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Indicators in the selection of priority areas of PSAH x SDG schemes of the 2030 Agenda

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ABSTRACT

With the excessive use of natural resources, the increasing degradation of ecosystems and water scarcity, consequently, the adoption of tools that assist in environmental and water resources management becomes increasingly necessary and urgent. Payment for Environmental Services (PSA) stands out for being an environmental management instrument capable of involving society without the use of command and control tools, promoting socio-environmental improvement. However, as it is a potential economic instrument, it is necessary that methods linked to criteria and indicators are clearly studied and chosen, in accordance with the multiple objectives proposed and in line with the Sustainable Development Goals (SDGs) of the 2030 Agenda. This article aimed to analyze national and international works, through a systematic literature review, which addresses methodologies used in the selection stage of areas for PSAH schemes, aiming to relate the indicators and criteria found with those pointed out in the SDGs of the 2030 Agenda. work was sought, through the adoption of Indicator 6.4.2 – Water Stress Level of SDG 6 of the 2030 Agenda, which is related to the criterion "Availability of surface water and overexploitation/contamination of aquifers", obtained for the river basin Ipojuca, exemplify how SDG indicators can be used to identify priority areas for intervention in PSAH. The results showed the relationship between the indicators and criteria used in the PSA with those highlighted in the 2030 Agenda and the possibility of adopting the indicators to point out priority areas for PSAH schemes.

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RESUMO

Com o uso desmedido dos recursos naturais, a crescente degradação dos ecossistemas e a escassez hídrica, por consequência, se torna cada vez mais necessária e urgente a adoção de ferramentas que auxiliem na gestão ambiental e de recursos hídricos. O Pagamento por Serviços Ambientais (PSA) destaca-se por ser um instrumento de gestão do meio ambiente capaz de envolver a sociedade sem o uso de ferramentas de comando e controle, promovendo uma melhoria socioambiental. Porém, por se tratar de um potencial instrumento econômico, é necessário que métodos atrelados a critérios e indicadores sejam claramente estudados e escolhidos, de acordo com os múltiplos objetivos propostos e em consonância com os Objetivos do Desenvolvimento Sustentável (ODS) da Agenda 2030. O presente artigo objetivou analisar trabalhos nacionais e internacionais, através de uma revisão sistemática de literatura, que aborda metodologias utilizadas na etapa de seleção das áreas para esquemas de PSAH, visando relacionar os indicadores e os critérios encontrados com os apontados nos ODS da Agenda 2030. Neste trabalho buscou-se, através da adoção do Indicador 6.4.2 – Nível de Estresse Hídrico do ODS 6 da Agenda 2030, que está relacionado ao critério "Disponibilidade de água na Superfície e superexploração/contaminação de aquíferos", obtido para a bacia do rio Ipojuca, exemplificar como os indicadores dos ODS podem ser usados para apontar áreas prioritárias de intervenção em PSAH. Os resultados apontaram a relação entre os indicadores e critérios usados no PSA com os apontados na Agenda 2030 e a possibilidade de adoção dos indicadores de apontar áreas prioritárias para esquemas de PSAH.

Palavras-Chave:
revisão sistemática de literatura, ODS, PSAH, indicadores.

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Introduction

In recent years, the excessive use of natural resources has made it necessary to develop measures that monetize them as environmental assets, including them in the economy (Garcia *et al.*, 2021). With this movement, the concept of ecosystem services and environmental services took shape. Ecosystem services (ES) are conceptualized as the services provided by natural ecosystems and the species that compose them, in sustaining and fulfilling the conditions for the permanence of human life on Earth (BRASIL, 2021 and Fidalgo *et al.*, 2017) and environmental services (ES) were used as a subset of ES, which can be generated as externalities of human activities.

Based on the conceptualization and interest in the protection of ecosystems, which had been suffering a decline in its functions, the Payment for Environmental Services (PES) has gained prominence (Coelho *et al.*, 2021), in recent decades, as an instrument of environmental policy. However, it is an instrument with broader characteristics, because in addition to improving the environmental services of a given area, it also aims at social and economic improvements, and constitutes a promising public policy strategy (Rosa *et al.*, 2016).

