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О. Motuzka,

PhD in Economics, Associate Professor, Associate Professor of the Department of Management, Marketing and Public Administration, National Academy of Statistics, Accounting and Audit
ORCID ID: <https://orcid.org/0000-0001-9028-6994>

M. Grod,

PhD in international economic relations, Associate Professor, Department of Management, Marketing and Public Administration, National Academy of Statistics, Accounting and Audit
ORCID ID: <https://orcid.org/0000-0002-7539-5778>

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STATISTICAL ACCOUNTING OF WATER: A FACTOR OF ENVIRONMENTAL SAFETY AND ECONOMIC STABILITY OF THE STATE

О. М. Мотузка,

к. е. н., доцент, доцент кафедри менеджменту, маркетингу та публічного управління,
Національна академія статистики, обліку та аудиту

М. І. Грод,

Доктор філософії зі спеціальності "Міжнародні економічні відносини", доцент кафедри менеджменту,
маркетингу та публічного управління, Національна академія статистики, обліку та аудиту

СТАТИСТИЧНИЙ ОБЛІК ВОДИ ЯК ЧИННИК ЕКОЛОГІЧНОЇ БЕЗПЕКИ ТА ЕКОНОМІЧНОЇ СТІЙКОСТІ ДЕРЖАВИ

The purpose of the article is to theoretically generalize and analytically substantiate the importance of water resource accounting as a principal tool for effective management, economic rationality, and environmental resilience in the context of global water scarcity. The study is based on the hypothesis that improving the statistical system for water accounting creates real prerequisites for more efficient water management, reduced irrational consumption, and the formation of an integrated sustainable development policy.

The findings confirm that water statistics represent a fundamental component of the environmental policy rather than a secondary technical tool. The availability of accurate and systematic data determines the capacity of governments and enterprises to make informed decisions on water allocation, use, and conservation. It is demonstrated that a coherent accounting system provides the informational basis for aligning environmental and economic interests by integrating physical indicators of water flows and stocks with economic measures such as production costs, revenues, and value added. The introduction of a harmonized national water accounting system aligned with international standards enhances management transparency, strengthens public trust, and reduces the risks of arbitrary data interpretation. Reliable statistical indicators have direct impact on the effectiveness of economic decisions, allowing for rational investment planning, fair pricing of water services, and assessment of environmental and financial impacts. Moreover, an effective system of water statistics contributes to the stability of trans-border river basins and helps prevent international resource conflicts by creating a shared foundation of trust and cooperation. These results confirm the strategic role of statistical water accounting in ensuring water security, economic stability, and ecological balance, making its improvement a crucial direction of the modern public policy.

The research further develops the theoretical understanding of water statistics as a structural factor of ecological security. It is shown that systematic and methodologically harmonized data collection on water quantity, quality, and use forms the basis for early detection of environmental risks and prevention of ecosystem crises. Water statistics should thus be viewed not merely as a technical process but as an informational mechanism for risk prevention that enables monitoring of ecosystem dynamics, evaluation of environmental programs, and scientific justification of policy measures.

The study also advances the conceptual understanding of water statistics as a determinant of economic resilience. It highlights the role of high-quality data in shaping evidence-based decisions on resource management, investment planning, and water pricing. Accurate statistical information fosters efficient water use, strengthens financial discipline in the water sector, promotes innovation in water-saving technologies, and ensures equitable resource distribution across economic sectors. Consequently, water accounting can be regarded as a key indicator of the stability of economic policy, since it links the physical dimensions of water balance with economic performance and resource regeneration.

