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Information support for the use of land resources in the Kyzylorda region, Kazakhstan: Analysis, assessment and forecasts

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ABSTRACT
Land use suitability analysis is one of the basic approaches in planning. This process is complex and multidimensional, and a large amount of variables must be considered at the same time. With recent technological advances, many opportunities have been provided to process large amounts of data in planning and decision-making processes. Methods based on spatial information and planning support systems are useful tools. In this research, combining GIS capabilities with the planning support system has presented a method to evaluate the suitability of urban land in the Kyzylorda region, Kazakhstan for use. This system, as one of these efficient tools, can help the planners in identifying useful works or policies by considering a large number of different indicators, the most favorable areas for each type of user in real time, and also provides the possibility of participation. Among all the changes, the most worrying situation is for agricultural lands. The results show that land use changes are the expansion of urban and industrial areas and the reduction of agricultural land use. Agricultural lands and gardens in 2023 included 180,000 hectares and could decrease to 105,000 hectares by 2050, i.e., a loss of 75,000 hectares compared to the coverage of agricultural lands and gardens in 2023. The results of the present study, based on the expansion of urban and industrial activities and the reduction of agricultural land in the region, require more attention from environmental planners for better decision-making and management.

Keywords: land use, ecology, natural resources, environment.
Article type: Short Communication.

INTRODUCTION
One of the key elements of land administration is land management and related data. This data can be digital or analog, but all Earth-related records are converted to digital format for easy storage and retrieval. From the land administration's point of view, data is a collection of raw entities that may be collected as numbers or text, for example, in a surveyor's office or digitally by a "data logger" and computer. Data may also be displayed graphically, such as maps or aerial images (Ramachandra & Kumar 2004; Theobald *et al.* 2005; Hallett *et al.* 2017). Data are information when processed in a way that is meaningful to a decision maker. The effectiveness of this information depends on the quality of the data, especially the timeliness, accuracy, completeness, meaningfulness, and comprehensibility of the data. However, good data only sometimes leads to good management decisions because other factors, such as user skill, are also involved. However, the reverse is always true, as poor quality data almost certainly leads to wrong decisions. Land-related data is increasingly managed using a Land Information System (LIS). Like other information systems, LIS uses a combination of human and

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technical resources and a set of classified processes to produce information supporting management activities. Technologies that increasingly drive data processing forward are elements of geographic information systems (GIS; Lilburne *et al.* 2020). There have been many debates about GIS; some people think of it as a collection of hardware, software, and data, and others think of GIS as containing regular regulations of which technology is only a part. In the current discussion, GIS is seen according to the first theory and is limited to accessing and collecting spatial data. Data processing, storage, maintenance, retrieval, analysis, and distribution are considered. Comparing a car engine to a GIS, it is the car's engine, and data is the fuel. However, working in a transportation system is a more complicated process. Today, land use determinations are highly complex multidimensional systems increasingly interconnected due to globalization and technological advances. Transformation is faster and less predictable than in the past, and its interactive dimensions - social, economic, cultural, political, environmental, and physical - are often simultaneous and irregular in nature (Banai 2005). Land suitability assessment is a process that determines land suitability for a defined use (Campbell 1983). At first, suitability was used as a tool for planners to provide a comprehensive view of sets of dependent spatial indicators in the field of environment. Land Suitability Assessment 1 is a multi-criteria assessment of the land's capacity for development, and it is based on the opinions of experts who determine the points and weights of each index (Uwa *et al.* 2023). Land suitability assessment has become a practical standard in land use planning (Debnath *et al.* 2023). GIS applications have widely provided spatial development based on specific factors on the land surface. However, such methods have yet to offer significant improvements. The most important limitation of this method is the lack of a standard process and, specifically, the problems related to the selection of the conceptual model and the definition of indicators in each of its parts (Nainggolan *et al.* 2024). The main purpose of land suitability analysis is to help planners and decision-makers find the most appropriate location and pattern of activities in the planned lands in a way that best fits the planning goals and interests of the beneficiaries (Mashala *et al.* 2023). Therefore, one of the important tasks of urban planners is to identify land use appropriateness indicators and examine these factors in different areas of the city to balance and increase efficiency in land use planning. Land changes (Belete *et al.* 2023) are one of the main topics of global environmental impacts and sustainable development. Urban development greatly impacts land use and cover (Admasu *et al.* 2023; Darem *et al.* 2023; Zhang *et al.* 2023; Beirami *et al.* 2024). The effects of land use change caused by rapid urbanization disturb the sustainability of the environment. Population growth and economic development are the driving factors and transformations in different land covers, such as vegetation and water. This continuous transformation of land use causes environmental destruction. The severity of these changes in response to the growth of the world population and its consequences on the environment doubles the necessity of conducting detailed studies on such changes. Analyzing the dynamics of land use changes in the long term is important for understanding and evaluating various changes in the environment that help achieve sustainable development goals (Li *et al.* 2023); Therefore, to provide rational science for regional planning decisions and sustainable development, land use prediction models can be used based on past preliminary information to build future scenarios of land use and land cover changes. Land use and land cover change prediction modeling creates an interesting prospect for applications in planning units such as river basins and makes it an effective tool for analyzing the causality of future landscape dynamics under different scenarios (Shekar & Mathew 2023). Land use models are considered as a powerful tool for understanding the spatiotemporal pattern of land use changes; such as Markov chain (Sun *et al.* 2023), cellular automata (Li *et al.* 2023) and hybrid models based on these methods (Hassan *et al.* 2023; Meimei *et al.* 2023; Wang *et al.* 2023a,b) which are widely used to simulate the spatial and temporal dimensions of land use.

