The Analysis of Water Resources in Relation to Sustainable Development of Regions

Olga A. Chernova*
Henrietta Nagy**
Inna V. Mitrofanova***
Inna A. Ryabova****

ABSTRACT

Research background: *Regions' sustainable development is highly determined by the state of their water resources since all activities need and use water. The state of water resources influences the economic, social and ecological subsystems of the region. Therefore, from a strategic perspective, the assessment of the impact of the state of water resources on sustainable regional development becomes a must.*

Purpose: *This article aimed at analyzing the state of water resources in the agro-industrial regions of the South of Russia and also to provide opportunities for the region's sustainable economic and social development. The target areas were the Volgograd and Rostov regions.*

Research Methodology: *The analysis was done based on statistical data about the state of water resources in the regions with the formation of analytical estimates.*

Result: *As a result of the analysis, it has been revealed that the most sensitive to the state of water resources in the Volgograd region is the ecological subsystem; while in the Rostov region it is the social subsystem.*

Novelty: *The methodology and approach proposed by the authors can contribute to the current analysis of regional strategies since it allows us to assess the relationship between the state of water resources and the region's sustainable development.*

Keywords: *sustainable development, water resources, regional economy, rational use of water resources, water consumption, regions of the South of Russia.*

JEL codes: *Q15, Q25*

INTRODUCTION

In the context of increasing anthropogenic load on the environment and increasing environmental problems, the tasks of sustainable development of territories are formed within the framework of national imperatives of resource conservation and resource efficiency. Water resources are of great strategic importance for the sustainable development of regions, especially for regions of agro-industrial specialization. Water participates

**Southern Federal University, Russian Information-analytical and Scientific-Research Water Management Center, Rostov-on-Don, Russia, chernova.olga71@yandex.ru*
***Kodolányi János University, Hungary, nagy.henrietta@kodolanyi.hu*
****Federal Research Centre the Southern Scientific Centre of the Russian Academy of Sciences (SSC RAS), Rostov-on-Don, Russia; Volgograd State University, Volgograd, Russia, mitrofanova@volsu.ru*
*****Volgograd State University, Volgograd, Russia,mia05011986@yandex.ru*

in the technological processes of agro-industrial enterprises, is used for watering and irrigation of lands, and is of vital importance for the health of the population. The water crisis is one of the most destructive for the economic complex of the region.

The processes of economic growth of regions inevitably increase the demand for water; economic development can be restrained by the degradation of water resources, a decrease in their biodiversity. Therefore, the state policy in relation to water resources management is aimed at preventing water losses, reducing the level of pollution of water bodies, as well as taking measures to improve the rationality of water consumption. The solution of these tasks is provided by a variety of measures in the strategies of water resources management in the regions. In developing these strategies, regional authorities based on the idea that the sustainability of economic systems development is largely determined by the state of available water resources. However, there is limited understanding concerning specific characteristics of water resources determining the sustainability of regional development. Whereas the study of the quantitative and qualitative characteristics of the state of the region's water resources, the determination of their role in creating the prerequisites for the sustainable development of the regional economy enables to assess compliance with the strategic development goals.

The article aimed at analyzing the state of water resources in the agro-industrial regions of the South of Russia and also to provide opportunities for the regions' sustainable economic and social development. The target areas were the Volgograd and Rostov regions. We believe that the regional policy in relation to water resources management should determine those factors that contribute to the sustainable development of the territory.

RESEARCH METHODOLOGY AND METHODS

The sustainability of the development of regional economies is understood as their ability to function effectively in the "economy - society - ecology" system. In world practice, systems of sustainable development indicators have been developed, the OECD indicator system and the UN Commission on Sustainable Development indicator system are the most famous of them. These systems require adaptation to the specifics of a particular country (region). Therefore, in practice, a fairly large number of various indicators are used to assess the sustainability of regional development. Their composition and number vary depending on the objectives of the study and the type of socio-economic system under consideration.

