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The Guarani Aquifer System: From a Beacon of hope to a question mark in the governance of transboundary aquifers

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ABSTRACT

Study region: Latin America. Parana Basin. Argentina, Brazil, Paraguay, Uruguay.
Study focus: This article traces the trajectory of transboundary cooperation over the past fifteen years for the Guarani Aquifer System.
A new insight for the region: The Guarani Aquifer System is a transboundary aquifer shared by Argentina, Brazil, Paraguay, and Uruguay. It stands as one of the largest reservoirs of freshwater worldwide and is one of the few transboundary aquifers whose management is regulated by an international treaty, the Guarani Aquifer Agreement (GAA). The latter is also the first to refer in its preamble to the UN International Law Commission Draft Articles on the Law of Transboundary Aquifers. A first period (2002–2010) of positive collaboration in which the four countries actively moved forward towards a better understanding of the aquifer, culminated with the adoption of the GAA in August 2010. A second period (2010–2017) has been marked by a slowdown in transboundary cooperation, limited in this period to sporadic cross-border projects and initiatives linked to past and existing international projects. In this period, Argentina and Uruguay, and more recently Brazil have ratified the GAA. A third phase seems to be emerging in 2017 due to the possibility that finally Paraguay ratifies the GAA allowing it to enter into force. This article argues that in the future implementation of the agreement countries should build on the good practices, both substantive and institutional, stemming from the first period of transboundary cooperation.

1. Introduction

The Guarani Aquifer System (GAS) is a transboundary aquifer (TBA) shared by four countries in Latin America: Argentina, Brazil, Paraguay, and Uruguay. It is considered as one of the largest reservoirs of freshwater in the world. This article wishes to highlight how the four countries have moved forward (and back) in the management of the GAS throughout the last fifteen years. The paper identifies two main management periods in this pendulum: the first one from 2002 to the adoption of the Guarani Aquifer Agreement (GAA) in 2010 and the second one from that day in August 2010 to current days. The first period can be framed as a period of increased management and transboundary cooperation. The second one has been a period of stagnation and limited activity. A third phase may have started in 2017 with a renewed interest for the transboundary cooperation dimension of the GAS. This paper argues that some good practices developed in the first period (between 2002 and 2010) are still valid and merit particular attention in this possible new phase. In particular, the institutional structure that underpinned transboundary cooperation in the first phase could

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serve as a source of inspiration for the future transboundary management of the GAS.

The paper is divided into four sections. Section 2 provides a brief account of the GAS aimed at giving a general understanding of the main scientific and socio-economic characteristics of the GAS. Section 3 of this paper will discuss the developments from 2002 to 2010. In this section, the article will present the path leading to the adoption of the GAA, which includes the Guarani project, and a more in-depth analysis of the GAA itself. The paper will then move on to Section 4 where the limited activities between 2010 and 2017 will be analysed. In particular, the article will discuss the countries different approach to the ratification of the GAA followed by an overview of domestic aquifer governance with direct or indirect transboundary implications. The final section of the paper will discuss the potential opportunities for the transboundary management of the GAS should the GAA enter into force.

2. The Guarani Aquifer System

The Guarani Aquifer System (GAS) is one of the most important hydrostratigraphic units in the southern portion of South America. The current resource exploitation exceeds 1.0 km^3/a, 93.6% in Brazil (of which about 80% is in São Paulo State), 2.8% in Uruguay, 2.3% in Paraguay and 1.3% in Argentina. Some 80% of the total is used for public water supply, 15% for industrial processes and 5% by geothermal spas (Foster et al., 2009). Although this water extraction is essential, it should be considered that it is still a small fraction of its full capacity.

The GAS comprises a sequence of sandy layers of Triassic-Jurassic age, with average thicknesses of 250 m (varying from > 50 m to < 600 m), deposited in continental, eolic, fluvial and lagoon environments, above a regional erosional surface (dated to 250 M years) and below an extensive layer of Cretaceous basalts (dated to 145–30 M years) in the basins of Paraná (Brazil and Paraguay), Chaco-Paraná (Argentina) and North (Uruguay). The so-called Guarani Aquifer is a set of different hydraulically connected geological units, including the formations: Misiones (Argentina and Paraguay); Botucatu, Pirambóia, Caturrita, Santa Maria (Brazil); and Tacuarembó (Uruguay). The current name was chosen to honour the Guarani, who are the original inhabitants of the region overlying the aquifer.

In regional terms, from replenishment zones (GAS outcrop areas) to the discharge zones, GAS groundwater flows tend to move from north to south, accompanying the orientation of the Paraná Sedimentary Basin.

In 80% of the area, the GAS is a confined aquifer with old to very old water (from 4000 to > 100.000 years). Groundwater in the city of São José do Rio Preto, the central region of the State of São Paulo (Brazil), and 150 km from the GAS outcrop zone, showed water of 120,000 years (Gastmans et al., 2013), indicating a flow velocity of 0.5-0.7 m/year. This value is compatible with the aquifer circulation model, where this flow is much more controlled by the low hydraulic gradients (0.1–0.3 m/km) than by the hydraulic conductivity, which is quite high (K_h = 5–10 m/d) (Foster et al., 2009). According to Rodríguez et al. (2013) and Wendland et al. (2015), the active groundwater flow into the deep confined aquifer is very limited, probably equivalent to 10–15 mm/a of vertical infiltration in the recharge area (1–2% of the annual rainfall), in contrast to 150–500 mm/a (10–30% of the rainfall) in the outcrop unconfined aquifer zone, that is usually a common circumstance in groundwater systems of this kind.

