The Efficiency of Water Resources Management in the Black Sea Region (Ukraine) in the Context of Sustainable Development Under the Conditions of Military Operations

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Abstract

The purpose of writing the article is to study the effectiveness of water resources management in the Black Sea region of Ukraine in the context of sustainable development under the conditions of military operations.

The theoretical approaches to defining the essence and functions of water resources management through the prism of sustainable development goals have been considered. The main problems of water resources management in the regions of Ukraine are systematised and the ways of their solution at the present stage of the reform are outlined. The author's approach to evaluating the effectiveness of water resources management in the context of the model of sustainable development is proposed using the example of the Black Sea region of Ukraine. Methodical approaches to assessing the effectiveness of regional water resources management that includes the main stages, the criteria for assessing, indicators for each criterion, and a mathematical apparatus for their calculation have been developed. In accordance with the author's approach, a diagnosis of the effectiveness of regional water resources management was conducted based on the example of the Black Sea region.

Keywords

freshwater resources, water resources management, Black Sea region, sustainable development, management functions, SDG, vectors of sustainable development, warfare

Introduction

Global freshwater resources are becoming increasingly scarce as a result of escalating demand due to population growth and the need to increase food production, industrialisation through rising living standards, pollution from anthropogenic activities, and the effects of climate change. Scientists predict that due to the shortage and poor quality of fresh water, by 2050, at least one in four people are likely to live in a country with a shortage of fresh water.

Thus, the problems of providing the population with water resources, their ecological status, and the implementation of models of rational use are the subject of research by many scientists, international organisations, and governments.

The war of the Russian Federation against Ukraine showed how vulnerable the freshwater resources management system is, which led to an ecological catastrophe not only in the middle of the country, but far beyond its borders. The undermining of the Russian Kakhovskaya HPP led to the flooding of a large area, human losses, pollution of fresh water, and the destruction of a significant ecological fund.

It is still difficult to predict the exact ecological consequences, but the destruction of the dam has obviously already led to an ecological disaster. Flooding threatens three nature conservation parks: „Nizhnyodniprovskyi", „Kamyanska Sich", „Biloberzezhya Svyatoslav", and the Black Sea Biosphere Reserve, which is protected by the UNESCO. These territories have the status of wetlands of international importance, which are protected by the Ramsar and Berne Conventions.

Russia's war against Ukraine began in 2014, when the Federation annexed part of the Donetsk and Luhansk regions. Active combat operations are currently taking place in the Kherson, Zaporizhzhia, Luhansk, Donetsk, and Kharkiv regions.

Various aspects and problems of water resources management have been studied by scientists Christ and Burritt (2017), Guerra and Reklaitis (2018), ChenZhan-Ming and Chen (2013), Mohammad Al-Saidi (2017), and others. They systematised current challenges and developed various methods for measuring and evaluating the efficiency of freshwater resources in the economy and for the needs of the population.

Despite different areas of research, most scientists emphasise that the formation of water resources management should be based on the principles of sustainable development. In particular, Sdiri et al. (2018) underscore that the main aspects are the following in water management: water quality and sustainable use, integrated water resources management, assessment of groundwater vulnerability, the quantity and quality of water streams, the potential for the treatment of these waters for recycle and/or beneficial reuse, and the economics of such treatment strategies as well as the management of irrigation water and durability (Sdiri et al., 2018).

Sheikh Mohammad Fakhrul Islam and Zahurul Karim emphasise that policies, institutions and implementation strategies should be adjustment at global, national, and local levels to develop capacities of organisations and farmers with the knowledge and financial resources. Knowledge sharing at local, national, and global levels focusing on land and water systems development will foster socio-economic growth across the globes reducing food insecurity and poverty (Fakhrul Islam & Zahurul Karim, 2018).

Sustainable development integrates economic development, social development, and environmental protection, with three overarching objectives and essential requirements: (1) poverty reduction, (2) changing unsustainable patterns of production and consumption, and (3) protecting and managing the natural resource base of economic and social development.

It is obvious that the effectiveness of the transition to sustainable use and development of freshwater resources requires improved water resources management at the global, national, and regional levels.

According to the World Bank Group, water resources management is the process of planning, developing, and managing water resources in terms of both water quantity and quality, across all water uses. It includes the institutions, infrastructure, incentives, and information systems that support and guide water management **(**World Bank Group Water Global, 2021).

Ensuring the accessibility and sustainable management of water resources has been adopted as one of the United Nations Sustainable Development Goals by 2030 (The SDGS in action 2015).