Sustainability is a more complex category than economic development, implying the intersection of economic, social and environmental goals. Therefore, to assess it, researchers often use analytical indicators that enable it to provide a more complete balanced view of the nature of the emerging relationships and interactions in each subsystem of the region on the basis of sub-indicators, (Brown, 2012). For example, Yu. Maksimov, S. Mityakov et al. define four regional subsystems: economy, innovation, ecology and social sphere, with the allocation of "costly" and "effective" indicators (Maksimov et al., 2011). G. Gagarina, L. Chainikova and others define the GRP per capita and the human development index as the main indicators that determine the sustainability of the development of the region, while ignoring the ecological subsystem (Gagarina et al., 2019). A. Dawodu et al. determining sustainable development indicators take into consideration various components of the problems of interaction between the social sphere, the environment and the economy: water resources management, transport, waste disposal, energy, etc. (Dawodu et al., 2019). Ch. Wulf et al. determining sustainability indicators suggest focusing not on problems but rather than on strategic development goals (Wulf et al., 2018).

When studying the effect of the state of water resources on the sustainability of regional development, most scientists focus on the ecological subsystem of the region (Giakoumis et al., 2020; Chen et al., 2017; Liu et al., 2021). At the same time, some authors pay attention to the role of water resources in the sustainable development of economic and social subsystems. So, in particular, E. Ahmadov notes that when managing the

region's water resources in the context of achieving sustainable development objectives, one should take into account: water demand for irrigation and for industrial production, water tariffs, impact on export potential (in the context of transboundary cooperation) (Ahmadov, 2020). M. Roobavannan et al. investigate the effect of the distribution of water resources on the level and structure of employment of the population (Roobavannan et al., 2017).

Within the framework of our research, we are based on the proposition that the stability of the regional economy is largely determined by the state of the water resources available on its territory and the characteristics of their use in production and economic activities. We have identified the set of indicators characterizing the impact of the state of water resources on the sustainability of regional development, in the context of economic, social and environmental subsystems (Table 1).

Table 1. Indicators for assessing the impact of water resources on the sustainable development of the region

Regional subsystem	**Indicators**	**Impact**
Economic subsystem	Water capacity of GRP Water intake; Loss of water during transportation	Possibilities for the development of agriculture and fisheries, industry, tourism; energy infrastructure development
Social subsystem	Provision of the population with river flow resources; Water tariffs; Compliance of the samples taken with the standards for sanitary and chemical indicators	Opportunities for creating recreational and resort areas supply of fresh water to the population
Ecological subsystem	Discharge of water resources; The share of contaminated and insufficiently treated waste water in the total volume of the discharge; Swampiness of the territory	Quality condition of water resources, maintenance of biodiversity in them

- The target area of the research were the Volgograd and Rostov regions. These regions are comparable in their sectoral structure, natural and climatic conditions, indicators of socio-economic development. This study is based on a statistical analysis of data on the state of water resources in the region with the formation of analytical estimates. The proposed toolkit for assessing the impact of the state of water resources on the sustainability of economic development in the region includes the following stages:

- determining trends in the state of water resources in the region;

- pair-wise comparison of the significance of the influence of the identified trends on the development of the economic, social and ecological subsystems of the region;

- building a matrix for comparing the development priorities of individual subsystems in the region;

- determining the final values of the indicators reflecting the impact of changes in the state of water resources on the sustainability of regional development.

RESEARCH RESULTS AND DISCUSSION

Volgograd and Rostov regions are regions with an extensive river network and a large number of natural and artificial reservoirs (Table 2).

Table 2. The main characteristics of the water resources of the Volgograd and Rostov regions

Indicator	The Volgograd region	The Rostov region
River network density, km / km^2	0,33	0,24
Average long-term river runoff, km3 per year	258,6	26,2
Anticipated groundwater resources, thousand m3 per day	3672,0	3836,0
Lakes, %	3,72	1,83
Surface water area, thousand hectares	525,0	401,1

The role of water resources in the development of the economic subsystem of the regions

One of the most important indicators that enable to assess the rationality of the use of water resources in the production and economic activities of the region is the GRP water capacity (Matveeva et al., 2018). The share of agricultural production and fish farming in the regions accounts for 10.5% of the GRP. In the regions, an important system-forming role is played by enterprises of the agro-industrial complex: agricultural machinery, food processing, storage and processing of agricultural crops, etc. In the Volgograd region, metallurgical production also has a significant share.

The dynamics of changes in the GRP water capacity level in the studied regions is shown in Figure 1.

