

## Problems of desertification of the territory of Kazakhstan: status and forecast

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**Abstract.** This article, devoted to one of the global environmental problems-desertification, presents an assessment of natural and anthropogenic factors with the determination of degree and type of impact. An integral assessment for five adopted degrees with the use of quality metering approach was carried out. Basic methodological approaches to the study of desertification on the territory of Kazakhstan and their impact on the organization of the territory of the country are given in the suggested article.

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### Introduction

Due to the scales of negative manifestation and possible consequences, desertification is highlighted by the international community as a global ecological problem, a threat to the sustainable development of individual territories and countries. On the recommendation of the UNEP, the current decade of 2010-2020 is declared as the "Decade of the United Nations dedicated to deserts and combating desertification". Arid lands are the most susceptible to desertification, they include 45% of the territory of dry land, on which lives 33,8 % of the population of Earth, they hold 46% of all carbon reserves and feed 50% of cattle, 44% of all cultivated areas of the planet are concentrated here [1,2].

The problem of desertification is highly relevant for Kazakhstan, 62,2 % of the territory of which is occupied by natural semi-deserts and deserts. Processes of degradation of natural systems of arid-steppe subzone and dry sub-humid zones such as forest-steppes and meadow steppes, are observed. Due to the fact that arid lands are widely used in agricultural production, industry and accompanying them engineering and transport infrastructure, the processes of anthropogenic desertification became widely spread [3]. Of 93428,2 thousand hectares of farmlands, 31,1% are more or less exposed to the processes of deflation, 6,1% - of erosion, including the territories of steppes and forest-steppes. Due to the fact that it is exactly in dry and arid areas the bulk of agricultural production of Kazakhstan is produced, desertification of these areas jeopardizes food security of the country.

Government of Kazakhstan signed a number of fundamental documents of the national and international levels, which are directly or indirectly

aimed at solving the problem of desertification of natural and economic systems. Strategic goals of the state policy of the Republic of Kazakhstan are ensuring and maintaining an optimal level of favorable environment for humans on the basis of the progressive development of production, sustainable management of natural resources and environmental protection. One of the major objectives in achieving this goal is to combat desertification and land degradation, which should primarily be based on the results of scientifically substantiated researches.

A large block of domestic and foreign publications on the conceptual and methodological, scientific and applied aspects of desertification is analyzed. The basis of the works is the experience of large complex researches of the experts of the Institute of Geography of the last quarter of the century on the instructions of the central and local executive bodies, which were conducted with the participation of prominent scientists of Kazakhstan [4-5]. Basic methodological approaches to the study of desertification of the Kazakhstan's territory and their impact on the organization of the territory of the country are given in the suggested article.

### Methods

The researches were conducted on the basis of the application of ecosystem approach according to a logic scheme: "identification of threats-impact-the current state of natural and economic systems - trends of change -management". The advantage of this approach is the possibility of integration and generalization of knowledge of the individual components of the environment in a single integrated system, convenient for the analysis, modeling and forecasting. In accordance with the developed

theoretical and methodological bases, a detailed component-wise analysis of natural (conditionally natural) and anthropogenic factors is conducted with the determination of degree and type of impact (Fig.1). Particular attention is paid to the trends of climate change, type and extent of anthropogenic impact. Conventional division of desertification in components allowed to deeper understand the causes and consequences, to determine the extent and intensity of the process behavior and the possibility of its forecasting.

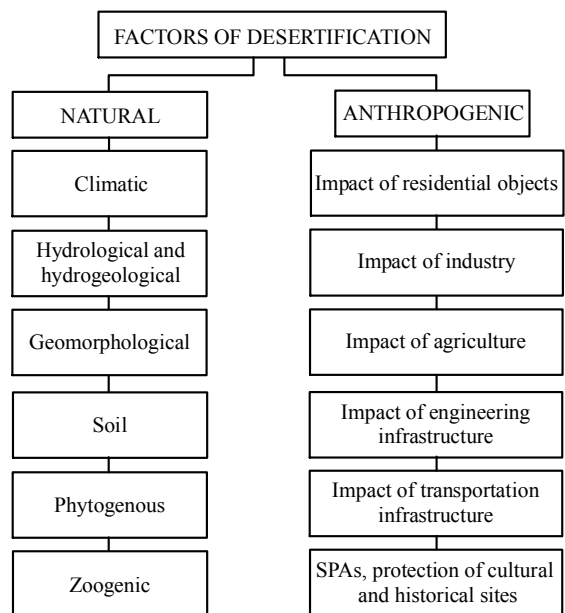
To assess desertification of the main components of natural and economic system, the initial parameters, indicators and rates were determined, their ranking was carried out. Detailed studies on the assessment of environmental degradation under the influence of the main forms of economic activities in the spatial and temporary context were conducted, that allowed to create cartographic models of inventory, assessment and forecast nature. Each of the main types of anthropogenic impacts (residential, industrial, agricultural, transportation, engineering infrastructure) was considered in relation to the most typical indicators that can be measured or calculated [6, 7](Table 1).

