ASSOCIATION OF UKRAINIAN CITIES
BY JOINT EFFORTS

INTEGRATED WATER RESOURCES MANAGEMENT VISION IN THE KHERSON REGION

Netherlands Enterprise Agency

Ministry of Foreign Affairs of the Netherlands

2025

VNG International

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DUTCH WATER AUTHORITIES

INTEGRATED WATER RESOURCES MANAGEMENT VISION IN THE KHERSON REGION

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The Integrated Water Resources Management Vision in the Kherson region was developed in the framework of the project "Water for Kherson: immediate damage reconstruction and sustainable solutions", implemented by VNG International, the Association of Ukrainian Cities, NGO "EcoClub" and VEI B.V. The consultative support in developing the Vision was provided by experts from the Dutch Water Authorities, an international organisation for regional water management.

This project is funded by the Ukraine Partnership Facility (UPF), a programme of the Netherlands Enterprise Agency, implemented on behalf of the Dutch Ministry of Foreign Affairs. The UPF supports projects for recovery and rehabilitation in the public and private sectors. The UPF aims to help the sustainable recovery of Ukraine's economy and society in the water, medical and agricultural sectors.

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FOREWORD

The Integrated Water Resources Management Vision in the Kherson Region is a strategic framework document developed in the framework of the project "Water for Kherson: immediate damage reconstruction and sustainable solutions". It is the result of cooperation between the Association of Ukrainian Cities, VNG International and other partners, which underscores its importance and international support. The document outlines a comprehensive approach to solving some of the most pressing environmental and socio-economic problems in the region.

The Vision is based on the Water Code of Ukraine, which defines the basin principle of management and Ukraine's European integration commitments. The implementation of the Vision corresponds to the implementation of six European Union directives on water quality and water resources management. The document accounts for the unique natural and geographical features of the Kherson region, which is characterised by an arid climate. The region's supply of local water resources is the lowest in Ukraine, making water resources management a critical issue.

The Vision analyses the devastating impact of the war, particularly the destruction of the Kakhovka Hydroelectric Power Plant. That led to the flooding of large areas, the destruction of ecosystems and a significant reduction in the size of water bodies. The total loss of ecosystem services is estimated at over 6.4 billion US dollars.

These catastrophic circumstances necessitate a shift away from traditional approaches and an immediate transition to sustainable management. In the first stage, solutions focused on "rational use" can be applied, such as the construction of temporary wells. However, all these actions must be part of a long-term plan that will not hinder the achievement of sustainable management goals in the future.

The Integrated Water Resources Management Vision considers management not only as a technical task, but also as a social process that requires the involvement of all stakeholders. The document analyses their interests, including agriculture, the public utilities sector, energy and nature conservation. An important component of the document is the use of international experience, that of the Netherlands, which gives the document additional practical value.

The strategic priorities of the Vision are in line with the international Sustainable Development Goals. It aims to balance the water needs of society and the economy without harming ecosystems. The Vision defines short-, medium- and long-term perspectives and sets targets for 2030 and 2050 for the sustainable restoration and development of the region.

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Executive Director of the Association of Ukrainian Cities,
PhD in Public Administration
Oleksandr SLOBOZHAN

Why develop an Integrated Water Resources Management Vision for the Kherson region right now? For the region, a part of which is occupied and the other part is in close proximity to the front line? Are long-term strategies relevant when it comes to daily survival and attempts to meet the basic needs of the population?

These questions were asked by representatives of VNG International and consortium partners while developing ideas for the project. The importance of combining urgent needs with the first steps towards long-term sustainable reconstruction and water resources management formed the basis of the project "Water for Kherson: immediate damage reconstruction and sustainable solutions". Thus, while planning the restoration of water supply and sanitation infrastructure in selected communities in the Kherson region and improving the capacity of water utilities, the idea of developing the Integrated Water Resources Management Vision in the Kherson region emerged.

The vision was developed by project experts under the leadership of the Association of Ukrainian Cities, based on Netherlands' experience in effective and sustainable water resources management. This comprehensive expertise was provided by the project's associate partner, Dutch Water Authorities, an international organisation for regional water management in the Netherlands. VNG International also paid a lot of attention to ensuring that local communities were actively involved in developing the Vision.

The emphasis on sustainable water management is one of the key elements of the proposed Vision. Sustainable management is a holistic system that includes an ecosystem approach, a long-term perspective and social responsibility. Successful implementation of sustainable management is only possible if the focus of management authorities changes. Hence, the combination of two different areas of expertise: community involvement (Association of Ukrainian Cities and VNG International) and excellent knowledge of water management organisation around the world (Dutch Water Authorities) is no coincidence in the development of the Vision. We are confident that this combination will lead to a change in the socially acceptable paradigm: from weak involvement to the development and discussion of a water resources management vision by a wide range of water users. This will lead to the responsible and sustainable implementation of the Vision.

As Mr. Slobozhan noted in his opening remarks, the Integrated Water Resources Management Vision in the Kherson region is a strategic framework document. This is the first step towards the sustainable recovery of the Kherson region after military aggression and the destruction of the Kakhovka Dam. This first step must be followed by specific strategies, programmes and projects with economic and engineering justification. VNG International, jointly with its partners, plans to continue to draw on Dutch expertise and knowledge in the field of water management to develop and implement specific programmes and projects for the restoration and improvement of water supply and sanitation in the Kherson region.

Director of VNG International
Pieter JEROENSE

1. REGULATORY, LEGAL AND CONCEPTUAL BASIS FOR INTEGRATED WATER RESOURCES MANAGEMENT

1.1. Legislative basis for integrated water resources management, including European approaches

In the field of water quality and water resources management, the right to water and sanitation in Ukraine is ensured through the implementation of six European Union (EU) directives that Ukraine has committed to implement in accordance with the Association Agreement, namely:

- Drinking Water Directive (98/83/EC updated 2020/2184);
- Water Framework Directive (2000/60/EC);
- Directive Concerning Urban Wastewater Treatment (91/271/EEC, updated 2022/0345);
- Directive concerning the Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources (91/676/EEC);
- Directive on the Assessment and Management of Floods Risks (2007/60/EC);
- Marine Strategy Framework Directive (2008/56/EC).

List of Directives that form the basis of EU water policy and require implementation in Ukraine to ensure effective water resources management:

- Directive on the Protection of Groundwater Against Pollution and Deterioration (2006/118/EC);
- Directive on Environmental Quality Standards in the Field of Water Policy (2008/105/EC);
- Regulation (EU) on Minimum Requirements for Water Reuse (2020/741).

The Integrated Water Resources Management Vision also takes into account the strategic priorities set out in the European Commission's policy document, approved in June 2024, entitled "River Basin Management in a Changing Climate" (this document is a joint strategy for the implementation of the Water Framework Directive and the Floods Directive and can be seen as a tool for regional adaptation support for regions facing the effects of climate change, especially floods and droughts), as well as in the European Water Resilience Strategy, published by the European Commission in June 2025. Under the Association Agreement, Ukraine is obliged to gradually align its national legislation with EU law and policy in the field of environmental protection. This applies to water quality and water resources management (Article 363), as well as the development of relevant sectoral strategies (Article 365b).

State management in the field of water use, protection and restoration of water resources is carried out on a basin basis, based on state, targeted, intergovernmental and regional programmes for water use, protection and restoration of water resources, as well as river basin management plans (Article 13 of the Water Code of Ukraine). The functions of state management and the names of the relevant central executive authorities in the field of water resources are schematically presented in Figures 1.1 – 1.4.

МІНІСТЕРСТВО ЕКОНОМІКИ, ДОВКІЛЛЯ ТА СІЛЬСЬКОГО ГОСПОДАРСТВА УКРАЇНИ

Ministry of Economy

- setting up the State Policy in the field of water protection and its rational use as well as restoration of water resources (including implementation of state policy in terms of marine environment protection).

Державне агентство водних ресурсів України

State Water Agency

- implementing the State Policy in the field of water protection and its rational use as well as restoration of **surface water land resources;**
- state monitoring of waters;
- preparing and implementing river basin management plans (RBMPs)

Державна служба геології та надр України

State Geological Service

- implementing the State Policy in the field of water protection and its rational use and restoration of groundwater resources;
- state monitoring of waters;
- preparing and implementing RBMPs.

УкрНЦЕМ

Ukrainian Scientific Centre for Marine Ecology

- implementing the State Policy for the protection and restoration of **marine ecosystems**;
- state monitoring of the Black and Azov Seas.

Державна екологічна інспекція України

State Ecological Inspection of Ukraine

- monitoring compliance with water legislation for all types of water bodies in Ukraine (including the sea).

Fig. 1.1. Formation and implementation of the State Policy in the field of water protection and its rational use and restoration of water resources

МІНІСТЕРСТВО ЕКОНОМІКИ, ДОВКІЛЛЯ ТА СІЛЬСЬКОГО ГОСПОДАРСТВА УКРАЇНИ

Ministry of Economy

- setting up the State Policy in the fields of fisheries and the fishing industry, protection, use and reproduction of aquatic biological resources, soil fertility, as well as land reclamation and operation of state-owned water management facilities for comprehensive use, inter-farm irrigation and drainage systems.

ДЕРЖАВНЕ АГЕНТСТВО РИБНОГО ГОСПОДАРСТВА

State Fisheries Agency

- implementing the State policy in the field of fisheries and the fishing industry, protection, use and reproduction of aquatic biological resources, as well as in the field of land reclamation and operation of state water management facilities for multiple purposes, inter-farm irrigation and drainage systems.

Fig. 1.2. Formation and implementation of the State Policy in the field of fisheries and hydromelioration

Міністерство розвитку громад та територій України

Ministry of Development

• setting up and implementing the State Policy in the field of housing and communal services.

Local authorities

• managing housing and communal services and interacting with enterprises engaged in drinking water supply, water disposal and wastewater treatment (water utilities).

National Commission for State Regulation of Energy and Public Utilities (NKREKP)

• setting up pricing and tariff policy, determines the structure of tariffs in the field of water supply and wastewater disposal.

ДЕРЖПРОД СПОЖИВСЛУЖБА

• implementing the State Policy in the areas of: safety and certain quality indicators of food products (quality of water in water bodies, water used for domestic and drinking supply, bathing), sanitary and epidemiological well-being of the population, and also exercises state supervision (control) over the above-mentioned areas.

Fig. 1.3. Formation and implementation of the State Policy in the field of drinking water supply and wastewater disposal

Міністерство внутрішніх справ України

Ministry of Internal Affairs of Ukraine

• setting up the State Policy in the field of civil protection, protection of the population and territories from emergencies and prevention of their occurrence, as well as in the field of hydrometeorological activities.

ДСНС України

State Emergency Service of Ukraine

• implementing the State Policy in the field of civil protection, protection of the population and territories from emergencies and prevention of their occurrence, as well as in the field of hydrometeorological activities
• preparing and implementing Flood Risk Management Plans (FRMPs);
• state monitoring of water.

Fig. 1.4. Formation and implementation of the State Policy in the field of hydrometeorological activities

Article 1 of the Water Code of Ukraine provides a definition of the "basin management principle" as a comprehensive (integrated) water resources management within a river basin district. The Ministry of Environmental Protection and Natural Resources of Ukraine defines the reform of approaches through the transition to integrated water resources management (IWRM) as a key objective for achieving and maintaining "good" ecological status of waters, ensuring their rational use and access to quality drinking water for the population.

IWRM reform in Ukraine provides for:

- ensuring equal access to high-quality drinking water that is safe for human health, as well as appropriate sanitary and preventive measures;
- ensuring the necessary amount of water resources for the restoration and rehabilitation of aquatic ecosystems, achieving sustainable water intake and supply;
- achieving and maintaining "good" ecological and chemical status of surface water bodies, ecological potential of artificial or significantly modified surface water bodies, as well as quantitative and chemical status of groundwater reservoirs;
- regulatory framework of environmental standards for the quality of surface and groundwater reservoirs in accordance with EU legislation;
- ensuring the implementation of the best available technologies and management methods in industrial and agricultural production aimed at reducing the level of water bodies pollution;
- reducing potential damage from the harmful effects of water, reducing the negative impact of climate change and overcoming the consequences of droughts;
- introducing state supervision (control) over the use, protection and reproduction of water resources, in particular compliance with the conditions of permits, established standards for the maximum permissible level of discharge of pollutants, limits on water intake, use and discharge of pollutants.

Ukraine's water policy is based on the following key legal acts:

- Law of Ukraine "On Environmental Protection", No. 1264-XII of 25 June 1991;
- Water Code of Ukraine, No. 213/95-VR of 6 June 1995;
- Code of Ukraine "On Subsurface Resources", No. 132-94-VR of 27 July 1994;
- Tax Code of Ukraine, No. 2755-VI of 2 December 2010;
- Law of Ukraine "On Land Reclamation", No. 1389-XIV of 14 January 2000;
- Law of Ukraine "On Drinking Water and Drinking Water Supply", No. 2047-VIII of 18 May 2017;
- Law of Ukraine "On Water Drainage and Wastewater Treatment", No. 2887-IX of 12 January 2023;
- Law of Ukraine "On the Public Health System", No. 2573-IX of 6 September 2022;
- Law of Ukraine "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period until 2030", No. 2697-VIII of 28 February 2019;
- Law of Ukraine "On the State Budget of Ukraine for 2023", No. 2710-IX 03 November 2022;
- Law of Ukraine "On the Budget Code of Ukraine", No. 2456-VI of 8 July 2010;
- Decree of the President of Ukraine, No. 722 of 30 September 2019 "On Sustainable Development Goals of Ukraine for the Period until 2030";
- Law of Ukraine "On Water User Organisations and Stimulation of Hydro-Technical Land Reclamation", No. 4017-IX of 15 November 2024;
- "Water Strategy of Ukraine for the Period until 2050", Resolution of the Cabinet of Ministers of Ukraine, No. 1134-r of 9 December 2022;

- "Strategy for Irrigation and Drainage in Ukraine for the Period until 2030", approved by the Resolution of the Cabinet of Ministers of Ukraine, No. 688-r of 14 August 2019;
- "Marine Environmental Protection Strategy of Ukraine", approved by the Resolution of the Cabinet of Ministers of Ukraine, No. 1240-r of 11 October 2021.

National and regional programmes currently being implemented in the field of water resources management in the Kherson region:

- "Strategy for irrigation and drainage in Ukraine for the period up to 2030", approved by the Resolution of the Cabinet of Ministers of Ukraine, No. 688-r of 14 August 2019;
- Programme for the restoration and development of irrigation in the Kherson region for 2025–2027, approved by the Resolution of the Head of the Kherson Regional (Military) Administration, No. 310 of 25 June 2025;
- Plans for the management of the Dnipro, Azov, Black Sea and Lower Danube river basins, which take into account the measures provided for in regional programmes;
- State Target Programme for Comprehensive Water Supply to Areas Affected by Military Operations for the Period until 2030, approved by the Cabinet of Ministers of Ukraine, No. 884-r on 17 September 2024;
- Programme for the development of the territories of the Kherson region for 2024-2027, approved by the Resolution of the Head of the Kherson Regional (Military) Administration, No. 873 of 19 December 2023 (as amended);
- Kherson Region Environmental Protection Programme for 2025–2027, approved by the Resolution of the Head of the Kherson Regional Military Administration, No. 657 of 19 November 2024 (as amended).

Detailed information on the assessment of the effectiveness of water resources management in Ukraine, the specifics of water resources management in the sector, the impact of climate change on the water supply situation in Ukraine, ways to improve management efficiency are comprehensively presented in the Report of the Institute of Water Problems and Land Reclamation of the National Academy of Agrarian Sciences of Ukraine "Conducting research on improving the efficiency of water resources management and water supply/water disposal systems and developing an analytical note for the Government of Ukraine" (2023).

The existing water resources management system is ineffective due to a number of unresolved and unregulated issues, namely the lack of:

– a comprehensive state water policy and a single authorised body responsible for its formulation and implementation;

– the separation of water resources management functions and the provision of ecosystem water use services;

– the powers of existing basin councils to carry out integrated water resources management;

– full involvement of water users in water resources management at all levels, etc.

Current state water resources management does not meet the requirements for the implementation of the UN Sustainable Development Goals, the achievement of adequate water security, in particular the Water and Health Protocol, and is in its early stages of compliance with the provisions of a number of EU directives, particularly the Water Framework Directive.

Water resources management is carried out according to the administrative and territorial principle without considering the main natural factors of formation and interconnection of water resources (surface, underground, coastal and marine) within river basins. The powers of the existing basin water resources management authorities are defined exclusively within the powers of the State Water Agency and do not allow for a full transition to integrated water resources management based on the basin principle with the involvement of all interested parties, including the public. The Basin Councils established under these administrations are purely advisory in nature and have virtually no influence on decision-making in the field of water resources management in the respective basins, which prevents state management authorities from considering the economic and environmental interests of stakeholders.

1.2. Conceptual differences between rational use and sustainable (integrated) management

First, it is important to distinguish between the concepts of "rational use" and "sustainable management". Rational use should be considered as one of the tools that can be part of sustainable management. Sustainable management is a holistic system that, in addition to rational use, also includes an ecosystem approach, a long-term perspective and social responsibility. Thus, an integrated approach is a key tool for achieving sustainability in the use and conservation of water resources.

Rational use can be implemented without considering resources recovery processes. Sustainable management, on the other hand, is impossible without resources conservation and usually involves restoration, monitoring, public involvement and long-term risk assessment.

Successful implementation of sustainable management is only possible if the focus of management authorities changes. The functions of supervision, control and distribution must be supplemented by transparent tools for coordinating the interests of all stakeholders. To this end, the concept of integrated water resources management (IWRM) was proposed at the time.

Today, there is a widespread belief that IWRM is equivalent to the soviet model of "integrated management," which was widely implemented in Ukraine. A significant proportion of water users are unaware of their responsibility for achieving sustainable development goals, and environmental policy authorities tend to position themselves as controllers of polluters and violators of legislation rather than as managers of natural resources. Consequently, they view environmental management reforms as a strengthening of "environmental protection" and traditional compliance monitoring, rather than as a means of achieving Sustainable Development Goals (SDGs) in a manner acceptable to society. The reasons for this misconception lie in outdated interpretations of the concepts of sustainable development, safety and risk. Accordingly, there is an identification of the concepts and approaches of "rational use" and "sustainable management".

To systematise these approaches and analyse them in the context of the Vision development, the main points are presented in Table 1.1.

Table 1.1.

Comparison of the approaches of "rational use" and "sustainable water management"

Approach	Rational use	Sustainable management
Basic idea	Efficient, economical and rational use of resources	Balance between use, conservation and renewal of resources
Perspective	Short- and medium-term effectiveness	Long-term environmental, social and economic stability
Answers the question:	How to use less or more efficiently?	How can we conserve resources for the long term and for future generations?
Environmental dimension	No environmental goal	Includes mandatory preservation of ecosystems
Typical examples	Reducing water, fuel and energy consumption	Water use planning that considers climate change, ecosystem services and the rights of community
Regulation	Often technical or sectoral (e.g. consumption standards)	Integrated management involving multiple stakeholders
Complies with the principles	Economic feasibility	Sustainable development (ecology + economy + society)

1.3. Application of approaches to water resources management in the context of the Kherson region

Water resources management in the Kherson region should account for a number of factors: arid climate, freshwater shortage, dependence on irrigation, as well as the consequences of military actions and the destruction of the Kakhovka Hydroelectric Power Plant.

At the first stage, approaches to water resources management in the Kherson region may be focused on classic "rational use". However, it is important that such decisions do not hinder the realisation of prospects achievable under conditions of sustainable management (Table 1.2).

Table 1.2.