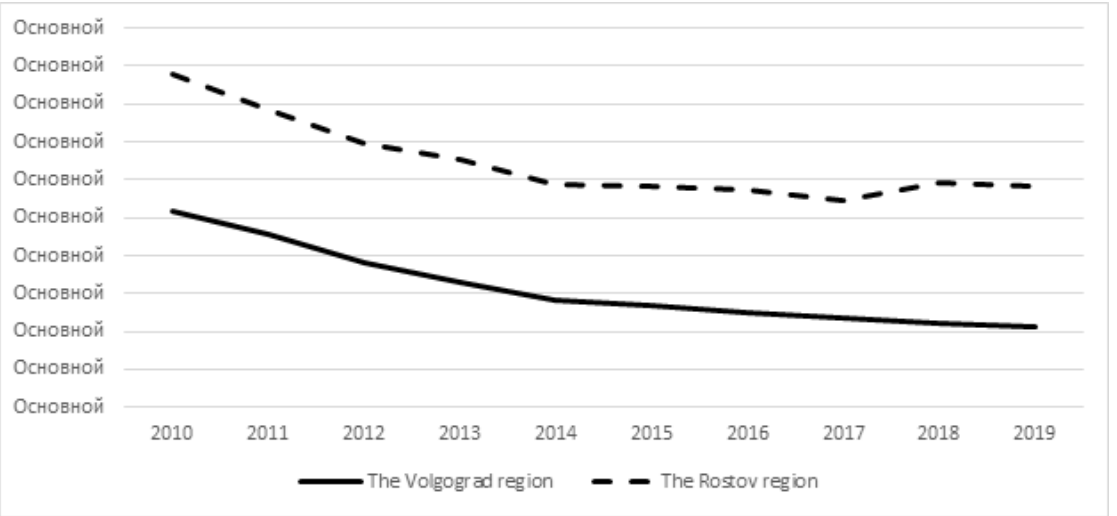

Figure 1. Water capacity of the GRP of the Volgograd and Rostov regions, m3/ rub.

As we can see from the above data, despite the existing tendency for a decrease in the level of GRP water consumption in both regions, in the Rostov region this indicator is 2 times higher than in the Volgograd region. Taking into account the comparability of the sectoral structure of the regional economy, it can be concluded that there is irrational water consumption in the Rostov region.

Considering the dynamics and structure of water intake (Fig. 2, 3), it can be noted that in both regions, reused water predominates in its structure, and in the Rostov region the increase in the volume of water intake occurs due to reused water. In the Volgograd region, on the contrary, there is a decrease in the volume of water intake, and also due to a decrease in the volume of reused water. However, the volume of water intake in the Rostov region is almost three times higher than in the Volgograd region. To a large extent, this situation is associated with significant water losses in the Rostov region during transportation and the need to compensate for these losses. Thus, if in the Volgograd region the total losses amount to about 11% of the withdrawn water (compared to the average Russian indicator), then in the Rostov region the water losses significantly exceed the average Russian indicator and amount to 22%.

