

## ANALYSIS OF THE LEVEL OF RENEWABLE FRESHWATER RESOURCES IN EUROPEAN UNION COUNTRIES

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**Purpose:** This article aims to draw attention to the problem faced by European Union countries regarding the availability of freshwater and renewable sources and analyze the situation of individual countries regarding water resources.

**Design/methodology/approach:** The article presents tables and charts based on statistical data from Eurostat, based on which the situation of EU countries in the field of renewable freshwater resources was analyzed, thanks to which it is possible to indicate the countries with the greatest problems with their availability, determine their direction of changes and make them aware of the need to take actions to improve the water situation in EU countries.

**Findings:** During the data analysis, the level of problems in EU countries related to freshwater and renewable sources of freshwater was indicated, and the direction of changes in the level of freshwater in the EU was graphically presented.

**Research limitations/implications:** The article analyzed data on renewable freshwater sources. The analysis should further determine the actions taken by individual countries to improve the water situation and analyze the results obtained, taking into account other countries and their capabilities.

**Practical implications:** The material presented in the article may be helpful in implementing research and projects related to the protection of renewable sources of fresh water, and above all, it may encourage deeper considerations of the problem of water deficit.

**Social implications:** The article and its analyses can increase society's awareness of water savings and protection against contamination, such as the lack of municipal sewage systems or illegal waste dumps.

**Originality/value:** The article touches on a very serious problem that the whole world is struggling with, namely the availability of water. Water is one of the basic foundations of life and the development of agriculture and the economy. Renewable sources of fresh water are a component of the broadly understood policy of using renewable sources, such as energy.

**Keywords:** renewable sources of fresh water, at-risk countries in terms of water availability.

**Category of the paper:** Research paper, general review.

## 1. Introduction

Freshwater is a resource of fundamental importance for life, the environment, and the economy. In the face of growing demand for water and ongoing climate change, renewable sources of freshwater are becoming one of the most important environmental and economic challenges in the European Union.

An extremely important aspect seems to be the analysis and classification of costs of preventing climate change and adapting to it, such as risk analysis, portfolio and scenario analyses, analysis of the costs of preventing climate change (expenditures on reducing sources, minimizing greenhouse gas emissions) (Dubiel, 2016). It is therefore necessary to obtain large amounts of data from many sources (Kokoszka, 2016) for analyzes performed when planning investments, as well as when estimating the Water Exploitation Index Plus (WEI+) - an indicator that the European Union uses to monitor renewable water resources. This indicator shows what percentage of renewable water resources are used in a given area and is calculated as the ratio of water consumption to renewable water resources. This knowledge allows for identifying regions exposed to water shortages, planning adaptation actions, analyzing the effects of excessive water abstraction, and supporting and implementing sustainable water management strategies. WEI+ values below 20% indicate a region with low water pressure - water resources are sufficient to meet needs. Values between 20% and 40% indicate moderate pressure on water resources - preventive measures should be taken. However, WEI+ index values above 40% indicate situations of serious water shortage - the region is at risk of water deficit. In most EU countries, the WEI+ indicator is relatively low.

Renewable freshwater resources include rainfall, rivers, lakes, and groundwater, renewed through the hydrological cycle. Unfortunately, geographical differences in the availability of these resources, climate change, and environmental pollution directly and indirectly affect the availability and renewability of water resources and water quality. The sources of contamination include agriculture and the chemical plant care and protection products used; industry producing harmful dust, gases, and sewage; transport, leaking fuels, exhaust fumes; burning of garbage in households; poorly secured waste dumps, or the so-called wild garbage dumps. Therefore, it is necessary to take all actions to minimize pollution, as well as to increase the possibilities of using groundwater and surface water, e.g. by water treatment (Wygoda, 2019)

The European Union is taking several actions to protect and effectively manage renewable water sources. The key document in this respect is the Water Framework Directive (WFD) of 2000, which introduces an integrated approach to water management at the river basin level. Its main goal is to achieve good status for all waters in the EU. The directive obliges Member States to develop and implement water management plans that consider protecting resources, minimizing pollution, and sustainable water use. For this purpose, member states are obliged

to assess the hydromorphological status of waters. One of the methods used for analysis is the River Habitat Survey (RHS), which is very useful in environmental monitoring, water management and preparation of expert opinions (Jusik, Przesmycki, Achtenberg, 2016). All investments implemented in water management and serving directly to improve water quality, as well as other investments not directly related to water management but which may threaten the achievement of water environmental objectives, must be consistent with the provisions of the WFD. If the investment has a negative impact on the condition of water bodies, it may be implemented only if the conditions set out in Art. 4, section 7 WFD (Kłosowicz, 2016).

