



## The water conflict in Alto São Marcos: characteristics, dilemmas, and challenges

### *O conflito hídrico no Alto São Marcos: características, dilemas e desafios*

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Article received on March 9, 2021, final version accepted on January 10, 2022, published on June 14, 2023.

**ABSTRACT:** Water scarcity is probably one of the greatest challenges imposed on modern societies and Alto São Marcos, a water planning unit located between the Federal District and the states of Goiás and Minas Gerais, represents well the conflicts that involve multisectoral water dispute as a resource. The conflict observed in this region is configured as a potential pilot case for the application of economic instruments for the management of the resource, being necessary, however, before, an adequate characterization of the economic environment, its dilemmas, and challenges. Thus, the objective of this work is to characterize the dispute between the irrigating and electric sectors, to present the history of the regulatory evolution of the instruments adopted, and to discuss the dilemmas and challenges imposed. To carry out this work, a contextualization of the basin was initially proposed regarding its main economic activities demanding the scarce resource; elaboration of a history of the main normative events tangent to the basin; and, finally, the identification of challenges to conflict resolution. Therefore, from the methodological execution, it was found that the complexity of the conflict crosses institutional limits and demands regulatory articulation between local and national priorities, in search of water security for the planning and expansion of uses. Situation that shows the importance of economic studies on the water and multisectoral remuneration dynamics in Alto São Marcos.

*Keywords:* water conflict; Alto São Marcos basin; electric sector; irrigation; water governance.

**RESUMO:** A escassez hídrica é, provavelmente, um dos grandes desafios impostos às sociedades modernas, e o Alto São Marcos, uma unidade de planejamento hídrico localizada entre o Distrito Federal e os Estados de Goiás e Minas Gerais, representa bem os conflitos que envolvem disputa multissetorial da água como recurso. O conflito observado nesta região configura-se como um potencial caso piloto de aplicação de instrumentos

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econômicos para a gestão do recurso, sendo necessário, contudo, antes, uma adequada caracterização do ambiente econômico, seus dilemas e desafios. Assim, o objetivo deste trabalho é fazer uma caracterização da disputa entre os setores irrigante e elétrico, apresentar o histórico da evolução regulamentar dos instrumentos adotados, e ainda, discutir os dilemas e desafios impostos. Para a consecução deste trabalho foi inicialmente proposta uma contextualização da bacia no que concerne as suas principais atividades econômicas demandantes do recurso escasso; elaboração de um histórico dos principais eventos normativos tangentes à bacia; e, por fim, a identificação dos desafios à resolução do conflito. Assim sendo, a partir da execução metodológica, verificou-se que a complexidade do conflito perpassa os limites institucionais e demanda articulação regulatória entre as prioridades locais e nacionais, em busca de segurança hídrica para o planejamento e expansão de usos. Conjetura que evidencia a importância de estudos econômicos acerca da dinâmica hídrica e remunerativa multisetorial no Alto São Marcos.

*Palavras-chave:* conflito hídrico; bacia Alto São Marcos; setor elétrico; irrigação; governança da água.

## ***1. Introduction***

Water scarcity is probably one of the greatest challenges imposed on modern societies and Alto São Marcos, a water planning unit located between the Federal District (DF) and the States of Goiás (GO) and Minas Gerais (MG), all in Brazil, represents well the conflicts that involve multisector dispute over water as a resource, in this case, for energy generation and irrigated agriculture. The conflict observed in this region is configured as a potential pilot case for the application of economic instruments for the management of the resource, being necessary, however, before, an adequate characterization of the economic environment, its dilemmas, and challenges.

Water management is bounded by four different domains with different levels of monitoring and inspection and faces the growth of consumptive uses upstream of the Batalha Hydroelectric Power Plant (HPP) above those granted by the National Water and Basic Sanitation Agency (ANA) for the enterprise. The consumptive uses are configured, above all, by irrigating farmers who adopt the technique of central pivots and stand out nationally

for their production, favored by the characteristics of climate, relief and soil of the region. Power generation takes place at the Batalha HPP, a regularization reservoir upstream of the cascade of large hydroelectric dams, such as the Itaipu HPP, belonging to the national interconnected system (SIN) and operated centrally by the Operator National System (ONS). The dynamics of uses in the region have been intensifying, inciting the dispute of interests, and demanding several management instruments for the regulation of use, coordination of interests and establishment of priorities by the management bodies, water resources councils and river basin committees.

The objective of this work is to characterize the dispute between the irrigating and electric sectors, to present the history of the regulatory evolution of the instruments adopted, and also to discuss the dilemmas and challenges imposed.

## ***2. Brief report on the current state of the art***

The management of water resources in basins where water scarcity and multisector conflicts take place requires more sophisticated approaches, such

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as negotiated water allocations and regulatory frameworks, as presented by the OECD (2015).

For the São Marcos River basin, whose watercourses have jurisdiction shared by the States of Goiás and Minas Gerais, the Federal District and the Union, the Water Use Regulatory Framework was established, agreed between ANA and the water resources management bodies from Goiás and Minas Gerais states. This instrument was adopted due to the need for compatibility between the uses of irrigation and electric energy, especially in the region upstream of the Batalha HPP known as Alto São Marcos, and the provision of Article 17 of Decree No. 3,692, of December 19, 2000 (BRASIL, 2000), to assign to ANA to define minimum flow requirements in the transition of bodies of water from the State to the Federal domain.

In establishing use priorities, the criteria for granting water rights contained in water resource plans will define how water will be shared between different geographic or administrative regions, sectors, and time scales. A clear distinction must be made between prioritization and optimization in the allocated decision process. While prioritization determines which regions or sectors should have an allocation preference, optimization ensures that water is allocated efficiently (OECD, 2015). Since prioritization is a more political process and optimization is a more technical process, both, however, are strategic for water governance. Based on this understanding, it is assumed that these are approaches those managers should consider in their decisions, especially in the case of the São Marcos basin due to the multiple domains, the national priority for hydroelectric power generation and the relevance at the state and local level and irrigated agriculture basin.

OECD (2015) highlights that a balance needs to be found between coherence with broader water resources policies and adaptation to local contexts. The document also highlights that there is a perverse incentive that results in oversized grant requests, considering that there are benefits, and few disadvantages, for users to request more water than they need. The situation is exemplified by what happens in Goiás, where 7% of the central irrigation pivots are inactive, but maintains the grant as an operational reserve. Aforesaid behavior that worsens distributive tensions among users.

In addition, there is the issue of monitoring, which in the São Marcos basin is still critical in relation to the large number of irregular central pivots. Bof (2018) highlights that the uses of water for irrigation in the basin far outweigh other uses, both in number of grants and in flow granted. The author states that 43% of the water flow consumed by Alto São Marcos irrigators would not be granted.

It is important to note that the grant, as an instrument of the National Water Resources Plan, stands out as fundamental for guaranteeing the effective exercise of the rights of access to water and for the control of uses. The lack of monitoring of the demands granted implies the difficulty of analyzing water availability and determining alternative use priorities, something also observed in the basin under study. Moreira *et al.* (2012) analyzes that the fact that no flows are granted is one of the reasons for water use conflict. The lack of information makes the Alto São Marcos conflict between the power generation and irrigation sectors critical about the established restrictions and the lack of vision about the growth of competing uses.