Comparison of approaches using the example of the Kherson region

Criterion	Rational use	Sustainable management
Objective	Maximally efficient use of available water resources for the needs of agriculture, municipal and industrial sectors. Example: after losing centralised water supply, farmers use less water to ensure harvests with minimal costs.	Ensuring long-term water security, ecosystem balance and adaptation to climate change. Example: developing a strategy to meet the basic needs of the population, preserve the natural water balance and adapt agriculture to new conditions.

Criterion	Rational use	Sustainable management
Planning horizon	Short and medium term (1–5 years) Example: an agricultural producer installs drip irrigation systems for a season or two, focusing on the survival of the farm in the coming years.	Long-term (10+ years). Example: developing a 10–20-year water management plan for the region, taking into account climate forecasts, changes in groundwater levels and community needs.
Typical actions	• Construction of temporary wells, revision of water intake schedules from canals. • Reduction of losses in irrigation systems. • Irrigation regulations. • Water conservation in households. • Use of drip irrigation. • Identification of priority needs: drinking water for the population – ecosystems – agricultural sector. • Water intake from temporary sources to support agricultural production.	• Inventory of underground aquifers, reduction of water intensive agricultural production, development of alternative water sources. • Assessment and restoration of groundwater quality. • Introduction of integrated water resources management. • Restoration of natural water storage systems (estuaries, wetlands). • Planning in the context of climate change and infrastructure depletion. •Transition to alternative sources (treated drainage water, precipitation, artesian horizons).
Environmental dimension	May be absent or superficial.	It is mandatory and includes the preservation of wetlands, river ecosystems and ecological flow.
Social aspect	Applies to water users. Example: A farm owner decides how much water to take without consulting other users or local authorities.	Takes into account the interests of all stakeholder groups (representatives of communities, businesses, farmers, environmental organisations, etc.). Example: basin management plans are created, strategic environmental assessments are carried out, climate scenarios are taken into account, and transparent resources management is implemented with the participation of all stakeholders.
Tools	Technical solutions, instructions, individual measures.	Policies, basin plans, strategic planning, climate change adaptation, community participation.

2. NATURAL, GEOGRAPHICAL AND WATER MANAGEMENT CHARACTERISTICS OF THE KHERSON REGION

According to information provided by the Kherson Regional Administration, a significant part of the localities in the Kherson region have been under temporary occupation by russian armed forces since 24 February 2022. The total area of the Kherson region is 2,850,170 hectares. Of these, 687,880 hectares (24.13%) have been deoccupied, while 2,162,290 hectares (75.87%) remain temporarily occupied [6].

As of 2023, 32.8% of the region's localities have been deoccupied, but 67.2% remain under occupation. The deoccupied right bank of the Kherson region is in the combat zone (direct fire contact with the enemy) or under constant enemy artillery and mortar fire.

2.1. Geographical location and hydrographic network of the region

The Kherson region is located in the south of Ukraine, in the Black Sea lowlands, in the steppe zone. It lies in the lower reaches of the Dnipro River and is washed by the Black and Azov Seas, as well as the Syvash (Fig. 2.1).

Fig. 2.1. Administrative and territorial structure of the Kherson region

Most of the river flow (80–90%) occurs in the spring. The rivers are mainly fed by snow. The annual regime is characterised by spring flooding and a long summer-autumn low water period with rare torrential floods. The rivers of the basin do not drain the main aquifers, so they have practically no underground supply.

The availability of local water resources in the Kherson region is the lowest compared to other regions: 0.14 km^3 and 110 m^3/year per capita. For comparison, the indicators for the most water-rich Zakarpattia region are almost 60 times higher, amounting to 7.92 km^3 and 6580 m^3/year per capita. The average level of water supply per person in Ukraine is 962 m^3, which is below the minimum level of water supply according to the UN classification (1700 m^3/year per capita).

The territory of the Kherson region is located within the river basins: the Lower Dnipro subbasin (39.7%), the Black Sea region (31.3%) and the Azov Sea region (29.0%) (Fig. 2.2). The corresponding River Basin Management Plans for 2025–2030 were approved in 2024 [14-16]. The RBMPs include a number of measures (e.g. construction of sewerage networks and treatment facilities). Accordingly, their practical implementation in the short and medium term is a top strategic priority for the restoration and sustainable development of the region.

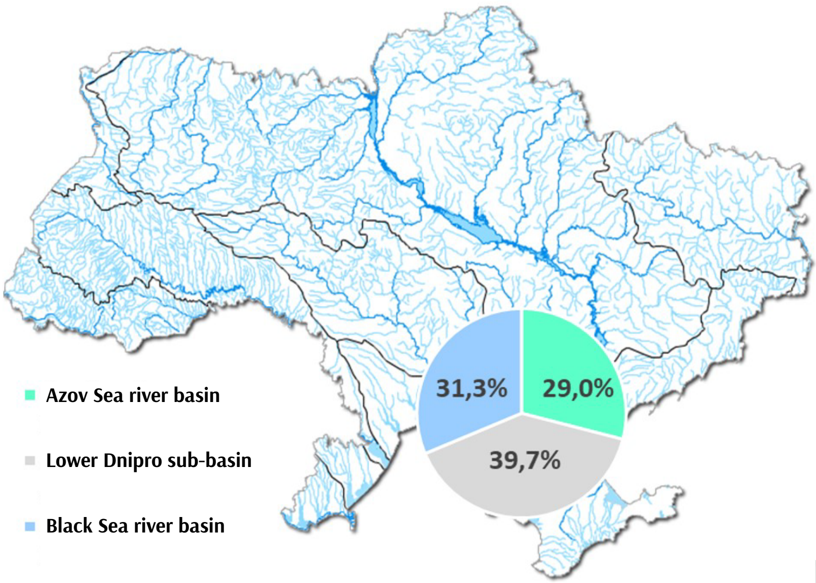


Fig. 2.2. Belonging of the Kherson region to certain river basins

The dynamics of water consumption and the water balance diagram typical for the estuary areas of the Inhulets and Dnipro rivers within the Kherson region are presented in Fig.2.4–2.7 [3]. These data demonstrate key hydrological processes that are critical for understanding the water status of the region and developing effective water management strategies.

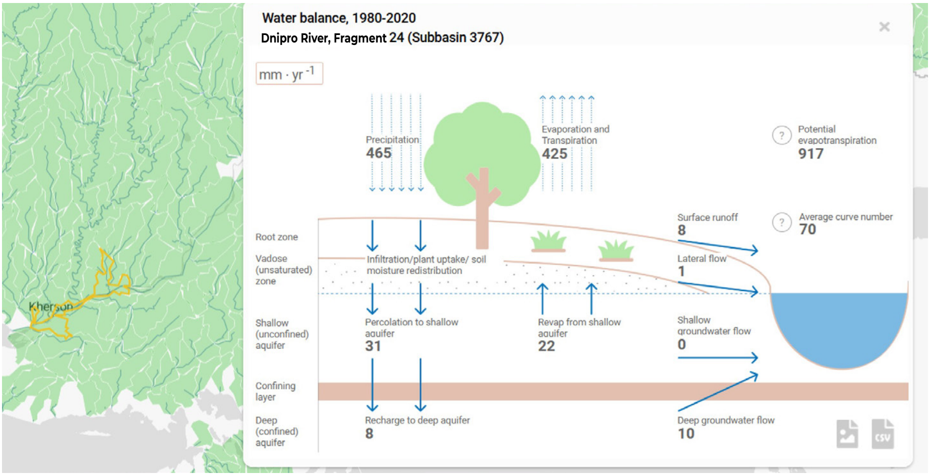


Fig. 2.3. Water balance diagram of the Lower Dnipro subbasin near the city of Kherson [3]

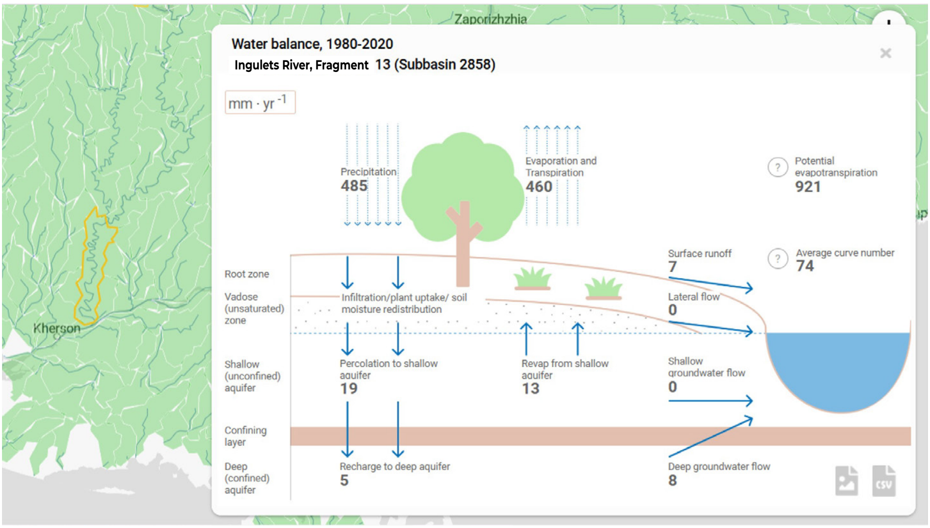


Fig. 2.4. Water balance diagram for the Inhulets River
Note: Curve number (CN) - number of the empirical dependence of surface runoff on precipitation [3]

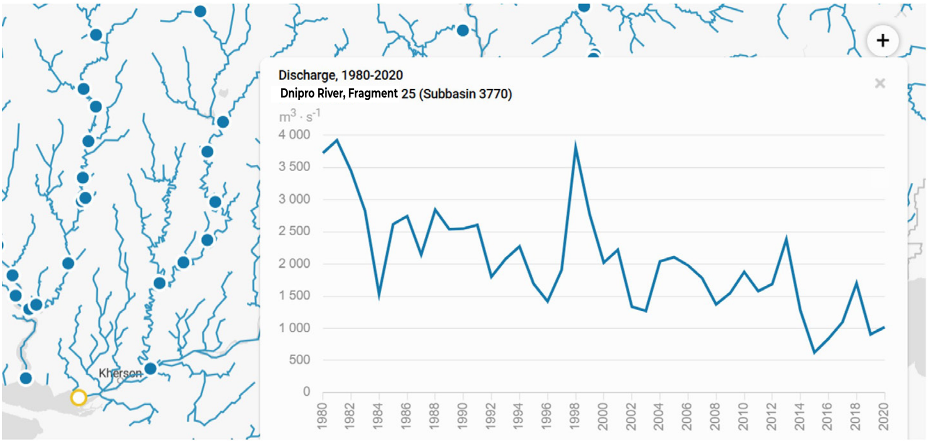


Fig. 2.5. Dynamics of water discharge in the estuary of the Dnipro River for 1980-2020[3]

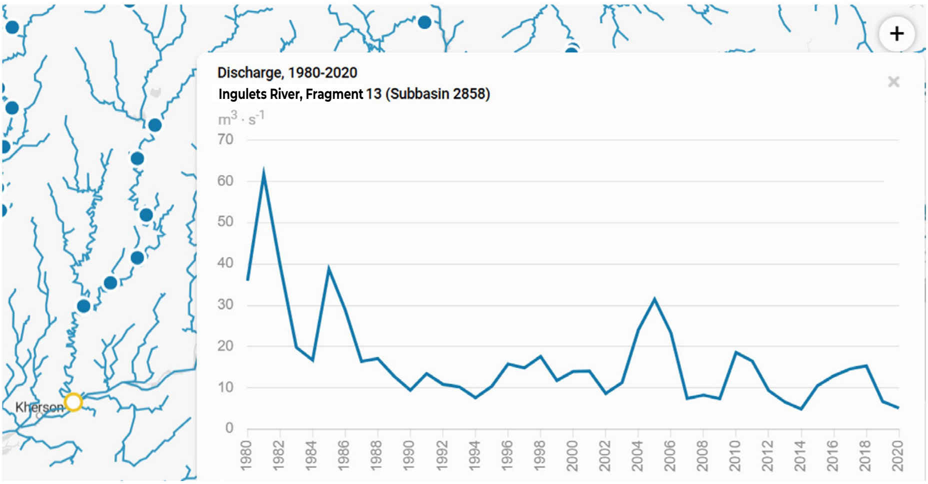


Fig. 2.6. Dynamics of water discharge in the estuary of the Inhulets River for 1980-2020 [3]

It is important to note that the projected potential for achieving good ecological status of surface water bodies within the three river basins of the Kherson region, according to the River Basin Management Plans (RBMP), is defined as being “at risk”.

Accordingly, achieving a good chemical and ecological status of surface water bodies by 2030 is unlikely (especially considering the risks caused by military actions and their direct and indirect consequences). However, it can be achieved through the implementation of measures provided for in the following RBMPs. The relevant maps confirming this assessment are shown in Figures 2.7–2.9.

Fig. 2.7. Map of the Dnipro basin, taking into account the administrative and territorial boundaries of the regions (a) and the potential for achieving good ecological and chemical status of surface water bodies by 2030 (b) according to the RBMP [14]

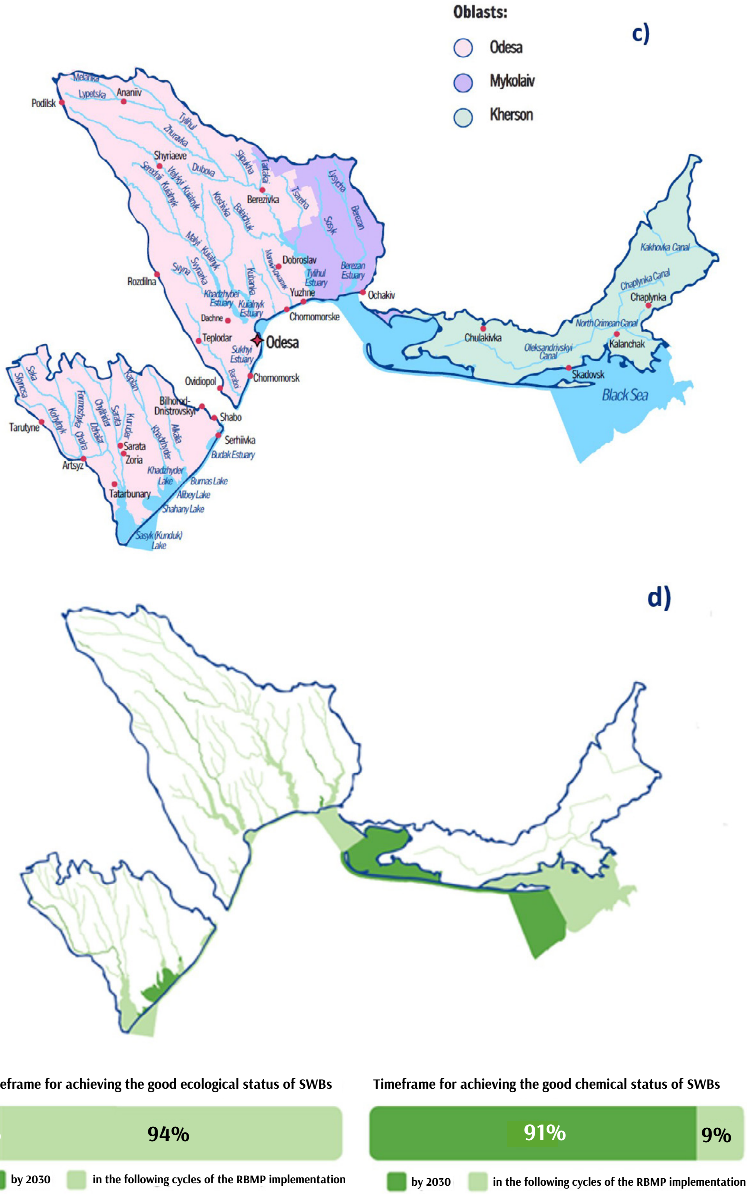


Fig. 2.8. Map of the Black Sea river basin, taking into account the administrative and territorial boundaries of the regions (c) and the potential for achieving good ecological and chemical status of surface water bodies by 2030 (d) according to the RBMP [16]

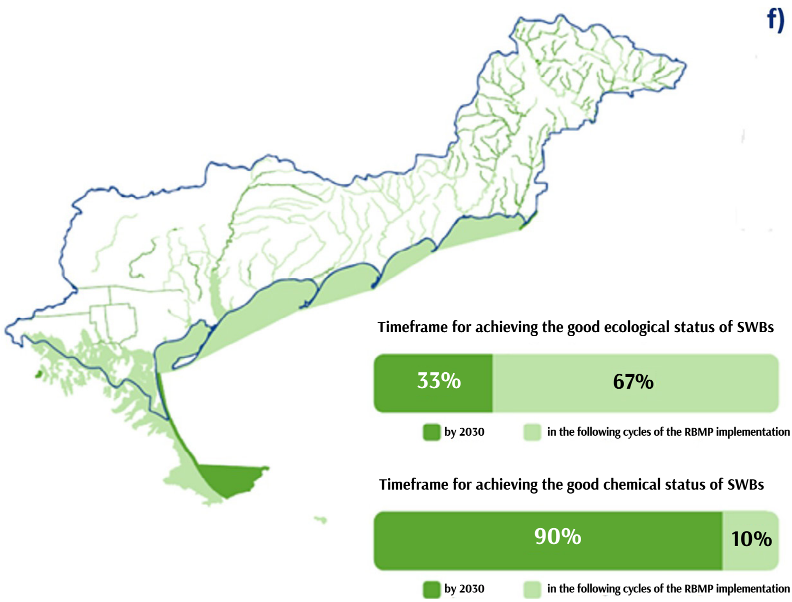


Fig. 2.9. Map of the Azov Sea river basin, taking into account the administrative and territorial boundaries of the regions (e) and the potential for achieving good ecological and chemical status of surface water bodies by 2030 (f) according to the RBMP [15]

2.2. Impact of natural, climatic and anthropogenic factors on water resources

Natural conditions and climatic features. Geographically, the Kherson region is located within the steppe climate zone. A typical feature of the region is the high level of agricultural development of the territory and, accordingly, the imbalance of the landscape structure. According to pre-war data [7], 71.3% of the land is agricultural, 15.2% is under water, 5.4% is forest and wooded areas, and 8.1% is other land. Agricultural development of the territory reaches 80%, and plowed land accounts for 62.5% (of which arable land accounts for 90.2%). This indicator is higher than the national average (59.3%) and significantly exceeds the average for EU countries (35%) ([6]).

Average climatic indicators (minimum and maximum atmospheric air temperature; precipitation) for the period 1991–2023 are given in Figs. 2.10–2.12[1], and the intensity of droughts is shown in Fig. 2.13[2].

