

Assessment of Changes in Water Use Indicators in the Agricultural Sector in the South of Western Siberia

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Abstract—In this paper, we made an assessment of the change in water use indicators of the agro-industrial sector (AIS) in the south of Western Siberia at the present stage of production and economic activity development. In order to solve planned tasks, an assessment of surface water resources was given in detail in the context of the entities of the south of Western Siberia of Russia; an analysis of the water availability of the studied agricultural sector area was carried out. The temporal dynamics of the main characteristics of water use, including using information technology, was investigated. All studies were performed using data from state statistical reporting on the characteristics of water use in the agro-industrial sector for the period of 1985-2018. The analysis showed that as a result of a quantitative assessment of water availability indicators of the territory of the Russian Federation entities, the latitudinal zonality and geographical location play an important role. The difference in humidification conditions and the structure of river basins objectively determine the differentiation of water resources and water availability in the south of Western Siberia. In general, the formation and use of water resources in the agricultural sector in the entities of the Russian Federation depends on the water availability of the territory.

Keywords—water resources, water consumption, water availability, rational use, temporal dynamics, water use, agricultural sector.

I. INTRODUCTION

The main indicators of the level of well-being of any society include the level of economic development of the country, which directly affects the level of material condition of each member.

With the growth of economic activity and the intensification of production, the human impact on the environment is increasing, including an increase in the anthropogenic load on river basins. A variety of water functionalities leads to an increase in water consumption. On the other hand, the growing shortage of water in many regions of Russia makes water resources an important and sometimes determining factor in the economic development of the agro-industrial sector.

In this regard, the furthestmost priority development conditions have those industrial facilities that are located in such areas where there are significant water resources, along with optimal climatic conditions. In other words, the territory's water resources are of particular importance for the normal economic development of the region. In turn, the

formation of water resources is subordinated to the physical-geographical, climatic and local features of the basin [1].

II. LITERATURE REVIEW

The study of the territory's water resources must be started by identifying the main factors affecting the amount of water coming from the catchment basin. The main role in the process of runoff formation is played by the climatic conditions of the territory. It is climatic features, such as heat and energy resources of the territory and humidification resources, which affect the amount of water resources of the catchment basin and their redistribution by season [2].

In addition, any territory has regional characteristics that affect the amount of water coming from the catchment basin, which form their operational resources. Local conditions mainly affect the redistribution of solid sediments on the catchment surface, the formation of surface and underground components, the time that water enters water bodies and also water quality. In this regard, the accounting and evaluation of all factors affecting the quantitative and qualitative characteristics of the territory's water resources is of great practical and scientific importance [3].

The magnitude, nature of the distribution in the territory and the temporary variability of water resources are determined mainly by the intracontinental position of the studied territory by the structure of the underlying surface and the level of economic activity of the region as a whole.

However, the level of economic and, accordingly, economic development is determined not only by the quantitative and qualitative characteristics of the emerging water resources, but mainly determined by the degree of use of water resources, i.e. water consumption [4].

The higher the water consumption in absolute and ratio terms, the more intensively the productive forces are developed and the higher the degree of use of water resources. Water consumption indicators also characterize the level of anthropogenic load on aquatic ecosystems, since some of the water is withdrawn from river runoff, and the part that is returned in the form of wastewater has a chemical composition and physical characteristics that differ from the initial ones, even in the case of preliminary treatment.

III. RESEARCH METHODOLOGY

At the present stage, the predicted values of water consumption for a specific settling period are an indicator of

the use of water resources, of any entity, river basin or part of a basin.

The forecast for water consumption can be made on the basis of agricultural development indicators. In our studies, the goal was set to assess the temporal dynamics and draw the suitable conclusions on the values of water use indicators for the entities of the south of Western Siberia based on retrospective materials of state statistical reporting for the period of 1990-2018 [5-6].

Achieving this goal required the following tasks:

- Assessment of surface water resources of the studied river basin, including in the context of the entities of the south of Western Siberia;
- Quantitative assessment and analysis of water availability in the studied area;
- Assessment of temporal dynamics, the main characteristics of water use in the context of the entities of the south of Western Siberia.