Such conception about the evolution of the conflict sought to be circumvented by studies de-

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veloped in the region. An example is that of Pinhati (2018), who adds to the discussion the perspective on the maximum irrigation expansion capacity that the São Marcos basin would be able to support with a base date of 2016. Concluding that, although there are almost 250,000 hectares of land available for installation of central pivots, only 64,608 hectares would be technically and economically feasible to be fully met for the water needs of corn in the winter harvest, corresponding to 3,779 potential central pivots. This result was obtained by a simulation that adopted a hypothetical scenario of all the central pivots existing in September 2006 with the corn crop, due to the high need for irrigation, higher than the bean and soy plantations, usual in the region. Thus, there is fundamental information for planning the uses and grants conferred in the São Marcos basin due to the upper limit of potential pivots.

It should be noted that, as Soares (2019) states, there is a contrast of the relief in the basin, where the Alto São Marcos is flat and wavy and the Baixo São Marcos, located downstream of the Batalha HPP, is rugged and mountainous. The flat areas, located in the highest parts of the water bodies that form the basin, are expressive and economically very important, due to the formation of shallow valleys and valleys with flat bottoms and smooth slopes. This characteristic at the top of the basin justifies the high concentration of central pivots and high agricultural productivity, leading the municipalities of Cristalina (Goíás) and Unaí (Minas Gerais) to be the 5th and 24th largest agricultural GDPs in Brazil, according to IBGE (2015) data.

Soares (2019) sought to optimize the surface water use in the São Marcos basin by mathematical simulations with the AQUATOOL computational tool with the OPTIGES optimization module between October 2014 and September 2017. That work concluded that the best water availability situation was with the replacement of the current grant criteria (50% of  $Q_{7.10}$ <sup>1</sup> in Minas Gerais and 70% of  $Q_{95}$ <sup>2</sup> in the State of Goiás) by 80% of  $Q_{7.10}$  and 70% of  $Q_{95}$ , in which 2.3% and 5, 5%, respectively, were the areas above the grantable limits. He characterized the situation in that basin as worrying regarding the volumes collected up to September 2017, mainly in Alto São Marcos, where the number of grants, mainly for irrigation, is very high. However, in the region of the Baixo São Marcos, the situation is comfortable, with few tributaries with grants above what is allowed, with good water availability.

Silva & Hora (2015) aimed in their work to analyze the conflict for the use of water between the current and future demand for irrigation and the hydroelectric use of the Batalha HPP, seeking to evaluate the question of the possible losses of energy produced, associated with the growing consumptive uses upstream of the hydroelectric plant. Through a simulation scenario using the computational tool Plant Simulation System with Water Consumption Uses (SisUCA), energy losses ranging between 8.0% and 19.7% for average energy, and between 7.6% and 19.2% for firm energy. In conclusion, the lack of references to problems solved and well-managed regarding conflicts over water use between the electricity sector and agriculture make the São

<sup>1</sup>  $Q_{7.10}$  is the minimum flow of 7 consecutive days and with a return period of 10 years.

<sup>2</sup>  $Q_{95}$  is the minimum expected flow rate 95% of the time (hydrological year).

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Marcos basin a region of great concern. Noting that, in the medium term, a discussion is needed to make the grants and energy guaranteed by the Batalha HPP more flexible.

Sado *et al.* (2018) aimed to obtain information that can subsidize the actions of water resources management bodies and that assist in directing actions to inspect water uses. For this, they applied a methodology for estimating the consumptive use of water in irrigation at a local scale, based on remote sensing data obtained from the Landsat 7, Landsat 8 and TRMM satellites. They concluded that the methodology allows estimating the use of water for irrigation by agricultural undertakings, with a correlation of 0.92 between the water volumes estimated by remote sensing and the volumes measured by hydrometers. An alternative to the Alto São Marcos River basin without the need for field work and, therefore, high-cost logistics.

Bof (2018) aimed to evaluate the economic trade-offs between energy and irrigated agricultural production in the region and show how this information could contribute to the negotiated allocation of water, based on its economic value, comparing with the current allocation system. An explicitly stochastic hydro-economic optimization model was used to determine the economic value of water and its variation in space and time, the results of which were used in a dynamic water accounting. It was concluded that the trade-offs are significant and that there are solutions with the possibility of economic compensation for losses between the sectors involved, solutions that would be the starting point to defuse a conflict situation and signal to users the spatial location and the pattern demand that can be accommodated in the basin, depending on the economic value of the water.

Finally, there is the pertinence of incorporating economic instruments in the management of water resources, given that Law No. 9,433, of January 8, 1997 (BRASIL, 1997), which institutes the National Water Resources Policy, creates the National Water Resources Management System, and makes other provisions, based on water as a limited natural resource with economic value. Charging is the instrument that recognizes water as an economic good and that gives the user an indication of its real value, in addition to encouraging the rationalization of water use and making it possible to obtain financial resources to finance the programs and interventions contemplated in the plans of water resources.

However, the OECD (2015) emphasizes that despite the economic instruments recommended in the referred Law nº 9.433, they should be used as tools of the water resources policy, in Brazil they are not used as such, on the contrary, they serve to generate tax revenues.

As Hartmann (2010) presents, the collection values are very low because they result from the definition by a central water regulation institution subject to social and political pressures.

As Rogers *et al.* (2002) affirm, this is not only an exclusive situation in Brazil, since also in other countries water is underpriced, not internalizing externalities, and generally leading to an unsustainable use of water resources, but declaring that if properly managed, this instrument has the potential to promote economic efficiency and social equity.

In this way, charging for the resource as established by the norm in force in Brazil does not reflect the marginal value of water, guides inefficient allocations by distorting economic incentives and ignores scarcity by treating the economic good as a free good.

### 3. Contextualization of the São Marcos Watershed

To better contextualize this work, a characterization of the São Marcos basin was carried out, as well as of the irrigation and hydroelectric generation instituted in the region.

#### 3.1. Alto São Marcos basin

The São Marcos basin is in the central region of the country, with a drainage area of 12,089.12 km<sup>2</sup> divided between the states of Goiás with 72.17% of the area and Minas Gerais with 27.41%, in addition to the Federal District with 0.41%, as presented by IBGE (2020).

