

## Functional zoning of the Kazakhstan's part of the Caspian Sea shore for optimization of nature management

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**Abstract.** The problems of functional use of the territory of the Kazakhstan's part of the Caspian Sea shore within Atyrau and Mangystau regions of Kazakhstan with an emphasis on resource supply and features of the economic development of lands are considered in the article. The result of the analysis of the socio-economic conditions and ecological state of the environmental components of the Kazakhstan's part of the Caspian Sea shore, affecting natural and resource potential, are given. The methodology is examined and geo-information mapping of functional zoning of the study area is carried out.

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**Keywords:** functional use, functional zoning, resources, nature management, land use, GIS mapping.

### Introduction

Problems of nature management of the Kazakhstan's part of the Caspian Sea shore were caused by natural, socio-economic, normative legal and environmental factors, under the influence of which specific economic activities or certain types of functional activity are formed. The basis of the performed in this vein of the studies were formed by the materials of the Institute of Geography on geological and geomorphological structure, soils, vegetation, socio-economic development, the study of processes of land degradation and desertification, collected and processed over the past 15 years in the framework of basic and applied research [1-4].

Sustainable development of natural and economic systems of the Kazakhstan's part of the Caspian Sea shore largely assumes the implementation of the principles of integrated management of the geosystem "sea – coastal area – land". Moreover, the coastal zone is a transition zone and the most complex subsystem, it consists of the territories and water areas. Within the considered geosystem, natural factors (physical-geographic, natural-ecological) are imposed by anthropogenic impact in the form of socio-economic (agricultural, industrial, transportation, recreation) and cultural-historical factors [5]. This is due to the fact that the territory of interaction of land and sea since ancient times has been a source of natural resources, has served as an important link for transport communications and trade, has been the most valuable area of habitat and

Methods. Functional zoning requires, above all, an analysis of the existing nature use and includes component-wise characteristics of the natural environment, analysis of socio-economic

recreation for people, i.e. it has been a territory of multifunctional use. As a result of the interaction, a complex combination of different, often conflicting interests of nature users was created. In this regard, under conditions of competition and urgent conflicts, it is necessary to develop the foundations for sustainable management aimed at improving the lives of the population, sustainable development of resources, resolution of conflicts, improving the ecological state and coordination of the activity of nature users.

Management of complex systems requires an integrated approach, where resources are used with maximum social, economic and ecological benefit. Functional zoning that determines on the basis of contemporary socio-economic development of the natural environment and ecological status of resources for each of the zones such types of nature use that can prevent or reduce the level of conflicts, promote the most favorable industries from the socio-economic and ecological point of view.

In connection with the above discussed, the socio-economic conditions of the Atyrau and Mangystau regions with an emphasis on resources and economic use of land features were examined in detail, the current ecological state of the environmental components of the Kazakhstan's part of the Caspian Sea shore, affecting resource potential, was studied. The methodology of functional zoning was considered, a series of maps was drawn up by the type of land use and the ecological status of the territory. and environmental situation of the territory [6, 7]. Types of nature use are studied and mapped, a classification in terms of impact on the natural environment is created.

The main stages of the functional zoning are the following:

- Collection and assessment of data on environmental components on the studied territory with the preparation of a set of thematic maps;
- Assessment of the ecological status of environmental components;
- Assessment of the socio-economic development of the territory and the types of land use;
- Assessment and mapping of types of land use;
- Analysis of land use, identification of ecological conflicts, analysis of the causes, search for acceptable solutions;
- Determining the optimal option of the use of the territory by sectors of activity with the allocation of zones requiring changes in the nature of use;

Collection and assessment of data on environmental components contains information about the state of the main components of the environment: climate, natural waters, relief, soils, flora and fauna and is the basis for the territorial organization. It includes assessment of environmental conditions and resources, their significance and the extent of their current use. Assessment and mapping of socio-economic development of the territory and the types of existing nature management is an important stage of functional zoning. Almost all lands are used in the natural or economic terms, the change in nature management leads to a redistribution of lands between sectors. For example, the territories allotted for the residential or industrial objects, are withdrawn from the agricultural land use, from reserve lands or other land categories. After some time, due to their degradation, they no longer will have that natural value they had before redistribution. On the maps of the actual nature management, the territories used by basic types of land use, are distinguished:

1. residential
2. industrial
3. agricultural
4. transport
5. forestry
6. water industry
7. recreational, tourist
8. environmental

To prepare the map of the existing land use and conduct functional zoning, it is necessary to clarify the main object functions of the sectors of activity (Table 1), determining the need for the use of the territory or water area.

