Conference Proceedings „Innovative development of agricultural business and rural areas“, 2 – 3.10.2025, Sofia
DOI: https://doi.org/10.37075/idara.2025.05

WATER USE IN BULGARIA BY ECONOMIC SECTORS – TRENDS AND EFFICIENCY ANALYSIS

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Abstract
The relevance of the topic related to the use of water in the various economic sectors in Bulgaria is predetermined by the uneven distribution and inefficient management of water resources in the country, which directly affects both agricultural and industrial production, and the services sector also. The aim of the paper is to track the trends in water use in Bulgaria by economic sectors and to analyze the efficiency of water use at the national and regional levels. On this basis summarized conclusions and recommendations are prepared. The paper contains an introduction presenting theoretical statements related to the use of water in the various economic sectors, the trends in the use of water resources in the sectorial aspect are tracked and an analysis of the efficiency in the use of water in agriculture, industry and services is made. Based on the analyses, conclusions and proposals related to the place of each economic sector in terms of water use are summarized.

Keywords: water use, agriculture, trends
JEL code*:* Q25, Q58, Q01

Introduction

The topic of water use by economic sectors in Bulgaria is particularly relevant, as uneven distribution and inefficient management of water resources directly affect agricultural, industrial, and service sectors. In recent years, the main challenge facing our country, related to the shortage of water in the four Basin regions, makes the topic of water resource use in the sectors of the economy extremely relevant. In recent years, Bulgaria has observed a trend towards deterioration in water resource management and their use, due to an outdated and depreciated water supply system, unmaintained reservoirs and their pollution, climate change and urbanization. According to Bliznakov et al. (2012), the change in production technologies in an ecological aspect will lead to an improvement in nature use more than environmental protection through conventional technologies. In her article, Shopova (2019) shares that each of the sectors of the economy depends on the provision of various resources, which are most often limited. This leads to problems related to the optimal distribution between different users, all of which applies especially to water resources. Baykov and Naydenov (2011) also point out that the

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use of water resources in Bulgaria by economic sectors is predetermined by their limitation and uneven distribution. Tipova (2018) expresses the opinion that the "productivity of terrestrial ecosystems" largely depends on and is regulated by water resources and in this regard, a balance is needed in the management of the water sector in order to distribute the necessary amounts of water across all economic sectors.

A significant share of the total water consumption in our country is used by the industrial sector, as the literature indicates (Sabotinova, 2020) that about three quarters of the water used in the industrial sector is for energy production and cooling. Trends in the industry in recent years have become increasingly large-scale, with an emphasis on the circular economy and reducing the ecological footprint. The agricultural sector also uses a large share of water use in the country. Tipova (2018) points out that agriculture is a sector due to which water in many regions of the world deviates from its natural path. According to another author (Gadzhev, 1996) the crop sector requires large amounts of water resources for irrigation. The services sector consumes the least water, but not in terms of importance. Naydenov (2016) defines water supply as both a "public health and welfare-related service" and an economic good offered by business. The aim of the paper is to track trends in water use in Bulgaria by economic sectors and to analyze the efficiency of water use at the national and regional levels. On this basis summarized conclusions and recommendations are prepared.

Methodology

The paper contains an introduction presenting theoretical statements related to water use in different economic sectors, trends in water resource use at the sectoral level are tracked and an analysis of efficiency in terms of water use in agriculture, industry and services is made. The analyses are at both the sectoral and regional levels. The study applies cross-sector and regional comparative analysis, as well as Data envelopment analysis (DEA). For the purposes of the cross-sector and regional analysis, data from the Infostat system of the National Statistical Institute were used. DEA analysis is output-oriented. It assumes one level of efficiency for optimality (Constant Return to Scale – CRS), defines it as 100% efficient and compares all units with it. An output-oriented model is chosen to determine how many times the respective comparative unit must increase each of the dependent variables in order to be efficient, provided that the same amount of water resource is used. This method was chosen in order to determine the efficiency coefficient of the water withdrawn by sectors and the created GVA and the gross output (production). The following models were constructed:

- ✓ Input – water used by sectors and outputs – the obtained GVA by sectors and the gross output (production), 2014;

- ✓ Input – water used by sectors and planning regions and outputs – the obtained GVA by sectors and the gross output (production), 2023;
- ✓ Input – water used by sectors and statistical regions and outputs – the obtained GVA and the gross output (production) by sectors and statistical regions, 2022.

