Sustainable development of water management in the context of climate change: Ukrainian experience

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**ABSTRACT:** Humans need access to clean water and sanitation for overall well-being, yet Ukraine faces significant challenges in meeting Sustainable Development Goal 6 (SDG6). This study explores Ukraine's progress, comparing its performance to Central and Eastern European peers and assessing water and climate risks using the World Wildlife Fund (WWF) Water Risk framework.

Relevant literature and statistical data from Ukrstat (2015–2023) and the UN (2024) were analyzed to evaluate SDG6 indicators for Ukraine. Comparative benchmarking was conducted against Poland, the Czech Republic, Slovakia, and Hungary. WWF water risk metrics, including Basin Physical Risk, were examined.

Ukraine demonstrated limited progress in key SDG6 indicators, including the share of rural and urban populations with centralized water drainage. Comparative analysis revealed Ukraine's underperformance in safely managed drinking water (87.6%) and wastewater treatment (50.2%). WWF data ranked Ukraine 74th globally in Basin Physical Risk, highlighting vulnerabilities in water availability and quality. Findings indicate a need for enhanced water protection practices and robust benchmarking methodologies to accelerate SDG6 progress. Strengthened monitoring, policy reforms, and international collaboration are critical for improving Ukraine’s water security and achieving SDG6 targets.

**Keywords:** sustainable development, water sector, climate change, SDG6, Ukraine.

Desenvolvimento sustentável da gestão da água no contexto das alterações climáticas: experiência ucraniana

**RESUMO:** Os seres humanos precisam de acesso à água limpa e saneamento para seu bem-estar geral, mas a Ucrânia enfrenta desafios significativos para alcançar o Objetivo de Desenvolvimento Sustentável 6 (ODS6). Este estudo explora o progresso da Ucrânia, comparando seu desempenho com os pares da Europa Central e Oriental e avaliando os riscos hídricos e climáticos usando a estrutura de Risco Hídrico do Fundo Mundial para a Natureza (WWF).

Foram analisados dados estatísticos da Ukrstat (2015–2023) e da ONU (2024) para avaliar os indicadores do ODS6 na Ucrânia. Realizou-se uma análise comparativa com Polônia, República Tcheca, Eslováquia e Hungria. Métricas de risco hídrico do WWF, incluindo o Risco Físico da Bacia, também foram examinadas.

A Ucrânia demonstrou progresso limitado em indicadores-chave do ODS6, como a proporção de populações rurais e urbanas com acesso a redes de esgoto centralizadas. A análise comparativa revelou desempenho inferior da Ucrânia em água potável gerida com segurança (87,6%) e no tratamento de águas residuais (50,2%). Dados do WWF classificaram a Ucrânia na 74ª posição global em Risco Físico da Bacia, destacando vulnerabilidades na disponibilidade e qualidade da água. Os resultados indicam a necessidade de práticas aprimoradas de proteção hídrica e metodologias robustas de benchmarking para acelerar o progresso no ODS6. Monitoramento fortalecido, reformas políticas e colaboração internacional são cruciais para melhorar a segurança hídrica da Ucrânia e alcançar as metas do ODS6.

**Palavras-chave:** desenvolvimento sustentável, setor hídrico, mudanças climáticas, ODS6, Ucrânia.

1. Introduction

Access to clean water, sanitation, and hygiene is a fundamental human need essential for health and well-being. Without significant acceleration in progress, billions of people will still lack these basic services by 2030. The global availability of freshwater is increasingly threatened by rising demand driven by population growth, the need for greater food and industrial production, pollution from human activities, climate change, and ongoing conflicts.

The number of urban residents facing water stress is expected to rise significantly, from 930 million in 2016 to between 1.7 and 2.4 billion by 2050. By 2022, approximately 2.2 billion people may lack access to safe drinking water, 3.5 billion may lack access to safe sanitation, and 2.0 billion may not have basic hygiene services. Surface water bodies such as lakes, rivers, and reservoirs are under pressure due to rapid global changes. Water pollution has become a major health concern worldwide, affecting both people and the environment (UN World Water Development Report, 2023). According to projections, by 2050, at least one in four people will live in a country facing freshwater shortages, primarily due to the depletion of resources and declining water quality. Consequently, one of the United Nations’ key goals is to ensure access to and sustainable management of water resources by 2030 (Serbov, Irtyshcheva, and Pavlenko, 2022).

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. This agenda outlines a collective framework aimed at ensuring peace and prosperity for both people and the planet, both now and in the future. It includes 17 Sustainable Development Goals (SDGs) (United Nations, 2024).

