Derbyana, ISSN 2764-1465, 46: e856, 2025.
DOI: 10.69469/derb.v46.856
Article/Advances in Hydrogeology and Brazilian Aquifers

GROUNDWATER GOVERNANCE IN THE STATE OF MATO GROSSO

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ABSTRACT

Brazilian states have jurisdiction over groundwater and are primarily responsible for its management. Mato Grosso has a state water resources policy and specific regulations for groundwater management, but there is a lack of studies evaluating whether or how this responsibility is being fulfilled. This article aims to assess groundwater governance in the state. To achieve this, besides a document analysis of legislation, scientific literature, and government documents, the methodology developed under the set of indicators of the Groundwater Governance Assessment System (SAGAS) is employed. The institutional and regulatory framework for promoting groundwater governance is shaped by the State Constitution, Law No. 11,088/2020, and Law No. 9,612/2011. Despite this legal and institutional structure, the state struggles to implement the obligations and institutions outlined in its legislation. The state displayed significant weaknesses in all four dimensions: technical (information on aquifers), operational-legal (water resources management tools), institutional-legal (water-focused institutions), and intersectoral political coordination (integration with other policies, such as environmental, sanitation, and agricultural). The score of 91 out of 169 reflects these limitations, which threaten regional water security and resilience. The priority is to consolidate the foundations of the national water resources policy, particularly by establishing all Basin Committees and developing the respective basin plans, as well as implementing water use charges and conducting studies to improve knowledge about the aquifers.

Keywords: Groundwater; Water governance; Mato Grosso; Indicators; Legislation.

RESUMO

GOVERNANÇA DAS ÁGUAS SUBTERRÂNEAS NO ESTADO DO MATO GROSSO. Os estados brasileiros possuem o domínio das águas subterrâneas, sendo os principais responsáveis pela sua gestão. O Mato Grosso possui uma Política Estadual de Recursos Hídricos e normas específicas para a gestão dos aquíferos, porém faltam estudos que avaliem se ou como esse dever é cumprido. O artigo visa avaliar a governança das águas subterrâneas no Mato Grosso. Para isso, além da análise documental da legislação, da literatura científica e de documentos governamentais, utiliza-se a metodologia desenvolvida no âmbito do conjunto de indicadores do Sistema de Avaliação de Governança das Águas Subterrâneas (SAGAS). O arcabouço instituticional

e normativo para promover a governança das águas subterrâneas é conformado pela Constituição Estadual, pela Lei nº 11.088/2020 e pela Lei nº 9.612/2011. Apesar dessa estrutura normativa e institucional, o Estado apresenta dificuldades em materializar as obrigações e instituições contidas em suas legislações, pois possui fragilidades importantes nas quatro dimensões: técnica (informações sobre os aquíferos), operacional-legal (instrumentos de gestão de recursos hídricos), institucional-legal (instituições dedicadas às águas) e coordenação política intersetorial (conexão com instrumentos de outras políticas, a saber ambiente, saneamento e agrícola). A pontuação 91 de 169 reflete essas limitações, que ameaçam a segurança e resiliência hídrica regional. A prioridade é consolidar as bases da Política Nacional de Recursos Hídricos, principalmente o estabelecimento de todos os Comitês de Bacia Hidrográfica e elaboração dos respectivos planos de bacia, bem como instituir a cobrança pelo uso dos recursos hídricos e promover estudos para melhorar o conhecimento sobre os aquíferos.

Palavras-chave: Águas subterrâneas; Governança das águas; Mato Grosso; Indicadores; Legislação.

RESUMEN

GOBERNANZA DE LAS AGUAS SUBTERRÁNEAS EN EL ESTADO DE MATO GROSSO. Los estados brasileños tienen la titularidad sobre las aguas subterráneas, siendo los principales responsables de su gestión. Mato Grosso cuenta con una Política Estatal de Recursos Hídricos y normas específicas para la gestión de los acuíferos, sin embargo, faltan estudios que evalúen si, o cómo, se cumple con este deber. El artículo tiene como objetivo evaluar la gobernanza de las aguas subterráneas en Mato Grosso. Para ello, además del análisis documental de la legislación, de la literatura científica y de documentos gubernamentales, se utiliza la metodología desarrollada en el ámbito del conjunto de indicadores del Sistema de Evaluación de la Gobernanza de las Aguas Subterráneas (SAGAS). El marco institucional y normativo para promover la gobernanza de las aguas subterráneas está conformado por la Constitución Estatal, la Ley nº 11.088/2020 y la Ley nº 9.612/2011. A pesar de esta estructura normativa e institucional, el Estado presenta dificultades para materializar las obligaciones e instituciones contenidas en sus legislaciones, ya que presenta debilidades importantes en las cuatro dimensiones: técnica (información sobre los acuíferos), operacional-legal (instrumentos de gestión de los recursos hídricos), institucional-legal (instituciones dedicadas al agua) y coordinación política intersectorial (conexión con instrumentos de otras políticas, como medio ambiente, saneamiento y agricultura). La puntuación de 91 sobre 169 refleja estas limitaciones, que amenazan la seguridad y la resiliencia hídrica regional. La prioridad es consolidar las bases de la Política Nacional de Recursos Hídricos, principalmente el establecimiento de todos los Comités de Cuenca Hidrográfica y la elaboración de sus respectivos planes de cuenca, así como instituir el cobro por el uso de los recursos hídricos y promover estudios para mejorar el conocimiento sobre los acuíferos.

Palabras clave: Aguas subterráneas; Gobernanza del agua; Mato Grosso; Indicadores; Legislación.

1 INTRODUCTION

Mato Grosso has a population of 3,658,649 inhabitants and is the third-largest Brazilian state in terms of area, covering 903,208.361 km². It shares borders with Bolivia and the states of Amazonas, Goiás, Mato Grosso do Sul, Pará, Rondônia, and Tocantins (Instituto Brasileiro de Geografia e Estatística [IBGE], 2022). The richness of its biodiversity is evidenced by the presence of three biomes: the Amazon Rainforest (54.2%), the Cerrado (39.1%), and the Pantanal (6.8%) (Capoane, 2022). Additionally, it is considered an important

water regulator for Brazil, housing headwaters and serving as both recharge and discharge areas, thus maintaining the base flow of rivers that feed into hydrographic regions of national and international significance, such as those of the Amazon, Tocantins-Araguaia, and Paraná-Paraguay. Furthermore, it sustains the Pantanal, one of the largest wetland ecosystems in the world (Mato Grosso, 2009b).

The state contains four hydrolithological domains, referred to as: 1) Granular, an extensive set of sedimentary rocks associated with the Alto Tapajós system, the Paraná Sedimentary Basin, the Parecis Sedimentary Basin, the Pantanal Sedimentary Basin, and the Bananal Sedimentary Basin; 2) Fractured, composed of rocks from the undifferentiated crystalline basement, undifferentiated metasedimentary basement, the Cuiabá Group, Serra Geral Formation, Paredão Grande Suite, and Tapirapuã Formation; 3) Fractured-Granular, formed by rocks from the Aguapeí Group, Bauxi Formation, Puga Formation, Upper Paraguay Group, in its terrigenous unit, and the Araguainha Unit; 4) Fractured-Karstic, composed of rocks from the Araras Formation (Abreu & Paula, 2020). These aquifers are vital for the permanence of the rivers that originate or cross the state's territory, especially considering the climate, which alternates between rainy and dry seasons (Figueiredo et al., 2024).

