Study of arid territories of Southern Russia from the perspective of improving the production base of fodder

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Abstract. Arid lands are areas with arid climate and lack of water resources necessary for productive activities within the agro-industrial complex (AIC). The factor of aridity of lands is one of the key negative factors for economically effective crop production and development of fodder base in the structure of animal husbandry. The main characteristic of these lands is the insufficient level of irrigation and moisture supply due to the lack of internal water and precipitation. In this connection for successful development of agroindustrial complex by means of application of mentioned territories it is necessary to search and identify complex measures and ways directed on preservation of natural-productive qualities at the expense of optimal combination of ecological and economic components in organization of regulation of moisture and water supply system. The specified development of a balanced set of measures of economic and ecological nature is aimed at preventing further increase in the level of aridity and desertification of agricultural lands.

1. Introduction

Natural specificity of arid soils are formed in conditions of increased moisture evaporation, which largely exceeds its inflow with precipitation. It causes necessity to compensate water deficit by means of establishing effective ways of its replenishment and rational application of available economic qualities on the basis of comprehensive analysis of occurring processes in environment with selection of productive methods of irrigation.

Thus, it is necessary to create a set of ecological and economic conditions, through which there are promising opportunities for the development of the structural components of agro-industrial complex and agricultural production on arid lands. Thus, the creation of a specific agrocenosis as a balanced natural-economic system in which processes of economic activity should be rationally combined by using the natural qualities of the available lands subject to full compliance with the norms of environmental safety is stipulated [1].

As a result of studies of the Russian Federation, taking into account the territorial specificity of individual federal districts and constituent entities of the Russian Federation, we should identify several regions in which the presence of arid lands should be noted, as shown in table 1.
Table 1. Regions of Russia, the territory of which is mainly or partially included in the desertification zone.

| Federal district                  | Subjects of the Russian Federation                                      |
|----------------------------------|------------------------------------------------------------------------|
| Central Federal District         | Belgorod region, Voronezh region                                       |
| Southern Federal District        | Astrakhan Region, Volgograd Region, Rostov Region, Krasnodar Territory, Republic of Kalmykia |
| North Caucasus Federal District  | Republic of Dagestan, Stavropol Territory                               |
| Volga Federal District           | Republic of Bashkortostan, Orenburg Region, Saratov Region, Samara Region |
| Ural Federal District            | Kurgan Region, Tyumen Region, Chelyabinsk Region                       |
| Siberian Federal District        | Republic of Khakassia, Republic of Tuva, Kemerovo Region, Novosibirsk Region, Omsk Region, Altai Territory, Krasnoyarsk Territory |
| Far Eastern Federal District     | Republic of Buryatia                                                   |

The data in table 1 show that the greatest threat of increased aridity is characteristic of the Siberian, Southern and Volga Federal Districts, which is due to climatic features and landscape.

Thus, on the specified territories, the need of increased investment in the processes of technological modernization of land reclamation systems is revealed, which is closely connected with the search of perspective ecological ways of land protection with prevention of increase in aridity level. This search consists in establishment of specificity of complex productive agricultural production through rational disposal of water resources under full observance of natural environment protection norms. It is supported by necessity of purposeful use of available quantity of water resources according to requirements of their quality during cultivation of appropriate agricultural crops.

From the economic point of view, the applied methods of land reclamation in the system of preservation and restoration of necessary economic qualities of lands in arid zones are based on obtaining the highest possible level of agricultural production under minimum possible losses and expenses. From the position of maintaining environmental safety and natural characteristics of land, the search for optimal ways to restore agricultural land as a result of damage caused by irrational land use and finding appropriate counteraction to the effects of climate change is in demand [2].

In connection with the above aspects, it is necessary to consider the following factors of change in the relationship between agricultural production and land use [3, 4]:

- Increasing vulnerability of irrigated agriculture as a key direction of water use in territories with deficit of water resources or presence of obstacles to access to them.
- The threat of soil erosion and salinization in terms of ecological stability and opportunities for economic use is of increased importance.
- Decrease of irrigation drainage or return flow quality that causes threat of repeated safe and productive water use in different spheres of AIC.
- Incomplete information provision of state and municipal authorities, as well as various enterprises and organizations functioning in the field of agriculture, on the current state of arid lands and emerging trends in their condition.
2. Assessment of the aridity of territories of southern Russia for agricultural production

Determination of effective ways of using arid territories in the economy and agriculture under conditions of maintaining their production stability is associated with the numerical identification of the level of aridity.

Considering the nature of studies of the degree of aridity of lands in Russia at the federal level in recent years, it is necessary to present indicators of erosion, which acts as an additional negative phenomenon associated with the increased aridity of territories, as shown in Table 2.