Among these, Goal 6 (clean water and sanitation) and Goal 13 (climate action) are particularly interconnected. In this context, ensuring universal access to sustainable water and sanitation services is a key strategy for mitigating climate change in the coming years. Limiting global temperature rise to 1.5°C, rather than 2°C, could significantly reduce the number of people facing water scarcity, although regional disparities exist (IPCC Sixth Assessment Report, 2021). Research (Snizhko et al., 2019; Hapich et al., 2024b) indicates that Ukraine has relatively limited water resources compared to much of Europe. The country’s internal river runoff is about 50 km³, and its available groundwater reserves total just 5 km³. With an internal renewable water resource of 1,200 cubic meters per person per year, Ukraine ranks 37th out of 50 European countries (Hapich et al., 2024b).

Ukraine's internal water resources are evidently constrained. Statistics show that only 28.6% (55.1 km³) of the country’s water resources originate domestically, while the remaining 120.2 km³ is sourced from neighboring countries. Furthermore, it is estimated that 97% of Ukraine’s water resources come from river runoff, with groundwater contributing only 3% (Khilchevsky, 2021). Additionally, water resources are distributed unevenly across the country.

The study by Snizhko et al. (2024) focuses on the southern, eastern, and central regions of Ukraine, where water resources are critically scarce. It highlights that the Danube basin, located in Ukraine's border regions, contributes the largest portion of water resources, accounting for about 50%, while the water demand in this area is approximately 5% of the total available water resources.

The water stress index, which measures the ratio of water withdrawal to average annual water resources, is notably high in southern and southeastern Ukraine, ranging from 40% to 80%. In certain areas, such as the Donetsk-Mariupol industrial region, it exceeds 80% (Snizhko et al., 2024). An analysis of the water stress index across Ukraine's regions from 2006 to 2017, conducted by S. Fedulova et al. (2021), yielded similar findings to those of Snizhko et al. (2024).

Global studies (Caparrós-Martínez et al., 2020; Khan et al., 2021; Qasemipour et al., 2020; Wu et al., 2020) emphasize that the reduction in Ukraine’s water supply is a key factor driving the country’s increasing import of virtual water, reaching critical levels (Arunrat et al., 2020; Obajana et al., 2020). Ukraine's water security is under significant threat from climate change-related factors, such as droughts and floods, which can lead to substantial economic losses. However, the most immediate concern is the potential impact of military actions on the country's water security. Russia's occupation of southeastern Ukraine and the annexation of Crimea in 2014, along with the full-scale invasion that began on February 24, 2022, have further exacerbated the state of Ukraine's water resources.

Between February 2022 and 2024, it is estimated that Russian forces caused the destruction of approximately one-third of Ukraine's freshwater resources, equating to around 18-20 km³ (Hapich et al., 2024). This damage has had a severe impact on water supplies for drinking, industry, and agriculture, particularly in the southern and eastern regions. The total social, economic, and environmental losses are estimated to amount to tens of billions of US dollars, with recovery costs for Ukraine projected at around $600 billion (Hapich et al., 2024).

Researchers, including S. Snizhko et al. (2024), have noted that the destruction of the Kakhovka Reservoir alone may have led to a loss of 10% of Ukraine's water resources, significantly affecting agriculture and industry in the southern regions and limiting access to safe drinking water for approximately 6 million people. Furthermore, up to 13 million people could face limited access to water for sanitation purposes.

The ongoing conflict has also resulted in extensive damage to Ukraine’s water infrastructure, including the destruction of 1,947 kilometers of water supply networks, 23 sewage treatment plants, and several other critical water systems (Kyiv School of Economics, 2024). Restoring this infrastructure is a central focus of Ukraine’s recovery efforts, as emphasized by N. Mahats (2023) and I. Kitowski et al. (2023). However, the continued conflict presents long-term challenges, not only for Ukraine's sustainable development but also for global efforts to achieve clean water, sanitation, and food security.

The 2024 progress report highlights that the world is not on track to meet the Sustainable Development Goals (SDGs) by 2030. As shown in Figure 1 of the report, out of 135 targets with available trend data and insights from relevant agencies, only 17 are expected to be achieved by 2030. Nearly half (48%) of these targets have deviated significantly from their expected progress, with 30% showing only minimal progress and 18% indicating moderate progress. Worryingly, 18% of targets have stalled, and 17% have regressed compared to the 2015 baseline.

The indicators for SDGs 6 and 13, which are particularly relevant to this context, are especially concerning. As shown in Figure 1, these goals have made the least progress toward their 2030 targets. For Goal 6, 64% of instances show only minimal to moderate progress, while 36% have either stagnated or regressed. Similarly, for Goal 13, 66% exhibit marginal or moderate progress, and 34% have either stalled or declined.