Despite the presence of important rivers and aquifers, the growing demand for water and environmental degradation have already led to situations of water shortage and hydric crises (Amorim et al., 2017; Ferreira et al., 2017; Souza et al., 2020). MapBiomas (2024a) reported that Mato Grosso lost 274 thousand hectares of surface water, corresponding to 33% of its hydric territory. Increasing demand, agricultural expansion, climate change, deforestation, wildfires, and biodiversity loss raise concerns about the state's water situation and its consequences. To mitigate water scarcity, there has been an increase in projects that rely on groundwater, in contrast with the lack of data on regional aquifers (Mato Grosso, 2009b).

The Federal Constitution assigns competence over groundwater to the states, making them primarily responsible for its management through the formulation and implementation of public policies for this strategic resource (Villar & Granziera, 2020). However, as in many Brazilian states, Mato Grosso lacks in-depth studies on aquifer governance and the challenges associated with its sustainability within the scope of public policies. As explained by Pereira et al. (2024), the literature on groundwater governance encompasses a wide range of approaches, including water security, the vulnerability of social and ecological systems, quantitative and qualitative criteria, conflict management, and sustainable use, as well as planning and the water–food–energy nexus. Nevertheless, few studies explore the role of subnational actors (states and municipalities) and how they organize public policies to promote the different aspects of aquifer governance.

In the case of the states, noteworthy contributions include the works of Fernandes and Oliveira (2018) and Fernandes (2019), which investigate the normative frameworks underpinning this governance, as well as the studies by Bohn et al. (2014), Goetten (2015), Ramos (2017), and Villar and Hirata (2022), which propose indicators for systematic assessments of state-level governance. In this context, the Groundwater Governance Assessment System (SAGAS, acronym in Portuguese, *Sistema de Avaliação da Governança das Águas Subterrâneas*) (Villar & Hirata, 2022) comprises a set of governance indicators based on obligations established in national legislation and binding on all states.

That said, the objective of this article is to assess groundwater governance in the state of Mato Grosso using the SAGAS methodology, to identify the progress, gaps, and weaknesses in the implementation of groundwater management instruments and institutions. To this end, the structure of the paper is organized as follows: a) presentation of the methodology; b) description of the constitutional and legal foundations of the state water resources policies, as well as the institutions responsible for their management; c) application of the SAGAS checklist to the case of Mato Grosso; and d) final considerations.

2 METHODOLOGY

The methodology employed in this study consists of a document-based analysis guided by the criteria set forth in the SAGAS tool, developed by Villar and Hirata (2022). SAGAS takes the form of a checklist, whose criteria are based on obligations established in federal water resources legislation and other public policies related to groundwater governance. Due to the system of concurrent competence, these federal norms serve as mandatory guidelines for the states, making SAGAS applicable throughout Brazilian territory. Villar and Hirata (2022) developed the checklist

criteria based on federal legislation; however, the responses are grounded in state-level realities and in the degree of implementation of each state's own legal framework.

To answer the SAGAS indicators, searches were conducted using the keywords associated with each criterion. The searches focused on state legislation repositories, such as the website of the Legislative Assembly of Mato Grosso (Available at: https://www.al.mt.gov.br/norma-juridica), and on official websites of state government agencies–particularly the State Secretariat for the Environment of Mato Grosso (SEMA-MT) (Available at: http://www.sema.mt.gov.br/inicio), which hosts the page of the State Water Resources Council (CEHIDRO) (Available at: http://www.sema.mt.gov.br/site/index.php/decisao-colegiada/conselho-estadual-de-recursos-hi-dricos). In addition, technical documents were consulted, with emphasis on the State Water Resources Plan, the State Solid Waste Plan (Available at: https://persmt.setec.ufmt.br/), and the Socioeconomic and Ecological Zoning of the State of Mato Grosso (Available at: https://geo.mt.gov.br/zsee2018/). Complementarily, searches were also conducted in scientific literature through Google Scholar to identify additional references related to the indicators assessed.

The SAGAS checklist is divided into eight columns, organized as follows: the first presents the assessed dimensions; the second and third provide the numbering and corresponding legal indicators; the fourth through seventh describe the application variables and their respective scores; and the eighth column provides the justification for the response, based on the analysis of state legislation (Villar & Hirata, 2022).

SAGAS comprises 48 primary indicators and 25 subordinate indicators, totaling a maximum score of 169 points, distributed across four dimensions: i) Technical – 11 primary indicators (33 points); ii) Operational-legal – 13 primary indicators and 3 subordinate (42 points); iii) Institutional-legal – 7 primary and 8 sub-indicators (29 points); and iv) Political Cross-sectoral Coordination – 17 primary and 14 sub-indicators (65 points), subdivided into three thematic areas: environment, sanitation, and agriculture (Villar & Hirata, 2022).

The primary indicators are classified according to the degree of implementation, which includes the following categories and assigned scores: a) "Nonexistent" (NE), which score 0 points; b) "Legal Provision" (LP), assigned 1 point; c) "Legal Regulation" (LR) or "Under Elaboration" (UE), assigned 2 points; and "Implemented" (IP), assigned 3 points. The subordinate indicators are evaluated using binary responses: "Yes" (1 point) or "No" (0 points). If the primary indicator is classified as "NE" the corresponding sub-indicators automatically receive a score of zero. However, if the main indicator is classified as "UE," practical cases already implemented may serve as a reference for evaluating the sub-indicators (Villar & Hirata, 2022). To facilitate visualization of the results, the responses to each criterion are highlighted by light gray shading in the corresponding cell.

To facilitate the interpretation of results, state-level governance performance is classified into quartiles: i) $\geq 75\%$ – good performance, indicating that the state has fulfilled the main obligations established in federal legislation; ii) 50% to 74% – moderate performance, suggesting that while there are several weaknesses in the incorporation of federal laws, a foundational basis for governance is already in place; and iii) $< 50\%$ – low performance, reflecting serious deficiencies in the implementation of legal obligations, which results in an unfavorable environment for groundwater governance (Villar & Hirata, 2022).

3 GROUNDWATER PROVISIONS IN THE STATE CONSTITUTION OF MATO GROSSO

The state constitutional basis for the protection of groundwater is established under Title V – On Economic and Social Development, with emphasis on Chapter III – On Natural Resources, which comprises Section I – On the Environment (Articles 263 to 283), Section II – On Water Resources (Articles 284 to 296), and Section III – On Mineral Resources (Articles 297 to 299) (Mato Grosso, 1989).

The Constitution of the State of Mato Grosso reaffirms the principles established in Article 225 of the Federal Constitution (Brazil, 1988), by recognizing, in Article 263, the "right to an ecologically balanced environment, a common good of the people and essential to a healthy quality of life" (Mato Grosso, 1989, authors' translation). To ensure this right, Article 263, §1, assigns several obligations to the Public Authorities, among which the following stand out: "to ensure the rational and sustainable use of natural resources" (item I); "to establish the state policy on basic sanitation and water resources" (item III); "to require [...] a prior environmental impact assessment, which must be made public, ensuring community participation

through public hearings and representation in all phases" (item IV); "to combat pollution and erosion" (item V); "to inform the population about pollution levels and environmental quality" (item VI); "to promote environmental education" (item VII); "to encourage the restoration of vegetation cover" (item VIII); "to protect fauna and flora, ensuring the diversity of species and ecosystems" (item IX); "to create, implement, and manage state conservation units" (item X); "to promote anthropic–environmental zoning of its territory" (item XV); and "to ensure free access to basic environmental information" (item XVIII) (Mato Grosso, 1989, authors' translation).

