Environmental-economic accounting for water: a global comparative analysis

Contas econômicas ambientais da água: uma análise comparativa global

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ABSTRACT
Water accounts emerge to express their physical volume in the environment and the economy, as well as the economic aspect of water supply and use. Therefore, it enables public policymakers to make the most appropriate decisions for its management. So, the research objective is to analyse how different countries disclose their environmental and economic accounts for water. Therefore, a categorical analysis model of 120 categories was developed based on the SEEA-Water framework and analysed in 13 countries. The results highlight the high adherence to the physical water supply and use tables. It is interpreted as a "starting point" for compiling water accounts. Despite this, water emission accounts have not been prioritis**ed, po**ssibly due to data unavailability. Both hybrid and asset accounts are in progress. Concerning the countries, Brazil, Mexico, and Costa Rica achieved the highest adequacy level for the proposed model.

Keywords: Water Accounting. National Accounts. SEEA-Water. Content Analysis.

RESUMO
Contas da água surgem para expressar os seus volumes físicos no ambiente e na economia, bem como os aspectos econômicos do fornecimento e uso da água. Portanto, possibilita que os formadores de políticas públicas tomem decisões mais adequadas para o gerenciamento do recurso. Assim, a pesquisa objetiva analisar como diferentes países evidenciam suas contas econômicas ambientais da água. Para tanto, foi desenvolvido um modelo de análise categorial composto por 120 categorias, embasadas na metodologia SEEA-Water, analisadas em 13 países. Os resultados apontam a elevada aderência das tabelas físicas de fornecimento e uso da água, interpretadas como "ponto de partida" para a compilação das contas da água. Contudo, contas de emissões na água não foram priorizadas, possivelmente pela indisponibilidade de dados. Tratando-se de contas híbridas e contas de ativos hídricos, ambas

se encontram em andamento. Entre os países, Brasil, Costa Rica e México obtiveram maior nível de adequação ao modelo proposto.

Palavras-chave: *Contabilidade da Água. Contas Nacionais. SEEA-Water. Análise de Conteúdo.*

INTRODUCTION

Billions of people still lack safely managed drinking water and sanitation, even though both services are recognised as human rights and common factors that drive development to shape a prosperous future (UN-Water, 2021; United Nations, 2023). This has made water levels and fluctuations in quantity and quality to ensure the sustainability of nations become one of the most pressing global issues of the 21st century, and many countries are greatly concerned about it (Chalmers; Godfrey; Lynch, 2012; Chalmers; Godfrey; Potter, 2012).

Therefore, ensuring the availability and sustainable management of water and sanitation for all is a challenge many economies have adopted to achieve Sustainable Development Goal 6. However, there is a concern about whether the current water resources policies will be sufficient to achieve the ambitious goals proposed by the 2030 Agenda (World Water Forum, 2018) since it is a duty mostly for governments (Ferrer *et al.*, 2022).

Since it is considered a public good, water-related issues involve public responsibility for its use, management, and protection (Signori; Bodino, 2013). Moreover, recognising that data management for decision support is a challenging aspect of any decision-making process, water management is no exception (Torres López; Barrionuevo; Rodríguez-Labajos, 2019).

In this regard, water data are critical to the water management process (Ferrer *et al.*, 2022; Pinto Filho; Rêgo; Lunes, 2019), both to base decisions and to measure the progress of the measures adopted (Dutta *et al.*, 2017). Considering that decision-makers rely on economic accounting methods for urban planning and infrastructure investments (Tapsuwan *et al.*, 2021), it is recommended that a water accounting system be implemented to organise water-related data (Bagheri; Babaeian, 2020). Thus, water accounts provide data on the stock and flow of water in physical, monetary, and qualitative terms and produce indicators that can translate the performance of water resources (Romeiro; Kuwahara, 2004).

According to Kilimani, Van Heerden and Bohlmann (2016), water accounts are vital to providing information to policymakers on the impact of current economic policies and growth patterns on water resources, making it possible to judge whether or not such policies are sustainable. Consequently, water account systems that record and report resource-related data in a relevant, reliable, understandable, and comparable way have gained prominence (Chalmers; Godfrey; Potter, 2012). Its multidisciplinary nature promotes the contribution of several fields beyond accounting, including engineering, hydrology, meteorology, geography, and law (Christ; Burritt, 2018; Russell, 2021).

Thus, while different nations develop and publish their water accounts differently, there is general agreement on the structure and scope of water accounting. This agreement is formalised by the publication of the System of Environmental and Economic Accounting for Water (SEEA-Water) (Berger *et al.*, 2018; United Nations, 2012).

SEEA-Water provides a conceptual framework for organising hydrological and economic information coherently and consistently, using the System of National Accounts (SNA) as a base framework. Therefore, when properly implemented, water accounts may provide a core set of reliable statistics needed in an increasingly fragmented information landscape (Bagstad *et al.*, 2020). Furthermore, it gives a standard for the compilation of economic statistics and the derivation of economic indicators, allowing the comparability of accounts compiled in and between countries (United Nations, 2012).