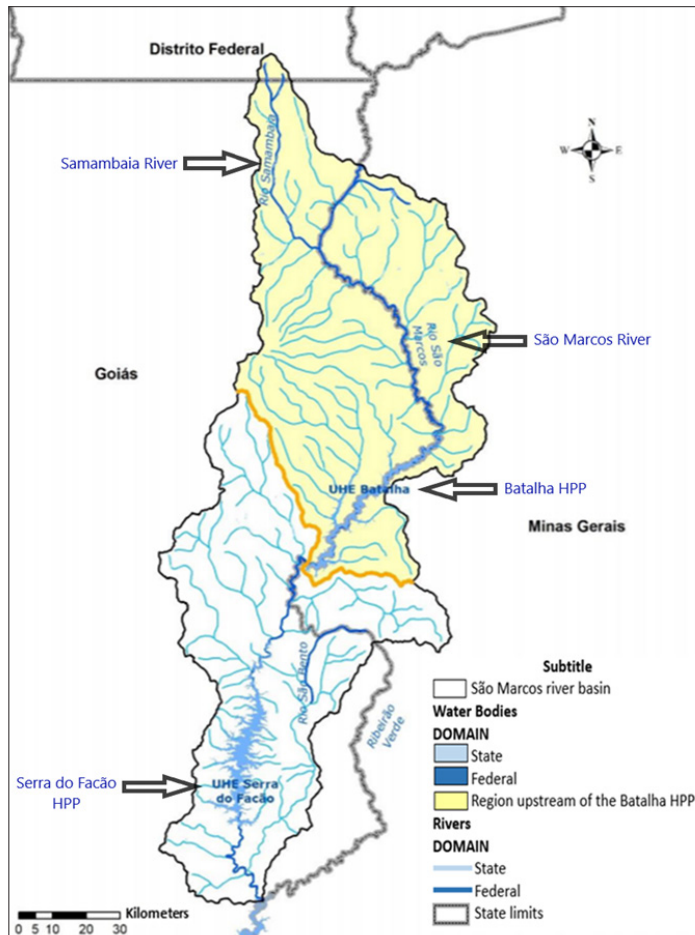


FIGURE 1 – Location the São Marcos River Watershed.

SOURCE: BRASIL (2020). Adapted by the authors.



The São Marcos basin belongs to the Parará River Hydrographic Region and more specifically to the Paranaíba River hydrographic basin. As shown in Figure 1, the main river in the hydrographic basin is the São Marcos, one of the main tributaries on the right bank of the Paranaíba river, this river is formed from the Samambaia stream, in the Federal District region, bordering the states of Goiás and Minas Gerais, and therefore of federal domain. There are also hydroelectric plants, installed and in operation, as Batalha and Serra do Facão.

According to the Paranaíba River Basin Water Resources Plan (WRP- Paranaíba) (ANA, 2013a), with a view to allowing proper planning, the Paranaíba River basin was divided into twenty Water Planning Units (WPU), among them WPU nº 18 Alto São Marcos, which is the study area of this work, indicated in Figure 1 by the area in yellow, representing the portion of the basin upstream of the Batalha HPP with 6,700 km<sup>2</sup> and occupying 55% of the area.

It is noteworthy that some WPUs, located in the boundaries of the states, are inserted in more than one Water Management Unit (WMU), since the WMUs respect the state limits of the basin, while the WPUs respect only the hydrographic and hydrological factors. In view of this situation, WPU Alto São Marcos is related to the WMUs presented in Table 1, a dynamic that justifies the establishment of the state hydrographic basin committees (CBH) that incorporate the region, as well as exemplifying the current water governance.

From that table, water governance in the Alto São Marcos watershed involves the dynamics of four CBHs that interact beyond state limits. It should be noted that CBHs are responsible for establishing priorities for granting specific use rights at the basin level through water resource plans. Therefore, the existence of the mapped committees allows us to infer that the dynamics of water allocation in the basin in question is more complex and requires articulation between the federal, state and basin levels.

TABLE 1 – Water governance in the São Marcos basin as a function of the state, state management body, Water Management Unit (WMU) and state hydrographic basin committees (CBH).

Water governance in the São Marcos basin				
State	Management body	WMU of WRP-Paranaíba	CBH - States	CBH -Interstate
Goiás (GO)	State Secretariat for the Environment and Sustainable Development (SEMAD-GO)	São Marcos	CBH of Corumbá River, Veríssimo River and the portion of the São Marcos River in Goiás State	
Minas Gerais (MG)	Minas Gerais Water Management Institute (IGAM-MG)	Minas Gerais tributaries of Alto Paranaíba	CBH of the Minas Gerais tributaries of the Alto Rio Paranaíba	CBH - Paranaíba
Federal District (DF)	Regulatory Agency for Water and Sanitation of Federal District (ADASA-DF)	Lago Paranoá; Descoberto; Corumbá; São Bartolomeu; São Marcos	CBH of Paranaíba-DF	

SOURCE: Elaborated by the authors.

We sought to highlight the relevance of the Alto São Marcos basin region from the survey of the area irrigated by central pivots from 1986 to 2015 and from the perspective of growth between 2015 and 2040, through Figure 2, using the data contained in ANA (2016a).

In the Figure 2, the progressive growth of the irrigated area in the São Marcos basin is effectively driven by the Alto São Marcos region, where there is a greater concentration of pivots. It should be noted that the percentage of irrigated area mapped in the basin in 2015 was 8% of the total area of 1,208,912 hectares, however, the Alto São Marcos corresponds to 79.1% of this amount. With the prospect of doubling its irrigated area before 2040, the representation of the Alto São Marcos region consolidates the intensification of the dispute over

the water resource, mainly because it is in this region where Batalha HPP is installed. In this way, the proposal of policies that debate the growth of the irrigated area in the region gains relevance and permeates the limitation of the water supply linked to the greater regularization of the installed users for the evolutionary monitoring of the demands.

It should be noted that a limitation for the installation of the pivots was the lack of electricity in the region (ANA, 2014), an obstacle that was supplied expansion of the distribution network linked to the installation and interconnection of hydroelectric plants in the basin, allowing greater availability of energy for irrigation pumps. Currently, the growth rate of the irrigated area tends to be limited by water restrictions, planted crops and infrastructure to support production and marketing.

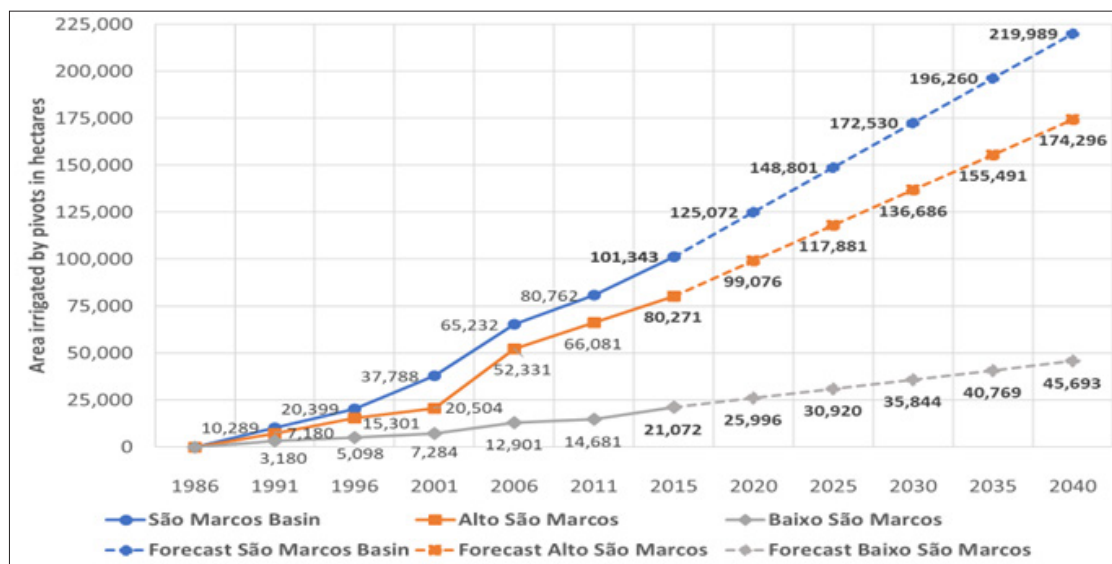


FIGURE 2 – Area irrigated by central pivots in the São Marcos Basin from 1986 to 2015 and its growth perspective for the period between 2015 to 2040.