The importance of achieving SDGs in Ukraine's agricultural sector is emphasized by M. Rudevska et al. (2024), who advocate for promoting agricultural processing in accordance with the Green Deal and supporting the transition of the sector to more sustainable practices. Achieving Goal 2, "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture," is closely linked to the realization of Goal 6, "Ensure availability and sustainable management of water and sanitation for all," and Goal 13, "Take urgent action to combat climate change and its impacts." Specifically, addressing water protection and irrigation is crucial for agriculture, while managing droughts and floods is essential for mitigating the effects of climate change.

It is also important to acknowledge that Ukraine’s economic growth, which is largely driven by the agricultural sector, may face limitations due to water availability. Consequently, experts suggest that the most effective path to sustainable economic growth may involve the implementation of water-saving technologies and the intensification of water conservation efforts in the region (Fedulova et al., 2021).

T. Gunda et al. (2019) observed that many water security studies tend to concentrate on water quantity, often neglecting the evaluation of water quality and its adequacy for meeting essential societal needs, which are key components of water security. It is crucial to understand that even when there is an adequate supply of water, its quality may still be insufficient. The combination of diminished water availability and the poor quality of water resources, exacerbated by climate change in different regions, can lead to water stress and significantly impact water security.

Water quality is a particularly critical issue for Ukraine, where surface water resources, primarily river runoff, make up 97% of the total water volume (Snizhko et al., 2019). In light of this, the water strategy for Ukraine, which is set to guide policies until 2025, highlights the considerable negative effects on water bodies caused by diffuse runoff from agricultural, urban, and industrial waste areas, as well as landfills (Dorosh et al., 2023).

Agriculture is a major diffuse source of water pollution. As suggested by the aforementioned authors, the establishment of water protection zones with regulated economic activities and coastal protection strips with limited economic use and specific agricultural land conditions might be an effective approach. However, it is worth noting that the previous procedure for allocating water protection zones, which was introduced in 1966, did not adequately address the requirements of EU Directives, such as Directive No. 91/676/EC, which aims to protect waters from nitrate pollution caused by agricultural sources (Dorosh et al., 2023).

The importance of assessing the quality of groundwater (well water quality), which is polluted by the above-mentioned diffuse sources of pollution and then used for drinking in developing countries, can be judged from the work (Gelsanda, Marchianti, & Nurdian, 2024).

To achieve SDG 6, effective facilities for urban and industry wastewater treatment are important, but as shown by V. Mykhailenko, T. Safranov, & M. Adobovska (2023), biological wastewater treatment plants may, in some cases, contribute to environmental pollution by persistent organic pollutants. This has been observed in the Odesa industrial-and-urban agglomeration.

The importance of using green bonds for the purposes of energy security and sustainable development is described by I. Sembiyeva et al. (2023). They showed that in the last five years, green bonds have been widely used to finance such areas of environmental improvement as sustainable infrastructure for clean and/or drinking water and wastewater treatment and adaptation to climate change, which are in line with SDG 6 and SDG 13.

Research shows that the threat of climate change worries not only scientists, politicians and public figures, but also the general population. Thus, in a three-year (2020–2022) experimental survey of 346 Polish households nationwide through computer-assisted web interviews, it was found that the threat of climate change was of great concern to 12.5% of respondents in 2020 and 20.2% of respondents in 2022. In terms of the growth rate of respondents over a three-year period, the threat of climate change (+7.7%) was in fourth place after the nuclear threat and use of mass destruction weapons (+16.5%), energy shortages (+9.7%) and local conflict (+8.3%) (Sapiński, Szydłowski, 2022).

Water security is becoming more vulnerable due to climate-related factors, such as droughts and floods, which can result in significant economic damage (Levkovska, Irtyshcheva, & Dubynska, 2020; Levkovska et al., 2023; Snizhko et al., 2019; Pokhrel et al., 2021; Quandt et al., 2022).

A. Demydenko (2020) explores the Global Water Partnership's experience in integrating risk-based Integrated Water Resources Management (IWRM) into Ukraine's water policy. He critiques the outdated post-Soviet "rational use" concept, which aims to meet specific standards and ensure water security. This concept, however, focuses only on human water risks and neglects the broader environmental context. Demydenko argues that effective environmental management is impossible without measuring its parameters. He therefore supports replacing the outdated model with a measurable, goal-driven approach that integrates risk management into water policy. It is important to highlight that this modern concept aligns closely with the principles of sustainable development goals.

This approach is currently being adopted by the Eastern Partnership countries of the European Union, including Armenia, Azerbaijan, Georgia, Moldova, and Ukraine. A. Belokurov et al. (2024) outline the progress and challenges these nations face in aligning their water management practices with EU and international standards, such as the EU Water Framework Directive, the United Nations Water Convention, and the Sustainable Development Goals. The authors emphasize that this approach should involve integrated water management across various water users, economic tools for resource management, funding strategies for the sector, participatory planning at the river basin level, comprehensive water monitoring that includes ecological factors, data sharing on water resources, and strengthened cross-border cooperation on shared waters.