However, uncertainties and challenges hinder the progress of the structure in some jurisdictions due to insufficient involvement from political decision-makers, data unavailability, and the need to tailor accounts to specific regions (Cavalletti; Corsi, 2022). Thus, recognising the challenges that permeate the advancement of water accounts, this study aims to analyse how different countries disclose their environmental-economic accounts for water. We then analyse the countries that have already compiled their environmental-economic accounts for water based on the SEEA-Water methodology.

Therefore, this research is justified by the benefits of compiling environmental-economic accounts for water recognised by the countries that have already done so. In Botswana, for example, it was noted that implementing environmental-economic accounts for water has become critical to achieving sustainable development and economic growth in the country (Setlhogile; Arntzen; Pule, 2017). In Mexico, through this implementation, the government promoted different programs for more efficient resource use, besides identifying an increase in water productivity from its first compilation to its most recent version. In China, technical and methodological issues in water resources management were overcome with the application of SEEA-Water, as there used to be a fragmentation of agencies responsible for collecting and disclosing water-related data (Gan *et al.*, 2012).

2 WATER ACCOUNTING

The role of accounting is recognised as a social science because its accountability directly affects the qualitative aspects of human and social relationships while also interacting with the quantitative aspects of measurement and mediation (Coliath, 2014). Recognising accounting beyond its focus on wealth and income promotes awareness of opportunities to use accounting knowledge and shape a system based on accountants' contributions and regulatory focus (Chalmers; Godfrey; Lynch, 2012). Additionally, through accounting for natural resources, the accounting approach adds analytical capacity to basic statistics, accurately reflecting the differences in natural resources in different periods and obtaining the effect of their measurement (Yang *et al.*, 2021).

Given that issues related to water access and management are among the most pressing economic, social, and environmental concerns today, the accounting profession increasingly recognises the implications associated with water risk and value (Christ, 2014). Hence, the Water Accounting Standards Board (2014) defines water accounting as a systematic process of identifying, recognising, quantifying, reporting, and assuring information about water, its rights, other claims, and obligations against this resource.

However, according to Christ and Burritt (2018), this aggregate of water-related information gives water accounting strong transdisciplinary features. Its collaboration intersects between, through, and beyond different fields, including engineering, accounting, hydrology, meteorology, geography, and law. According to Russell (2021), because water issues are multidisciplinary in nature, a range of professionals from different fields can work together to develop policies and practices that promote resource preservation.

Consequently, standardised water accounting methodologies are being developed for different geographical and organisational levels, increasing the quality and credibility of the information available to various stakeholders. Thus, water accounting standards at the macroeconomic level can serve the public interest as the quality and credibility of the information available to stakeholders increase. Based on water accounts, decision-makers can make informed choices about the allocation of resources, which can impact economic growth and environmental protection (Chalmers; Godfrey; Lynch, 2012). With the assistance of macroeconomic regulation and market control, water resources can be allocated optimally, promoting its sustainable use and socioeconomic development (Sun et al., 2017).

For this reason, different water accounting frameworks have been proposed to organise hydrological and economic data in an integrated manner to provide a platform for assessing water resource systems

(Bagheri; Babaeian, 2020). However, although the Dutch 'National Accounting Matrix, including Water Accounts' and the 'Australian Water Accounting Standards' are recognised methodologies, physical and economic data on water in many nations are becoming more widely integrated by adopting the SEEA-Water (Bagstad *et al.*, 2020).

2.1 SYSTEM OF ENVIRONMENTAL AND ECONOMIC ACCOUNTING FOR WATER (SEEA-WATER)

Although the SNA is a universal economic statistical system that provides effective economic analysis for decision-makers, it does not cover concepts related to sustainable development. Therefore, in 1993, the United Nations (UN) and the World Bank launched the first System of Environmental and Economic Accounting (SEEA) to complement the SNA (Sun *et al.*, 2017). The SEEA was created by the statistical community in collaboration with ecologists, economists, and other scientists to provide countries with a framework for compiling environmental and natural resources statistics (Esen; Hein, 2020).

While previous developments encompassed a variety of environmental accounts, such as the SEEA – Central Framework, there emerged a need to create a more detailed methodology specifically addressing water resources. Consequently, the SEEA-Water was established between 2004 and 2007. This methodology emerged to standardise water reporting among countries, replacing the previous ad hoc approach (Vardon *et al.*, 2012). Thus, it employs accounting principles for valuing different capital forms and physical terms, generating more coherent environmental data and facilitating their integration with economic information (Obst, 2015). Furthermore, it defines a series of accounting identities to enable consistent comparisons across areas and over time (Vardon *et al.*, 2012).

