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INTERNAL AND EXTERNAL FACTORS OF USE AND CONSERVATION OF WATER RESOURCES IN ZHYTOMYR REGION

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Abstract. The water resources of Zhytomyr region are an important national asset, the condition of which affects people's health, economic development and the "good" environmental condition of the region. The current state of water resources in Zhytomyr region is of some concern due to a number of challenges, including: water pollution with organic materials, nutrients and toxic elements due to incomplete or no wastewater treatment, leaching of pollutants from agricultural land and plastic waste. The challenges also include limited access to quality drinking water in some regions, underdeveloped water supply and sanitation systems, unregulated water consumption and violations of water protection regulations, and hydromorphological changes related to hydropower and water flow regulation, including problems with coastal protection zones and water protection zones, as well as the effects of climate change, including floods and droughts.Taking this into consideration, conducting a SWOT analysis for the use and conservation of water resources in Zhytomyr region gets a particular relevance. The purpose of the study is to conduct a SWOT analysis that will not only allow a deeper analysis of the strengths and weaknesses of the regional water management system, but also to identify potential opportunities for improvement and risk reduction. The SWOT analysis will serve as the basis for developing strategies that will promote the conservation and rational use of water resources, strengthen the environmental well-being of the region, and ensure sustainable economic development and public health in Zhytomyr Region.

Keywords: environmental safety, water resources management, sustainable development, SWOT-analysis.

1. Introduction

The hydrographic network of Zhytomyr region is located within the Prypiat River sub-basin (56 % of the territory or 16.6 thousand km^2) and the Middle Dnipro (44 %), or 13.2 thousand km^2. The average river runoff is 3300 million m^3, of which 2800 million m^3 is generated in the region. Surface water resources in the region are formed mainly from local runoff in the river network, mainly on its own territory, due to precipitation, as well as transit runoff coming from neighboring regions. The water content of the region's rivers is quite uneven across seasons and climatic zones. Thus, the water content of the rivers in the northern regions is 1.5–2 times higher than in the southern regions, up to 70 % of the river runoff falls on spring floods or summer floods, and only 30 % – on the rest of the year. There are no large rivers in the structure of the hydrographic network; the medium-sized rivers include the Teteriv, Sluch, Irsha, Ubort, Stviga, Slovechna, Uzh, and Irpin (Regional reports on the state of the environment in Ukraine, 2023).

There are 53 reservoirs in the Zhytomyr region, with a total area of 7.6 thousand hectares and a total volume of 165.6 million m^3 and 2075 ponds with a total area of 12.3 thousand hectares and a total volume of 148.9 million m^3, of which 4 reservoirs with a total area of 0.48 thousand hectares are on the balance of the Pripyat River Basin Management Unit (here and after – RBMU) (Denyshi Reservoir, located in the village of Denyshi. 255 hectares; Otsechne Reservoir, located in the village of Teterivka, 320 hectares; Zhytomyr Reservoir, located in Zhytomyr, 390 hectares;

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Malyn Reservoir, located in Malyn, 805 hectares) and 61 ponds with a total area of 1.1 thousand hectares, as well as 61.6 km of protective dams. 76 rivers with a length of 1110.5 km are registered as main canals, and 361 hydraulic structures have been built on them. The use of artificial water bodies in the region is carried out to meet the needs of energy, drinking water supply and domestic needs of the population (Environmental passport of Zhytomyr region, 2023). Most of the ponds in Zhytomyr region are built on small rivers and streams, and as a result, their water flow is regulated by 30–60 %.

The source of water supply for the population and economic sectors of the region is surface water – 65.34 million m^3 (77 %) and groundwater – 19.89 million m^3 (23 %). The largest source of water supply is the Teteriv River basin, a right tributary of the Dnipro, from which 52.457 million m^3 were withdrawn in 2022, or 62.0 % of the total water intake in the region (Regional reports on the state of the environment in Ukraine, 2023).

In total, in 2022, 52.61 million m^3 of wastewater was discharged into the region's surface water bodies, including "normatively clean without treatment" – 26.89 million m^3, "normatively treated at treatment facilities" – 24.43 million m^3, "insufficiently treated" – 1.105 million m^3, "polluted without treatment" – 0.184 million m^3 of return (waste) water (Agency of Water Resources of Ukraine, 2023).