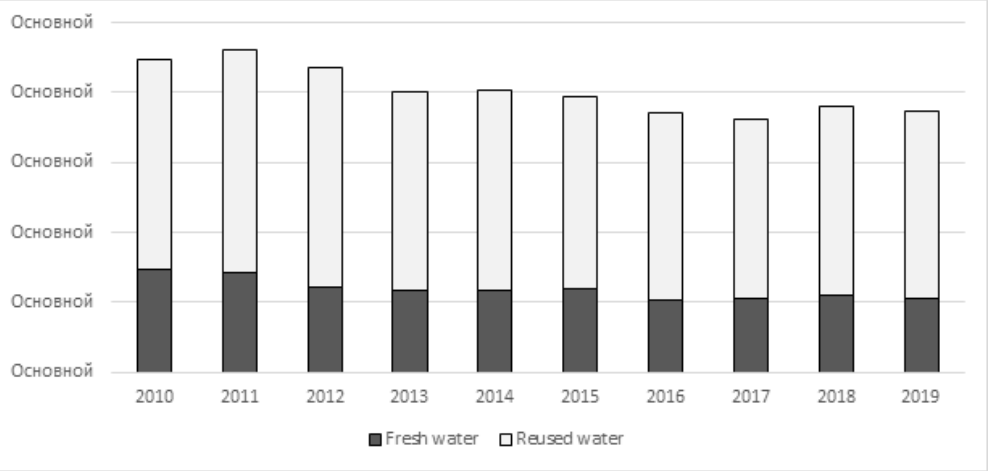

Figure 2. Structure of water intake in the Volgograd region, mln. m3

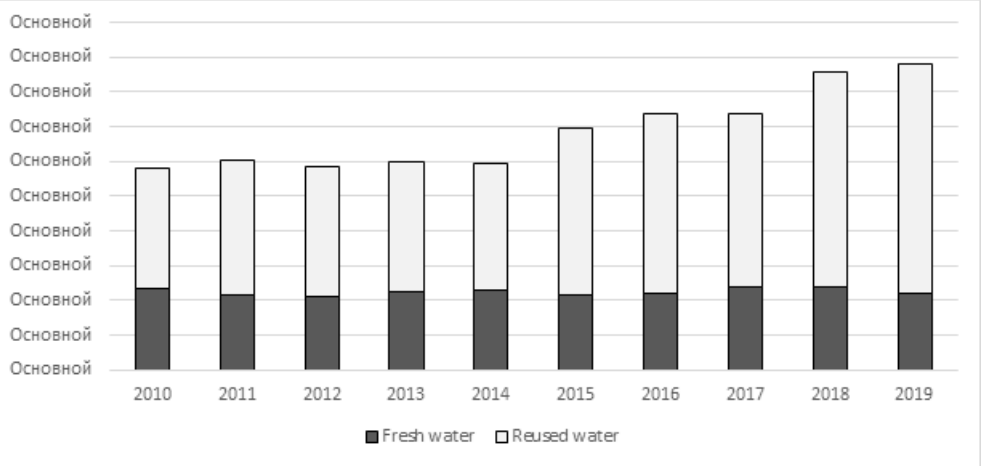

Figure 3. Structure of water intake in the Rostov region, mln. m3

In both regions, 96% of water withdrawals are from surface water sources. However, for the Volgograd region, this is 0.5% of the river flow, while in the Rostov region - 24%.

The efficiency of water resources use in the economy of the Rostov region is much lower than in the economy of the Volgograd region. A high level of losses of water resources during transportation, a significant load on the river network together with irrational use of water resources create high risks for the sustainable development of the economy of the Rostov region. In the Volgograd region, the role of water resources in creating the prerequisites for sustainable development of the regional economy can be assessed positively.

The role of water resources in the development of the social subsystem of regions

From the point of view of the provision of the population with water resources, the situation in the Rostov and Volgograd regions also develops in different ways. The provision of the population of the Rostov region with water resources is 15 times lower than the average Russian indicator and almost 6 times lower than the indicator of the Southern Federal District. As of January 1, 2020, only 78.4% of the region's population is provided with high-quality drinking water from centralized water supply systems. In the Volgograd region, the provision of the population with water resources is more than 2 times higher than the average for Russia and almost 5 times higher than the indicator of the Southern Federal District.

Drinking water tariffs in the Rostov region are significantly higher than in the Volgograd region. So, in the Rostov region from 01.2021. until 30.06.2021 the tariff in the field of cold water supply including VAT is 44.95 rubles. per m3, and from 01.07.2021 it was increased to 45.8 rubles. In the Volgograd region, the tariffs are 25.09 and 26.09 rubles per m3 respectively. The tariffs for wastewater disposal in the Rostov region are also almost two times higher than the corresponding tariffs in the Volgograd region. At the same time, according to Rospotrebnadzor (Russian Federal State Agency for Health and Consumer Rights), the quality of drinking water in the water supply network does not correspond to the sanitary and chemical indicators in 34% of the samples taken. In the Volgograd region, the proportion of samples that do not meet the requirements is 12%. The average proportion for Russia is 13%.

Thus, we can conclude that the state of the quality of water resources in the Rostov region does not ensure sustainable development of the social subsystem of the region. In the Volgograd region, the influence of the state of water resources on the sustainability of the development of the social subsystem can be assessed as positive.