Due to its notorious importance as a tool in environmental management, several states have their own legislation when it comes to PES, such as Pernambuco, with Law No. 15,809, of May 17th, 2016, which institutes the State Policy for Payment for Environmental Services, creates the State Program for Payment for Environmental Services and the State Fund for Payment for Environmental Services. Due to the decentralization of PES policies at the national level, there was a need for legislation at the Federal level and, after years of debates in the National Congress, Law No. 14,119 was instituted on January 13th, 2021, which defines concepts, objectives, guidelines, actions, and criteria for the implementation of the National Policy for Payment for Environmental Services (PNPSA) and provides for other measures related to PES (Brasil, 2021).

The growing studies, societal efforts and government measures, such as Law No. 14,117, of 01/13/2021, focusing on environmental protection and improvement, are initiatives that express the real concern with natural resources, but mainly as part of a global commitment in line with the 17 Sustainable Development Goals (SDGs). Established and adopted by the UN in 2015, the SDGs are known as global goals as they are a universal call in order to end poverty, protect the planet and ensure that by 2030 all people enjoy peace and prosperity, which is why it is called the UN 2030 Agenda (UNDP, [between 2015 and 2023]). Figure 1 illustrates all the SDGs of the 2030 Agenda.

Figure 1.

The 17 Sustainable Development Goals of the 2030 Agenda.

Source: UN (2015). poverty eradication, zero hunger and sustainable agriculture, health & wellness, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reducing inequalities, sustainable cities and communities, responsible consumption and production, action against global climate change, life on the water, terrestrial life, peace, justice and strong institutions, partnerships and means of implementation.

Among the commonly implemented PES designers, or schemes, are those related to Sustainable Development Goal (SDG) 6: Clean Water and Sanitation, called Payments for Water Environmental Services (PSAH) schemes (Vuletic, 2020 and Jones *et al.*, 2022). However, in the choice of priority areas for PES, little is said about the methodologies for indicating such areas and the indicators used in prioritization that maximize the positive result with the limited resource allocated (Gjorup *et al.*, 2016), and their relationship with the Sustainable Development Goals of the 2030 Agenda (SDGs), which goes beyond SDG 6, as many are closely related to water resources. As a result of this and because of its importance as an instrument in achieving the global goals established by the UN, PES schemes should point to the indicators of the related Sustainable Development Goals.

Thus, taking into account the need for more national and international information about the methodologies and criteria used to indicate priority areas in the implementation of PSAH schemes and the need to relate the indicators in studies of this nature with the SDG indicators, a systematic literature review was carried out, adopting the PRISMA method as a writing guide.

This article aimed to analyze national and international studies, through a systematic literature review, which addresses methodologies used in the stage of selection of areas for PSAH schemes, aiming to relate the indicators and criteria found with those pointed out in the Sustainable Development Goals of the 2030 Agenda.

In this work, through the adoption of Indicator 6.4.2 - Water Stress Level of SDG 6 of the 2030 Agenda, which is related to the criterion “Surface water availability and overexploitation/contamination of aquifers”, obtained for the Ipojuca River basin, we sought to exemplify how the SDG indicators can be used to point out priority areas for intervention in PSAH.

Methodology

Study area

The Ipojuca River basin is located in its entirety in the state of Pernambuco, between latitudes 8°09'50" and 8°40'20" south and longitudes 34°57'52" and 37°02'48", west of Greenwich. It occupies an area of 3,587.24 km2 and 320 km in length, corresponding to 3.49% of the state of Pernambuco and is located in the hydrographic region of the Eastern Northeast Atlantic, being part of the Development Regions - RD of Sertão do Moxotó, Southern Agreste, Central Agreste, South Forest and Metropolitan.

Due to its regional scope (agreste, forest and coastal), the Ipojuca River basin exhibits a complex environment, evidencing climatic, relief, soil and vegetation cover contrasts, as well as socioeconomic ones, which require a model of water and environmental management, to meet its subregional and local particularities (PERNAMBUCO, 2010).

