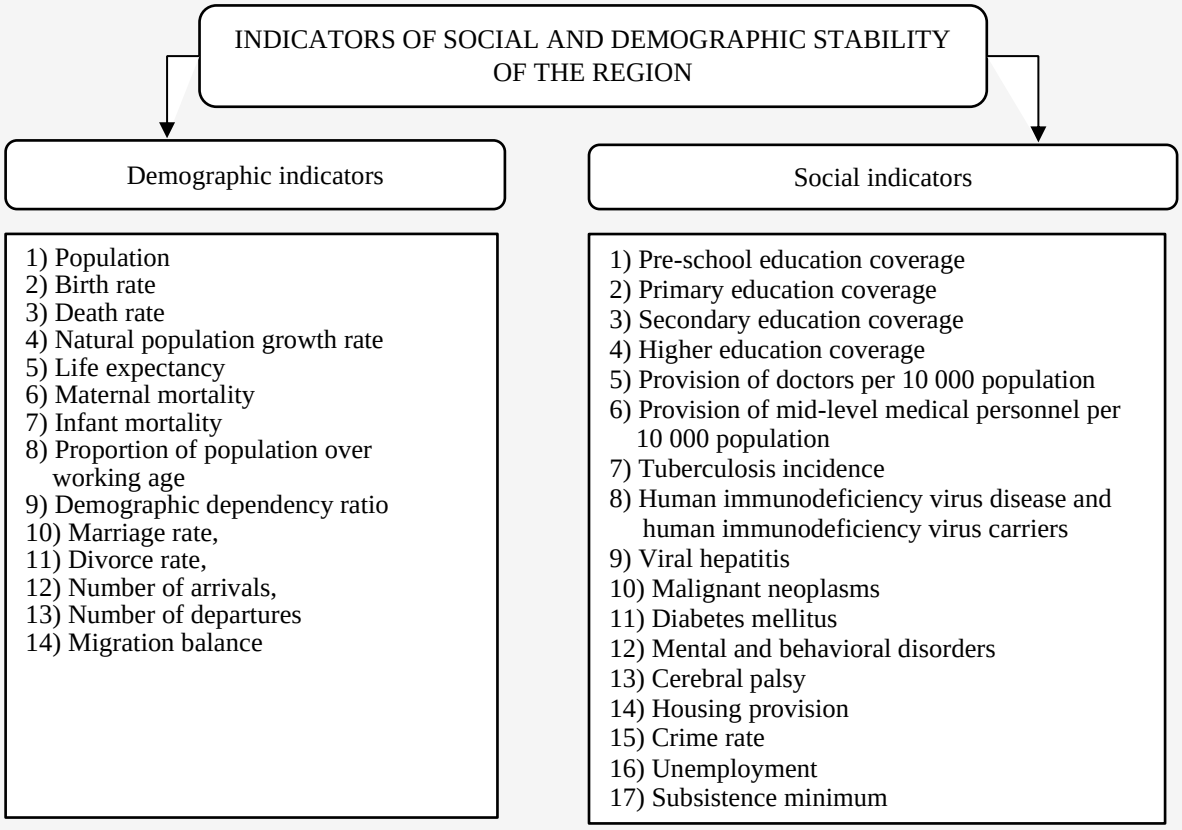

Figure 3: Indicators of socio-demographic stability of the region

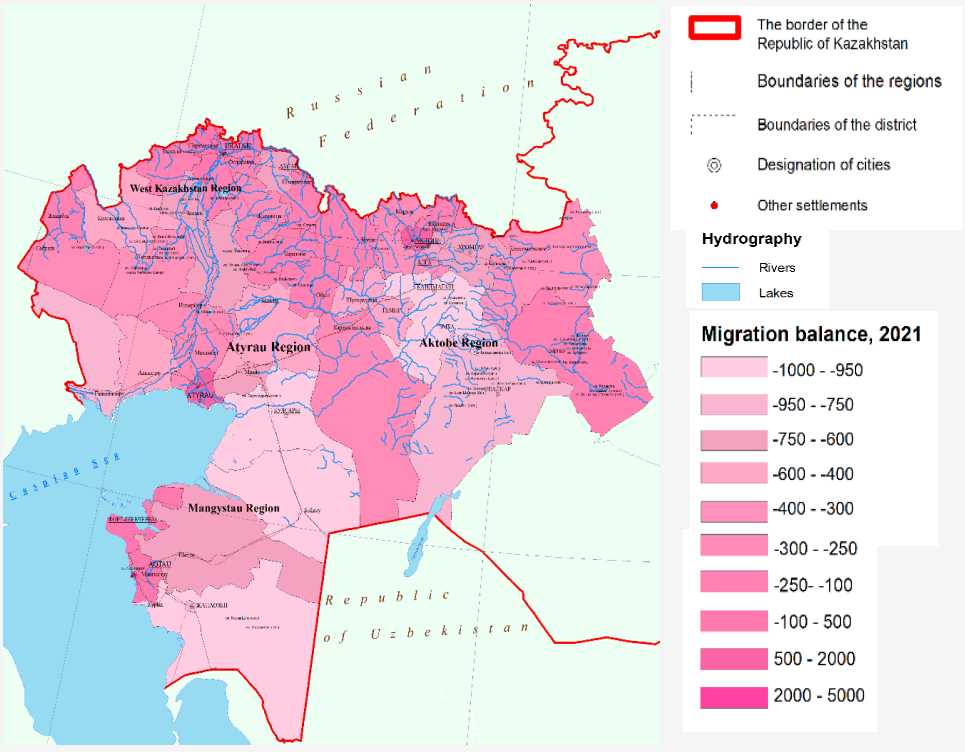

Figure 4: Migration balance of West Kazakhstan region 2021

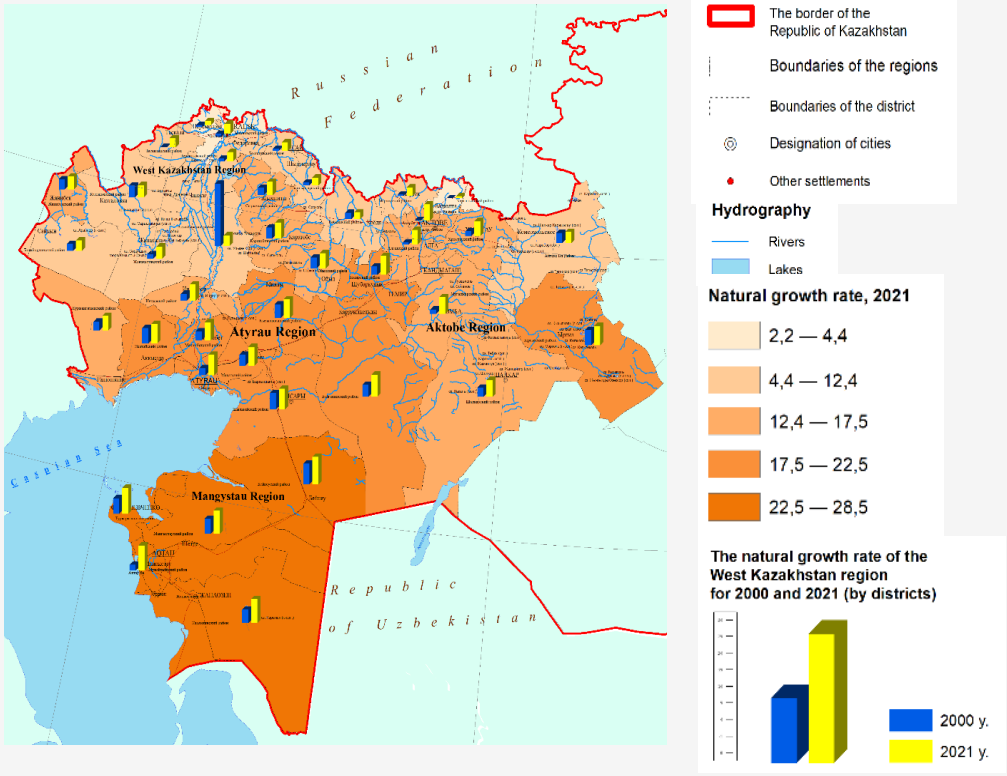

Figure 5: Natural growth of West Kazakhstan region 2000-2021

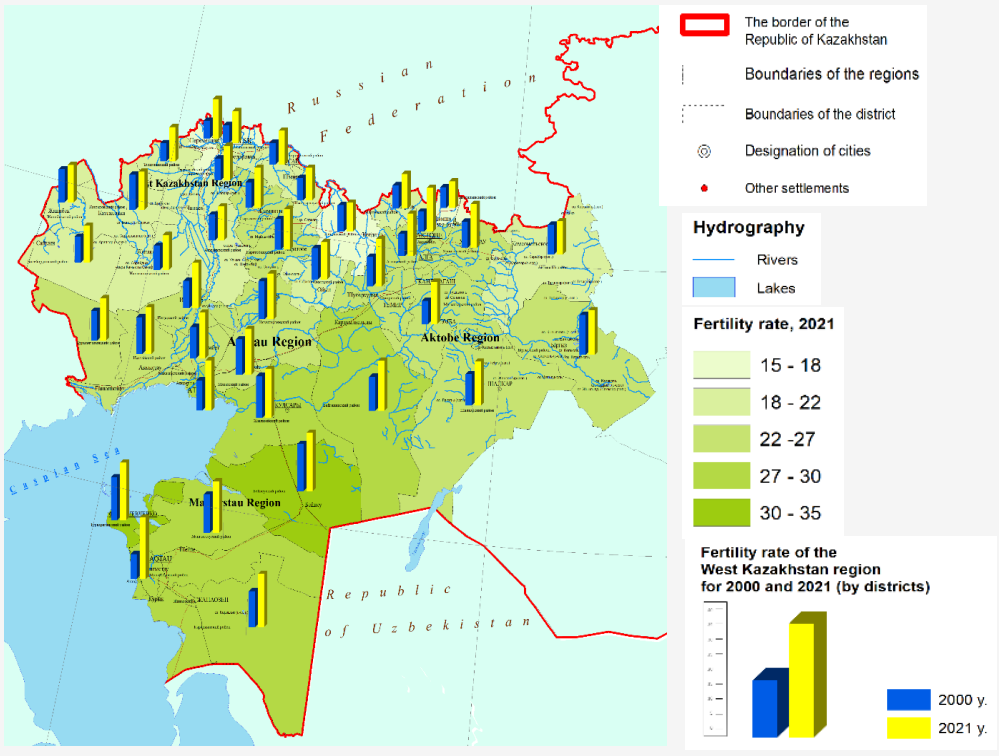

Figure 6: Fertility rate of West Kazakhstan region 2000-2021

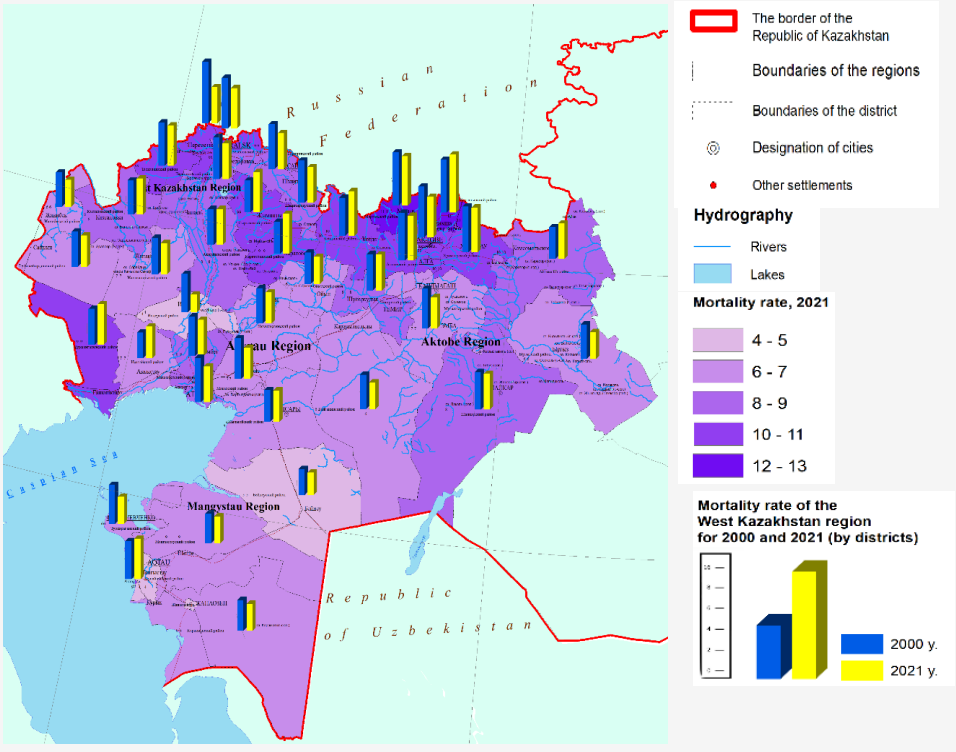

Figure 7: Mortality rate of West Kazakhstan region 2000-2021

Thematic maps were formed by linking statistical indicators of SDG indicators uploaded to the site representing administrative districts and their visualization using the cartogram method, which provides a clear picture of the intensity of economic, demographic and social processes and phenomena, and supports the spatial differentiation of district development. This approach made it possible to display the territorial aspects (features) of the processed information and use a wide range of geographic and cartographic techniques and methods in further analysis (Figures 4 to 7). Based on the uploaded statistical data, the site provides a function