In 2012, the UN released the latest version of the SEEA-Water, which provides a conceptual framework designed to organise hydrological and economic information coherently and consistently, which facilitates the systematic organisation of water flow from the environment to the economy within the economy and back to the environment compatible with the SNA. Notably, this system of satellite accounts also includes principles for organising data on water stocks or assets, water reuse, and various financial items related to water supply and sanitation (Tello; Hazelton, 2018; United Nations, 2012). More specifically, the tool suggests dividing water accounts into four "water statements" - Physical Water Supply and Use Tables, Water Emissions Accounts, Hybrid Accounts, and Water Asset Accounts.

3 METHODOLOGICAL PROCEDURES

For this research's development, countries that have already compiled their environmental-economic accounts for water using the SEEA-Water were analysed (United Nations, 2012). Thus, the following countries met the established criteria: Armenia, Australia, Botswana, Brazil, Colombia, Costa Rica, Fiji, Netherlands, Mauritius, Mexico, Rwanda, Uganda, and Zambia.

First, to enable the recognition of these 13 countries, the Statistics South Africa's (2017) document and the Waves - *Wealth Accounting and the Valuation of Ecosystem Services*' (2021) electronic address were used. Thus, 29 countries were initially analysed.

Then, data on the environmental-economic accounts for water were collected from these 29 countries using three sources of information: the Waves (2021) electronic address, the electronic addresses of the national statistical agencies responsible for compiling the accounts in each country, and, when not available, emails forwarded to these agencies.

Based on the previous email responses and data collection, of the 29 countries analysed, 13 meet the established criteria and base this research sample. The remaining 16 were excluded for not adopting the

SEEA-Water methodology (adopting only the SEEA-Central Framework or another non-corresponding methodology), not publicising their water accounts, or not making them available via email.

Regarding the time frame, we seek to analyse each case's most recent accounts compilation. Considering that the research was carried out in 2021, we found publications between the periods from 2017 to 2020, although the publications provide retroactive information.

The categorical analysis technique was used as a data analysis technique. According to Bardin (2010, p. 199), this "works through operations of dismembering the text into units, into categories according to analogical regroupings." Gray (2016) emphasises that this is about making inferences about research data and systematically and objectively identifying special characteristics (classes or categories) among them.

Given this, Bardin (2010) highlights some necessary qualities to develop good categories: mutual exclusion, homogeneity, relevance, objectivity and fidelity, and productivity. By adhering to these qualities, a categorical analysis model based on the SEEA-Water (United Nations, 2012) is organised into four major categories: (i) physical water supply and use tables; (ii) water emissions accounts; (iii) hybrid accounts; and (iv) water asset accounts. Table 1 presents the proposed model based on the SEEA-Water (United Nations, 2012), with 120 categories listed. The different colours between the categories aim to organise the analysis in the next section.

Table 1 – Content Analysis Categories

1. Physical water supply and use tables		21	Service economic activities
1.1 Flow from the environment to the economy		**1.2.2 Water received from other economic units**	
01	Abstraction for own use	22	Use of water received from other economic units
02	Abstraction for distribution	23	Reused water from other economic units
03	Abstraction from inland water resources	24	Wastewater to sewerage from other economic units
04	Abstraction from surface water	25	Desalinated water from other economic units
05	Abstraction from groundwater	26	Consumed by economic activities
06	Abstraction from soil water	27	Consumed by households
07	Abstraction from the sea	28	Exportation
08	Collection of precipitation	**1.2.3 Supply of water to other economic units**	
09	Abstraction from other water resources	29	Supply of water to other economic units
10	Total water abstraction to the economy	30	Reused water supplied to other economies
1.1.1 Supplementary items		31	Wastewater sewerage to other economies
11	Abstraction for hydroelectric power generation	32	Desalinated water to other economies
12	Abstraction for irrigation water	33	Supplier economic activities
13	Abstraction for mine water	34	Supplier households
14	Abstraction for urban run-off	35	Importation
15	Abstraction for cooling water	**1.3 Flow from the economy into the environment**	
1.2 Flow within the economy		36	Returns to inland water resources
1.2.1 Breakdown of the economic activities		37	Returns to inland water resources – surface water
16	Agriculture, forestry and fishing	38	Returns to inland water resources – groundwater
17	Mining and quarrying, manufacturing, and construction	39	Returns to inland water resources – soil water
18	Electricity, gas and steam supply	40	Returns to other sources
19	Water collection, treatment and supply	41	Returns to seawater
20	Sewerage	42	Total returns into the environment