The assessment of the impact of each factor by two or more indicators created the necessity of obtaining an integral evaluation with a territorial bound by five adopted degrees. A detailed assessment and geoinformational mapping on a scale of 1:5 000 000 of the current state of the extent of degradation of each of the components of natural environment was made considering the given conditions: climate, underground and surface waters, relief, soils, vegetation and wildlife.

It should be noted that in assessing the effects of the processes of erosion, deflation and salinization of soils, vegetation degradation, technogenic impact, the percentage of damage of the territory and the intensity of their manifestation were considered.

When assessing the integral component of the degree of desertification a qualimetric approach was applied[8]. The «input» of each of the factors into desertification was calculated through expert evaluation by percentage ratio (Tables2, 3).

The aggregate amount of the indicators for all classification factors allowed to create an algorithm for assessing the type, degree and rates of desertification. At the same time a great attention was paid to desertification of transitional territories of natural zones, which are faster destroyed and the last to recover.



**Fig. 1. Main factors of desertification**

**Table 1. Indicators of anthropogenic impact in the context of administrative regions (by the example of residential factor)**

Factors of impact	Indicators
Residential	area of lands under settlements
	population density and population size of settlements
	urbanization processes
	number of cities and townships
	density and size of population of settlements
	duration of the existence of settlements
	predominant type/types of economic specialization

**Table 2. Qualimetric approach in assessing the degree of desertification of the components of natural environment**

Components of natural environment	climate	under-ground water	surface water	relief	soils	vegetation
Climate	0	1	2	3	1	1
Underground waters	5	0	4	2	2	1
Surface waters	5	4	0	4	2	3
Relief	5	1	4	0	3	4
Soils	5	2	3	4	0	4
Vegetation	5	2	4	4	4	0
<b>Total points</b>	<b>25</b>	<b>10</b>	<b>17</b>	<b>17</b>	<b>12</b>	<b>13</b>
Qualimetric ratio, %	100	40	68	68	48	52

**Table3. Qualimetric approach in assessing the degree of desertification under the impact of anthropogenic factors**

Type of impact (of territorial organization)	residential	social	industrial	agricultural	transportation
Residential	0	2	5	4	5
Social	3	0	5	1	5
Industrial	5	1	0	5	2
Transportation	5	1	4	0	3
Agricultural	5	4	4	2	0
Total points	18	8	18	12	15
Qualimetric ratio, %	100	44,4	100	66,7	83,3

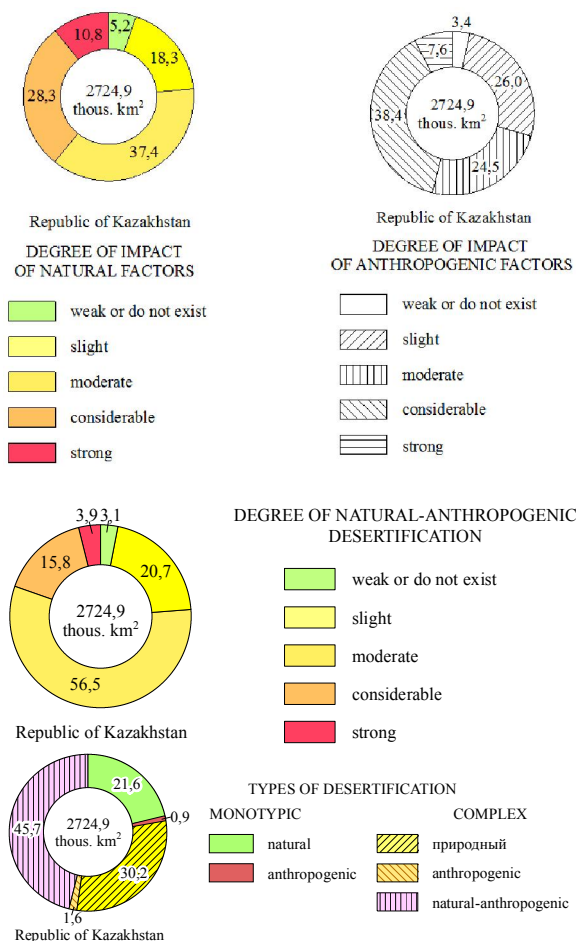
Taking into account the values obtained by methods of geoinformation mapping the integral “Map of desertification of natural systems” and “Map of desertification under the impact of anthropogenic factors” on a scale of 1:5 000000, as well as a resulting map “Desertification on the territory of the Republic of Kazakhstan” on a scale of 1:1 500000 were created.