Мета статті полягає у теоретичному узагальненні та аналітичному обґрунтуванні значення статистичного обліку водних ресурсів як ключового інструменту забезпечення ефективного управління, економічної раціональності та екологічної стійкості у сучасних умовах глобального водного дефіциту. В основі статті лежить дослідницька гіпотеза, що вдосконалення системи статистичного обліку водних ресурсів створює реальні передумови для підвищення ефективності водного менеджменту, зменшення нераціонального споживання і формування інтегрованої політики сталого розвитку, дійшли низки висновків. В статті підтверджено, що статистичний облік водних ресурсів не є другим порядком інструментом екологічної політики, а становить її фундаментальну складову. Саме від наявності достовірних даних залежить здатність держави і підприємств ухвалювати обґрунтовані рішення щодо розподілу, використання і збереження води. Доведено, що системний облік води формує інформаційне підґрунтя для поєднання природоохоронних і економічних інтересів. Він забезпечує можливість інтегрувати показники фізичних потоків і запасів води з економічними параметрами виробництва, витрат і прибутків, що є необхідною умовою переходу до моделі зеленої економіки. Встановлено, що впровадження узгодженої національної системи водної статистики, зорієнтованої на міжнародні стандарти, підвищує прозорість управління і сприяє зміцненню довіри між владою, бізнесом і громадськістю. Завдяки цьому зменшується ризик довільного тлумачення даних і посилюється підзвітність у використанні водних ресурсів. Підтверджено, що якість статистичних показників прямо впливає на результативність економічних рішень. Точні дані дозволяють планувати інвестиції у водну інфраструктуру, визначати справедливі тарифи, розраховувати екологічні збитки та оцінювати економічну віддачу від водокористування. Доведено, що наявність ефективного системи водної статистики є запорукою стабільності у транскордонних водних басейнах і важливим чинником попередження міждержавних конфліктів за ресурси. Спільні облікові стандарти створюють основу для взаємної довіри і партнерства між країнами. Окреслене доводить, що статистичний облік водних ресурсів має стратегічне значення для забезпечення водної безпеки, економічної стійкості та екологічної рівноваги, а його вдосконалення є одним з ключових напрямів сучасної державної політики сталого розвитку.

В статті дістало подальшого розвитку обґрунтування ролі статистичного обліку водних ресурсів як системоутворювального чинника екологічної безпеки. Уперше показано, що регулярне і методологічно узгоджене збирання даних про запаси, якість і використання води формує основу для раннього виявлення екологічних ризиків та запобігання кризовим явищам у довкіллі. Запропоновано розглядати статистичний облік не як суто технічну процедуру, а як інформаційний механізм попередження загроз, який забезпечує моніторинг динаміки водних екосистем, контроль виконання екологічних програм і наукове обґрунтування природоохоронних рішень. У цьому аспекті статистика води трактується як складова системи екологічної безпеки держави, що дає можливість підвищити результативність політики охорони довкілля.

Дістало подальшого розвитку концептуальне розуміння статистичного обліку води як чинника економічної стійкості держави. Розкрито його значення для формування доказової бази економічних рішень, які пов'язані з управлінням водними ресурсами, інвестиційним плануванням та ціноутворенням на водні послуги. Обґрунтовано, що якісний облік створює передумови для підвищення продуктивності водокористування, зміцнення фінансової дисципліни у водному секторі, розвитку інноваційних технологій водозбереження та забезпечення справедливого розподілу ресурсів між секторами економіки. Запропоновано розглядати статистичний облік як ключовий індикатор стабільності економічної політики, оскільки він дає змогу поєднати фізичні показники водного балансу з економічними параметрами виробництва і відтворення.

Key words: Water resources, statistical accounting, sustainable development, environmental security, economic resilience, water management, data reliability, resource efficiency, policy transparency, ecological balance, statistical indicators, data analysis, evidence-based management.

Ключові слова: водні ресурси, статистичний облік, сталий розвиток, екологічна безпека, економічна стійкість, управління водними ресурсами, достовірність даних, ефективність використання ресурсів, прозорість політики, екологічна рівновага, статистичні показники, аналіз даних, управління на основі доказів.

INTRODUCTION

Water is gaining the status of a crucial factor in the human development in our times. No longer regarded as a mere natural phenomenon, it tends

to be valued as an economic, social, and political resource. Its availability and quality is a core determinant of human life, food safety, energy supply, industry, municipal economy, and environ-

mental performance. While land, labor, and capital were considered as core categories of economic accounting in the past, nowadays they are rightly supplemented by nature resources, water in the first place.

Climate change, rapid urbanization, increasing population, and degradation of ecosystems have caused the occurrence of a new phenomenon referred to by experts as water scarcity. As estimated by international organizations, the forthcoming decades will see water scarcity in the majority of countries. It means that the cross-sector competition for access to water resources will inevitably be stronger. Agriculture, energy supply, industries, and utility services start vying for water today, and this rivalry tends to acquire a political nature.