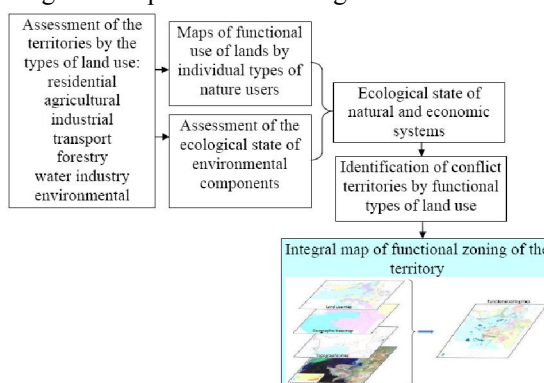
**Table 1. Object functions of types of land use**

Type of land use	Object function
residential	Resettlement of the population Placement of the facilities of infrastructure of the settlement.
industrial	Placement of the facilities of industry with sanitary and protection zones
transport	Placement of the facilities of transport and communications, including pipelines, power lines
agricultural	Crop production (including dacha) Livestock farming
recreational, tourist	Placement of the facilities of infrastructure and the use of the territory for the purposes of recreation and the population's health improvement and tourism
forestry	Forest management, reforestation
water industry	Placement of the facilities of water industry for the purposes of water supply to the population, fisheries, industry and irrigation
environmental	Conservation of nature territories and environmental quality. Recovery of the territories for the conservation of natural objects

A separate map of land use is compiled for each sector of activity based on its main objective function. Specific features of land use (for example, for agriculture - arable land, pastures, hayfields, orchards) are allocated on the map of actual land use, for what the corresponding notations on the map are introduced.

The next unit of work, in accordance with Fig. 1 is a socio-economic characteristics and mapping of each of the allocated types of land use and their subsequent analysis with regard to their ecological status.

Additionally, GIS mapping is one of the main tools for the purposes of functional zoning, as the possibility of combining various layers of information for a given algorithm and obtaining an integrated map of land use is significant.



**Fig. 1. Logical scheme of conducting functional zoning**

Main part. The assessment of the socio-economic development is a complex procedure

For example, Fig. 2 shows the distribution of lands in Atyrau and Mangystau regions by the types of land use as of 01.11.2013, the comparative analysis of the two regions revealed a significant difference in their use [8].



**FUNCTIONAL ZONING**

0 10 20 30 40 km

**TYLES OF LAND USE\***

- A** Agricultural
  - 1 - arable lands
  - 2 - pastures
- S** Residential (settlements)
- I** Industrial
- uog** - operated deposits of oil and gas
- pog** - prospective deposits of oil and gas
- T** Transport
- E** Nature conservation
- U** Under-used lands (solonchaks, soils)
- N**

\*The main types are shown by the coloured background; subtypes are indicated by letters and numbers

**LEVEL OF FUNCTIONAL CONFLICT RESOLUTION**

- a** - activities permitted
- b** - activities permitted with certain restrictions
- c** - activities prohibited or impractical

**DEPOSITS**

- Oil
- Oil and gas
- Combustible gases

**ROADS**

- Motor roads
- Railways

**PIPELINES**

- Oil pipelines
- Gas pipelines

**TYLES OF FUNCTIONAL ZONING**

- Conflict-free (monofunctional area)
- Symbiosis - conflict-free even with imposition (polyfunctional area)
- Neighbourhood - joint borders
- Under-used creation of a buffer zone is possible (poly-functional area)
- Antagonism - incompatible, mutually exclusive functions (polyfunctional area) in case of absence of choice - creation of buffer zones
- Complex (polyfunctional area)

Monofunctional conflict area is formed on the territories with marked prevalence of a particular function, when the degree of intensity of use of the territory and the increased degree of anthropogenic degradation lead to a reduction or even to the withdrawal of the territory from economic circulation. For example, it is irrigated agriculture in the delta of Zhaiyk river, leading to activation of the processes of secondary salinization and practically the withdrawal of these lands from agricultural circulation.

