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Environment

Water resource accounting: information and awareness for sustainable use

Contabilidade dos recursos hídricos: informação e sensibilização para uso sustentável

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ABSTRACT

This article aims to show each inhabitant's share in the municipality of Alagoinhas (State of Bahia, Brazil) in the water demand in 2050 in monetary values. In methodological terms, this case study is empirical and exploratory. The Balance Sheet of Nations accounting technology allows identifying countries' environmental assets, liabilities, and equity. The environmental water asset based on the region's gross domestic product is determined, the environmental net worth by the residual balance of the water reserves, and the environmental water liability by accounting equivalence using the Basic Accounting Equation. Results showed a surplus of US$ 3.04 per capita in 2017 and a deficit of US$ 12.68 per person projected for the year 2050. This result offers the possibility that the municipality of Alagoinhas does not have water resources in the year 2050. It also points to the importance of how inhabitants should take care of their water resources in the coming decades and contributes to future research highlighting the relevance of accounting information aimed at these natural resources' patrimonial situation.

Keywords: Sustainable water management; Sustainability evaluation; Urban water systems; Ecosystem water measurement; Water reuse

RESUMO

Este artigo tem como objetivo mostrar a participação na demanda de água de cada habitante no município de Alagoinhas (Bahia, Brasil) e a demanda projetada para 2050 em valores monetários. Em termos metodológicos, este artigo é um estudo de caso, empírico e exploratório. A teoria da contabilização do Balanço das Nações permite identificar os ativos, passivos e patrimônio ambientais dos países e regiões. O ativo ambiental da água com base no produto interno bruto da região é determinado, o patrimônio líquido ambiental e o balanço residual das reservas de água e o passivo ambiental da água por equivalência contábil usando a Equação Básica da Contabilidade. Os resultados mostraram um superávit de US$ 3,04 per capta em 2017 e,para o ano de 2050, um déficit projetado de US$ 12,68 por pessoa. Esse resultado mostra a possibilidade de o município de Alagoinhas não ter recursos hídricos no ano de 2050. Também aponta à importância de como os habitantes devem cuidar de seus recursos hídricos nas próximas décadas, também contribui para pesquisas futuras evidenciando a relevância da informação contábil voltada para a situação patrimonial desses recursos naturais.

Palavras-chave: Gestão sustentável da água; Avaliação de sustentabilidade; Sistemas urbanos de água; Medição de água do ecossistema; Reuso de água

1 INTRODUCTION

Half of the world's population is projected to live underwater stress by 2025 (WWC, 2000). Access to safe drinking water is crucial for human development (DAS *et al*., 2019). Water is a fundamental necessity for lives and livelihoods, economic prosperity, health and development, environmental sustainability (ISON *et al.*, 2007; PAHL-WOSTL, 2006). Nevertheless, this vital resource remains undervalued (CDP, 2018). In developing countries, available water quantity decreases, and quality worsens (KARAVOLTSOS *et al*., 2008; WWAP, 2006). The rate of depletion of groundwater levels and deterioration of surface water quality is of great concern worldwide that adds to the lack of public access to safe drinking water (SCHWARZ; MATHIJS, 2017; UL HASAN; RAI, 2020; WHO, 2011).

According to García-Cáceres *et al*. (2019), water treatment to make it potable and adequate for human consumption is central. More than 50% (and rising) of the world population live in cities (VERGRAGT *et al*., 2016). The treatment systems are an essential part of the public drinking water home service (MA *et al.*, 2020).

In Brazil, despite various government schemes for initiatives to distribute drinking water and equitably, piped water supply is deficient throughout the country Ribeiro and Rolim (2017).

According to Stindt (2017), considering the sustainability aspects of value creation induces a new set of challenges within decision making that affects the systems intended to treat public drinking water and the water supply chain. Planning of water production is framed in a tactical-operational decision context that seeks to satisfy regulatory requirements and increase the system's efficiency (GARCÍA-CÁCERES *et al*., 2019). Production planning can be assisted by decision-making support systems that maximize profit (total cost minimization), minimizing waste, and forecasting future demands (GRAY, 2000).