The aforementioned background dramatically increases the importance of reliable and regular statistical accounting of water resources. Without robust data on stocks, consumption and quality of water, a nation, its enterprises and local communities lose the capability for rational governance. The lack of statistical indicators creates a room for arbitrary decisions, ineffective use of resources, and conflicts between water users.

The statistical accounting of water lays the fundament of the current sustainable development policy. Its objective is to measure in the systematic manner all the scopes of water involved in the economic circulation, used in production, consumed by population, and coming back to the environment. These data allow for assessing the efficiency of water use, the losses in water supply systems, the scopes of pollution, and the cost of water-related services.

Water resources are not only a nature category, but also an economic one. They provide for the operation of all the economic sectors, from energy supply and transport to food industry. Therefore, a regular water accounting enables to combine physical indicators such as scopes and stocks with economic parameters, e.g. costs, revenues or value added. This lays the ground for taking balanced management decisions and setting an integrated policy of nature use.

The importance of statistical accounting is also determined by geopolitical factors. There are more than two hundred trans-border river systems across the planet, jointly used by two or more countries. The lack of coherent statistical data in these basins can often be a cause for tensions and even conflicts. Only a shared accounting of water resources can lay a background for trust, partnership, and joint planning.

Besides that, the contemporary water crisis is not confined to the scopes of water. Not less serious is the problem of its declining quality, polluted sources of surface and ground water, and the degraded natural self-purification capacity of water reservoirs. The water accounting system should, therefore, include the scopes of water along with its environmental characteristics. This enables to monitor the conditions of rivers, lakes and underground waters, to reveal timely degradation tendencies, and to plan measures for recovery.

In the era of digital technologies, water has become a principal indicator of sustainability. Its availability and quality are determinants of social stability, economic competitiveness, and environmental security of a nation. While energy resources can be substituted by other sources, water is irreplaceable. The recording of its use has, therefore, not merely technical importance, but also strategic one. The statistical accounting of water resources lays the basis for the management system allowing for not only a mere description of the current condition, but also for predicting the effects of climate change, for planning the water allocation, and for assessing investment risks.

The relevance of water statistics has been widely recognized in the global research agenda. Over the last decade, scientific interest in this area has shifted from descriptive analyses of water use to integrated frameworks that connect environmental accounting with economic and governance dimensions.

THE LITERATURE REVIEW

The literature review is structured to reflect both international and national perspectives on the development of water statistics and its role in ensuring environmental and economic sustainability. The study takes into account global approaches to water statistics, including the provisions of the System of Environmental-Economic Accounting for Water (SEEA-Water) developed under the auspices of the United Nations, as well as the principles of the sixth United Nations Sustainable Development Goal, which aims to ensure access to water and its rational use. This makes it possible to consider the proposed theoretical framework within the context of global trends and international standards for natural resource management. The analysis of contemporary scientific sources demonstrates that the issue of water accounting has evolved into an essential component of integrated environmental and economic management. Global studies highlight the strategic role of reliable statistical

systems in supporting sustainable water governance and informing policy decisions. One of the most comprehensive works in this field provides a global review of water accounting practices and indicators of best performance for effective water governance [1]. This research offers a methodological foundation for integrating physical and economic data into national accounts and contributes to understanding the systemic value of water statistics in decision-making processes.

Another significant contribution presents an overview of the corporate dimension of water accounting, emphasizing the importance of accurate measurement and reporting within enterprises [2]. This study expands the discourse on how statistical water data can be incorporated into corporate sustainability strategies, enhancing transparency and accountability in resource use. Its findings are particularly relevant for bridging the state and corporate levels of water data management.

Further empirical evidence is provided by a global review focusing on accountability and advocacy mechanisms in the water sector [3]. This work demonstrates that statistical data serve as the backbone of effective governance and public trust, linking social responsibility with evidence-based management. The findings underscore that transparent and harmonized data systems are fundamental for equitable distribution of water resources and for preventing socio-environmental conflicts.

The national context of the research is grounded in the official framework of the State Agency of Water Resources of Ukraine [11], which defines procedures for the state water use accounting system. This source provides a realistic picture of how data collection and processing are organized within the Ukrainian institutional framework and reveals existing methodological gaps that need modernization in line with international standards.