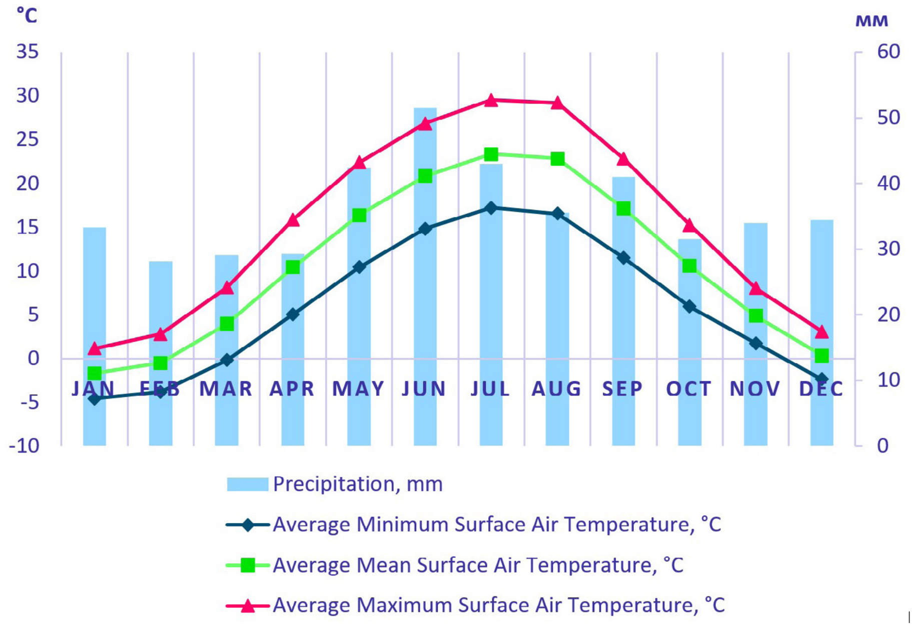


Fig. 2.10. Average climate indicators for the Kherson region for 1991-2023 [1]

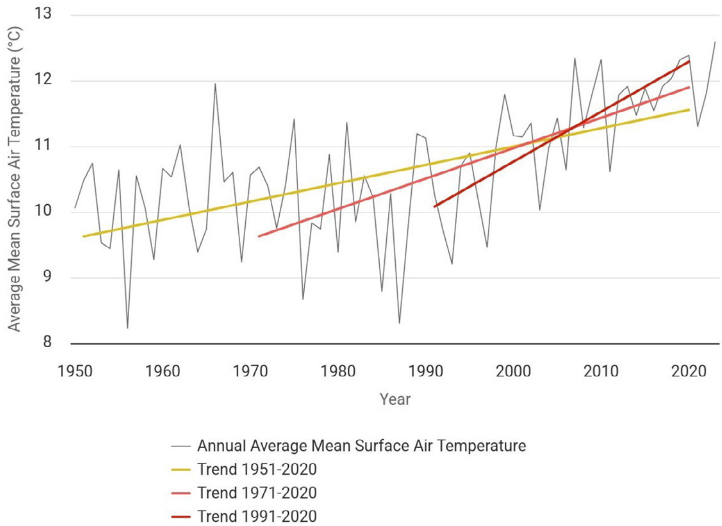


Fig. 2.11. Trend of increase in the average annual atmospheric air temperature for the period 1951-2023 [1]

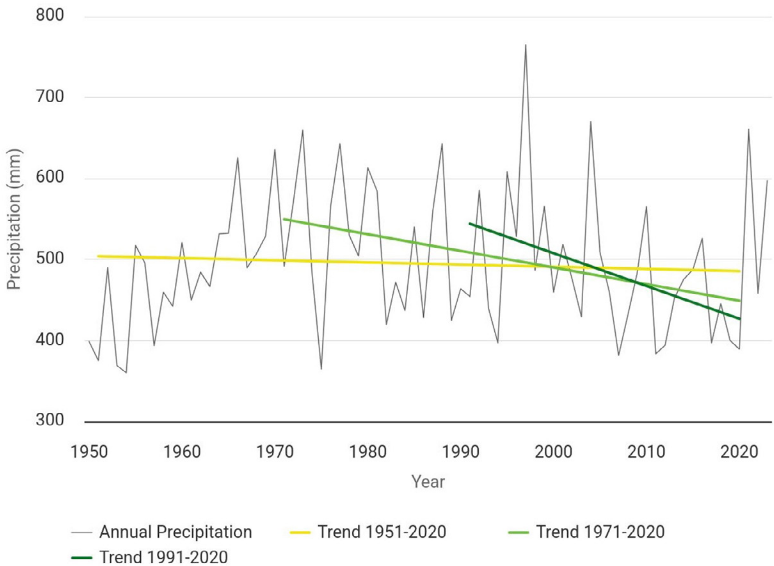


Fig. 2.12. Trend of decrease in total annual precipitation for the period 1951-2023 [1]

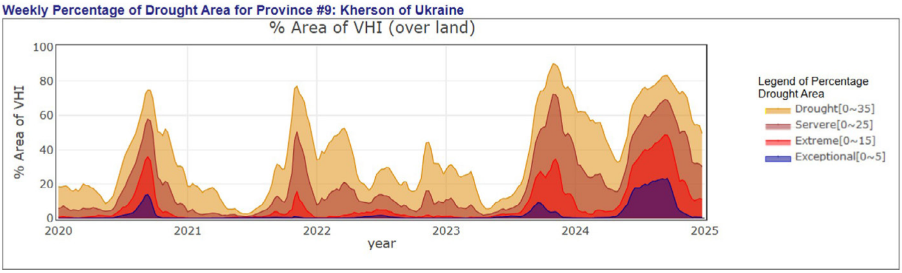


Fig. 2.13. Intensity of droughts within the Kherson region [2]

When planning economic activities, it is important to take into account projected climate scenarios. In the future, the Kherson region will experience a gradual increase in the average annual atmospheric temperature (Figs. 2.14, 2.15) due to global climate change. According to the Climate Change Knowledge Portal, the average annual precipitation will range from 380 to 600 mm per year (projected scenarios for 2050).

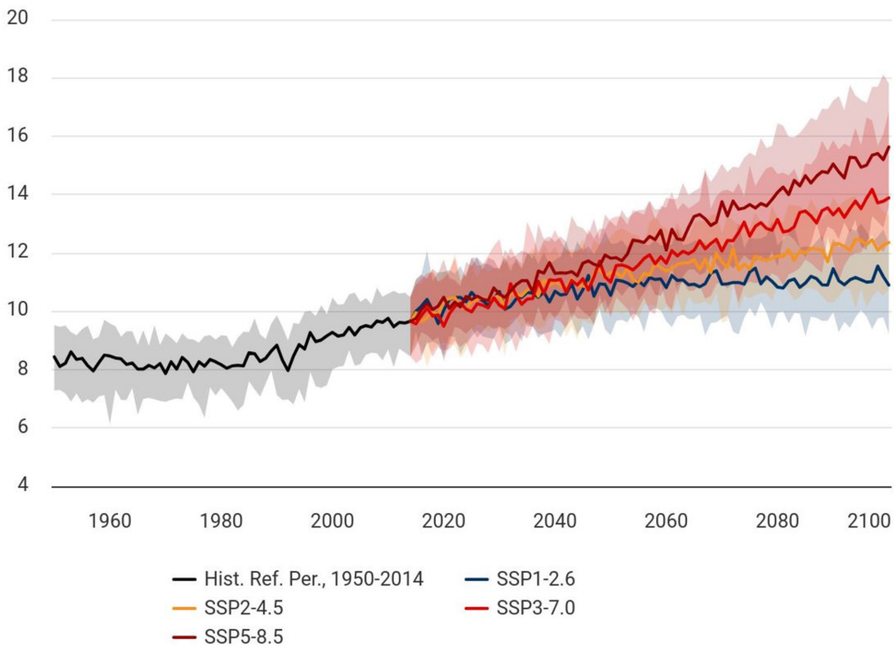


Fig. 2.14. Projected climate scenarios for an increase in the average annual atmospheric temperature [1]

Mineral resources and hydrogeological conditions. The region's mineral resources consist of 53.1% of minerals used in the construction industry and 36.8% of fresh and mineral groundwater. The rest (11.1%) is accounted for by fuel and energy and mining and chemical minerals, mineral salts and therapeutic mud [8].

The hydrogeological conditions of the artesian basin in this region are very complex. This is due to the diversity and inconsistency of the distribution of both water-bearing and water-resistant deposits, the facies and lithological variability of rock composition, and the diversity of the qualitative composition of groundwater. Given the peculiarities of hydrogeological conditions, the main aquifers are in Miocene and Pliocene-Quaternary deposits. Underground aquifers are also characterised by variable water mineralisation and widespread occurrence of brackish and saline waters.

Information on projected resources, exploitable reserves and groundwater extraction for individual regions in the southern Ukraine is presented in Table 2.1, Fig. 2.15 and Fig. 2.16.

Table 2.1.

Projected groundwater resources (PGWR), exploitable groundwater reserves (EGWR) and groundwater extraction (data for 2020) [14-16]

Region	PGWR, thousand m³/day	PGWR per person, m³/d	EGWR, thousand m³/d	Exploration, %	Extraction of PGWR, thousand m³/d	Extraction of EGWR, thousand m³/d	EGWR Exploitation, %	PGWR Exploitation, %
Donetsk	2464,0	0,60	1084,2	44,0	257,428	69,81	6	10
Kherson	**4970,8**	**4,89**	**930,5**	**18,7**	**121,043**	**88,1**	**9,2**	**2**
Zaporizhzhia	1550,7	0,93	316,3	20,4	76,044	46,0	15	5
Odesa	736,7	0,31	487,4	66,2	74,51	31,0	6	10
Mykolaiv	441,6	0,40	102,9	23,3	32,842	11,4	11	7

The explored projected groundwater resources (PGWR) within the Kherson region amount to 18.7%. The volume of PGWR is 4,970.8 thousand m³/day (values for other southern regions of Ukraine are given in Table 2.1 for comparison). The indicators of PGWR and exploitable groundwater reserves (EGWR) suggest that groundwater extraction could be increased. The main data from the state register of drinking and technical groundwater in the Kherson region (for 2020) are given in Appendix A, Table A.1.

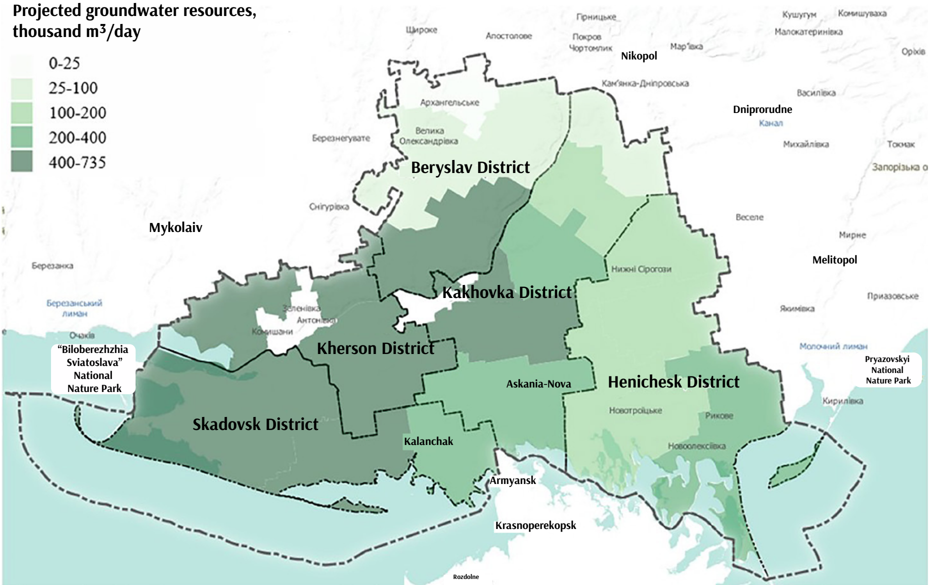


Fig. 2.15. Projected groundwater resources in the Kherson region, thousand m³/day

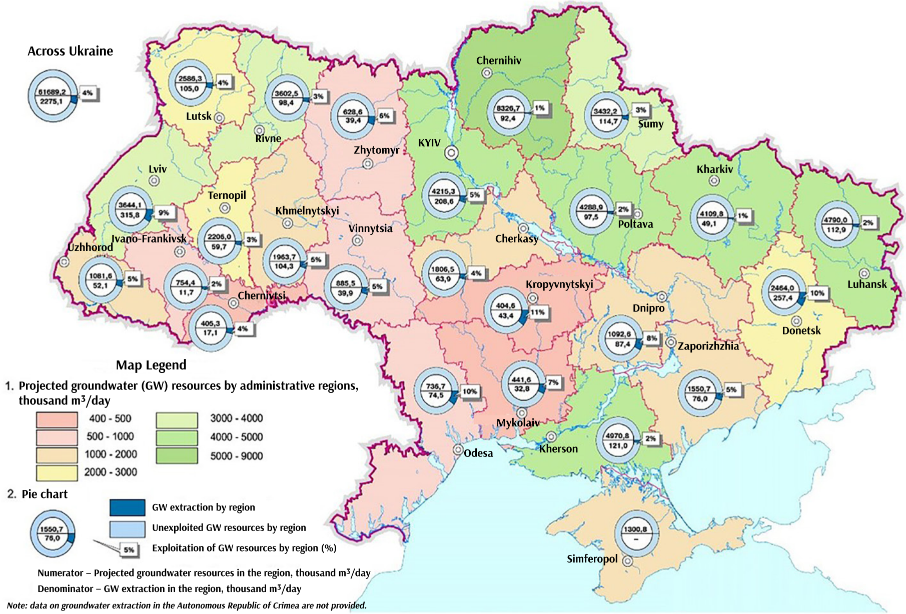


Fig. 2.16. Projected resources and extraction of drinking and technical groundwater as of 2021 [12]

Given the specific geological and hydrogeological structure and conditions of groundwater formation within the Lower Dnipro subbasin, the largest number of projected resources of groundwater is associated with the Dnipro-Donetsk and Black Sea artesian basins. The hydrogeological region of the Ukrainian Shield and the Donetsk Folded Region have smaller groundwater resources. The trend towards a decrease in groundwater extraction observed in the pre-war period contributed to the restoration of groundwater levels in the main operational aquifers and complexes of the Lower Dnipro subbasin.

The current level of PGWR development is higher in administrative regions of Ukraine with significant economic potential. For comparison, in the Kherson region, this indicator is 2%. The low level of groundwater resources exploitation indicates that there are no problems associated with possible depletion of groundwater and, conversely, allows for a significant increase in the volume of groundwater extraction (Fig. 2.17; Fig. 2.18).

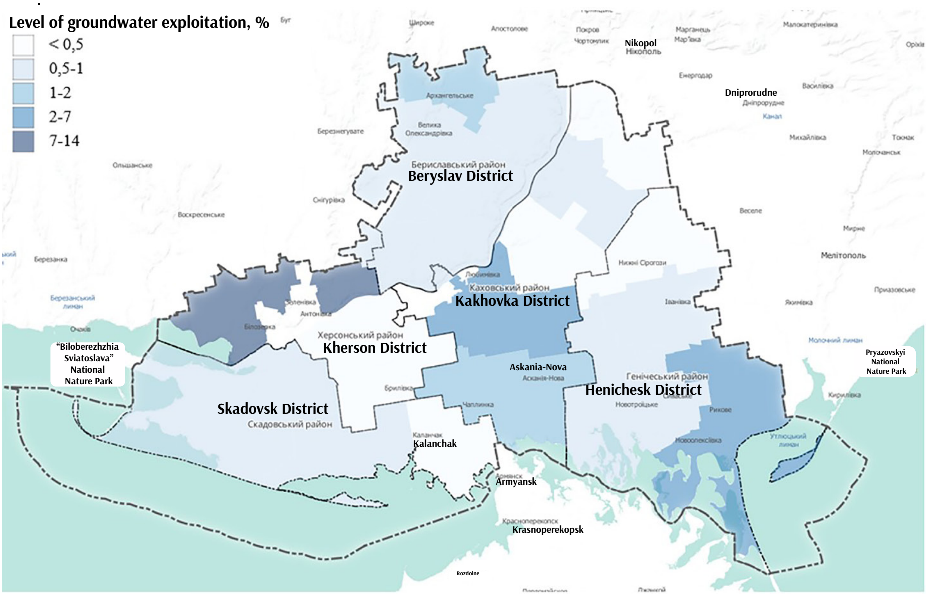


Fig. 2.17. Exploitation of groundwater resources in the Kherson region, %

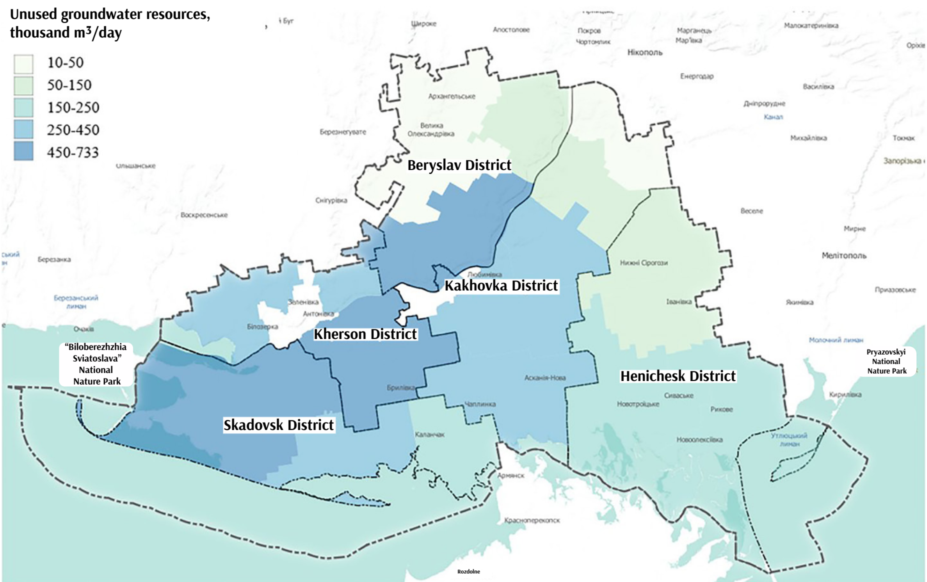


Fig. 2.18. Unused groundwater resources in the Kherson region, thousand m³/day

Land resources. The current state of land resources use in the region does not always meet conservation standards. Human activity has led to the disruption of environmentally safe land use, particularly the optimal ratio of different types of land, such as arable land, pastures, hayfields, as well as water and forest resources, has been disrupted.

The excessive increase in arable land has led to a disruption of the ecologically balanced ratio between different types of land: arable land, natural forage land, forests and water bodies. This, in turn, has negatively affected the sustainability of agricultural landscapes and caused significant man-made damage to the ecosphere. The decline in soil fertility in the region is of particular concern. Typical processes occurring in the soil include an annual negative humus balance, a decrease in nutrient content, soil decalcification, increased acidity, and a deterioration in physical and physicochemical indicators.

One of the key problems of land use in the region is soil degradation. The high level of agricultural development of the territory, combined with an arid climate and frequent dry winds, causes wind erosion. In areas with significant relief, intensive water erosion is observed. In total, about 264.3 thousand hectares, or 13.4% of the total agricultural land area, are prone to water erosion. Virtually the entire territory of the region, which is 1,706,300 hectares, or 86.6% of the total agricultural land area, is at risk of deflation. Among agricultural lands, arable lands suffer the most from erosion, which is associated with high ploughing intensity – 90.3%.

Erosion and deflation lead to the loss of humus, nitrogen, phosphorus, potassium and other nutrients, reducing their content in the soil and negatively affecting their balance. This is especially true for humus. The average annual loss of humus in soils is 0.3 tonnes per hectare, which is a consequence of imperfect farming practices.

Other negative factors, such as salinisation and alkalisation, also affect the quality of land resources. In addition, hydrometeorological and hazardous exogenous geological processes (e.g., destruction of the Black Sea coast, riverbanks and reservoirs) have a significant impact on the state of land resources and many economic objects.

Against the backdrop of a profound disturbance of the ecological balance between natural and economically modified land, as well as intense erosion, the greatest threat to the soil cover of the Kherson region is agrochemical degradation. This process includes accelerated depletion of soil fertility elements, deterioration of soil environment, humus condition and nutrient regime.

There is a negative trend towards a decrease in areas with high and elevated humus content, which are being transformed into lower agrochemical classes. This is explained by the cessation of organic fertiliser application and the saturation of areas with row crops. In modern agriculture, extremely unfavourable conditions have developed, where the agrochemical condition of soils is deteriorating not because of excessive application of agrochemicals, but because of a profound violation of the basic ecological law of agrochemistry. This law requires compensation for the leaching of nutrients from the soil by applying ecologically appropriate fertilizer rates [8].