1.3.1 Supplementary items		79	Economic activities intermediate consumption
43	Returns from hydroelectric power generation	80	Final consumption by households
44	Returns from irrigation water	81	Final consumption by government
45	Returns from mine water	82	Capital formation
46	Returns from urban run-off	83	Exports
47	Returns from cooling water	**3.2 Physical units**	
48	Returns from treated wastewater	84	Total supply of water
49	Losses in distribution due to leakages	85	Supply of water to other economic units
1.4 Water consumption		86	Supply of wastewater to sewerage
50	Water consumption by the whole economy	87	Total returns
51	Water consumption by economic activities	88	Output of economic activities
52	Water consumption by households	89	Supply by households
53	Losses not due to leakages	90	Imports
2. Water emission accounts		91	Total use of water
2.1 Pollutant emissions by economic units		92	Total abstraction
54	Gross emissions of pollutants	93	Abstraction for own use
55	Emissions by economic activities	94	Use of water received from other economic units
56	Emissions by households	95	Intermediate consumption of economic activities
57	Direct emissions to water	96	Final consumption by households
58	Direct emissions after treatment	97	Exports
59	Direct emissions without treatment	98	Total emission of pollutants
60	Direct emissions to inland water resources	**4. Water asset accounts**	
61	Direct emissions to the sea	99	Opening stocks
62	Emissions to sewerage	100	Increases in stocks
2.2 Pollutant emissions by sewage system		101	Returns
63	Emissions after treatment	102	Precipitation
64	Emissions without treatment	103	Inflows
65	Emissions into water resources	104	Inflows from upstream territories
66	Emissions into the sea	105	Inflows from other resources in the territory
2.3 Supplementary items		106	Decreases in stocks
67	Pollutant content	107	Abstraction
68	Volume of sludge generated by sewerage	108	Evaporation/actual evapotranspiration
69	People with access to improved sanitation	109	Outflows
3. Hybrid accounts		110	Outflows to downstream territories
3.1 Monetary units		111	Outflows to the sea
70	Total water output and supply	112	Outflows to other resources in the territory
71	Natural water output and supply	113	Closing stocks
72	Sewerage services output and supply	114	Surface water
73	Economic activities output	115	Surface water – artificial reservoirs
74	Imports	116	Surface water – lakes
75	Taxes	117	Surface water – rivers
76	Total intermediate consumption and use	118	Surface water – snow, ice, and glaciers
77	Natural water intermediate consumption and use	119	Groundwater
78	Sewerage services intermediate consumption and use	120	Soil water

Source: Prepared by the authors based on the SEEA-Water (United Nations, 2012).

4 RESULTS AND DISCUSSION

In this chapter, to display whether a certain category is disclosed or not in a specific country, the matrices have their corresponding space (water account "x" and country "y") highlighted with green colour for disclosure and red colour for no disclosure. Furthermore, the accounts expressed in the left column are represented by different colours based on their categorisation, which can be found in Table 1 in the previous section. At the right and bottom edges, respectively, immediately after the total value, there is the percentage of the total number of countries that disclose each account (right column) and the total number of accounts disclosed by each country (bottom row). These are presented with colour gradients from red to green to make it easier to visualise the percentage tens representing disclosure. The closer the colour is to red, the lower the disclosure, and the closer it is to green, the higher the disclosure.

4.1 PHYSICAL WATER SUPPLY AND USE TABLES

Physical Water Supply and Use Tables (PWSUT) aim to demonstrate the flow of water from its initial abstraction from the environment by the economy, its supply and use within the economy, and its final discharge back into the environment, with all entries being expressed in quantitative terms (United Nations, 2012). Thus, we decided to separate them into blocks that reflect these flows. Matrix 1 illustrates the observed disclosure findings.

Matrix 1 – Physical Water Supply and Use Tables

	Armenia	*Australia*	*Botswana*	*Brazil*	*Colombia*	*Costa Rica*	*Fiji*	*Netherlands*	*Mauritius*	*Mexico*	*Rwanda*	*Uganda*	*Zambia*	*Total Countries*	*%*
1														10	77%
2														10	77%
3														6	46%
4														13	100%
5														13	100%
6														6	46%
7														8	62%
8														9	69%
9														5	38%
10														11	85%
11														6	46%
12														4	31%
13														3	23%
14														0	0%
15														1	8%
16														12	92%
17														12	92%
18														12	92%
19														13	100%
20														10	77%
21														9	69%

	Armenia	*Australia*	*Botswana*	*Brazil*	*Colombia*	*Costa Rica*	*Fiji*	*Netherlands*	*Mauritius*	*Mexico*	*Rwanda*	*Uganda*	*Zambia*	*Total Countries*	*%*
22														11	85%
23														6	46%
24														6	46%
25														1	8%
26														13	100%
27														13	100%
28														7	54%
29														11	85%
30														10	77%
31														11	85%
32														2	15%
33														13	100%
34														13	100%
35														7	54%
36														9	69%
37														10	77%
38														9	69%
39														7	54%
40														6	46%
41														6	46%
42														13	100%
43														5	38%
44														3	23%
45														2	15%
46														0	0%
47														1	8%
48														3	23%
49														7	54%
50														9	69%
51														9	69%
52														11	85%
53														8	62%
Total	**26**	**35**	**35**	**40**	**36**	**36**	**32**	**29**	**29**	**33**	**36**	**30**	**18**	**415**	
%	49%	66%	66%	75%	68%	68%	60%	55%	55%	62%	68%	57%	34%	60%	

Where:

Colours of water accounts (1st column): See categories in Table 1

Matrix "x" (water accounts) by "y" (countries): Undisclosed Disclosed

Percentage colour gradient: 0% 100%

Source: Prepared by the authors (2023).