The aim of this article was to draw attention to the problem faced by European Union countries in terms of the availability of freshwater and their renewable sources, to analyze the situation of individual countries in terms of water resources and their critically low level in some regions of the European Union, which in turn should be a contribution to taking actions aimed at improving the level of freshwater availability and increasing public awareness of saving water and paying attention to its contamination.

## 2. Analysis of renewable freshwater sources in EU countries

The table below shows the volume of renewable freshwater resources from 2013-2022 in individual European Union countries.

**Table 1.**

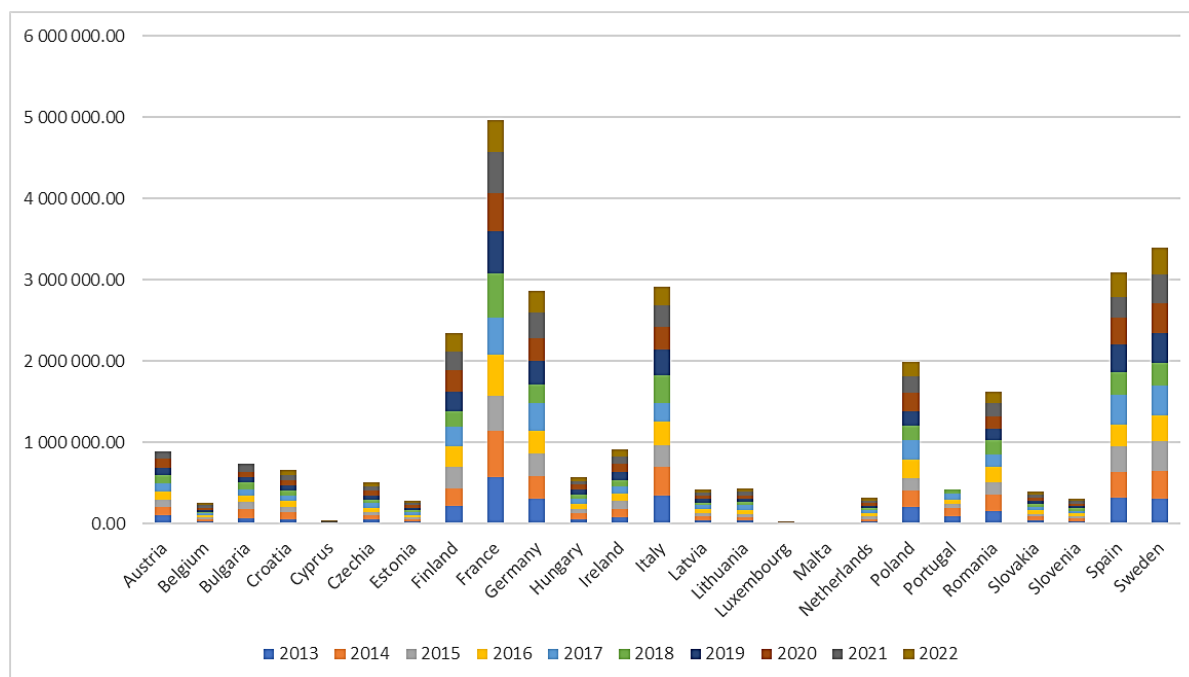
*The volume of renewable freshwater resources over the years 2013-2022*