These constitutional guidelines reflect a state-level commitment to integrating environmental protection and sustainable development, promoting a balance between ecological conservation and human needs, while ensuring democratic access to environmental information. Articles 273 and 274 grant special status to the Pantanal, Cerrado, and Amazon Rainforest biomes located in Mato Grosso, which are considered priority areas for environmental protection. Additionally, the Constitution recognizes as state heritage the region of Chapada dos Guimarães and the portions of the river basins of the Paraguay, Araguaia, and Guaporé Rivers that lie within the territory of Mato Grosso (Mato Grosso, 1989).

Articles 284 and 286, in turn, require the Public Administration to define a state water resources policy, keep the State Water Resources Plan up to date, and establish both the financial resource management system and the institutional mechanisms necessary for water governance. Article 288 prioritizes the supply of water to populations in the use of surface and groundwater. Article 289 grants special status to groundwater, classifying it as "a strategic reserve for economic and social development and valuable for supplying water to populations" (Mato Grosso, 1989, authors' translation). Moreover, it mandates the implementation of a permanent program for its conservation and protection against pollution and overexploitation, which has yet to be regulated (Mato Grosso, 1989).

With regard to water protection, Article 291 recognizes the role of municipalities in water management, stemming from their competence over land-use planning and sanitation. Accordingly, it requires that municipal organic laws include provisions "related to the use, conservation, protection, and control of water resources, both surface and groundwater" (see Article 291 and its items) (Mato Grosso, 1989, authors' translation). In turn, Article 294 establishes that irrigation activities may only be developed after the implementation of the Water and Energy Resources Policy and the corresponding soil and water conservation programs. Article 297 states that the State must establish a State Policy on Geology and Mineral Resources, which should include the management of mineral waters. However, this issue remains unregulated to date (Mato Grosso, 1989). State Constitution lays the foundation for the conception of the State Water Resources Policy and the State Water Resources System, including the ideal of integrated management and the duty to promote specific actions for groundwater.

4 MATO GROSSO STATE WATER RESOURCES POLICY AND GROUNDWATER

The state's first water policy dates to Law No. 6,945/1997, which was replaced by Law No. 11,088/2020, addressing the State Water Resources Policy, establishing the State Water Resources System, and enacting other provisions (Souza & Vilpoux, 2023). This law defines the functions of water; the objectives, principles, and guidelines of the water policy; management instruments; the state water resources system; infractions and penalties; the state water resources fund; and transitional provisions (Mato Grosso, 2020b).

Article 4, item III, expressly recognizes that the management of water resources must consider "all processes of the hydrological cycle, particularly the integration of surface and groundwater, in their quantitative and qualitative aspects" (Mato Grosso, 2020b, authors' translation). Law No. 11,088/2020 applies to all waters under state competence, whether surface or groundwater. This law establishes the main management instruments, and Article 7, item V, stipulates that River Basin Plans must include groundwater management programs, encompassing research, planning, and monitoring (Mato Grosso, 2020b).

The composition and responsibilities of the State Water Resources System are defined in Articles 25 to 38 of Law No. 11,088/2020. The system is composed of the State Water Resources Council (Conselho Estadual de Recursos Hídricos - CEHIDRO), the River Basin Committees (RBC), the coordinating/management body, and the water agencies (Figure 1). The responsibilities of these institutions are defined, respectively, in Article 28 (CEHIDRO), Article 30

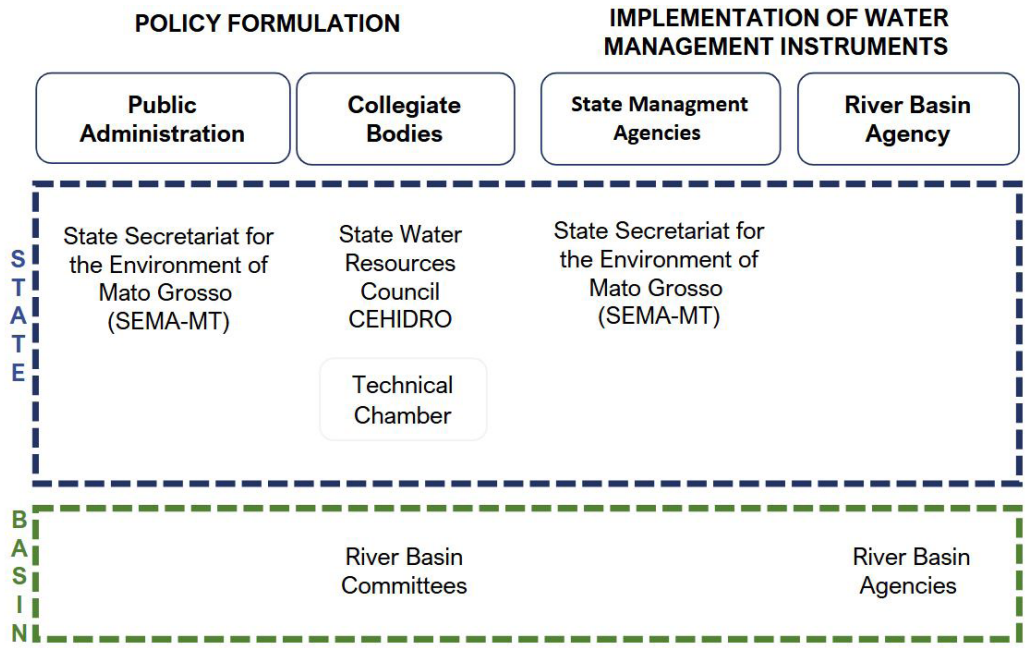

FIGURE 1 – State Water Resources System of Mato Grosso. Prepared by the authors.

(RBCs), Article 35 (SEMA-MT), and Article 37 (River Basin Agencies) (Mato Grosso, 2020b).

SEMA-MT serves as the coordinating/management body, with a prominent role in managing water resources in terms of both quality and quantity. Within its organizational structure, it has a Water Resources Superintendency, which is composed of three coordinating offices: i) the Water and Air Monitoring Coordination; ii) the Water Resources Control Coordination, which includes a Groundwater Management Division responsible for evaluating groundwater use permits; and iii) the Water Management Coordination (Ferreira, 2022).

The CEHIDRO is regulated by Decree No. 796 of January 22, 2021 (Mato Grosso, 2021a). The council includes a Technical Chamber on Groundwater (*Câmara Técnica de Águas Subterrâneas - CTAS*), which is responsible for discussing groundwater management in the state and for formulating related guidelines. According to CEHIDRO Resolution No. 23 of November 6, 2008, it is the responsibility of the CTAS to submit proposals for regulations on groundwater use to CEHIDRO, to develop technical criteria for the analysis of water use permits, to monitor their implementation, to issue technical opinions, to request input from bodies of the State Water Resources System, and to invite experts when necessary (Art. 2) (Mato Grosso, 2008).

The state has defined a total of 27 Planning and Management Units (*Unidades de Planejamento e Gestão - UPGs*), which are part of three national hydrographic regions (Amazon, Tocantins-Araguaia, and Paraguay) and five state-level hydrographic regions, as established by CEHIDRO Resolution No. 5 of August 18, 2006: I – Aripuanã River; II – Juruena–Teles Pires River; III – Xingu River; IV – Upper Paraguay River; and V – Araguaia River (Mato Grosso, 2006).

A total of 13 River Basin Committees (RBC) have been established in Mato Grosso, namely: i) RBC Covapé; ii) RBC Sepotuba; iii) RBC Left Bank Tributaries of the Lower Teles Pires; iv) RBC São Lourenço; v) RBC Right Bank Tributaries of the Upper Teles Pires; vi) RBC Left Bank Tributaries of the Cuiabá River; vii) RBC Cabaçal; viii) RBC Middle Teles Pires Tributaries; ix) RBC Jauru River; x) RBC Upper Araguaia Tributaries; xi) RBC Upper Paraguay (Dionel, 2021); and RBC Arinos River (Mato Grosso, 2025a). Basin agencies or water agencies have not yet been established, and Article 38 authorizes CEHIDRO to delegate its functions to non-governmental, non-profit entities—referred to as delegated entities—until such agencies are formally created (Mato Grosso, 2020b).