According to the update of the Pernambuco State Water Resources Plan (2022), the Ipojuca river basin constitutes the planning unit (UP5), figure 7, bordering the north with the Capibaribe river basin (UP3) and the state of Paraíba; to the south, with the basins of the Sirinhaém (UP6) and Una (UP7) rivers; the western limit is made by the State of Paraíba and the basins of the Moxotó (UP10) and Ipanema (UP9) rivers and to the east by the Atlantic Ocean and the basins of the South Metropolitan (UP04) (SEINFRA, 2022).

The course of the Ipojuca River, with about 320 km, is predominantly oriented in a west-east direction, and its fluvial regime is intermittent, becoming perennial from its middle course, in the vicinity of the city of Caruaru (EMBRAPA, 2021).

Throughout its extension, the basin covers partial territories of 25 municipalities, of which 12 have their headquarters within the hydrographic basin.

The Ipojuca River cuts through several municipal seats, highlighting: Bezerros, Caruaru, Escada, Chã Grande, Gravatá, Ipojuca, Primavera, São Caetano and Tacaimbó, its estuary has been greatly altered in recent years as a result of the installation of the Suape Port Complex (EMBRAPA, 2021).

Description of methods

The systematic literature review was based on a research protocol with the help of the PRISMA checklist (2020), which aims to guide researchers in their systematic reviews. The

Scopus databases were used, as it is the largest database of abstracts and citations of peer-reviewed literature. The first phase of the research is qualitative, using the collection of secondary data in the chosen databases. The database was chosen because it has one of the most comprehensive international databases, intelligent research tools and a vast set of published articles from the most diverse authors and renowned research areas.

The keywords were used with Boolean compositions, as shown in Chart 1. The composition of the keywords followed the need to filter results and restrict the breadth of the search to works directed to the proposed objective.

The surveys took place in the month of January, 2023. Exclusion filters were used in the following order: Documents from the years 2013-2023 (filter 1), documents in Portuguese and English (filter 2) and only scientific articles (filter 3). Duplicate articles have been deleted (filter 4).

After the filters previously described, the resulting articles underwent a qualitative analysis for the purpose of selecting those that addressed the theme of payment for water environmental services (PSAH), criteria and indicators that guide the selection of priority areas and those whose objective was the implementation of PSAH.

The analysis of the inclusion and exclusion of articles in the Systematic Literature Review (RSL) stage was carried out in two phases: In the first, titles, keywords and abstracts were read in order to exclude articles with discrepant subjects; the second phase consisted of the complete reading of the articles in order to identify those that would be part of the RSL and subsequent data extraction to compose the present study.

Relationship of the indicators and criteria found with the SDG indicators of the 2030 Agenda

A comparative table was made in order to relate, by similarity of purpose or methodology, the most relevant indicators and criteria found in the Systematic Literature Review, with the indicators pointed out in the Sustainable Development Goals (SDGs) of the 2030 Agenda.

Indicator 6.4.2 - Water stress level: Proportion of freshwater withdrawals in relation to the total freshwater resources available in the Ipojuca River basin - PE

To exemplify the results obtained from one of the indicators pointed out in this study, the history of Indicator 6.4.2 - Water stress level for the Ipojuca River basin was evaluated. This step was carried out with the support of a Geographic Information System software, ArcGIS Pro 3.0.3, based on data from the Eastern Northeast Atlantic Hydrographic Region and the São Francisco Hydrographic Region, since the area of the Ipojuca River basin comprises these two regions.

The data used for the preparation of the map were produced by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE) and made available on its institutional portal. Data from 2019 were selected from Indicator 6.4.2. The limit of the Ipojuca river basin and the municipal limits of Pernambuco obtained from the Spatial Data Infrastructure (INDE) were used.

The data collected from the IBGE portal, in relation to Indicator 6.4.2, presented numerical values, which were reclassified in order to better understand the map, as shown in Table 1.

Table 1.

Data reclassification parameters for map production in ArcGIS PRO 3.0.3.

Indicator Value 6.4.2 (%)	Reclassification
0.1 - 0.1	Excellent/Comfortable
0.1 - 1.8	Worrying
1.8 - 10	Critical
Over 10	Very critical

Source: Prepared by the authors (2023).