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Austria	105 303.00	106 870.00	82 146.00	105 883.00	103 905.00	91 077.00	99 189.00	103 708.00	91 580.00	:
Belgium	24 955.22	26 391.68	24 912.73	26 903.56	24 875.15	21 326.23	25 780.38	24 852.73	29 543.52	26 538.05
Bulgaria	70 865.00	115 306.00	82 073.00	74 713.00	84 411.00	85 254.00	63 437.00	67 783.00	89 899.00	:
Croatia	61 108.00	85 551.00	62 330.00	70 769.00	64 839.00	65 029.00	63 712.10	60 968.70	63 763.90	61 049.50
Cyprus	1 770.00	2 358.00	2 904.00	2 580.00	1 956.00	3 642.00	4 782.00	2 832.00	2 724.00	2 760.00
Czechia	56 439.00	51 675.00	41 824.00	49 960.00	53 288.00	41 244.00	49 806.00	60 267.00	53 674.00	49 984.00
Denmark	:	:	:	:	:	:	:	:	:	:
Estonia	26 035.20	27 391.20	25 899.60	32 182.40	32 679.60	23 187.60	30 419.60	29 967.60	27 752.80	23 820.40
Finland	221 166.00	214 401.00	265 130.00	251 689.00	248 210.00	183 618.00	239 499.00	265 431.00	225 303.00	231 479.00
France	578 153.19	567 368.82	429 458.41	509 575.92	452 142.07	540 203.18	526 593.90	462 417.52	510 177.38	389 243.24
Germany	304 700.00	284 000.00	274 100.00	286 700.00	336 300.00	230 600.00	289 100.00	278 200.00	316 900.00	265 900.00
Greece	:	:	:	:	:	:	:	:	:	:
Hungary	62 031.00	70 680.00	51 429.00	65 751.00	58 218.00	56 962.50	58 234.70	56 981.10	47 650.00	46 236.40
Ireland	83 886.46	97 854.67	105 540.69	82 540.43	87 278.82	85 926.00	96 204.22	104 397.71	85 590.95	89 062.21
Italy	343 940.14	363 242.59	265 068.92	288 539.98	228 820.18	333 699.87	326 027.22	275 007.11	269 116.69	217 220.58
Latvia	40 642.00	48 556.00	38 852.00	51 010.00	52 713.52	30 198.00	41 053.99	39 727.90	39 570.14	41 765.91
Lithuania	43 151.54	41 197.66	38 517.18	51 985.00	57 852.17	36 346.66	40 499.96	42 153.01	45 011.60	43 703.84
Luxembourg	2 444.74	2 352.29	1 872.07	2 213.62	1 545.94	2 054.40	1 815.58	2 126.30	2 295.79	1 647.28
Malta	151.54	159.37	155.23	102.65	137.81	189.51	172.60	122.26	175.76	116.29
Netherlands	30 496.90	31 678.16	35 341.40	32 032.35	35 199.31	25 238.51	32 417.47	32 155.74	33 273.00	29 646.00
Poland	210 158.10	199 869.90	155 817.90	218 545.20	248 836.50	174 920.60	181 028.20	220 458.70	200 110.10	184 332.50
Portugal	91 445.48	99 259.61	54 088.58	54 581.79	69 352.96	53 763.07	:	:	:	:
Romania	162 798.90	197 196.00	152 358.00	187 738.10	157 892.30	166 543.20	144 154.20	155 285.30	166 419.00	134 329.00
Slovakia	42 348.00	46 806.00	35 248.00	45 289.00	40 535.00	32 982.00	41 564.00	43 425.00	37 301.00	31 126.00
Slovenia	34 848.00	39 897.00	24 144.00	31 315.40	31 835.50	27 857.60	32 047.30	29 785.10	27 296.90	24 319.60
Spain	327 020.10	308 555.20	313 706.80	276 273.85	359 446.24	275 494.87	345 324.43	327 742.76	251 994.26	310 195.17
Sweden	311 506.00	336 488.00	375 110.00	315 176.00	359 510.00	279 373.00	367 414.00	370 646.00	355 402.00	329 990.00

Source: [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table/?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table/?lang=en&category=env.env_wat.env_nwat)

Based on the data in the table, an analysis of the volume of renewable freshwater resources over 2013-2022 will be presented. Due to the need for more data availability from countries such as Denmark and Greece, the analyses will be prepared omitting these countries. In the case of Portugal, where there are gaps from 2019-2022, the analyses will only cover the period with available data, i.e., they will cover the years 2013-2018.

The chart below (Figure 1) shows the volume of renewable freshwater resources. Based on this, it can be clearly determined which countries achieve the highest volume of renewable freshwater resources and which have serious problems achieving even a satisfactory level.



