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Analysis of International Practices of Water Resources Protection in Conflict Regions: Lessons for Ukraine

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ABSTRACT

It is determined that the norms of international humanitarian law, in particular Articles 54 of Additional Protocol I and 14 of Additional Protocol II to the Geneva Conventions of 1949, form a comprehensive regime for the protection of water infrastructure, prohibiting its destruction or use as a means of pressure on the civilian population. It has been found that modern conflicts are characterized by high vulnerability of water bodies to asymmetric attacks, cyberattacks and manipulation of water levels, which requires the integration of effective monitoring and early response mechanisms. The importance of harmonization of the national legislation of Ukraine with international standards to ensure the legal protection of water infrastructure and responsibility for violations was emphasized. The role of international initiatives, in particular the Global Alliance for the Protection of Water Resources, in the formation of a systematic approach to coordinating the actions of states and humanitarian organizations in conflict regions was emphasized. It was stated that digital technologies, including satellite monitoring and unmanned platforms, significantly increase the accuracy of risk assessment and the efficiency of response to damage to water infrastructure. It has been established that the involvement of local communities and increasing their capacity is a necessary prerequisite for the sustainability of water supply and recovery of systems after conflicts. It is noted that international UN resolutions, the Geneva Principles and national guidelines outline legal guidelines for the protection of water resources and minimization of humanitarian and environmental risks. It has been established that a comprehensive combination of legal, technological, humanitarian and institutional instruments forms the basis for stable and safe water resources management. It was emphasized that the implementation of these measures during the post-war recovery period creates preconditions for the protection of civilians and ensuring the sustainability of Ukraine's water systems in the long term.

KEYWORDS

protection of water resources, water infrastructure, international humanitarian law, conflict regions, civilian population, cyberattacks, post-war reconstruction.

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Аналіз міжнародних практик захисту водних ресурсів у конфліктних регіонах: уроки для України

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СТАТТЯ

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АНОТАЦІЯ

У статті досліджено питання захисту водних ресурсів у конфліктних регіонах. Визначено, що норми міжнародного гуманітарного права, зокрема статті 54 Додаткового протоколу I та 14 Додаткового протоколу II до Женевських конвенцій 1949 року, формують комплексний режим охорони водної інфраструктури, забороняючи її руйнування або використання як засобу тиску на цивільне населення. З'ясовано, що сучасні конфлікти характеризуються високою вразливістю водних об'єктів до асиметричних атак, кібератак та маніпуляцій рівнями води, що потребує інтеграції ефективних механізмів моніторингу та раннього реагування. Наголошено на важливості гармонізації національного законодавства України з міжнародними стандартами для забезпечення правової захищеності водної інфраструктури та відповідальності за порушення. Підкреслено роль міжнародних ініціатив, зокрема Глобального альянсу із захисту водних ресурсів, у формуванні системного підходу до координації дій держав та гуманітарних організацій у конфліктних регіонах. Констатовано, що цифрові технології, включно з супутниковим моніторингом і безпілотними платформами, значно підвищують точність оцінки ризиків та оперативність реагування на пошкодження водної інфраструктури. Встановлено, що залучення місцевих громад і підвищення їх потенціалу є необхідною передумовою стійкості водопостачання та відновлення систем після конфліктів. Зауважено, що міжнародні резолюції ООН, Женевські принципи та національні інструкції окреслюють правові орієнтири для захисту водних ресурсів та мінімізації гуманітарних і екологічних ризиків. Встановлено, що комплексне поєднання правових, технологічних, гуманітарних та інституційних інструментів формує основу для стабільного і безпечного управління водними ресурсами. Підкреслено, що реалізація зазначених заходів у період повоєнного відновлення створює передумови для захисту цивільного населення та забезпечення стійкості водних систем України у довгостроковій перспективі.

КЛЮЧОВІ СЛОВА

захист водних ресурсів, водна інфраструктура, міжнародне гуманітарне право, конфліктні регіони, цивільне населення, кібератаки, повоєнне відновлення.