Scheili *et al.* (2016) wrote that small distribution systems face numerous challenges because of financial insufficiency. TANG *et al*. (2013) said that human error contributes to one of the major causes of the prevalence of drinking water contamination incidents. The analysis involves future efforts and direction for embedding resilience into drinking water risk.

The research's objective was to highlight the environmental balance of water in the municipality of Alagoinhas and project it for 2050 in monetary values.

2 WATER SCARCITY, NATIONS BALANCE SHEET, STUDY AREA

After the Eighth Biennial Emergency Conference, the need to revisit the procedures and assumptions used to calculate the geo-biosphere baseline emerged as a need to strengthen environmental accounting and remove sources of ambiguity misunderstanding - potential understandings (BROWN; ULGIATI, 2010; BROWN *et al.*, 2016).

Clear and consistent definitions of the land system's boundaries and its categories, including water, are essential for its interpretation (WANG *et al*., 2009). They are a necessary prerequisite for meaningful comparisons consistent with LCA and Emergency Synthesis, which is identified and discussed as the basis for calculating environmental performance indicators (BROW; ULGIATI, 2010; BROWN *et al.*, 2012).

Odum (1996; 2000) calculated the total environmental support for the geo-biosphere in terms of the emergent concept, measuring the total energy available, directly and indirectly, involved in the processes of the geo-biosphere, whose calculation of transformity factors for the main sources are based on these developed works.

Several methods have been proposed to calculate the water cycle's global transformity (ODUM, 1996). Subsequently, Odum (2000) accounted for the potential chemical-physical transformations for continental rain and demonstrated the importance of this cycle for life on earth (BROWN; ULGIATI, 2016).

2.1 Water scarcity

According to Vieira *et al.* (2006), the planet Earth on its surface is formed in 75% of water and 25% in emerging land (above water). This volume of water creates necessary conditions for life and maintains the balance of nature. In this context, 97.3% of that water is salty, and 2.7% is freshwater. However, of this freshwater percentage, 77.2% corresponds to ice in the polar ice caps; 22.4% represents groundwater; 0.35% lakes and swamps; 0. 04% rivers; and 0.01% atmosphere. Studies show that 33 countries will suffer a too high-water crisis in 2040, Chile, Spain, and other 14 countries belonging to the Middle East (CIRILO, 2015; GERHARDT; NODARI, 2016).

In this context, Pereira *et al.* (2015) and Ison *et al*. (2007) believe that local effects cause global consequences and that global society needs to seek sustainable consumption measures.

The United Nations (UN) publishes the World Report on Water Resources Development (World Water Development Report - WWDR). These reports present water resources globally and what measures have been implemented to solve scarcity and consumption of drinking water (UNESCO, 2017).

A 55% increase in water demand is expected at the global level for the year 2050, with the agricultural sector currently responsible for 70% of average water extractions worldwide, accompanied by industries and energy production contributing to the significant increase in the consumption of water resources (UNESCO, 2015).

The UNESCO report (UNESCO, 2017, p.5) reports that "recent research has shown that currently, two-thirds of the world’s population live in areas suffering from water scarcity for at least one month a year." That implies that the population has suffered from water scarcity, calling attention, in particular, that about 50% live in China and India (CDP, 2018).

Research by Richey *et al*. (2015), between the years 2003 to 2013, treated the situation of the 37 largest underground aquifers in the world, 21 of which resulted in a water deficit (withdrawal of water more remarkable than the inlet), 8 of which were considered with almost no natural replenishment to compensate for the use. Among these aquifers stands out the Arabic aquifer (source of water for more than 60 million people), resulting from the world’s most critical water deficit.