SOURCE: ANA (2016a) data. Prepared by the authors.



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### 3.2. Irrigation in the basin

The survey of agriculture irrigated by central pivots in Brazil from 1985 to 2017 (ANA, 2019a) highlighted that the municipalities of Unaí (MG), Paracatu (MG) and Cristalina (GO) form the largest concentration of pivots in Brazil, with 2,558 points -pivots in 191 thousand hectares, It should be noted that only the São Marcos hub of RH Paraná showed a 41% growth from 2000 to 2017 and an area equipped for irrigation by central pivots, reaching 100,872 hectares in 2017 and occupying second place in the national ranking of area and density.

ANA (2014) had already declared that since the first irrigation projects developed in the São Marcos basin, the central pivots were adopted as being the ideal equipment to irrigate the large extensions of land with small slopes, characteristics of the plains and valleys the basin. The high degree of energy efficiency and consumption in terms of water and the low demand for labor for their operation have made the central pivots unanimous in the region, with very few irrigating farmers who do not use them. Statements that consolidate the diagnosis obtained by surveys of irrigated agriculture in the basin, and that allow orienting policies focused on this technique and seeking efficiency goals for the use and inspection of grants.

The evolution of the irrigating sector in Alto São Marcos can be seen by surveying the average annual flows available for the consumptive uses upstream of the Batalha HPP until the year 2040, in cubic meters per second. Such flows were delimited by Resolution No. 364, of August 29, 2005 (ANA, 2005), which established the Declaration of Water Availability Reserve (DRDH) of Batalha HPP, later

converted into a grant by Resolution of ANA No. 489, of 19 August 2008 (ANA, 2008), which came to be amended by Resolution No. 564, of October 25, 2010 (ANA, 2010d) and, more recently, by Resolution No. 88/2018, of March 27, 2018 (CBH-Paranaíba, 2018). In addition, the flow demanded by the irrigated areas was estimated based on the growth perspective established for the period from 2011 to 2040, presented in ANA (2014).

By Technical Note No. 104/2010 / GEREG / SOF-ANA, on August 30, 2010 (ANA, 2010b), the average annual unit water consumption by irrigation in the São Marcos basin was set at 0.13 l / s / ha. However, CBH-Paranaíba (2018) established that in the regularization of the uses of the area of interest, for irrigation purposes, the limit would be 0.20 l / s / ha / year on average for the basin and integrated a second projection from 2017. The adoption of the two values was addressed in the analysis regarding the flows demanded by the irrigating consumption in Alto São Marcos presented in Figure 3, compared to the analysis of the flows made available in the norms.

From this figure, it is possible to observe the growth of the flows made available for consumptive uses to follow the growth forecast of this irrigating sector and its water need. From the point of view of the electric sector, the values delimited by the DRDH are considered as planning instruments, because they delimit the water reserve for consumptive uses upstream of the reservoir and allow to measure the flow available for the operation of the hydroelectric plant. In 2010 this limit was not being respected, which motivated the revision of the flow made available for the consumptive uses by ANA (2010d). Such resolution increased the value of the flow reserved for consumptive uses upstream of the

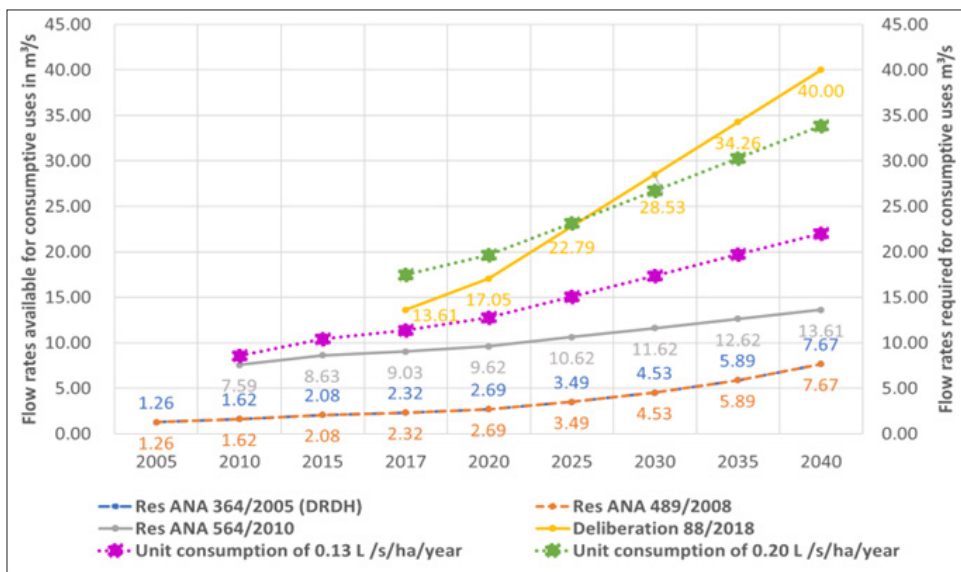


FIGURE 2 – Area irrigated by central pivots in the São Marcos Basin from 1986 to 2015 and its growth perspective for the period between 2015 to 2040.

SOURCE: ANA (2016a) data. Prepared by the authors.

hydroelectric plant and, consequently, decreased the water supply to the Batalha HPP to values below those expected only in the year 2040.

However, when confronting the available flows with the defendants, it is noticeable, especially for the unit consumption of 0.13 l / s / ha / year, the water conflict that started in 2010, even before the beginning of the operation of the Batalha HPP in 2014, with greater demand than the water supply, despite the established regulatory updates. When changing the base of unit consumption to 0.20 l / s / ha / year it is seen that only from 2025 it is estimated that there would be a change in the panorama of the situation with a gap for water demand in comparison with the new limits assigned by CBH-Paranaíba (2018). Such behavior will impact the water reserve

for energy generation but incorporates the forecast for growth of the irrigated area for the period.

Finally, it is emphasized that the demand analysis was made based on the growth projection and that it did not consider any water, structural or environmental restrictions, which can be considered a conservative estimate and, therefore, interpretive caution is needed. In addition, the registration and regularization of users face a high degree of uncertainty regarding irrigated crops and the market prices of commodities, which makes a more robust forecast difficult. The error in surveying the area irrigated by satellites and the high number of users who do not request a grant culminate in a smaller safety margin for local water planning and quantification of existing consumptive and non-consumptive demands.

### 3.3. Hydroelectric generation in the basin

In addition to the use for irrigation, the geomorphological characteristics of the valley favored the construction of two waterfall HPPs. The Batalha HPP is located between the municipalities of Cristalina (GO) and Paracatu (MG) and has a generating capacity of 52.5 MW - enough energy to supply a city of 130 thousand inhabitants, with the use of water supplied to the company Furnas Power Plants by ANA (2008). The HPP Serra do Facão, located in the state of Goiás, between the municipalities of Catalão and Davinópolis, has a capacity of 210 MW, sufficient to serve a city with 1.2 million inhabitants, being one of the largest undertakings of its State, according to Cunha (2019).