After all the methodological procedures described, the processing for the extraction of data from Indicator 6.4.2 by the Ipojuca River basin boundary was carried out in ArcGIS Pro 3.0.3.

The database used to monitor Indicator 6.4.2 for the hydrographic districts in which the Ipojuca River basin is located was consulted on the metadata platform of the National Water and Sanitation Agency (ANA), from 2015 to 2019.

Results and discussion

Criteria and indicators used in the selection of PSAH priority areas

The results related to the search strategies used in the Scopus database for Systematic Literature Review are presented in Chart 1 and, after refinement by filters for qualitative analysis, in Chart 2. Duplicate articles have been deleted with the help of the Mendeley Desktop reference manager (Filter 4).

Chart 1.

Results of searches in Scopus databases.

Databases	Keywords	Documents returned
Scopus	*(TITLE-ABS-KEY (payment* AND environmental AND service* AND water*) AND TITLE-ABS-KEY (priorit* AND area*))*	***56***
Scopus	*(TITLE-ABS-KEY (payment* AND environmental AND service* AND water*) AND TITLE-ABS-KEY (select* AND area*))*	***36***
Scopus	*(TITLE-ABS-KEY (payment* AND environmental AND service* AND water*) AND TITLE-ABS-KEY ("indicators"))*	***41***
Scopus	*(TITLE-ABS-KEY (payment* AND environmental AND service* AND water*) AND TITLE-ABS-KEY ("priority*"))*	***78***
	Total	***211***

Source: Prepared by the authors (2023).

Chart 2.

Results of the search strategies in the databases by applied filter.

Databases	Number of documents	Filter 1 (Years of 2013-2023)	Filter 2 (Portuguese and English languages)	Filter 3 (Scientific articles)	Filter 4 (Duplicate)
Scopus	211	182	182	168	107

Source: Prepared by the authors (2023).

After the preliminary reading of the 107 articles resulting from the filtering stage, 89 articles that did not correspond to the main focus of the research were excluded when the titles, keywords and abstracts were analyzed. The remaining 18 articles underwent a thorough reading in order to define those that would be included in the RSL and those that would be strictly excluded. This stage resulted in 8 articles, which referenced the criteria and indicators used in the selection of priority areas of PSAH.

With the selected articles, Chart 3 was composed, with the authors and the main criteria or indicators used in the selection of areas for PSAH and their relationship or correspondence with the indicators of the Sustainable Development Goals (SDGs).

Chart 3.

Most relevant criteria or indicators found in the RSL, in the selection of areas for PSAH and the relationship with the indicators of the 2030 Sustainable Development Goals.

Authors	Criteria or indicators pointed out in PSAH schemes	Indicators of the 17 SDGs of the 2030 Agenda
Atisa *et al.*, 2014; Sims *et al.*, 2014; Souza *et al.*, 2021; Garcia *et al.*, 2020; Valente *et al.*, 2021; Rosa *et al.*, 2016.	Soil use and ocupation.	15.1.1 - Percentage of forest areas of the total land area; 15.1.2 - Percentage of sites of importance for freshwater and terrestrial biodiversity that are covered by protected areas, by type of ecosystem; 15.3.1 - Percentage of land that is degraded over the total land area; 6.6.1 - Changes in the extent of water-related ecosystems over time.
Sims *et al.*, 2014; Lopes *et al.*, 2020; Souza *et al.*, 2021.	Surface water availability and overexploitation/contamination of aquifers.	6.4.2 - Water stress level: Proportion of freshwater withdrawals in relation to total available freshwater resources.
Sims *et al.*, 2014.	Permanent preservation areas.	15.1.2 - Percentage of importante places for freshwater and terrestrial biodiversity that are covered by protected areas, by ecosystem type; 15.4.1 - Coverage of protected areas of important places for mountain biodiversity; 6.6.1 - Changes in the extent of water-related ecosystems over time.
Lopes *et al.*, 2020; Roberts *et al.*, 2021.	Indicators and indices related to water quality.	6.3.2 - Proportion of water bodies with good environmental quality.
Lopes *et al.*, 2020; Souza *et al.*, 2021;	Erosion potential.	6.3.2 - Proportion of water bodies with good environmental quality.