It includes 5 goals and 13 indicators that characterise the quality, availability of external resources for the population, and their consumption in the economies of countries, regions, and individual territories. These goals are used to measure the progress of territories in the context of the use of freshwater resources at different levels of government.

According to Setegn and Donoso (2015), "Integrated water resources management (IWRM) is capable of promoting all three objectives by providing stakeholders with a framework for integrating and coordinating the various aspects of water management in a sustainable and holistic manner" (p. 2).

An integrated water management model develops solutions by involving all the essential components into an optimisation scheme. The resources are used in relation to social and economic activities and functions. There is a need for laws and regulations for the sustainable use of the water resources (Chandra, 2016).

Realisation of water management within the boundaries of the catchment is possible only across administrative divisions. The required dialogue of communes located upstream and downstream of the water-course is hindered by the differing interests of the central city (the core of the metropolitan area) and suburban communes (particularly rural and town and rural) (Mrozik et al., 2015).

Forests devastated by fires and cut down by the occupiers, groundwater, soil contaminated with heavy metals and toxic chemicals, and wild animals affected are some of the less discussed victims of the war. But even the available fragmentary data reveals a picture of an ecological disaster. According to preliminary calculations by scientists based on satellite images of the European Sentinel-2 mission, in 2022, at least 50 fires occurred on the Kinburn Peninsula occupied by the Russian military, affecting 10,000 hectares. This is an approximate estimate; it also considers repeated fires in the same area. But because the total area of the Kinburn Peninsula is 21.6 thousand hectares, almost half of it was burned – this is a lot. The Kinburn spit, as well as many other areas of the Ukrainian coast of the Black and Azov seas, is of great importance from the point of view of bird protection.

Moreover, their importance is wider than the borders of Ukraine, because, for many birds from the Baltic countries and Scandinavia, the Kinburn spits, with its numerous lakes and shallow waters, is a nesting place or a resting point on the long migration journey. If the areas favoured by birds for thousands of years are destroyed by fire or shells explode nearby, the birds may die or risk not leaving offspring. In addition, Russian forces attack infrastructure along the coasts of the Black and Azov seas as well as ships at anchorages, leading to water pollution and the spread of toxins into the sea (Ministry of Environmental Protection and Natural Resources of Ukraine, 2022).

The system of risks and uncertainties is important in the management of freshwater resources. Thus, Tomasz Walczykiewicz (2019) in his publication considers a comprehensive presentation of risk analysis methods related to integrated water resources management, based on case studies. The results show that the performance of water resources governance is markedly better in the catchment with Integrated Water Resources Management practices than the base catchment unaffected by these practices. The examined key themes include water resources governance styles, water resources governance systems presence, functionality, the performance of good governance principles, and water resources management effectiveness (Katusiime & Schütt, 2020).

Thus, freshwater resources are now becoming one of the determining factors of the region's competitive advantages, a key factor in ensuring food security, economic development, and demographic growth. This is why the management of such valuable natural resources requires the formation of a new concept based on an integrated strategic approach, the main goal of which should be the protection, sustainable use, and preservation of them for future generations. The formation of water resources management at the regional level should be based on a quality information base, take into account local characteristics, and comply with the national sustainable development policy.

The purpose of writing the article is to study the effectiveness of water resources management in the Black Sea region of Ukraine in the context of sustainable development under the conditions of military operations.

The current state of water resources management in Ukraine

Ukraine is one of the countries with a sufficient level of water resources. However, water recourses distribution is uneven by region, and use of fresh water is irrational from the standpoint of sustainable development. Continued irresponsible exploitation of water resources poses a threat to food, social, and environmental security, and requires the formation of new balanced models of regional management based on the conceptual framework of sustainable development of territories.

The importance of effective management of freshwater resources in both global and national contexts is confirmed by their role in the approved Sustainable Development Goals of Ukraine until 2030 as one of the priorities of state and regional governance. As stated in the document: "The National Water Strategy must ensure the achievement of good state of water resources and lay the groundwork for overcoming the significant disparity in the population's access to quality water supply and sanitation, which has developed between urban and rural areas" (Sustainable Development Goals: Ukraine 2030).

The results of the assessment of achievements in the field of freshwater resources in the context of sustainable development under Objective 6 „Clean Water and Sanitation" showed that in general at the national level there is progress on some indicators. In particular, the level of water intensity of GDP as a whole and in relation to the base 2015 is significant progress. Thus, in 2020, the level of water intensity of GDP was 3.2%, which is almost 20% lower than in 2015. This reduction is partly due to lower production of industrial products, including metallurgy, as well as reduced water intensity of agriculture as a result of innovative technologies of irrigation and reclamation. At the same time, the share of the rural population with access to centralised drainage systems and the level of safety and quality of drinking water remains low.