In addition to these projects, the hydroelectric enterprise (HE) of Mundo Novo and Paraiso were designed in studies of the hydroelectric inventory of the São Marcos River basin carried out by Furnas between 1997 and 1998 and approved by

the National Electric Energy Agency (ANEEL) in 1999, as stated in ANA (2014). Figure 4 shows the fall division adopted and illustrates for planning purposes the spatial distribution of AHEs and the year of implementation.

In the Figure 4, it is observed that, among the undertakings, only the HEs Batalha and Serra do Facão were implemented, due to the economic and environmental viability. HE Mundo Novo has had its reinventing process suspended since 2014 by ANEEL Order No. 1806/14, according to ANA (2016b). However, it is a strategic development, located upstream of the others and, according to ANA (2014), it would have a storage capacity of 3,230 km<sup>3</sup> and an installed capacity of 67 MW. HE Paraiso has an inventoried generation capacity of 48 MW and had its DRDH requested from ANA in 2015.

The fact that water is considered a public good, in the sense of the law and not in the microeconomic sense, implied that the construction of the Batalha HPP required several regulatory steps. And the pa-

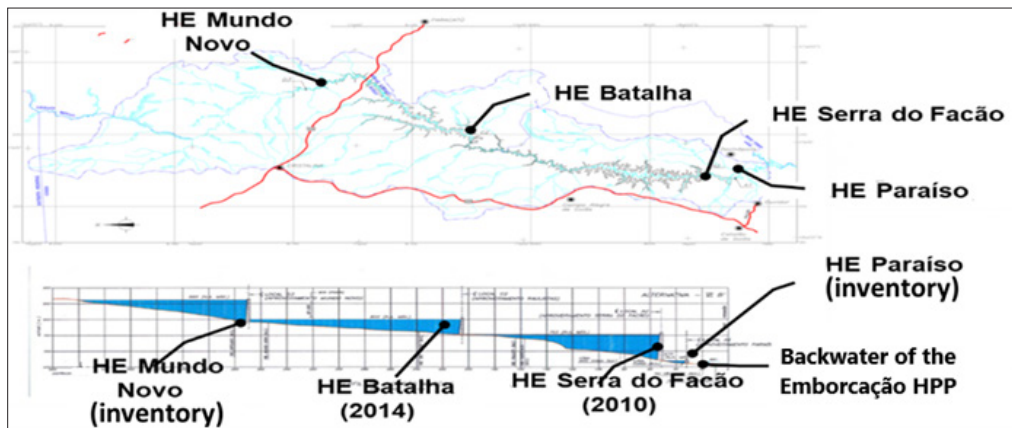


FIGURE 4 – Fall division for the São Marcos River at the source until the backwater of the Emborcação reservoir, showing the hydroelectric enterprise (HE), spatial distribution and year of implementation.

SOURCE: ANA (2014). Adapted by the authors.

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norama delimited by Law No. 9433, of January 8, 1997 (BRASIL, 1997), for the use of water resources in the exploitation of hydroelectric potentials subject to the granting by the Public Power and subordinate to the National Water Resources Plan obeyed the discipline of sector-specific legislation. Thus, the above-mentioned processes involving the Batalha HPP run through the articulations between the sectorial policies for water resources and electricity and have established several environmental and operational restrictions on the reservoir, in addition to delimiting the water security established for the planning of the enterprise through its DRDH (ANA, 2005), allowing firm energy contracts to be signed with the electricity sector and supporting the hydro-energy security of the system.

The regulatory restrictions involved between the sectors allowed for reviews of the value of the assured energy allocated to the Batalha HPP every five years or in the event of relevant facts, enabling changes to be made to the water reserve to balance the flows made available for consumptive uses with the flows demanded by irrigated agriculture. However, as shown in Figure 3, such measures were insufficient in view of the evolution of water use in irrigation. An arrangement whose complexity involves, in addition to the dynamics of the agricultural sector, the regulation of water resources and electricity and requires studies on the effectiveness of such changes, as well as on the impact on the energy guarantee, the financial viability of the enterprise, growth, profitability and water consumption of central pivots in the region.

#### ***4. Event history***

The survey of the history of the main normative events tangent to the basin is necessary to consolidate the understanding of the actions of the bodies involved, as well as the impact of mitigating measures and the relationships established between agents and regulatory bodies. Figure 5 is presented with a brief chronological survey of the events.

In Figure 5, the actions of the management bodies that implied the establishment of parameters for the operationalization and use of the water resource are highlighted, given the current reality and the studies and forecasts adopted. The first moment is the publication of the DRDH for Batalha HPP by Resolution n° 364, of August 29, 2005 (ANA, 2005), which defined the conditions for the holding of Auction 002/2005 of ANEEL, of October 26, 2005, see appendix A, annex 1 of the public notice that regulated the referred auction (ANEEL, 2005). The auction notice was published with a view to contracting energy from new hydroelectric projects, including Paulistas HPP, located in the State of Goiás and Minas Gerais, which later changed its name and is now called Batalha HPP. Subsequently, Preliminary License No. 222/2005 was issued on December 6, 2005 (IBAMA, 2005), by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) to Empresa Furnas Centrais Elétricas S.A.; approving the location and design of the project in the preliminary planning phase, attesting its environmental feasibility, and establishing basic requirements to be met in the next phases of implementation.

Following the explanation of Figure 5, in 2006 the auction was consolidated through the signing of Concession Contract No. 002/2006-MME- Batalha HPP, of August 15, 2006 (MME, 2006), for use of public asset for the generation of electric energy,

which the Union and the Company Furnas Centrais Elétricas SA celebrate. This contract regulates the exploration, by the concessionaire, of the hydroelectric use of Batalha HPP for a period of thirty-five years, counting from the date of its signature. The

said concession for the exploration of the hydraulic potential by Batalha HPP in a stretch of the São Marcos River was granted by Decree of July 25, 2006, published in the Official Gazette of July 26, 2006 (BRASIL, 2006).