**Figure 1.** The volume of renewable freshwater resources over the years 2013-2022.

Source: own study based on [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat)

The table (Table 2) thoroughly analyzes the volume of renewable freshwater resources over 2013-2022 by individual EU countries. The country that has a significant advantage over other countries is France. Over the years 2013-2022, it obtained 4965333.63 million cubic meters. In the analyzed period, France overtook Sweden by 1564718.63, which obtained 3400615 million cubic meters in the analyzed period. The next country with the largest volume of renewable freshwater resources is Spain, which reached 1869579.95 million cubic meters, smaller than the volume of renewable freshwater resources, achieving a value of 3095753.68. The lowest results in obtaining renewable freshwater resources were demonstrated by Malta (1483.02), followed by Luxembourg (20368.01) and Cyprus (28308). The difference between France and Malta was 4963850.61 million cubic meters.

**Table 2.**

*Minimum, maximum, and total volume of renewable freshwater resources in the period 2013-2022*

	<b>Minimum value of renewable freshwater resources</b>	<b>Maximum value of renewable freshwater resources</b>	<b>The volume of renewable freshwater resources in the period 2013-2022</b>
Austria	82146.00	106870.00	1464231.00
Belgium	21326.23	29543.52	434989.91
Bulgaria	63437.00	115306.00	1218857.00
Croatia	60968.70	85551.00	1120163.10
Cyprus	1770.00	4782.00	51600.00
Czechia	41244.00	60267.00	864647.00
Estonia	23187.60	32679.60	55867.20
Finland	183618.00	265431.00	863533.00
France	389243.24	578153.19	4458652.43
Germany	230600.00	336300.00	7960868.85
Hungary	46236.40	70680.00	4364116.40
Ireland	82540.43	105540.69	188081.12
Italy	217220.58	363242.59	1420701.57
Latvia	30198.00	52713.52	1462374.77
Lithuania	36346.66	57852.17	4425953.58
Luxembourg	1545.94	2444.74	620396.08
Malta	102.65	189.51	648425.85
Netherlands	25238.51	35341.40	90887.27
Poland	155817.90	248836.50	406913.84
Portugal	53763.07	99259.61	623232.24
Romania	134329.00	197196.00	3286452.80
Slovakia	31126.00	46806.00	554186.56
Slovenia	24144.00	39897.00	2455485.70
Spain	251994.26	359446.24	1194462.50
Sweden	279373.00	375110.00	1099135.90

Source: own study based on [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat)

In addition to the data related to the acquisition of renewable freshwater resources, the total volume of renewable freshwater resources obtained in the subsequent years of 2013-2022 is also important.