1. Introduction

The issue of ensuring adequate protection of water resources in conflict regions occupies an important place in modern aspects of international security, because water is a strategic element of civilian infrastructure, the vulnerability of which increases in the context of armed confrontations. Given the increasing frequency of attacks on water supply facilities and the use of water infrastructure as a means of pressure on the civilian population, there is a need for a systematic analysis of current trends and international legal norms governing the protection of water systems, which, remarkably, determines the relevance and subject of this study.

2. Literature Review

The analysis of recent studies and publications shows that the problem of the relationship between armed conflicts and water degradation has acquired a systematic scientific understanding within the framework of modern interdisciplinary approaches. In particular, J. Schillinger, G. Özerol, Ş. Güven-Griemert and M. Heldeweg prove that armed conflicts significantly disrupt water resources management [1]. At the same time, O. Shumilova, K. Tockner, A. Sukhodolov, V. Khilchevskyi, L. De Meester, S. Stepanenko, G. Trokhymenko and P. Gleick, based on empirical data, demonstrate the large-scale impact of the Russian-Ukrainian armed conflict on the state of aquatic ecosystems and critical infrastructure of Ukraine [2]. G. Özerol and Schillinger J. summarize important patterns of the impact of hostilities on water management systems [3]. S. Döring focuses on the need to integrate water governance with policies for overcoming conflicts and responding to climate risks [4]. Z. Nouri, W. B. Salah and N. M. AlOmran substantiate the importance of strengthening international legal mechanisms for the protection of water resources in armed conflicts as a basic prerequisite for ensuring the security of the civilian population [5].

3. Problem Statement

The article is aimed at analyzing international practices of water resources protection in conflict regions and outlining relevant lessons for Ukraine.

4. Methods and Materials

In the process of the study, a set of methods was used that provided a comprehensive analysis of international practices for the protection of water resources in conflict regions and the formation of recommendations for Ukraine.

1. Theoretical and legal analysis. It was used to study the norms of international humanitarian law, in particular the Geneva Conventions of 1949, Additional Protocols I and II, UN resolutions, and the Geneva Principles for the Protection of Civilian Infrastructure. This made it possible to systematize legal mechanisms for the protection of water resources during armed conflicts.

2. Comparative legal method. It was used to compare the normative approaches of different countries included in the analysis (Syria, Iraq, Afghanistan, Israel-Palestine, Ethiopia, Yemen), as well as to compare the national legislation of Ukraine with international standards. This made it possible to identify gaps and opportunities for improving legal regulation.

3. System analysis of international cases. Based on the reports of international organizations (UN-Water, ICRC, UNICEF, UNESCO, Global Water Security Alliance), the structures of water resources management models in conflict conditions, approaches to responding to infrastructure destruction, countering cyberattacks and asymmetric threats have been carried out.

4. Content analysis of analytical and expert materials. More than 60 international reports, studies, analytical reviews, and official recommendations have been processed, including on satellite monitoring, the use of unmanned systems, and digital platforms for early response.

5. Method of institutional analysis. Used to assess the role of key international actors – the UN, ICRC, international humanitarian missions, water partnerships – in coordinating the protection of water systems in conflict regions.

6. Elements of predictive modeling. Possible scenarios for the development of risks for the water infrastructure of Ukraine are analyzed, taking into account modern challenges (cyberattacks, targeted destruction, water blockade), as well as the potential of digital technologies to minimize them.

The materials of the study included: international treaties, conventions and protocols on international humanitarian law; official reports of the UN, ICRC, WHO, UNICEF, UNESCO, UNDP; analytical documents of international water partnerships and research centers; satellite data, open maps and technical reports on the state of water infrastructure in conflict regions; Ukrainian legislation and government strategies in the field of water security and restoration. The application of these methods ensured comprehensiveness of the study, a combination of legal, technological, humanitarian and institutional aspects of water resources protection.

5. Results and Discussion

Article 54 of Additional Protocol I to the Geneva Conventions of 1949 [6], which regulates the protection of victims of international armed conflicts, expressly prohibits any impact on objects that ensure the life of the civilian population. In particular, the normative provision contains a requirement not to attack, destroy, decommission or render unusable water supply infrastructure and related water supplies. Also, irrigation systems, if their deliberate failure could make it impossible for civilians to access the resources necessary for subsistence. It is noteworthy that this provision applies regardless of the motives of the parties to the conflict, including cases when the destruction of infrastructure is carried out to create conditions of famine, forced displacement or other forms of pressure on the civilian population.