In accordance with the Water Framework Directive (Directive 2000/60/EC, 2000), the Prypiat RBMU provides diagnostic water monitoring and analysis of the quality status of surface water bodies in the Prypiat and Middle Dnipro sub-basin within Zhytomyr Region at 14 monitoring sites for chemical (priority) substances and chemical (basin-specific) substances. Of these, seven surface water bodies on the Teteriv, Sluch, Irsha, Hnylopyat, Uzh and Viznya rivers and 1 transboundary water body, the Ubort River, Rudnia Khochynska village, Korosten district, are monitored for chemical and physicochemical parameters, and water is abstracted to meet the drinking and household needs of the population. Priority and basin-specific indicators are determined by the Water Laboratory of the Northern Region of the Interregional Office of the Dnipro Reservoirs Protection Arrays, Vyshhorod. In total, in 2022, 88 samples were taken in Zhytomyr region and 1760 measurements of surface water composition and properties were performed. The portal "Monitoring and Environmental Assessment of the Quality of Surface Waters of Ukraine" is updated with the measurement results on a monthly basis (Portal of open data of state monitoring, 2023).

In 2022, emergency discharges of wastewater from sewage pumping stations in Zhytomyr were recorded. Zhytomyr of the ME "Zhytomyrvodokanal" in the amount of 2.8 thousand m^3 into the Teteriv River and its tributary Kamyanka River, and the wash water at the water treatment plant of the IInd lift from the washing of filters and contact clarifiers from the water supply treatment facilities was discharged into the Teteriv River without treatment in the amount of 111.2 thousand m^3. Thus, according to the State Ecological Inspectorate of the Polissia District (State Ecological Inspectorate of Polissya District, 2021), it is the Zhytomyrvodokanal that is the main polluter of surface water bodies in Zhytomyr region (the Teteriv and Kamianka rivers).

Thus, the geographical location and characteristics of the hydrographic network of Zhytomyr Oblast, spread between the sub-basins of the Prypiat and Dnipro rivers, together with the huge volume of river runoff generated mainly in the region, emphasize the importance of surface water resources for the region. At the same time, the presence of a large number of reservoirs, ponds and hydraulic structures, as well as the diverse use of water bodies to meet energy, drinking water and other domestic needs, underscores the complexity of managing and preserving these resources. The diversity of water sources, including both surface and groundwater, requires an integrated approach to water use. Therefore, the implementation of SWOT-analyzing the use and conservation of water resources in Zhytomyr region is a relevant and necessary step. Such an analysis will identify strengths, such as the significant amount of water resources and the diversity of water bodies that can be used for various purposes. At the same time, weaknesses will be identified, including existing challenges related to water pollution and inefficient wastewater treatment facilities. The analysis will identify opportunities for improvement, such as infrastructure modernization and the introduction of innovative water treatment technologies, as well as threats, including those related to climate change and uncontrolled use of water resources. In the context of the recently resumed reconstruction of the sewage treatment plant in Zhytomyr with funding from the World Bank, the SWOT analysis will be an important tool for assessing the current state of water resources, identifying management priorities, and planning further steps to ensure sustainable use and conservation of the region's water resources. This approach will help to ensure efficient water supply for the needs of the

population and economy, as well as contribute to the preservation of the ecological balance in the region.

2. Materials and Methods

The term SWOT is formed by the first letters of the words: (Strengths) strengths and (Weaknesses) weaknesses, (Opportunities) opportunities and (Threats) threats (Integrated spatial planning for amalgamated hromadas, 2018). The SWOT philosophy can be summarized as: build on strengths, eliminate weaknesses, and seize opportunities. SWOT analysis is a qualitative tool that allows to understand the community's strengths and weaknesses, identify opportunities and external factors that may hinder the achievement of development goals. Strengths and weaknesses include internal aspects, factors, and resources-those that are owned by the communities in the region or that the communities can control. Strengths and weaknesses determine the current state of water resources. Examining the strengths and weaknesses of water use and conservation in Zhytomyr region can be useful for understanding the environmental, economic, and social aspects of water management. Opportunities and threats are external factors and trends that can affect the development of a community but are not under its control. For example, geographic location determines opportunities or threats. Opportunities and threats also reflect possible future changes caused by these factors.