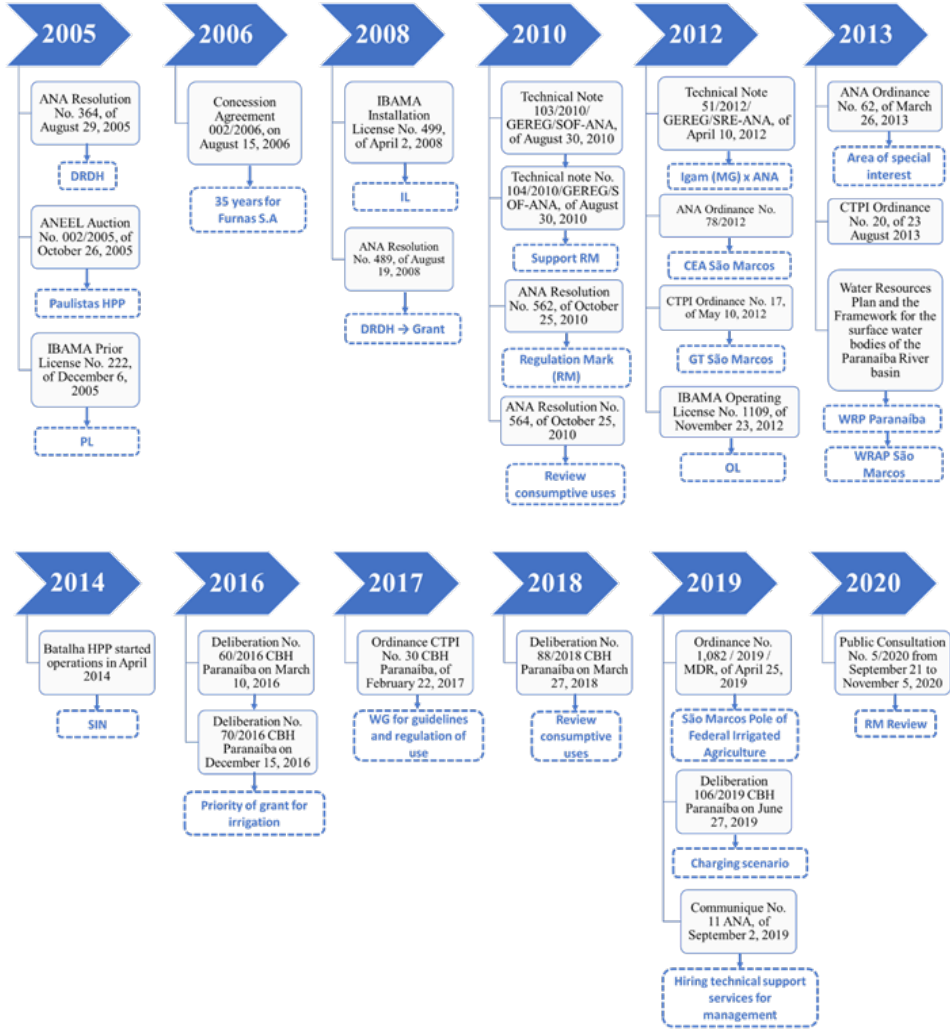


FIGURE 5 – Chronological survey of events, regulations, deliberations, and ordinances applied to the conflict in the Alto São Marcos. SOURCE: Prepared by authors.



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Later in 2008, Installation License No. 499/2008, of April 2, 2008 (IBAMA, 2008), was granted by IBAMA, to Empresa Furnas Centrais Elétricas SA In addition to the publication of Resolution No. 489, of August 19, 2008 (ANA, 2008), in which the Agency transformed the DRDH into the Granting of the Right to Use Water Resources to the Company Furnas Centrais Elétricas SA maintaining the consumptive usage values provided for in the DRDH.

The year 2010 stood out in relation to supply mitigation measures. Such measures were implemented in response to the growth in demand in the São Marcos River basin, when there was an increase in areas irrigated by satellite images. The publication of Technical Note 103 / GREG / SOF-ANA, of August 30, 2010 (ANA, 2010a), commented that the verified expansion signaled the possibility that more water should be allocated for irrigation, to the detriment of the generation of energy. However, it was understood that there was no immediate legal basis for such reallocation, given that there is no such prioritization, whether in the form of laws or water resource plans. In such a way that this document made an analysis of the economic value of water in the São Marcos basin for the irrigation and power generation sector and compared them. As a result, it was recommended that it would be economically consistent to reallocate water from the power generation sector to the irrigation sector, only in the case of irrigators with relatively high efficiency.

Technical Note No. 104/2010 / GREG / SOF-ANA, on August 30, 2010 (ANA, 2010b), also provided subsidies for the elaboration of the regulatory framework in the São Marcos River basin and proposed a strategy to make competing

uses compatible for the Maximum Irrigated Area by Central Pivot (AIEPC) in the proportion of 52% in Goiás and 47% in Minas Gerais, as the allocation unit to be adopted. The Technical Note highlighted the need for commitment by the state management bodies with the competence to issue grants in the basin, with priority being given to regularizing existing pivots that have not yet been granted. It was recommended to continue the verification of the management bodies for meeting the water availability and the review of the granting of the Batalha HPP, in addition to carrying out diligences with the states of Goiás and Minas Gerais, to institutionally replicate the Regulatory Framework in the respective management bodies.

Continuing, ANA established the Regulatory Framework for the Use of Water in the São Marcos basin, agreed between the water resources management bodies of the States of Goiás and Minas Gerais, jointly with ANA, through Resolution No. 562, of 25 October 2010 (ANA, 2010c). It should be noted that, subsequently, there was a review of the grant granted to Batalha HPP through Resolution No. 564, of October 25, 2010 (ANA, 2010d), which changed the flows of consumptive uses defined in ANA (2008).

In 2012, Technical Note No. 51/2012 / GREG / SER-ANA was published on April 10, 2012 (ANA, 2012), which dealt with the analysis of a proposal by IGAM, the water resources management body of the State of Minas Gerais, to define minimum flows at the confluence of the rivers in its domain with the São Marcos River. It has been shown that the defined delivery flows are in breach of regulations established by ANA, as in the case of ANA (2010c), as it allows the state of Minas Gerais to grant above the flow / irrigated area allocated to it.



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Such delimitations would lead to the water infeasibility of ventures granted in the federal rivers and to the insufficiency of affluent flow for the operation of the Batalha HPP. Therefore, with the analysis of this document, it was reaffirmed by the validity of the Regulatory Framework for the use of water in the São Marcos basin.

In 2012 was constituted the Special Commission for Monitoring the Management of Water Resources in the São Marcos Basin (CEA) by the ANA Ordinance No. 78/2012, with the purpose of proposing the review, monitoring and inspection of compliance with the milestone regulatory. As a result of the creation of CEA, for example, Ordinance CTPI No. 17 was established, on May 10, 2012 (CBH-Paranaíba, 2012), which formalized the creation of the Technical Working Group, GT São Marcos, and defined arrangements for its operation.

Also this year, Operating License No. 1109/2012 was issued on November 23, 2012 (IBAMA, 2012) by IBAMA to Empresa Furnas Centrais Elétricas S.A.; one of the conditions that enabled the Batalha HPP to start operating in 2014.

In 2013, the Water Resources Plan and the Framework for Surface Water Bodies of the Paranaíba River Basin (WRP-Paranaíba) were published (ANA, 2013a), which highlighted the fact that the flows made available by the basin's regulatory framework of São Marcos for consumptive uses have been extrapolated by existing demands. This scenario motivated the periodic review of the framework, through negotiation between management bodies and users. As a product of the WRP-Paranaíba, the Water Resources Action Plans (WRAPs) were produced for each WMU in the Paranaíba river basin, among them the WRAP São Marcos, ANA (2013b), which also pointed out several stretches of river with

higher demand than water availability in this region due to the expansion of irrigation.

ANA Ordinance No. 62, of March 26, 2013 (ANA, 2013c), declared of special interest for the management of water resources, according to the qualitative and quantitative water balance, stretches in water bodies under the domain of the Union. Among these stretches, there are the Samambaia River, and its federal tributary on the left bank, and the São Marcos River, from the source to the Batalha HPP in the São Marcos basin belonging to the Paraná Hydrographic Region. Additionally, Ordinance CTPI No. 20, of August 23, 2013 (CBH-Paranaíba, 2013) replaced CBH-Paranaíba (2012); becoming the attribution of the WG - São Marcos: elaborate context analysis of the conflicts related to water resources in the São Marcos basin, elaborate actions foreseen in the Plan referring to the São Marcos basin and present a report indicating the strategies and actions necessary to solve the conflicts.