The role of water resources in the development of the ecological subsystem of the regions

Water resources form the basis for the socio-economic development of the territory. However, economic growth leads to the emergence of many negative effects of the scale of production, expressed in anthropogenic impact on water resources. The discharge of contaminated wastewater into water bodies leads to a decrease in the sustainability of the development of the ecological subsystem of the region. An additional load on water resources is created by shipping transport, which pollutes the waters of the regions with oil products and fuels and lubricants.

The dynamics of the indicators of the discharge of polluted wastewater in the Rostov and Volgograd regions are shown in Figure 4.

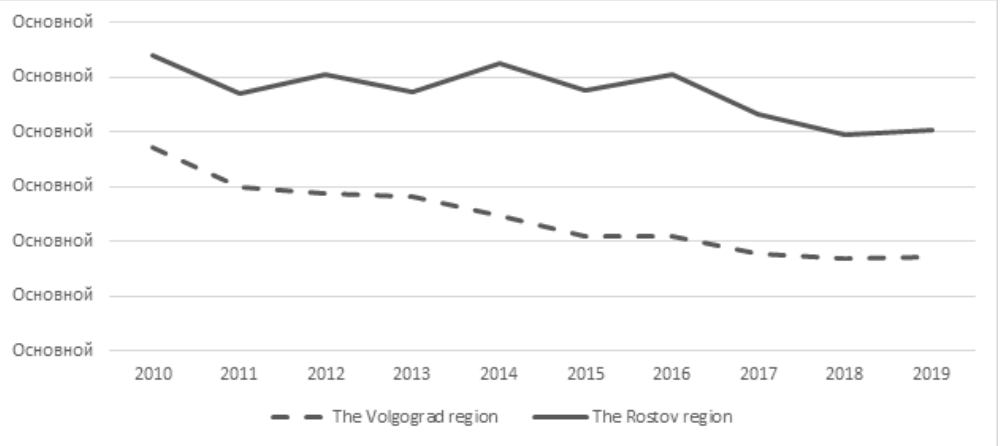

Figure 4. Dynamics of discharge of contaminated wastewater in the Volgograd and Rostov regions, mln. m3

The main pollutants in the Rostov region are sodium, magnesium, sulfides and hydrogen sulfide, in the Volgograd region - chloroform. The share of polluted and insufficiently treated water in the total volume of discharged water in the Rostov region is 19.3%, in the Volgograd region - 81.6%.

All this negatively affects the recreational potential of the region, the possibilities and conditions for the development of the tourism business, the formation of resort and recreation areas; on the functioning of the housing and communal services in the region, namely, on the quality of freshwater supplied to the population (Mitrofanova et al., 2021). Along with this, insufficient engineering preparation of technical structures leads to the swamping of territories. So, in the Volgograd region, the swampiness of the territory is 0.33%, in the Rostov region - 0.54%.

Thus, the state of the water resources of the regions does not contribute to the sustainable development of their ecological subsystems.

Assessment of the impact of the state of water resources on the sustainability of regional development

At the first stage, we will conduct a pair-wise comparison of the significance of the influence of the identified trends on the sustainability of the development of the economic, social and ecological subsystems of the region. For this, we will use a 10-point scale. If the influence of the compared trends is of equal significance, 5 points are assigned. If the influence of the trend is not equal, a greater number of points is assigned, while the sum of the marks for the compared criteria should be equal to 10.

The results of the pair-wise comparison of the influence of the identified trends on the stability of regional subsystems, carried out by the authors, are presented in Table 3.

Table 3. Results of pair-wise comparison of the influence of the identified trends on the stability of regional subsystems 1

The Volgograd region			
Impact on the state of the economic subsystem			
	Water capacity of GRP	Water intake	Loss of water during transportation
Water capacity of GRP	0	5	6
Water intake	5	0	3
Loss of water during transportation	4	7	0
Impact on the state of the social subsystem			
	Water supply for the population	Water tariffs	Sample compliance
Water supply for the population	0	6	6
Water tariffs	4	0	5
Sample compliance	4	5	0
Influence on the state of the ecological subsystem			
	Discharge of water resources	Share of polluted wastewater	Swampiness of the territory
Discharge of water resources	0	3	8
Share of polluted wastewater	7	0	7
Swampiness of the territory	2	3	0
The Rostov region			
Impact on the state of the economic subsystem			
	Water capacity of GRP	Water intake	Loss of water during transportation
Water capacity of GRP	0	5	2
Water intake	5	0	4
Loss of water during transportation	8	6	0
Impact on the state of the social subsystem			
	Water supply for the population	Water tariffs	Sample compliance
Water supply for the population	0	2	5
Water tariffs	8	0	8
Sample compliance	5	2	0
Influence on the state of the ecological subsystem			
	Discharge of water resources	Share of polluted wastewater	Swampiness of the territory
Discharge of water resources	0	7	8
Share of polluted wastewater	3	0	6
Swampiness of the territory	4	3	0