Although the GAS is presented as a sole aquifer system, apparently due to its size and long geological history of its formation, it is possible to recognize (even regionally) several units with different aquifer capacities. From the northern regions of the aquifer (mainly in the states of São Paulo and Mato Grosso do Sul) to the north of the state of Paraná and even in areas of Paraguay and Uruguay, GAS has wells with high production (above 300 m^3/h). In the southern states of Brazil (including Paraná, Santa Catarina and part of Rio Grande do Sul) and in Argentina, there is a substantial reduction of its potentiality.

In spite of the age of its waters, the GAS presents waters of excellent quality, with low mineralization (indicated by electric conductivity of < 1000 µS/cm). Except in regions such as Argentina, where salinity can be very high, and in isolated areas in southern Brazil, the GAS waters are potable and suitable for all uses (Sracek and Hirata, 2002).

The salinity of this aquifer and its geochemical anomalies are associated with the formations below the GAS (mostly saline aquitards) that contribute to the increase, further to major ions, of some trace elements (particularly F and more strictly As) (PSAG, 2009a).

The GAS presents a high vulnerability to anthropogenic contamination only in its outcrop areas; in areas where it is covered by fractured basalts (up to 100 m thick); or even in some basalt “windows”, where the absence of the aquitard connects the GAS directly with more superficial formations. In the rest of the area, the GAS presents a very low or almost non-existent vulnerability to contamination, confirmed by the millenarian age of its waters. In confined aquifer areas, the only chance of contamination would be related to connections between the surface and the GAS through abandoned or poorly designed wells, which would serve as a bypass to persistent substances in high amounts.

Water availability (exploitable potential) in a confined aquifer of such vast dimensions as the GAS can be defined as the quantity of water available for use. Such availability can be calculated by active reserves as the quantity of water that can be abstracted from a static reserve or from a permanent storage during a given period, without causing irreversible environmental damage, except the exhaustion of the aquifer. Estimates of volumes of GAS water range from 29,550 km^3 ± 4000 km^3, to 32,830 km^3 ± 4400 km^3. To calculate the volume of GAS water that can effectively be exploited, it is necessary to establish abstraction scenarios in line with the operating limits of pumping equipment and well-construction techniques (PSAG, 2009b). The revised conceptual hydrogeological model of the GAS allowed defining five distinct resource management zones (Zone I to Zone V) (Foster et al., 2009), based on the conceptual model, which are described as follows (Fig. 1):

Zone I) unconfined recharge (and discharge) zone: totally renewable resource associated to rainfalls that percolate into the aquifer in the outcrop areas. In this zone, the GAS presents a high vulnerability to contamination and the operation of many anthropic activities may jeopardize the excellent natural quality (with virtually no problem of geochemical anomaly) of its waters. The total