To ensure financial support, the State Water Resources Fund (FEHIDRO) was created and is administered by SEMA. The funding sources for

FEHIDRO are set forth in Article 3 of Decree No. 715/2020 (Mato Grosso, 2020a) and are detailed in the State Water Resources Fund Application Plan, which is approved annually in advance by CEHIDRO (Article 49 of Law No. 11,088/2020) (Mato Grosso, 2020b). The fund's resources have been composed of transfers from the federal government, particularly from the National Water and Sanitation Agency (*Agência Nacional de Águas e Saneamento Básico – ANA*), through programs aimed at water resources management (PROGESTÃO[1]/QUALIÁGUA[2]); financial compensation from oil and mining activities; financial compensation for hydroelectric uses; and state revenue from fees and fines related to water resources.

Groundwater is specifically protected by Law No. 9,612/2011 (Mato Grosso, 2011b), which addresses its administration and conservation within the state. The topics covered include: a) the definition of groundwater (Art. 1, §1); b) the authority of CEHIDRO to establish regulations for the use of groundwater intended for human consumption through bottling (Art. 1, §2); c) the recognition of the hydraulic interconnection between groundwater, surface water, and meteoric water, subject to the temporal evolution of the hydrological cycle (Art. 2); d) the definition of management actions (Arts. 3 and 4); e) actions to protect water quality, with emphasis on the regulation of water use permits and procedures related to drilling wells (Arts. 5 to 12); f) types of protection areas for groundwater (Arts. 14 to 18); g) permits to use groundwater (Arts. 20 to 34); h) monitoring, infractions, and sanctions (Arts. 35 to 37); and i) transitional provisions (Arts. 38 to 44) (Mato Grosso, 2011b).

5 GROUNDWATER GOVERNANCE IN MATO GROSSO AND SAGAS INDICATORS

Mato Grosso's institutional and regulatory framework for groundwater governance is made up of the State Constitution, Law 11.088/2020 and Law 9.612/2011 (Mato Grosso, 1989, 2011b, 2020b). However, the implementation of these rules faces challenges, including those related to constitutional provisions. One example is the permanent program for the conservation and protection of groundwater against pollution and overexploitation, provided for in art. 289 of the State Constitution, which has not yet been implemented.

Furthermore, although state and federal laws establish basic instruments for water management, there is a regulatory gap in terms of infra-legal norms, which are scarce and make it difficult to apply the legal guidelines in practice. The lack of regulation compromises the operationalization of public policies aimed at the protection and sustainable use of aquifers. The SAGAS checklist demonstrates these limitations (Table 1). The cells shaded in gray represent the response to the indicator, in which it is possible to see a high frequency of indicators classified as non-existent or only legally foreseen.

The technical dimension, with 11 criteria, achieved 21 points out of the 33 expected, meeting 63.6% of the indicators. However, these figures deserve attention, as several of the obligations marked as fulfilled have structural flaws. The State Water Resources Plan (*Plano Estadual de Recursos Hídricos – PERH*) (Mato Grosso, 2009b, p. 45) recognizes that the state is "faced with a lack of studies with an integrated view of the potential and limitations of using its groundwater resources". The lack of data is reaffirmed in several chapters of the PERH (Mato Grosso, 2009b), which raises questions about the reliability of the products developed, because although they exist, they have limitations in demonstrating the situation of regional aquifers. The state does not have basic data on the hydrogeology of its aquifers, nor does it have a real diagnosis of the quality and quantity of these reserves or their use (Ferreira, 2022).

Therefore, the score of 3, attributed to several of the indicators, should be viewed with caution, since the existing studies are based on a limited technical base of information. The state scored 0 for indicators 4 (studies to delimit well perimeters) and 9 (groundwater quality report). Indicators 2 (studies to delimit aquifer protection zones), 7 (quality monitoring) and 8 (quantity monitoring) received a score of 1 due to the legal provision in the State Policy and actions included in the PERH. Monitoring depends on data generated by the Brazilian Geological Service (*Serviço Geológico Brasileiro - SGB*) through the Integrated Groundwater Monitoring Network (*Rede Integrada de Monitoramento das Águas Subterrâneas - RIMAS*), which has 26 wells in the state[3]. This number of points reveals the fragility of data availability, especially when considering

[1] For more information check PROGESTÃO website: https://progestao.ana.gov.br/

[2] For more information check QUALIÁGUA website: https://www.gov.br/ana/pt-br/assuntos/monitoramento-e-eventos-criticos/qualidade-da-agua/programa-qualiagua)/

[3] More information available at: https://rimasweb.sgb.gov.br/layout/

TABLE 1– Groundwater Governance Assessment System (SAGAS) in Mato Grosso (Legend: NE = Nonexistent; LP =Legal Provision; LR= Legal Regulation; UE= Under Elaboration; IP=Implemented). Prepared by the authors based on Villar and Hirata (2022).

Dimension	*N°*	*Criterion*	*LEGAL CONTEXT*				*Legal Fundamentals*
			NE	*LP*	*LR UE*	*IP*	
Technical Scoring 21/33	1	Studies to delimitate recharge areas	0	1	2	3	Law 11088/2020 (art. 51, I - III); Mato Grosso Hydrogeological map
	2	Studies to delimitate aquifer protection zones	0	1	2	3	Law 9612/2011 (Art. 14), Law 11088/2020 (Art. 51, I)
	3	Studies about aquifer vulnerability	0	1	2	3	Mato Grosso, 2009b, figs. 13/14 – Diagnosis (Part 4)
	4	Studies for the delimitation of well perimeters	0	1	2	3	No information found
	5	Groundwater availability assessment	0	1	2	3	Mato Grosso, 2009b, figs. 19, 20, and 21 (Part 2 Prognostic Report)
	6	Groundwater demand assessment	0	1	2	3	Mato Grosso, 2009b (Table 11, Prognosis – Part 2)
	7	Groundwater quality monitoring network	0	1	2	3	Law 11,088/2020 (Art. 7, V). Mato Grosso (2009b, p. 99) provides for a program to monitor water quality
	8	Groundwater quantity monitoring network	0	1	2	3	Law 11,088/2020 (Art. 7, V). Mato Grosso (2009b) Quali-quantitative groundwater monitoring project
	9	Groundwater Quality Report	0	1	2	3	Exists only for surface water
	10	Groundwater Users Registry	0	1	2	3	Law 11,088/2020 (Art. 37, II), Law 9,612/2011 (Art. 4), SEMA Norm. Instr. 9/2021 (Art. 6)
	11	Registry of Groundwater Contamination Sources	0	1	2	3	State Technical Registry of Potentially Polluting Activities or Activities Using Environmental Resources (Law 11,096/2020)

TABLE 1– (Continuation) Groundwater Governance Assessment System (SAGAS) in Mato Grosso (Legend: NE = Nonexistent; LP =Legal Provision; LR= Legal Regulation; UE= Under Elaboration; IP=Implemented). Prepared by the authors based on Villar and Hirata (2022).