In Brazil, the water reserve is approximately 12% of the world’s total (CERH, 2007). However, the heterogeneity in the hydrographic regions is quite significant, like the Amazon Hydrographic Region, which has 78.7% of its total freshwater. The region where the Municipality of Alagoinhas is located has 9.7 million inhabitants, equivalent to 5.1% of the total population, and has 0.2% of drinking water in Brazil (GERHARDT; NODARI, 2016; PEREIRA, 2018).

The State of Bahia has heterogeneous water availability; of the seven municipalities belonging to the State of Bahia, 217 suffer from water scarcity every year. The drought registered in 2017 was considered the largest in the last 80 years (TOPÁZIO, 2017).

2.2 Nations balance sheet

The Accounting Balance of Nations highlights the account that each citizen will have to bear in the face of global climate change phenomena. It shows surplus or deficit situations and allows individual and collective reflections on global, regional, and local actions concerning environmental preservation policies and mechanisms (KASSAI *et al*., 2010). Each country has the assets represented by its natural resources. The liabilities correspond to the obligations concerning preserving the environment (KASSAI *et al*., 2009). The net worth means the residual portion destined to recover the natural reserves for the current and future generations.

The assets are valued monetarily (US$), adopting the gross domestic product - purchasing power parity (PPP), adjusted by the average energy consumption in ton equivalent of oil, or tons of oil equivalent (TOE) as an opportunity cost. Equity is quantified according to the residual balance between emissions and natural carbon capture (CO_2) for each country or region, calculated based on the estimated cost of carbon capture and the scenarios provided for in the Special Report on Emission Scenarios of the IPCC (NAKIC'ENOVIC *et al*., 2000).

Liabilities are determined by accounting equivalence (KASSAI *et al*., 2010). The Balance Sheet of Nations is a forecast threshold of the environmental balance in a specific region for a given. The threshold value reflects the interaction between the water environment and socio-economic development activities and is a crucial characteristic closely related to sustainable development within a basin (ISON *et al*., 2007). There are considerable differences among regions due to the geographic location and regional conditions (LOUETTE, 2009; TANG *et al*., 2013). This view has been widely recognized in many countries (PEREIRA *et al*., 2015).

2.3 Water accounting

According to Zhao *et al.* (2019), the accounting of water from the regional water perspective has traditionally focused on local water supply, i.e., managing water to support local production's water demand. From the consumption perspective, all water use, we use the Accounting Review of Nations model, which occurs along the chains of production and distribution are allocated according to accounting principles (LENZEN *et al*., 2013; KASSAI *et al*., 2009). Hence, the balanced perspective can show the impacts on water resources in one region from the same or another region, thus informing consumer responsibility. Overall, it is essential to address both perspectives (Debts and Assets) to understand the balance of water's environmental costs from the countries/regions of consumers to producers (KASSAI *et al*., 2010).

The challenge is how to improve accounting given the lack of available data on which planning can conduct their decisions about water scarcity, water surpluses, and water management opportunities. Water Management Accounting is a recently proposed extension to Environmental Management Accounting designed to support management decisions (TANG *et al*., 2013; ZHAO *et al.,* 2017). Accounting Science has been molding itself to promote studies and generate information about these natural resources, allowing managers and society greater visibility of these resources' patrimonial situation. Therefore, researching this theme in Alagoinhas will contribute to a reflection and construction of technical products that disseminate the more significant accounting science insertion in Environmental Sciences activities.

3 METHODOLOGY

A case study methodology has been used to approach and investigate a contemporary in depth and within its real-life context when boundaries between phenomenon contexts are not evident (STAKE, 2005; YIN, 2014). A case study

(Section 3.1) is a trans paradigmatic and transdisciplinary heuristic. That involves the careful delineation of the phenomena for which evidence is being collected (MOLINA-MATURANO *et al.*, 2020; VAN WYNSBERGHE; KHAN, 2007).