The next step is to determine the average values of the elements in the rows in Table 3 for each indicator. Next, we will determine the integral values of the level of impact of the state of water resources on regional subsystems as weighted average values. The values of the weight values are determined in such a way that for each subsystem their sum is equal to 1. The results of calculating the integral values of the indicators are shown in Table 4.

Table 4. The results of calculating the integral values of indicators the comparison of organisations on various dimensions of managerial effectiveness and its correlates.

Regional subsystems	Assessment indicators	Average score	Weight	Total
The Volgograd region				
Economic subsystem	Water capacity of GRP	5,5	0,5	4,95
	Water intake	4	0,2	
	Loss of water during transportation	5,5	0,3	
Social subsystem	Water supply for the population	6	0,4	5,1
	Water tariffs	4,5	0,3	
	Sample compliance	4,5	0,3	
Ecological subsystem	Discharge of water resources	5,5	0,2	6,25
	Share of polluted wastewater	7,0	0,7	
	Swampiness of the territory	2,5	0,1	
The Rostov region				
Economic subsystem	Water capacity of GRP	3,5	0,3	5,2
	Water intake	4,5	0,3	
	Loss of water during transportation	7	0,4	
Social subsystem	Water supply for the population	3,5	0,3	9,45
	Water tariffs	8	0,4	
	Sample compliance	3,5	0,3	
Ecological subsystem	Discharge of water resources	7,5	0,4	5,5
	Share of polluted wastewater	4,5	0,4	
	Swampiness of the territory	3,5	0,2	

For clarity, we will graphically display the indicators of the influence of water resources on the sustainability of the development of the studied regions (Fig. 5).

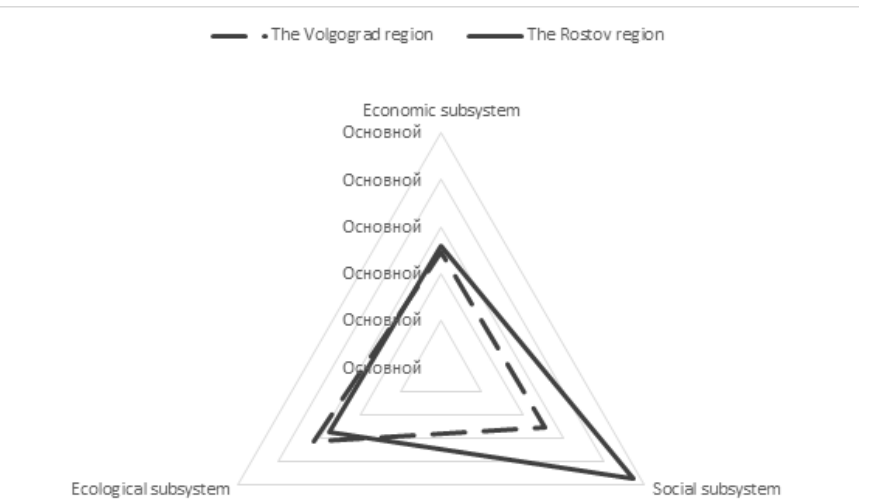

Figure 5. Integral values of indicators of the impact of the state of water resources on the sustainability of the development of the Volgograd and Rostov regions

As can be seen from the data presented, for the Volgograd region, the influence of water resources on individual subsystems of the region is generally equivalent. In this case, the greatest influence is exerted on the ecological subsystem. In the Rostov region, the most significant is the impact on the social subsystem, which is associated, as indicated earlier, with high water tariffs, low quality of drinking water and a low level of provision of the population with water resources.