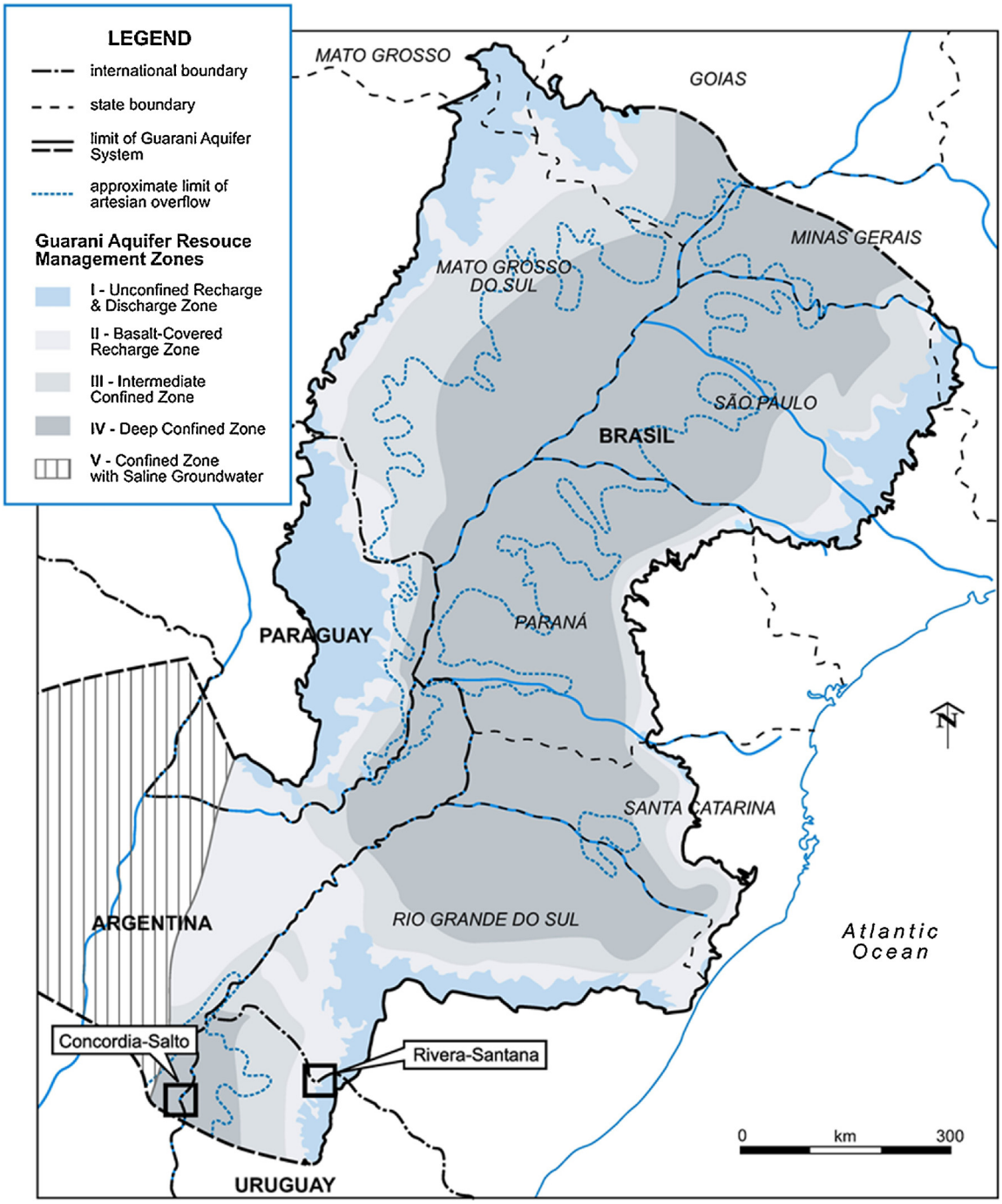

Fig. 1. Guarani Aquifer System and resource management zones (Foster et al., 2009).

water available for extraction can surpass 45 km^3/year (PSAG, 2009a).

Zone II) basalt-covered recharge zone: the GAS is semi-confined in this zone, covered by fractured basalt (< 100 m of thickness). The recharge is associated with some natural vertical flow through basalts or induced by pumping (in addition to horizontal groundwater flow from the Zone I). In this zone, the resource is (partially) renewable, but due to the lack of knowledge of the vertical flows through these basalts, the quantification of the total exploitable flow rate is still uncertain. In addition, it is known that in several parts of the State of São Paulo, the recharge of GAS in this zone is very limited (Fernandes et al., 2016).

Zone III) intermediate confined zone: there is not significant recharge and the water residence time is typically higher than 10,000 years. All the water extractions are considered 'non-renewable' (mining condition) and the total amount of available water from the

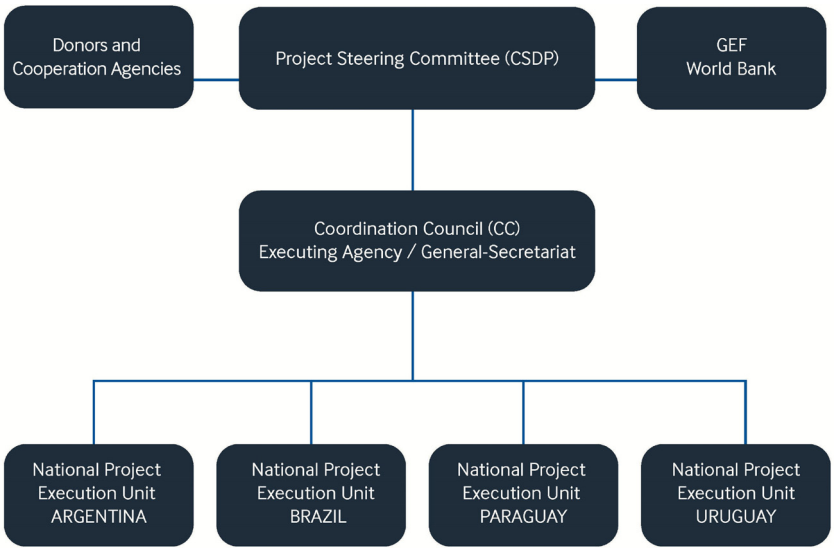

Fig. 2. Diagram of the institutional structure of the Guaraní project (Guarani Aquifer Project: strategic action program) (PSAG, 2009a).

storage is 2000 km^3 that could be extracted just one time (Fig. 2).

Zone IV) deep confined zone: in this zone, the base of the aquitard that confined the GAS is deeper than 400 m below surface and the exploitation is unlikely to be economic except for hydro-geothermal application. In a practical sense, it is possible to pump water just from the storage, and the total confined water available for extraction is limited to 50–100 km^3 that could be extracted just one time.

Zone V) confined zone with saline groundwater: restricted to Argentina, in this zone, the GAS is confined and groundwater has high salinity. The water of this zone can be used only in SPAs and other hydro-geothermal applications or for other purposes after treatment where this is economically feasible.