The management of freshwater resources, based on monitoring the achievement of quantitative SDG6 indicators, is discussed in the works of Sebrov (2021) and Serbov, Irtyshcheva, & Pavlenko (2022). These research efforts highlight the importance of taking into account the equilibrium among the three core aspects of sustainable development: economic, environmental, and social.

An analysis of the key challenges in water management, such as non-compliance with European standards, outdated infrastructure, and the absence of effective planning, monitoring, and control systems for water resource usage, indicates that these issues primarily stem from the shortcomings of the state’s water resources management system.

To tackle these challenges, O.A. Diegtiar and colleagues (2020) suggested an algorithm aimed at establishing an efficient water resource management system at the state level. This approach would entail the creation and execution of public-private partnership initiatives that adhere to the principles of effective water management.

M. Cherkashyna (2024) suggests that a new version of the Water Code of Ukraine could be beneficial, as the current law has not undergone significant updates since its adoption in 1995. The existing code contains outdated provisions and contradictions that cannot be fully addressed by simple amendments.

V. Uberman & L. Vaskovets (2020) propose that Ukraine’s water protection strategy may need to evolve, shifting from an economic focus to a more environmental one, in line with EU principles. An alternative to revising the Water Code could be the creation and adoption of a new Law of Ukraine “On Water Protection.”

S. Fedulova et al. (2020) discuss the need to classify water infrastructure as a critical sector of infrastructure in Ukraine and its regions. Their findings have contributed to new ideas on securing the economic stability of regional socio-economic systems, particularly those prioritizing the development of engineering and technical infrastructure.

M. Iskakova (2024) addresses the role of lifelong learning and e-learning in achieving the Sustainable Development Goals, emphasizing the importance of education in this context. Pazos et al. (2023) similarly highlight education as a fundamental pillar of sustainable development.

Thus, this literature review showed a practical absence of publications on the quantitative analysis of SDG6 indicators for Ukraine, including their comparison with other countries, as well as the absence of publications on the quantitative assessment of water and climate risks for Ukraine.

Since Ukraine is participating in the SDGs programme) and goals 6 and 13 fall within the proposed research topic, it is important to find out what is being done to achieve the 2030 goals in this country. This will be the focus of the literature review. It will identify unexplored challenges within the quantitative analysis of the SDGs and WWF Water Risk indicators. The following research questions will be posed:

1. To study the dynamics of time series of values of indicators of Sustainable Development Goal 6 "Clean water and sanitation" based on Ukrainian statistics, and to show for which indicators Ukraine is far behind in achieving the 2025 and 2030 goals;
2. To make a comparative analysis of the current values of indicators of Sustainable Development Goal 6 "Clean water and sanitation" of selected countries of Central and Eastern Europe, including Ukraine, on the basis of UN statistics, and to show in which indicators Ukraine lags far behind its competitors;
3. To make a comparative analysis of the current values of the World Wildlife Fund Water Risk (WWF Water Risk) for Ukraine and its closest competitors and to study the structure of values of this indicator against the background of values for other countries of the world;
4. To disseminate these comparative analyses within the framework of internal and competitive benchmarking.

2. Materials and methods

The procedure for searching for relevant publications for writing a literature review was as follows (October 5, 2024). In the advanced search of Google Scholar, in its first line (search for articles in which all words occurs), the term “water sector” was written in quotation marks so that the search occurred by the exact phrase, in the second line (search for articles in which the exact phrase occurs), the term sustainable development was written without quotation marks, in the third line (search for articles that contain at least one of the words), the word Ukraine was written. As a result, 1,100 responses (publications) were received, the most relevant of them, with good metadata and full texts were located on the first five pages (50 publications).

We chose 32 journal articles from this collection, primarily from journals indexed in the Scopus and Web of Science databases. Among these were prominent and influential publications such as Sustainability, Science of the Total Environment, Water International, Global Ecology and Conservation, Water Security, Water Policy, Nature Climate Change, Ecohydrology & Hydrobiology, Frontiers in Water, Regional Environmental Change, and Ecological Economics. A total of 47 publications were used to write the article, including reports from international organisations containing statistical data. Approximately 40 publications, including all journal articles, were used to write the Introduction and Literature review.

The analysis of these publications revealed issues that had not yet been explored in the literature.

This analysis shows that the issues of quantitative analysis of SDG6 indicators for Ukraine, including their comparison with other countries, as well as issues of quantitative assessment of water and climate risks for Ukraine, have been practically unexplored. In the first case, statistical data from Ukrstat (Sustainable Development Goals, 2024) and the UN (United Nations, 2024) were used to study these issues, and in the second case, statistical data and methodology from the World Wildlife Fund (WWF, 2024 a, b, c) were used.