Table 2. Area of agricultural lands subjected to wind erosion total area of surveyed agricultural lands.

|                          | 2016   | 2017   | 2018   | 2019   | Average value |
|--------------------------|--------|--------|--------|--------|---------------|
| Total area of agricultural land | 197700.0 | 197700.0 | 197800.0 | 197700.0 | 197725.0 |
| of them are subject to: wind erosion: |        |        |        |        |               |
| Total surveyed area      | 6623.9 | 10485.5 | 13822.1 | 12773.4 | 10926.2 |
| Area exposed to wind erosion | 1403.4 | 1424.2 | 1252.8 | 1643.8 | 1431.1 |

Table 2 considers the period of four years in terms of availability of agricultural land, which allowed us to note a fairly stable preservation of the total area. But there is a negative tendency of expansion of lands subjected to erosion, which is an additional factor of aggravation of aridity problem and implementation of additional measures aimed at restoration of productive qualities of lands. In accordance with individual values for each of the four years the average indicators are calculated.

It is necessary to indicate different indicators on irrigation of agricultural lands taking into account total area of reclaimed lands. Areas of different economic purpose, which require application of special methods of fertility improvement, including questions of water supply increase with establishment of different aridity indices, are singled out separately (Table 3).

Table 3. Dynamics of indicators on the area of reclaimed land (at the beginning of the year; thousands of hectares).

|                          | 2017    | 2018    | 2019    | 2020    | Average value |
|--------------------------|---------|---------|---------|---------|---------------|
| Total area of reclaimed land | 11331.3 | 11255.0 | 11239.2 | 11232.9 | 11264.6 |
| including:               |         |         |         |         |               |
| irrigated land of which have a state of irrigation | 4659.7   | 4658.7   | 4639.9   | 4633.2   | 4647.9 |
| good                     | 2168.8   | 2172.7   | 2164.2   | 2162.9   | 2167.2 |
| satisfactory             | 1333.9   | 1340.8   | 1321.5   | 1329.4   | 1331.4 |
| unsatisfactory           | 1157.0   | 1145.2   | 1154.2   | 1140.9   | 1149.3 |
| The area where land improvement and improvement of the technical level of reclamation systems are required | 5966.5   | 6020.0   | 5984.4   | 6073.1   | 6011.0 |

Table 3 shows the indicators of the area of reclaimed land with the allocation of three special categories according to different levels of water availability. In this case, the period of four years is also analyzed, with the category of lands with "good irrigation condition" decreased when comparing 2017 and 2020. In addition, there is a threat of expansion of lands, for which it is necessary to improve the technical level of reclamation systems through the modernization of water supply technologies in the treatment of agricultural areas [5, 6].
Along with the application of economically effective and environmentally safe ways to restore and maintain the economic and productive qualities of arid lands through the rational transformation of the use of available water resources, it is necessary to note the implementation of specialized measures for chemical reclamation in various areas of agricultural production in the functioning of various economic entities. These measures are especially demanded when high level of aridity of lands is revealed, which, in particular, is connected with application of reclamation by different chemical means (table 4).

|                                | 2016 | 2017 | 2018 | 2019 | Average value |
|--------------------------------|------|------|------|------|---------------|
| **Acidic soils produced, mln ha** | 0.2  | 0.2  | 0.3  | 0.3  | 0.25          |
| Limestone flour and other lime materials were introduced: |      |      |      |      |               |
| total, mln t                  | 1.9  | 2.1  | 2.5  | 2.3  | 2.2           |
| per hectare, t                | 8.5  | 8.6  | 8.5  | 7.6  | 8.3           |
| Performed gypsum saline soils, thousand hectares | 3.7  | 5.6  | 2.6  | 2.4  | 3.6           |
| Gypsum, phosphogypsum and other gypsum-containing rocks were introduced: |      |      |      |      |               |
| total, thousand t             | 15.2 | 27.0 | 13.0 | 15.3 | 17.6          |
| per hectare, t                | 4.2  | 4.9  | 5.0  | 6.2  | 5.1           |
| Phosphoritization of acidic soils, thousand hectares | 17.5 | 8.6  | 12.6 | 21.7 | 15.1          |
| Phosphate meal was applied:   |      |      |      |      |               |
| total, thousand tons          | 20.4 | 7.6  | 11.0 | 20.6 | 14.9          |
| per hectare, t                | 1.2  | 0.9  | 0.9  | 1.0  | 1             |

Table 5 highlights the indicators of chemical land reclamation also for the period of four years. At the same time, key parameters of using special means for increasing the level of economic efficiency of land use with calculation of average indicators for the given period are shown. Depending on different types of the mentioned means, different situation of decrease and increase by separate years is seen. So, for example, on application of phosphogypsum in total mass of development in agricultural production, but there is a stability in processing of one hectare of cultivated land.