Simultaneously, regional differentiation of water supply, water use, and drainage indicators are quite high. This depends, first of all, on a difference in the geographical location, economic development, and specialisation of the regions, and a variable attitude of local authorities to the problems of water supply and drainage. In some regions, a situation with water supply and drainage systems seems to be not so bad, still even their existing infrastructure is outdated and run down, therefore requiring significant public and private investment. Local authorities are fully responsible for addressing these issues as well as for controlling the discharges of polluted water (UNDP 2019).

Research shows that at the regional level, the water management system is not currently in place, and the goals of sustainable development are achieved primarily through population reduction and industrial decline.

The main functions of water management according to the classical approach include planning, organisation, motivation, regulation, and control. Coordination of functions is based on an effective system of communication and decision-making, the quality and level of performance of which depend on an effective management structure.

Problems of improving the water management system in the regions are studied by Ukrainian scientists, among whom are Shirokov (2017), Diegtiar, (2020), Ovcharenko (2019), and Kozhushko et al. (2020). Based on their research, we have systematised the main problems in the implementation of water management functions in the regions of Ukraine:

1) The planning of works in the water management system in Ukraine is based on outdated approaches and covers mainly such areas as: flood protection of settlements, repair and modernisation of individual water supply and sewerage infrastructure, planning measures to monitor the status of individual water bodies' projects. The current plans do not contain a clear definition of objectives, indicators of their implementation, and sources of funding (usually funding is based on the residual principle), and are weakly focused on the introduction of innovative technologies;

2) The function of the organisation is realised primarily through the creation of effective organisational structures for water resources management, a clear division of responsibilities, rights and powers of management and supervisory bodies. At this stage, the process of reforming the water management system is underway, which aims to create effective basin management. The reform process is hampered by the lack of reliable information and legal framework.

3) Motivation as a function of water management in general is to form a set of incentives and restrictions that will affect the behaviour of businesses, people, and staff of water management to

achieve the goals of sustainable development. Currently, the motivation system in the context of water resources management is not significant. The implementation of this function in the context of ensuring the economical use of water resources is carried out by setting appropriate tariffs for water supply services for the population and business, and the use of sewerage systems. Certain sanctions mechanisms, quotas, etc. are also used as incentives to reduce pollutant emissions. However, these mechanisms are not properly regulated.

4) According to the legislation of Ukraine, the central bodies responsible for general management and supervision of compliance with legislation, implementation of state programmes in the field of protection, and reproduction of water resources, planning and formation of legislative initiatives include the Ministry of Environment and Natural Resources and State Water Agency, State Geo Subsoil Administration. However, the issue of distribution of powers between the representation of the state water agency in the regions is represented by representations of other governing bodies, offices, etc., which causes duplication of powers.

Thus, the implementation of regulatory and control functions is currently limited due to the lack of a single water cadastre and water resources accounting system, „gaps" in the legal framework for the distribution of powers between different levels of government, duplication of supervisory and control functions at the state and regional levels, the lack of transparent mechanisms and „rules of the game" in the water market. These problems, in our opinion, should be addressed in the context of forming effective models of sustainable development and use of water resources. It will also ensure a balance between economic, environmental, and social goals, as well as contribute to the conservation of aquatic ecosystems.

Methodology

The results of the study of regional strategies and programmes show that the goals of sustainable development in the field of water use and their indicators are almost not used as targets at the regional level.

Since 2015, Ukraine has been conducting statistical analysis and assessment of trends in achieving the goals of sustainable development of the regions in accordance with the indicators recorded in the Sustainable Development Goals (SDG) (Tracking progress SDG 2019). However, the goals are not structured according to the vectors of sustainable development; there are no indicators that take into account the peculiarities of economic development of the regions.

To simplify the implementation of sustainable development indicators in the regional management system, it is proposed that methodological approaches to measuring and assessing sustainable water use be improved. These methodological approaches involve the following stages:

1) Systematisation of water use indicators and their supplementation in accordance with the three vectors of sustainable development: environmental, social, and economic. In this case, the basic indicators SDG (UNDP 2019) were used as a basis. This will allow for benchmarking and determine the degree of critical inconsistencies with the generally-accepted benchmarks. The system of indicators of sustainable water use and relevant indicators is shown in Figure 1.