Anthropogenic factors and their impact on water resources. In terms of economic activity, the Kherson region is characterised as an economically developed agricultural region. Diffuse sources of pollution from the agricultural sector place a significant burden on water collection basins. On average, 0.98 to 1.56 kg/ha of pesticides and 82-106 kg/ha of mineral fertilisers are applied per 1 ha of cultivated land. The maximum amount of chemicals used on agricultural land is applied in the Azov Sea basin within the Azov Sea coast. Thus, pesticides and fertilisers are the main cause of the deterioration in the quality of unconfined groundwater and surface water bodies [14].

The consequences of unfavourable exogenous geological processes caused by natural and climatic features, gradual climate change and excessive agricultural development of territories are:

- soil degradation;
- water erosion;
- coastal abrasion;
- disruption of the hydrological regime of small and medium-sized rivers (in summer, there is a decrease in water content, shallowing, silting of riverbeds, rising groundwater levels, swamping of river beds, and deterioration of water quality);
- hydromorphological changes (disruption of free river flow and unhindered migration of living aquatic resources, hydrological changes, modification of river morphology);
- flooding of land and localities in the region;
- increased drought periods.

3. ANALYSIS OF KEY STAKEHOLDER GROUPS

Stakeholders in the integrated water resources management system are all individuals and groups who have an interest in water and water resources and who influence their use and management. They can be either direct water users (industry, agriculture, etc.) or those who influence its condition through their activities, such as government agencies, non-governmental organisations, scientists and local communities.

The distribution of water consumption among key stakeholder groups in the Kherson region is shown in Figure 3.1. The main consumer of water is the agricultural sector, in particular irrigation, which accounts for 92% to 95% of total water use in different years. Industrial and domestic needs account for 2% and 3%, respectively. For comparison, the average figure for Ukraine (according to the State Agency of Water Resources of Ukraine) is 17% for irrigation, 64% for industrial needs and 19% for domestic needs.

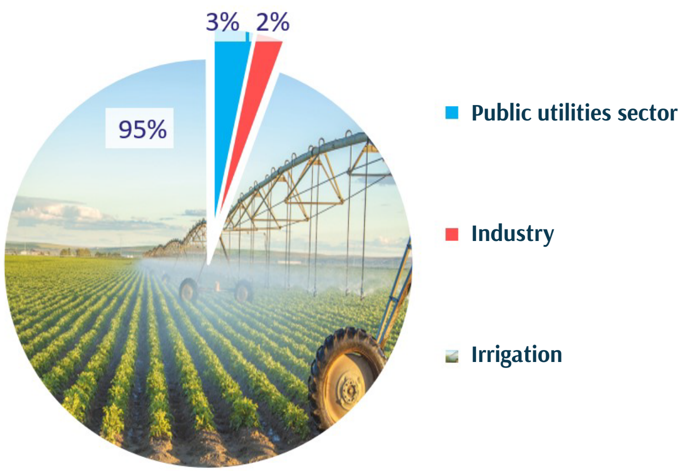


Fig. 3.1. Water use by main stakeholder groups (Kherson region)

The overall dynamics of water intake to meet the needs of all stakeholders in the Kherson region, as well as the percentage ratio of water intake from surface and groundwater sources for all water users, are presented in Fig. 3.2 and Fig. 3.3.

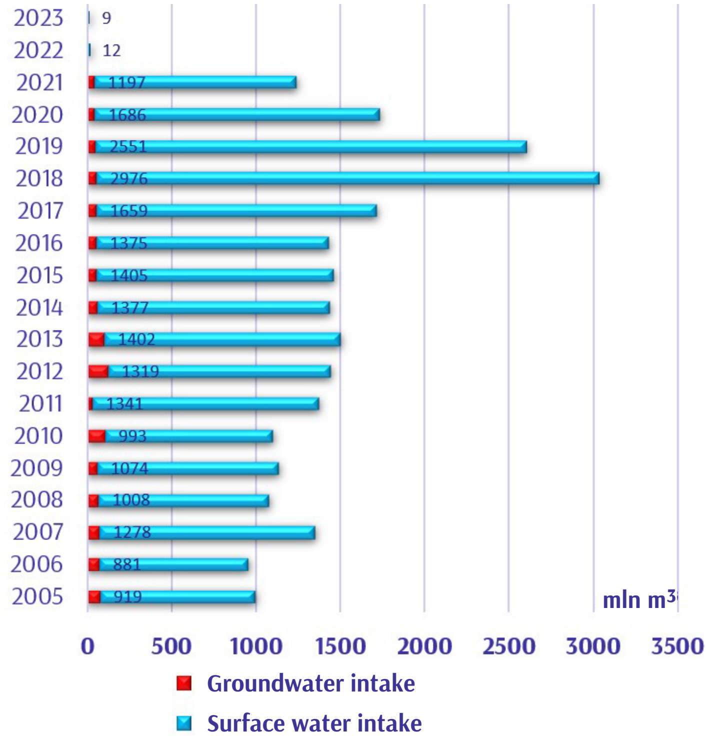


Fig. 3.2. Overall dynamics of water intake to meet the needs of all stakeholders in the Kherson region

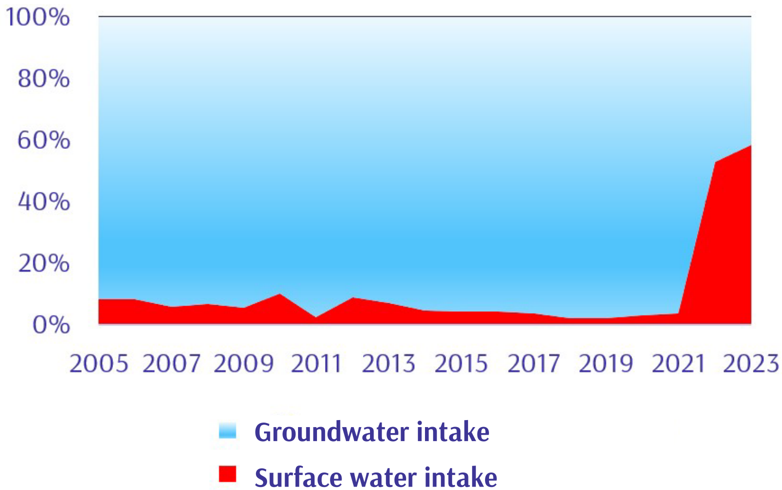


Fig. 3.3. Percentage ratio of water intake from surface and groundwater sources to meet the needs of all water users

3.1. Agriculture and irrigated farming

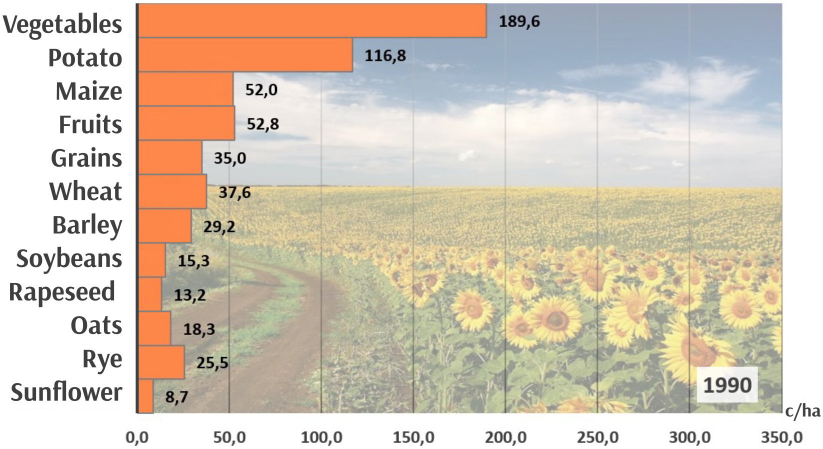
The total area of agricultural land in the Kherson region is 1.9 million hectares, of which 1.7 million hectares are arable land. The area of agricultural land potentially contaminated with explosive objects in the deoccupied territory of the region reaches 508,300 hectares.

The importance of the Kakhovka Hydroelectric Power Plant and Reservoir for Ukraine's economy. The Kakhovka Hydroelectric Power Plant and Reservoir were extremely important for Ukraine's socio-economic development. They supplied water to the Kakhovka, North Crimean and Oleksandrivka canals, as well as the Dnipro-Kryvyi Rih canal. These canals played a key role in the uninterrupted supply of drinking water to a number of regions, including Kherson, Mykolaiv, Dnipro, Donetsk and Zaporizhzhia, as well as irrigation systems in the south and south-east of Ukraine.

In particular, the Kakhovka Reservoir provided water to almost 95% of irrigation systems in the Kherson region, 75% in the Zaporizhzhia region, and 30% in the Dnipropetrovsk region. By 2022, these regions accounted for about a quarter of all cultivated agricultural land in Ukraine and about a fifth of the harvested crop. A wide range of crops were grown in this region, including more than 40% of Ukraine's winter barley and more than 20% of winter wheat, rapeseed, sunflower and spring barley.

Given the microclimate and availability of irrigation, winter crops were often combined with oilseeds, which ensured two harvests per year. Prior to russia's full-scale invasion of Ukraine, this territory was a major producer of fruits and vegetables, which was only possible under irrigated farming conditions. The comparative dynamics of the yield of major crops from agricultural enterprises in the Kherson region are presented in Fig. 3.4.

Impact of the destruction of the Kakhovka Hydroelectric Power Plant on the agricultural sector. According to experts' estimates, the breach of the Kakhovka Hydroelectric Power Plant dam caused damage and losses to the agricultural sector (primarily crop production due to the lack of irrigation) amounting to USD 376.7 million, which represents 92% of the total losses in this sector. More than 306,000 hectares of agricultural land were negatively affected. Damage and losses to fisheries and aquaculture accounted for 8% of the total, reaching USD 31.5 million. It should be noted that fishing in reservoirs, rivers and deltas accounted for 13.1% of the total fish catch in Ukraine in 2021 [12]. The absence of irrigated agriculture in the steppe agroclimatic zone of Ukraine could lead to a significant reduction in yields (according to experts, up to 70%) if traditional crops are maintained. This also threatens the loss of two harvest yields on irrigated land, as grain and oilseeds crops can be replaced by others.



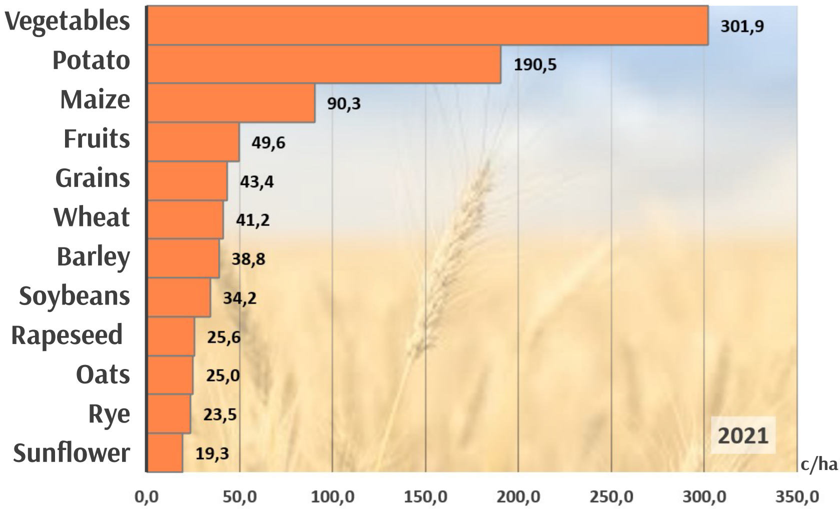


Fig. 3.4. Comparative dynamics of major crops and vegetables yields in the Kherson region in 1991 and 2021 [18]

Environmental problems of irrigated agriculture and soil degradation. It should be noted that certain environmental problems of irrigated agriculture were also observed in the pre-war period. In quantitative terms, these are significant losses of water through evaporation and infiltration, and in qualitative terms, the issue of the suitability of irrigation water. Since 2000, irrigated lands in the Kherson region have been watered exclusively with water of "limited suitable" quality, which has led to adverse agro-ecological consequences (Fig. 3.5; Appendix B, Table B.1)[7].

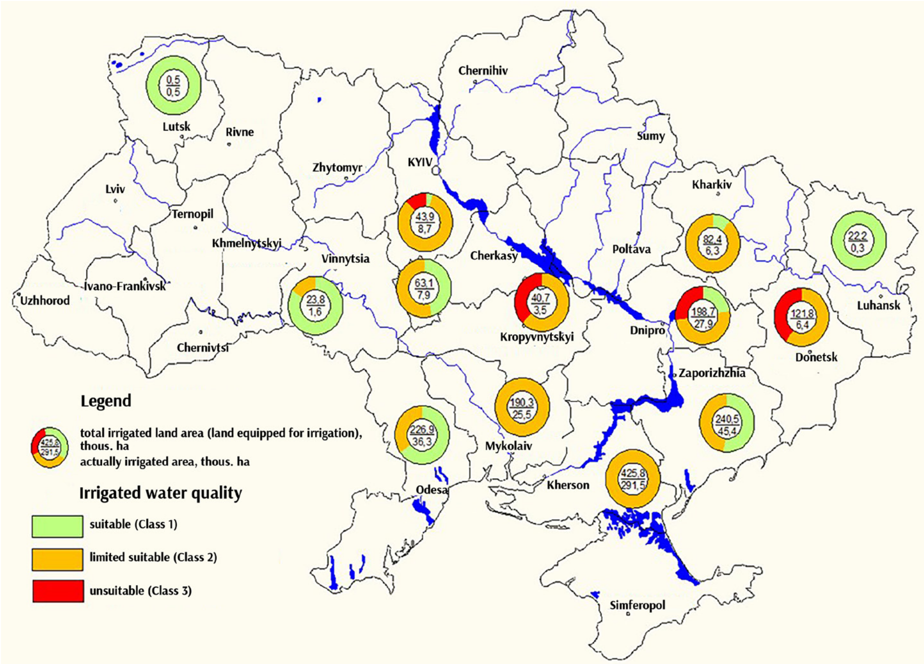


Fig. 3.5. Distribution of irrigated lands in Ukraine using water of different quality (according to the State Agency of Water Resources of Ukraine, 2015) [6]

According to data from the Hydrogeological and Land Reclamation Service of the State Agency of Water Resources of Ukraine, the area of naturally and secondarily salinated lands in terms of toxic salt content in the top metre layer ranged from 7–8% to 9–10% of the total irrigated area. More than half of all saline soils on irrigated lands are concentrated in the Kherson region (about 90% of the region's irrigated land). Irrigation violations have led to a significant decrease in groundwater levels and an increase in salinisation. The south-eastern part of the region is typically at risk of gradual desertification of arable land.

Climate risks and challenges for agriculture. Global climate change, insufficient soil moisture during the growing season, and prolonged and frequent droughts are natural risk factors for potential crop losses (from 10% to 70%). Insufficient moisture supply encourages farmers to switch to more drought-resistant varieties and hybrids. However, this solution does not fully solve the problem of water shortage for irrigation needs. Accordingly, it is unproductive to obtain high stable yields of agricultural crops under rain-fed farming conditions, especially in the south of the country.

The current ecological and reclamation state of irrigation water and land in the Inhulets irrigated area.

The Inhulets irrigation system is one of the oldest and largest in Ukraine and plays a key role in the water management complex and agricultural sector of the Kherson and Mykolaiv regions. However, over decades of operation, a number of problems have accumulated that pose significant environmental and economic risks to the region. The most acute of these are the progressive deterioration of irrigation water quality, leading to secondary salinisation and soil salinisation, as well as the critical physical deterioration of the system's infrastructure.

According to the Lower Dnipro Basin Water Resources Administration, the annual irrigation plan for the Kherson region in the pre-war period was no more than 15,000 hectares (of which almost 4,000 hectares were drip irrigated). At the same time, the design capacity provided for the irrigation of 33,600 hectares of land, of which 18,100 hectares were irrigated by the Inhulets irrigation system, 2,700 hectares by the Batumi irrigation system, and 12,800 hectares by local water sources. To irrigate the land in the Inhulets Irrigation Area (within the Kherson region), water from state irrigation systems (Inhulets and Batumi) is used, and local sources include water from the Dnipro and Inhulets rivers, as well as surface runoff water accumulated in ravines (dams) and artificial reservoirs.

Irrigation water from the Inhulets irrigation system, which is classified as Class II quality according to agronomic criteria, should be used subject to the mandatory application of a set of agricultural improvement measures to prevent soil degradation: application of soil improvers (crushed limestone, defecate, phosphogypsum), as well as adherence to scientifically based crop rotations with the mandatory inclusion of perennial grasses (primarily alfalfa).

The main problem of the Inhulets irrigation system is the unsatisfactory quality of irrigation water, which is characterised by increased mineralisation (1.5-2.2 g/dm^3) of the chloride-sodium composition and unfavourable chemical composition. The source of irrigation for the system is the Inhulets River, which is subject to significant anthropogenic pressure due to the discharge of highly mineralised mine water from enterprises in the Kryvyi Rih iron ore basin.

As a result of prolonged irrigation with poor-quality water, degradation processes are occurring in the Inhulets irrigated area, in particular:

1. *Secondary salinisation* – accumulation of water-soluble salts in the upper soil layers, which inhibits the growth and development of agricultural crops.

2. *Salinisation* – an increase in the content of exchangeable sodium in the soil absorption complex, which destroys the soil structure, making it unstructured, dense and impermeable to water. This, in turn, impairs its agrophysical properties and fertility.

According to data from the Kakhovka hydrogeological and reclamation expedition, irrigated lands with residual saline soils are widespread within the Inhulets Irrigated Area, covering 32.5 thousand hectares (96.6% of the surveyed area) in the Kherson region, including slightly saline soils – 31.2 thousand hectares (92.7%), moderately saline soils – 1.2 thousand hectares (0.36%) and strongly saline soils – 0.1 thousand hectares (0.3%). There are also 2,088 hectares of saline lands (6.2%) in the irrigated lands of the Inhulets massif within the Kherson region, including 1,936 hectares (5.8%) of slightly saline lands and 152 hectares (0.5%) of moderately saline lands [11].

According to the assessment of the hydrogeological and reclamation status of irrigated lands in the Inhulets massif within the Kherson region, 3.3% are in good reclamation condition, 89.6% are in satisfactory condition, and 7.1% are in unsatisfactory condition. The reasons for the unsatisfactory reclamation status of the land are moderate to severe salinity and soil salinity, and an unacceptable groundwater level (GWL) depth of 92 ha.

The existing scheme for improving the ion-salt composition of water, which involves mixing Dnipro and Inhulets waters in the Inhulets main canal, unfortunately does not give the desired result and does not meet the design requirements, especially in the current economic conditions.

The situation with the Inhulets irrigation system in the context of full-scale war is complex, characterised by significant destruction, but at the same time active restoration thanks to the efforts of farmers and international partners. In the long term, solving the irrigation problem in southern Ukraine will require not only finding alternative water sources and using them efficiently, but also bringing the quality of irrigation water up to agronomically safe standards.

Key technologies for adapting Ukraine's water and agricultural sectors are outlined in the reports of Ukrainian experts from the UNEP TNA project, in particular:

– **agriculture** (drip irrigation combined with environmentally friendly farming methods, agroforestry practices (reconstruction of forest belts), integrated pest and disease control, development of an agrometeorological early warning system);

– **water management** (climate-smart irrigation, drought risk assessment and mapping, flood risk assessment and mapping).

3.2. Public utilities services

The issue of water supply and sanitation in the Kherson region has long faced a number of problems in terms of both the quantity and quality of drinking water supplied to the population. In the context of the war and the consequences of the terrorist attack on the Kakhovka Hydroelectric Power Plant, this problem has become significantly more acute, requiring new approaches to its solution.

The total estimated cost of the consequences of the disaster caused by the dam breach for the water supply and sanitation sector in Ukraine is USD 148.74 million. The losses account for about 56% of the total cost of the consequences [13].