Thus, the following main stages of SWOT analysis can be distinguished:

– *Preparatory stage:* at this stage, a group of experts was formed and methodological approaches to the analysis were developed. The main goals and objectives of the study were also defined. A group of 16 experts was formed to conduct the assessment. These experts were selected on the basis of their professional experience and knowledge in water resources management, ecology, hydrology and related sciences. To ensure a comprehensive analysis, the expert group included representatives from different fields of expertise, which allowed for a variety of perspectives and aspects of the water sector;

– *Information collection*: the experts were provided with information on the current state of water resources in Zhytomyr region, including data on their quantity, quality, main problems and challenges;

– *Assessment of factors*: experts identified and assessed key internal and external factors that affect the use and conservation of water resources. The expert assessment of the mutual influences between internal and external factors of water resources use and conservation in Zhytomyr region was carried out as follows:

1) first, it is necessary to collect expert ratings for each factor on a 7-point Miller scale, where 1 means the weakest impact and 7 means the strongest (Foresight, 2023);

2) after collecting the data, they are aggregated, i.e., for each factor, the average values of the ratings from all experts are calculated and such data are normalized in the range from 0 to 1;

3) based on the normalized data, indicators are calculated for each group of factors. These indicators allow us to determine the effectiveness of internal and external factors of water resources use and conservation in Zhytomyr city united territorial communities (here and after – UTC).

– *Analysis and synthesis:* based on the assessments, experts conducted an analysis that allowed them to identify the most important factors. These factors were divided into four categories of SWOT analysis.

3. Results and Discussion

As a result of the work of the expert group, the most important internal (Table 1) and external factors (Table 2) that affect the use and conservation of water resources in Zhytomyr region were identified and evaluated on a 7-point Miller scale (1 – minimum value, 7 – maximum value).

Fig. 1 shows the distribution of strengths by the values of the effectiveness indicator. The effectiveness indicator characterizes the ability of a strength to influence opportunities and threats.

The analysis shows that the development of water supply and wastewater infrastructure (S2), modern water treatment technologies (S3), availability of qualified personnel (S8), greening of industry (S9), and international cooperation (S10) are the most effective areas for investment and effort. They help not only to improve water management but also to reduce potential water-related threats. Investing in these areas can bring significant benefits, including improved water quality, more stable water supplies, and improved environmental conditions.

Focusing on these strengths will ensure more sustainable and effective water management.

After analyzing the weaknesses by the values of the performance indicator, it was found that critical weaknesses (Fig. 2) indicate the main challenges in the field of water resources management:

– Lack of comprehensive integrated water resources management (W3): This indicates the need to develop and implement coherent management strategies that cover all aspects of water resources;

Table 1

The most significant internal factors of the use and preservation of water resources of Zhytomyr region

Strong factors (indicators) of use and conservation of water resources of Zhytomyr region		Quantitative values	Weak factors (indicators) of the use and conservation of water resources of Zhytomyr region		Quantitative values
S1	The presence of numerous reservoirs and water bodies	5.63	W1	Water pollution	6.44
S2	Development of water supply and drainage infrastructure	5.19	W2	Clogging with household waste	5.81
S3	Introduction of modern water purification technologies	5.06	W3	Lack of comprehensive integrated management of water resources:	5.75
S4	Availability of recreational and ecological zones	5.19	W4	Lack of drinking water in some areas of the region and unsatisfactory quality of drinking water as a whole	5.44
S5	Involvement of the public in the protection of water resources	4.88	W5	Insufficient level of development of water supply and drainage in some settlements, lack of sewage systems	5.81
S6	Water activity: open water competition “Teteriv Open”, championship of Ukraine “Drakons” in Teteriv, etc.	5.0	W6	Uncontrolled use of water resources and water protection zones	5.88
S7	The presence of reservoirs that can be used for the production of renewable energy.	4.56	W7	Non-compliance with the regime of coastal protective strips and water protection zones	5.5
S8	Availability of qualified personnel to work in the field of water resources protection	5.5	W8	Inefficient use of water both in industry and in the population	6.31
S9	Gradual greening of industry	5.31	W9	Outdated infrastructure and technologies	5.75
S10	International cooperation, cooperation with MFIs	5.63	W10	Insufficient cooperation between local self-government bodies, business and the public	5.13
–	–	–	W11	Insufficient awareness of the population	5.31
–	–	–	W12	Lack of financial resources	5.44
–	–	–	W13	Loss of local biodiversity and increase in biological invasions	5.94
–	–	–	W14	Lack of alternative sources of drinking water	5.31