In turn, Article 14 of Additional Protocol II to the Geneva Conventions of 1949 [7] duplicates and specifies the prohibition on attacks, destruction and rendering unusable objects critical for the survival of the civilian population, including infrastructure for the supply of drinking water, water resources and irrigation facilities. The content of this article emphasizes the universality of the approach of international humanitarian law to the protection of water resources; after all, it fixes a separate group of objects that have a special humanitarian status in any conflict environment.

It should be noted that the consistency of Articles 54 and 14 forms a comprehensive regulatory regime that protects water resources as an element of life support and, at the same time, emphasizes the prohibition of the use of water infrastructure as an instrument of military or political pressure. In view of this, international humanitarian law actually establishes a complex standard for the protection of water bodies, which covers the physical inviolability of infrastructure and the inadmissibility of its transformation into a means of influencing the behavior of the civilian population or the opposing party. In the context of the study of water protection practices in conflict regions, the relevance of these provisions lies in the fact that they set clear international legal guidelines for states and non-state actors regarding the inadmissibility of harmful actions against water infrastructure. At the same time, their implementation in modern conditions demonstrates significant challenges, in particular those related to asymmetric conflicts, the use of unconventional tactics, and the high vulnerability of water systems. Under these conditions, the formation of appropriate mechanisms of control and responsibility is of particular importance for minimizing humanitarian risks.

Instead, the Instruction on the Procedure for the Implementation of International Humanitarian Law in the Armed Forces of Ukraine, approved by the Order of the Ministry of Defense of Ukraine dated 23.03.2017 No. 164 [8], determines that the category of serious violations of international humanitarian law directed against the civilian population includes the restriction of people's access to water resources. The document directly emphasizes the prohibition of destruction, removal, or deliberate disabling of objects, necessary to ensure the livelihood of the civilian population, in particular facilities for the supply of drinking water, its storage and irrigation systems. The Regulation clarifies that such objects can be hit only if they are used to ensure the activities of enemy military units or direct support of its hostilities. It is noteworthy that the regulation applies to the protection of material objects of water infrastructure and to guarantee stable access of the population to critical resources.

In turn, modern international initiatives also focus on the criticality of water infrastructure in conflict situations. Thus, during the Civilian Protection Week 2024, Slovenia, Switzerland and the Geneva Water Hub initiated the creation of the Global Alliance for the Protection of Water Resources from Armed Conflict. armed conflicts on freshwater resources and related infrastructure. The new initiative received support from Costa Rica, Jordan, Indonesia, Mozambique, Panama, Senegal, Vietnam,

as well as UNICEF, PAX and the Geneva Call [9]. At the same time, the materials of these discussions emphasize that the consequences of the armed conflict for water supply facilities and other vital services are characterized by duration, scale and significant humanitarian, environmental and socio-economic risks. At the same time, children, women and the elderly are especially vulnerable in such conditions.

It should be emphasized that the formation of the Global Alliance reflects the systematic transition of the international community to the creation of institutionalized mechanisms for coordinating actions to protect water resources in conflict regions. The initiative actually integrates different approaches to overcoming the consequences of the destruction of water infrastructure, combining humanitarian, legal and environmental instruments. At the same time, the coordination of efforts of states and international organizations forms the basis for the introduction of long-term response models that minimize humanitarian losses and ensure the sustainability of water systems in the future. In this context, it is especially important to take into account that most modern conflicts are accompanied by targeted attacks on water infrastructure, which are increasingly used as an element of pressure or a tool of destabilization. Accordingly, the formation of international alliances aimed at protecting water resources creates an opportunity to rethink the safety standards of water systems and adapt them to new types of threats. This aspect opens up prospects for the development of new practices of monitoring, prevention and responsibility within the international community.