When analyzing the time series of values of selected SDG6 indicators for Ukraine, their target values for 2025 and 2030 from Sustainable Development Goals (2017) were used, and for comparison with the values of current SDG6 indicators for Ukraine, Poland, the Czech Republic, Slovakia and Hungary were taken (United Nations, 2024).

In the first case, it is proposed to consider and develop this time series analysis within the framework of the internal benchmarking methodology, and in the second case - within the framework of the competitive benchmarking methodology.

The comparative analysis of WWF Water Risk indicators for Ukraine and its closest competitors is proposed to be considered and developed within the competitive benchmarking methodology.

3. Results and discussion

Time series of values of selected indicators of Sustainable Development Goal 6 "Clean water and sanitation" for Ukraine are presented in Table 1. We took the structure of this table from the work (Serbov, Irtyshcheva, & Pavlenko, 2022), in which we corrected errors in the digital data and added data for 2021 - 2023 based on Sustainable Development Goals (2024), and also clarified the target data for 2025 and 2030 based on Sustainable Development Goals (2017).

It is interesting to see in which time series there are fairly sharp jumps, starting with Russia's military aggression (2022). We observe such jumps for indicators 1.1 (urban area), 1.2 (both indicators), 4, 7. In terms of achieving target values (2025 and 2030), the worst situation is with indicators 2, 3, 7.

The proposed Table 1 can serve as a basis for future internal benchmarking, when achieving SDG6 target indicators will be achieved through the use of best water protection practices.

Such benchmarking in our case should be called SDG6 benchmarking. The integral indicator in this benchmarking should be SDG Index, which varies in the range from 0 to 100% and shows the degree of approximation of the indicator value to its target value of 100%. It can be calculated both for individual SDG6 indicators and for the totality of all indicators for which target values are defined. Let us consider the second case for Table 1.

Table 1. Time series of key indicators for Sustainable Development Goal 6, "Clean Water and Sanitation," in Ukraine (Séries temporais de indicadores selecionados do Objetivo de Desenvolvimento Sustentável 6 “Água limpa e saneamento” para a Ucrânia)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Indicators | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2025\* | 2030\* |
| 1. Safety and quality of drinking water in terms of microbiological indicators (by % of non-standard samples) |
| 1.1. By type of area |
| Urban | 3.1 | 4.3 | 4.6 | 5.1 | 5.7 | 4.7 | 5.1 | 2.1 | 2.7 | \*\* | \*\* |
| Rural | 7.6 | 10.4 | 11.2 | 11.8 | 11.4 | 13.8 | 11.9 | 11.4 | 11.0 | \*\* | \*\* |
| 1.2. By type of water supply |
| Centralized | 4.6 | 6.4 | 6.7 | 7.7 | 8.2 | 7.6 | 7.5 | 3.5 | 4.3 | \*\* | \*\* |
| Decentralized | 18 | 23.1 | 20.4 | 23.4 | 24.6 | 22.6 | 22.9 | 28.3 | 25.1 | \*\* | \*\* |
| 2. Percentage of the rural population with access to centralized water drainage. | 3 | 2.2 | 2.5 | 2.5 | 1.8 | 5.3 | 5.2 | 5.3 |  | 50 | 80 |
| 3. Percentage of the urban population with access to centralized water drainage. | 92 | 94.1 | 95.1 | 96.0 | 96.6 | 71.7 | 74.2 | 74.8 | - | 100 | 100 |
| 4. The amount of untreated or inadequately treated wastewater discharged into water bodies, measured in millions of cubic meters | 875.1 | 698.3 | 997.3 | 952 | 737.2 | 518.4 | 541.5 | 374.0  | 375.7 | 557 | 279 |
| 5. The proportion of untreated or inadequately treated wastewater discharged into water bodies as a percentage of the total discharge volume. | 16.38 | 12.93 | 21.15 | 18.27 | 13.72 | 10.05 | 11.56 | 12.25 | 11.74  | 10 | 5 |
| 6. Water usage per unit of GDP, expressed in cubic meters of water per 1000 UAH of GDP (at current prices). | 23.62 | 19.44 | 15.13 | 11.59 | 10.30 | 9.94 | 7.33 | 4.27  | 3.74  | 2.9 | 2.5 |
| 7. Current water intensity of GDP, expressed as a percentage relative to the 2015 level. | 100 | 82.3 | 64.06 | 48.08 | 43.61 | 42.08  | 31.05  | 18.06  | 15.84  | 80 | 70 |

Note. \* Reference point, \*\* indicator is specified

Source: Serbov, Irtyshcheva, & Pavlenko (2022); Sustainable Development Goals (2017, 2024).