Results and discussion

Trends in water use

Table 1 presents data on water use – in total and by economic sectors. For the period 2014-2023, water use varied from 4476 million cubic meters in 2015 to 4052 in 2020, which can also be explained by the Covid-19 pandemic and a decrease in the amounts used, especially in the industry sector.

The smallest consumer of water use is the services sector, in which the relative share of the total amounts varied from 1.5 to 2% of the total amounts, i.e. less than 2%, and the amounts of water used decreased by 7% for the analyzed period. The amounts of water used by the agriculture, forestry and fisheries sectors followed an increasing trend from 289.2 million cubic meters to 320.8 million cubic meters, which is an increase of about 10%. This is the sector in which the most pronounced increase trend is observed. In comparison to other sectors, the relative share in it varies from 6.8 to 8.3%. Industry is the main consumer of used water, and despite the fact that for the analyzed period there was a decrease in quantities by about 1.6%, the sector consumes over 90% of the total quantities throughout the analyzed period.

Table 1. Water used – total and by economic sectors

Year	Agriculture, forestry and fisheries		Industry		Services		Total	
	million m^3	%	million m^3	%	million m^3	%	million m^3	%
2014	289,2	6,8	3887,2	91,4	78,5	1,8	4255,0	100
2015	359,6	8,0	4036,7	90,2	80,6	1,8	4476,9	100
2016	355,2	8,0	4041,4	90,5	67,3	1,5	4463,9	100
2017	306,6	6,9	4091,2	91,4	77,6	1,7	4475,4	100
2018	311,7	7,1	3995,4	90,9	86,7	2,0	4393,8	100
2019	326,7	7,5	3928,0	90,8	73,3	1,7	4327,9	100
2020	336,1	8,3	3650,3	90,1	66,5	1,6	4052,8	100
2021	339,1	7,8	3924,3	90,6	66,3	1,5	4329,7	100
2022	303,1	6,9	4029,3	91,2	83,9	1,9	4416,2	100
2023	320,8	7,6	3823,8	90,7	73,0	1,7	4217,6	100

Source: NSI, Environment, Water statistics

Table 2 presents data on water use by sectors and by statistical regions. In a comparative aspect, regional differences in the structure of water consumption are observed. In the agricultural sector, the largest amounts of water used were in 2023 in the Southcentral region, where the water used (225.3 million cubic meters) is many times more than in all other regions, which can be explained by the development of irrigated agriculture in the region and the cultivation of crops requiring irrigation. The second largest consumer of water in the agricultural sector is the Southeast region (57.3 million cubic meters). In the Northwest, Northcentral, Northeast and Southwest regions, the values are relatively low compared to those recorded in the other two Southern regions. The largest water consumption in the industrial sector is observed in the Northwest region (2691.2), which exceeds all others many times, followed by the Southeast region (860.4). In the remaining regions, the values are below 125 million cubic meters. Northcentral and Northeast regions have particularly low levels (31.9 and 51.4, respectively). This clearly highlights the industrial dominance of the Northwest region with productions that require the use of water. In the services sector, water consumption is lower in absolute values, but regional differences are also observed. Consumption is the highest in the Southwest region (24.7), which can be explained by the concentration of the population in and around the capital. On second place is Southcentral (16.9), followed by Southeast region (13.3). In the three Northern regions, the least amounts of water are used in the services sector.