The Global Alliance for the Protection of Water from Armed Conflict directs its activities to consolidate international efforts in the field of ensuring the human dignity of the population suffering from hostilities. Within the framework of this format, it is envisaged to disseminate legal and technical instruments aimed at protecting freshwater resources and related infrastructure from the negative impact of armed conflicts [10]. It is noteworthy that this initiative covers responding to the consequences of attacks, as well as the formation of strategic methods for the prevention of risks associated with the destruction of water systems. In turn, important areas of current and potential cooperation between states, international organizations and technical partners include the development of analytical tools to raise awareness of the long-term consequences of attacks or military use of water bodies. These consequences include social divides, degradation of ecosystems and deterioration of general life support conditions in conflict regions. At the same time, an important task is to form a list of practical actions that parties to armed conflicts can take to strengthen the level of protection provided for by international humanitarian law, in particular through its wider dissemination, involvement of non-state armed groups, implementation of lessons learned and best practices [10].

It should be noted that the rethinking of the methods of international humanitarian law is considered as a necessary prerequisite for improving the norms governing the protection of water infrastructure in armed conflicts. In this context, it is particularly important to ensure consistency in the interpretation of the relevant provisions with their basic objects and objectives, which are to guarantee the safety of the civilian population and the inviolability of civilian objects [11]. It is noteworthy that modern challenges are primarily associated with the indirect, long-term and cumulative consequences of hostilities, which significantly complicate the practical application of the principles of proportionality and precautionary measures. In addition, the dissemination and enforcement of international humanitarian law is a shared responsibility of all states, regardless of their direct involvement in the conflict. According to the established doctrine, third states should avoid actions that may contribute to violations, in particular the supply of weapons, and at the same time actively promote compliance with humanitarian standards [11]. Incidentally, it should be noted that national and universal jurisdiction play an important role in bringing to justice serious violations of international humanitarian law, in particular those related to water resources. States are obliged to investigate the facts of possible war crimes within the framework of international and non-international armed conflicts, if such actions were committed by their citizens or on their territory. Of particular importance is the issue of responsibility for the deliberate creation of famine conditions or disproportionate attacks on water infrastructure, which may qualify as a war crime under the Rome Statute.

At the same time, the use of modern digital technologies opens up significant opportunities for improving the accuracy of risk assessment, monitoring the state of water infrastructure and ensuring a prompt response to cases of its damage. Satellite imagery, unmanned platforms, and remote sensing systems allow obtaining near-real-time data on the extent of destruction [11]. At the same time, analytical forecasting models can optimize humanitarian planning and reduce potential risks to civilians. However, digitalization is accompanied by limitations associated with the risks of technical

errors, cyberattacks, information manipulation and the spread of disinformation, which necessitate the development of high-quality data verification protocols and increasing the digital resilience of institutions. At the same time, it is worth emphasizing that the effective use of technology can significantly increase the transparency of the actions of the parties to the conflict, in particular by independently documenting attacks on water infrastructure.

Moreover, taking into account the role of local communities in the preservation and restoration of water systems is a necessary prerequisite for the effective protection of water infrastructure during conflicts. Local organizations have unique knowledge about the characteristics of water resources, the structure of water supply systems and the vulnerability of individual facilities [11]. Thanks to this, they can provide a rapid response to primary threats and contribute to maintaining a basic level of services even in conditions of limited access to humanitarian structures. Therefore, empowering local actors through skills development, providing technical resources and implementing risk management standards strengthens their capacity to rebuild systems after conflicts. An important role is also played by international support aimed at integrating the efforts of different states and organizations in the system of a single strategy for the sustainability of water systems.

Since 2020, according to the platform [12], 105 incidents have been recorded in which water or water infrastructure facilities have become a direct target of armed influence. These dynamics demonstrate the systematic expansion of practices in the use of water resources and water systems as a tool for warfare. Along the way, it is worth emphasizing that the geographical structure of these incidents covers a wide range of regions: from North Africa and the Middle East to North America, which confirms the growing vulnerability of important water bodies in modern conflicts. At the same time, the content of Table 1 allows us to state that the nature of threats is complicated by the transition from traditional destruction of hydraulic structures to targeted cyberattacks on automated control systems. In particular, cases in the United States, Israel and Ethiopia demonstrate a new format of risks, when harmful digital interventions can disrupt the chemical balance of water or stop critical facilities, creating potentially large-scale humanitarian consequences. It is noteworthy that these forms of influence actually neutralize the territorial boundaries of conflicts, because virtual attacks can be carried out at a considerable distance from the place of physical confrontation.