Table 2

The most important external factors of the use and preservation of water resources of Zhytomyr region

Factors determining new opportunities for the use and conservation of water resources of Zhytomyr region		Quantitative values	Factors determining threats to the use and preservation of water resources of Zhytomyr region		Quantitative values
1		2	3		4
O1	Development of tourism and water recreation	5.56	T1	Climate change (including floods and droughts)	5.69
O2	Implementation of new water purification and water supply technologies	6.31	T2	Hydromorphological changes	5.69
O3	Infrastructure improvement: modernization of dams and reservoirs and flexible management of reservoirs	6.06	T3	War and the impact of military operations on water resources	5.88

Continuation of Table 2

1		2	3		4
O4	Facilitating and encouraging the introduction of technologies for the economical use of water resources and the installation of local treatment facilities by business entities	5.88	T4	Increasing pollution of water resources by industrial, agricultural and household waste	6.31
O5	Creating favorable conditions for attracting investments in infrastructure development	5.81	T5	Uncontrolled drilling of wells, as well as excessive extraction of groundwater	5.81
O6	Increasing public awareness of the importance of preserving water resources	5.81	T6	Soil erosion and clogging of watercourses	5.75
O7	Development of a system for monitoring the state of water resources	6.31	T7	Loss of biodiversity of aquatic ecosystems	5.75
O8	Development of cooperation between authorities, enterprises, public organizations and citizens	5.5	T8	Lack of effective management of water resources	6.13
O9	Development and implementation of a program of activities for the revitalization and decontamination of small rivers	6.25	T9	Non-compliance with the regime of coastal protective strips and water protection zones	5.75
O10	Development of integrated storm sewerage and treatment systems	6.19	T10	Conflicts over water resources	4.88
O11	Promotion of cooperation with scientists and conducting scientific research	6.0	T11	Threat to public health	5.56
–	–	–	T12	Impact on economic development	5.31

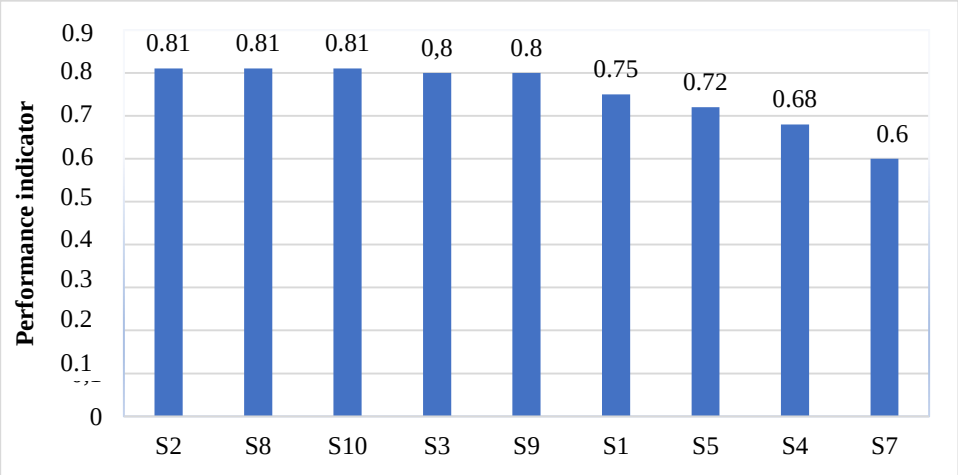

Fig. 1. Distribution of strengths by performance indicator values

- uncontrolled use of water resources and water protection zones (W6): This indicates the need to strengthen the control and monitoring of water use, as well as the protection of water protection zones;

– Uneconomical use of water by industry and population (W8): This emphasizes the need to promote the efficient use of water resources and to educate the public and industrial enterprises about the importance of water conservation;

– water pollution (W1): This emphasizes the problem of water pollution and the need to take measures to reduce and control pollutants.

The Weaknesses Effectiveness Indicator characterizes the ability of a weakness to influence

opportunities and threats (calculated on the basis of the values of the Weaknesses Indicator and the Strengthening of Threats Indicator).