The GAS is thus unquestionably a totally 'storage-dominated' groundwater system, and this reality is reflected widely in its water exploitation management. The expected problems in the border regions between countries are related to the aquifer contamination by anthropic activities, especially those that have diffuse sources and covering wide areas, such as extensive agriculture, or areas of intense groundwater exploitation, that can cause strong hydraulic interference between wells or restrict its long-term use due to reduced recharge where the aquifer is confined.

3. From a Beacon of hope (GAS transboundary cooperation between 2002 and 2010)

The second section of this article will discuss the developments from 2002 to 2010. In this section, the paper will present the path leading to the adoption of the GAA, which includes the Guarani project, and a more in-depth analysis of the GAA itself.

3.1. The process leading to the Guarani Aquifer Agreement

To argue that until the beginning of the Guarani project there was no understanding of the GAS would be inaccurate. Several studies had been undertaken from different universities, which led, for example to the knowledge that a huge aquifer was present under the four countries (Rebouças, 1976; Gilboa et al., 1976; Silva, 1983; Rocha, 1997; Montaño et al., 1998; Araujo et al., 1999; Rebouças, 1999; Tujchneider et al., 2007).

What is accurate is that a much more comprehensive understanding of the GAS came thanks to the Guarani Project (PSAG, 2009a). The latter was shaped by Argentina, Brazil, Paraguay, and Uruguay between 2000 and 2003 and lasted six years from 2003 to 2009. It was implemented by the Organisation of American States (OAS) and supported by the Global Environmental Facility (GEF). The Guarani project had three main components and concluded with the adoption of a Strategic Action Programme (SAP). It enhanced the hydrogeological understanding of the GAS and it mapped the socio-economic pressures on the GAS together with an analysis of the relevance of the GAS for dependent ecosystems. The third component was legal and institutional and it assessed the readiness of the four countries in the field of groundwater management and transboundary aquifer cooperation (PSAG, 2009a).

An essential element of the Guarani Project was the decision to zoom in on four pilot areas, which showcased particular pressures for the GAS. Of relevance to this paper are two of these pilot studies in particular, due to their transboundary nature. The first one was developed around the cities of Salto in Uruguay and Concordia in Argentina, an area where the GAS is very deep and where groundwater stemming from the aquifer is used solely for thermal purposes. The second one was the Rivera (Uruguay)/Santana do Livramento (Brazil) pilot study where the GAS is much more vulnerable with recharge zones close to the urban area. Here groundwater from the aquifer is used for multiple purposes including human and agricultural needs. The paper shows that the

informal transboundary cooperation developed in the pilot studies also reverberated after the Guarani project (Sindico, 2016a).

The institutional structure that was developed and maintained throughout its duration was also another critical element for the Guarani Project (Santa Cruz et al., 2017). A secretariat was established in Montevideo providing the necessary leadership. National committees comprising technical expertise needed to advance the understanding of both the hydrogeological and the socio-economics of the GAS were established. During the project, a network of people in the region working on the GAS grew and started working together building not only expertise, but also very important relationships that slowly but steadily "glued" the four countries together.

The end result of the Guarani Project was, as mentioned, the adoption of a SAP that included options for future transboundary cooperation aimed at the management of the GAS. The choices varied considerably with different financial implications. Some mentioned MERCOSUR as the appropriate forum where to anchor the management of the GAS; others proposed a loose framework of not-legally binding arrangements. Another one identified the La Plata Basin Treaty framework as the appropriate institutional hub for the management of the GAS but linked to an ad-hoc treaty (legally binding instrument) on the GAS.

This last option was precisely the outcome in 2010 of several years of inter-governmental negotiations between the four GAS countries (Sindico, 2011). In 2004, talks took place within the MERCOSUR framework, and in 2005, a draft treaty was ready to be adopted, but insurmountable differences on the dispute settlement provision did not allow the text to move forward. From 2005–2010, the countries did not reinitiate talks, although they were cooperating positively in the framework of the Guarani project. It was only in 2010 that negotiations were restarted. This time after just a couple of meetings, the four countries agreed on the text of a treaty that was finally adopted on 2 August 2010 in the Argentinean city of San Juan (Sindico, 2011).

3.2. The Guarani Aquifer Agreement

Before sketching the content of the GAA, it is important to highlight that one of the best practices stemming from the GAA is the legal instrument itself. What this means is that the four countries sharing the GAS decided to negotiate a treaty in the absence of serious conflict over the natural resource (Villar and Ribeiro, 2011). The GAA is preventative in nature and it has been hailed as a success story in that sense (Sindico, 2011). The extent to which the content of the GAA should also be praised in the same favourable terms depends very much on what one expects from an international treaty. If the expectation is one of explicit, strong, precise, detailed enforceable provisions, then the GAA will, like many other international environmental treaties, be a major disappointment. If, on the other hand, what one was expecting was a framework promoting the management of the GAS, then the overall judgement over the GAA may well be more positive (Sindico, 2017).