Dimension	*N°*	*Criterion*	*LEGAL CONTEXT*				*Legal Fundamentals*
			NE	*LP*	*LR UE*	*IP*	
Operational--legal Scoring 22/42	12	State Water Resources Plan (SWRP)	0	1	2	3	Law 11,088/2020 (Arts. 7 and 8); Dec. 2,154/2009
	12a	SWRP with guidelines for Groundwater	No		Yes		
	13	River basin plan	0	1	2	3	No plan for several basins
	14	Classification of GW bodies according to use	0	1	2	3	Res. CEHIDRO 109/2018
	15	Groundwater use permits	0	1	2	3	Law 11,088/2020; Dec. 336/2007; SEMA Norm. Instr. 9/2021; CEHIDRO Res. 44/2011, 61/2013 and 62/2013
	15a	Campaigns to promote well regularization	No		Yes		Project: Technical standardization campaigns for groundwater abstraction (Mato Grosso 2009b, p. 137)
	16	Charging fees for groundwater use	0	1	2	3	Law 11,088/2020 (Arts. 4, V; 18–21; and 52)
	17	Groundwater information system	0	1	2	3	Law 11,088/2020 (Art. 6, VI). No website was found
	17a	The system has a user-friendly and accessible online platform	No		Yes		No information found
	18	Aquifer protection areas	0	1	2	3	Law 9,612/2011 (Arts. 14–17)
	19	Groundwater restriction and control areas	0	1	2	3	Law 9,612/2011 (Arts. 14 and 15)
	20	Wellhead protection areas	0	1	2	3	Law 9,612/2011 (Art. 18)
	21	Well closure procedure	0	1	2	3	SEMA Norm. Instr. 3/2012. Mato Grosso (2024b)
	22	Procedure to conduct the artificial aquifer recharge	0	1	2	3	Law 9,612/2011 (Art. 41)
	23	Sanctions for non-compliance with groundwater protection legislation	0	1	2	3	Law 9,612/2011 (Arts. 36 and 37), Law 11,080/2020, and Dec. 620/2023)
	24	Procedure to share information between the water resources organ and the mineral resources organ	0	1	2	3	Not implemented

Derbyana, ISSN 2764-1465, 46: e856, 2025.

TABLE 1 – (Continuation) Groundwater Governance Assessment System (SAGAS) in Mato Grosso (Legend: NE = Nonexistent; LP =Legal Provision; LR= Legal Regulation; UE= Under Elaboration; IP=Implemented). Prepared by the authors based on Villar and Hirata (2022).

Dimension	*N°*	*Criterion*	*LEGAL CONTEXT*				*Legal Fundamentals*
			NE	*LP*	*LR UE*	*IP*	
Institutional--Legal Scoring 25/29	25	State Water Resources Management System	0	1	2	3	Law 11,088/2020 (Art. 25) and Dec. 796/2021
	25a	Training and capacity-building programs on groundwater	No		Yes		CEHIDRO Res. 102/2018, 124/2020, and 178/2024
	26	State Water Resources Council (CERH)	0	1	2	3	Law 11,088/2020 (Art. 26), Dec. 6,822/2005 and Dec. 796/2021
	26a	CERH equipped with a Technical Chamber for groundwater	No		Yes		Res. CEHIDRO 23/2008
	27	River Basin Committee (RBC)	0	1	2	3	Dec. 695/2016, CEHIDRO Res. 167/2023, and Mato Grosso, 2025a. Not all RBC were created
	27a	Participation of municipalities in the RBC	No		Yes		Res CEHIDRO 167/2023 (Art. 9, I)
	27b	Participation of Public Administration is limited to half of the members	No		Yes		Res. CEHIDRO 167/2023 (Art. 9 § 7°)
	27c	Users' participation in the basin committees	No		Yes		Res. CEHIDRO 167/2023(Art. 9, II)
	27d	Users' hold 40% of the total of votes	No		Yes		Participation is divided 50% to Public Authorities and Civil Society (25% civil organizations & 25% users)
	27e	Participation of civil society in the RBC	No		Yes		Res. CEHIDRO 167/2023 (Art. 9)
	27f	Civil society holds at least 20% of the total votes	No		Yes		Same as answer 27d
	28	State agency responsible for granting the water permits	0	1	2	3	Law 9,612/2011 (Arts. 4º, 20 a 31)
	29	Water agencies or delegated entities acting as executive secretariat	0	1	2	3	Law 11088/2020 (Articles 25, item IV, and 34 to 38)
	30	State Water Resources Fund	0	1	2	3	Law 11088/2020 and Dec. 715/2020
	31	State Environmental System	0	1	2	3	Complementary Law 38/1995

TABLE 1– (Continuation) Groundwater Governance Assessment System (SAGAS) in Mato Grosso (Legend: NE = Nonexistent; LP =Legal Provision; LR= Legal Regulation; UE= Under Elaboration; IP=Implemented). Prepared by the authors based on Villar and Hirata (2022).

Dimension	*N°*	*Criterion*	*LEGAL CONTEXT*				*Legal Fundamentals*
			NE	*LP*	*LR UE*	*IP*	
Political cross-sectoral coordination Scoring 23/65	32	Environmental licensing of potentially polluting activities	0	1	2	3	Complementary Law 38/1995, Dec 336/2007, Res. CONSEMA 41/2021
	33	Well drilling license or administrative authorization	0	1	2	3	Law 9612/2011 (Art. 9º)
	34	State Environmental Information System	0	1	2	3	Complementary Law 38/1995 (Art. 11, item I) – Environmental registration, record, and information system
	34a	The system has a user-friendly and accessible online platform	No		Yes		Dispersed information, links did not open or required registration
Political cross-sectoral coordination Environment Scoring 11/27	35	Procedure for state-level management of contaminated areas (CA)	0	1	2	3	There is no legal provision
	36	Report on CA published on institutional portals	0	1	2	3	Does not exist
	37	Financing funds for remediation	0	1	2	3	Does not exist
	38	State Ecological-Economic Zoning (EEZ)	0	1	2	3	Law 9523/2011 on Socioeconomic and Ecological Zoning was suspended and is under review
	38a	EEZ includes groundwater	No		Yes		Unable to assess
	39	State Climate Change Plan (SCCH)	0	1	2	3	Complementary Law 582/2017 (Art. 14, I)
	39a	SCCP includes guidelines for state water security	No		Yes		There are no guidelines for water protection

Derbyana, ISSN 2764-1465, 46: e856, 2025.

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Dimension	*N°*	*Criterion*	*LEGAL CONTEXT*				*Legal Fundamentals*
			NE	*LP*	*LR UE*	*IP*	
Political cross--sectoral coordina-tionn Sanitation 6/16	40	State Basic Sanitation Plan	0	1	2	3	Law 7638/2002 (Art. 3, item I) – State Plan for Water Supply and Sanitary Sewerage
	40a	Goal of universal access to water	No		Yes		There is no state plan
	40b	Goals for universal access to the sewage	No		Yes		There is no state plan
	40c	Sewage treatment goals	No		Yes		There is no state plan
	40d	Measures for groundwater	No		Yes		There is no state plan
	41	State Solid Waste Plan	0	1	2	3	Law 7862/2002 and Mato Grosso (2022a)
	41a	Actions for the elimination and remediation of dumpsites	No		Yes		Mato Grosso (2022a, p.548)
	41b	Identification of suitable zones for the location of solid waste treatment units or final disposal of rejects	No		Yes		No information was found
	42	State Information System for Public Basic Sanitation Services	0	1	2	3	Law 7638/2002 (Art. 20, XIV) Sanitation information system for the State of MT
	42a	The system has a user-friendly and accessible online platform	No		Yes		There is no system
Political cross-sectoral coordination Agriculture Scoring 6/22	43	Program for spring restoration	0	1	2	3	Project for the Protection of Aquifer Recharge Areas through Restoration and/ or Conservation of Drainages and Headwaters – SZEE (Mato Grosso, 2009b)
	44	Program for the proper management of animal waste	0	1	2	3	Not found
	45	State Environmental Regularization Program	0	1	2	3	Law 592/2017 and regulations
	46	State Information System on Irrigation	0	1	2	3	There is no state information system on irrigation
	46a	The system has a user-friendly and accessible online platform	No		Yes		Does not exist
	47	State Irrigation Plan (SIP)	0	1	2	2	Law 12717/2024 – State Irrigation Program and Irrigation Master Plan (Decree 1406/2025, Arts. 34, items IV and V)
	47a	SIP includes the availability of GW for irrigation	No		Yes		Does not exist
	47b	Prioritization of regions for irrigation projects based on GW in the SEI	No		Yes		Does not exist
	48	Agroecological zoning (AZ)	0	1	2	3	Law 6115/1992 (Art. 6, d): It is the responsibility of the Public Authority to regulate land use and occupation according to its suitability. There is only the annual Agricultural Zoning for Climate Risk published in the Official Gazette (DOU)
	48a	AZ includes groundwater	No		Yes		Not covered