Due to the fact that river runoff is the main source of water supply, the river basins of the entities of the south of Western Siberia were studied. This paper considers water resources and their use within 10 entities: Kurgan, Sverdlovsk, Tyumen, Chelyabinsk, Kemerovo, Novosibirsk, Omsk and Tomsk Regions, Altai Republic and Altai Krai.

The main factors that have an impact on the formation of the territory's water resources include climatic and orographic conditions, which are characterized by the radiation regime and atmospheric circulation. It is a fact that the climatic features of the territory are determined by its geographical location.

The studied territory, located in the flat-lowland relief of Western Siberia, has a peculiar climate character due to the moisturizing role of the Atlantic Ocean from the west and the powerful winter anticyclone of Eastern Siberia from the east [7-8].

The Ural ridge, located in the western part, serves as a natural barrier to air masses from the west, and from the east – the East Siberian Upland.

The southern part of Western Siberia in the summer is influenced by dry winds blowing from the north, and sometimes hot winds coming from Central Kazakhstan. Wind coming from the south brings dried air, exacerbates the moisture, adversely affecting agricultural activity and the agro-industrial sector as a whole.

IV. RESULTS

As a result of the abovementioned features of the intracontinental location, the features of atmospheric circulation and the nature of the relief, the studied territory is characterized by a severe long winter with strong winds, blizzards, stable snow cover and quite hot summers. Transitional seasons are short, with sharp fluctuations in temperature. Spring and early summer are arid.

Within the studied territory there are about 75 thousand waterways with a total length of 309 thousand km. Rivers with a length of 10 km make up 93% of the total amount.

The density of the river network ranges from 0.1 (Ob-Irtysh interfluve) to 0.9 km/km² (Tomi river basin). The

ivers of the territory are poorly studied. Only 49 rivers with a total length of about 12 thousand km were examined along the entire length.

When analyzing the quantitative assessment of the territory's water supply, the latitudinal zonality and the geographical location of the territory play an important role [9]. So, the entities located to the south have a lower value of the water availability indicator, and accordingly, the entities located to the north have a greater value, due to climatic features, topography and geological structure (Table I). The calculations and analysis indicate that the difference in moisture conditions and the structure of river basins objectively determine the differentiation of water resources and water availability in the south of Western Siberia.

TABLE I. WATER AVAILABILITY IN THE AVERAGE YEAR FOR THE ENTITIES OF THE SOUTH OF WESTERN SIBERIA

Entity of the south of Western Siberia	Water availability, Thousands of m ³ /year per 1 person
Kurgan Region	3.3
Sverdlovsk Region	6.5
Tyumen Region	180.2
Chelyabinsk Region	2.0
Altai Krai	17.5
Novosibirsk Region	21.8
Omsk Region	18.0
Tomsk Region	171.7

To assess the temporal dynamics of the main characteristics of water use in the studied river basin and in the context of the entities of the south of Western Siberia, retrospective data of state statistical reporting on water use characteristics for the 1985-2018 period were used as initial materials.

Assessment of the main indicators of water use for river basins in the context of the entities of the south of Western Siberia was carried out according to the following indicators: water withdrawal from natural water bodies for further use; discharge of polluted wastewater into surface water bodies; volumes of circulating and sequential use of water; water loss during transportation [10]. In addition, an assessment of the volume of fresh water was made that was used in the agricultural sectors – for irrigation, agricultural water supply and for production needs.

Analysis of statistical data on water withdrawal over a 33-year period allows us to reliably identify several periods of decrease in the growth of volumes of withdrawn water in the entities of southern Western Siberia (Figure 1). In particular, the first period of growth in water consumption was observed in the period of 1985-1993 (from 10.4 million km³ to 11 million km³), followed by a fairly significant drop in the volume of water taken from natural sources in the 1993-2013 period. Obviously, this is due to the general economic decline in the production activities of enterprises and the economy of our country as a whole. The total decrease in this case amounted to 4.05 million km³. At the same time, at the background of a general decrease in the indicated period, a slight increase was also observed, which falls on the period from 1998 to 2000. The increase in water consumption was from 8.0 million km³ to 8.7 million km³. But since year 2013, there has been a clear increase in water consumption by an average of 1.85 million km³. This indicates the growth of production activity, despite the restraining attempts at

economic growth undertaken by Western countries in the form of sanctions against the Russian Federation.