Table 2. Water used by activities and statistical regions

Statistical region	Agriculture, forestry and fisheries	Industry	Services
Northwest	15,1	2691,2	3,9
Northcentral	6,0	31,9	4,3
Northeast	8,9	51,4	9,9
Southeast	57,3	860,4	13,3
Southwest	8,3	63,1	24,7
Southcentral	225,3	125,7	16,9

Source: NSI, Environment, Water statistics

The data on the quantities of water used to create 1 million BGN of gross value added (GVA) in the three main sectors for the period 2014 – 2023 show trends of decreasing water intensity of the economy, but with different speed and dynamics in the different sectors (Table 3). In the agricultural sector, at the beginning of the analyzed period, about 75 thousand cubic meters of water are used to create 1 million BGN of GVA, which decreases to about 69 cubic meters in 2023. For the

analyzed period, the trend is decreasing, but with distinct fluctuations, which shows the sensitivity of the sector to climatic conditions and the yields obtained. In the industrial sector, a trend of decreasing water intensity is also observed, as 197 thousand cubic meters of water are used to produce 1 million BGN of GVA at the beginning of the period, and in 2023 the value decreases more than twice to about 91 thousand cubic meters. The positive trend of water quantity reduction is constant and smooth for the analyzed period, which is due to modernization processes, implementation of innovations and more efficient use of water resources in the industry. The trend in the services sector is also positive, as in 2014, 1,588 cubic meters of water were used in the sector for the production of 1 million leva GVA, and in 2023 they decreased more than two and a half times to 630 cubic meters.

Table 3. Water used in cubic meters for the production of 1 million BGN GVA

Year	Agriculture, forestry and fisheries	Industry	Services
2014	75389,95	197041,4	1588,48
2015	98835,52	187543	1544,124
2016	91870,23	173285,1	1225,538
2017	73850,08	166086,7	1303,902
2018	83589,55	164032,2	1293,854
2019	85246,64	152205,5	992,9098
2020	80854,78	138133,8	892,2423
2021	56138,04	135535,7	760,531
2022	48509,65	94584,98	832,0141
2023	68791,39	91103,73	630,5113

Source: NSI and own calculation

The data in Table 4 show strongly pronounced differences both between statistical regions and between economic sectors. In the agricultural, forestry and fisheries sector, the highest water intensity is observed in the Southcentral region, where over 240 thousand cubic meters of water are used to produce one million BGN of GVA. In second place is the Southeast region, and in Northcentral the consumption is the lowest – about 7,350 cubic meters. This shows that in different regions the dependence of agriculture on water resources is uneven. In industry, large differences are also noticeable. In the Northwest region, the water used to produce 1 million BGN of GVA is the highest and exceeds 650 thousand cubic meters.

Table 4. Water used in cubic meters for the production of 1 million BGN of GVA by statistical regions, 2023

Statistical region	Agriculture, forestry and fisheries	Industry	Services
Northwest	19639,05	654857,90	614,04
Northcentral	7350,24	8797,12	580,46
Northeast	10322,56	11604,37	906,50
Southeast	83356,13	97789,21	1220,70
Southwest	13847,87	4621,27	367,02
Southcentral	241665,09	17117,26	1302,19

Source: NSI and own calculation

In second place is the Southeast region, but the indicator in this region is six times lower. The industry with the lowest dependence on water is in the Southwest region, where only about 4,621 cubic meters of water are used to produce 1 million BGN of GVA. The services sector differs significantly from the other two. It has a much lower water intensity throughout the country. Values range from about 367 cubic meters in the Southwest region to about 1,300 cubic meters in the Southcentral region. Differences in the services sector between regions exist, but are small compared to agriculture and industry.

Data envelopment analysis (DEA)

The data from the DEA analysis regarding the water used by sectors (independent variable) and the obtained GVA by sectors and the produced output in 2013 and 2024 show the effect of the amount of water used in the three sectors on the GVA and the produced output (Table 5). In both analyzed years, the services sector is determined as the most efficient in terms of the dependent variables, followed in 2014 by the agriculture sector and finally by the industry sector, and in 2023 it is followed by the industry sector and the agriculture sector remains in third place. In 2014, the efficiency coefficient for the services sector is 1, which defines the sector as efficiently using the withdrawn water. In comparative terms, between 2014 and 2023, the efficiency of water used in the services sector is maintained, while in the other two sectors it decreases. Data on the calculated projections of the desired values of GVA by sector and the produced output show that both indicators need to be significantly higher in the agriculture and industry sectors in order to achieve water use efficiency in these sectors.