Thus, these weaknesses are the most critical, as they have the greatest impact on the environment and human health. To address them, measures should be taken to establish an effective water management system, control the use of water resources and water protection zones, and raise public awareness of the importance of water conservation and preventing water pollution.

The possibilities are distributed according to the values of the feasibility indicator (Fig. 3), which characterizes the ability to perceive the positive effects of strengths and resist the influence of weaknesses (calculated on the basis of the values of the indicator of sensitivity to the influence of strengths and the indicator of sustainability to the influence of weaknesses). The values of the feasibility indicator indicate how feasible it is to realize certain opportunities in the context of strengths and weaknesses. High values of this indicator mean that the realization of a certain opportunity, despite the existing weaknesses, is quite likely and effective.

Thus, the opportunities with the highest feasibility indicators, and thus with the highest chances of successful implementation within Zhytomyr region, are the following:

O9. Development and implementation of a program of measures for the revitalization and decontamination of small rivers;

O10. Development of integrated stormwater management and treatment systems;

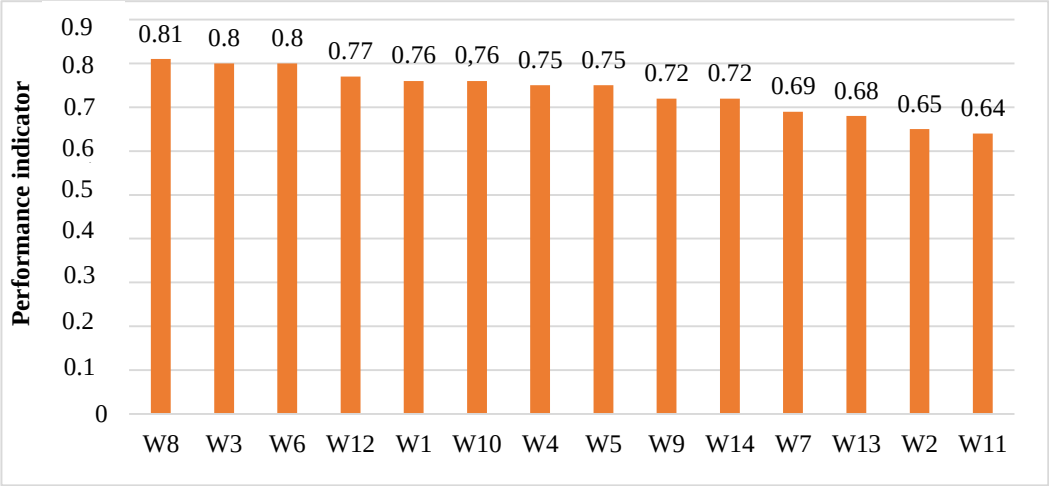

Fig. 2. Distribution of weaknesses by performance indicator values

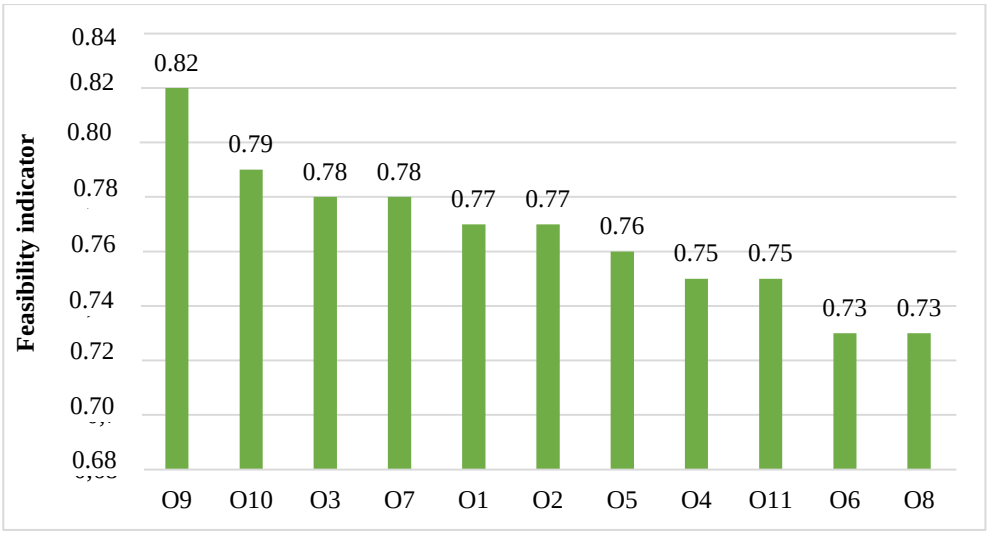

Fig. 3. Distribution of opportunities by the values of the feasibility indicator

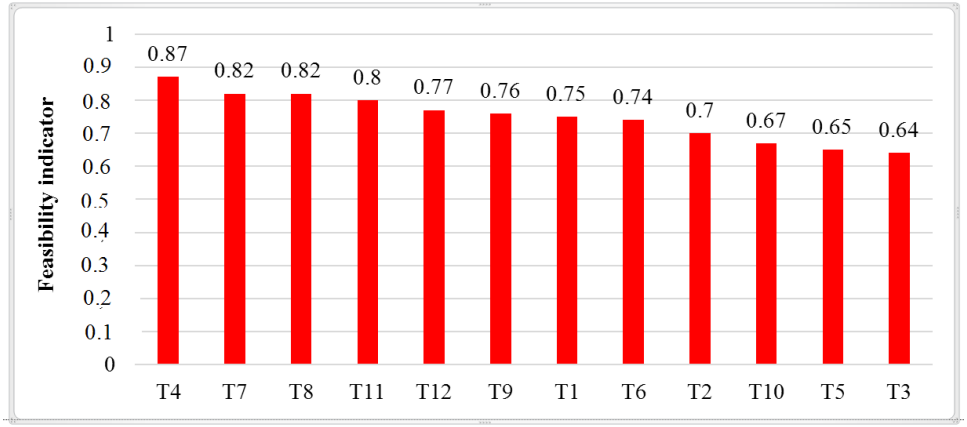

Fig. 4. Distribution of threats by the values of the feasibility indicator

O7. Development of a water resources monitoring system;

O3. Improvement of infrastructure: modernization of dams and reservoirs and flexible reservoir management.

Thus, these areas should be considered as priorities for investment and development.

The study also assessed the feasibility of the identified threats. The higher the value of the feasibility indicator for a particular threat, the more likely it is that this threat may arise or worsen due to the impact of weaknesses. At the same time, strengths can offset or reduce these threats. Thus, for effective water resources management, it is necessary to take this indicator into account in order to understand the risks and plan strategies to minimize or eliminate them. According to the analysis (Fig. 4), it was found that the following threats have the highest feasibility indicator scores:

T4. Increased pollution of water resources by industrial, agricultural and household waste;