Valente *et al.*, 2021; Rosa *et al.*, 2016.		
Valente *et al.*, 2021.	Proximity to springs.	6.6.1 - Changes in the extent of water-related ecosystems over time.

Source: Prepared by the authors (2023), from RSL.

Chart 3 shows some of the criteria and indicators for the selection of priority areas most cited in the publications analyzed. Among the 8 studies included in the RLS, none addressed the Sustainable Development Goals of the 2030 Agenda and the positive impact on the most diverse SDGs that the implementation of PSAH schemes can cause. In addition to the clear link between the criteria presented in Table 3 and SDG 15: Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss, and SDG 6: Ensuring the availability and sustainable management of water and sanitation for all, PSAH schemes also have a positive impact on poverty alleviation (Sims *et al.*, 2014) in line with SDG 1, improved management practices through sustainable agriculture (Atisa *et al.*, 2014) - SDG 2 and SDG 13, as all measures also have an impact on climate change.

The survey of the relevant criteria for the selection of priority areas, aiming at the implementation of PSAH schemes, should be carried out in conjunction with an accurate analysis of the SDGs.

It is also important to highlight the importance of the PSAH as an instrument of environmental management and its close relationship with the goals, which can even subsidize, with its indicators, research in relevant areas, which encompass environmental and social aspects addressed as relevant in PES and PES research (Sims *et al.*, 2014; Rosa *et al.*, 2016).

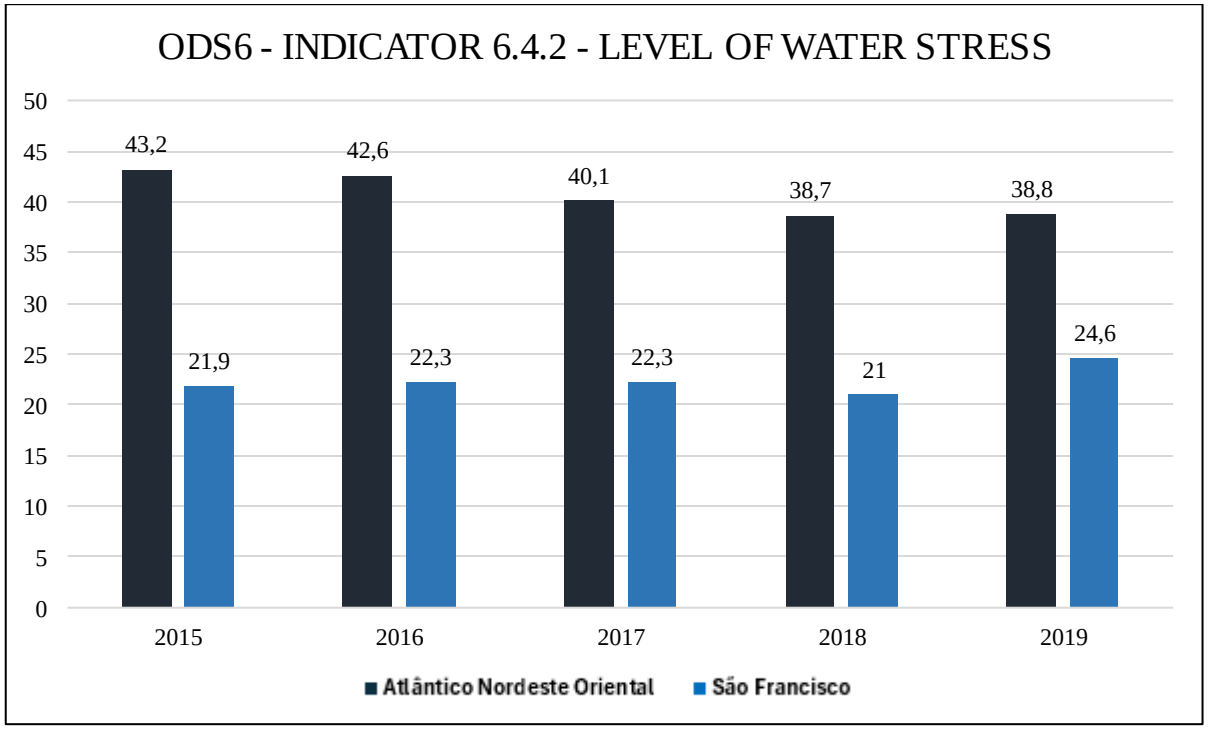
There are few studies related to the implementation of PSAH schemes with clear, robust and widely used methodologies, leaving a large space for future research, mainly bringing to light aspects and objectives agreed upon in global agendas, thus strengthening more and more investments in the area and dissemination of PSAH projects, since it strengthens the commitment assumed by Brazil to achieve the goals by 2030.