The GAA sets out indeed a general management framework. It contains the general rules of international law applicable to transboundary water resources (surface and groundwater). Countries, although sovereign, have an obligation to cooperate and not to cause significant harm to neighbouring states (GAA, art. 6). Countries must use the aquifer in an equitably and reasonably (GAA, art. 4). There is no single way to define what equitable and reasonable means. It will always be a weighing and balancing exercise based on a number of factors. While these are not listed in the GAA, they can be found in the emerging international legal framework applicable to transboundary aquifers (UNWC, 1997, art. 6; and UNILC, 2008, art. 5). Other management practices are included in the treaty, such as the obligation to exchange information and to monitor the aquifer (GAA, art. 8). Of particular importance is the obligation to notify other States if a planned activity may lead to cause significant harm (GAA, art. 9). Notification is then followed by an environmental impact assessment (GAA, art. 10.1). A further provision that is worth highlighting is the reference to critical transboundary areas (GAA, art. 14), which may warrant particular attention.

Moving from the substantive and procedural part of the GAA to the institutional side, article 15 clarifies that a Commission will be established in the La Plata Basin treaty framework (del Castillo Laborde, 2011) to implement the objectives and goals of the GAA. The 1969 La Plata River Treaty governs the water resources present in the La Plata basin and includes Argentina, Uruguay, Brazil, Paraguay, and Bolivia. The four countries in the management of the GAS will need to work primarily in the framework of an already existing regional legal structure. The article will return to the importance of this Commission when the possible third phase of the management of the GAS, the one following the entry into force of the GAA, will be discussed.

The GAA, not surprisingly, does not have a provision about dispute settlement, nor an Annex on this. However, the treaty does indicate that the Commission created under article 15 will be the first port of call when a conflict over the interpretation or application of the GAA takes place, should peaceful negotiations not settle the dispute (GAA, art. 16). However, the Commission will only be able to issue non-legally binding recommendations, leaving a more legalistic approach to an arbitration procedure that the countries will need to negotiate once the GAA enters into force (GAA, art. 19).

In conclusion, whatever one thinks of the content of the GAA, it was (and still is) one of the few international legal instruments to have been negotiated to manage specifically a TBA. This was a milestone in itself and was the culmination of a period of eight years from 2002 to 2010 in which the four countries cooperated amongst themselves when it came to the GAS. There were high hopes in 2010 for the transboundary management of the GAS and commentators and observers hoped for a speedy entry into force of the GAA. The second period of cross-border cooperation of the GAS (2010–2017), which the paper will now address, showed that those hopes were maybe just a little bit too high.

4. To a question mark (GAS transboundary cooperation between 2010 and 2017)

The second period of GAS transboundary management covered in this article was not as successful as the first one. The years from 2010 to 2017 have been characterised by the lengthy and not completed process of ratification of the GAA and by sporadic and

casuistic examples of transboundary cooperation. This section of the paper comments on both these aspects.

4.1. The ratification of the Guarani Aquifer Agreement

Following the adoption (i.e. signature) of the GAA in 2010, there were hopes for a speedy entry into force of the agreement. The latter required all four countries to ratify. If one considers treaties like the Paris Agreement on Climate Change entering into force in less than one year and having more than one hundred parties, the prospects of a deal with only four countries entering into force quickly should not have been considered a chimera. The truth has been very different and seven years after its adoption the GAA is still not in effect. Argentina and Uruguay have ratified the GAA in 2012 and Brazil in 2017. Paraguay, after having decided against ratification in 2012, seems to be opening the debate once again over the possible ratification of the GAA.

Argentina ratified the GAA on 31 October 2012 with Law 26.780. The process leading to the ratification of the GAA reveals a constant challenge when talking about aquifers, the difficulties in understanding the natural resource. From the early days of the Guarani project, there had been the misconception that the GAS was akin to an underground river where harmful practices in one part would be felt immediately, or very quickly, in other parts of the aquifer. This is apparently not the case with groundwater within the GAS flowing exceptionally slowly with insufficient connectivity between distant areas of the aquifer. The real immediate challenges when it comes to pollution or overexploitation will usually be perceived within focused areas of the aquifer. When it comes to the transboundary dimension of the aquifer, these challenges will be felt mainly along the border. This is not to say that the GAS does not operate as a “system”, and that management of the TBA should not be considered holistically and cover all the aquifer, but it is important to differentiate how a TBA and a transboundary river operates. This was an important issue in Argentina, and an element that helped in the ratification process was the delivery of technical evidence before the Congress. Leading experts in the natural resource itself were invited to dispel any myths that could confuse members of Parliament who were then asked to approve the law ratifying the GAA. The extent to which such technical advice boosted the relatively quick ratification of the GAA in Argentina may be a matter of speculation, but it is fair to say that it helped assist the Congress in taking an informed decision.