Initially, to comprehend the flow from the environment to the economy, it is essential to have access to information about the amount of water abstracted from natural resources for distribution. Therefore, it is observed that all the countries analysed have compiled accounts that show the abstraction of both surface water and groundwater (categories 04 and 05) within their respective territories.

Rwanda decided to subdivide the 'abstraction from surface water' account according to the water resources involved. This was done by creating separate accounts for lakes, rivers, and reservoirs. According to the SEEA-Water, PWSUT can be compiled at varying levels of detail, depending on the country's policy concerns and data availability (United Nations, 2012).

After analysing water account reports, we observed discrepancies regarding the importance given to different water resources in different territories. For example, when it comes to groundwater, households in Rwanda abstract more than twice the volume of water compared to what is extracted by water supply agencies from sources such as groundwater since the agencies' supply is limited (Government of Rwanda, 2019). In the Netherlands, groundwater abstractions are limited due to their serious impact, including leading to water stress situations (Statistics Netherlands, 2017). In Costa Rica, problems such as saline intrusion into groundwater have arisen due to the overexploitation of wells, prompting initiatives to desalinate seawater (Banco Central de Costa Rica, 2019).

Regarding the abstraction for hydroelectric power generation (11) account, reported by 46% of countries, these typically reflect their energy profiles. Countries such as Brazil, Costa Rica, and Rwanda note that this abstraction is one of the reasons why the energy sector uses the largest volume of water among economic activities.

Finally, in formulating the categories, the water received by the rest of the world has been classified as "export" and water supplied as "import." For instance, Botswana imports water from South Africa via the Molatedi Dam (Republic of Botswana, 2017).

Regarding the flow from the economy into the environment, the economic unit responsible for discharges (industries, families, and the rest of the world) is considered the "supplier", while the environment is the "destination" of these flows (United Nations, 2012). Through the analysis, we noted that all countries have disclosed at least the total water return to the environment. However, the behaviour changes according to each country's reality when this "headline" account is disaggregated among the resources. For example, considering the returns to seawater (41), four countries that do not disclose it are not located in coastal regions to justify such return — Armenia, Botswana, Uganda, and Zambia.

Concerning the 'returns from cooling water' account (47), this is disclosed only by the Netherlands. Their report noted that despite significant water abstraction for cooling purposes, the flow typically returns to the environment after use (Statistics Netherlands, 2017). This type of flow is known as non-consumptive use, meaning that an economic process utilises water and returns almost entirely to the environment without significant physical or chemical changes (Banco Central de Costa Rica, 2019; IBGE, 2018; Inegi, 2019).

With a slightly higher level of disclosure (54%), the account "losses in distribution due to leakages" (49) was observed in seven countries. Rwanda comments that most of these leaks are due to the old and damaged water supply infrastructure, poor maintenance, and general breakdowns (Government of Rwanda, 2019). On the other hand, "losses not due to leakages" (53) refer to losses that do not return directly to water resources. Among them, we can mention evaporation losses (Mexico), metering errors (Costa Rica), ineffective water bill collection (Botswana), illegal use of water resources (Costa Rica), losses in the purification process (Fiji), and water incorporation into products (Uganda).

4.2 WATER EMISSION ACCOUNTS

Following the PWSUT, the second section of categories addresses water emissions accounts. As seen in Matrix 2, only two countries (15%) provided information about these – Costa Rica and Mexico.

Matrix 2 – Water Emission Accounts

	Armenia	*Australia*	*Botswana*	*Brazil*	*Colombia*	*Costa Rica*	*Fiji*	*Netherlands*	*Mauritius*	*Mexico*	*Rwanda*	*Uganda*	*Zambia*	*Total Countries*	*%*
54														1	8%
55														2	15%
56														0	0%
57														1	8%
58														0	0%
59														0	0%
60														0	0%
61														0	0%
62														1	8%
63														1	8%
64														0	0%
65														0	0%
66														0	0%
67														0	0%
68														0	0%
69														1	8%
Total	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**7**	
%	0%	0%	0%	0%	0%	31%	0%	0%	0%	13%	0%	0%	0%	3%	

Where:

Colours of water accounts (1st column): See categories in Table 1

Matrix "x" (water accounts) by "y" (countries): Undisclosed Disclosed

Percentage colour gradient: 0% 100%

Source: Prepared by the authors (2023).