To exemplify in a practical way the possibility of using the SDG indicators of the 2030 Agenda, indicator 6.4.2 - Water stress level: Proportion of freshwater withdrawals in relation to the total available freshwater resources was selected for the purposes of temporal analysis in the Ipojuca River basin, as shown in Figure 2. The indicator was chosen for its relationship with the criteria found in the RSL and its relevance in providing an estimate of the pressure on renewable freshwater resources, exerted by the total demands, allowing the visualization of temporal trends and ensuring the planning of actions and projects, such as PSAH, aimed at

sustainability in freshwater supply in the most diverse sectors, promoting a substantial reduction in the number of people suffering from water scarcity.

Figure 2.

Temporal analysis of indicator 6.4.2 in the period 2015 - 2019 in the hydrographic districts, in which the Ipojuca River basin is inserted.



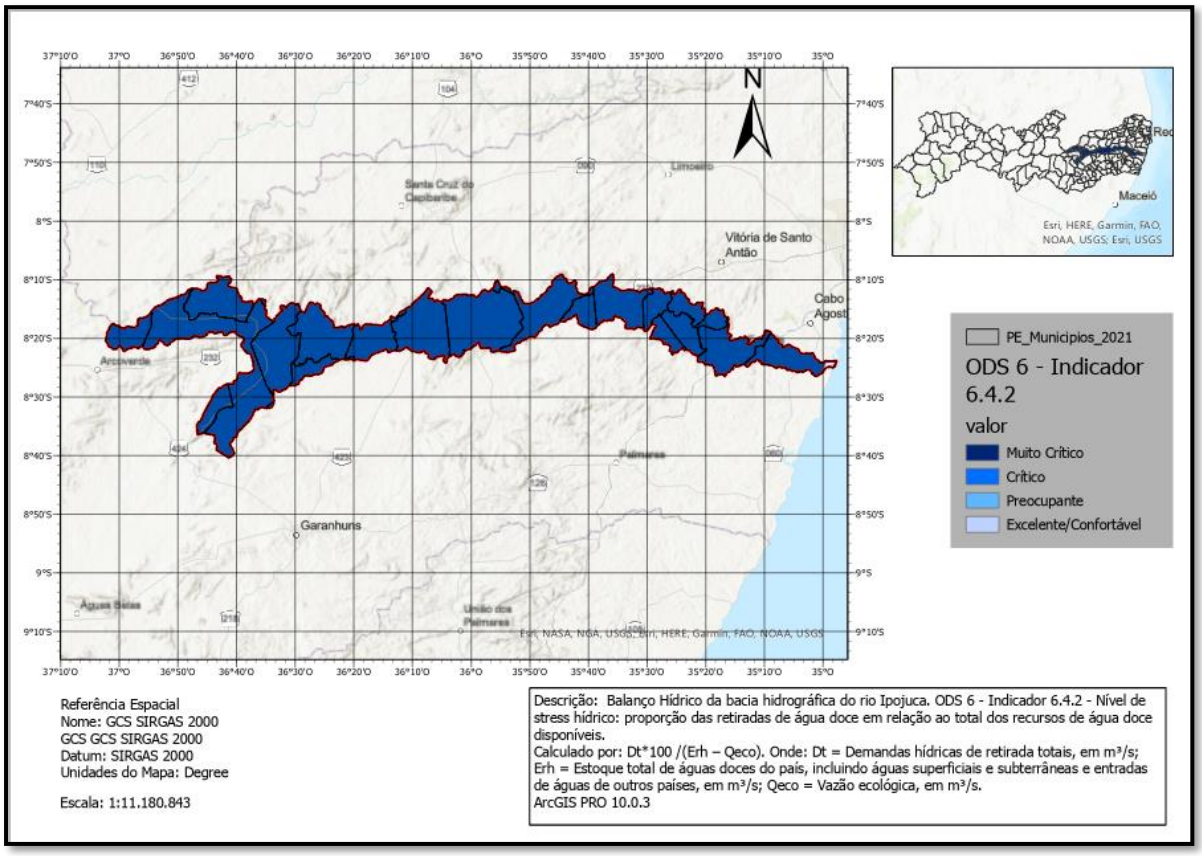
Source: National Water and Sanitation Agency (*Agência Nacional de Águas e Saneamento Básico* - ANA) - National Water Resources Information System (*Sistema Nacional de Informações sobre Recursos Hídricos* - SNIRH) (2023).