The performed analysis showed that the noted features of the dynamics of the volumes of the withdrawal water are synchronous with water consumption in the agricultural sector for industrial needs, irrigation and agricultural water supply, which determine both the magnitude and dynamics of water intake in the agricultural sector of the entities of the south of Western Siberia (Figure 2). At the same time, a decrease in the volume of water used for production needs, by the entities as a whole, is in good agreement with a decrease, over the same periods, in the volume of production of the most water-intensive industries.

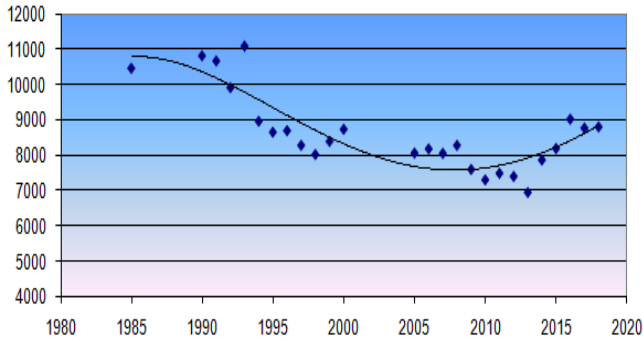


Fig. 1. The total water withdrawal from natural sources in the period of 1985-2018 in entities of the south of Western Siberia, million m³

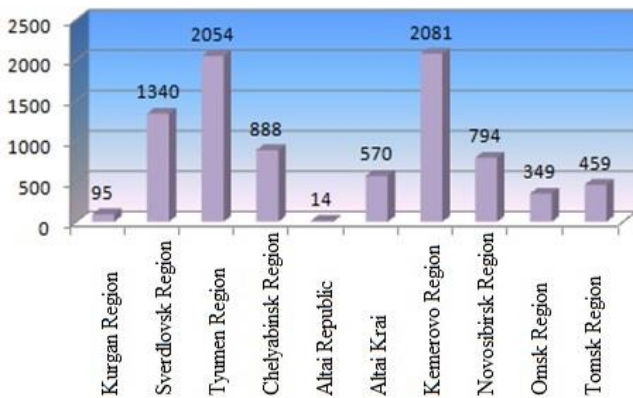


Fig. 2. Average value of fresh water withdrawal from natural sources for the period of 1985-2018 in entities of the south of Western Siberia, million m³

Based on the analysis, it should be noted that the observed growth trend in total water use, especially in the production sector of the region, should be taken into account when drawing up a scheme for the integrated use of water resources for entities of the south of Western Siberia for the subsequent period.

It should be remembered that with an increase in water consumption, volumes of unavoidable losses will increase [11]. In this regard, from the point of view of rational use of water resources and their protection, it seems appropriate to analyze the dynamics of the volume of polluted wastewater discharged into surface water bodies (Figure 3) and the volume of water losses during transportation (Figure 4). Given that the efficiency of water use at the present stage of development of the agro-industrial sector mainly depends on the various schemes used in water supply, it should be noted

that there is a tendency for changes in the volumes of recycled and sequential water use (Figure 5).

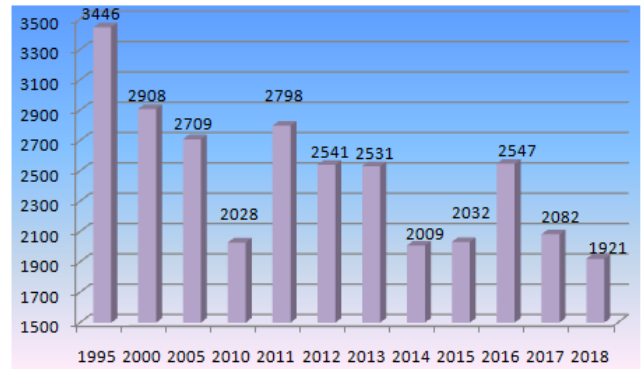


Fig. 3. Collection of polluted wastewater into surface water bodies in entities of the south of Western Siberia, million m³

As the practice of water use shows, the volumes of water withdrawn from water sources are more or less returned to water bodies after undergoing quantitative and qualitative changes. It is important to remember that for the most part, the quality of the returned water does not always meet the requirements for maximum permissible discharges. In this regard, accounting and analysis of discharge volumes, monitoring their quality status can be attributed to measures of protecting water bodies and efficient use of water resources of the basin.