According to the Operation History (ONS, 2020) the Batalha HPP started operating by dispatching centrally at the SIN in April 2014. In 2016, with the conflict properly established and increasingly impacting the rights to use water resources, CBH-Paranaíba positioned itself by deliberations to define priorities for use in the basin. Among these regulations, Deliberation No. 60/2016, of March 10, 2016 (CBH-Paranaíba, 2016a) and Deliberation No. 70/2016, of December 15, 2016 (CBH-Paranaíba, 2016b) defined the priority for granting the right to use water resources upstream of the Batalha HPP on the São Marcos River for the use of surface water for irrigation, subject to the provisions of item VIII of article 7 of Law No. 9433, of January 8, 1997 (BRASIL, 1997). This item delimits the priorities for granting rights to use water resources as content

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of the Water Resource Plans, which at the basin level should be defined, in principle, by the hydrographic basin committees through their consultative and deliberative functions.

In 2017, CBH-Paranaíba instituted through Ordinance CTPI No. 30, of February 22, 2017 (CBH-Paranaíba, 2017), WG for proposing guidelines for the regulation of uses of the São Marcos River basin aiming at guaranteeing multiple uses. The normative established as GT's attributions to propose limits for irrigation in the basin, to propose guidelines to Organs management bodies for the regularization of the installed water uses and to propose an eventual reduction of flow granted to the Batalha HPP, seeking to maintain its physical guarantee and to propose guidelines for regulation of uses in the basin.

In 2018, CBH-Paranaíba approved the guidelines for the regulation of uses in the São Marcos River basin through Deliberation No. 88/2018, of March 27, 2018 (CBH-Paranaíba, 2018). As a result, the limit flow for the consumptive uses upstream of the Batalha HPP was increased, thereby reducing the flow reserved for energy generation. In addition, with a view to achieving regularity in meeting the obligations imposed because of the management agreement, the management bodies should encourage the collective processes of local management of water resources by sub-basin. Such processes were exemplified by the identification of the uses implemented and the revision of the granted grant values, negotiated allocation, rationalization of irrigation and collective reserve of surplus water.

In the following year, in 2019, São Marcos was selected as one of the twenty-six National Poles, special areas for the management of water resources for irrigated agriculture on a national scale,

according to Ordinance No. 1,082 / 2019 / MDR, of April 25, 2019 (MDR, 2019), which establishes the Federal Government's Irrigated Agriculture Poles initiative, and therefore highlights the relevance of the region and the sector's incentive strategies from the perspective of regional development. At the basin level, CBH-Paranaíba by Deliberation No. 106/2019, of June 27, 2019 (CBH-Paranaíba, 2019), approved a scenario considering the implementation of charging for the use of water resources in hydrographic basins affluent to the Paranaíba River, among them São Marcos. Normative that aimed to ensure financial viability for the maintenance of a delegating entity in the Paranaíba River basin, considering the implementation with horizon from 2020.

Additionally, ANA, through Communique No. 11, on September 2, 2019 (ANA, 2019b), informed the hiring of a company specialized in technical services in support of the management and regulation of water use in the São Marcos River. It is understood that this is an action that tends to allow updating of the current characterization of the conflict and, thus, to guide actions that promote greater water security for present and future users of the resource.

More recently, in 2020, from September 21 to November 5, Public Consultation No. 5/2020 (BRASIL, 2020) was opened to obtain suggestions from society for the revision of the Regulatory Framework for the Use of Water in the Surface Water Bodies of São Marcos River Basin. The proposal for a joint resolution by ANA, ADASA, IGAM, SEMAD / MG and SEMAD / GO is for the maximum grantable limit of average annual consumption in the portion of the basin located upstream of the Batalha HPP of  $13.61 \text{ m}^3 / \text{s}$ , defining coefficients

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average annual consumption rates as parameters for verifying the limit for use whose purpose is irrigation, broken down by systems, and for other purposes. There is also a requirement of a minimum efficiency of 85% for issuing a license for irrigation, and the establishment that the license holders, regardless of domain, must install and maintain a measurement system or equipment that allows the monitoring of water abstractions.

### ***5. Dilemmas and challenges***

An analysis is proposed about the dilemmas involved for the flow limits of consumptive uses upstream of Batalha HPP from 2010 to the year 2040, in 5-year intervals, according to ANA (2005), which granted the DRDH to the hydroelectric in question and it was the only norm that delimited the seasonality for the flows, and with ANA (2010d), whose flow limits comprise the range under study. Additionally, series were made for the limits of 20 m<sup>3</sup> / s and 25 m<sup>3</sup> / s of flow granted for consumptive uses, in view of the maximum grantable flow of 20.86 m<sup>3</sup> / s obtained in the work of Silva & Hora (2015). It should be noted that these authors adopted the limit of 70% of the Q95 established in Resolution No. 542, of November 3, 2004 (ANA, 2004), for the federal management agency.

The proposed analysis is complemented with the use of data on federal irrigants granted upstream of HPP Batalha presented in ANA (2010a), allowing for the comparison of the seasonal distribution of irrigants, as well as their demand for flows. Such irrigators occupy an area that represents 12% of the projection of the area for 2010 presented in ANA (2014), therefore, it was considered that an approxi-

mation of ten times the number of federal irrigators would be a reasonable hypothesis for comparison during the projected time horizon. Figure 6 graphically represents the average monthly flows reserved for consumptive uses upstream of the Batalha HPP from 2010 to the year 2040, according to ANA, (2010d) and the seasonality delimited in ANA (2005), compared to the flows' minimum history.

From the Figure 6, there is a plan for the irrigation sector to be more concentrated during the months of March to October, a fact that can be observed in the distribution in federal irrigators, but which, however, when considering the perspective of ten times the number of users, ends up presenting a water demand greater than the distribution limits presented in the DRDH. Compared with the perspective of the year 2010 until 2040 of ANA (2010d), the flows of ten times the federal irrigators exceed most of the time the limits made available.

Another point of analysis is the comparison with the minimum flows of the historical series of the flow affluent to the Batalha HPP with the annual series of projection of the flows destined to consumptive uses. It is observed that for the months of July, August and September, starting from the series of the year 2025, flows reserve higher than the historical minimum are expected, which could indicate the perspective of the occurrence of a negative water balance in the region, in view of the demand being greater than the supply.