A literature review was conducted to gain insights on constraint-based on accounting reviews of Nations in different contexts. Their impact on sustainability measurement and the need for context-specific frameworks was ident infield in understudied geographical areas such as Alagoinhas.

3.1 Case study methodology

A case study methodology is often used in exploratory studies and preserving real-life events (GERRING, 2004; YIN, 2014, 2017). The present study is exploratory, and the case-based research was identified as suitable. Also, the case approach is suitable for studying phenomena with limited information because of its capacity to combine primary and secondary data (YIN, 2017). Moreover, case studies have previously been applied for investigating both community response to environmental changes (HUTCHINGS, 2015; VOIGT *et al.*, 2007), pressure on the natural environment (FANG *et al.*, 2020).

The first step in the research design of a case study is developing the conceptual framework underlying the research and explaining its main aspects (YIN, 2014). The development was based on a literature review to create the analysis lens (PEREIRA, 2018). The second step is the unit of analysis. Accounting Review of Nations for national environmental valuation (LOUETTE, 2009; KASSAI *et al*., 2010; PEREIRA *et al*., 2015) Brazilian Institute of Geography and Statistics (IBGE, 2017) databases were consulted over a period from 2015 to 2019; to ensure reliable and up-to-date information. The region of the case study was chosen for the personal interest of the researchers. The case is selected based on the expectations regarding their information availability and content (Table 1). This analysis unit was considered suitable as the goal was to explore how the waters' features and the analysis units' motivation provided a good enough background to apply the sustainability evaluation framework.

Tabela 1 – Data from Alagoinhas from 2014 to 2017

Year	GDP [US$]	Population [inhabitant]	Water withdrawal [MCM/year]	Water withdrawal/inhabitant/year [m3/inhabitant/year]
2018	*	150,832	17.4	115.4
2017	6,801.72	155,979	15.7	100.7
2016	6,275.57	155,362	15.6	100.6
2015	4,538.29	152,803	14.8	96.9
2014	6,760.24	151,879	13.4	88.5

Source: Sistema Nacional de Informações sobre Saneamento (2018) Historical data, National Sanitation Information System. Historic series]. Available in: http://app4.cidades.gov.br/serieHistorica/
MCM - million cubic meters. *No data were present from 2018 onwards.

Data triangulation data were processed and secondary data (official web presence, blogs, newspaper articles, and digital magazines) using excel software. The methodology was presented at the III National Seminar on Integration of the Network Graduate Program in the National Network for the Teaching of Environmental Sciences (PEREIRA, 2018).

Three rounds of revisions (one in the thesis presentation, the other one in an international congress) were done by multiple researchers. After the presentation, the cases were once again checked for necessary content by the experts who evaluated its sustainability and replicating the methods used in the sustainability evaluation frameworks. Given the specific focus on water and the diverse social utility models in Alagoinhas, a quantitative analysis was not feasible due to the lack of available data. Hence, the research has limitations due to its explorative nature and the limited number of cases investigated.

Furthermore, case study research has certain limitations in general (MERRIAM, 2009). The central is validity and reliability due to the small sample size and researcher bias; meanwhile, there is no reason to believe that there is any difference compared to other research approaches regarding the last argument.

The critique that a lack of representativeness and generalizability limits case studies. As Molina-Maturano *et al.* (2020) assume, formal generalization is overvalued in environmental affairs and that context-dependent knowledge is more valuable in this realm than general knowledge. The detailed investigation of a case in its context, using different sources and kind of data, may not enable a generalization but broaden the understanding of the case as one of its kind, embedding and the external factors influencing it and being influenced by it. There is also the argument that case studies are particularly suitable for explorative research; they can also test hypotheses, concepts, and theories and build or develop them (EISENHARDT; GRAEBNER, 2007).