RESULTS AND CONCLUSIONS

The analysis of the impact of the state of water resources on the sustainability of regional development, carried out by the authors, shows that the characteristics of the use of water resources have an impact on the state of individual regional subsystems. Effective management of water resources must be carried out not only from an environmental, but also from an economic and social perspective.

The indicators used by the authors for the assessment enabled to determine the influence of the prevailing trends in the main indicators of the efficiency of water resources use on the state of the economic, social and ecological subsystems of the Rostov and Volgograd regions. From the point of view of sustainable development, the Rostov region turned out to be the most sensitive to the impact of water resources on the social subsystem of the region, and for the Volgograd region - on the ecological subsystem.

The proposed toolkit can become an important addition to the existing tools for regional strategizing, since it enables to study the relationship between the state of water resources and sustainable development of the territory.

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BIBLIOGRAPHY

- Ahmadov E., Water resources management to achieve sustainable development in Azerbaijan, Sustainable Futures, 2020, vol. 2, p. 100030, ISSN 2666-1888, https://doi.org/10.1016/j.sftr.2020.100030.
- Brown M.G. Beyond the Balanced Scorecard. Moscow, "Olimp" Publ., 2012. ISBN: 978-5-9693-0212-9. 248 p.
- Chen X., Chen Y., Shimizu T., Niu J., Nakagami K., Qian X., Jia B., Nakajima J., Han J., Li J. Water resources management in the urban agglomeration of the Lake Biwa region, Japan: An ecosystem services-based sustainability assessment, Science of The Total Environment, 2017, vol. 586, pp. 174-187, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2017.01.197.
- Dawodu A., Cheshmehzangi A., Williams A. Expert-initiated integrated approach to the development of sustainability indicators for neighbourhood sustainability assessment tools: An African perspective, Journal of Cleaner Production, 2019, vol. 240, p. 117759, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2019.117759.
- Gagarina G., Chainikova L., Arkhipova L. The role of analysis of sustainable development of Russian regions in strategic planning, Federalism, 2019, no. 4, pp. 5–21. http://dx.doi.org/10.21686/ 2073-1051-2019-4-5-21
- Giakoumis T., Vaghela C., Voulvoulis N. Chapter Six - The role of water reuse in the circular economy, Editor(s): Paola Verlicchi, Advances in Chemical Pollution, Environmental Management and Protection, 2020, vol. 5, pp. 227-252, ISSN 2468-9289, ISBN 9780128201701, https://doi.org/10.1016/bs.apmp.2020.07.013.
- Liu X., Iqbal A., Dai J., Chen G. Economic and environmental sustainability of the optimal water resources application for coastal and inland regions, Journal of Cleaner Production, 2021, vol. 296, p. 126247, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2021.126247.
- Maksimov Yu.M., Mityakov S.N., Mityakov E.S. System of indicators of sustainable development of the region, Economy of the region, 2011, no. 2, pp. 226-231.
- Matveeva L.G., Chernova O.A., Kosolapova N.A., Kosolapov A.E. Assessment of water resources use efficiency based on the Russian Federation's gross regional product water intensity indicator, Regional Statistics, 2018, vol. 8, no. 2. pp. 154-169. https://doi.org/10.15196/RS080201
- Mitrofanova I., Chernova O., Pyankova S., Kleitman E. Environmental and economic risks in estimating investment potential of coastal areas of the south of Russia, International Journal for Quality Research, 2021, vol. 15(3), pp. 961–976. https://doi.org/10.24874/IJQR15.03-17.
- Roobavannan M., Kandasamy J., Pande S., Vigneswaran S., Sivapalan M. Allocating Environmental Water and Impact on Basin Unemployment: Role of A Diversified Economy, Ecological Economics, 2017, vol. 136, pp. 178-188, ISSN 0921-8009, https://doi.org/10.1016/j.ecolecon.2017.02.006.
- Wulf Ch., Werker J., Zapp P., Schreiber A., Schlör H., Kuckshinrichs W. Sustainable Development Goals as a Guideline for Indicator Selection in Life Cycle Sustainability Assessment, Procedia CIRP, 2018, vol. 69, pp. 59-65, ISSN 2212-8271, https://doi.org/10.1016/j.procir.2017.11.144