Notably, the only account evidenced by both countries is the "emissions by economic activities" (55). Regarding Mexico, the country mentions in its report that the compilation of this account arose from available data on the emission of tons of biochemical oxygen demand (BOD) from the industry and services sectors.

Regarding this account, Costa Rica has legislation that simplifies the compilation of this data. As per the country's regulations, any entity that discharges wastewater into the sewer system is obligated to submit an operational report to the Ministry of Health, indicating the discharged flow and laboratory analysis parameters (Banco Central de Costa Rica, 2019). Finally, the account "people with access to

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adequate sanitation" (69) in Costa Rica indicates that 99.60% of the population had access to adequate sanitation in 2016.

Although the challenges of compiling water emission accounts are acknowledged, a greater number of countries are expected to initiate their development. These accounts are a unique feature of the SEEA-Water, filling a gap left by the SEEA-Central Framework. Thus, emission accounts constitute a useful tool for designing economic instruments, including new regulations aiming to reduce water emissions (United Nations, 2012).

4.3 HYBRID ACCOUNTS

The disclosure of hybrid water accounts is illustrated in Matrix 3. Hybrid accounts provide both monetary information (categories in yellow) and physical information (categories in orange) about the supply and use of water (United Nations, 2012).

Matrix 3 – Hybrid Accounts

	Armenia	*Australia*	*Botswana*	*Brazil*	*Colombia*	*Costa Rica*	*Fiji*	*Netherlands*	*Mauritius*	*Mexico*	*Rwanda*	*Uganda*	*Zambia*	*Total Countries*	*%*
70														6	46%
71														5	38%
72														5	38%
73														4	31%
74														3	23%
75														4	31%
76														6	46%
77														6	46%
78														5	38%
79														6	46%
80														6	46%
81														3	23%
82														4	31%
83														3	23%
84														5	38%
85														3	23%
86														3	23%
87														4	31%
88														4	31%
89														3	23%
90														3	23%
91														5	38%
92														5	38%
93														4	31%
94														3	23%

	Armenia	*Australia*	*Botswana*	*Brazil*	*Colombia*	*Costa Rica*	*Fiji*	*Netherlands*	*Mauritius*	*Mexico*	*Rwanda*	*Uganda*	*Zambia*	*Total Countries*	*%*
95														5	38%
96														5	38%
97														3	23%
98														1	8%
Total	**28**	**18**	**0**	**27**	**0**	**13**	**0**	**0**	**0**	**28**	**0**	**0**	**8**	**122**	
%	97%	62%	0%	93%	0%	45%	0%	0%	0%	97%	0%	0%	28%	32%	

Where:

Colours of water accounts (1st column): See categories in Table 1

Matrix "x" (water accounts) by "y" (countries): Undisclosed Disclosed

Percentage colour gradient: 0% 100%

Source: Prepared by the authors (2023).

In relation to the hybrid accounts, evidenced by six countries, Armenia, Brazil, and Mexico disclose them nearly completely. Australia and Costa Rica also presented hybrid accounts, but they are not entirely consistent with the SEEA-Water methodology, which has affected their level of disclosure. On the other hand, Zambia has chosen to disclose only monetary accounts and has left its physical accounts solely in the PWSUT.

Regarding the compilation of suppliers and/or consumers of water-related services, economic activities form hybrid accounts in most countries. Australia is an exception as it lacks the "water production by economic activities" account. However, the government justifies its omission by claiming a lack of reliable data to generate accurate estimates, considering the large number of companies that abstract water for their own use (Australian Bureau of Statistics, 2019).

Households are also included in the hybrid accounts. In Armenia and Mexico, the 'household' account is broken into 'final consumption' and 'government social transfers.' This is because water services are not directly purchased by families but are provided free of charge, or nearly so, by the government and non-profit institutions (Inegi, 2019). Thus, another user agent of water services is the government (81). However, only Armenia, Brazil, and Mexico use this category.

4.4 WATER ASSET ACCOUNTS

Regarding stocks or water asset accounts, Matrix 4 summarises the disclosure. Only five countries (45.45%) have these accounts—Brazil, Costa Rica, the Netherlands, Mauritius, and Rwanda. Among them, it is notable that all adhere to the basic structure of the SEEA-Water or the categories in question. The level of disaggregation of certain information is what modifies the level of disclosure in each country.