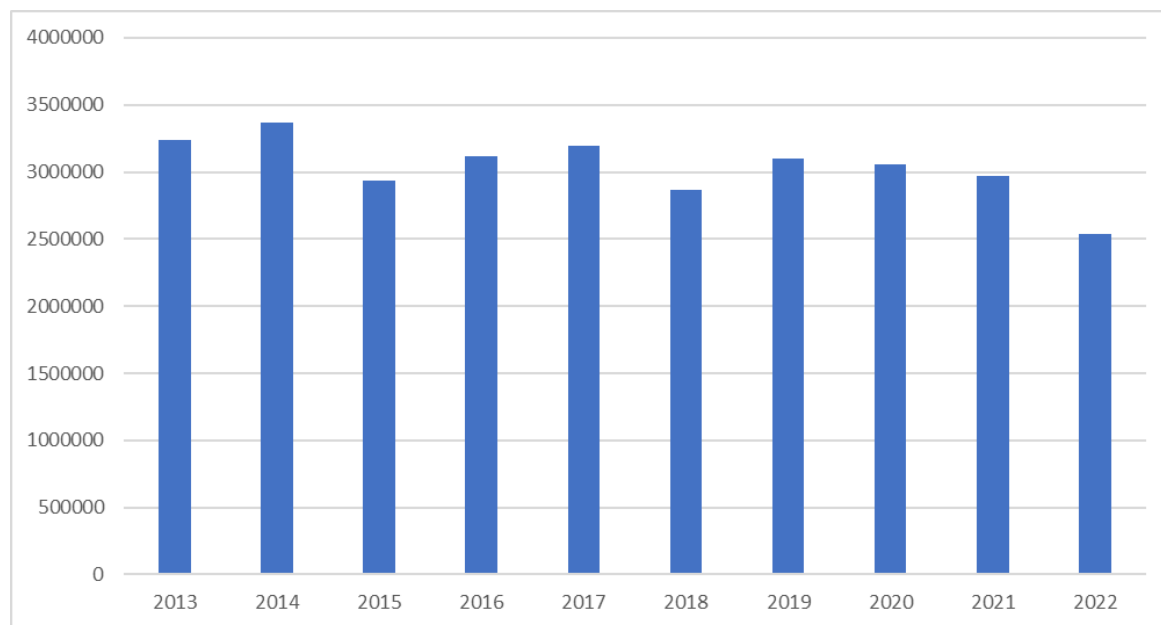
**Table 3.**

*Total volume of renewable freshwater resources in particular years 2013-2022*

	<b>Total volume of renewable freshwater resources in particular years</b>
2013	3237363.51
2014	3 365 105.15
2015	2 938 027.51
2016	3 114 050.25
2017	3 191 780.07
2018	2 866 730.8
2019	3 100 276.85
2020	3 056 441.54
2021	2 972 524.79
2022	2 534 464.97

Source: own study based on [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat)

The values of renewable freshwater resources obtained are presented in the chart below. Occurring fluctuations can be observed, but with a downward trend—the level of freshwater value in 2022 compared to 2013 decreased from 3,237,363.51 to 2,534,464.97. This fact should be of great concern.



**Figure 2.** Total volume of renewable freshwater resources in particular years the period 2013-2022.

Source: *own study based on* [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat)

An extremely important aspect in analyzing the achieved freshwater level is controlling changes occurring in subsequent analysis periods. For the years 2013-2022, the percentage change from year to year was determined for individual EU countries. The results are presented in the table below (Table 4).

**Table 4.**

*Percentage change in the value of renewable freshwater resources from year to year in 2013-2022*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	Min	Max
Austria	1.49%	-23.13%	28.90%	-1.87%	-12.35%	8.91%	4.56%	-11.69%	:	-23.13%	28.90%
Belgium	5.76%	-5.60%	7.99%	-7.54%	-14.27%	20.89%	-3.60%	18.87%	-10.17%	-14.27%	20.89%
Bulgaria	62.71%	-28.82%	-8.97%	12.98%	1.00%	-25.59%	6.85%	32.63%	:	:	:
Croatia	40.00%	-27.14%	13.54%	-8.38%	0.29%	-2.03%	-4.31%	4.58%	-4.26%	-27.14%	40.00%
Cyprus	33.22%	23.16%	-11.16%	-24.19%	86.20%	31.30%	-40.78%	-3.81%	1.32%	-40.78%	86.20%
Czechia	-8.44%	-19.06%	19.45%	6.66%	-22.60%	20.76%	21.00%	-10.94%	-6.87%	-22.60%	21.00%
Estonia	5.21%	-5.45%	24.26%	1.54%	-29.05%	31.19%	-1.49%	-7.39%	-14.17%	-29.05%	31.19%
Finland	-3.06%	23.66%	-5.07%	-1.38%	-26.02%	30.43%	10.83%	-15.12%	2.74%	-26.02%	30.43%
France	-1.87%	-24.31%	18.66%	-11.27%	19.48%	-2.52%	-12.19%	10.33%	-23.70%	-24.31%	19.48%
Germany	-6.79%	-3.49%	4.60%	17.30%	-31.43%	25.37%	-3.77%	13.91%	-16.09%	-31.43%	25.37%
Hungary	13.94%	-27.24%	27.85%	-11.46%	-2.16%	2.23%	-2.15%	-16.38%	-2.97%	-27.24%	27.85%
Ireland	16.65%	7.85%	-21.79%	5.74%	-1.55%	11.96%	8.52%	-18.01%	4.06%	-21.79%	16.65%
Italy	5.61%	-27.03%	8.85%	-20.70%	45.83%	-2.30%	-15.65%	-2.14%	-19.28%	-27.03%	45.83%
Latvia	19.47%	-19.99%	31.29%	3.34%	-42.71%	35.95%	-3.23%	-0.40%	5.55%	-42.71%	35.95%
Lithuania	-4.53%	-6.51%	34.97%	11.29%	-37.17%	11.43%	4.08%	6.78%	-2.91%	-37.17%	34.97%
Luxembourg	-3.78%	-20.41%	18.24%	-30.16%	32.89%	-11.62%	17.11%	7.97%	-28.25%	-30.16%	32.89%
Malta	5.17%	-2.60%	-33.87%	34.25%	37.52%	-8.92%	-29.17%	43.76%	-33.84%	-33.87%	43.76%
Netherlands	3.87%	11.56%	-9.36%	9.89%	-28.30%	28.44%	-0.81%	3.47%	-10.90%	-28.30%	28.44%
Poland	-4.90%	-22.04%	40.26%	13.86%	-29.70%	3.49%	21.78%	-9.23%	-7.88%	-29.70%	40.26%

Cont. table 4.