Before the war, the Kherson region got its water from surface water and the Black Sea basin groundwater. Drinking water was supplied to the population from underground sources, as well as from a single water intake point on the Kakhovka Main Canal, from where the water was purified and disinfected before being supplied to the Ivanivka group water pipeline. The projected groundwater resources are unevenly distributed across the regions: the indicator ranges from 11.6 thousand m^3/day (Vysokopilliya district) to 735.4 thousand m^3/day (Oleshky district).

Since 2000, about 60 rural water pipelines in the region have ceased to operate, requiring reconstruction of pumping and power equipment and wells.

On a permanent basis, 36 rural localities were supplied with drinking water with excessive mineralisation levels. Already 25 years ago, the question arose of finding alternative sources of water supply for the local population.

In certain areas of the Kherson region, the problem of supplying localities with drinking and irrigation water in the pre-war period was one of the most acute. This was particularly true in districts such as Vysokopilliya, Novovorontsovka, Velyka Oleksandrivka, Beryslav, Hornostaivtsi, Velykolepetsk, Verkhniy Rohachyk and Nyzhni Sirohozky. Despite being located relatively close (up to 30 km) to the Kakhovka Reservoir, many steppe villages and settlements were not provided with sufficient water; sometimes it was supplied for only 2 hours a day.

According to data from the Kherson Regional Laboratory Centre of the Ministry of Health of Ukraine, 30% of domestic and drinking water sources consistently supplied water that did not meet the requirements of sanitary rules and standards for the physical and chemical indicators of the salt block: total hardness, sulphates, chlorides, dry residue. The greatest deviations from the norms in terms of physical and chemical components were observed in Henichesk, Beryslav, Kherson, Kakhovka, and Nyzhni Sirohozky, Hornostaivtsi and Novotroitske districts.

A comparative analysis of the quantity of water samples that did not meet the standards (as a percentage of the total quantity) for 2021 and 2023 is presented in Fig. 3.6.

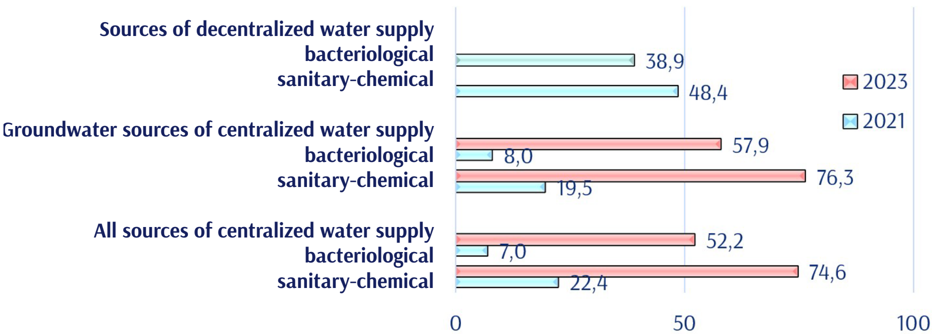


Fig. 3.6. Comparative analysis of the quantity of water samples that did not meet the standards (as a percentage of the total quantity) for 2021 and 2023

In the pre-war period, the Kherson region faced acute environmental problems in the field of water use. These included:

- Pollution of the Kakhovka Reservoir with untreated wastewater from the city of Beryslav.
- Pollution of the Dnipro River with untreated wastewater from the city of Nova Kakhovka.
- The extremely unsatisfactory condition of the treatment facilities in the Kalanchak settlement.
- Pollution of the Black Sea coast with wastewater discharged by municipal enterprises in the city of Skadovsk and the Lazurne settlement in the Skadovsk district.

It should be noted that in Lazurne, since 2014, the concentration of ammonia in drinking water exceeded the maximum permissible limit by 1.2–3.4 times.

The wastewater treatment facilities and sewerage networks of localities in the Kherson region have long failed to meet the requirements of technological and environmental safety. The equipment and networks are worn out beyond the norm. The main problem in the water supply and sanitation sector is caused by physical wear and tear and the operation of energy-intensive equipment.

As of early 2022, the share of emergency municipal water supply networks reached almost 50%, and wastewater networks – almost 40% of their total length. This poses a potential risk of pollution of water bodies and recreational areas of the Dnipro, Azov and Black Sea basins with insufficiently treated and untreated (emergency discharges) wastewater [12].

According to statistical data, between 55 and 90 million m³ of wastewater is discharged into surface water bodies in the Kherson region every year. The wastewater distribution by treatment level is shown in Fig. 3.7 [7].

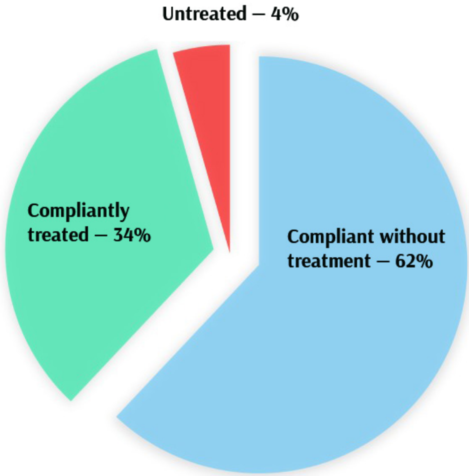


Fig. 3.7. Wastewater distribution by treatment level, %

As of 2021, the provision of water supply and wastewater disposal services to localities in the Kherson region was as follows:

- **centralised water supply** – all 9 cities, 29 settlements (93.5%), 641 villages (97.4%). Centralised water supply was partially absent in 2 settlements (Rykovo in the Henichesk City Territorial Community and Vysokopillia in the Vysokopillia Settlement Territorial Community) and in 17 villages.
- **centralised water disposal** – all 9 cities, 19 settlements (61.3%), 70 villages (10.6%). There was no centralised water disposal in 12 settlements (Rykovo, Arkhangelske, Velyka Lepetykha, Kalininske, Verkhniy Rohachyk, Ivanivka, Novovorontsovka, Lyubymivka, Bila Krynytsia, Myrne, Karierne, Syvaske) and in 588 villages.

The region's population was covered by services as follows:

- **centralised water supply:** in cities – 514,300 people (100%), in settlements – 112,000 people (95.7%), in villages – 385,000 people (97.1%);
- **centralised water disposal:** in cities – 514,300 people (100%), in settlements – 51,000 people (43.6%), in villages – 42,000 people (10.6%).

Imported drinking water in the region's water supply system was partially used in two localities: in the Rykovo settlement– for 1,480 people (42% of the total population of the settlement) and in the Vysokopillia settlement– for 3,564 people (80% of the total population of the settlement). Thus, a total of 5,044 people used imported drinking water, which is 0.5% of the region's population.

For comparison, in 2014, imported water was the main source of drinking and domestic water for the population in seven rural settlements, covering a total of 8,100 people.

Water intakes. Prior to the full-scale invasion, there were 1,802 centralised water intakes in the region, only one of which was surface based. There were 1,959 wells. The total capacity of water intakes was 206.3 million m³/year, while the need for additional capacity was estimated at 8.52 million m³/year.

As of the beginning of 2025, the provision of localities and the population with centralised water supply and sanitation systems is distributed as follows (% indicated in relation to the actual number of the existing population):

- **centralised water supply** – 2 cities, 11 settlements (84.6%), 163 villages (76.5%). There was no centralised water supply in 2 settlements and 50 villages;
- **centralised sewerage** – 2 cities, 7 settlements (58.3%), 4 villages (1.9%). There is 1 city, 2 settlements and 64 villages in areas with limited water resources.

The population of the region was covered by services as follows:

- **centralised water supply:** in cities – 66.1 thousand people (100%), in settlements – 23.9 thousand people (96.94%), in villages – 40.6 thousand people (98.0%);
- **centralised water disposal:** in cities – 64,000 people (96.9%), in settlements – 8,950 people (36.4%), in villages – 620 people (0.014%) [12].

Fig. B.1 of Appendix B shows the summarized dynamics of water supply and drainage for the population of the Kherson region.

As of early 2022, the number of public utilities companies providing water supply and sanitation services in the region had decreased from 65 to 25. Water supply to the population is partially compensated for by water intake wells: while in 2020 there were 51 such wells, providing water to only 3% of the population, there are now 85 wells serving 13.4% of the region's residents.

Infrastructure damage to the water supply and sanitation system in the Kherson region as a result of the destruction of the Kakhovka Hydroelectric Power Plant dam is presented in the appendices (Table 3.1). During 2023, with the assistance of charitable organisations and local budgets, centralised water supply networks were restored in localities where the security situation allowed.

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Table 3.1

Infrastructure damage of to the water supply and sanitation system of the Kherson region as a result of the destruction of the Kakhovka Hydroelectric Power Plant dam [17]

Territorial community	Damaged/destroyed facilities (name, units, km	Restored (units, km)	Not restored, (units, km)	Needs
Daryivka	Water supply station "Dnipro-Mykolaiv" with water intake from the Dnipro River (0th lift pumping station) - 1 unit (the facility is on the balance of "Mykolaiv-Vodokanal" municipal enterprise (Mykolaiv region)	-	1	The need is not determined due to the challenging security situation
	Artesian wells - 3 units	-	3	New wells need to be drilled
Mylove	Three artesian wells in the villages of Milove and Respublikanez and Novokairy have dried up.	-	3	Drilling of 4 artesian wells in the villages of Milove (two), Respublikanez (one), and Novokairy -1
Novooleksandrivka	Eight artesian wells in the villages of Novooleksandrivka (3 units), Havrylivka (1 unit), Mykhailivka (2 units), and Zolota Balka (2 units) have dried up.	-	8	Drilling of 8 wells in the villages of Novo-oleksandrivka (2), Havrylivka (2), Mykhailivka (2), Zolota Balka (2). Of these, drilling of 4 wells has been completed in the villages of Novooleksandrivka (2) and Havrylivka (2), and the installation of pipelines is in process
Novoraysk	Two artesian wells No. 2-87 and No. 3-33 in the village of Chervonyi Mayak have dried up.	-	2	Drilling of 4 artesian wells are planned in the village of Chervonyi Mayak
Novovorontsovka	One well in the village of Osokorivka has dried up.	-	1	Drilling of 1 artesian well is planned in the village of Osokorivka
Tyagynka	Two pumping stations in the villages of Lvove and Mykolaivka were destroyed.	-	2	Replacement of 2 pumping stations in the villages of Lvove and Mykolaivka

Territorial community	Damaged/destroyed facilities (name, units, km	Restored (units, km)	Not restored, (units, km)	Needs
Beryslav	Sixteen artesian wells in the town of Beryslav and the villages of Novoberyslav, Shlyakhove, and Zmiyivka have dried up.	-	16	Drilling of 15 wells in the town of Beryslav (10) and the villages of Novoberyslav (2), Shlyakhove (2), Zmiyivka (1) are planned once the security situation improves
Kalinivka	Water supply network in the village of Nalynivske with a length of 700 m	-	water supply network of 700 m	Replacement of a water supply network is planned for 2025
Kherson	Water supply pumping station No. 6 (VNS-6) - 1 unit	partially – 1 unit	-	Funding is insufficient for complete restoration
	Artesian wells - 3 units	partially – 3 units.	-	
	Sewage pumping stations (SPS) - 4 units	-	4	Funds required

On 17 September 2024, the State Target Programme for Comprehensive Water Supply to Areas Affected by Military Actions for the Period until 2030 was approved. The programme provides for:

- construction of 93 artesian wells to ensure water supply to localities in the Kherson region (for 2024–2025);
- construction of the Ivanivskyi group water pipeline from the village of Nyzhni Sirohozy to the village of Verkhni Sirohozy in the Henichesk district of the Kherson region (2028–2030);
- overhaul of water supply networks to provide water supply to localities in the Kherson and Beryslav districts of the Kherson region, in particular the village of Kalynivske, the villages of Bobrovyi Kut, Lymanets, Daryivka, Dudchany, Pravdyne, Chornobaivka (2024) [17].

As a result of active hostilities and constant shelling by the russian federation (in particular, the destruction of the Kakhovka Hydroelectric Power Plant), water supply networks, facilities and buildings of critical infrastructure for the life support of the local population have suffered significant damage.

According to the Kherson Regional Military Administration, water supply in 36 localities is provided through reservoirs (1), wells (3), private boreholes, artesian wells (28) or by water delivery (4). Currently, 100% of the region's localities where people live are provided with water supply, which is 93% of the total number of localities on the right bank of the region.

The issue of drinking water supply is being addressed by drilling new wells. Thanks to the assistance of international charitable organisations, the following work has been successfully completed: 27 new wells have been drilled, 13 existing wells have been restored, 87 wells have been cleaned, 34 water towers have been installed, and 13 water towers have been repaired, 23 water towers have been restored, 57 water purification systems have been installed, and 39,466 containers suitable for drinking water were delivered.

Projects are currently underway to drill 22 new wells and install 6 water towers.

3.3. Energy sector and industry

In the pre-war period, energy supply in the Kherson region was characterised by a lack of diversification of sources, as the Kakhovka Hydroelectric Power Plant was the only generating facility in the region. Its capacity was insufficient to cover local consumption levels. According to data, the annual electricity deficit in the region, calculated on the basis of the average annual production of the hydroelectric power plant, reached almost 900 million kWh [8].

The Kakhovka Reservoir was critical for the cooling systems of the Zaporizhzhia Nuclear Power Plant (ZNPP), Ukraine's largest nuclear power plant. In addition, the destruction of the Kakhovka Hydroelectric Power Plant dam led to the loss of additional water supply to the cooling reservoir of the Kryvyi Rih Thermal Power Plant, which resulted in a 600 MW reduction of its generation capacity.

On average, the Kakhovka Hydroelectric Power Plant generated 1,420 million kWh of electricity per year. Therefore, with the loss of the reservoir, Ukraine lost a source of electricity generation with a capacity of 334.8 MW. The average annual electricity consumption of irrigation canal pumps accounted for about 15% of the total production of the hydroelectric power plant, but during the dry summer months, almost all the electricity could be used to supply water to the canals. In terms of land use efficiency, the Kakhovka Hydroelectric Power Plant was at the bottom of the list of power plants in the Dnipro cascade, producing 6,590 kWh per hectare.

The Kherson region has significant potential and feasibility for the construction of alternative energy sources. A part of the Kherson region, located in the Black Sea lowlands, has a flat terrain, which is favourable for the construction of wind farms based on wind turbines of any size and large solar power plants.

According to scientists, the current technically achievable annual potential of renewable energy sources in the region is 2,860,000 tonnes for wind energy and 310,000 tonnes of conventional fuel per year for solar energy. This will allow the construction of power plants with a total installed capacity of 4.4 GW in the Kherson region. If alternative energy projects are implemented and the regional potential of renewable energy sources is achieved, energy production in the region could exceed consumption by 2.8 times. In terms of its "solar" potential, the Kherson region ranks among the top in the country. The number of sunny days per year is 240, or 65%. The average solar insolation in the region is 1.25 MW/m^2 per year [8].

Significant attention was also paid to the production of fuel briquettes, taking into account the agro-industrial specifics of the region.

In the Kherson region, enterprises that processed sunflower husks into briquettes (in the cities of Nova Kakhovka and Kakhovka) operated successfully.

3.4. Nature reserve and forest fund

According to experts from the State Environmental Inspection of the Southern District, the total damage caused to the nature reserve fund of the Kherson region from the start of the full-scale invasion until the beginning of August 2025 exceeded UAH 434 billion.

When analysing the dependence of various stakeholder groups on the availability (both quantitative and qualitative) of surface and groundwater resources, it is advisable to single out nature reserves and forestry sites, as well as the tourism and recreation sector, as a separate group. The sustainable socio-economic potential and development of the region largely depend on the ecosystem services provided by this group of stakeholders.

According to preliminary estimates by experts, the total economic value of five ecosystem services caused by the destruction of the Kakhovka Hydroelectric Power Plant (recreational, hydrological services, protection of biodiversity habitats, non-timber forest products and greenhouse gas removal) is estimated at USD 451 per hectare per year. Based on this, the total loss of ecosystem services in the forestry sector amounts to USD 5.1 million per year [10].

The forest fund of Kherson region and the impact of hostilities. The area of forestry land in Kherson region is 172,000 hectares. Of these, only 24% (40,100 hectares) are located in the de-occupied part of the region, which is potentially contaminated with explosive objects and requires humanitarian demining. The forests of Kherson region are mainly man-made (except for floodplains along the Dnipro River and small rivers) and perform mainly ecological, water conservation, protective and recreational functions. In the pre-war period, the average forest cover in the region was 4.6% and varied from 0.8% to 20.4%. The largest forest areas were concentrated in the Kherson district (Oleshky municipality), Skadovsk district (Holoprystan municipality) and the city of Nova Kakhovka.

Experts estimate that the destruction of the Kakhovka Hydroelectric Power Plant dam has had a negative impact on approximately 61,500 hectares of forest land, which is 36% of the total area of forest land. According to GIS observations reflected in Global Forest Watch, from 2001 to 2023, the loss of tree cover in the Kherson region amounted to 3.95 thousand hectares due to fires and 5.23 thousand hectares due to all other causes (Fig. 3.8). The year with the greatest loss of tree cover due to fires during this period was 2024 – 3.73 thousand hectares, which is 41% of all tree cover losses for that year.

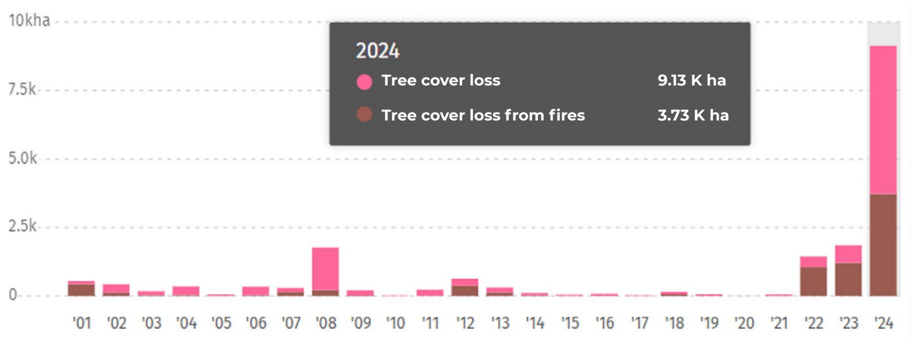


Fig. 3.8. Dynamics of tree cover loss in the Kherson region according to Global Forest Watch data

As a result of forest loss in the region, unfavourable processes typical of the steppe zone of Ukraine are predicted to develop. These include the occurrence of sandstorms, dune movement, wind erosion, soil erosion processes and gully formation.

Nature reserve fund (NRF) territories. In the Kherson region, 11.3% of the territory is allocated to the nature reserve fund (NRF), which covers 84 sites with a total area of 365,472.28 hectares. Of these, 16 sites are of national importance and 68 are of local importance. Before the full-scale invasion, there were plans to expand the NRF network and create new sites. For example, work was underway to create the Kurgan Valley Landscape Reserve in the Holoprystan district [6, 9].

As of early 2025, 29 of the 84 nature reserve sites in the Kherson region have been completely or partially deoccupied.

There are 55 territories and sites of the nature reserve fund remaining in the combat zone, with a total area of approximately 347,712.64 hectares (approximately 95% of the total area of the region's nature reserve fund).

Wetlands and the Emerald Network of the Kherson Region. Seven wetlands of international importance included in the Ramsar List are located wholly or partly in the Kherson Region:

- Yahorlytska Bay Wetland (39,692.70 hectares);
- Tendra Bay Wetland (55,021.96 ha);
- Eastern Syvash Wetland (165,000 ha);
- Central Syvash Wetland (104,512.75 ha);
- Karkinit and Dzharylhach Bay Nature Reserve (147,556.66 ha);
- Velykyi Chapelsky Basin Wetland (2,359 ha);
- Dnipro River Delta Wetland (34,425.83 ha).