In Table 1, we have 6 indicators for which we have defined targets at the 2030 level. For each indicator, we define the SDG6 Index as the percentage of the distance covered to reach 100%. After that we determine the arithmetic mean of six values of individual SDG6 Index, as a result we get the total SDG6 Index, which is equal to 37.1% for the level of 2022-2023 for Ukraine.

A similar index calculated by D. Voza (2024) for the level of 2017 based on the Sustainable Development Goals Report (2018) for 13 upper middle-income countries, including Ukraine, was equal to 72.25%. The same paper calculated the SDG6 index for 28 high-income countries, which was equal to 83.30%.

J. Rajapakse, M. Otoo & G. Danso (2023) calculated SDG Index for Eastern Europe and Central Asia countries, which was equal to 69.9% for 2017 and 71.6% for 2022.

As we can see, our calculated SDG6 Index for Ukraine is two times lower than the average values of this index for groupings of countries that include Ukraine.

A recent study conducted by L. V. Korolchuk (2024) qualitative analysis shows that there is no progress in achieving Goal 6, which is consistent with our results.

Table 2. SDG6 indicator values for selected Central and Eastern European countries (Valores indicadores do ODS6 para países selecionados da Europa Central e Oriental)

|  |
| --- |
| 6.1.1. Percentage of the population with access to safely managed drinking water services, % (2022) |
| Ukraine | Poland | Czech Republic | Slovakia | Hungary |
| 87,6 | 88.9 | 97.9 | 99.2 | 100 |
| 6.3.1. Proportion of Safely Treated Domestic Wastewater Flows, % (2022)  |
| Ukraine | Poland | Czech Republic | Slovakia | Hungary |
| 50.2 | 77.4 | 91.3 | 82.0 | 82.1 |
| 6.3.2. Percentage of water bodies with good overall water quality, % (2023) |
| n/d | 67.6 | 15.5 | 61.4 | 13.0 |
| 6.4.1. Water Conservation Efficiency (United States Dollars Per Cubic Meter) (2021)  |
| Ukraine Total – 7.77 | Industries –4.96 | Agriculture –0.11 | Services – 20.3 |
| Poland Total – 51.7 | Industries – 2.9 | Agriculture – 0.11 | Services – 173 |
| Czechia Total – 139 | Industries –82.0 | Agriculture –1.62 | Services – 210 |
| Slovakia Total – 153 | Industries – 106 | Agriculture – 1.71 | Services – 205 |
| Hungary Total – 26.3 | Industries – 9.78 | Agriculture – 0.46 | Services – 135 |
| 6.4.2. Water Stress Level: Freshwater Withdrawal Relative to Available Freshwater Resources, % (2021) |
| Ukraine Agriculture – 3.8 | Industries – 5.02 | Services – 3. 44 | Total – 12, 3 |
| Poland Agriculture – 4.54 | Industries – 20.7 | Services – 6.83 | Total – 32, 1 |
| Czechia Agriculture – 0.56 | Industries – 10.4 | Services – 9.53 | Total – 20, 5 |
| Slovakia Agriculture – 0.13 | Industries – 1.02 | Services – 1.28 | Total – 2.44 |
| Hungary Agriculture – 0.95 | Industries – 5.98 | Services – 1.14 | Total – 8.07 |
| 6.5.1. Proficiency in Implementing Integrated Water Resources Management, %  |
| Ukraine (2020) | Poland (2023) | Czechia (2023) | Slovakia (2023) | Hungary (2023) |
| 39 | 75 | 80 | 57 | 76 |
| 6.5.2Proportion of Transboundary Aquifers with Established Water Cooperation Agreements, % (2023) |
| Ukraine | Poland | Czechia | Slovakia | Hungary |
| 63.8 | 66.5 | 100 | 27.9 | 100 |
| 6.6.1. Permanent Water Area of Lakes and Rivers (sq km) |
| Ukraine (2022) | Poland (2021 | Czechia (2021) | Slovakia (2022) | Hungary (2022) |
| 3.93K | 1.18K | 893 | 106 | 1.14K |

Source: (United Nations, 2024).

From the website of the Department of Economic and Social Affairs (United Nations), we have selected current data on eight available SDG6 indicators for Ukraine and four countries of Central and Eastern Europe (United Nations, 2024) and presented them in Table 2. As can be seen from this table, Ukraine had the worst performance compared to other countries for the key indicators of the shares of population using safety managed drinking water services (6.1.1) and safely treated domestic wastewater flows (6.3.1). The same was noted for indicator 6.5.1, that is, Ukraine is doing poorly with integrated water resources management.

Ukraine also had the worst value for the water use efficiency indicator (6.4.1). Note that this indicator in Table 1, compared to Table 2, had the inverse value (m3/1000 UAH) in terms of GDP.