2) Analytical assessment tools include a number of calculation stages. The first stage of calculation is the standardisation of indicators of the region relative to the average value of the relevant indicators achieved in all regions in the comparative period or relative to the target for this period according to the formulas:

– For indicators that are stimulators of sustainable development:

$$N_{ir} = \frac{I_{ir}^{t}}{\overline{I}_{i}^{t}} \tag{1}$$

– For indicators that are disincentives of sustainable development:

$$N_{ir} = \frac{\overline{I}_{i}^{t}}{I_{ir}^{t}} \tag{2}$$

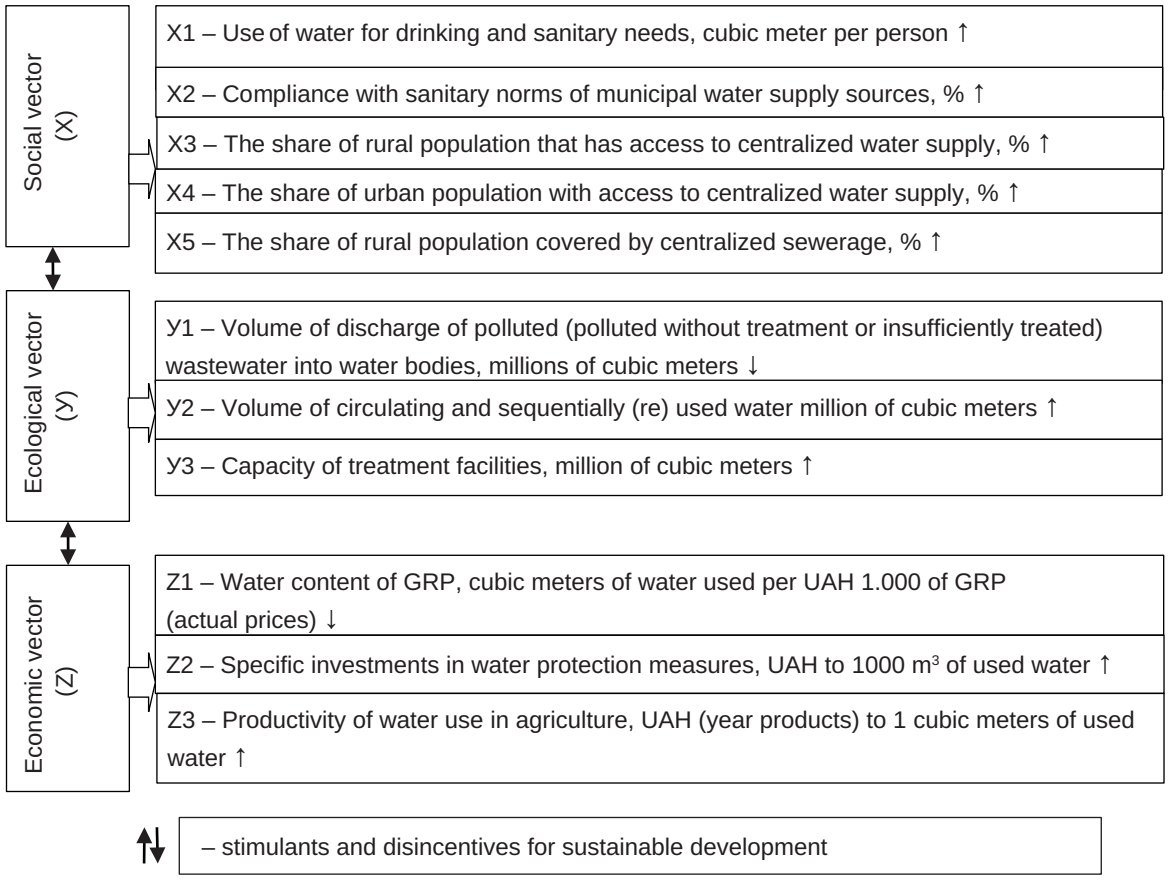

Figure 1. Indicators for assessing the use of water resources in the region in the context of sustainable development

Source: Systematised by authors.

There, $I_i r^t$ – The value of the indicator of sustainable development of regional water resources in the analysed year;

$\overline{I_i}^t$ – The average national (or planned) value of the indicator of sustainable development of water resources in the analysed year.

At the next stage, we determine the increase of indicators in the sustainable development of water resources in the region and on average in the national economy relative to the baseline by the formulas:

– For indicators that are stimulators of sustainable development:

$$\Delta I_{ir} = \left(\frac{I_{ir}^t}{I_{ir}^{t0}} - \frac{\overline{I_i}^t}{\overline{I_i}^{t_0}} \right) \tag{3}$$

– For indicators that are disincentives of sustainable development:

$$\Delta I_{ir} = \left(\frac{\overline{I_i}^t}{\overline{I_i}^{t0}} - \frac{I_{ir}^t}{I_{ir}^{t0}} \right) \tag{4}$$

There, ΔI_{ir} – increase (decrease) in the value of the indicator of sustainable development of water resources in the comparative year relative to the baseline and compared to the average increase in all regions.