Table 1. The Largest Water Conflicts of an Armed Nature

Year	Event	Country	Description
2020	Attack on a water pumping station in Libya, which cut off the water supply to 2 million people	Libya	An armed group seized a control station in Schwerif, causing a temporary water cutoff for the population of the capital, Tripoli, demonstrating the high level of vulnerability of civilian water infrastructure in armed conflicts.
2020	Cyber attack on Israel's water supply systems	Israel, Iran	Iran's attempt to interfere with Israel's water supply systems through a cyber attack underscores the urgency of cyber threats to water infrastructure.
2020	Plan for water poisoning by neo-Nazi groups in the United States	USA	Neo-Nazi organizations planned a terrorist attack by polluting water; Law enforcement agencies made seven arrests, indicating the risks of using water as a means of terror.
2021	Manipulation of Water Treatment Chemical Parameters in Florida	USA	Unauthorized access to the software led to an increase in the alkalinity of drinking water; the incident was localized in time, demonstrating the need for monitoring and control of water supply systems.
2021	Damage to a wastewater plant by malware in Nevada	USA	The attack on the SCADA system of the wastewater treatment plant highlighted the vulnerability of the infrastructure to cyber threats and the need to increase the cyber resilience of water bodies.
2021	Ransomware attack on a drainage system in Maine	USA	The ransomware disabled the automated system, forcing the switch to manual control, demonstrating the critical importance of the continuous functioning of the water infrastructure.
2022	Destruction of the dam that blocked water to Crimea	Ukraine, Russia	The destruction of a concrete dam built by Ukraine in 2014 to block the North Crimean Canal has caused significant disruptions to water supplies, underscoring the strategic role of water bodies in conflicts.
2022	Cyberattack on the Great Ethiopian Renaissance Dam	Egypt, Ethiopia	An attempt to cause flooding downstream and disrupt energy supply, illustrating the use of water infrastructure as an instrument of political pressure.