Matrix 4 – Water Asset Accounts

	Armenia	Australia	Botswana	Brazil	Colombia	Costa Rica	Fiji	Netherlands	Mauritius	Mexico	Rwanda	Uganda	Zambia	Total Countries	%
99														5	38%
100														5	38%
101														5	38%
102														5	38%
103														2	15%
104														5	38%
105														5	38%
106														5	38%
107														5	38%
108														5	38%
109														2	15%
110														5	38%
111														5	38%
112														5	38%
113														5	38%
114														5	38%
115														3	23%
116														3	23%
117														3	23%
118														0	0%
119														5	38%
120														5	38%
Total	**0**	**0**	**0**	**21**	**0**	**16**	**0**	**18**	**19**	**0**	**19**	**0**	**0**	**93**	
%	0%	0%	0%	95%	0%	73%	0%	82%	86%	0%	86%	0%	0%	33%	

Where:

Colours of water accounts (1st column): See categories in Table 1

Matrix “x” (water accounts) by “y” (countries): Undisclosed Disclosed

Percentage colour gradient: 0% 100%

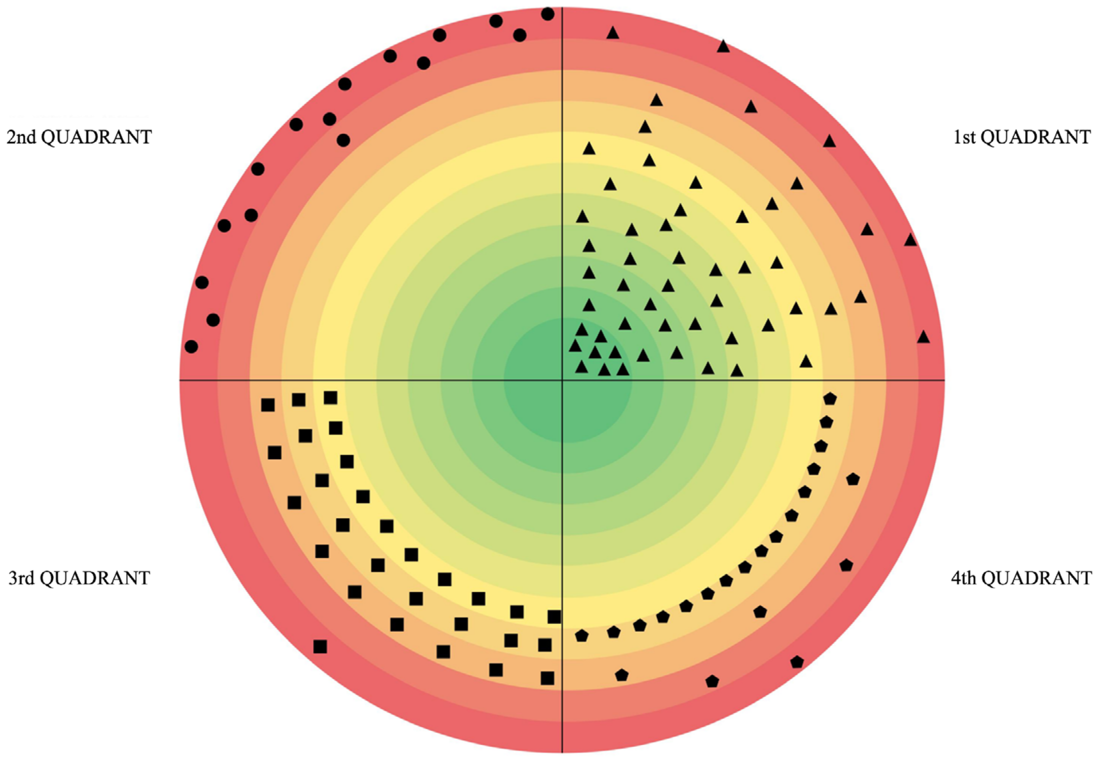
Source: Prepared by the authors (2023).

For instance, the disaggregation of surface water accounts into artificial reservoirs, lakes, and rivers (115, 116, and 117) underscores the challenge of measuring such water resources separately. Although Rwanda has provided a disaggregation of surface water accounts, the classification boundaries are not always precise, indicating the difficulty of measuring these resources separately.

Alongside the measurement challenge, there may be a lack of disclosure of accounts that do not align with the country’s context. This is exemplified by the “surface water - snow, ice, and glaciers” account (118), which is not disclosed by any country in the sample, as most countries considered are characterised by a climate that does not include these resources.

4.5 GENERAL ANALYSIS

This section provides an overview of the levels of disclosure after analysing the specific disclosed categories. For this reason, Figure 1 summarises the percentage of countries that disclosed each of the 120 determined categories. The first quadrant demonstrates the level of disclosure of the 53 categories of the PWSUT; the second quadrant shows the 16 water emission accounts; the third quadrant comprises 29 hybrid accounts; and the fourth quadrant includes 22 water asset accounts. Additionally, each point on the figure represents one of the 120 categories, and the closer the point is to the circumference, the less that category was disclosed. Similarly, the closer the point is to the centre, the better its level of adoption by countries.



Where:

1st Quadrant: Physical Water Supply and Use Tables

2nd Quadrant: Water Emissions Accounts

3rd Quadrant: Hybrid Accounts

4th Quadrant: Water Asset Accounts

Disclosure colour gradient: 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Figure 1 – Disclosure of the Proposed Categories

Source: Prepared by the authors (2023).