This stage allows us to determine the degree of lead or lag of the region on a single indicator compared to other regions or the degree of lag or lead in achieving the target values.

At the third stage, we determine the vector of movement of the region that shows its achievements on the path of sustainable development according to a certain indicator relative to the comparative year and other regions according to the formula:

$$V_{ir} = \Delta I_{ir} \times N_{ir} \tag{5}$$

There, V_{ir} – Vector of movement of the region according to the i-th indicator.

At the last stage, we determine the degree of achievement of the goals of sustainable development of the region in the context of social, environmental, and economic components. To ensure comparability of results for each component, the evaluation of which may involve a different number of indicators, it is proposed that a weighting factor be used. The weighting factor (k) can be determined according to the priority of indicators in the evaluation system or by the formula:

$$k_i = \frac{1}{n}; k \in (0;1) \tag{6}$$

There, *n* – The number of indicators.

To determine the total length and direction of the vector of sustainable development, the formula is proposed:

$$X = \sum_{i=1}^{n} V_{ir} \times k_i \tag{7}$$

3) Evaluation of results. The results of calculations at each stage allow for determining the strengths and weaknesses of the region on certain indicators. Summary indicators highlight the main direction of movement (progress or regress) and the speed of the region in the process of achieving sustainable development goals compared to general trends in Ukraine.

The proposed approaches can be used to monitor and analyse the process of achieving the goals of sustainable development of water resources in the regions, to determine the degree of balance of water management, and to identify the main problems that need to be addressed. In addition, this approach can be used to assess the process of sustainable development of the region in terms of other comprehensive objectives outlined in the National Strategy for Sustainable Development.

Assessment of the water resources management effectiveness in the Black Sea region of Ukraine

Efficient use of freshwater resources is an extremely important problem in the regions of the Black Sea region of Ukraine due to their uneven distribution on the territory, high level of strategic needs, and difficult environmental situation.

The Black Sea region consists of three regions: Odesa, Mykolaiv, and Kherson (Figure 2). According to the Odesa Regional Council, „Odesa Oblast is located in the extreme southwest of the country with a total area of 33.4 thousand square meters. km Odesa region is a coastal and border region of Ukraine. There are 1,134 small rivers and streams, 15 freshwater and sea estuaries within the region. It is located within the river basins of the Danube (24% of the territory of the region), the Dniester (16%), the Southern Bug (8%) and the rivers of the Black Sea (52%)" (Odesa Regional Council, 2021).

„Mykolaiv Oblast is located in the southern part of Ukraine. It is located in the basins of the Southern Bug River (59.5%), the Dnipro River (23.5%) and the rivers of the Black Sea (17%). In total, 7.3% of the territory of the region is occupied by water bodies, including 19.8 thousand hectares under rivers and streams; canals, collectors and ditches – 5.6 thousand hectares, lakes, closed reservoirs and estuaries – 90.1 thousand hectares, reservoirs, ponds and other artificial reservoirs – 17.8 thousand hectares, swamps occupy 21.1 thousand hectares, hydrotechnical and other water management structures – 5.6 thousand hectares" (Regional office of water resources in the Mykolaiv region, 2021)