MATERIALS AND METHODS

The research method is descriptive-analytical in terms of the type of method and applied in terms of the kind of goal. The descriptive-analytical method is based on defining and describing basic concepts and factors affecting the subject under study. In this method, an attempt is made to break down the issue into its component parts with a logical process and to identify the factors affecting land use suitability, and finally, through the analysis of these factors and their influence, to present land suitability into categories different by using the planning support system. The desired information of the selected indicators in this research is extracted from the information in the comprehensive plan, and after grouping different land uses and preparing the land suitability analysis layers, at first, several major groups of land use are considered, and indicators to determine land suitability for each group.

These uses are defined, and the weight, importance coefficient and value of each index are explained by a questionnaire completed by experts and city officials.

Study area

Kyzylorda Province is one of the provinces of Kazakhstan. It is located in the south of the country, in an area of 226 thousand km², and in the eastern part of the Aral Sea. It has a continental climate with hot summers and cold seasons with little rain. Many areas are covered with sand, brown, gray, sandy, and salty soil. In addition, 15% of the territory suitable for agriculture is located in the Syr Darya floodplain, 21% in barren areas, and 64% in the desert area.

Fig. 1. Studied area.

In this research, the user's change in ERA (in two time periods: 2000 to 2020, 20 years, and 2020 to 2040, 20 years) and from 2000 to 2040 was modeled.

RESULTS

Factors of climate change

The most important cause of climate change is the emission of greenhouse gases, and its result is severe damage to the ozone layer and severe climate changes with global warming, which pose the greatest risks to the safety of the planet and humans [8, 24]. Among the greenhouse gases, the emission of carbon dioxide gas due to the combustion of fossil fuels plays the first role. Fig. 2 shows the global emissions of carbon dioxide gas from the combustion of fossil fuels for the period 1910-2050, and it can be seen that there has been a significant increase in the 20th century.

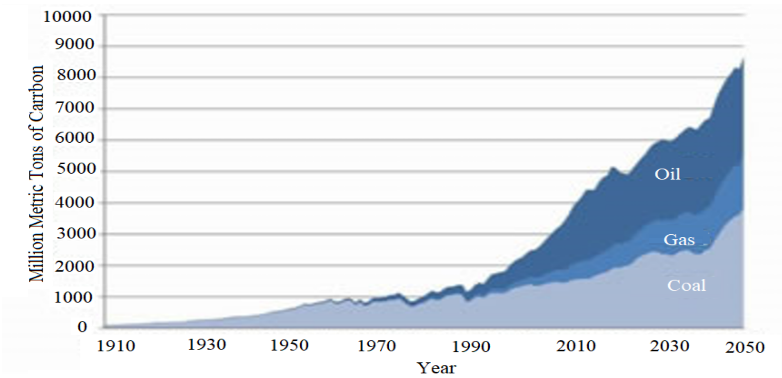

Fig. 2. CO_2 emission trends.

All its dimensions must be considered to achieve the goals of sustainable development. In terms of economic development, the goal of economic growth should be the well-being of the individual and society through the optimal use of natural resources within the framework of fair distribution of resources and wealth. The social dimension includes human-to-human relations, the purpose of which is access to services, health, sanitation, education, and security. Human valuing and poverty alleviation should be at the center of the activities of the

social dimension of sustainable development. In the ecological dimension, the activities are focused on protecting and strengthening the physical, biological resources and the sustainability of the ecosystem and finally the balanced relationship between man and nature. Sustainable development is not only preserving the environment because development can establish a balanced relationship with the environment with an acceptable level of economic and social justice. The World Commission on Environment and Development has provided requirements for sustainable development, which include:
- Existence of a political system that provides security for citizens and makes them participate in decisions.
- Existence of an economic system that can solve the tensions caused by the imbalance of development.
- Existence of a flexible management system that has the capacity of self-correction.

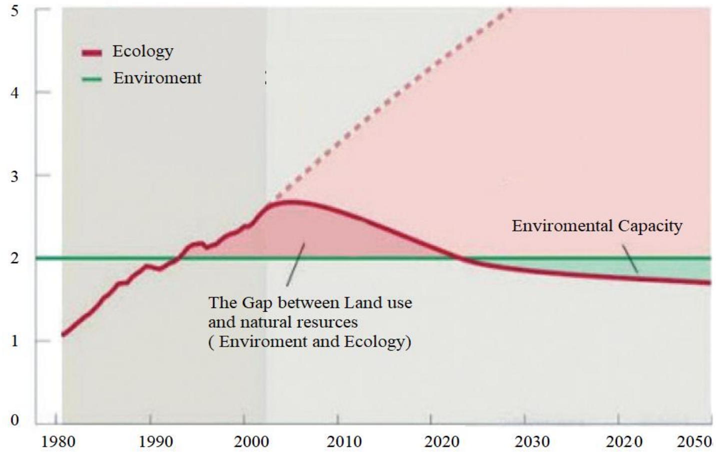

Fig. 3. Capacity of environment and ecology in land usages.