In Uruguay, the GAA was presented before the Senate already in November 2011. The document submitted to Uruguayan senators is interesting as it highlights a number of elements that explain some of the points present in the GAA itself, several of which have been criticised quite heavily in the literature (República Oriental del Uruguay, Law N° 18913). The document takes the reader through the socio-political and economic historical developments in the region highlighting that one of the ways that the debt of Latin American countries could have been paid off was through the privatisation of its natural resources. It stresses the vast amounts of freshwater in the GAS and defines them as “strategic” for the First world (sic) countries. It is within this context of the defense of its own natural resources vis à vis the interference of developed nations elsewhere in the world that the notion of sovereignty present in article 3 of the GAA should be framed. The GAA passed without any problems the domestic legislative hurdles in Uruguay and was approved with Law no. 18.913 on 12 June 2012 paving the way for the formal ratification of the latter.

Brazil did not ratify the GAA until 2017. In fact, it was only in late 2016 that the issue of the GAA resurfaced in Brazilian politics. Some different international treaties that Brazil had signed were bundled together, including the GAA, and discussed before in one of the two houses of the Parliament. On 14 February 2017, the National Congress, and on 2 May, the Senate finally approved the GAA with Legislative Decree 52/2017. One can point to many factors leading to the slow ratification in Brazil. The GAA, important as it may be, has not been a political priority for the country in the past years, despite the very damaging droughts in the Southern region (including the city of São Paulo) whose maximum expression occurred in 2014. Even from an environmental perspective, it may well be that groundwater resources and the GAS are not on the top list of priorities. To these factors, one can add the internal constitutional complexities very particular to Brazil where the GAS is shared between eight States. Groundwater is of exclusive competence of the States while surface water pertains to the Federal and State governments making the management of aquifers not straightforward (Gesicki and Sindico, 2014). Finally, the fact that Paraguay had not ratified could have been a further reason for the slow process in Brazil.

Paraguay deserves a special mention as it has the opportunity of triggering the entry into force of the GAA as it would be the last country to ratify the agreement. When this happens, Paraguay will be hailed and remembered within transboundary water cooperation circles as has happened for other nations like Vietnam whose ratification triggered the entry into force of the United Nations Watercourses Convention, or the Russian Federation that enabled the Kyoto Protocol to enter into force back in 2005. Paraguay did have an opportunity to ratify the GAA back in 2012 but decided against it. This decision may have been linked to internal political debates rather than genuine concern over the GAA itself. The situation currently is hopefully different and a technical discussion on the GAA was scheduled in April 2017, along with the lines of what happened in Argentina before the ratification of the agreement in that country. The debate had to be rescheduled due to internal problems in the Congress in Asuncion the days before the scheduled date and was postponed for the second part of 2017. By today, the GAA was approved by the Paraguayan Senate and waiting for the final agreement from the Congress. It is possible that a combination of technical clarification over the content of the GAA, and a more favourable political climate could lead to the ratification of the GAA on behalf of the Congress in Paraguay.

In conclusion, despite the promising signs from Paraguay, the GAA is not yet in force, and the transboundary management of the GAS resides outside the contours of the treaty.

4.2. The Guarani Aquifer System without the agreement

This sub-section will discuss the few examples of GAS transboundary management practices that can be found in the period

between 2010 and 2017. These experiences can be traced back to informal cooperation between border cities and to domestic involvements (mainly in Uruguay) that have indirect transboundary implications.

Starting with the management of border cities, these can be divided between those that form the legacy of the Guarani project and border cities in the framework of projects linked to the La Plata Basin Treaty. As mentioned earlier in this paper, one of the characteristics of the Guarani Project was the establishment of two pilot studies with a transboundary nature: Concordia-Salto between Uruguay and Argentina and Rivera-Santana do Livramento between Uruguay and Brazil.

The Concordia-Salto example is particularly relevant and warrants special attention (Sindico, 2016a). During the Guarani Project, a Commission was established that comprised experts and political representatives from the two border cities. The Commission met regularly and exchanged information that was collected through joint monitoring activities. When the Guarani project came to an end in 2009, the Commission of the pilot study continued, despite lacking a formal legal backing in the form of an ad-hoc agreement between the two countries, except for what had been agreed in the framework of the now expired Guarani project. It is interesting to note that, even without a formal written agreement in force between the two countries, or even just the two municipalities, the main activities (for example joint monitoring) continued throughout the years thanks to the leadership of the local members of the Commission and to their creativity that enabled them to fund activities (Rivero-Godoy, 2016). Finally, on 23 March 2017 an agreement between the cities of Concordia and Salto was signed and now gives legal backing to the Commission (República Argentina, 2017). This is an important and interesting transboundary legal arrangement, rather than agreement as it is not negotiated between the two countries and, hence, it is difficult to see how it could be considered legally binding under international law. However, from a political perspective, it is a very strong and persuasive document between the two municipalities (Sindico, 2016a). The Concordia-Salto 2017 arrangement confirms many of the management practices and needs that have been developed in the Guarani project, enshrined in its SAP and present also in the GAA. Article 1 encourages the two cities to boost further knowledge of the aquifer and exchange information. Article 4 deals with monitoring and provides legal backing to the already existing Monitoring Technical Committee. Article 3 additional deals with the institutional structure creating the Commission for the support of the management of groundwater resources. This Commission is based on the one that has worked uninterruptedly since the inception of the Guarani project and will include local members derived from civil society, both public and private.