In terms of water stress level (6.4.2), Ukraine had intermediate values among the countries under consideration, i.e. its values were higher than those for Slovakia and Hungary and lower than those for Poland and the Czech Republic.

According to the values of the indicator “Proportion of Transboundary Aquifers With An Operational Arrangement for Water Cooperation”, Ukraine ranked fourth among the five countries under consideration. According to the total permanent area of rivers and lakes, Ukraine ranked first among the countries under consideration.

It should be noted that the UN SDG6 indicators differed from the indicators of Ukrainian statistics.

Taking the first two indicators from Table 2 for which the target indicators are equal to 100%, the average SDG6 Index for Ukraine is 68.9%, while the average SDG6 Index for the four countries under consideration is 89.9%. As we noted above for the same 2022 SDG6 Index for Eastern Europe & Central Asia, calculated on the basis of a larger number of individual indicators, was equal to 71.6%. (Rajapakse, Otoo, & Danso, 2023).

The values of the Water Stress indicator (6.4.2) in Table 2 are close to the values of this indicator for the five countries under consideration, calculated in the FAO and UN Water (2021) report for the level of 2018: Ukraine - 13.87%, Poland - 33.22%, Czechia - 24.19%, Slovakia - 2.39%, Hungary - 7.65%.

From the SGD6 indicators, we will move on to a more complex system of indicators proposed by the World Wildlife Fund (WWF), which has not yet been discussed in Ukrainian scientific literature. The SGD methodology with its 17 goals considers individual indicators that are not aggregated to obtain aggregated and integral indicators. The WWF methodology uses weighted aggregation of individual indicators to calculate integral indicators, with initial individual indicators determined both on the basis of statistical hard data and on the basis of expert surveys.

In 2012, the World Wildlife Fund (WWF) introduced the Water Risk Filter, designed as a screening tool for corporations and investment portfolios to identify water-related risks and prioritize actions regarding water resources. It's worth mentioning that the WWF operates in over 80 countries worldwide.

The WWF Water Risk Filter framework is structured into three levels: First, it categorizes risks into three types: physical, regulatory, and reputational. Second, there are 12 risk categories that provide insights into each risk type. Finally, it includes 42 indicators, with various indicators corresponding to different risk categories. Most of these indicators are derived from publicly available, peer-reviewed datasets. We understand that these indicators are reviewed and updated every two years, incorporating the latest research and the best available data.

The weighting coefficients within this framework were established using expert assessment methods. The values for all individual and aggregated indicators are scaled from 0 to 5, with the overall Risk Score automatically fitting within this range. An overview of the WWF Risk Filter Suite and its tools can be found in the Guide (WWF, 2024 a), while the detailed calculation methodology is outlined in (WWF, 2024 b).

In the following discussion, we will focus on physical risks, particularly basin physical risks, that encompass both water and climate-related hazards. It is crucial to recognize that these physical risks arise from the reliance of businesses and their supply chains on various natural and anthropogenic factors affecting land, freshwater, climate, and marine environments. Additionally, it is important to consider that these pressures may compromise ecosystem services over time.

Country profiles for water risks as of 2020 are provided in (WWF, 2024 c). The structure of the Risk Score in the Ukrainian Basin Physical Risk is provided in Table 3. From it we see that the values of the integral and aggregate risks are worse than the average value for the entire sample of countries, if we conditionally take 2.5 for this value. From this table we also see that the integral indicator (Physical Score) consists of five aggregated sub-indicators, which in total consist of 23 individual indicators.

Table 3. Risk score structure in Ukrainian Basin Physical Risk (Estrutura de pontuação de risco na Bacia Ucraniana de Risco Físico)

|  |  |  |  |
| --- | --- | --- | --- |
| Basin Risk | Risk Score | Ranking | Number of Indicators |
| Physical Risk | 2.69 | 74 | 23 |
| Water Availability | 1.9 | 51 | 4 |
| Drought | 3.24 | 68 | 2 |
| Flooding | 2.29 | 61 | 2 |
| Water Quality | 3.52 | 108 | 9 |
| Ecosystem Services status | 2.44 | 49 | 6 |

Source: WWF (2024 c).

Positioning of Ukraine in terms of basin physical risk against the background of the nearest competing countries is given in Table 4. In this table we have listed the countries with the best and worst Physical Score values, as well as their ranks. The maximum risk is observed for the Palestinian Territory, and the minimum for Norway. Since the Palestinian Territory rank is 119, we see that the World Wildlife Fund makes quantitative Physical Score estimates for 119 countries. Ukraine's closest neighbors in terms of Risk Score values, with the exception of three countries in central eastern and southern Europe, are island countries, as well as countries in Africa and Latin America.