An equally important part of the ecological network is the nature conservation areas included in the Emerald Network. These are areas of special conservation importance, important for the preservation of biodiversity, protected by the Bern Convention. These sites include species and habitats of very high international value, as confirmed by the governments of 49 countries and the European Union, which are signatories to this convention.

According to information from the Department of Environmental Protection and Natural Resources of the Kherson Regional State Administration, 27 Emerald Network sites are located wholly or partly in the region (Fig. 3.9).

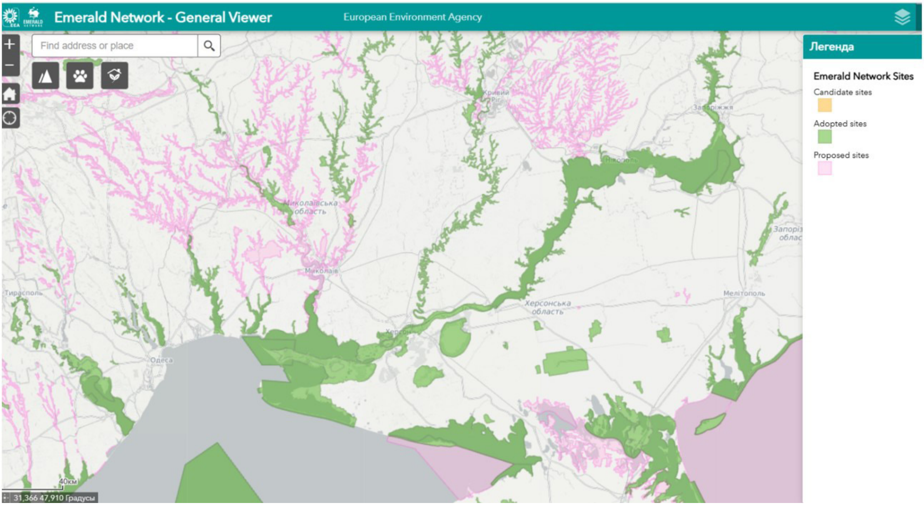


Fig. 3.9. Emerald Network sites in southern Ukraine (Bern Convention website https://emerald.eea.europa.eu/)

Environmental consequences of the destruction of the Kakhovka Hydroelectric Power Plant. The breach of the Kakhovka Hydroelectric Power Plant dam caused an environmental disaster, flooding 620 km² of land and affecting 333,000 hectares of nature reserves and 11,300 hectares of forest land. The morphology of the river changed, leading to chemical pollution and destruction of habitats. According to the report "Post-Disaster Needs Assessment of the Kakhovka Hydroelectric Power Plant" (PDNA), prepared by the Government of Ukraine in cooperation with the United Nations, the loss of ecosystem services is estimated at over USD 6.4 billion (58% of total losses) due to the impact on nature conservation areas and forests. Some environmental impacts are irreversible and may have a cascading effect on other sectors for decades [12].

The consequences of this terrorist attack affect 75 protected areas of international and national importance (in particular, those of national and international importance, as well as natural habitats protected by the Bern Convention). In total, more than 80% of the flooded areas are nature conservation areas of national and international importance (including UNESCO biosphere reserves). Areas located upstream suffered mass deaths of aquatic organisms and habitat destruction, while areas located downstream suffered habitat loss, water eutrophication, chemical pollution and changes in water salinity. Experts estimate that the disaster has resulted in the loss of approximately 11,300 hectares of forest land, with potential long-term impacts on biotopes.

4. STRATEGIC PRIORITIES FOR INTEGRATED WATER RESOURCES MANAGEMENT AND SUSTAINABLE DEVELOPMENT IN THE KHERSON REGION

Integrated water resources management (IWRM) is an internationally recognised approach that helps balance the conflicting needs of society and the economy for water without harming the sustainable development of vital ecosystems.

IWRM is a holistic approach, and its practical implementation is only possible if a favourable environment is created, effective institutions are established, stakeholders are involved, and management and financing tools are available. The practical implementation of IWRM requires strong institutions with clearly defined powers and effective mechanisms for inter-sectoral coordination. Such a mechanism ensures the rational allocation of funds and fair consideration of the needs of all water user groups[4].

1. Compliance with global SDG 6 indicators

The UN-approved international approach to achieving SDG 6 "Clean water and sanitation" identifies IWRM as one of the global indicators of SDG 6. This goal covers the following aspects:

6.1. Drinking water;
6.2. Sanitation and hygiene;
6.3. Wastewater;
6.3. Quality of water;
6.4. Water use efficiency;
6.4. Water stress;
6.5. Water resources management;
6.5. Cross-border cooperation;
6.6. Ecosystems;
6.a. International cooperation;
6.b. Community participation (support and strengthen the participation of local communities in improving water supply and sanitation management).

Adequate water supply and sanitation play a key role in achieving sustainable development goals, including those related to public health and gender equality. SDGs are focused on future generations. Accordingly, their integration in the IWRM strategy ensures that water resources management will be:

- long-term (considering the needs of future generations);
- resilient to change (able to adapt to challenges such as climate change and industrialisation);
- risk-oriented (focus on preventing risks rather than eliminating consequence).

This will help to avoid short-term decisions that may have negative consequences in the future.

2. Ability to assess the situation at the regional level

Based on the SDG 6 targets for 2030, it is possible to use specific data to assess the current and future situation within a particular region, namely the Kherson region.

The introduction and implementation of SDGs at the local and regional levels is an important condition for achieving not only national goals, but also global goals worldwide. Localising the SDGs at the regional level means establishing a closer link between local government programmes and global goals and national programmes on the one hand, and the strategic priorities of local governments on the other.

The specific targets of SDG 6, including water resources management in the Kherson region, as well as the prospects for achieving them, are summarised in the corresponding matrix (Table 4.1). It is based on the principles and concepts of state water policy, taking into account European integration approaches and strategic tasks for achieving the Sustainable Development Goals (SDGs) by 2030. The list of targets in the table is based on the principles of the IWRM, as well as on the defined tasks and indicators for achieving sustainable development goals in Ukraine for the period up to 2030 (based on SDG 6).

The SDG targets and indicators (including SDG 6) presented in Table 4.1 were approved by the Resolution of the Cabinet of Ministers of Ukraine "On Certain Issues of Ensuring the Achievement of Sustainable Development Goals in Ukraine", No. 1190-r 29 November 2024.

Table 4.1.

Matrix of potential achievement of SDG 6 by individual indicators in the short-, medium-, and long-term perspective

Specific target	Actual value	Target (indicator) by 2030 (if available) perspective	Perspective		
			Short-term (year)	Medium-term (by 2030)	Long-term (by 2050)
Percentage of population with access to centralised water supply, %*					
- urban	100	100	+		
- rural	76,5	35	+		
Share of worn-out water supply networks in the total length of water supply networks, %	50	30			
Drinking water that complies with state sanitary standards and regulations by type of indicator, % of non-standard samples for sanitary chemical/bacteriological indicators:					
- municipal water supply systems	74,6/52,2	6,5/1,5			

Specific target	Actual value	Target (indicator) by 2030 (if available) perspective	Perspective		
			Short-term (year)	Medium-term (by 2030)	Long-term (by 2050)
- decentralised water supply	60,0/57,9	29,5/15,5	[red]	[yellow]	[green]
Structure of drinking water consumption among the population by supply method, %			[red]	[yellow]	[green]
- centralised water supply	87	80	[green] +	[green]	[green]
- decentralised water supply	-	20			
Percentage of population with access to centralised water disposal systems, %*					
- urban	96,9	95	[green] +	[green]	[green]
- rural	0,014	8	[red]	[yellow]	[green]
Share of worn-out water disposal systems in the total length of water disposal systems, %	40	30	[red]	[yellow]	[green]
Share of polluted wastewater discharges (unpurified and insufficiently purified) into water bodies in the total volume of discharges, %	4	5	[green] +	[green]	[green]
Share of surface water bodies with "good" ecological and chemical status, %	-	>5	[red]	[red]	[yellow]
Number of river basins for which management plans have been approved, units	3	3	[green]	[green]	[green]
Environmental risks caused by climate change			[red]	[red]	[red]
Meeting the needs of different water users' groups (taking into account quantitative and qualitative needs)					
- agriculture	-	-	[red]	[red]	[yellow]
- utilities	-	-	[red]	[yellow]	[yellow]
- industry	-	-	[yellow]	[green]	[green]
- recreation	-	-	[yellow]	[yellow]	[yellow]

The colour gradient indicates the prospect of achieving a specific target indicator:

[green] target achievable
[yellow] likely, subject to positive institutional decisions
[red] target not achievable by the specified deadline
\+ task completed
* calculated based on actual resident population

At the state level, one of the most recent fundamental documents is the Water Strategy of Ukraine for the period up to 2050, approved by the Government in December 2022. Its importance is due to a number of critical factors related to water security, environmental well-being and sustainable development of Ukraine.

The key objective of the Strategy is to implement integrated water resources management (IWRM) based on the basin principle, in line with European standards. The Strategy sets ambitious but vital goals for the coming decade, thereby ensuring:

- access to quality drinking water for the entire population;
- improvement of the ecological and chemical status of water bodies;
- reducing risks associated with both water shortages (droughts) and excess water (floods).

The Water Strategy of Ukraine also includes guiding instruments for sustainable and integrated water resources management, the main purpose of which is the timely identification, analysis and elimination of gaps in water resources management. This document is a kind of long-term vision for Ukraine's water sector, setting the foundations for sustainable water use, environmental sustainability and effective adaptation to climate change.

Ukraine's Water Strategy for the period up to 2050 sets out the following five long-term goals:

Goal 1	Ensuring equal access to high-quality drinking water that is safe for human health and adequate sanitary and preventive measures.
Goal 2	Improving the quality of water bodies by achieving and maintaining "good" ecological and chemical status of surface water bodies, ecological potential of artificial or significantly modified surface water bodies, and quantitative and chemical status of groundwater bodies.
Goal 3	Ensuring the necessary amount of water resources for the restoration and rehabilitation of aquatic ecosystems and achieving sustainable water intake and supply.
Goal 4	Reducing the growing risks of water scarcity and water abundance.
Goal 5	Introducing integrated water resources management based on the basin principle and the principles of the Organisation for Economic Co-operation and Development (OECD) on water governance in river basins, coastal and marine waters.

Under current conditions, the key gap in the capacity to implement the IWRM is the aspect of financing and budgeting. This is since all of Ukraine's financial resources, including significant international assistance, are directed towards ensuring military victory and the deoccupation of Ukrainian territories.

Recovery priorities have been identified as logical sequence of measures. The most urgent of these include the return of a significant proportion of displaced person, providing them with housing, water and other municipal services, as well as addressing urgent needs in all sectors of the economy, particularly water supply. In the short term, one of the most important and complex elements of recovery is overcoming the environmental consequences of the dam disaster to the extent that it affects the overall reconstruction process. It should be noted that systematically overcoming these environmental consequences will take decades.

The Integrated Water Resources Management Vision in the Kherson region (Vision) considers several regional challenges. These include a significant water shortage, the fact that surface water bodies are already below "good" environmental quality standards, excessive anthropogenic pressure, the critical state of infrastructure, the environmental consequences of war, and potential threats caused by climate change.

For this region, the prioritisation of approaches is based on solving vital tasks that ensure access to quality drinking water in the short term and water of sufficient quality for use in the agricultural sector.

Key aspects of the Integrated Water Resources Management Vision in the Kherson region in the medium and long term are presented in Fig. 4.1 and Table 4.2. The concept of the Vision is based on guiding principles of the (UN) and requires the direct involvement of all stakeholder groups for the successful implementation of the Vision. At the same time, the priority areas of post-war recovery should be based on modern resource-efficient, low-waste technologies, principles of sustainability, and the prevention of environmental risks, rather than merely eliminating their actual consequences.

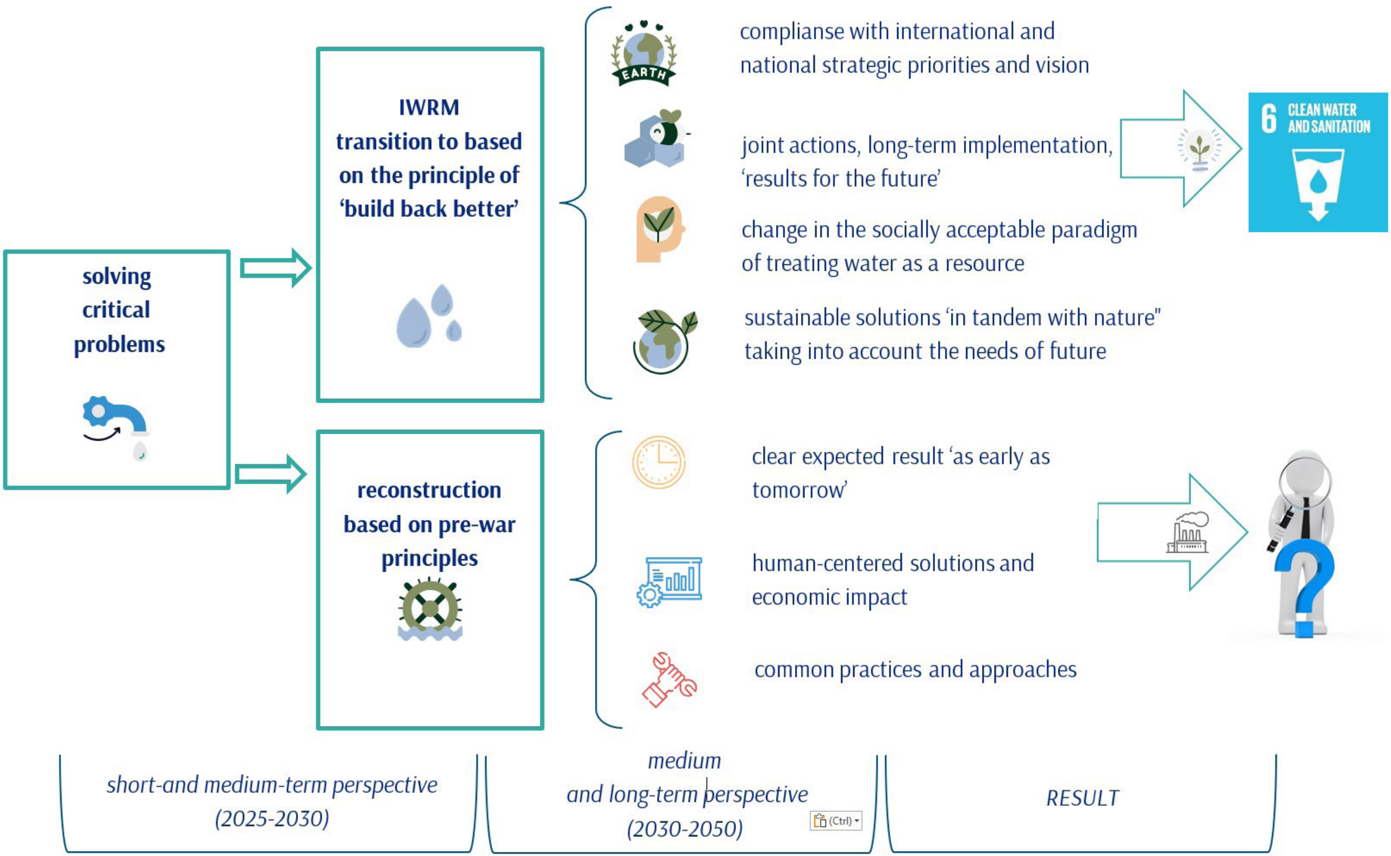


Fig. 4.1. Basic scheme of water resources management in the Kherson region according to different models

Table 4.2.

Table 4.2. Post-war water management scenarios for the Kherson region: prerequisites, risks, concepts, and expected outcomes

No.	Water resources management scenarios	Prerequisites, risks, prospects	Basic concept	Set of measures	Expected result
1	**Prolongation of the current state** This scenario is based on the assumption that the active phase of hostilities will continue, leading to further destruction and destabilisation in the region. The main goal is to address priority life support issues, in particular, providing the population with high-quality drinking water 	**Prerequisites:** • prolonging the active hostilities; • continuation of the left bank occupation; • the right bank remains in a zone of ongoing or potential hostilities. **Risks:** • *environmental* (pollution of water bodies and soil, leading to negative consequences for public health and ecosystems); • *social* (further depopulation of the territory, reduction in drinking water consumption needs); • *economic* (increased losses for water supply companies and possible suspension of water supply); • *climatic* (increased risks associated with climate change). **Perspective:** short- and medium-term	Addressing urgent needs to provide the population with high-quality drinking water (paying attention not only to quantity but also to the compliance of water quality from non-centralised water supply sources with established requirements), maintaining critical infrastructure in good condition, and reducing the volume of polluted water.	**1) Ensuring drinking water needs:** • commissioning of groundwater that is safe for health; • implementing modern approaches and equipment for water quality measurement and monitoring; • constructing alternative reservoirs for water storage; • reconstructing reservoirs and hydraulic structures to reduce water losses; • economic and technical stabilisation of existing enterprises; • diversifying water intakes and water supply sources; • introducing resouce-saving technologies and water and energy conservation modes. **2) Strategic planning:** • to elaborate strategic development visions for municipalities and regions that integrate IWRM principles for sustainable management for the period until 2050; • focus on: the River Basin Management Plans (RBMPs), Water Strategy of Ukraine for the Period until 2050 and State Target Program for Comprehensive Water Supply to Areas Affected by Military Operations for the Period until 2030 documents. **3) Staff training:** education and training of experts in the field of water supply and wastewater disposal	Providing the local population with high-quality drinking water

No.	Water resources management scenarios	Prerequisites, risks, prospects	Basic concept	Set of measures	Expected result
2	**Model I – Recovery “build back better”** This scenario represents a transition from rational water use to integrated water resources management (IWRM). It provides for the restoration of infrastructure and practices, taking into account new approaches and technologies	**Prerequisites:** **(according to UN guidelines):** • creating a favorable environment and effective management institutions; • availability of effective management tools and stable sources of funding; • decentralisation of water supply systems and introduction of water use standards. **Risks:** • *time frame* (duration of water treatment and safety processes); • *financing* (insufficient funding may slow down implementation); • *inconsistency* (lack of a unified vision and fragmentation of actions among stakeholders); • *public awareness* (skeptical attitude towards innovative approaches). **Perspective:** medium- and long-term	Addressing the needs of all stakeholder groups through post-war reconstruction based on the principle of “build back better”. Particular emphasis is placed on the comprehensive use of all available water resources, water saving, climate-oriented solutions, nature protecting, and the involvement of international experience.	**1. For local governments (LGs):** • *planning and assessment* (analysis of stakeholder needs, systematic risk assessment, development of climate change adaptation plans); • *state administration* (changing the role of basin councils with the involvement of municipality representatives, coordinating development strategies with the RBMPs and the SDG); • *information technologies* (creating of municipal geographic information systems for recording and monitoring water bodies); • *educational work* (conducting environmental awareness campaigns to change perceptions of water as an unlimited resource); • *investments* (attracting investment for the development of climate-resilient infrastructure, investing in rainwater accumulating and wastewater treatment). **2. For the energy sector:** • *integration* (planning water and energy supply to optimise water use); • *efficiency* (promoting the development of renewable energy technologies with minimal water requirements (solar, wind). **3. For the agricultural sector:** • *efficiency* (introducing progressive tariffs and precision irrigation, use of humidity sensors); • *adaptation* (transition to climate-adapted varieties and hybrids of agricultural crops, technologies for growing non-traditional niche, energy, and medicinal plants on irrigated and non-irrigated lands; restoration of irrigated agriculture based on the principles of the ‘green’ economy, energy conservation, and water conservation; development of organic farming and greenhouse farming; restoration of agroforestry) • *infrastructure* (developing infrastructure for small irrigation systems, inventory and management of infrastructure at the municipal level). **4. For nature reserve fund sites:** • *preservation* (promoting the conservation of wetlands and biodiversity); • *research* (reporting on the results of research on the state of biodiversity in aquatic environments); **5. Decisions based on the Netherlands experience:** • *security planning* (developing the water safety plans for large water consumers); • *cooperation* (stakeholders partnership in pollutants monitoring); • *adaptability* (flexibility and systematic adjustment of tasks in response to changes).	• Achieving Sustainable Development Goals (SDG 6); • Compliance of quantitative and qualitative water parameters with the requirements of all stakeholders; • Stability and preservation of terrestrial and aquatic ecosystems.