Portugal	8.55%	-45.51%	0.91%	27.06%	-22.48%	:	:	:	:	:	:
Romania	21.13%	-22.74%	23.22%	-15.90%	5.48%	-13.44%	7.72%	7.17%	-19.28%	-22.74%	23.22%
Slovakia	10.53%	-24.69%	28.49%	-10.50%	-18.63%	26.02%	4.48%	-14.10%	-16.55%	-24.69%	28.49%
Slovenia	14.49%	-39.48%	29.70%	1.66%	-12.50%	15.04%	-7.06%	-8.35%	-10.91%	-39.48%	29.70%
Spain	-5.65%	1.67%	-11.93%	30.11%	-23.36%	25.35%	-5.09%	-23.11%	23.10%	-23.36%	30.11%
Sweden	8.02%	11.48%	-15.98%	14.07%	-22.29%	31.51%	0.88%	-4.11%	-7.15%	-22.29%	31.51%

Source: own study based on [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat)

Latvia recorded the most significant decrease (42.71%) compared to 2017 (decrease from 52713.52 in 2017 to 30198 in 2018). Cyprus observed the most significant increase (86.2%) in 2018 (a change from 1,956 in 2017 to 3,642 in 2018).

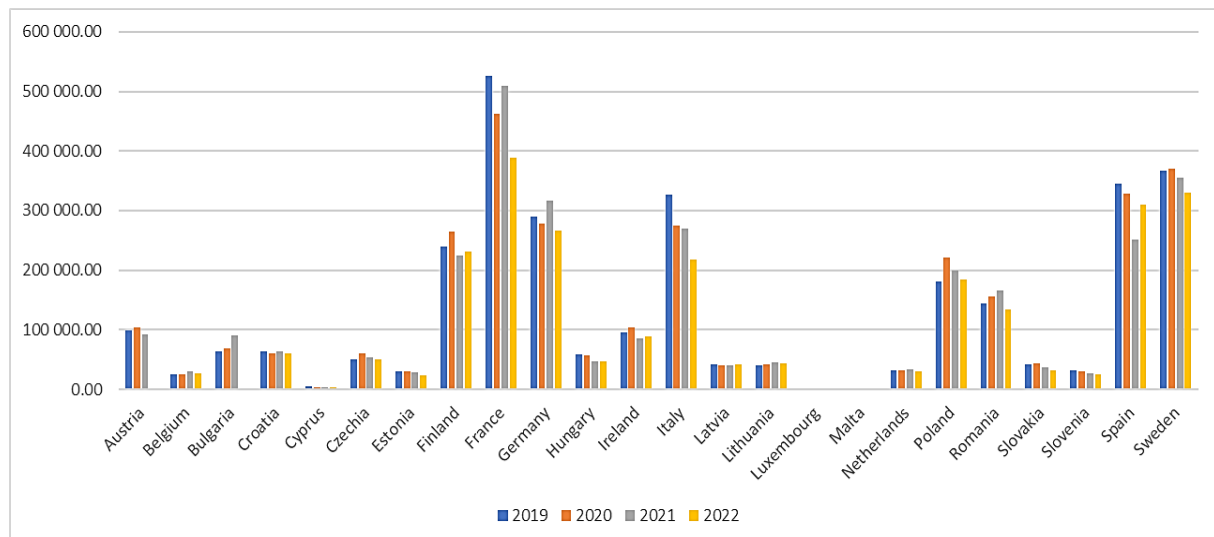
**Table 5.**

*Values of renewable freshwater resources in the last four years of the analyzed period in ascending order*