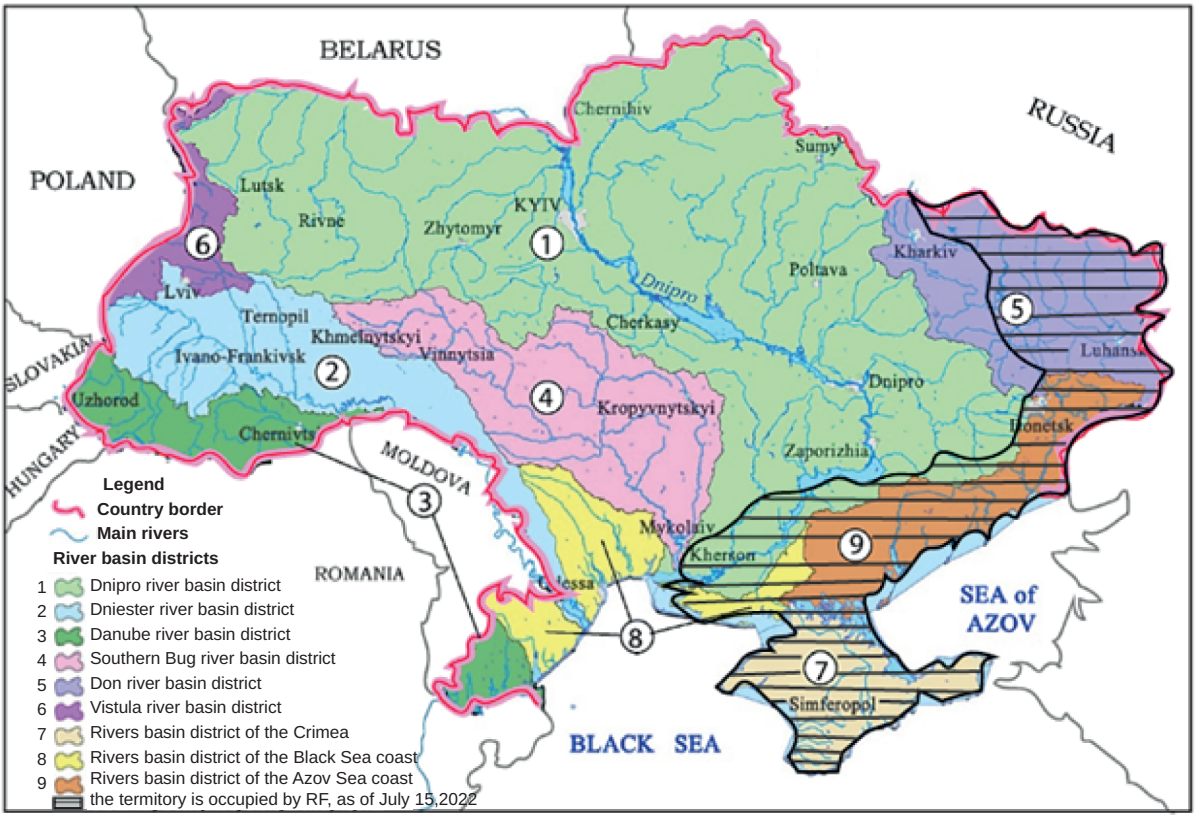

Figure 2. Map scheme of hydrographic zoning of Ukraine, on which black dashed lines indicate the territory controlled by the troops of the Russian federation as of August 1, 2022 (Khilchevskyi & Grebin, 2022)

"Unlike Mykolaiv Oblast, Khersonska is located in the dry steppe zone at the watershed of the lower Dnieper and Black Sea rivers, washed by the Black and Azov Seas, as well as the Sivash (Rotten Sea). It should be noted that the water bodies of the Kherson region occupy 430.5 thousand hectares, but the amount of water per inhabitant of the region is 15–20 times less than in other regions of Ukraine. Twenty-six rivers flow through the territory of the region, there are 693 lakes with a total area of 170.22 thousand hectares and 1154 ponds with an area of 12.3 thousand hectares. Artificial reservoirs occupy 64.28 thousand ha" (Kherson Regional Department of Water Resources, 2021). Therefore, the rivers of the southern part of the steppe are used for small irrigation of agricultural lands and for water supply, which is why in summer there is a decrease in water content, shallowing, and pollution of small rivers.

Despite the different levels of supply of territories and the population with freshwater resources by regions, the Black Sea region is characterised by a number of common problems regarding the state of water supply and water efficiency, including:

– uneven distribution of surface freshwater reservoirs and river runoff throughout the region;
– high level of wear of pumping station equipment and other water infrastructure facilities;
– imperfect control system and significant amounts of pollutants discharged;
– low quality of drinking water for the population;
– irrational use of freshwater resources, pollution by household waste, runoff from industrial enterprises, agricultural waste, etc.

To determine the effectiveness of water resources management in the Black Sea region, we have monitored the status and use of freshwater resources for the period 2015–2021. The initial data for the calculations are shown in Table 1.

