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THE HIERARCHY OF WATER ACCOUNTING SYSTEMS: THE METHODOLOGICAL POSITION OF SEEAW WITHIN THE STRUCTURE OF ENVIRONMENTAL-ECONOMIC STATISTICS

ІЄРАРХІЯ СТАТИСТИЧНИХ СИСТЕМ ОБЛІКУ ВОДИ: МЕТОДОЛОГІЧНЕ МІСЦЕ SEEAW У СТРУКТУРІ ЕКОЛОГІЧНО-ЕКОНОМІЧНОЇ СТАТИСТИКИ

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The article examines the methodological position of the System of Environmental Economic Accounting for Water (SEEAW) within international statistical systems and clarifies its functional links with hydrological, environmental, and economic statistics. A theoretical and methodological analysis of international standards, including SEEA CF and SEEAW, demonstrates that SEEAW serves as a key instrument of environmental-economic integration, enabling the transition from fragmented hydrological data to a comprehensive analytical framework combining physical water flows with economic valuation. The structure of SEEAW, including physical supply and use tables, hybrid accounts, asset and water quality accounts, is outlined. It is shown that SEEAW ensures methodological compatibility between hydrological indicators and the System of National Accounts, supports macroeconomic analysis of water use, and provides a statistical basis for monitoring SDGs 6 and 12 and for international comparisons of water use efficiency.

Keywords: SEEAW, SEEA CF, water statistics, water resources, environmental-economic accounting, System of National Accounts (SNA), sustainable development, methodological integration.

Метою статті є визначення методологічного місця Системи екологічно-економічного обліку води (SEEAW) у структурі міжнародних статистичних систем, з'ясування її функціональних зв'язків із гідрологічною, екологічною та економічною статистикою, а також розкриття ролі SEEAW як інтеграційного механізму між природними процесами водного циклу та системою національних рахунків. У статті здійснено теоретико-методологічний аналіз розвитку статистичного обліку води та узагальнено підходи, закладені в міжнародних стандартах SEEA CF і SEEAW. Обґрунтовано, що SEEAW є спеціалізованим інструментом реалізації концепції екологічно-економічної інтеграції, який забезпечує перехід від фрагментарної гідрологічної статистики до комплексної аналітичної системи, у межах якої фізичні характеристики водних ресурсів поєднуються з їх економічною оцінкою. Розкрито зміст і структуру SEEAW, що включає фізичні таблиці постачання та використання води, гібридні рахунки, рахунки активів і якості води. Показано, що зазначені елементи формують взаємодоповнювальні аналітичні виміри оцінювання водокористування – від кількісного обліку водних потоків до аналізу економічних та екологічних наслідків господарської діяльності. Проведено порівняльний аналіз SEEAW і SEEA CF, який дозволив визначити їх спільні методологічні засади, структурні відмінності та логіку інтеграції SEEAW у загальну архітектуру міжнародної статистичної системи. Доведено, що SEEAW функціонує як проміжна ланка між природничими та економічними доменами статистики, забезпечуючи методологічну узгодженість гідрологічних показників із Системою національних рахунків. Обґрунтовано роль



SEEAW у гармонізації статистичних даних для моніторингу Цілей сталого розвитку (ЦСР6і12) та у формуванні методичної основи для міждержавних порівнянь ефективності водокористування. Зроблено висновок про стратегічне значення SEEAW для підтримки обґрунтованих управлінських рішень і реалізації політики сталого розвитку.

Ключові слова: SEEAW, SEEA CF, водна статистика, водні ресурси, екологічно економічний облік, Система національних рахунків (SNA), сталий розвиток, методологічна інтеграція.

Statement of the problem. The water accounting statistics is not a separate category of the hydrological statistics, although historically it sprang from it. In the system of international standards (e.g. SEEAW and SEEA) it is interpreted as a component of the environmental-economic statistics, which is part of the economic statistics. Hierarchically, it looks as follows: (i) the economic statistics, (ii) the environmental-economic statistics, and (iii) the statistics of environmental-economic accounting for water (SEEAW).

The hydrological statistics, while belonging to the natural (physical) statistics of the environment, is not part of the economic accounting system. It measures natural processes: precipitations, runoffs, level of ground waters, etc.

SEEAW is designed to integrate hydrological data in the statistical system of economic analysis, creating a *bridge between natural and economic statistics*. Water accounting statistics within SEEAW belongs to the environmental-economic statistics that is a component of the system for national statistics of economic activities, and its data are used to supplement SNA with information about natural resources.

Analysis of recent research and publications. The evolution of international approaches to water accounting has been shaped by the gradual integration of environmental and economic dimensions into a unified statistical framework [1–3]. Foundational international standards, including the SEEA-CF and SEEAW, define the conceptual and methodological basis for the consistent measurement of interactions between the economy and the environment, particularly regarding water as both a natural resource and an economic asset [1–2]. These frameworks complement the System of National Accounts (SNA), providing tools for the inclusion of environmental resource data in economic analysis and decision-making [4–5].