Three following main kinds of spatial combinations of functions on the territory can be distinguished: symbiosis, adjacency and antagonism.

With symbiotic relationship the functions without conflict are realized within a single plot of

the territory even with overlapping. Functions-neighbors have common borders and their mutual influence on each other is not significant. Antagonism of the functions occurs while simultaneously using the territories by activities that are incompatible with each other. These functions-antagonists are the following: residential – environmental, residential – industrial, recreational – industrial, environmental – transport and industrial, residential, agricultural. In this connection, difficulties arise as the interests of the antagonistic functions should be considered. This is possible through the creation of buffer zones that absorb impacts of the antagonists on each other.

The most difficult type of conflict area is a complex territorial conflict, which combines features of monofunctional and polyfunctional conflict. This type is characterized by rapid exceeding of the parameters of environmental threshold of the capacity of the territory and the formation of an environment with low quality characteristics. Formation of the complex conflict area occurs on the territories characterized by both incompatibility of functions and violation of one (or more) functions due to exceeding maximum capacity for a specific type of use of the territory.

The possibility of rational and sustainable nature management depends on the optimization of the activities and the development of conflict resolution mechanisms in conflict areas. Analysis of the map shows that the main land areas suitable for grazing, currently account for about 93 % of the total area of lands of agricultural use. Then, with a descending of the area as a percentage of the study area, come unused lands, technologically-used, used under settlements and road-transport communications, power lines, irrigated lands.

According to natural conditions and feed resources, the pastures are divided into 4 types, and their development by areas is shown as a percentage of the total area of rangelands: sandy (27,2 %), saline (60,0 %), upland (6,8 %) and flooded (6,0 %). The given ratios reflect the natural characteristics of the lands suitable for pastures. Saline pastures primarily include significant areas of denudation plains of Mangystau and Ustirt plateau formed on the surface by eluvial-diluvial carbonate and gypsum-bearing loam. Soils are brown, gray-brown solonchic-saline, vegetation cover is formed by *Artemisia lercheana*, *Anabasis salsa*, *Salsola arbuscula* and *Salsola gemmascens* associations [9; 10].

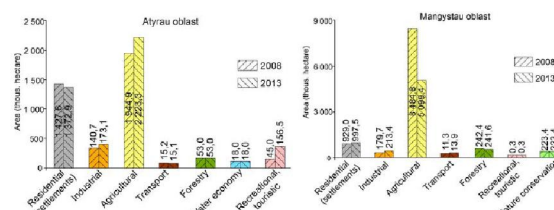
About a third part of pasture areas falls on pastures of sand areas, the largest of which are Narynkumy, Pre-Caspian Karakums, sands of Bostankum-Karynzhyark district.

Approximately equal areas are occupied by upland and flooded pastures. The pastures of deltas and coasts, seasonally flooded during floods and wind-driven waves are referred to flooded.

The unused lands on the study territory include: most part of large overdeepened sor depressions with steep dissected slopes, chinks of Ustirt plateau, most part of the Mountainous Mangyshlak, areas of shifting sands, sor plains, lowland coasts waterlogged by sea.

More than 3,6 % of the surveyed lands are occupied by the objects of oil and gas production industry, developing in the region for over 110 years. Comparative analysis of the dynamics of areas by types of land use indicates that in Atyrau and Mangystau regions industrial lands in the last five years increased by 18,7 and 15,8 %, respectively (Fig. 4). Production of hydrocarbons, which occupies a leading position as a part of industrial production in the Pre-Caspian region, in most cases, led to a sharp deterioration of the ecological status of the region. On the territories of the deposits, considering that about 200 are explored within the Atyrau and Mangystau regions and about 70 oil and gas fields are operated, processes of deflation, waterlogging, salinization intensified, but the most dangerous for the health of the region are the processes of pollution of soils, groundwater with petroleum products, heavy metals and radiation contamination.