Based on Fig. 4, the incremental trend of urban-rural development land use change for 2000-2040 is observed. So, the abovementioned land use area for agricultural land has increased from 14000 hectares in 2000 to 151000 hectares in 2040. It has decreased from 180000 hectares to 105000 hectares. The expansion of development and reduction of agricultural lands have followed the current trend of land use and land cover change in the region. Industry use is also predicted to increase from 4500 to 13000 hectares between 2000 and 2040. The analysis of the transfer potential of land use and land cover changes is presented in Table 1. To interpret the table, for example, it can be stated that based on the procedure from 2000 to 2020, the probability that class 1 (agriculture) will change to class 1 is 0.76. The probability that class 2 (Urban-rural constructs) will change to class 2 is 0.91, and class 3 (industry) changing rate to class 3 is 0.75. Also, the probability of changing agriculture use to Urban-rural constructs and agriculture to industry is 0.14 and 0.08, respectively. The probability of changing the use of Urban-rural constructs to agriculture and industry is 0.05 and 0.03 respectively. In looking at the land use classes, it can be noted that agriculture can expand around the Syr Darya River. This current expansion of agricultural crops is a potentially worrying scenario for the Syr Darya watershed. We have estimated that agricultural lands and gardens in 2030 could reduce by about 20% and decrease to 105,000 hectares by 2040, which means a loss of 75000 hectares compared to the coverage of agricultural lands and gardens. These results show the need to pay more attention to the environmental degradation program in the region in terms of the expansion of urban and social activities and the reduction of agricultural lands and gardens.

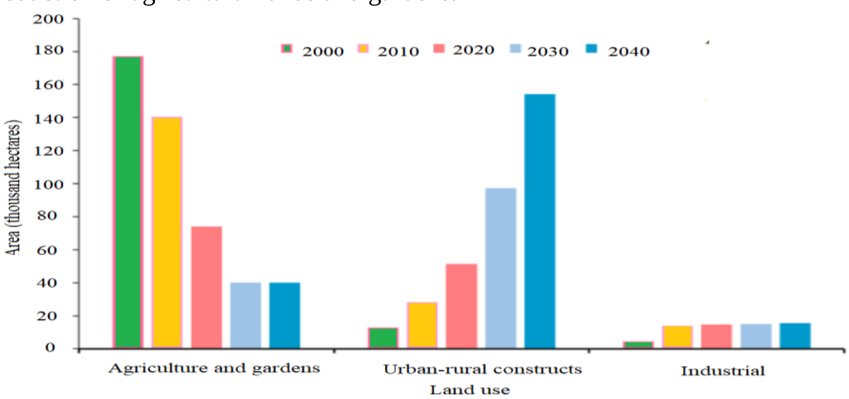

Fig. 4. Classification of land use.

Table 1. Probability of land use change in different years.

Probability of changes				Year	Land Use
Others	**Industrial**	**Urban-rural constructs**	**Agriculture and gardens**		
0.02	0.08	0.14	0.76	2000-2020	Agriculture and gardens
0.07	0.11	0.21	0.66	2020-2040	
0.02	0.03	0.91	0.05	2000-2020	Urban-rural constructs
0.09	0.09	0.81	0.01	2020-2040	
0.13	0.75	0.12	0.00	2000-2020	industrial
0.11	0.70	0.14	0.05	2020-2040	
0.94	0.02	0.03	0.01	2000-2020	others
0.85	0.02	0.10	0.03	2020-2040	

CONCLUSION

The Syr Darya River basin is considered one of the region's most important ecosystems. Since it has a basic environmental role and performs the task of water storage, its maintenance is essential for the ecological integrity of the water source and the preservation of ecology. Because mining industries are located in this area, it is necessary to investigate the change in land use to maintain the ecosystem services of plant and animal species in the region. Therefore, the results obtained in this study can be a useful tool in planning and creating local policies for sustainable economic development in the Syr Darya River basin. These results can also contribute to the discussion on the effects of agricultural land destruction and draw attention to more control of plant cover preservation in the region. The planning support system has many capabilities related to land suitability analysis and providing a suitable land-use model. But what may affect the effectiveness of this system regarding its use in the cities of Kazakhstan is its need for very accurate and detailed information at the neighborhood level. As it was observed in this research, the impact of many important indicators such as land price, user relationship with the number of trips and the transportation network in general, the exact effects of the used patterns on the environment, etc., due to the lack of information are ignored. Only indicators were used for fit analysis whose information was available or could be prepared for the system. Therefore, if this support system is to be used for planning in urban projects and in a professional environment, it is necessary to first ensure the existence of a detailed and extensive information system about the area to be planned, so that more capabilities can be used in this system and achieved more complete and accurate results.

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