Contemporary research emphasizes the growing role of water accounting as an essential component of environmental-economic statistics, which enables the development of indicators for sustainable resource management and integrated policy formulation [6–8]. Empirical studies demonstrate how the adoption

of SEEAW principles contributes to improved governance, transparency, and comparability of national data, strengthening both water resource efficiency and institutional capacity for sustainable management [6].

At the national level, the practical implementation of state water accounting systems reflects ongoing efforts to align administrative and hydrological data with international statistical frameworks [7–9]. The Ukrainian experience in this context reveals the need for methodological harmonization between physical and monetary indicators, as well as integration of environmental data into the broader economic accounting system.

The theoretical basis of sustainable development and environmental-economic integration has also been advanced through interdisciplinary works exploring macroeconomic security, global sustainability, and the transition to green and circular economies [10–18]. These studies form the conceptual background for understanding water resource accounting not merely as a technical procedure but as a mechanism of systemic balance between ecological imperatives and economic growth priorities.

Recent publications have expanded this discourse to the domain of environmental governance, emphasizing institutional mechanisms for achieving sustainable compromises between the right to development and the ecological imperative of sustainability [19–22]. In particular, research on water markets and the regulation of water pollution within the framework of the green transition highlights the relevance of SEEAW as a statistical foundation for evaluating environmental performance and policy outcomes [22].

Thus, the reviewed sources demonstrate that the modern concept of water accounting has evolved from a narrowly hydrological framework into a multidimensional system of environmental-economic statistics, serving as a bridge between physical processes and economic policy instruments.

Highlighting previously unresolved parts of the overall problem. Latest studies feature conceptual and methodological gaps in

determining the status of the water accounting statistics within the hierarchy of international statistical systems. The conventional hydrological statistics is focused on measurements of physical characteristics of the water cycle, whereas SEEAW offers an integrated approach combining physical and economic data in a single analytical procedure. This integration creates a background for cross-industry comparisons, assessment of the efficiency of use of water resources, and analyses of causal links between economic activities and the status of water ecosystems.

The study is based on the hypothesis that the implementation of environmental-economic accounts of water on the basis of SEEAW methodology transforms fragmented hydrological and environmental data into a holistic environmental-economic statistical system. This system provides for a single platform for estimating the efficiency of water use, determining the economic value of water resources, and support of management decisions focused on the sustainable development.

The objective of the article is to highlight the status of the water accounting statistics within the international hierarchy of statistical standards, to delineate the concepts of hydrological, environmental, and environmental-economic statistics, and to specify on the role of SEEAW as a systemic tool for integrating natural and economic data to ensure holistic management of natural resources.

Summary of the main research material. Developments in statistical systems for water accounting reflect a broader evolution of economic measurement systems towards gradual integration of environmental dimensions in the conventional economic analysis. SNA, while providing for a holistic structure for accounting of production, revenues and accumulation in the economy, fails to account for depletion or degradation of natural resources, water in particular [2–4]. Therefore, SEEAW had to be a conceptual bridge linking hydrological data with economic indicators, and extending analytical capacities of the national statistics [1–2].

Unlike the hydrological accounting per se, depicting the physical circulation of water through precipitations, runoffs, infiltration and evaporations, SEEAW integrates these information in a system where water is interpreted as not a mere natural phenomenon, but as an economic asset. Within this system, water acquires the status of a resource with a

measurable economic value, which exploitation affects productivity, resilience, and resource safety of the national economy. Hence, SEEAW transforms the water statistics into a component in the integrated environmental-economic informational infrastructure enabling for analyses of causal links between environmental processes and economic results.

From the methodological perspective, SEEAW operates at several interlinked analytical levels [1–2]. The first level is comprised by physical supply and use tables (PSUT) showing the scopes of water coming from natural sources to the economic circulation, water consumption, reuse and return to the environment. The second level includes hybrid tables combining physical volumes with economic variables – expenses, prices, value added – thus enabling analyses of water productivity and water intensity of production. The third level is accounts of assets reflecting changes in the stocks of water resources over time, including natural replenishment, anthropogenic withdrawal, and losses caused by degradation.

This structuring lays a background for multidimensional statistical analyses. The aligning of PSUT with international economic classifications (ISIC, CPC) enables for identifying water-intensive industries, estimating the elasticity of water use relative to GDP and by-industry intensity of pollution [1–2;5]. Hybrid and monetary tables allow for incorporating environmental expenses in indicators of production and consumption, to create a basis for more realistic assessments of economic resilience.