**Main part**

Mapping of the integral indicator and the analysis of the obtained results revealed some regularities in distribution of the territories, in a varying degree prone to desertification under the impact of natural and anthropogenic factors.

The analysis of “Map of desertification of natural systems” shows that territories of specially protected areas (SPAs) and hard-to-reach undeveloped and underdeveloped mountainous areas of the southeast, making 5,2% of the Kazakhstan's territory, are practically in “conditionally natural” state (Fig. 2). Territories, slightly affected by desertification, occupy almost one-fourth of the country's territory (18,3%). They include areas of plain forest-steppe landscapes of the north of the country and steppe, dry steppe and semidesert landscapes of basement denudation plains and of hummock of the eastern slope of Sary-Arka, small areas of the intermountain plains of the south-east of Kazakhstan.

Most of the country's territory is affected by the processes of desertification of natural systems to the moderate degree– 37,4%. Plots of such lands are present in the forest-steppe and steppe zones, but most part is confined to semi-desert and desert regions. 28,3%of the Kazakhstan's territory is prone to desertification processes to a strong degree, they include the territories of sandy deserts of the Pre-Caspian, Pre-Aral and Pre-Balkash regions. Areas of development of shifting sands and sor-suffusion plains are affected by a strong degree of desertification (10,8%).



**Fig. 2. Distribution of areas of the Kazakhstan's territory by the degree of desertification of natural systems, under the impact of anthropogenic factors and by the types of desertification, %**

The analysis of the “Map of desertification of the territory under the impact of anthropogenic factors” showed that desertification do not exist or is developed to a lesser extent on 3,4% of the country's territory (Fig.2). This is primarily sparsely populated and poorly developed areas. Territories of deserts and semi-deserts within the least developed areas of southeast of the Atyrau, south of the Aktobe, south of the Mangystau, western part of the Kyzylorda and Zhambyl regions, constituting almost one-fourth of Kazakhstan, are slightly prone to desertification (26,0 %). Northern part of West Kazakhstan, the central latitudinal part of the Mangystau region, northern and south-eastern parts of South Kazakhstan region are moderately susceptible to desertification. Area of moderate impact of anthropogenic factors is 24,5 % of the Kazakhstan's territory.

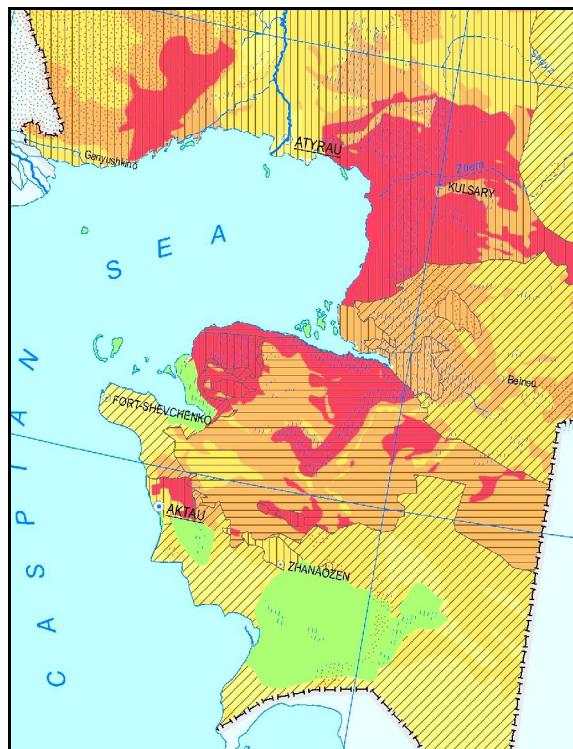
Particular attention should be given to

territories that are prone to desertification to a considerable and strong degree, which together occupy more than half of the country's territory and make up 38.4%. Strong degree of desertification is typical for areas of active industrial development in the Karaganda, Pavlodar and East Kazakhstan regions. A certain vector of intensification of the impacts of anthropogenic factors from south-west to north-east of Kazakhstan are outlined. The exceptions are the territories of oil and gas fields of West Kazakhstan, where there is also a high degree of negative anthropogenic transformation.