the size of the territory, its water diversity and the high demand for groundwater (Ferreira, 2022). The state has a Water Users Registry (Mato Grosso, 2020b; 2011b) and a Technical Registry of Potentially Polluting Activities or Activities that Use Environmental Resources (Mato Grosso, 2020c); however, the data from these registries are not publicly available.The performance of the operational-legal dimension is worrying, as it shows the state's difficulties in applying the central instruments of Federal Law No. 9.433/1997: water resources plans, classification of water bodies according to use, water use permits, charging for the use and the National Water Resources Information System (Brazil, 1997). Mato Grosso scored 22 out of a possible 42 points. Although the result classifies governance as moderate (52.3%), the percentage is very close to the low performance range. This score reflects difficulties in both the regulation and implementation of these instruments.

The state has a State Water Resources Plan (PERH) (indicator 12), which includes groundwater. It was approved through Decree No. 2.154/2009 (Mato Grosso, 2009a); however, the plan has not been updated, despite the enactment of a new water law in 2020. The development of the plan's forecast was based on scenarios projected through 2027[4]. Both Law No. 11,088/2020 (Art. 8, §1) and Decree No. 2,154/2009 (Art. 3) establish that "partial or total updates" of the PERH "must be carried out whenever the evolution of issues related to the use of water resources so recommends" (Mato Grosso, 2009a, 2020b, authors' translation). The condition for initiating updates is broadly defined, granting the public administration wide discretionary power. No specific validity period was established, nor was any requirement imposed for periodic reviews or formal mechanisms to monitor the implementation and effectiveness of the proposed actions. Water resources management is a dynamic process, influenced by increasing demand, land use and occupation patterns, and the impacts of climate change. The lack of updates and monitoring may compromise PERH's ability to adequately respond to emerging pressures. Its revision is scheduled to take place only in 2027, twenty years after its initial development.

Most of the Water Resources Planning and Management Units (UPG) in Mato Grosso do not have a river basin plan[5] (indicator 13). However, some progress has been made[6], such as the development of the Water Resources Plan for the Paraguay River Hydrographic Region (PRH Paraguay), a federal initiative of the National Water Resources Council (*Conselho Nacional de Recursos Hídricos - CNRH*), carried out by the National Water and Sanitation Agency (ANA), with the participation of the states of Mato Grosso and Mato Grosso do Sul. In the case of Mato Grosso, this plan covers seven UPGs: P-1 Jauru; P-2 Upper Middle Paraguay; P-3 Upper Upper Paraguay; P-4 Upper Cuiabá River; P-5 São Lourenço; P-6 Correntes-Taquari; and P-7 Paraguay-Pantanal. At the state level, only the Integrated Water Resources Plan for the Middle and Upper Alto Paraguay[7] (UPG P2 - P3) has been approved, through CEHIDRO Resolution No. 155/2022 (Mato Grosso, 2022b). The River Basin Plan for the Upper Cuiabá River UPG (UPG 4) is currently under elaboration[8].

The classification of groundwater bodies (indicator 14) is provided for in State Law No. 11.080/2020 (Art. 6, item III, and Art. 10) and in CEHIDRO Resolution No. 109/2018 (Mato Grosso, 2020b; 2018b); however, it has not yet been regulated or implemented. The granting of water use rights (indicator 15) is regulated by Decree No. 336/2007 (Mato Grosso, 2007) and by SEMA Normative Instruction No. 09/2021 (Mato Grosso, 2021b). In the case of groundwater, CEHIDRO Resolution No. 44/2011 (Mato Grosso, 2011c) must be observed, as it establishes the technical criteria for evaluating groundwater use permit applications. Additionally, CEHIDRO Resolutions Nos. 61/2013 and 62/2013 apply to cases involving the drilling of wells and the permits to use groundwater for irrigation purposes on areas larger than 30 ha (Mato Grosso, 2013a, 2013b). The permitting procedure is outlined in a manual of technical and administrative procedures published by the managing authority (Mato Grosso, 2024b).

[4] More information available at: http://sema.mt.gov.br/site/index.php/sema/noticias/1739-plano-estadual-de-recursos-h%C3%ADdricos-perh

[5] More information about River Basin Committees available at: https://www.gov.br/ana/pt-br/assuntos/gestao-das-aguas/fortalecimento-dos-entes-do-singreh/comites-de-bacia-hidrografica/comites-estaduais/mt.

[6] For more information about River Basin Committees check: http://sema.mt.gov.br/site/index.php/unidades-administrativas/recursos-hidricos/category/398-planos-de-bacias-hidrogr%C3%A1ficas

[7] *Plano de Recursos Hídricos Integrado do Alto Paraguai Médio e Alto Paraguai Superior.* For more information see: http://sema.mt.gov.br/site/index.php/unidades-administrativas/recursos-hidricos/category/398-planos-de-bacias-hidrogr%C3%A1ficas

[8] For more information check: https://RBCcuiaba.wixsite.com/home/plano

It is worth highlighting that CEHIDRO Resolution No. 119/2019 (Mato Grosso, 2019), by establishing criteria for permits to use surface water resources, required that applications be evaluated considering the interdependence between surface and groundwater and the interactions observed within the hydrological cycle. However, this requirement has not been fulfilled (Ferreira, 2022). The state has an Integrated Environmental Licensing and Monitoring System (SIMLAM-Hídrico) to support the decision-making process regarding surface water use permits; however, this system does not cover groundwater, which makes any type of integrated water analysis unfeasible (Ferreira, 2022).

An increase in the number of groundwater use permits has been observed (Machado, 2024), but the issue of irregular wells persists, highlighting the need for regularization campaigns which, although foreseen in the PERH (Mato Grosso, 2009b), have never been implemented. The lack of data and the existence of unregistered wells are challenges that water management agencies must address to enable sustainable groundwater governance (Machado, 2024).

Charging for the use of water resources (indicator 16), as provided in Article 6, item V, and Articles 18 to 21 of State Law No. 11.080/2020 (Mato Grosso, 2020b), has not yet been regulated or implemented. This undermines the financial sustainability of the system and weakens the perception of water as an economic good. Likewise, a Water Resources Information System (indicator 17) has not been established, despite its provision in the State Law No. 11.080/2020 (Mato Grosso, 2020b). The Water Resources Plan for the Paraguay River Hydrographic Region (PRH Paraguay) explicitly acknowledges the lack of "an integrated and comprehensive system to store all water resources-related information" (Agência Nacional de Águas [ANA], 2018, p. 72). Although SEMA requests data on groundwater pumping rates and water quality during the permitting process, this information is not made publicly available.