In the theoretical dimension, SEEAW implements the concept of environmental-economic integration, embedded in SEEA-CF, thus transforming natural processes into measurable economic variables [2]. This approach ensures a consistency between various statistical domains, and creates a single framework for assessing the environmental policy efficiency. Hence, SEEAW constitutes a methodological background for creating satellite accounts supplementing SNA indicators with information about natural capital and services of ecosystems. This is why the water resource statistics within SEEAW have immediate positive impact on the assessment of green growth and monitoring of the progress towards Sustainable Development Goals (SDGs).

A comparative analysis of national implementations of SEEAW shows different levels of the institutional maturity of accounting

systems. Countries with well-established schemes for water resource management demonstrate a higher consistency of data and cross-industry coordination, whereas developing countries face fragmentation of information sources and lack of methodological resources. Yet, the standardization implemented by the United Nations Statistics Division and other international organizations ensures gradual harmonization of approaches, thus creating conditions for international comparability and benchmarking [1–2; 5].

It is conceptually important that SEEAW transform the functional purpose of water statistics from descriptive recordings of natural processes into a tool supporting the policy for sustainable management of resources. While the conventional hydrological statistics reflect

only the natural status and dynamics of water systems, SEEAW integrates these indicators with economic factors and outcomes. Integrated indicators like water productivity (GDP per unit of used water) or the share of reused cleaned water allow for a systemic display of the links between resource efficiency and economic performance [1; 6].

An important methodological gain of SEEAW is its capacity to account for feedbacks between the status of water resources and macroeconomic dynamics. Via the asset accounting system, it makes it possible to estimate how excessive exploitation of water affects the economic capacity in future periods, and to integrate indicators of environmental devaluation in the overall estimate of the national welfare [1–2; 6]. This consolidates the analytical framework of

Table 1

A comparative characteristic of systems for statistical accounting of water resources

Criterion	Hydrological statistics	Environmental statistics	System of Environmental-Economic Accounting for Water (SEEAW)
Object of measurement	Natural processes of the water cycle: precipitations, runoff, evaporations, ground water level	Environmental performance, pollution sources, scopes of emissions, environmental effects of human activities	Physical and economic flows of water, causal links with water resources and economic activities
Indicator category	Physical (m ³ , mm)	Physical and qualitative (mg/l, t, g/m ³)	Physical and monetary (m ³ , mln UAH / mln USD, value of assets)
Methodological background	Hydrological observations, measurement methods involved in natural sciences	Environmental monitoring programs, statistical surveys	SEEA and SEEAW – standardized accounts in accordance with SNA
Accounting purpose	Exploring natural characteristics of the water environment	Estimating the environmental performance and the anthropogenic impact	Integrating natural and economic data for sustainability analyses
Observation units	River basins, reservoirs, Річкові басейни, водойми, water-bearing aquifers	Pollution sources, industries, territories	Institutional sectors of the economy, economic activities by ISIC
Measurement results	Water cycle balance, runoffs and stocks	Indicators of water quality and pollution, environmental indicators	Physical and hybrid tables, asset accounts, water productivity indicators
Data uses	Scientific research, forecasting of water regimes	Environmental policy, monitoring of environmental status	Economic analyses, resource management, assessment of environmental performance
Link with SNA	None	Indirect, via environmental indicators	Direct: integration of accounts in the system of national accounts

Source: formed on the basis of [1–5]

Table 2

**Hierarchical positions of statistical systems for water resource accounting
in the international classification**

Level of statistical system	Principal object of measurement	Methodological source	Examples of systems
I. Economic statistics	Production, consumption, investment, incomes, expenses	System of National Accounts (SNA 2008 / 2025)	Accounts of GDP, production, consumption of resources
II. Environmental-economic statistics	Interactions between economy and environment, resources, pollution	System for Environmental-Economic Accounting (SEEA Central Framework)	SEEA-CF, accounts of resources, emissions, energy accounts
III. Industry modules of SEEA	Selected natural resources or ecosystems	Specialized modules of SEEA	SEEAW (water), SEEA-EEA (ecosystems), SEEA-Energy
IV. Environmental statistics	Parameters of environmental status, physical characteristics, quality of water, air, soils	United Nations Guidelines on Environmental Statistics	Programs for environment monitoring, data of UNEP, WHO
V. Hydrological statistics	Physical cycle of water, precipitations, runoffs, evaporations, underground waters	Methods of the World Meteorological Organization and hydrotechnical services	Hydrological balances, climate reports, basin research

Source: formed on the basis of [1–5]

environmental policies, and makes management and fiscal decisions better informed (tables 1, 2) [1–2; 6].

For fuller understanding of the methodological status of SEEAW within the body of international statistical standards, it should be examined in comparison with the basic System for Environmental-Economic Accounting (SEEA-CF) (Table 3). Both systems are built on similar principles and with the same purpose of integrating natural and economic data, but SEEAW constitutes a specialized module adapting general principles of SEEA to the specifics of the water sector. A comparison of the two systems is given in Table 3.