Scientifically grounded measures of ecological and economic character at restoration and increase of level of fertility of arid territories are defined in several directions of administrative activity, connected with use of influence of a number of natural factors and components of natural environment and ways of economic and agricultural activity. The specified directions act: 1) management of processes of influence on land use from the landscape side of those or other territories; 2) optimal application of ecological and economic effects from forests and perennial plants; 3) regulation of processes of economic development of climate change; 4) management of order of use of water resources in irrigation and overcoming the problem of water scarcity; 5) regulation of application of natural qualities of soil, and improvement of economic quality of pastures in cattle breeding 5) establishment of economic character of services provided to population related to natural environment protection; 6) expansion of ways of application of electronic and digital technologies for comprehensive information support of complex processes on overcoming obstacles of economic activity in arid lands; 7) structural and functional transformation of the system of functioning of public administration bodies regarding activation of private entrepreneurship in arid zones.

Each of the highlighted functional directions in the system of ecological and economic preservation of agricultural parameters of arid lands should be considered separately.

Management on use of ecological-natural landscape influence is connected with assessment of seasonal and spatial changes of agricultural lands productivity. This is expressed in productive accounting of lowlands and uplands when regulating irrigation processes. In particular, there are changes in grazing regime for pasture restoration in arid zones. Water supply methods for farming individual plots are evaluated in order to prevent useless loss of available water resources without appropriate
irrigation of those or other plant crops. On the basis of landscape approach economically grounded programs of land fertility restoration and forest planting can be developed taking into account degree of aridity and peculiarities of land treatment in conditions of drought [7].

Productive management in conditions of climate change in the organization of arid land cultivation is expressed in the transition to a proactive counteraction to the negative phenomena associated with a lack of precipitation. In this connection the following special measures can be realized [8]:

- Increase of true value of predicted fluctuations of weather conditions and preliminary assessment of general tendencies in climate dynamics.
- Making the most accurate scenarios of how climate change will affect ecological processes and ecosystem parameters with respect to arid lands and identifying specifics of further aggravation or stabilization of arid territories.

Scientifically grounded planning and step-by-step formation of so called "sustainable landscapes" on the basis of optimal combination of perspective methods of land irrigation and economically effective increase of fertility level and ecological parameters of natural qualities of lands in conditions of arid climate. Related to this is rational integration of effective water use with reduction of negative consequences of natural disasters and use of energy-saving technologies.

Productive regulation of processes of protective forest plantations expansion is determined by development of special forest belts, which provides necessary water balance with increased sustainability of agricultural productivity of arid lands [3, 13]. Comprehensive monitoring of forest condition on arid territories with prevention of their reduction is connected with it.

In this connection the following measures can be taken:

- Decrease of forest plantations density of protective character, which determines decrease of natural water consumption by vegetation on these territories.
- Elimination of dry plant biomass reduces the risk of fire, while better structured and more mature forests favor the preservation of the necessary amount of carbon and counteract the negative effects of the effects of dry winds.
- Increase the planting of perennial plants with increased phenotypic plasticity and genotypes that can sustainably tolerate changes in the natural environment.

The experience with these measures is particularly characteristic of countries whose rather vast territories are characterized by increased aridity. An example of this is the opposition to the expansion of dry excessive plant biomass in the United States and the Republic of South Africa.

Regulation of water use processes is focused on solving problems caused by climatic and global changes and is aimed at increasing the level of productivity of all available sources of surface and groundwater for agricultural production while preserving the biodiversity and natural qualities of the respective areas. Thus, a set of economic and managerial functions is implemented to provide the demanded by specifics of farming in arid lands watershed In particular, it is focused on maintenance of soil protection from harmful impact from environment, as well as on elimination of unbalanced movement of water resources between watersheds of mountainous areas and lowlands. At the same time, integrated use of surface and groundwater is supported, which is a promising way to increase the level of economic profit and efficiency of the water supply system of land use in areas with increased threat of expansion of deserts and semi-deserts.

Regulation of water use in the AIC system in respect of arid lands can be presented as a set of actions combining economic and ecological aspects of farmland preservation and development. These actions are the following [9, 10]:

- Identification and use of ways to generate additional income from land reclamation and agricultural production in accordance with integrated watershed management.
• Development of integrated projects of arid land cultivation taking into account climate change with the definition of the content of “road maps” of their implementation under the state support of private economic entities in these territories.

• Expanding the use of digital technologies aimed at comprehensive collection and analysis of information on the condition of arid territories with identification of appropriate measures to neutralize further increases in aridity.

In the framework of state support to private businesses and farms operating in areas with arid climate, measures may be taken to provide tax incentives and additional subsidies to compensate for the additional costs of reclamation work. There is also a need for financial support to increase the level of land treatment technologies used, which implies effective adaptation of agricultural producers to climate change.