Ukrainian scholars also address related issues within the broader paradigm of sustainable economic development and ecological security [1-9]. Their contributions emphasize the need to integrate environmental statistics into the country's economic policy and demonstrate how water accounting aligns with the principles of resilience, transparency, and evidence-based governance. Particularly, national works on global and regional environmental challenges [10] help establish the theoretical link between ecological processes, natural capital accounting, and economic sustainability.

Overall, the selected literature combines global methodological approaches with national

research traditions. International sources outline conceptual and analytical frameworks for water accounting, while Ukrainian academic and institutional contributions provide the regional dimension of implementation. This synthesis enables a comprehensive understanding of water statistics as both an instrument of environmental security and a driver of economic stability. Consequently, the review confirms the relevance of addressing water accounting within a multidisciplinary framework that integrates environmental, economic, and governance dimensions.

THE PURPOSE OF THE ARTICLE

The purpose of the article is to provide a theoretical synthesis and analytical grounding of the importance of the statistical accounting of water resources as a crucial tool for the efficient management, economic rationality and environmental sustainability amidst the current global water deficit.

RESEARCH RESULTS

To grasp the water accounting significance, one needs to realize that the nature itself constitutes a complex object of economic, environmental, and social interactions. Water is a component of the environment, a production resource, and a social good at the same time, which accessibility is a determinant of the population's life. This multi-dimensional nature entails the complexity of water resource management and requires accurate statistical recording of the conditions and dynamics of water resources.

The statistical accounting of water has several interacting functions. Its foremost function is the cognitive one, providing for evidence-based understanding of the water balance in a country. It allows one to reveal the patterns of change in the stocks, consumption, and regeneration of water resources. The next function is managerial, because the accounting data lays the basis for planning of water use, elaborating water preservation strategies, and predicting the effects of anthropogenic burden. The third function is economic, because the quantitative indicators of water flows have immediate effects for the calculation of production costs, tariffs, and investments in water infrastructures.

Amidst contemporary challenges caused by climate change, increasing population and intensive urbanization, the statistical accounting will be indispensable tool enabling to reveal in a timely manner the tendencies of water deficits, to predict its consequences, and to elaborate corrective measures. Water statistics data reflect not only the

scope of water resources but the structure of their use, which is important in setting priorities of the public policy. Whenever these data are missing, a water management strategy will be formal and devoid of a practical value.

Especially important is the compliance of a water statistics system with international standards. In practice, it means the adoption of a model for integrated environmental-economic accounting combining physical and cost-based indicators. This methodology allows for assessing the economic effect from water use, the cost of water losses and the damage caused by pollution. It transforms the statistical accounting into a tool for measuring not only water resources, but also the efficiency of the public policy on water resources.

The collected data will not have an analytical capacity unless they reflect a full picture of water movement within the national economy. It includes natural sources, water consumption in industry, utility services, agriculture, as well as the scopes of water reuse and purification. The integrated recording of these processes lays the basis for calculating the water balance, allowing for measuring the water deficit along with estimating the efficiency of management decisions.

An important issue is reliability and regularity of data. The continual statistical observation is indispensable for the monitoring of water use dynamics and control over implementation of state programs. That is why the statistical accounting of water needs to rely on the established procedures of collection, verification, and aggregation of data compliant with the international requirements for comparability and transparency.

When it comes to the environmental safety, statistical information allows for revealing spatial and time tendencies in pollution, changes in the quality of ground and surface water, and for assessing the efficiency of treatment facilities and the compliance with environmental norms. It is indispensable for recording the consequences of environmental degradation and duly avoidance of adverse situations. The statistical accounting, therefore, transforms into a preventive tool providing for the scientifically informed basis for natural resource protection.

The economic role of the statistical accounting is in creating the basis for estimating the fair value of water services and planning of costs. When the government has accurate data on water use, it can adjust the tariff system, stimulate water conservation, and ensure the fair cross-sector allocation of water resources. In so doing, the government will contribute in enhancing the economic resilience, because the effective water management

has immediate effects for the industrial productivity and the social welfare.