No.	Water resources management scenarios	Prerequisites, risks, prospects	Basic concept	Set of measures	Expected result
3	**Model II – Reconstruction based on pre-war principles** This scenario envisages restoring the region's water management system using the models and technologies that existed before the full-scale invasion.	**Prerequisites:** • restoring based on economic and technical models of the pre-war period; • implementing practices that are clear and familiar to stakeholders, with the possible introduction of some elements of resource efficiency. **Risks:** • *climate change* (enhancing the climate change and its consequences will become more noticeable over time); • *economic* (increasing the cost of water and energy will lead to an increase in the cost of agricultural products); • *man-made and natural* (functioning of large technical systems and structures is vulnerable to disasters, natural disasters, and hostilities); • *environmentally friendly* (threat of disruption to the natural restoration processes of the Great Meadow/Velykyi Luh and risk of another ecocide). **Perspective:** medium- and long-term	Renewing of existing practices and technological solutions aimed at restoring the Kakhovka Hydroelectric Power Plant, irrigation canal network, and irrigated agriculture.	• Restoring the Kakhovka Hydroelectric Power Plant • Overhaul of main canals • Replacing the damaged pumping stations • Drilling new artesian wells • Replacing water supply networks • Restoring water pumping stations	Quick and clear economic results, which means meeting the quantitative needs of stakeholders

On the issue of restoring the Kakhovka Reservoir and Hydroelectric Power Plant

Since the destruction of the Kakhovka Hydroчelectric Power Plant, the State Agency of Water Resources of Ukraine has approved the Dnipro River Basin Management Plan (Resolution of the Cabinet of Ministers of Ukraine No. 1077-r of 01 November 2024) and the State Target Programme for Comprehensive Water Supply to the Areas Most Affected by Military Actions. These documents provide for the reconstruction of reservoirs and hydraulic structures using innovative solutions to reduce water losses, as well as the creation of alternative reservoirs for water storage.

Experts from the Ukrainian Nature Conservation Group emphasise: "Decisions regarding the future of the former Kakhovka Reservoir must include an assessment of the consequences of the terrorist attack. Contamination with toxic substances makes it impossible to use the area for agriculture, while the natural restoration of forest vegetation calls into question the feasibility of creating a new reservoir, as this would require the destruction of the largest forest area in the steppe zone of Ukraine. Ukraine faces the task of developing a modern scenario for the post-war restoration of the southern region, taking into account the issue of creating a reservoir or finding alternative solutions. The traditional idea of restoration boils down to rebuilding infrastructure and the economy. However, the quality of life in the region directly depends on the state of natural ecosystems: water resources, air purity, soil fertility, climate and recreational opportunities. Therefore, the restoration of nature is the basis for the sustainable development of the region, which may surpass the soviet model created in the 1950s in terms of efficiency".

Continuing the scientists' argument, which is difficult to disagree with, it is worth adding: firstly, flooding the renaturalised territory in the distant future will lead to the loss of unique biotopes; secondly, painful experience has already shown that it is unrealistic to eliminate environmental risks in today's high-tech world. Accordingly, the feasibility of constructing large technological facilities is increasingly being called into question [9].

The restoration of the Kakhovka Hydroelectric Power Plant is a highly controversial issue, but it is currently part of the Ukrainian government's strategy for recovery and reconstruction after the russian federation's invasion. Therefore, the restoration programme will be based on the guiding principles of restoration and reconstruction set out in the Lugano Declaration on the Reconstruction of Ukraine, as well as a number of additional guiding principles based on international experience in the field of restoration and reconstruction after conflicts and disasters.

In the Post-Disaster Needs Assessment (PDNA) Report, UN experts emphasise that in order to begin reconstruction in the affected regions of Kherson, Mykolaiv, Zaporizhzhia and Dnipro, the priority task will be to meet urgent needs for restoration and reconstruction in all sectors. According to preliminary estimates, the restoration of the dam may take more than six years. The cost of rebuilding the destroyed Kakhovka Hydroelectric Power Plant will depend on the potential of the site, as well as from the results of the wreckage investigation, but preliminary analysis shows that it could cost nearly $1.2 billion. At the same time, experts emphasise that dealing with the aftermath of the disaster is also an opportunity for Ukraine to consider the latest climate-friendly technologies and environmental solutions and to ensure that the restoration is "**build back better**" [13].

5. INTEGRATED WATER RESOURCES MANAGEMENT VISION IN THE KHERSON REGION, WITH REFERENCE TO THE EXPERIENCE OF THE NETHERLANDS

The integrated water resources management in the Kherson region is a coordinated, comprehensive approach that sets the direction for decision-making in the water sector. It combines technical, social and environmental solutions aimed at ensuring the sustainability, accessibility and efficient use of water resources. It is based on principles that have already proven their effectiveness in countries such as the Netherlands.

Our strategic vision for the future of water management in the region must meet a number of key requirements:

- to take into account the needs of people, nature and the economy;
- to be based on the use of all water resources (surface, groundwater, wastewater);
- to cover the interests of all stakeholders: from drinking water consumers to farmers and industry representatives;
- to ensure the equal participation of all interested parties in the decision-making process;
- to be consistent with the ecosystem approach and sustainable development principles;
- take into account all potential risks.

A conceptual model of the Integrated Water Resources Management Vision in the Kherson Region, which summarises these requirements and demonstrates the logical connection between key areas of implementation and expected results, is presented in Figure 5.1.

I. INTRODUCTION

The Kherson region is critically important for the water, food and environmental security of southern Ukraine. After the destruction of the Kakhovka Hydroelectric Power Plant and the full-scale invasion, the region faced catastrophic challenges: lack of irrigation infrastructure, drinking water shortages, flooding risks, soil degradation and loss of wetland ecosystems.

If the provisions of the Vision are implemented in practice, the Kherson region will become an example of sustainable, ecosystem-based and climate-resilient water management. The region will actively apply best practices in water conservation, including the experience of the Netherlands. Management will be carried out in an integrated manner, taking into account the basin approach, community participation and partnerships at all levels, from local to international.

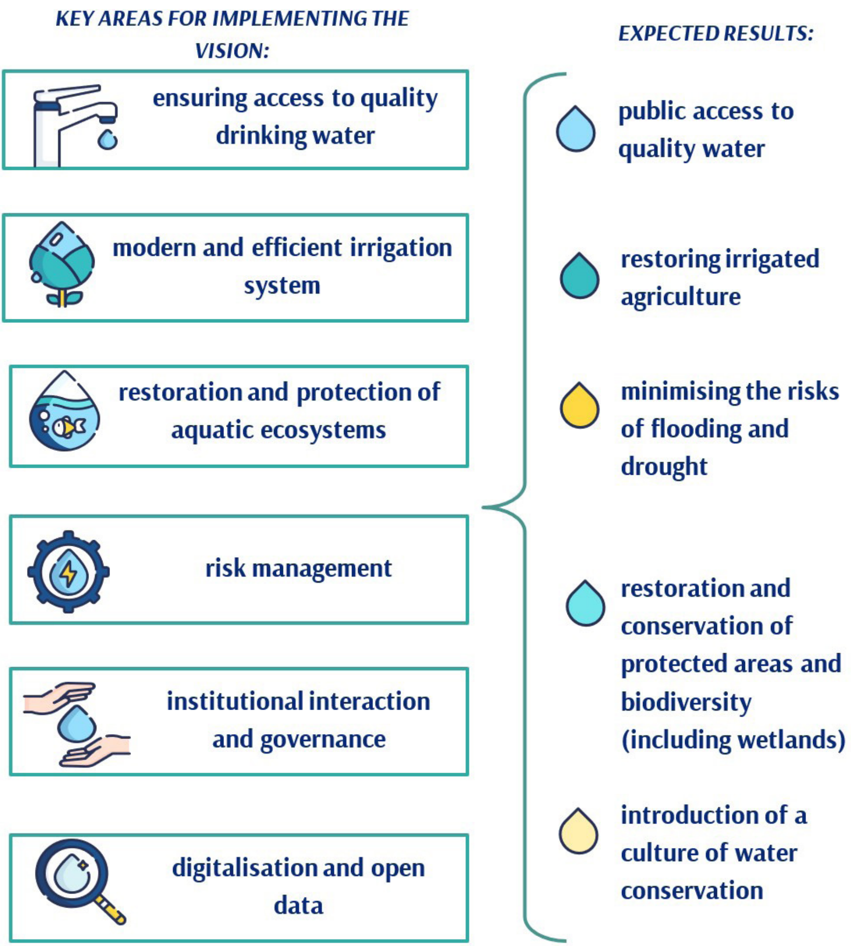


Fig. 5.1. Conceptual model of the Integrated Water Resources Management Vision in the Kherson region

II. KEY AREAS FOR IMPLEMENTING THE VISION

1. Ensuring access to quality drinking water

Following the destruction of the Kakhovka Hydroelectric Power Plant, ensuring a sustainable and secure water supply in the Kherson region is a top priority. Based on proven Dutch approaches, the following steps are proposed:

1.1. Reconstruction and expansion of artesian well networks by constructing a backup water supply system that does not depend on surface sources, within the limits of the existing hydrogeological potential. Particular attention is paid to energy-efficient solutions, in particular the use of solar power plants.

1.2. Introduction of mobile and stationary water treatment systems, for example, modular desalination, reverse osmosis and filtration units. Water treatment methods, facility parameters, and reagent doses should be selected based on the quality of the source water, local conditions, the purpose of the water supply system, and the capacity of the station. For new construction, these decisions should be based on preliminary technical studies, and for reconstruction, on experience operating similar facilities in similar conditions.

1.3. Modernisation of existing and construction of new water supply systems. The focus is on the introduction of innovative technologies that will ensure high energy efficiency and reliability of water supply systems.

1.4. Creation of rainwater retention systems, or separation of storm water and domestic wastewater systems. Following the experiense of the Netherlands, the use of separate collectors will reduce the load on treatment facilities and allow rainwater to be reused.

1.5. Collection and reuse of rainwater by constructing rainwater storage systems in buildings, schools, and greenhouses (following the experience of Dutch "water buffers"). This water can be used for domestic needs.

1.6. Real-time water quality monitoring. It is proposed to install sensors and IoT systems for continuous monitoring of the bacterial, chemical and salt composition of water in wells and distribution systems.

1.7. Public education and participation. Conducting campaigns to raise awareness about the rational use of water.

2. Modern and efficient irrigation system

With the loss of the Kakhovka Reservoir, the Kherson region needs to create an adaptive, economical and environmentally balanced irrigation system. Flooded reservoirs located in ravines and gullies in the coastal areas of the Dnipro River could be an alternative. It would be advisable to fill them with water from the Dnipro using solar-powered pumping stations.

The Vision includes the following key components:

2.1. Development of a regional irrigation strategy based on the use of new irrigation sources, including artesian aquifers (subject to proper scientific justification), rainwater and treated wastewater.

2.2. Introduction of high-tech precision irrigation. For example, the creation of drip irrigation, micro-sprinkler, and pulse irrigation systems, the use of mobile sprinkler installations and modern sprinkler technology. Systematic monitoring of soil moisture (such as Water4All or Smart Irrigation Netherlands) using soil moisture sensors, weather stations, satellite data, AI or IT technology for real-time decision-making. This will allow water to be delivered directly to the root system in doses, reducing losses by 50–70%.

2.3. The introduction of a water use accounting and tariff system provides for the establishment of fair rules for water distribution among agricultural producers, which will help avoid conflicts and encourage the economical use of resources.

2.4. Use of treated wastewater in agriculture. Use this water for irrigation of industrial crops. This should be preceded by the introduction of quality standards for treated wastewater.

2.5. Operating on the principle of "as much water as needed", which involves systematising data on climate, soil and crop growth stages to determine the minimum amount of irrigation required (following the experience of Deltares and Waterwijzer Landbouw programmes).

2.6. Restoration of natural water regulation systems, such as floodplain complexes, wetlands, etc. Construction of storage basins. Use of beams and artificial watercourses for temporary water storage. Construction of storage basins with anti-filtration coating near irrigation systems (on elevated areas) for water accumulation between irrigation periods with subsequent gravity flow to irrigation systems. Installation of solar power stations above canals to reduce evaporation.

2.7. Cooperation between agricultural producers through the establishment of water user associations for joint management, accounting and maintenance of irrigation infrastructure.

3. Restoration and protection of aquatic ecosystems

The aquatic and wetland ecosystems of the Kherson region play a key role in preserving biodiversity, regulating the microclimate, retaining floodwaters and ensuring water security. Their degradation following military action requires a systematic and integrated approach to restoration, protection and conservation.

This direction includes:

3.1. Revitalisation of wetlands. Restoration of the hydrological regime of floodplains, mudflats and estuaries through the revitalisation of natural watercourses.

3.2. Integration of nature-based solutions (NbS). Use of bio-plates (phytopurification systems, multifunctional buffer zones) along rivers to clean surface runoff, reduce erosion and conserve moisture in the landscape.

3.3. Protection of water sources and tributaries. Identification of vulnerable areas in small river basins, restriction of economic activity in buffer zones and introduction of public environmental monitoring.

3.4. Creation of urban water buffers. Implementation of the concept of "water squares" in cities, following the experience of the Rotterdam Waterplan. Integration of such environmental solutions into urban ecosystems will allow water to be retained during floods, reducing the load on the sewerage system and creating recreational areas.

3.5. Development of green corridors along water bodies (elements of the ecological network). Creation of landscape and ecological transitions along water bodies, which will contribute to the stabilisation of the natural balance.

3.6. Monitoring and impact assessment. Introduction of wetland monitoring systems using satellite data and public monitoring, including the involvement of eco-activists, proactive citizens and volunteers, similar to the Dutch experience of biodiversity accounting.

3.7. Fundraising. Active involvement in obtaining grants for projects that will ensure not only environmental restoration, but also social and economic benefits for communities.

4. Risk management

Climate change, droughts and infrastructure damage have significantly increased the water vulnerability of the Kherson region. Effective risk management should be based on scenario planning, prevention and adaptation.

4.1. Scenario planning based on climate data:

- *Development of hydroclimatic scenarios.* Development of several scenarios (e.g., based on RCP/SSP models) with forecasts of water balance and extreme events until 2100.
- *Use of scenarios in planning.* Application of these scenarios for irrigation planning, urban planning, and placement of critical infrastructure facilities.

Creating adaptive systems. Developing flexible adaptation systems that respond to changes and provide for continuous updating of models in line with new data.

4.2. Early warning and infrastructure protection:

- *Implementation of digital hydrological models.* Integration of data from weather stations, drones and satellites to predict floods, droughts and abnormal events. An example is the recommendation of the World Meteorological Organisation (WMO) on the development of national early warning systems (EWS).
- *Creation of a municipal network of hydrometeorological stations. Installation of stations with real-time data transmission.*
- *Modelling and forecasting floods.* Development of models based on rainfall indices, soil moisture and the condition of pressure structures.
- *Inventory of hydraulic structures.* Conducting a complete inventory of the condition of all existing hydraulic structures and assessing the priority of their reinforcement, taking into account the risks of breaches and terrorist acts.

4.3. Using the example of the "Room for the River" Programme in the Netherlands:

- *Giving rivers "space".* Reducing the risks of floods and high-water levels through controlled flooding of floodplains, which may include the justified dismantling of individual protective structures. Construction of flood control polder systems that can not only protect against flooding, but also serve as freshwater reservoirs for further irrigation.
- *Introduction of "dual-purpose land use".* Seasonal use of floodplains that can be flooded for grazing or recreation.

4.4. Implementation of ecosystem approaches to risk reduction (Eco-DRR, Ecosystem-based Disaster Risk Reduction). This is an approach to reduce the risks of natural disasters through the conservation, restoration and sustainable use of ecosystems. In other words, it is a way to reduce damage from floods, droughts, landslides, storms, etc. by supporting natural processes and ecosystem functions.

- *Creation of natural barriers* such as floodplains, forest belts and wetlands. This is an approach to water resources management and land protection based on the use of nature's ecosystem functions according to the principle of "Nature-Based Solutions" or "green" infrastructure.
- *Renaturalisation and protection of ecosystems.* Restoration and protection of ecosystems capable of retaining, filtering and slowing down the course of natural disasters.

5. Institutional interaction and governance

Effective water resources management in the Kherson region requires a clearly structured and transparent system of institutions at the local, basin and national levels. The experience of the Netherlands, where water boards (Waterschappen) operate successfully, can serve as a model for the development of regional water policy.

Main directions of institutional development:

5.1. Involvement of stakeholders in the basin councils of the Black Sea, Azov Sea and Lower Dnipro rivers. Inclusion of residents in the process of electing representatives to water councils and delegating some of their functions to them.

5.2. Implementation of good water governance. Adherence to the principles of transparency, participation, efficiency, and accountability. Development of a Water Co-management Code for the region.

5.3. Strengthening the role of the public in decision-making. Raising public awareness through training and educational campaigns. Creating an online resources "Kherson Region Water Platform" for discussing projects.

6. Digitalisation and open data

The integration of digital technologies will enable rapid monitoring of the situation, ensure transparency and enable forecasting. The experience of the Netherlands (Digital Delta, Waterveiligheid 21e eeuw) shows that digital transformation increases the efficiency of water resources management.

The main areas of digitalisation are:

6.1. Remote Earth Observation (REO). Use of satellite images to monitor water levels, flooding, soil moisture and identify areas of degradation, analyse seasonal dynamics of soil moisture, vegetation index and surface temperature, identify areas of salinisation, degradation or unauthorised water intake.

6.2. Online real-time water monitoring systems. Installation of sensors at key points in the water network and their integration with mobile applications.

6.3. Use of cloud-based geoinformation platforms. Processing of large volumes of spatial data for modelling water balance, irrigation, flooding and drought scenarios. Provision of decision-making tools for communities and businesses.

6.4. Public water cadastre and open data. Creation of a platform with data on water bodies, wells, water quality and risks. Ensuring access to up-to-date information for citizens, businesses and managers.

6.5. Digital platforms for strategic management. Combining hydrological models, forecasts and sensor data in a single environment for operational analysis. Enabling rapid analysis of the situation and visualisation of alternative solutions. Focus on integrating data from various sources: governmental, academic and private.

6.6. Involving communities in data collection. Creating mobile applications or web platforms for reporting pollution, flooding, desertification, etc. (crowdsourcing). Conducting educational programmes on the use of spatial data in schools, communities and agricultural enterprises.

As one of the tools, digitalisation can ensure transparent, integrated and dynamic water resources management, which is particularly important in conditions of high uncertainty, climate challenges and post-war recovery.

III. EXPECTED RESULTS

The implementation of the Integrated Water Resources Management Vision in the Kherson region will contribute to the achievement of the following objectives:

1. Public access to quality water for the population:

- Full coverage of localities with centralised or decentralised water supply.
- Ensuring access to drinking water in crisis situations through mobile purification units.
- Introduction of permanent water quality monitoring systems (sensors, laboratories, crowdsourcing).
- Conducting information campaigns on hygiene, source protection and the economical use of water resources.