These areas of public-management support for private entrepreneurial initiatives are closely linked to the elimination of biodiversity in arid areas with support for scientific research focused on the search for innovative means to continue agricultural production in arid zones. In particular, there may be research on how to overcome seasonal drought and fires, and on the identification of genetic resources to produce adapted plant varieties and livestock breeds that can successfully survive water scarcity and hot climates.

The regional network of plant genetic resources under the auspices of the Association of Agricultural Research Institutes in the Middle East and North Africa is an example of the search for these plant and animal species. Thus, an interstate system of agricultural and ecological partnership on exchange of practical experience in setting priorities for effective economic activities under water scarcity and arid climate was established. In this regard, a genetic material bank of more than 131,000 accessions of cereals, food legumes and forages, including cultivated, indigenous and wild relatives has been established. Subsequent use of this databank allows the creation of plant species and the breeding of new animal breeds that successfully tolerate the negative effects of periodic drought and heat cycles in certain areas.

Innovative methods of managing the processes of using various agricultural qualities are expressed in the establishment of means and methods that contribute to maintaining the biochemical state of the soil. This is associated with the allocation of practice-oriented methods of reducing the rate of erosion with monitoring the specificity of water absorption and the ability of soil to retain water. Successful implementation of these management functions in the area of soil use is a key factor in the adaptation of agricultural crops to moisture deficiency, which is caused by unbalanced precipitation and elevated temperatures in the area [11, 12].

With regard to maintaining the economic sustainability of livestock farming in arid zones, adaptive management of rangelands is carried out. In this case, the implementation of mobile cattle breeding, taking into account the specifics of the growth of different types of grasses, is quite promising.

One of the key sources of support for the activities of agricultural producers is the provision of special environmental services. These services represent the fullest possible use of productive qualities of available components of the natural environment. With regard to support of activity on arid lands these services can be optimal regulation of water supply and necessary level of water treatment.

An effective combination of economic ways to increase productivity of arid lands with observance of ecological standards of protection of the main components of natural environment should be based on the use of electronic-digital technologies, which allow significantly expanding information support for implementation of economic activities in these territories. In particular, it is demanded in the assessment of the dynamics of various indicators reflecting positive and negative trends in changes in the production characteristics of used lands, which is associated with the development of specialized irrigation systems, taking into account the degree of depletion or lack of available water resources [13, 14].

At the local level, staff of relevant scientific organizations and representatives of state and municipal governments should have modern tools for analyzing, summarizing and systematizing multidirectional
information on the condition of different types of soils in arid territories, which allow making effective decisions to address water supply problems in arid lands. Use of effective information technologies also promotes development of integrated strategic plans of water use regulation, which determine differentiated order of water resources use taking into account natural condition of some agricultural lands [15].

Within the framework of this management, the following principal tasks are solved:

- Optimization of spatial and temporal water distribution within an irrigated farm or irrigation system.
- Feasibility study of projects on water resources involvement and additional development.
- Optimization of water allocation among users depending on level of use in large region, river basin, economic and environmental indicators, part of which is water use definition in irrigated farming [16].

Improvement of reclamation process regulation efficiency on arid lands is provided by continuous collection of diverse data on soil state dynamics. Analysis of maximum possible information data about correspondence of irrigation method and obtained economic effects is closely connected with this. Operative collection and systematization of such information allows to form a sufficiently objective picture of the true state of arid territories, which is the basis for the development of sound management decisions in the activities of state and municipal administration bodies and private entrepreneurs, operating in the specific conditions of overcoming the problem of increased aridity [17].

In order to maintain an environmentally safe irrigation process regime, technologies that are able to match the level of natural precipitation are required. In this regard, the problem of useless moisture loss, which occurs due to unproductive water flows during deep filtration as well as in the case of surface runoff formation, needs to be eliminated. This problem can be complemented by an increased probability of washing away and compaction of the topsoil with loss of necessary nutrients, which are washed out beyond the main rooting layer of the soil. Also, one of the consequences of unproductive water flows is a rise in the groundwater table.

3. Conclusion

Thus, the taken ecological-economic measures for preservation of agricultural lands in arid zones should provide comprehensive accounting and establishment of conditions of reproduction of natural resources necessary for maintenance of a natural condition of soil and expansion of productive qualities of lands. Establishment of irrigation methods with maximum full moistening of lands with minimum moisture loss is connected with this.

Obtaining the necessary level of yield on arid lands while using limited amount of water per unit of agricultural production is possible under the condition of rational combination of ways of maintaining the necessary level of ecological safety and economic productivity, which ensures maintenance of energy and water balances as well as contributes to expansion of agrocenosis biodiversity in arid territories.

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