State Law No. 9,612/2011 (Mato Grosso, 2011b) established several specific instruments aimed at the protection and management of groundwater, which also remain unregulated. This is the case for recharge protection areas (indicator 18), referred to in the state law as maximum protection areas (Art. 15, item I); restricted and controlled groundwater use areas (indicator 19) (Art. 15, item II); wellhead protection zones (indicator 20), classified as sanitary and alert protection perimeters (Art. 18); and artificial recharge (indicator 22), provided for in Article 41. The state, however, has established a procedure for the sealing of wells (indicator 21) (Mato Grosso, 2012, 2024b) and has defined infractions and penalties intended to prevent conduct that may harm groundwater (indicator 23), as established in Law No. 9,612/2011, Law No. 11,080/2020, and Decree No. 620/2023 (Mato Grosso, 2011b; 2020b; 2023a).

CNRH Resolution No. 76/2007 (Brazil, 2007) established, at the national level, guidelines to integrate the state-level management of groundwater resources, conducted by the respective state water authority, with the management of mineral, thermal, gaseous, table, or balneary-use waters, which fall under the Mineral Waters Code and are the responsibility of the National Mining Agency (*Agência Nacional de Mineração - ANM*). This integration would occur primarily through data sharing (indicator 24), since groundwater, depending on its properties or intended use, may receive distinct legal treatment and be simultaneously classified as both a water resource and a mineral resource (Villar & Granziera, 2020). In regions with intensive extraction of mineral waters, conflicts are common, as this type of use is often not accounted for in the basin's water balance. However, SEMA-MT and ANM have not established formal procedures for data exchange. Such integration would be particularly relevant given that Mato Grosso has four municipalities among the one hundred largest extractors of mineral water in the country: Chapada dos Guimarães, Santo Antônio de Leverger, Jaciara, and Dom Aquino. Most extraction concessions (in both number and volume) are granted for bottling purposes (ANM, 2022).

The institutional-legal dimension showed good performance, scoring 25 out of a possible 29 points (86.2%). The state has a State Water Resources Management System (indicator 25), as well as a water resources training plan that is periodically updated, as established in CEHIDRO Resolutions 102/2018, 124/2020, and 178/2024 (Mato Grosso, 2018a, 2020d, 2024c). With regard to collegiate bodies, the state has already established the CEHIDRO (indicator 26), but must intensify efforts to implement River Basin Committees (RBCs) (indicator 27), since, despite having the legal basis for their creation – Law No. 11.080/2020, Decree No. 695/2016, and CEHIDRO Resolution No. 167/2023 (Mato Grosso, 2016, 2020b, 2023b) – a considerable portion of the state territory still lacks these collegiate bodies. The literature also highlights

the need to strengthen the RBCs already in place (Bruno & Fantin-Cruz, 2020; Figueiredo et al., 2024; Rodrigues et al., 2024), which face challenges such as "lack of financial resources, absence of basin plans, and limited effectiveness in publicizing data" (Bruno & Fantin-Cruz, 2020, p. 341). Participation in ANA's Progestão and Procomitês programs has contributed to improving the performance of this dimension, whether by strengthening the committees themselves or through the training of their members (Bruno & Fantin-Cruz, 2020).

State legislation ensures equal representation among the stakeholder segments. CEHIDRO Resolution No. 167/2023 (Mato Grosso, 2023b) organizes River Basin Committees (RBCs) into two groups: (a) Public Authorities, subdivided between representatives of the state and municipal governments; and (b) Civil Society, composed of representatives from civil society organizations and water users. Each of these four categories holds 25% of the seats on the RBCs, ensuring parity between sectors. Public authority participation is limited to 50%, in accordance with Article 39, §1 of Federal Law No. 9,433/1997. Although the state legislation adopts a participatory model, its representation structure differs from that proposed by CNRH Resolution No. 5/2000 (Brazil, 2000), which sets a different distribution: up to 40% of votes for public authority representatives, 40% for water users, and at least 20% for civil society (Art. 8). This lack of alignment in representation models may lead to legal disputes, as has occurred in the State of São Paulo.

The political cross-sectoral coordination dimension showed low performance, scoring only 23 out of 65 possible points (35%). In the environmental axis, the result was 11 out of 27 points (41%). The State Environmental Code, established by Complementary Law No. 38/1995 (Mato Grosso, 1995), defines the State Environmental System (indicator 31), environmental licensing (indicator 32), and the Environmental Registration, Records, and Information System (indicator 34). However, there is no legal provision for the management of contaminated areas (indicator 35), nor for the preparation of reports on such areas (indicator 36), or for the creation of funding mechanisms for their remediation (indicator 37). The Ecological-Economic Zoning (*Zoneamento Socioeconômico Ecológico – ZSEE*) (indicator 38), provided for by Law No. 9.523/2011 (Mato Grosso, 2011a), has been suspended by judicial decision. The ZSEE proposal was developed in 1992, but the project was only enacted into law in 2011. However, a public civil action filed by the Public Prosecutor's Office led to the suspension of the law. The preliminary injunction was upheld in the final judgment in 2016.

Pereira and Rodrigues (2022) warn that climate projections indicate scenarios of increased pressure on water resources and greater vulnerability in water security across the Cerrado biome. Despite this reality, the State Climate Change Plan (indicator 39), provided for in Complementary Law No. 582/2017 (Mato Grosso, 2017a), has not been developed. Integration between environmental and water resource management is essential, especially considering that Mato Grosso, along with Pará, leads national deforestation rates, which impact the hydrological cycle not only at the regional level but also on broader scales (Tavares, 2023).

The sanitation axis showed low performance, scoring only 6 out of a possible 16 points (38%). Of the 137 municipalities in Mato Grosso equipped with a general water distribution network, 78 are supplied by deep wells and 8 by shallow wells (Instituto Brasileiro de Geografia e Estatística [IBGE], 2017a). Groundwater accounts for more than 35% of the total volume extracted to supply the public water distribution system (IBGE, 2017a). The State Basic Sanitation Plan (indicator 40) and the State Sanitation Information System (indicator 42) have only legal provisions and have not yet been implemented (Mato Grosso, 2002). These instruments would play a strategic role, especially when considering the state of sanitation at the municipal level. According to IBGE (2017b), out of 141 municipalities, only 32 had a municipal basic sanitation plan established by legal instrument, 14 had no regulation in place, and in 69 the plan was still under elaboration.

Lima et al. (2018) highlights problems related to water supply and sewage coverage in the state, as well as the lack of data produced by sanitation policy managers. The authors analyzed 109 municipalities, of which 75.2% (82 municipalities) do not have a sanitary sewage system. Only 8.7% of the total population is served by sewage systems, with greater coverage in urban areas, where 44.4% of the population is served (LIMA et al., 2018).

The State Solid Waste Plan (indicator 41) does not identify favorable zones for the location of solid waste treatment units or final disposal sites for residual waste (indicator 41b). It is important to highlight that, at the municipal level, the solid waste scenario is concerning. According to IBGE (2021),

out of the 141 municipalities evaluated, only 64 have an Integrated Solid Waste Management Plan.

The performance of the agriculture axis was also low, with only 6 out of 22 possible points (27%). Spring protection programs (indicator 43) are mentioned solely in the State Water Resources Plan – PERH (Mato Grosso, 2009b), and there is no provision for the development of programs aimed at the proper management of animal waste (indicator 44). The State Environmental Regularization Program, established by Complementary Law No. 592/2017 (Mato Grosso, 2017b), has already been institutionalized, enabling the regularization of rural properties.