While the alignment of SEEAW with SEEA-CF ensures the methodological integrity of statistical standards, specialization of SEEAW allows for detailing environmental-economic processes in the water sector. Hence, SEEAW appears as an example of the applied extension of SEEA-CF, transforming general principles of the integrated accounting into a practical system for industry-level analysis and management. It demonstrates that SEEAW creates a new paradigm for statistical recording of interactions between natural and economic systems. It brings water

out of the category of external environmental factors, to make it a measurable component of the economic structure and the national wealth. Consequently, statistics of environmental-economic accounting of water becomes a driver for the transition from a fragmentary natural statistics to an integrated analytical system designed to support sustainability-related decisions.

Conclusions. This study aimed at determining the SEEAW status within the structure of the environmental-economic statistics and specifying its causal links with hydrological and economic statistics led to the following conclusions.

1. SEEAW has an intermediate position between hydrological and economic statistics, allowing for integrating physical characteristics of natural water resources with their economic estimate. SEEAW sets an analytical bridge between the data on natural phenomena and the system of national accounts, allowing to quantify interlinks between the status of water resources and results of economic activities. This enabled to specify the systemic role SEEAW as an interdisciplinary scheme for harmonization of environmental and economic dimensions of statistics.

Table 3

A comparison of SEEA-CF and SEEAW: similar principles and distinctions

Criterion	SEEA-CF (System of Environmental-Economic Accounting – Central Framework)	SEEAW (System of Environmental-Economic Accounting for Water)
Methodological status	Central Framework of International Standards for Environmental-Economic Accounting	Industry module of SEEA-CF, focused on water resources
Accounting object	All the natural resources: energy, minerals, land, forest, water, wastes, emissions	Water resources: surface, underground, intercepted, used and returned to the environment
Account category	Physical, hybrid, and monetary accounts for all the categories of natural resources	Physical, hybrid accounts, account of assets and water quality; specialized water use indicators
Principal purpose	Integrating natural and economic data in the system of national accounts	Integrating water statistics with economic accounts, analysis of the water use efficiency
Link with SNA	Conceptually linked and structurally aligned with SNA	Uses SNA principles via SEEA-CF, to include water indicators in economic accounts
Key tables	Tables of supply and use of water resources; asset accounts; accounts of expenses for environmental protection	Physical supply and use tables (PSUT); water asset accounts; water quality accounts
Observation units	Economic sectors, economic activities by ISIC, territorial levels	Economic sectors and categories of water users, basin level, sub-industries
Analytical purpose	Constructing macroeconomic indicators of sustainability, resource productivity, environmental efficiency	Estimating water productivity, water intensity, management efficiency, and policy of sustainable water use
Level of detailing	Aggregated cross-resource level	Specialized, industry, with deep detailing of indicators
Principle applications	Environmental policy setting, macroeconomic planning, monitoring of sustainable development	Water resource management, elaboration of water policy, monitoring of SDG 6 and SDG 12
UN publication	SEEA-CF (United Nations, 2014)	SEEAW (United Nations, 2012)

Source: formed on the basis of [1–5]

2. Statistics of environmental-economic accounting of water is an integral component of the environmental-economic statistics, being, in its turn, integrated in the economic statistics system. This hierarchical build-up – economic statistics, environmental-economic statistics, SEEAW – reflects a consistent movement from macroeconomic analysis to integrated measurement of natural resources used in the economy. This enables to pose SEEAW more accurately within the body of international standards, and to enhance its methodological alignment with other accounting systems.

3. Each of the principal structural components of SEEAW – physical tables of water supply and use, hybrid tables, asset accounts, and water quality accounts – is designed for a separate

analytical function, but taken altogether they create a comprehensive set of indicators applicable for monitoring, analyses, and international comparisons. This enabled to deepen understanding of the logic behind SEEAW buildup as a multidimensional information base for water resource management.

4. SEEAW is aligned with the conceptual principles of SNA and SEEA (SEEA-CF), thus enabling incorporation of environmental data in extended economic accounts. This integration helps create a more complete portrayal of the national welfare by accounting for production and nature-resource dimensions of economic activities. It enables to interpret SEEAW as a systemic tool extending the boundaries of traditional economic analyses.

5. The practical significance of SEEAW stems from creating a single information base for setting the policy for sustainable management of water resources. SEEAW allows for enhancing the efficiency of water use, making cross-country comparisons, and monitoring the progress towards SDGs, especially SDG 6 “Clean water and sanitation of all”, and SDG 12 “Responsible consumption and production”. It is a clear evidence that SEEAW is an international tool for standardization of the environmental-economic statistics focused on management of natural resources in the sustainability context.

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