An analysis of the study period (1995-2018) indicates that the dynamics of the volume of polluted wastewater discharges into surface water bodies is multidirectional in nature with long periods of their decline and rise. At the same time, there is a steady positive trend towards a decrease in the volume of polluted wastewater discharges, as evidenced by the abovementioned graph (Fig. 3). In general, it should be noted that the dynamics of wastewater discharges is synchronous with the dynamics of water withdrawal in all entities of Western Siberia.

Based on the performed analysis, it should be assumed that the growth in water consumption indicators and the positive dynamics of water disposal indicators point to the economic development of the region as a whole and the revival of production sectors.

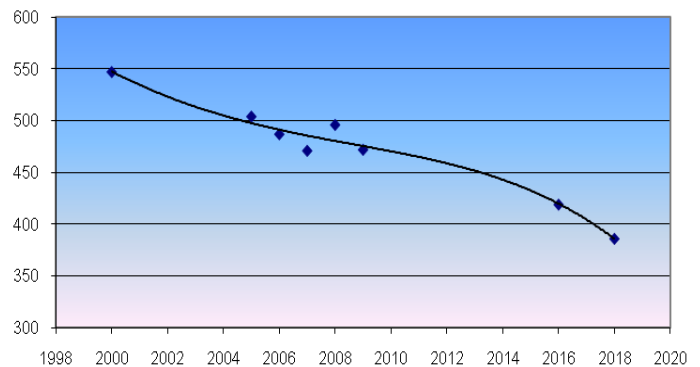


Fig. 4. Volumes of water losses during transportation in entities of the south of Western Siberia, million m³

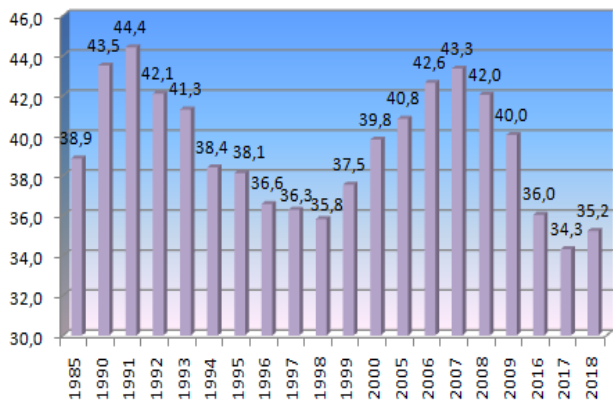


Fig. 5. Volumes of circulating and sequential water use by entities of the south of Western Siberia, million km³

Another rather important component of the expenditure part of the balance of water supply is the volume of local and streaming losses observed during transportation of water to the place of consumption. Large volumes of leaks from water supply systems can negatively affect not only the efficiency of their use, but can also cause significant damage to the surrounding area, increasing the problems of flooding of agricultural complexes. Therefore, accounting for such losses and control in order to reduce them is a prerequisite for the construction and operation of water supply facilities. The results of the analysis showed that the average rate of water loss during transportation for the period 2000–2018 amounted to 5.7% of the total water withdrawal from surface water bodies. At the same time, there is a tendency towards a decrease in this indicator, so for year 2018 the losses rate amounted to 4.4% of the total water withdrawal, which in turn is 2% lesser than compared to year 2000. The reduction of such losses indicates not only a careful attitude to water resources from water consumers, but also the better performance of various regulatory bodies.

V. CONCLUSION

The performed studies allow us to draw the following conclusions. The variety of moistening conditions in the territories of the south of Western Siberia and the differences in the morphological characteristics of river basins objectively determine the differentiation of water resources by river basins and the production activities of the agricultural sector.

In general, the water resources of the considered entities indicate sufficient water availability within the territory and form the direction of their use in the agricultural sector.

The results can be used by design organizations and other involved in developing schemes for the integrated and rational use of water resources as one of the areas of rational nature management in the river basins of the south of Western Siberia.

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