3.2 Study area

Alagoinhas was chosen for convenience due to accessibility, and the first author lives there. The municipality and due to Alagoinhas is known as an essential water reservoir for the dissemination of the São Sebastião aquifer, located in the North Reconcavo Sedimentary Basin (ALVES; NASCIMENTO, 2015), to the academic community and government policy and action planners, and to raise awareness of the importance of preserving and caring for the knowledge of the local population. Reconcavo Baiano is a geographic region comprising the All-Saints Bay area (in Portuguese, Baia de Todos os Santos) about 1100 km^2 and the adjacent countryside, totaling 16,300 km^2 between 12°S and 13°15'S and 38°W and 39°30'W.

The Alagoinhas municipality (Figure 1) has 141,949 inhabitants and a Gross National Product (GNP) *per capita* annual equivalent of US$ 6,824.36 according to the Brazilian Institute of Geography and Statistics (IBGE, 2010). The total area is 707,835 km^2. It is located around 12°8′9″S, 38°25′8″W situated on the interior of Bahia became an emancipated settlement in the municipality of Inhambupe in 1852 (DAMASCENO, 2015; ALAGOINHAS, 2020).

The State of Bahia has 11 groups of aquifers, including the Aquifers of the Sedimentary Basin - Reconcavo, where the aquifer system of the Marizal - São Sebastião Formation is located. In quantitative terms, these hydrogeological domains have concepts such as water potential and water availability (NEGRÃO, 2007).

The supply of water resources to the municipality occurs by exploring groundwater, coming from the São Sebastião Formation aquifer system, located in the Reconcavo Norte and Inhambupe Planning Region. The data were collected in the State Water Resources Management System of Bahia (BAHIA, 2005) and the National Water Resources Information System (SNIRH) to identify water resources' reserve and consumption (SNIS, 2018).

Figure 1 - Location of Alagoinhas - North Reconcavo and Inhambupe Hydrographic Region

Source: IMARH (2014). Região de Planejamento e Gestão das Águas: XI Reconcavo norte e Inhambupe [Institute of Environment and Water Resources. Region of Water Planning and Management: XI north concave and Inhambupe]. Available in: http://www.inema.ba.gov.br/wp-content/files/XI-RPGA-DO-RECONCAVO-NORTE.pdf.

3.3 Sustainability evaluation frameworks

With these data in hand, the Balance Sheet for Water Resources (BSWR) was calculated and analyzed. The Environmental Water Asset (EWA) was calculated based on the region's Gross Domestic Product (GDP) per capita, equivalent in national currency, and adjusted by the Environmental Water Exhaustion (EWE), calculated based on a Water Exhaust Factor (WEF). The WEF is established as the coefficient between water consumption per capita of the municipality divided by its equivalent consumption (KASSAI *et al*., 2009; KASSAI *et al*., 2010;).

The formulas for measuring the Hydro Environmental Asset (HEA) were:

EWA = (Annual GDP per capita) / (Annual consumption per capita) (1)

Adjusted HEA = HEA / Water Exhaustion Factor (2)

WWP = (RA - CA) x PRH (3)

A justification for adjustment in assets, the UN guidance of 100 out of 100 liters of water per day was considered. This corresponding to 40.15 m^3 of water per capita per year (WHO, 2003). This EAH results in a negative adjustment for inhabitants who consume above what the UN proposed and a positive adjustment for the inhabitant with a UN's consumption result below recommended.

The Environmental Hydraulic Net Equity (EHNE) was determined by the residual balance of water reserves, per capita and in cubic meters, calculated among the estimated available water reserve for the region, less consumption, and valued at the price of the environmental service determined by competent organ.

The Environmental Water Liability (EWL) was calculated by accounting equivalence using the Basic Accounting Equation and represents the balance of each citizen's obligations concerning their livelihood and preserving the environment.