for automatically creating diagrams for each indicator in dynamics from 2000 to 2022 in the context of the districts of the Western Kazakhstan region. Site user can independently select one of the necessary SDG indicators to track the dynamics of a particular process in the administrative region or district of interest. The constructed diagrams allow to track patterns, trends, relationships and the structure of the SDG indicators difficult to see when studying the numerical values of the table. The geoanalysis and modeling function of the web portal allows, by means of superimposing thematic layers of economic, social, demographic and natural-ecological indicators allow interactive inspections of maps of the regions of Western Kazakhstan for 2000-2022. These cartographic models allow to visually analyze the situation, identify development patterns, relationships in spatial distribution, and to identify trends in the development of processes. This aims at the solving of specific problems, in this case for monitoring and managing SDG indicators and making decisions to ensure sustainable development in the regions of Western Kazakhstan.

4. Conclusions

Geoportals are a new stage in the development of digital geoinformation technologies, formed at the junction of the latest achievements in the field of digital multimedia technologies, cartography and development of management interfaces. The work demonstrates the methodology for creating a web portal for analyzing, monitoring and managing SDG indicators in the regions of Western Kazakhstan. As one component an expanded geoinformation base of economic, social, demographic SDG indicators in dynamics for 2000-2022 was created. A methodology for creating a web portal has been developed, which is based on the statistical and spatial data of SDG indicators. The geoportal will automate the processes of processing and calculations, systematization of storage and structuring of a large volume of statistical and spatial information.

Digitalization of SDG research through a geoportal plays an important role in the analysis, monitoring and management of the socio-economic development of spatial-territorial systems. The use of the web portal "Sustainable Development of Natural-Industrial and Socio-Economic Systems of the West Kazakhstan Region" will provide an opportunity to obtain operational geospatial information on dynamics of economic, social, demographic and natural-ecological indicators of the SDGs of the regions of Western Kazakhstan in the form of maps, statistical tables, graphs and text descriptions. The materials of the geoinformation base, consolidated into a single system, make it possible to fully characterize the socio-economic situation of the Western region of Kazakhstan and determine the strategy for its sustainable development. The created extensive database of the geoportal will serve as the basis for the development of a regional block of the fundamental digital infrastructure of spatial data.

Being an important component of the information system, thematic maps of the web portal will provide scientific, methodological and informational support: in economic sectors – to state programs for improving social, demographic, economic and natural-ecological indicators; in the field of science – to promising scientific research and applied developments, the development of thematic mapping, the formation of sectoral and universal databases of applied orientation.

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