Assessment and mapping of the integral maps of desertification of natural systems and desertification of the territory under the impact of anthropogenic factors allowed to create a composite map of natural and anthropogenic desertification of the Kazakhstan's territory on a scale of 1:1 500 000. Materials indicate that over 76, 2% of the territory of Kazakhstan is prone to moderate, considerable and strong degrees of desertification. Out of them 105,4 thousand km<sup>2</sup> (3,9 %) are affected to a high, 432 thousand km<sup>2</sup> (15,8%) – to a considerable, 1539,3 thousand km<sup>2</sup> (56,5%) – to a moderate degrees (Fig.2). And most of the territory with a considerable degree of desertification is characteristic not for natural deserts but for dry-steppe and steppe zones due to the development of negative processes (deflation, erosion and salinization) within the arable lands. Strong degree of desertification is observed in areas of active development of resources of the fuel and energy complex (Pre-Caspian oil & gas, Karaganda coal, etc.). Leading type of desertification, occupying 464,0 thousand km<sup>2</sup> of the country's territory, is a complex type, including technogenic impact with a degradation or complete destruction of the soil and vegetation cover.

The main types of desertification in Kazakhstan are vegetation degradation, erosion, deflation, salinization, dehumidification and chemical pollution of soils, technogenic land disturbance (Fig. 2).

On the map of “Desertification of the territory of the Republic of Kazakhstan” on a scale of 1:1 500 000 created in geoinformation systems, background color shows the degree of natural-anthropogenic desertification, shading – types of desertification (Fig.3).



**Fig. 3. Fragment of the map of “Desertification of the territory of the Republic of Kazakhstan”**

The first attempt is made to assess and map the projection (trends) of the desertification of the Kazakhstan's territory in 2030-s on favorable and unfavorable development scenarios. A forecast of desertification of the environmental components was carried out on the basis of study of major trends and the rates of development of natural processes is made by two (2005, 2010) or several time samples. The basic approach in assessing the risk was a comparative analysis of the degrees of desertification for the indicated periods. Analysis of the risk of desertification and its mapping allowed to carry out the zoning by the degree of risk of desertification, emitting zones of low, moderate and high risks. Zones of low risk are characteristic for plain areas of dry-steppe landscapes of the northeastern and desert and semi-desert landscapes of the south-western Kazakhstan. Areas of Central and South-East Kazakhstan are referred to zones of moderate risk to a greater extent confined to the hummocky and mountainous regions. Territories at high risk, which occupy almost a third part of Kazakhstan, are referred to the central areas of the regions of moderate risk, they are connected to a greater extent with the sites of active anthropogenic impact.

Anthropogenic, including technogenic, impact on the type, degree and rate of desertification



was based on different levels of effectiveness of the implementation of environmental technologies. Basis for the creation of predictive maps of industrial and agricultural pressures on the environment was the analysis of the development of industry and agriculture for 1997-2010, as well as the accounting for changes in the future in accordance with the adopted strategies of the development of the Republic of Kazakhstan and the General Scheme of the organization of the territory of the Republic of Kazakhstan till 2030 [9].

### Conclusion

On the basis of the development of integral approaches to the assessment of natural and anthropogenic desertification and degradation of natural and economic systems, an information and cartographic support for combating desertification processes, including an assessment of the current state of degree and types of desertification, risk of the development of natural and anthropogenic desertification through the application of geoinformation technologies, as well as the elaboration of a set of measures to reduce the rates and degree of desertification, is created.

An assessment and cartographic unit with the identification of major natural and anthropogenic factors of the emergence and development of desertification processes, as the identification of the threats to sustainable land management, is created. Zoning of the territory of Kazakhstan on conditions of formation and the level of risk of impact of desertification, is made. Scientific and applied fundamentals of natural resources management associated with the impact of natural and socio-environmental objects on desertification in order to prevent and reduce damage from desertification processes are elaborated.

A set of measures to reduce the rates, risks and damage from the impact of desertification on natural and economic systems of Kazakhstan is developed [10]. Assessment and mapping of degree, types, rates and risk of desertification is one of the complex criteria of the state of the territory and may underlie the formation of a rational organization of the territory.

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