Obviously, the following calculations on Risk Score will lead to even worse values of this indicator for Ukraine, since they will be carried out in wartime or post-war times with destroyed water infrastructure.

Table 4. Positioning of Ukraine in terms of basin physical risk against the background of the nearest competing countries

|  |  |  |
| --- | --- | --- |
| Country | Risk Score | Rank |
| Palestinian Territory | 3.678 | 119 |
| Mexico | 2.724 | 77 |
| Guadeloupe | 2.719 | 77 |
| Gambia | 2.71 | 76 |
| Czech Republic | 2.705 | 75 |
| Moldova | 2.688 | 74 |
| Ukraine | 2.688 | 74 |
| Mauritania | 2.687 | 74 |
| US Virgin Islands | 2.682 | 73 |
| British Virgin Islands | 2.682 | 73 |
| Greece | 2.675 | 72 |
| Togo | 2.669 | 72 |
| Norway | 1.622 | 1 |

Source: WWF (2024 c).

Based on a 5-level uniform classification scale for Risk Score (Opperman et al., 2022), we see that the Risk Score for Ukraine falls into the interval 2.6-3.4, which corresponds to medium risk. At the same time, M. Serbov (2022) notes that the considered indicator for Ukraine is in the zone of “high risk” and is steadily moving towards “very high risk” status.

Tables 2 and 4 that we have reviewed can be used in the future to construct competitive benchmarking procedures, where the achievement of the values of the leaders’ target indicators will be achieved through the use of best water protection practices.

For our purposes, this benchmarking will be called SGD6 benchmarking. For SGD benchmarking in general, the procedure was described in ESPON's SDGs benchmarking tool (2020), which consisted of selecting a SDG, selecting an indicator, selecting an EU region (NUTS 2) and comparing the regions on the SDG6 index. This does not address the technical issue of actually accelerating the movement towards SDG6 through the use of best practices, as required by the benchmarking. This shortcoming was overcome in (Alzlzly, 2024), where best practices for SGD7 benchmarking were described, but the four steps of the SDGs benchmarking tool (2020) were not considered. Therefore, the development of a full-fledged SGD6 benchmarking process requires further efforts.

The analysis of SDG indicators over time for Ukraine (see Table 1) allows us to tackle the initial research question presented in the Introduction. It demonstrates that there has been limited advancement towards the targets set for 2025 and 2030 concerning the proportion of the rural population with access to centralized water drainage, the proportion of the urban population with similar access, and the current water intensity of GDP compared to levels in 2015.

Moreover, a comparative evaluation of the current statistics for Sustainable Development Goal 6, "Clean Water and Sanitation," across selected Central and Eastern European nations, including Ukraine, using UN data (see Table 2), sheds light on the second research question mentioned in the Introduction. This evaluation reveals that Ukraine performs the worst among its counterparts in crucial indicators, such as the percentage of the population with access to safely managed drinking water services (6.1.1) and the percentage of the population with access to safely treated domestic wastewater flows (6.3.1).

Furthermore, a comparative evaluation of the current values of the World Wildlife Fund Water Risk (WWF Water Risk) for Ukraine and its closest competitors (Tables 3 and 4) addresses the third research question raised in the Introduction, demonstrating the values of the aggregate indicators (water availability, drought, flooding, water quality, ecosystem services status) and the integral indicator (physical risk) for Ukraine are worse than the average values of these indicators for 119 countries of the world.

It is shown that the time series analysis of SDGs indicator values for Ukraine can be conveniently transformed into an internal benchmarking procedure to track the movement of these indicator values towards their target values, if the achievement of these target indicator values is achieved through the use of best water protection practices. Similarly, the comparative analysis of SDG6 and WWF Water Risk indicators of Ukraine and other countries (research questions 2 and 3) can be transformed into a competitive benchmarking procedure, if the achievement of the target indicator values of the leaders will be achieved through the use of best water protection practices. This is the answer to the fourth research question.

4. Conclusions

This study analyzed Ukraine's progress toward achieving Sustainable Development Goal 6 (SDG6), comparing its indicators with those of Central and Eastern European countries and evaluating water and climate risks using the WWF Water Risk framework. The findings revealed significant shortcomings in Ukraine's performance. Key SDG6 indicators, such as access to centralized water drainage for rural and urban populations and safely managed drinking water services, lagged far behind regional peers. Comparative analyses with Poland, the Czech Republic, Slovakia, and Hungary highlighted Ukraine's consistent underperformance, particularly in wastewater treatment and water-use efficiency. Furthermore, Ukraine ranked 74th globally in Basin Physical Risk, with vulnerabilities in water availability, drought, flooding, and water quality.

Achieving the 2025 and 2030 SDG6 targets requires urgent implementation of best practices in water protection, robust policy reforms, and benchmarking procedures.

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