21,9 % of the land area is occupied by settlements. This type of land use is also characterized by an increase of desertification processes due to pasture digression from the settlements, the destruction of soil and vegetation cover during construction of housing and laying roads, pipelines, activation of deflation processes, gully erosion and other negative manifestations of modern relief-forming. Areas of this type of land use increases, that is due to the raising of the rates of development of natural resources in the Pre-Caspian region.



**Fig. 4. Dynamics of the areas by the types of land use of Atyrau and Mangystau regions**

One of the important types of land use in the study area is irrigated agriculture. Area of land suitable for tillage is limited and tends to the



sources of irrigation. In the study area they are located on the alluvial-deltaic plains of Zhaiyk and partly of Volga. The main focus is the cultivation of vegetables and forage crops. 0,3 % of the territory in Atyrau region and 0,05 % of the area in Mangystau region are occupied under irrigated agriculture.

Cartographic analysis of land use types shows that most of the study area is occupied by accumulative and denudation plains, is monofunctional and used for pasture. Degree of anthropogenic degradation of these lands is connected with increased grazing loads near settlements, the created conflict situation threatens by withdrawal of these lands from economic circulation. Local areas of lands, suitable for pasture, are occupied by facilities of industry and transport, i.e. areas of conflict are formed with using the lands by these two functions at the same time. Polyfunctional conflict areas on these lands are associated with negative changes in environmental quality in the zone of more high-intensive functions of the facilities of oil and gas sector, which limits the possibility to use the area for grazing or other function. Determination of spatial combination of the functions for this conflict situation is possible only by an antagonistic type with the creation of buffer zones around deposits.

Local areas of combined use of rangelands and water resources are related to symbiotic type of non-conflict or weak-conflict situation. Non-conflict situation in the study area is created by the imposition of lands of forest and water reserves by the type of function-neighbors. They have common borders and their mutual interaction is very little that allows to keep parameters for the development of both functions.

Most attention in the study area should be given to territories with the simultaneous use of activities, incompatible with each other (antagonistic type). These functions-antagonists include: residential – environmental (for example, villages of Peshnoye, Damba, Taskala and others in the Atyrau region, located within SPA), residential – industrial (villages of Sarykamys, s. Karaton and Tengiz Gas Processing Plant), recreation – industrial (conservation area in the northern part of the Caspian Sea and the exploration and preparation to develop oil and gas fields of the North Caspian shelf), environmental - transport and industrial (conservation area in the northern part of the Caspian Sea - the development of sea transport corridors), etc. Interests of antagonistic functions can be taken into account through the creation of buffer zones that absorb the impacts of antagonists

on each other. The possibility of rational and sustainable nature management of the Kazakhstan's part of Caspian shore depend on the optimization of activities and the development of mechanisms for resolution of existing or potential conflicts in conflict areas.

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In view of the decisions taken to mitigate or eliminate the inter-sector conflicts, an integrated map with the recommended functional zoning of the territory is compiled.

As a result, a graphical representation of the optimal variant of using the territory considering numerous factors – functional zoning – will be obtained. Functional zoning establishes a set of possible interventions in the existing natural management for each of the zones in order to prevent or mitigate the level of conflicts, as well as stimulate the industries, most favorable from the socio-economic and ecological point of view.

Conclusion. Management of complex systems requires an integrated approach where resources are used with maximum social, economic and ecological benefit. In turn, functional zoning, based on an assessment of the current socio-economic development of the natural environment and ecological state of resources, is aimed at defining such types of nature management for each of the zones that can prevent or mitigate the level of conflicts, promote the most favorable from the socio-economic and environmental point of view industries. A comprehensive approach applied for this work allowed to determine the following:

- types and degree of anthropogenic development of each ecosystem
- profitability of the existing anthropogenic use
- the recommended type of anthropogenic activities
- identifying restrictions on certain types of anthropogenic activities
- determining the time interval of the limit (year-round, season, etc.)

A classification, based on attracting the statistical, mathematical and expert data, was developed for each of the assessments.

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