Table 1. Indicators of Sustainable development of Water resources in Ukraine and Black Sea regions

Indicators		Ukraine	Mykolaiv region	Odessa region	Kherson region	Ukraine	Mykolaiv region	Odessa region	Kherson region
		2015	2021	2015	2021	2015	2021	2015	2021
SOCIAL VECTOR (X)									
X1	Use of water for drinking and sanitary needs, cubic meter per person	29.6	27.2	26.7	26	35	33	36.4	36
X2	Compliance with sanitary norms of municipal water supply sources,%	2.4	2.5	3.8	3.9	7	6.8	2.8	2.5
X3	The share of rural population that has access to centralized water supply, %	24.2	24.1	57	58	35.4	36	85	84
X4	The share of urban population with access to centralized water supply, %	89.9	26	100	100	95.3	97	100	100
X5	The share of rural population covered by centralized sewerage, %	4.1	4.8	3	3.8	19	21	1	1.8
ECOLOGICAL VECTOR (У)									
У1	Volume of discharge of polluted (polluted without treatment or insufficiently treated) wastewater into water bodies, millions of cubic meters	35.6	18.7	21	20	44	36	0.2	1
У2	Volume of circulating and sequentially (re) used water million of cubic meters	1670	1393	3141	3353	120	72	21	18
У3	Capacity of treatment facilities, million of cubic meters	214	204	67	56	281	276	102	137
ECONOMIC VECTOR Z									
Z1	Water content of GRP, cubic meters of water used per UAH 1.000 of GRP (actual prices)	23.8	10.3	4.83	2.5	7.62	4.39	45.5	42
Z2	Z2– Specific investments in water protection measures, UAH to 1000 m3 of used water	87.5	157	23.4	243	6.2	38.2	2.4	1.8
Z3	Z3– Productivity of water use in agriculture, UAH (year products) to 1 cubic meters of used water	37.4	51.5	74.6	86.4	27.9	27.4	7.8	6.2

Source: State Statistics Service of Ukraine; The Main Department of Statistics in the Mykolaiv Region; The Main Department of Statistics in the Odesa Region; The Main Department of Statistics in the Kherson Region.

The main indicators and vectors of sustainable development of freshwater resources of the Black Sea region are calculated based on the data in Table 1 and formulas 1–7. The calculation process is shown in Table 2.

Table 2. Calculation of vectors of sustainable use and development of freshwater resources in the Black Sea region

I	*ki*	Mykolaiv region			Odessa region			Kherson region		
		N_{ir}	ΔI_{ir}	V_{ir}	N_{ir}	ΔI_{ir}	V_{ir}	N_{ir}	ΔI_{ir}	V_{ir}
X1	0.2	1.0	0.06	**1.01**	1.2	0.03	**1.26**	1.3	0.08	**1.41**
X2	0.2	1.6	–0.02	**1.54**	2.7	–0.07	**2.65**	1.0	–0.15	**0.85**
X3	0.2	2.4	0.02	**2.43**	1.5	0.02	**1.51**	3.5	–0.01	**3.48**
X4	0.2	3.8	0.71	**4.56**	3.7	0.73	**4.46**	3.8	0.71	**4.56**
X5	0.2	0.8	0.10	**0.89**	4.4	–0.07	**4.31**	0.4	0.63	**1.00**
X				**2.09**			**2.84**			**2.26**
У1	0.2	0.94	–0.43	**0.51**	0.52	–0.29	**0.23**	18.75	–4.47	**14.28**
У2	0.4	2.41	0.23	**2.64**	0.05	–0.23	**–0.18**	0.01	0.02	**0.04**
У3	0.4	0.27	–0.11	**0.16**	1.35	0.03	**1.39**	0.67	0.39	**1.07**
У				**1.22**			**0.53**			**3.30**
Z1	0.4	4.12	–0.09	**4.03**	2.35	–0.14	**2.20**	0.25	–0.49	**–0.25**
Z2	0.4	1.54	8.57	**10.11**	0.24	4.38	**4.62**	0.01	–1.05	**–1.04**
Z3	0.2	1.68	–0.22	**1.45**	0.53	–0.40	**0.13**	0.12	–0.59	**–0.47**
Z				**5.95**			**2.76**			**–0.61**

Source: Calculated by authors.

In general, the results of the calculations show that in all regions there is some progress in the context of the transition of freshwater management to an innovative model of sustainable development. This is evidenced by the obtained values of the vectors that together characterise the movement as progressive. In terms of individual indicators, it is possible to analyse the position of the region relative to others, as well as the relative speed of reforms in the investigation area.

In the context of the implementation of the social vector, we can conclude that in all areas there are some positive changes. The greatest achievements in this area are in Odessa region (2.84). The relatively strong positions of Mykolaiv (5.95) and Odessa region (2.76) in the vector of economic development are typical. This is due to the relatively low water content of Gross regional product (GRP), investment in water treatment, and a fairly high level of productivity of water use in agriculture.

In the Kherson region, the analysed indicators are lower than the normative value, and the progress in their improvement is insufficient during the last 5 years. As a result, we obtained a negative value of the vector. Results of achievement of the Goals of Sustainable Development of water resources in the Black Sea regions according to the main vectors are illustrated in Figure 3.