Observing the graph, we can see that countries show a higher level of adherence to the PWSUT, with a minimum disclosure rate of 50% for most of their accounts. This category stands out as the only one with a notable level of adherence among countries. Furthermore, we can notice that countries often use these categories as a “starting point” for compiling water accounts.

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However, the analysis of water emission accounts reveals a different pattern. With disclosure levels not exceeding 20%, this does not seem to have been prioritised by the countries. Some countries cite the unavailability of necessary data for proper compilation as a justification.

Finally, a similar trend is observed in the disclosure of hybrid and water asset accounts. Both categories are in the early stages of development. Furthermore, these broad categories include some accounts whose information is derived from the PWSUT. This highlights the significance of compiling data from the PWSUT and justifies the increased availability of disclosed data.

Matrix 5 presents another comprehensive analysis to complement the developed categorical analysis, which revisits the disclosure level of each of the four major categories developed while also adding the total disclosure level of the analysed countries.

Matrix 5 – Combined Analysis of the Categories

	Armenia	*Australia*	*Botswana*	*Brazil*	*Colombia*	*Costa Rica*	*Fiji*	*Netherlands*	*Mauritius*	*Mexico*	*Rwanda*	*Uganda*	*Zambia*	*Total*
PWSUT	49%	66%	66%	75%	68%	68%	60%	55%	55%	62%	68%	57%	34%	60%
Emission	0%	0%	0%	0%	0%	31%	0%	0%	0%	13%	0%	0%	0%	3%
Hybrid	97%	62%	0%	93%	0%	45%	0%	0%	0%	97%	0%	0%	28%	32%
Asset	0%	0%	0%	95%	0%	73%	0%	82%	86%	0%	86%	0%	0%	33%
Total	45%	44%	29%	73%	30%	58%	27%	39%	40%	53%	46%	25%	22%	

Where:

PWSUT: Physical Water Supply and Use Tables

Emission: Water Emissions Accounts

Hybrid: Hybrid Accounts

Asset: Water Asset Accounts

Percentage colour gradient: 0% 100%

Source: Prepared by the authors (2023).

Based on this data, it is evident that Brazil is the country that disclosed the most water accounts according to the proposed category model (73%). Despite not compiling water emission accounts, Brazil is recognised for its high level of compliance, particularly in hybrid accounts and water assets. Subsequently, we find Costa Rica (58%) to be another notable country, followed by Mexico (53%).

Costa Rica was the only country to disclose information related to all four major categories of analysis; however, it did not delve deeply into any of them.

Mexico, on the other hand, stood out in the level of disclosure of hybrid accounts, with a 97% alignment. However, water asset accounts were not presented, and only 13% of water emission accounts were disclosed.

Zambia, Uganda, Fiji, Botswana, and Colombia, in that order, were the countries that showed the least engagement with water accounts. Except for Zambia, these were the only ones to disclose information in just one group of categories – PWSUT. Although it presented some hybrid accounts (monetary only), Zambia had limited engagement with water accounts, with a 22% disclosure rate. However, it should be noted that the country emphasises in its report that this is a preliminary presentation of its water accounts. Thus, future developments should demonstrate greater engagement among these countries and new adherents to the SEEA-Water.

5 FINAL CONSIDERATIONS

The present research analysed how different countries disclose their environmental-economic accounts for water based on the SEEA-Water methodology. Therefore, the study employs a categorical analysis encompassing 120 categories, subdivided into PWSUT, water emission accounts, hybrid accounts, and water asset accounts.

Based on this, we observed that PWSUTs tend to be the primary information highlighted by the countries developing water accounts, given their significant level of adherence. On the other hand, water emission accounts were the least disclosed. The unavailability and difficulty in obtaining data for these accounts are among the justifications cited by those who do not disclose them.

Regarding the level of disclosure of hybrid accounts and water asset accounts, the countries exhibit a similar rate. Approximately half of the countries present some of these accounts, indicating they are in a developmental phase. Some countries' interest in future compilations reflects this trend.

In terms of contributions from this research, we highlight economic, environmental, managerial, and social contributions. Economically, it promotes the recognition of water as natural capital by elucidating its information in both physical and monetary terms. Environmental and social contributions arise from how the research encourages the disclosure of information about water resources. This disclosure fosters more significant engagement with resource management and preservation by developing organised data that drives more informed decision-making. It then catalyses the development of public policies to preserve water, mitigate water stress, and ensure resource quality.

Concerning this research's limitations, it is relevant to acknowledge that certain accounts, reports, and information on water accounts from some countries were unavailable and, therefore, not analysed. It is also worth mentioning that the language barrier in some publications may have hindered the analysis of water account disclosures in some cases, such as those from Armenia.

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