In the field of irrigation, although there is legal provision, the state has not implemented essential obligations, such as the State Irrigation Information System or the State Irrigation Plan (indicators 46 and 47). Law No. 12.717/2024 (Mato Grosso, 2024a), which repealed Law No. 5.975/1992, established the State Irrigation Program (*Programa Estadual de Irrigação – PROEI*) and the State Policy on Irrigated Agriculture (indicator 47). Decree No. 1.406/2025 (Mato Grosso, 2025b) assigns the Rural Infrastructure Coordination Office the responsibility of contributing to the implementation of the Master Irrigation Plan for the State of Mato Grosso. These instruments have not yet been regulated, which is concerning given the importance of the agricultural sector in the state's economy and the large volume of groundwater permits issued for irrigation purposes. Their implementation would support the sustainable expansion of irrigation. Machado (2024), based on data from the SEMA-MT Geoportal, found that out of 13,720 groundwater permits, 12,963 were issued for irrigation, while only 587 were for public supply, 72 for industrial use, and 98 for other uses. This highlights the urgent need for an irrigation plan that considers its effects on groundwater availability and incorporates compensatory measures.

The promotion of irrigation in the state is supported by the Federal Government through the Irrigated Agriculture Hubs initiative, led by the Ministry of Integration and Regional Development (MIRD), with the aim of implementing the National Irrigation Policy (PNI). This initiative has already established 13 Irrigated Agriculture Hubs[9] across the country, three of which are located in Mato Grosso: a) Sustainable Irrigation Hub of Southern Mato Grosso (Brazil, 2020); b) Araguaia-Xingu Irrigated Agriculture Hub (Brazil, 2022); and c) Sustainable Irrigation Hub of Mid-Northern Mato Grosso (Brazil, 2023).

The promotion of irrigated agriculture takes place in a context marked by a lack of technical information regarding the water availability of aquifers and their interaction with surface water resources (Mato Grosso, 2009b).This data gap, coupled with factors such as climate change, vegetation loss, and soil compaction, as well as the absence of regulation and full implementation of water resources management instruments, poses substantial risks, including irreversible damage to aquifers and the degradation of surface water and wetland areas.

The state does not have an agricultural environmental zoning plan (indicator 48), which would help identify areas where aquifers are vulnerable to agrochemicals or zones designed for maintaining groundwater recharge in rural areas. According to MapBiomas (2024b), native vegetation cover in Mato Grosso has declined from 87% to 60%, while pasture areas have expanded from 6% to 24%. The National Program for Agricultural Zoning of Climate Risk, governed by Federal Decree No. 9,841/2019 (Brazil, 2019), is the only initiative. However, its purpose is to minimize risks related to adverse climatic phenomena and to enable municipalities to identify the optimal planting periods for crops, based on different soil types and crop cycles.

The compatibility between the use of agrochemicals and the preservation of water quality should be incorporated into agricultural policies. This aspect is not addressed by SAGAS, as there are no clear federal legal guidelines mandating such an obligation. However, scientific literature has already confirmed the presence of pesticides in groundwater in Mato Grosso, which should prompt public authorities to act – especially given the high usage rates of these substances and the state's strong agricultural profile (PIGNATI et al., 2021).

In this context, Table 2 presents the results of the governance assessment based on the total score and by dimension, including data from the axes within the political-institutional coordination component.

State-level governance scored 91 points, equivalent to 54% of the obligations, and was classified as moderate. However, the results are very close to the threshold for a "low" classification. In fact, the cross-sectoral

[9] For more information check: Ministério da Integração e do Desenvolvimento Regional. (2020).

TABLE 2 – Groundwater Governance Performance in Mato Grosso. Prepared by the authors based on Villar and Hirata (2022).

Dimensions	*Score*		*Classification*		
	Expected	*Obtained*	*Good*	*Moderate*	*Low*
Technical	33	21		64%	
Operational and Legal	42	22		52%	
Institucional and Legal	29	25	86%		
Political cross-sectoral coordination	65	23			35%
Environmental Axis	27	11			41%
Sanitation Axis	16	6			38%
Agriculture Axis	22	6			27%
Total	*169*	*91*		*54%*	

* Good: equal to or greater than 75%; Moderate: equal to or greater than 50%; Low: less than 50%.

coordination dimension fulfilled only 35% of its obligations, showing low performance across all its axes. The state has yet to implement essential water management instruments, and coordination with the environmental, sanitation, and agricultural sectors remains weak due to the absence of key instruments within these policy areas.

The results presented in Table 2 reveal structural weakness in the implementation of management instruments and in the consolidation of key institutions essential to groundwater governance. The absence of these instruments, combined with weak political cross-sectoral coordination, undermines efforts to achieve integrated and sustainable water resource management. This scenario highlights the urgency of actions aimed at addressing the identified gaps and strengthening the technical foundations, management tools, and institutional frameworks necessary for effective water policies. The state also faces the challenge of preparing for the impacts of climate change – which are already affecting water resources and biodiversity – while striving to consolidate the essential pillars of water governance and the key instruments needed to support sustainable economic development.

6 FINAL CONSIDERATIONS

The application of SAGAS in the context of Mato Grosso revealed some progress, but also highlighted significant challenges and weaknesses in the implementation and operationalization of key groundwater management instruments and institutions. State policies in this area present important structural gaps that undermine their effectiveness. Although, in the overall framework, governance is classified as moderate, the results approaching the low-performance range – combined with the low performance of the political cross-sectoral coordination dimension – show that a significant portion of legal obligations has not been regulated or implemented, making their practical materialization unfeasible.

The score of 91 out of 169 reveals technical, operational, institutional, and political limitations that put the state's water security at risk. Mato Grosso must intensify its efforts, as – despite the presence of a legal foundation – its regulation and implementation remain insufficient. The technical knowledge base on aquifers is precarious, and the absence of River Basin Committees (RBCs) or basin plans in several Planning and Management Units undermines the participatory management process and informed decision-making, which are essential pillars of effective water governance.

The State must apply and strengthen key water resources management instruments. The criteria for updating and monitoring the State Water Resources Plan (PERH) need to be better defined, as well as ensuring the completion of basin plans and monitoring their development, fostering the creation of a technical foundation to guide decision-making processes.

Although the granting of water use permits is in place, it is being issued without the basic information necessary to assess whether increased use may affect groundwater and surface water levels. This situation is further aggravated by irrigation incentive policies, as their short-, medium-, and long-term impacts cannot be properly assessed. In this context, developing water and soil conservation programs to support irrigation, as provided for in the State Constitution, should be a priority – along with the establishment of a state aquifer monitoring network in areas of intense exploitation. Developing partnerships for monitoring with the agricultural sector could serve

as a counterpart requirement for the installation of irrigation infrastructure.

The regulation and application of water charges are essential for strengthening water management and River Basin Committees (RBCs), which often depend on federal resources or other policy instruments. Furthermore, without these charges, it becomes unfeasible for users to recognize the economic value of water.

7 REFERENCES

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Manuscript submitted on 2 January 2025, accepted on 28 March 2025.
Portuguese version available at https://doi.org/10.69469/derb.v46.846

How to cite:
Villar, P. C., Agnoletto, E., & Rossette, A.N. (2025). Groundwater governance in the State of Mato Grosso. *Derbyana*, *46*, e856.

Authors' contribution:
P.C.V.: Conceptualization, Methodology, Writing – original draft, Formal analysis, Investigation, Legal analysis. E.A.: Data curation, Formal analysis, Writing – review & editing, Geology expertise, SAGAS framework support. A.N.R.: Validation, Writing – review & editing, SAGAS framework support.

Competing interests:
The authors declare no competing interests.