The exploration of the São Sebastião aquifer's water reserves today focuses on human and animal supply in the cities and towns of Reconcavo, meeting the needs of several industries installed in the basin area oil exploration, mineral extraction, in the production of beverages. Furthermore, mineral waters and, to a lesser extent, in irrigated agriculture (BRANDÃO, 2008).

The water potential corresponds to the "water volume that can be used annually, including, eventually, a portion of the permanent reserves, which can be exploited, with constant discharge, during a specific period." COSTA (2012) points out that the permanent reserve consisting of water volume accumulated does not vary due to the potentiometric surface's seasonal fluctuation.

The supply of water resources to the municipality of Alagoinhas occurs through the exploration of groundwater, which is concentrated in the aquifer system of the Marizal/São Sebastião Formation. Thus, the municipality's water potential corresponds to 94.2 MCM (NASCIMENTO *et al.*, 2004). However, due to the lack of data available in the water control and management bodies in the State of Bahia, it was not possible to show the water availability in the municipality of Alagoinhas. Table 2 presents the potential and flow of Alagoinhas water per inhabitant for the years 2014, 2015, 2016, 2017 and projection for 2050.

Values present water potential per capita in respective years decreased due to the number of inhabitants between 2014 and 2017, and there was an average decrease of 0.88%. However, after the projection for 2050, this decrease resulted in 12.3%, taking 2017 as a parameter.

Withdrawal water per capita between 2014 - 2015 decreased 8.7%; between 2015 and 2016, an increase of 13.8%. From 2016 to 2017, a reduction decreased by 0.01%. In the projection for 2050, concerning 2017, an increase of 2511%, resulting in an average of 1.7% between 2014 to 2017.

Table 2 – Potential water per capita and water withdrawal per capita WWP, 2014 - 2017 and 2050 (in m3/yr)

Year	Potential water per capita	Per capita water withdrawal
2050	529.9	2,627
2017*	603.9	100.6
2016	606.3	100.7
2015	616.5	88.5
2014	620.2	96.9

Source: Nascimento, S.A.M.; *et al*. (2004). Quali-Quantitative Study of Groundwater in the Municipality of Alagoinhas as a Component of the Municipal Environmental Sanitation Plan. Rev. Águas Subterrâneas. Available in: https://aguassubterraneas.abas.org/asubterraneas/article/view/22647.

According to data from the Autonomous Water and Sewage Service of Alagoinhas (AWSS), provided for in the National Sanitation Information System (SNIS, 2018), the year 2017 saw water withdrawal around 15.7 MCM, equivalent to 100.7 m^3 per inhabitant per year and, in 2018, 17,4 MCM or 115.4 m^3 per inhabitant per year. Table 1 shows data from Alagoinhas between 2014 and 2017 for GDP, population, total water withdrawal per year, and water withdrawal per inhabitant per year.

According to data from the Groundwater Information System (SIAGAS) developed by the Geological Survey of Brazil, a former Mineral Resources Research Company, Alagoinhas has 63 registered artesian wells, 28 wells for urban supply and, of these, eight wells are deactivated. However, the system does not have information on the quantity of water withdrawn from these wells, for data collection, for the related research (SGB, 2019).

4 RESULTS AND DISCUSSION

In this section, the Alagoinhas imbalance watershed context is summarized to articulate existing solutions and have a common baseline of comparison, as suggested in previous studies. Then the similarities found among FI and the cases are presented (Table 3). For each one of the three features of frugal innovation (Figure 1), the innovators' motivations and the solutions' origins. After that, we presented the scores of the sustainability evaluation.