Year	Event	Country	Description
2022	Damage to the Pechenega dam on the Seversky Donets	Ukraine, Russia	The blowing up of two locks and a road to complicate the offensive emphasizes the tactical use of water infrastructure in combat conditions.
2022	Flooding of territories north of Kyiv to deter Russian armored vehicles	Ukraine, Russia	The destruction of a hydraulic structure near Kozarovychi in order to flood the floodplain of Irpin demonstrates the strategic use of water resources in defensive operations.
2023	Manipulation of the water level in the reservoir behind the Kakhovka dam	Ukraine, Russia	Russian troops have changed the volume of water discharge, posing a threat to the water supply of Enerhodar, Melitopol, Berdyansk and the cooling systems of the ZNPP, highlighting the complexity of water management in wartime.
2023	Destruction of the Kakhovka dam on the Dnieper	Ukraine, Russia	Large-scale floods, more than 50 deaths, environmental and infrastructure losses, and interruption of water supply to several settlements which demonstrate the catastrophic consequences of the destruction of key water bodies.
2023	Destruction of the dam on the Mokri Yali River	Ukraine, Russia	The explosion of the dam caused flooding and was intended to slow down the Ukrainian counteroffensive, illustrating the tactical use of water resources in military operations.
2023	Capture of water sources in the West Bank	Palestine, Israel	Israeli settlers have established control over water bodies, causing damage to Palestinian rural areas, which highlights the socio-political dimension of water conflicts.
2023	Complete Water Shutdown Gaza	Palestine, Israel	The shutdown of the water supply under the blockade demonstrates the use of water as an instrument of humanitarian pressure.
2023	Attacks on school water systems in Iran	Iran	A series of poisonings of more than 100 people in Qom reflects the threat to the safety of water systems in civilian institutions.
2023	Water pump explosion in Oi	Burkina Faso	The IED caused the death of 21 civilians and damage to water infrastructure, demonstrating the direct impact of conflicts on civilian objects.
2023	Water poisoning at Farah religious school	Afghanistan	The hospitalization of about 40 schoolgirls after consuming contaminated water illustrates the need to protect educational institutions.
2023	Blowing up Al Shabaab water wells	Somalia	The destruction of infrastructure and damage to homes in the villages of Ceel Qoxle and Ceel Garas demonstrates the strategic use of water in unstable regions.
2023	Protests against the increase in water prices	Ecuador	The seizure of the El Ceibal water treatment plant, which led to the cessation of water supply for about 400 thousand people. people, emphasizes the socio-economic aspects of water conflicts.
2024	Attempted poisoning of water tanks in Homs	Syria	The execution of a QDW member after a failed water poisoning attempt demonstrates the critical importance of water system security in high-risk areas of violence.
2024	Pro-Russian hacktivists gain control of water supply in Texas	USA	Unauthorized access to water body control systems caused flooding, highlighting the current cyber risks to critical infrastructure.
2024	Killing civilians and destroying a water tower in Mali	Mali	FAMA and Wagner forces killed five civilians and blew up a water tower, illustrating the direct impact of armed groups on water infrastructure.
2024	Destruction of more than 30 water wells in Gaza	Palestine / Israel	Hostilities have led to massive losses of water resources, highlighting the humanitarian aspect of water conflicts.
2024	Cyberattack on Tipton Treatment Plant	USA	The Tipton Wastewater Plant's system was hacked, forcing the switch to manual control mode, demonstrating the importance of cyber defense.
2024	Two-day cyberattacks on wastewater systems	USA	A pro-Russian group manipulated HMI systems by posting videos of attacks, highlighting the threat to public safety due to cyber incidents.
2024	Shutdown of RSF water supply in Northern Darfur	Sudan	The seizure of the reservoir and the closure of pipelines at Hazan Golo demonstrate the impact of armed conflicts on the population's access to water.
2024	Explosion of the central reservoir of Rafah	Palestine / Israel	The destruction of a tank with a volume of 3 million liters of water had a critical impact on the region's water supply.
2024	Protest at the Ancipa dam (Sicily)	Italy	The blockade of distribution facilities has caused the suspension of water supply to several municipalities, demonstrating the social consequences of water scarcity.
2024	Attack on Texas water utilities by a group linked to Russia	USA / Russia	Equipment manipulation caused tanks to overflow, highlighting the global risks of water infrastructure in the context of cyber conflicts.

Source: Compiled based on [12].

It is also worth paying attention to the cases of deliberate flooding of territories and destruction of dams observed in the context of the Russian-Ukrainian war. In particular, the events of 2022-2023, namely the explosion of dams, manipulation of reservoir levels, and the destruction of facilities in the area of the Kakhovka hydroelectric power plant, reflect the tendency to use water as a factor of operational and tactical deterrence, which at the same time forms long-term environmental and social risks for the civilian population. It is synonymous that such actions violate international legal norms for the protection of life-supporting infrastructure.

Special emphasis should be placed on incidents related to water poisoning in educational institutions and religious communities (Iran, Afghanistan), which demonstrate the ambivalence of water threats. Therefore, such cases reflect significant gaps in the monitoring and safety systems of public water use in certain regions. It is also significant that in 2024 there will be an increase in the frequency of hybrid attacks, which combine physical strikes, cyber interference and social destabilization due to blocking or intercepting control over water supply. These incidents, primarily in the United States, Palestine, Mali, and Sudan, indicate increased competition for access to water resources and conflict-induced degradation of water infrastructure management systems. The summary shows that since 2020, there has been an increase in the number of armed incidents targeting water infrastructure, with cyberattacks, blowing up of hydraulic structures and deliberate manipulation of water resources dominating.

At the same time, UN Security Council Resolution 2573 (2021) [13] emphasizes the importance of preventing damage or destruction to civilian infrastructure, particularly facilities that meet the basic needs of the population in conflict conditions. The document focuses on the systemic interconnectedness of critical services and condemns unlawful attacks or misuse of such facilities. It is noteworthy that the resolution expands the scope of protection, directly including "facilities critical for the provision of essential services", which forms the basis for the modern interpretation of water infrastructure as an important element of life support.