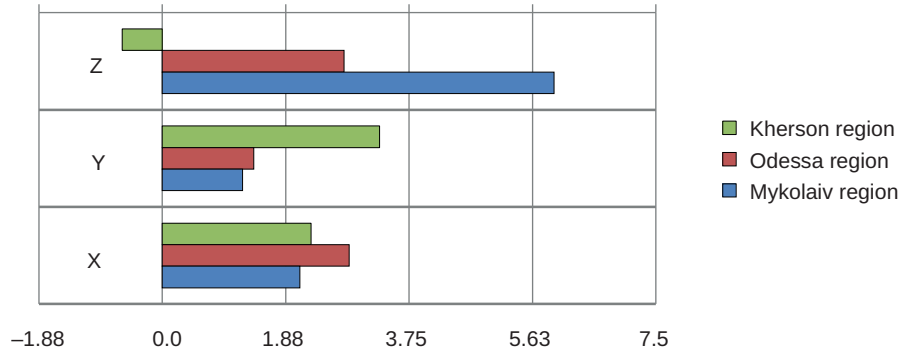

Figure 3. Achievement water management goals of in the Black Sea regions

It is graphically shown that management measures aimed at the development and sustainable use of freshwater resources in the region are insufficiently balanced. The most organic growth within the main vectors is provided in Odessa region. The main priorities for providing water resources to the population and the economy of the region are adhered to. High economic return from water use allows increasing investments and current costs for the development of water infrastructure. Slightly less attention is paid to the environmental component, which should be taken into account when formulating strategies and regional water development programmes.

The main priorities of the Mykolaiv region in water management are concentrated on providing with water resources of economy of region. The social vector is also positive, which indicates some progress in the water supply system, especially in rural areas. The environmental condition of surface waters and water bodies, which are associated with large discharges of insufficiently treated wastewater from enterprises and agriculture, remain problematic. An additional problem is climate change, which forces us to reconsider the existing irrigation technologies.

Despite the high level of water resources availability in the Kherson region, their use in the economy and to meet the needs of the population is not effective enough. The Goals of Sustainable Development in the field of providing the rural population with central water supply and sewerage systems, as well as the quality of water supplied to the population for domestic and sanitary needs are the worst realisation in the region.

Thus, the analysis showed that despite some positive changes in the sustainable use of freshwater resources in the case of the Black Sea region, significant progress can be achieved only through increased innovation and investment in this branch. In addition, the water management system in the region needs to be improved on aspects such as:

– a revision of the organisational structure of management with clarification of the rights, responsibilities, and powers of state, regional, and territorial bodies;

– the development of effective motivational systems aimed at the development of water management personnel and for users of water resources, which will stimulate economically-, socially-, and environmentally-responsible attitude to water resources;

– the formation of an effective system of monitoring, coordination, and control over the state and use of water resources, which will be based on the updated regulatory framework and modern information systems (in particular Big Data);

the optimisation of systems for planning and forecasting the development of water resources and its demand based on a comprehensive strategic approach that takes into account not only general trends and current needs, but also trends in domestic and world economy, demographics, climate change, and more.

Conclusions

Thus, general conclusions can be drawn:

1. Effective water resources management is implemented through appropriate management functions (planning, organisation, regulation, motivation, and control), which together contribute to the realisation of water complex development goals, ensuring the balance of interests of all water entities and sustainable use of existing potential in the context of satisfying the current needs of the population and the economy.

2. In Ukraine, the water management system at this stage is at the stage of reform, which is accompanied by certain problems of political, legal, organisational, and economic nature. These problems create barriers to the quality transition of water systems to sustainable use and development.

3. The Sustainable Development Goals approved by the Government in 2016 (including Goal 6 „Clean Water and Sanitation”) do not find full support at the regional level, are not comprehensively presented in regional strategies, and are not analysed to improve the situation. Given the lack of a systematic approach to measuring and evaluating the effectiveness of regional water resources management in the context of their sustainable development, methodological approaches for filling this „gap” are proposed in article.

4. The proposed approaches include: a comprehensive system of indicators for assessing the process of sustainable water use in terms of key vectors of sustainable development, mathematical tools for assessing the progress of the region towards sustainable water use, and identifying key issues in terms of individual indicators and targets.

5. The implementation of the proposed methodological approaches in the case of the Black Sea region made it possible to assess the sustainable development of freshwater resources, determine the level of water policy balance, and outline the main strategic objectives for the future. The results of this research will improve the system of information and analytical support of water resources management in the region and outline the main tasks in the context of forming a model of sustainable development.

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