2. Restoring irrigated agriculture:

- Transition to efficient, low-cost precision irrigation systems.
- Introduction of water consumption management based on climatic and agronomic models.
- Use of alternative water sources: treated wastewater, rainwater and soil moisture.
- Providing financial and technical support to farmers in the implementation of new technologies.

3. Minimising the risks of flooding and drought:

- Building a comprehensive early warning and response system (EWS).
- Restoring buffer zones, floodplains and ecosystems capable of retaining floodwaters.
- Implementing the "Room for the River" practice in small and medium-sized rivers.
- Spatial planning that takes climate risks into account.

4. Restoration and conservation of protected areas and biodiversity (including wetlands):

- Revitalisation of floodplains, estuaries and ravines using nature-based solutions.
- Integration of ecosystem services, biodiversity conservation and the network of protected areas into water policy and community budget planning.
- Revival of traditional types of floodplain use (fishing, biomass, ecotourism).
- Monitoring the dynamics of wetlands and other protected areas using remote sensing and field observations.

5. Introduction of a culture of water conservation:

- Introduction of differentiated tariffs and water metering systems.
- Scaling up educational programmes based on Dutch practices ("water awareness").
- Inclusion of the topic of rational and sustainable water use in school education and vocational training.
- Development of incentive programmes (grants, certification) for businesses and households.

IV. NEXT STEPS

To implement the Integrated Water Resources Management Vision in the Kherson region, the following steps need to be taken in the short and medium term:

1. **Provide detailed information on the status and quality of groundwater.**
2. **Develop and approve a regional IWRM strategy (2026–2030).** Integrate water policy into the regional recovery strategy under the leadership of the State Agency of Water of Ukraine, the regional military administration and in partnership with international organisations.
3. **Consult and ensure stakeholder participation.** Engage communities, farmers, businesses and environmental organisations in joint planning through public discursions and online platforms.
4. **Develop pilot projects in each community.** Prepare engineering projects and attract funding from international donors, the budget and the private sector.
5. **Create a water infrastructure register.** Develop a GIS platform with data on wells, dams and treatment plants, integrating it with state cadastres.
6. **Introduce a modern water accounting system** to improve water use efficiency.
7. **Train experts.** Develop training programmes and courses on water resources management for community representatives and government officials.
8. **Form a partnership network.** Sign memoranda of cooperation between the regional administration, higher education institutions, international donors and businesses.

These steps will form the foundation for the practical implementation of the Vision, ensure consistency of action and effective monitoring of reforms in the field of water management. The goal is not only to restore, but also to create a modern, sustainable and transparent system that is adapted to future challenges.

V. RECOMMENDATIONS FOR COMMUNITIES

Water resources management in the Kherson region should bring together stakeholders at all levels. This includes residents who care about the environment, ministries that provide the legislative framework and attract funding, as well as donors. The community is a key participant and connecting link in this field of stakeholders.

Communities play a key role in implementing water policy at the local level. Many decisions and projects can be adopted and implemented by local authorities. Some of them are presented as recommendations in Table 5.1.

Table 5.1.

Recommendations for communities in the Kherson region based on the Integrated Water Resources Management Vision

No.	Area	Recommendations
	1. Water supply and efficient water use:	
1	Reliability of water supply systems	To modernize existing water supply systems and construction of new ones. Introduction of innovative technologies to ensure high energy efficiency and reliability of water supply systems.

No.	Area	Recommendations
2	Energy efficiency	To expand artesian well networks and use of solar power stations to power pumping equipment, reducing dependence on centralised power grids.
3	Treatment systems	To introduce mobile and stationary water treatment systems (e.g. reverse osmosis) to ensure access to quality drinking water in crisis situations.
4	Rainwater collecting	To arrange rainwater harvesting and reuse systems in residential buildings, schools and agricultural land, following the example of "water buffers".
5	Quality monitoring	To install sensors and IoT systems for continuous monitoring of water quality in wells and distribution networks, ensuring rapid response to any changes.
6	Cooperation between agricultural producers	To establish water user associations for joint management, accounting and maintenance of irrigation infrastructure.
2. Ecosystem restoration and risk management		
7	Land revitalisation	To participate in the restoration of the hydrological regime of floodplains, floodplains and estuaries using nature-oriented solutions such as bio-plates.
8	Protection of sources	To participate in the identification of vulnerable sections of rivers and springs, restriction of economic activity in buffer zones for their protection.
9	Spatial planning	To introduce the concept of "water squares" in cities for temporary water retention, which will help reduce the load on the sewage system and mitigate the microclimate.
10	Early warning system	To create a municipal network of hydrometeorological stations for real-time data collection, which will enable the forecasting of floods and droughts.
3. Institutional interaction and digitalisation		
11	Participation in water governance	To get actively involved in river basin councils and "water dialogues" for joint decision-making on water policy.
12	Awareness raising campaigns	To conduct campaigns and training to raise public awareness of rational and sustainable water use.
13	Use of digital tools	To use mobile applications and web platforms for data collection (crowdsourcing) on pollution or flooding.
14	Fundraising	To use grant programmes to finance environmental restoration projects and create additional social and economic benefits for the community.

References

1. Climate Change Knowledge Portal. The World Bank Group. URL: https:// climateknowledgeportal.worldbank.org/.

2. NESDIS STAR. Centre for Satellite Applications and Research. NOAA. URL: https:// www.star.nesdis.noaa.gov/star/index.php.

3. Osypov, V., Matviienko, Y., Bonchkovskyi, A., Osadcha, N., Mossur, H., Ahafonov, Y. Land & Water: Land & Water: An interactive web cartography platform for hydrological research in Ukraine, in 17th International Conference Monitoring of Geological Processes and Ecological Condition of the Environment, Nov 2023, Volume 2023, p.1 - 5. URL: https:// doi.org/10.3997/2214-4609.2023520162.

4. Progress on implementation of Integrated Water Resources Management Mid-term status of SDG Indicator 6.5.1 and acceleration needs, with a special focus on Climate Change (2024). United Nations Environment Programme. ISBN: 978-92-807-4171-1.

5. State Target Programme for Comprehensive Water Supply to Areas Affected by Military Operations for the Period until 2030, No. 884-r of 17 September 2024. URL: https:// zakon.rada.gov.ua/laws/show/884-2024-%D1%80#n77.

6. Ecological passport of the Kherson region for 2023. Kherson Regional Military Administration. 2024.

7. Report on Strategic Environmental Assessment. Draft Strategy for Irrigation and Drainage in Ukraine until 2030. Ministry of Ecology and Natural Resources of Ukraine. Kyiv. 2019.

8. Report on the Strategic Environmental Assessment of the Kherson Region Development Strategy for 2021-2027. Official website of the Kherson Regional State Administration. URL: https://khoda.gov.ua/strateg%D1%96ja-rozvitku-2021-2027.

9. Destruction of the Kakhovka Reservoir: Environmental Impact / Compiled by V.V. Kolodezhna, O.V. Vasilyuk. Chernivtsi: Druk Art, 2025.

10. Guidance on implementing OECD principles of water governance at the river basin and local levels. Official website of the Ministry of Environmental Protection and Natural Resources of Ukraine. URL: https://mepr.gov.ua/wp-content/uploads/2024/07/Kerivnytstvo-z-vprovadzhennya-pryntsypiv-OESR-z-vodnogo-vryaduvannya_10_07_2024.docx.

11. Kozlenko E.V., Morozov O.V., Morozov V.V. Inhulets Irrigation System: status, problems and prospects for development. Monograph [edited by O.V. Morozov, Doctor of Agricultural Sciences, Professor]. Kherson: Ailant, 2020.

12. National reports on drinking water quality and the state of drinking water supply in Ukraine for 2009–2023. Ministry for Development of Communities and Territories of Ukraine. URL: https://mtu.gov.ua/content/nacionalna-dopovid-pro-yakist-pitnoi-vodi-ta-stan-pitnogo-vodopostachannya-v-ukraini.html.

13. Post-Disaster Needs Assessment (PDNA). The 2023 disaster at the Kakhovka Hydroelectric Power Plant, Ukraine. United Nations, Ukraine. URL: https://surl.li/ppmxrf.

14. Dnipro River Basin Management Plan for 2025-2030. approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1077 of 01 November 2024.

15. River Basin Management Plan for the Azov Sea Region for 2025-2030. approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1079 of 01 November 2024.

16. River Basin Management Plan for the Black Sea Region for 2025-2030. approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1079 of 01 November 2024.

17. Special report of the Ukrainian Parliament Commissioner for Human Rights on the state of compliance with citizens' rights to clean and accessible water under martial law. Official website of the Ukrainian Ombudsman. URL: https:// www.ombudsman.gov.ua/storage/app/media/uploaded-files/cpetsdopoviddruk-1.pdf.

18. Statistical information. State Statistics Service of Ukraine. URL: https:// www.ukrstat.gov.ua/.

Appendix A

Table A.1.

Basic data from the state register of drinking and technical groundwater for 2020 in the Kherson region

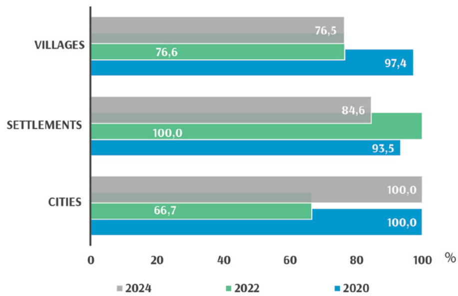
Administrative districts	Projected groundwater resources, thousand m³/day				Exploiration of resources, %	Extraction, thousand m³/day				Exploitation,%		Unused, thousand m³/day		% extraction, reserves to total extraction
	Total	Including explored reserves				Total	including explored reserves		Invaluable drainage	Resources	Reserves	Resources	Reserves	
		Total	Numb. of GWR	Numb. of EGWR			Total	Numb. of EGWR						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bilozerka	428,7	199,695	3	15	47	58,338	52,659	14		14	26	370,362	147,036	90
Beryslav	483,5	30,200	1	5	6	3,955	2,113	4		1	7	479,545	28,087	53
Velyka Oleksandrivka	46,5					0,558				1		45,942		
Velyka Lepetykha	124,6					0,823				1		123,777		
Verkhnii Rohachyk	28					0,033				0		27,967		
Vysokopillia	11,6					0,231				2		11,369		
Henichesk	219,2	15,600	1	1	7	5,584	2,389	1		3	15	213,616	13,211	43
Hola Prystan	659	83,871	5	5	13	4,215	1,048	2		1	1	654,785	82,823	25
Hornostaivka	262,9					0,651				0		262,249		
Ivanivka	123,4					0,715				1		122,685		
Kalanchak	214,9	11,400	1	1	5	0,252	0,175	1		0	2	214,648	11,225	69
Kakhovka	446,4	226,308	3	13	51	29,169	20,814	9		7	9	417,231	205,494	71
Nyzhni Sirohozy	144,7					0,501				0		144,199		
Novovorontsovka	63,5					0,459				1		63,041		
Novotroitske	161,8	0,124	1	1	0	2,267	0,022	1		1		159,533	0,102	1
Skadovsk	421,7	50,800	2	3	12	4,193	2,951	3		1		417,507	47,849	70
Oleshky	735,4	210,342	4	4	29	2,620	1,432	1		0		732,780	208,910	55
Chaplynka	395	102,200	3	8	26	6,479	4,544	4		2		388,521	97,656	70
Total:	**4970,8**	**930,540**	**23**	**56**	**19**	**121,043**	**88,147**	**40**	**0**	**2**	**9**	**4849,757**	**842,393**	**73**

Appendix B

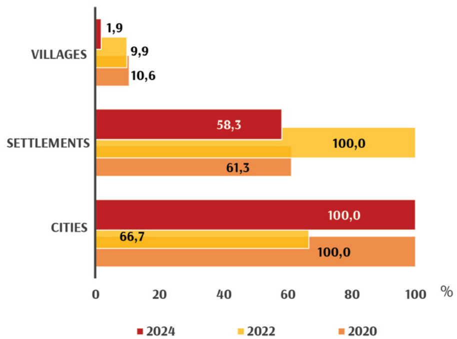
Table B.1.
Dynamics of land areas in the Kherson region covered by water of different quality [6]

Years	Irrigation, million, m^3	Irrigated land area		Irrigation water					
				Suitable		Limited suitable		Unsuitable	
		total	actually irrigated	thousand hectares	%	thousand hectares	%	thousand hectares	%
1990	1783								
1995	885								
1996		470,8	414,6	457,1	97,1	8,9	1,9	4,9	1,0
2000	499	461,9	209,6	0,0	0,0	205,6	98,1	4,0	1,9
2005	515	424,5	273,9	0,0	0,0	273,6	99,9	0,3	0,1
2009		425,1	285,0	0,0	0,0	284,8	99,9	0,3	0,1
2010	695								
2015	961	425,8	291,5	0,0	0,0	291,3	99,9	0,2	0,1
2017	1203								
2020	898								

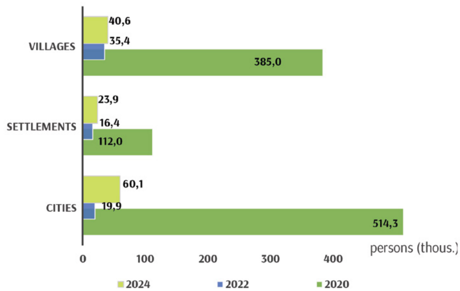
Appendix C



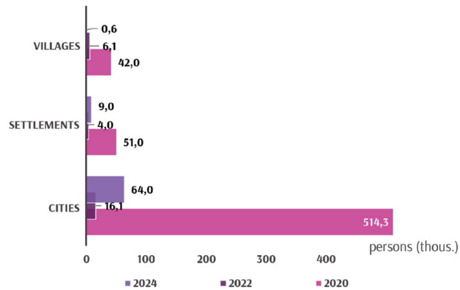
a) centralised water supply (% of the actual number of population)



b) centralised water disposal (% of the actual number of population)



c) centralised water supply (distribution by population)



d) centralised water disposal (distribution by population)

Fig. C.1. Dynamics of centralised water supply and drainage for the population of the Kherson region by type of localities

GLOSSARY

Anthropogenic factors are factors caused by human activity that directly or indirectly affect living organisms, their environment, ecosystems and the biosphere.

Basin management principle is an integrated approach to water resources management that is implemented within the boundaries of a river basin rather than according to administrative and territorial divisions. This approach aims to comprehensively address water and environmental issues by involving all stakeholders in management decisions, in line with current European practices.

Biodiversity is the variety of all living organisms, including animals, plants, aquatic life, birds, algae, fungi, etc., which interact with each other to form a variety of ecosystems.

Coastal protection strip is a part of a water protection zone of a certain width along a river, sea and around reservoirs, where stricter economic activity regulations apply.

Eutrophication is the process of enriching water bodies with biogenic elements (nitrogen, phosphorus), which leads to excessive algae growth ("water blooms").

Flood is a sudden and short-term rise in the water level in a river caused by heavy rainfall or rapid snowmelt.

Flooding is a phase of the river's water regime that recurs annually under certain climatic conditions in the same season of the year, characterised by the highest water content, high and prolonged rise and fall of water levels in rivers, lakes and reservoirs.

Geographic information system (GIS) is a modern computer technology that allows combining a model image of a territory (electronic representation of maps, diagrams, satellite and aerial images of the Earth's surface) with tabular information (various statistical data, lists, economic indicators, etc.).

Hydrographic network is a set of watercourses and water bodies within a certain territory of a river system or river basin.

Hydrological regime is regular changes in the hydrological elements of a water body over time, caused by the physical and geographical conditions of the basin, primarily climatic conditions.

Hydromelioration is a set of hydraulic engineering measures aimed at improving the water regime of soils and lands to increase their fertility and effective use in agriculture.

Hydrotechnical structure is an engineering structure that helps to implement certain water management measures both in terms of water resources use and protection against the harmful effects of water.

Integrated water resources management (IWRM) is a management system based on accounting for all types of water resources (surface, groundwater and recycled water) within geographical boundaries (river basins), which links the interests of different industries and levels of water use hierarchy, involves all stakeholders in decision-making, and promotes the efficient use of water, land and other natural resources for the sustainable provision of nature and society's water needs.

Irrigated agriculture is a complex of agrotechnical, meliorative and organisational and economic measures for the intensive agricultural use of irrigated land.

Maximum permissible concentration (MPC) is an indicator of the safe level of harmful substances in the environment, the maximum amount of a harmful substance per unit of volume or mass in water, air or soil that has virtually no effect on human health.

Nature reserve fund is areas of land and water, natural complexes and objects that have special environmental, scientific, aesthetic, recreational and other value and are designated for the purpose of preserving the natural diversity of landscapes, the gene pool of the animal and plant world, maintaining the overall ecological balance and ensuring background monitoring of the environment.

Pollutant is any substance that, when released into a water body, deteriorates its quality.

Public utilities sector is responsible for water supply and sanitation for the population.

Rational nature management is the use of natural resources in quantities and ways that ensure sustainable economic development, harmonisation of the interaction between society and the natural environment, rationalisation of the use of natural resources potential, and economic mechanisms for environmentally safe nature management.

Reservoir is an artificial reservoir created to accumulate water reserves for economic use and flow regulation.

Resources-saving technologies are methods and solutions aimed at the rational use of natural resources, reducing costs and minimising negative impacts on the environment.

River basin management plan (RBMP) is a strategic document developed with the aim of achieving and maintaining “good” water status in the basin, addressing key water and environmental issues (pollution, hydromorphological changes, climate change impacts, etc.) and fulfilling Ukraine’s European integration commitments.

Sanitary protection zone is an area and water area where a special sanitary and epidemiological regime is introduced to prevent contamination of centralized water supply sources.

Self-purification of water bodies is the ability of ecosystems to restore their condition after receiving excessive amounts of pollutants, including excess dead organic matter (detritus).

Stakeholders are interested parties involved in water resources management, including agriculture, public utilities sector, energy and nature conservation.

State water monitoring is a system for observing, collecting, processing, storing and analysing information on the state of water bodies, forecasting changes and developing scientifically based recommendations for management decisions.

Sustainable Development Goals (SDGs) is a set of 17 global goals developed by the UN, which Ukraine is committed to achieve, particularly, SDG 6 “Clean water and sanitation”.

Sustainable management is a long-term approach to water resources management that ensures water security, ecosystem balance and adaptation to climate change.

Wastewater is water generated as a result of domestic and industrial activities.

Water balance is a quantitative comparison of water resources and water needs of all sectors of the national economy in a given territory.

Water balance is a quantitative ratio of water gains, losses and accumulation over a given period (year, season, month, etc.) for any territory or water body.

Water Framework Directive (2000/60/EC) is a European Union regulatory act that establishes a framework for the protection of all water bodies (including marine waters up to one nautical mile from the coast). It is one of the key EU directives that Ukraine has committed to implementing to improve water resources management.

Water intake is a structure for taking water from a river, reservoir, etc. for the purpose of supplying it to localities, irrigating agricultural land, etc.

Water monitoring is a system of continuous observation, collection and processing of data on the state of water bodies, forecasting changes and developing scientifically based recommendations for management decisions that may affect the state of water.

Water quality is a set of physical, chemical and biological indicators that characterise the suitability of water for a particular type of water use. **“Good water status”** or **“good ecological and chemical status”** is key to assessing and managing water resources. **The ecological status of a surface water body** is determined by biological indicators using hydromorphological, chemical and physicochemical indicators and, based on ecological water quality standards, is classified as “excellent”, “good”, “satisfactory”, “poor” or “very poor”.

Wetlands are natural ecosystems that include water bodies, marshes, peat bogs and other swampy areas, which are important sources of water and centres of biodiversity, acting as natural filters and flood protection.