Table 5. Efficiency coefficient of economic sectors from water use using the CCR model

Economic sectors	2014	2023	Change
Agriculture, forestry and fisheries	0,07	0,025	-0,065
Industry	0,059	0,037	-0,022
Services	1	1	0

Source: own calculation

The DEA analysis, oriented towards the output, in terms of water use by sectors (independent variable) and the resulting GVA and gross output (production), shows by sectors and by statistical regions in 2022 the effect of the amount of water used on GVA and gross output (production) in sectorial and regional aspect. In 2023, the agriculture, forestry and fisheries sector is the most efficient in terms of water used in the Northcentral, Northeast and Southwest regions and the least efficient in the Southcentral, followed by the Southeast and Northwest regions (Table 6).

Table 6. Water use efficiency coefficient by economic sectors and by planning regions using the CCR model, 2022

Statistical region	Agriculture, forestry and fisheries		Industry		Services	
	Coefficient	Rank	Coefficient	Rank	Coefficient	Rank
Norwest	0.375	4	0.007	6	0.587	3
Northcentral	1	1	0,523	2	0.685	2
Northeast	0.744	2	0,407	3	0.407	4
Southeast	0.093	5	0,047	5	0.312	5
Southwest	0.547	3	1	1	1	1
Southcentral	0.03	6	0,269	4	0.283	6

Source: own calculation

The most inefficient in terms of water use and the created GVA and gross output (production) in the industry sector are the Northwest and Southeast regions. The efficiency coefficient is highest in the Southwest region, followed by the Northcentral and Northeast regions. In comparative aspect, among the statistical regions in terms of the efficiency coefficient of water use in the services sector, the Southwest region has the favorable position, followed by Northcentral, Northeast and Northwest regions. The lowest efficiency coefficient is in Southcentral and Southeast region.

Conclusion

The analysis of the use of water resources in Bulgaria for the period 2014–2023 reveals clear differences both between economic sectors and between individual statistical regions. On a national scale, a sustainable trend towards a decrease in total water consumption is observed, especially in industry, where more than twice the decrease in water intensity for the production of gross value added (GVA) is observing. The services sector has the highest efficiency and the lowest dependence on water resources, while agriculture remains highly dependent on climatic conditions and the data in this sector show the greatest fluctuations. The regional analysis presents clearly expressed disparities. The comparative analysis shows a strong regional specificity related to the use of water resources in economic sectors and differences in resource load. The Southcentral region stands out with its dominance in terms of water use in the agricultural sector, in the Northwest region the largest quantities are used in the industrial sector, and in the Southwest the load on water resources is observed in the services sector. In agriculture, the Southcentral region is the leader in terms of water consumption (225.3 million cubic meters), but at the same time the most inefficient in terms of converting the water use into GVA. In the Northcentral region, water intensity is minimal (about 7,350 cubic meters for the production of 1 million leva of GVA). In industry, the Northwest region is dominant in terms of absolute volumes of water use, but at the same time the most inefficient in terms of creating GVA, while the Southwest region achieves the most positive results with the lowest water dependence. In the services sector, the Southwest region is the most efficient in terms of using water to create GVA, while the Southcentral and Southeast regions remain the least represented in terms of using water to create GVA.

The DEA analysis highlights the sustainable efficiency of the services sector, while agriculture and industry lag behind and show a permanent need for technological and organizational improvements. The ranking by statistical regions shows that the Southwest and Northcentral regions are leading in terms of overall efficiency, while the Southcentral and Southeast regions are in the most negative position. The data on the calculated projections of the desired GVA values by statistical regions and the produced output show that both indicators need to be significantly higher to achieve water use efficiency in the statistical regions where the efficiency coefficient is low.

Some of the recommendations that can be made to increase water use efficiency could be related to modernization of irrigation infrastructure, implementation of water-saving technologies and incentives for crops with lower water dependence (Southcentral region), investments in energy and water-efficient technologies in industry, as well as strengthening control over industrial water consumption (Southeast), restructuring of industrial production towards less water-intensive

activities and stimulating the implementation of circular practices for recycling and reuse of water (Northwest region).

At the national and regional levels, positive trends in the use of water resources at the sectoral level are observed, but there are significant regional and sectoral challenges that require a differentiated approach and a targeted selection of measures and initiatives to increase the efficiency of water use and to improve water resources management.

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