Consistent with these provisions is Resolution 2417 (2018) [14], which emphasizes the crucial role of water resources and water management systems in ensuring food security in conflict situations. This document certifies that damage to water bodies makes it impossible for agricultural systems to function normally and thereby increases humanitarian risks. At the same time, the document emphasizes the need for strict compliance with international humanitarian law, including the ceasefire and restrictions on the supply of weapons. Incidentally, it should be noted that the systematic violation of these norms in modern conflicts reinforces the relevance of the assessment of international mechanisms for the protection of water infrastructure.

It is appropriate to note that the totality of these resolutions forms the conceptual basis for the further development of international standards for water safety. They fix the legal obligations of states and form practical guidelines for minimizing risks to the civilian population. In this context, the norms aimed at preventing attacks on water bodies as an important component of life support are of particular importance, because it is water infrastructure that most often becomes an instrument of pressure in modern conflicts.

In addition, the Geneva List of Principles for the Protection of Water Infrastructure [15] summarizes the provisions of international law regulating the protection of water systems in armed conflicts. Although most of the included principles reproduce current legal obligations, the document complements them with recommendations that go beyond the direction of formally enshrined norms. In particular, it provides for the possibility of establishing special protected zones around water bodies and negotiating the inclusion of provisions on water infrastructure security guarantees in ceasefire agreements.

Significantly, such recommendations are largely based on the practice of functioning of international missions and humanitarian organizations in conflict regions. The above allows us to adapt the regulatory framework to the conditions of a particular conflict and ensure its effective application in situations where legal mechanisms are insufficient. In this aspect, it is especially important to take into account the experience of states that have already integrated these principles into national strategies for managing water resources in conditions of danger. Thus, international experience demonstrates the need for an integrated approach to the protection of water infrastructure in conflict conditions. With this in mind, Ukraine can identify the following important steps to strengthen water security and ensure the livelihood of the civilian population:

1) harmonization of national legislation with international standards (it is recommended to strengthen the compliance of Ukrainian legislation with the norms of international humanitarian law; it is important to ensure a clear regulation of the procedure for the protection of water bodies, including determining the conditions for their possible destruction only if they are used to support enemy hostilities);

2) development of monitoring and early response mechanisms (it is necessary to introduce systems for monitoring and monitoring the state of water bodies using modern digital technologies for prompt detection of physical and cyber attacks);

3) increasing cyber resilience and physical protection of water infrastructure (Ukraine should create comprehensive measures for cyber protection of water body management systems, as well as strengthening physical structures: dams, pumping stations, reservoirs and treatment facilities);

4) institutional and international cooperation (it is necessary to intensify Ukraine's participation in international initiatives);

5) developing the capacity of local communities and humanitarian preparedness (to actively involve local organizations and communities in the conservation and restoration of water systems, improve their skills, provide technical resources and risk management standards);

6) legal regulation and responsibility for violations (Ukraine should strengthen mechanisms of legal responsibility for intentional damage to water infrastructure and restriction of access to water, including the investigation of war crimes). However, these steps should be implemented already in the post-war recovery period in order to lay the foundation for sustainable and safe water resources management in the future.

6. Conclusions

Summarizing the results of the study, it should be stated that the international experience in the protection of water resources in conflict regions demonstrates the need for an integrated approach that combines legal, humanitarian, technological and institutional tools aimed at ensuring the life support of the civilian population and the inviolability of water infrastructure. The analysis showed that the harmonization of national legislation with international standards, the development of monitoring and early response mechanisms, increasing cyber resilience and physical protection of water bodies, intensifying international and local cooperation, developing the capacity of communities and ensuring legal responsibility for violations form a systemic basis for water security. At the same time, the relevance of these measures is due to modern challenges, including asymmetric conflicts, cyberattacks and manipulation of water systems, as well as the need to integrate the lessons of international initiatives and practices of humanitarian organizations. Therefore, the implementation of the experience of other states, the use of digital technologies to monitor and engage local communities, increases the resilience of water supply systems, and international alliances provide a platform for agreeing on response strategies and minimizing humanitarian risks. The recommended implementation of these measures, already in the period of post-war recovery, will create the basis for stable and safe management of water resources in Ukraine in the future.

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