As regards the global tendencies, the statistical accounting of water acquires the features of a backbone sustainability indicator. It allows for assessing the country's progress toward the Sustainable Development Goals, e.g. the rational water use, the population's access to clean water, and the reduction of pollution. The water statistics, therefore, apart from the information function, has the strategic one, laying the ground for setting priorities of the public policy and directions of the international cooperation.

The abovementioned demonstrates that the statistical accounting of water resources is not a separate field of statistics, but rather a comprehensive system of knowledge and procedures integrating natural, economic, and social dimensions of development. The set of statistical indicators provides a required tool for building the government's capacity for the effective management of water resources, for sustaining the environmental balance and the economic stability.

Further developments of the system for statistical accounting of water resources are driven by the need of integrating the information coming from natural sciences, economics, and management in a single analytical framework. The contemporary theory and practice of public management agree that the water statistics, apart from quantitative data recording, needs to explain the causalities between the performance of water resources and economy.

The statistical accounting of water lays the basis for the efficiency assessment of water use. The available data on actual scopes of water intake and consumption allow for estimating the productivity of water use in industry, agriculture, and public utilities. A high productivity gives evidence of the effective management, whereas a low one confirms the losses and irrational use. Such analysis helps reveal problematic spots and adjust the resource allocation policy.

Water management is strategically important for the environmental stability. Statistical accounting data allow for measuring the anthropogenic burden on water ecosystems, with predicting potential effects from climate change. The regular collection of data on pollution, temperature, the condition of underground waters, and the scopes of water cleaning creates a real picture of the environmental performance of water reservoirs. This information can shape management decisions aimed to reduce the burden and sustain the balance in nature.

From the economic perspective, the availability of statistical data enables for calculating the economic value of water as a resource. It allows for estimating not only direct costs of water use, but indirect effects related with degradation of ecosystems or increasing costs of water supply in the future. The accurate accounting of costs and results helps justify tariff-making policies and elaborate the stimuli for introduction of water-saving technologies.

Also, the statistical accounting is essential for strengthening the financial discipline in public and private entities operating in the water sector. Regular reporting on the scopes of water use and water losses is a factor of transparency and accountability in the nature use domain. This increases the trust between government, business, and population, reduces risks of corruption, and creates a friendly environment for investment in water infrastructures.

The institutional development of water statistics system requires a clear delineation of authorities between public administration bodies, research institutions, and business entities. Coordinated efforts of these entities is a premise for completeness and coherence of data. Successful international practices show that the system will be effective when a continual information exchange is established between statistics bodies, nature protecting ministries, and regional departments, with the standard methodology of data collection.

From the technical point, an important area of development is introduction of digital technologies. Applications of remote sensing systems, computerized sensors, and geo-information platforms increase the accuracy and promptitude of the accounting data. It allows for creating integrated databases combining natural and economic parameters and ensuring the comprehensiveness of economic analysis. Digitalization of water statistics helps create open information systems accessible for R&D, business, and broader public.

The development of water statistics has the social dimension. When the data on water resources utilization are open, the environmental culture of society will be higher. The citizens become conscious about the water as a shared asset. The information transparency increases individual responsibility, with the immediate impact on the efficiency of the water-saving policy.

As regards the global dimension, the significance of statistical accounting goes far beyond the national interests. As water resources do not know administrative borders, creating harmonized international accounting systems has become a

premise for the avoidance of conflicts and stability. The lack of reliable shared data often provokes tensions between the countries using a shared water basin. On the other hand, coordinated accounting can promote a dialog and shared resource management, thus reducing the risks of discords and consolidating the regional security.

The above said leads to the conclusion that the statistical accounting of water resources constitutes a backbone component of the public policy in environmental and economic domains. Its efficiency determines the government's capacity to predict the risks, to set long-term strategies, and to assure the balanced development. Apart from the quality of water resource management, the performance of the statistical accounting system determines the environmental safety, the economic resilience, and the social stability in a country.

To sum up the findings of this study, it can be argued that the statistical accounting of water resources has dual nature. It offers a tool to explore nature resources, on the one hand, and a mechanism for regulation of socio-economic relations in the nature use, on the other. Its principal purpose is to create a reliable information base for decision-making on preservation of water resources, prevention of their depletion, and enhancing the effectiveness of their use.