Table 3 – Composition of Hydro Environmental Asset, Alagoinhas for the years 2014, 2015, 2016 and 2050 (in US$)

Year	**Hydro Environmental Asset HEA**	**Water Exhaust Factor WEF**	**Environmental Water Exhaustion EAH**	**Adjusted: Hydro Environmental Asset adjusted HEA adjusted**
2050	60.32	65.43	59.40	0.92
2017	67.55	2.51	40.63	26.91
2016	62.38	2.51	37.53	24.85
2015	46.83	2.41	27.40	19.43
2014	76.39	2.20	41.32	34.44

Source: Nascimento, S.A.M.; *et al*. (2004). Quali-Quantitative Study of Groundwater in the Municipality of Alagoinhas as a Component of the Municipal Environmental Sanitation Plan. Rev. Águas Subterrâneas. Available in: https://aguassubterraneas.abas.org/asubterraneas/article/view/22647.

In 2014, Alagoinhas GDP grew on average of 8.0 % per year. In 2015, is reduced by 1.3%, in 2016 an increase of 15.4%, and in 2016 an increase of 10.0%. It is worth mentioning that until the conclusion of the survey, IBGE did not publish 2018 (IBGE, 2018).

In the average population growth between 2014 and 2018, there was a reduction of 0.02%. In 2014 increased by 0.06%, 2015 an increase of 1.7%, 2016, an increase of 0.04%, and a 3.3% reduction in 2017. Between 2014 - 2017 the withdrawal water increased 29.0%, an average increase of 6.8% per year. It is worth mentioning the expressive increase of 10.8%, corresponding to 2018 compared to 2017.

In accounting, the Water Balance Sheet (BPH) represents the set of assets and rights (HEA), obligations (PAH), and residual balance (WWP) of the inhabitants resulting from the use of environmental resources. The Environmental Water Asset (HEA) represents the portion of the population comprised in monetary values of the water resources that each inhabitant acquired for their livelihood were. It was necessary evidence of this asset to adjust this HEA. For that, the Water Exhaustion Factor (WEF) was used. The term depletion corresponds to a reduction in value, resulting from the exploitation of mineral, forest, and other exhaustible natural resources (MCASP, 2018).

In this context, when it comes to an entity that develops activities to exploit non-renewable natural resources, exhaustion is performed for elements of exhaustible natural resources. That has a limited economic useful life and has the fundamental characteristic of reducing the asset’s value, and the leading cause of the weight reduction is exploitation (MCASP, 2018).

WEF represents an indicator resulting from the division of annual water consumption per capita by annual water consumption per capita recommended by the UN. It is worth mentioning that the WHO (2003) recommends 110 liters of water per day, ideal for an individual to satisfy his vital needs. Table 2 corresponds to the Hydro Environmental Asset (HEA) measurement of Alagoinhas between the years 2014 to 2017 and a projection for the year 2050.

In this context, the HEA for the year 2050 was reduced by 98.5%, and the average WEF between 2014 to 2017 corresponds to 2.4%. Therefore, the average adjusted HEA between 2014 and 2017 is 84.5%.

The environmental hydraulic net equity (WWP) represents the annual balance of water reserve per capita in cubic meters, calculated between the estimated water reserve (EWR) per capita, less the yearly Water Consumption (WC), multiplied by the price of the use of water resources (UWR) established by Federal Law No. 9433 (BRASIL, 1997). In this work, the PRH is supported by Decree 9747 (BAHIA, 2005) and corresponds to US$ 0.006.

For the projections related to the year 2050, the geometric progression method was used, represented by the formula:

$$Pp = (Tx+1)^{n} \times Pa \tag{4}$$

where *Pp* = Projected period, *Tx*= growth rate, *n* = number of periods to be projected, and *Pa* = Current period.

To calculate the growth rate, the formula was used

$$Tx = (Pa/Pi)^{1/n} - 1 \tag{5}$$

where, *Tx* = Growth rate; *Pa* = Current period; *Pi* = Initial period; and *n* = number of periods.

The Water Balance Sheet demonstrates qualitatively and quantitatively the equity situation of water resources arising. The use of each citizen and is composed of Environmental Water Asset (EWA), adjusted by the Environmental Water Depreciation (EWD), Environmental Water Liabilities (EWL), and Environmental Water Net Equity (EWNE).