The Concordia-Salto experience is an example of how through local leadership transboundary cooperation can continue. However, the continuous efforts to negotiate an agreement between the two cities also shows the possible nervousness of local actors towards a voluntary arrangement that depended too heavily on the goodwill and the time of few people. The Concordia-Salto arrangement (both in its informal and now more formal versions) also raises internal constitutional issues and challenges, both in Argentina and in Uruguay (Rivero-Godoy, 2016). In fact, it is not entirely clear whether cities have competences to strike “deals” with cities in other countries. Interestingly, despite the doubts that may arise from the capital as to the legal effects of such agreements, the reality is that the deal was still negotiated and now underpins the on-going collaboration in the transboundary management of the portion of the GAS present under Concordia and Salto on the Argentinean and Uruguayan border.

The Guarani project has another transboundary pilot study within the cities of Rivera in Uruguay and Santana do Livramento in Brazil. Contrary to the Concordia-Salto experience, the transboundary cooperation between these two cities did slow down after the expiry of the Guarani project and in the aftermath of the adoption of the GAA. However, it did not grind to a complete halt.

The GAS cross-border cooperation can also be found around border cities linked to the Framework Project implemented under the framework of the La Plata Basin Treaty (CIC Cuenca del Plata, 2016). The towns of Artigas in Uruguay and Quaraí in Brazil fall within this category. A pilot project was developed around water conflict in the Cuareim/Quaraí river basin in the framework of the La Plata Basin Treaty project (CIC Cuenca del Plata, 2016). The latter focused mainly on surface water and highlighted the existence of the Mixed Brazilian-Uruguayan Commission for the Development of the Cuareim/Quaraí River Basin (CRC/CRQ).

The project’s report on the status of groundwater in the La Plata Basin mentions the work of the thematic group on groundwater in the Cuareim/Quaraí River Basin (Bervig and Foleto, 2014; CIC Cuenca del Plata, 2016). The joint work of Brazilian and Uruguayan experts has increased the knowledge on the transboundary groundwater resources through the development of joint hydrogeological maps and other activities. A further aspect of the Mixed Brazilian-Uruguayan Commission for the Development of the CRC/CRQ is that it built on the previous experience of the Guarani Project. This not only meant that the project could rely on already existing information, but it also brought with it institutional expertise within the two countries. This made it easier to implement the project from its inception in October 2012.

The second set of experiences that have a GAS transboundary management dimension have taken place at a domestic level. This is the case, for example, of Uruguay wherein 2013 the Guarani Aquifer Commission was incorporated in the Uruguay River Water Resources Regional Council with advisory body status through Presidential Decree N° 183/2013. The goal of such incorporation was to implement a truly integrated and participative water resources management in the country that duly took into account social, economic and environmental aspects. The Decree clarifies the role and the composition of the Guarani Aquifer Commission, but does not mention any input from neighbouring countries. However, in practice Brazilian and Argentinean representatives have been invited to sit as observers in meetings of the Uruguayan Guarani Aquifer Commission strengthening, albeit informally, transboundary aquifer cooperation.

5. Added value of the entry into force of the Guarani Aquifer Agreement (the future of GAS transboundary cooperation)

The trajectory of the GAS transboundary cooperation in the last fifteen years has been characterised by a swing of ups and downs. However, it could be at a turning point with recent developments pointing to the concrete possibility that the GAA could enter into force in the not so distant future. With this in mind, it is worth turning the attention to a discussion about how the transboundary

cooperation of the GAS would benefit from the GAA, once it has entered into force (Hirata et al., 2017).

5.1. Implementation of the GAS transboundary management

The two main reasons why the entry into force could prove beneficial for the transboundary management of the GAS are the increased possibility of attracting finance and investment and the opportunity to develop an institutional structure capable of operationalising the GAA. Both are needed to propel the transboundary management of the GAS into reality, rather than it is only on paper.

If an international treaty is in force, it will be easier to attract investment aimed at the management of, in this case, the GAS. This does not imply that the absence of a formal legal arrangement prevents funding, as exemplified by the Guarani project itself that took place precisely in the absence of any treaty on the aquifer. However, the entry into force of the GAA can focus funding towards the management of the GAS in a way that was not possible before. Projects could be directed at the implementation of an ad-hoc formal legal instrument and its objectives, as happens for many of the activities related to the La Plata Basin Treaty in Southern America or the Plan Trifinio in Central America (1997), not to mention the panoply of international projects linked to the SADC Watercourses Convention in Southern Africa (World Bank, 2011) or to the Mekong Treaty in South East Asia (Kinna and Clarke, 2017).

However, further funding alone will not be enough to deliver effective transboundary management in the GAS. The GAA needs to be accompanied by an institutional structure capable of planning, promoting and implementing TBA management in the region. This process cannot be kick-started until the GAA enters into force. Until then, the Commission mentioned in article 15 of the GAA remains a hypothetical entity. It is only when the four countries will have ratified the GAA that the prospects of such a Commission become real.