Statistical data on water are not confined to the quantitative dimension. They measure the pace of economic processes, the environmental awareness of society, the development of technologies and the resource management culture. Hence, the quality of statistical accounting can be regarded as an indicator of the civilizational level of a country. A nation that is able to measure, analyze, and predict changes in the water environment is capable to ensure own stability and security.

The contemporary paradigm of nature resource management is based on the integrated approach. It assumes that the statistical accounting of water is part of a broader system of environmental-economic analysis, combining natural and financial indicators. This approach allows for assessing the real value of the nature capital, accounting for environmental losses in economic processes, and planning of sustainability strategies with consideration to natural-specific limitations.

Further improvements in the system for statistical accounting of water resources necessitate the development of research methods, computerization of data collection, extension of open access to environmental information, and consolidation of cross-sectoral cooperation. These are required conditions enabling statistics to perform its

functions of a strategic management tool combining the competencies, responsibility, and prediction.

CONCLUSIONS

Our study resting on the hypothesis that improvements in the system for statistical accounting of water resources lay a firm background for enhancing the water management efficiency, reduction of irrational water consumption, and setting up an integrated sustainability policy led us to several conclusions.

First, it was confirmed that the statistical accounting of water resources was not a minor tool of the environmental policy, but rather its fundamental component. The availability of reliable data makes government and businesses capable to take informed decisions on allocation, use, and preservation of water.

Second, it was demonstrated that the regular water accounting could create an information base for combining nature-protection and economic interests. It allows for integrating indicators of physical flows and stocks of water with economic parameters of production, costs and revenues, which is a necessary condition for the transition to the green economy model.

Third, it was revealed that the implementation of a coherent national system for water statistics compliant with international standards could increase the transparency of management and the trust between government, business, and broader public. This reduces the risk of arbitrary interpretations of data, and ensures the accountability in using water resources.

Fourth, it was confirmed that the quality of statistical indicators had direct impact on the effectiveness of economic decisions. Accurate data allow for planning investment in water infrastructures, estimating fair tariffs, calculating environmental losses, and assessing the economic return from water use.

Fifth, it was demonstrated that the availability of an effective water statistics system was key to the stability in cross-border water basins, and an important factor of prevention of international collisions for resources. Shared accounting standards create the basis for mutual trust and partnership between the countries. The abovementioned demonstrates that the statistical accounting of water resources is strategically important for water security, economic resilience, and economic balance; its improvements constitute a principal area of the public sustainability policy in our times. The practical value of the results is their applicability for improvements in the national statistical

observation of water resources. The elaborated theoretical conclusions can lay the groundwork in adapting the official statistics methodology of Ukraine to the EU requirements, e.g. in creating integrated environmental-economic accounts and constructing indicators of water efficiency at regional level.

This study contributes to the substantiation of the role of the statistical accounting of water resources as a backbone factor of the environmental security. Its novelty lies in demonstrating that regular and methodologically consistent collection of data on stocks, quality and use of water lays the basis of early detection of environmental risks and prevention of adverse phenomena in the environment. It was proposed to interpret the statistical accounting as not a merely technical procedure, but as an informational mechanism for warning about threats, enabling for monitoring of water ecosystem dynamics, control over the implementation of environmental programs, and evidence-based substantiation of nature-protection decisions. Water statistics are treated from this perspective as a component in the national environmental safety system, enabling to enhance the performance of the environment protection policy.

This study contributes to the conceptualization of the statistical accounting of water as a factor of the nation's economic resilience. It highlights its significance in building the evidence base for economic decisions related with water resource management, investment planning, and pricing of water services. It was demonstrated that a robust accounting could lay the groundwork for enhancing the performance of water use, strengthening financing discipline in the water sector, developing innovative water-saving technologies, and fair distribution of resources across economic sectors. It was proposed to consider the statistical accounting of water as a central indicator of the stability of economic policy, because it enables to combine physical indicators of the water balance with economic parameters of the production process and regeneration.

The obtained results lay a theoretical and methodological base for further studies devoted to the integrated natural and economic accounting of water resources. Practical implementation of the above theses will help enhance the performance of the public environmental policy, extend the information base for management decisions, and ensure the compliance of the national water statistics with the international sustainability standards.

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