	2019		2020		2021		2022
Malta	172.60	Malta	122.26	Malta	175.76	Malta	116.29
Luxembourg	1 815.58	Luxembourg	2 126.30	Luxembourg	2 295.79	Luxembourg	1 647.28
Cyprus	4 782.00	Cyprus	2 832.00	Cyprus	2 724.00	Cyprus	2 760.00
Belgium	25 780.38	Belgium	24 852.73	Slovenia	27 296.90	Estonia	23 820.40
Estonia	30 419.60	Slovenia	29 785.10	Estonia	27 752.80	Slovenia	24 319.60
Slovenia	32 047.30	Estonia	29 967.60	Belgium	29 543.52	Belgium	26 538.05
Netherlands	32 417.47	Netherlands	32 155.74	Netherlands	33 273.00	Netherlands	29 646.00
Lithuania	40 499.96	Latvia	39 727.90	Slovakia	37 301.00	Slovakia	31 126.00
Latvia	41 053.99	Lithuania	42 153.01	Latvia	39 570.14	Latvia	41 765.91
Slovakia	41 564.00	Slovakia	43 425.00	Lithuania	45 011.60	Lithuania	43 703.84
Czechia	49 806.00	Hungary	56 981.10	Hungary	47 650.00	Hungary	46 236.40
Hungary	58 234.70	Czechia	60 267.00	Czechia	53 674.00	Czechia	49 984.00
Bulgaria	63 437.00	Croatia	60 968.70	Croatia	63 763.90	Croatia	61 049.50
Croatia	63 712.10	Bulgaria	67 783.00	Ireland	85 590.95	Ireland	89 062.21
Ireland	96 204.22	Austria	103 708.00	Bulgaria	89 899.00	Romania	134 329.00
Austria	99 189.00	Ireland	104 397.71	Austria	91 580.00	Poland	184 332.50
Romania	144 154.20	Romania	155 285.30	Romania	166 419.00	Italy	217 220.58
Poland	181 028.20	Poland	220 458.70	Poland	200 110.10	Finland	231 479.00
Finland	239 499.00	Finland	265 431.00	Finland	225 303.00	Germany	265 900.00
Germany	289 100.00	Italy	275 007.11	Spain	251 994.26	Spain	310 195.17
Italy	326 027.22	Germany	278 200.00	Italy	269 116.69	Sweden	329 990.00
Spain	345 324.43	Spain	327 742.76	Germany	316 900.00	France	389 243.24
Sweden	367 414.00	Sweden	370 646.00	Sweden	355 402.00	Bulgaria	:
France	526 593.90	France	462 417.52	France	510 177.38	Austria	:

Source: own study based on [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat)

It should be particularly noted that in the last years of the period under review, France achieved the highest value of renewable freshwater resources, ahead of Sweden and Spain (except for 2021, when Germany and Italy overtook it).



**Figure 3.** Values of renewable freshwater resources in the last four years of the analyzed period in ascending order

Source: own study based on [https://ec.europa.eu/eurostat/databrowser/view/env\\_wat\\_res/default/table?lang=en&category=env.env\\_wat.env\\_nwat](https://ec.europa.eu/eurostat/databrowser/view/env_wat_res/default/table?lang=en&category=env.env_wat.env_nwat)

### 3. Summary

Protecting renewable sources of freshwater is one of the key challenges facing the European Union. In addition to the Water Framework Directive, the European Union is investing in research and technologies supporting the efficient use of water and implementing innovative projects to improve the situation in the field of renewable sources of freshwater. One of the solutions is adaptation to climate change through investments in water infrastructure, development of monitoring systems, and promotion of water saving. Co-financed by the European Commission, research programs such as Horizon Europe and regional initiatives focus on developing technologies, monitoring water resources and implementing sustainable water management practices such as digital water monitoring systems (AQUACLOUD, Water4Future), hydrological models, increasing efficiency water use: water recycling based on treated wastewater for irrigation (REWAISE), rainwater recovery and retention: retention infrastructure (RAINMAN), green infrastructure, combating pollution and improving water quality: groundwater purification (AQUAREHAB), biotechnologies, adaptation to climate change (DRYLAND), seawater desalination, economic models of water management and research towards restoring natural water ecosystems (NATWATER). Education and social involvement are also important aspects, where actions at the national and European level, supported by local communities and the private sector, are the key to achieving success in protecting renewable sources of freshwater.



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