T7. Loss of biodiversity of aquatic ecosystems;

T8. Lack of effective water resources management;

T11. Threat to public health.

Threats with high feasibility scores indicate serious risks to water management. To minimize these threats, it is necessary to: introduce stricter regulations on pollutants, strengthen control over emissions from industry, agriculture, and domestic sources; introduce measures to protect aquatic ecosystems, including banning or restricting activities that harm biodiversity; develop and implement integrated approaches to water management, engage experts, and take into account international experience; ensure the quality of drinking water, and regularly monitor and respond to water quality problems. Implementation of these measures will require joint efforts of the government, the public and the private sector.

4. Conclusion

The data analysis points to key aspects that need to be considered to improve water management in the community. Strengths, such as the development of water supply and sanitation infrastructure (S2), availability of qualified staff (S8), and international cooperation (S10), if further developed and focused on, can contribute to more sustainable and efficient water management. At the same time, the most critical weaknesses need to be addressed, which include the uneconomical use of water (W8), lack of integrated management (W3), and uncontrolled use of water resources (W6). These challenges need to be addressed immediately to prevent further deterioration. At the same time, potential areas for investment and development, such as the revitalization of small rivers (O9), the development of integrated sewerage systems (O10), and the development of monitoring systems (O7), should be considered as a priority. Investing in these areas can help solve existing problems and strengthen community water resources. Indicators of the feasibility of threats, such as increasing water pollution (T4), loss of biodiversity (T7) and lack of effective management (T8), should be part of the ongoing risk analysis. Understanding these risks will help in formulating strategies to minimize or eliminate them.

Therefore, a water resources management strategy should be multidimensional, taking into account strengths, weaknesses, opportunities for development, and potential threats. The water management strategy should have a comprehensive approach that includes

technical improvements, human resource development, international partnerships, and active community participation to ensure sustainable water management.

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