The EWNE represents the residual balance of the portion of the population comprising in monetary values of the water resources that each inhabitant acquired for their livelihood, which, when positive, includes a surplus negative, it is equivalent to the deficit (Table 4).

Table 4 – Water Balance Sheet for Alagoinhas (in US$)

Year	**Environmental Water Asset** **EWA**	**Environmental Water Depreciated** **EWD**	**Environmental Water Net Equity** **EWNE**
2014	34,68	30,67	4,00
2015	19,39	16,73	2,66
2016	24,88	21,78	3,10
2017	26,69	23,91	3,04
2050	0,92	13,60	*-12,68*

Source: Nascimento, S.A.M.; *et al*. (2004). Quali-Quantitative Study of Groundwater in the Municipality of Alagoinhas as a Component of the Municipal Environmental Sanitation Plan. Rev. Águas Subterrâneas. Available in: https://aguassubterraneas.abas.org/asubterraneas/article/view/22647.

The EWNE represents the residual balance of the portion of the population comprising in monetary values of the water resources that each inhabitant acquired for their livelihood, which, when positive, contains a surplus. When negative, it is equivalent to the deficit. Compared to 2015, there was a 2.4% reduction in the rest (Table 4) due to the high-water consumption in that period (Table 3). In 2050, the water consumption projection, based on 2015, increased astonishingly 3587% in this natural resource's consumption. Thus, this high consumption resulted in a deficit of US$ 12.68.

5 LIMITATIONS

Although water research has developed over the past 30 years, it is still early due to a lack of empirical studies (MA *et al*., 2020; PAHL-WOSTL, 2006.). Likewise, the concept of the value of an environmental asset is still under development, and the related definitions are yet being studied. Recent literature shows that the idea may depend on the geographic region (HURLIMANN *et al.,* 2009; MOLINA-MATURANO *et al.,* 2020). The present work does not aim to advance environmental concepts due to their exploratory nature and open new discussions in the region's water sector.

The context and data available from the selected case studies also bring their challenges to the applicability of a quantitative approach (AMARATUNGA *et al.*, 2002) mainly due to the lack of databases and information to gather an adequate sample size (FRISCHKNECHT *et al*., 2004).

As a result, an exploratory case study project was applied and combined with a sustainability assessment. As an added benefit, the sustainability assessment framework used has been validated using various experts and academics. For research fields with sufficient data available, using a comprehensive approach, such as assessing life cycle sustainability or calculating the ecological footprint, would likely add even more insight into an aquifer's real sustainability and can potentially be combined with the structure used in this article.

6 CONCLUSIONS

The purpose of the research was to show, employing accounting technologies, the share of each inhabitant located in the municipality of Alagoinhas through the use of water resources, including monetary values. The literary framework was used, in contrast to the discussions published in technical materials. Concerning the data to show the Water Balance Sheet, the Information Systems on Water Resources, State and National were explored. The results showed a surplus in 2014 and 2015 but a deficit after the projection for 2050.

The study proves the contribution of Environmental Accounting in generating information on the consumption of water resources. This science is inserted in the context of Environmental Education practices. The research results demonstrate the importance of how the inhabitants should take care of their water resources in the following decades. It also contributes to future investigations that show the relevance of accounting information focused on these natural resources' patrimonial situation.

The data generated by the National Sanitation Information System. Historic series which shows water consumption per inhabitant, was limiting for the research, as these data only represent the water supplied by the municipal authority. Therefore, it does not cover the exploitation of water resources by private entities, which use their resources to capture these natural resources. It is not possible to infer the quality and quantity of the same.

The research contributes to future studies that demonstrate the importance of Accounting for the analysis of water resources. These resources are scarce and need to be monitored and inspected, not only by managers but also by society. Finally, it is suggested to continue the study with data from 2018 and later, referring to the number of inhabitants, GDP per capita, and water consumption per capita in Alagoinhas.

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