Figure 2 presents a graph with the temporal analysis of the indicator related to water stress in the Hydrographic Districts (RH) that make up the indicator of the Ipojuca River basin. Both RHs characterized by severe water scarcity and water stress above 20%, when the values are acceptable by the IBGE target, are below 10%, so that they are not considered a risk of causing a major commitment in consumption and possible severe water scarcity (ANA, 2022). Thus, the analysis shows that the Ipojuca River basin is under strong water pressure throughout the study period and in a very critical state of water stress, Figure 3.

Figure 3 shows the map with the levels of Indicator 6.4.2 in the Ipojuca watershed.

Figure 3.

Map of the Ipojuca River basin with indicator 6.4.2.



Source: Prepared by the authors (2023).

The basins of the Northeast Region of the country, where the Ipojuca River basin is located, present a predominantly very critical situation due to low water availability (ANA, 2019), configuring a region sensitive to drought and with a strong need for interventions that ensure water availability, such as PSAH schemes.

The Ipojuca River basin, in particular, in addition to its climatic characteristics and because it is a drought-sensitive region, suffers from great anthropogenic pressures throughout its extension (SEINFRA, 2022). For the purpose of analyzing priority areas for the implementation of PESS programs and projects, taking into account anthropogenic pressures, two indicators can be used to assess the level of criticality and assist in decision-making, in addition to validating not only the specific basin, but as a more universal methodology, are the indicators 6.6.1 - Changes in the extent of water-related ecosystems over time, due to environmental degradation related to land use and occupation, and 6.3.2 - Proportion of water bodies with good environmental quality, which is directly related to the level of pollution of water bodies, which is a characteristic of the basin (Silva and Carneiro, 2021).

Conclusion

There is a great need for further studies that explore indicators for the selection of priority areas in the implementation of PES and that present the strong relationship of the economic instrument of environmental management with the Sustainable Development Goals of the 2030 Agenda, as a way to foster the importance of PES programs in favor of a common global goal.

The relationship between the SDGs and criteria and/or indicators used in PSAH programs is quite extensive, as shown in Chart 3. The objectives of PSAH programs have a demonstrably positive impact on SDGs 6 and SDG 15, as well as their relationships and positive impacts on SDG 2 and SDG 13.

Further studies are needed within this theme in order to develop methodologies for the selection of priority areas for the implementation of PSAH programs and projects, based on indicators of the SDGs of the 2030 Agenda, since they have universal characteristics in relation to application in different biomes, climates and regions with different characteristics, seek to achieve the SDGs and can be more easily validated as a reference protocol.

In the analysis of indicator 6.4.2 - Level of water stress, of the SDGs of the 2030 Agenda, it was possible, even analyzing a single criterion, to identify a strong need for intervention in the Ipojuca River basin, due to the very critical situation of the basin with a large discharge of domestic and industrial effluents, environmental degradation and, consequently, the result in the indicator, in addition to its importance in supplying the state of Pernambuco.

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