Finally, the hypotheses of average annual water demand of 20 m<sup>3</sup> / s and 25 m<sup>3</sup> / s are configured as critical situations for the availability reserve in view of the minimum series of flows for the months of June to September. However, they present a greater margin of water allocation and planning for the irrigating sector, in view of the difficulty of

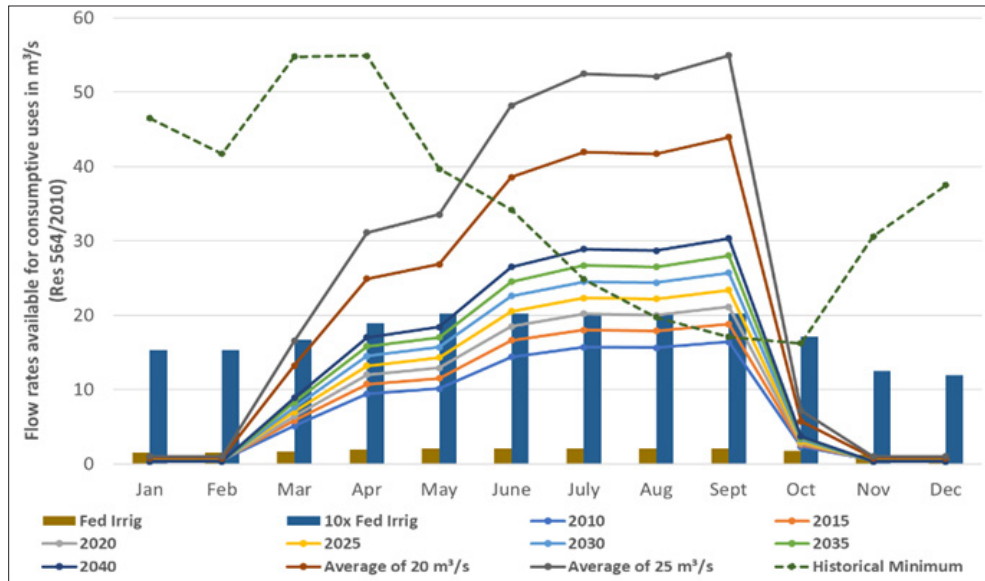


FIGURE 5 – Chronological survey of events, regulations, deliberations, and ordinances applied to the conflict in the Alto São Marcos. SOURCE: Prepared by authors.

the updated survey of users who draw water in the region above the insignificant limit, the possibility of the existence of private reservoirs built at amount of the Batalha HPP, and the signaled in OECD (2015), which states that there is an estimate that about 40% of the water uses in the São Marcos basin are not regularized.

Given the context and the dilemmas of the basin, the history of events, regulations, deliberations and ordinances applied to water management in the region and the one presented in ANA (2017), it appears that the São Marcos conflict presents management as one of its main challenges of four water domains, each with its management organ and linked to the performance of the national water resources councils of the Federal District and the states of Goiás and Minas Gerais, in addition to the hydrographic basin committees.

It should be noted, however, that this is not just an institutional conflict due to the complexity of articulation between the actors involved, the main dilemma being the articulation between local interests and national interest, represented by two policies built from different perspectives of water use and resource priorities. In this way, the referred instances of water governance overlap the boundaries between the executive, consultative and deliberative functions of the agents involved in the conflict and demand a more robust management of the water resource. The condition makes it essential to establish a rational economic use among agents linked to the promotion of water security and the integrated management of water allocation.

The OECD report (2015) highlights as a challenge in Alto São Marcos the management of the transition from a regime in which the resource has

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been excessively allocated to a sustainable arrangement. For this appointment, the possible solution is the establishment of collective grants through incentives for the non-mandatory development of Water Users Associations (AUAs) and the multipurpose operation of the Mundo Novo reservoir upstream of the Batalha HPP.

Collective grants are understood to be unique grants for the sector, capable of simplifying management requirements by transferring managerial responsibility to local users. OECD (2015) argues that such a process reduces the number of control points, shortening the cost and time of monitoring by the water resources manager, and increases the notion that water allocation is a zero-sum game, in which users who capture more than they are entitled to end up restricting the supply of water rightly allocated to others. However, issues related to the AUA scale, and the self-regulation of collective grant holders must be resolved. Interesting solution for São Marcos, considering that the dynamics of irrigators in the region involve the management of the grants of each user, their location and effective use, factors linked to the valuation for the sale of land, security for planning grain cultivation and the construction of water reservoirs.

The operation of the Mundo Novo dam as a multipurpose reservoir is presented by the OECD (2015) as an option that would catalyze the integration of sectoral plans into water resource plans and allow sectoral involvement in the management of the hydrographic basin. However, it would be necessary to define instruments for multipurpose management, because while the actors involved generally wait for more administrative and regulatory requirements, voluntary consultations, and direct exchange between interested parties, intra or

inter-sector, could be more efficient in terms of time and transaction costs. Therefore, the said alternative would only remedy the rivalry of uses through a greater supply of water through the regularization promoted by the reservoir. In such a way that there remains a need to establish a joint water governance between the agents, based on an effective monitoring and efficient allocation of water to guarantee a sustainable water balance for the region.

There is also the possibility of establishing a special management area in the basin. Such an option would constitute a pilot case to experience the decentralization of responsibility for the management of federal rivers, in view of the dominance of the São Marcos River. A precedence that, according to the OECD (2015), requires an assessment of the willingness of both states to assume responsibility for managing the river in a coordinated way and their ability to engage in such a collaborative effort.

In general, the various solutions presented for the conflict in the São Marcos basin include ensuring greater water security for current and future water users. It is necessary to establish supply limits that support a reallocation of water and a prioritization of the resource, between sectors and individual users, consistent with the plans for the basin.

## **6. Conclusions**

Based on the above, it can be concluded that the São Marcos conflict is complex, as it involves the dynamics between the relevance of irrigated agriculture in the region and the water guarantee for the Batalha enterprise, which belongs to a priority sector nationally, scenario that demands regulatory



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articulation of sectoral policies and integration of economic mechanisms and water resources.

The little perspective on the uses present in the basin at the time of granting to the Batalha HPP and subsequent disordered growth of the irrigated sector culminated in the non-compliance with the limits established by the regulatory framework and generated insecurity for the agents involved in the conflict. Thus, it has become essential to improve management by reallocating water within the water system through the establishment of usage priorities, raising awareness of water supply scenarios and an effective agreement among users. However, the dual domain of water management in the basin is linked to the dynamics of uses, a challenge for state and federal competences related to the allocation of water in hydrologically connected rivers, such as São Marcos.

The rivalry between uses lacks instruments for economic measurement of institutional decisions that signal water scarcity to users and treat water as an economic good. In such a way, the normative limits are the result of a greater articulation between the representatives of the institutions operating in the basin and can thus be respected and monitored regularly.

Thus, this work sought to contribute to the debate about the water conflict in Alto São Marcos by proposing a characterization of the dispute between the irrigating and electric sectors in a playful and consolidated way, through the discrimination of the water governance of the basin and the presentation of the available and demanded flows for advisory uses. A history of the regulatory evolution of the main norms tangent to the basin was presented to consolidate the impact of mitigating measures and the relationships between agents and regulatory

bodies. In this way, it is possible to foster a discussion on the dilemmas and challenges imposed by the rivalry of uses within the scenario of water scarcity in the region.

In view of the problem presented, it is important to understand how the dynamics of demand and remuneration for water resources are configured among economic agents in the Alto São Marcos basin. Considering that the region is potentially a pilot case for the application of economic instruments, studies are needed to measure the economic effect of the flows granted upstream of the Batalha HPP and to delimit its opportunity cost, thus contributing to the debate regarding the reallocation of the water and prioritizing efficient uses.

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