Even then, the latter does not just appear, and it needs to be established from within the La Plata Basin treaty framework. It is, in fact, one of the first, but not the only, items on the “to do list” once the GAA enters into force. Leaving aside for the moment the composition of the Commission, one of the possible activities that it could carry out could be an iterative process leading to a fruitful exchange of good practices. A possible option is to devise a regular meeting (once every two or three years) in which the four countries share their experiences in the management of the GAS. To do so, countries could be asked to compile their efforts in national submissions, which would be submitted to the Commission. It is important to highlight that such submissions should be voluntary and their presentation at the regular meeting would not be subject to an assessment akin of a “judgement”. The review of national submissions should be based on the following characteristics: cooperative, non-intrusive and respectful of national sovereignty.

A regular exchange of national practices on the transboundary management of the GAS of this nature (i.e., cooperative rather than conflictive) would align itself with general trends in international environmental governance (Sands and Peel, 2013). In fact, international regimes governing global climate change, biodiversity or sustainable development all point in that direction. Efforts to deal, for example, with the mitigation of and adaptation to climate change in the Paris Agreement (van Asselt et al., 2016), or the implementation of the Sustainable Development Goals (SDGs) (Persson et al., 2016), all include a set of formal submissions to a central institution where the national efforts are reviewed, but in a supportive and non-intrusive manner.

Transboundary water cooperation, exception for the regime developed around the United Nations Economic Commission for Europe (UNECE) Water Convention (Tanzi et al., 2015), is usually based on more general principled frameworks where only sporadically an institution serves as a clearinghouse for good practice, but it is not unheard of. The GAA and its future institutional structure could present itself as an innovative example of transboundary cooperation if it is able to develop an institutional structure capable of driving forward GAS cooperation through, also, the exchange of good practices from which countries have the capacity and opportunity to learn from each other.

But will the Commission, established under article 15 of the GAA within the La Plata River Basin Treaty framework, be able to deliver such an ambitious goal? This discussion is obviously speculative, but considering the other functions it will have to perform according to articles 16 and following of the GAA, it will not be an easy task. In fact, let’s not forget that the Commission is also due to deal with initial conflicts over the interpretation and application of the Agreement, complying, hence, with a quasi-judicial function. Despite the fact that its recommendations over possible disagreements will not be legally binding, this will be a complex and potentially (hopefully not) time-consuming role.

Considering the potential other functions that the Commission will be asked to perform, and the fact that the transboundary management of the GAS is not solely about promoting the exchange of good practices, the question that needs to be asked is what kind of structure would allow the Commission to deliver all of its tasks. Here, looking back at past transboundary management and institutional practices of the GAS can prove helpful. Sometimes the wheel does not need to be reinvented. It has already been argued that one of the good methods stemming from the Guarani project was the institutional structure that had been developed and maintained throughout its duration (Santa Cruz et al., 2017). The extent to which a system based on a Secretariat providing the necessary leadership and national technical committees can be replicated is unclear. What is clear, however, is that, if the Commission will be the institutional hub for the transboundary management of the GAS, it will need to be supported in order to efficiently coordinate well monitoring, development of planned activities with potential transboundary impacts, and joint planning of critical transboundary areas, amongst other elements present in the GAA.

One option that needs further research and consideration, and that can just be presented in this paper, is to develop a permanent program comprised by technical experts that would work under the Commission developed ex-article 15 of the GAA to aid in the operationalisation of the transboundary management of the GAS. The precise composition and structure of a possible “programme” would need to be developed by the four countries sharing the GAS, but it would be wise to look back at the first period of

transboundary cooperation analysed in this paper (the beacon of hope period) and look for already existing good practices.

If potentially increased streams of funding and an operationalised institutional structure are two potentially concrete benefits stemming from the entry into force of the GAA, there are other "external" benefits that also deserve proper consideration.

5.2. Global leadership

The entry into force of the GAA will put the four countries in a position of global leadership when it comes to transboundary water cooperation, hence enhancing their worldwide reputation. However, this is not only about reputation, it is also about enabling such countries to meet better other international environmental obligations, such as the ones the nations have under the Paris Agreement or within the Sustainable Development Goals (SDGs).

There are currently 592 TBAs and groundwater bodies worldwide (UNESCO/IGRAC, 2015) with only six of them featuring an ad-hoc international agreement or arrangement aimed at its management (Movilla-Pateiro, 2016). The GAA is a member of this exclusive club and the first to provide for in its preamble a reference to the UN General Assembly Resolution 63/128 on the law of transboundary aquifers, which includes in its annex the work stemming from the UN International Law Commission (UNILC) on the same topic. The Draft Articles on the Law of cross-border aquifers developed by the UNILC represent the emerging global legal norms (obligations and rights) in the field of transboundary aquifers (Eckstein and Sindico, 2014; Eckstein and Sindico, 2014). When the GAA enters into force, the four countries will be at the forefront of transboundary water cooperation. Considering the content of the GAA (principles, substantive and procedural provisions, and the seeds of an institutional structure) and its preventative nature (let's not forget that the GAA was negotiated in the absence of conflict or of particular water stress in any of the four countries), the entry into force of the GAA should be hailed as a historical moment for transboundary cooperation more generally, not just in the context of water cooperation. The four countries will be in a position to lead an example of collaboration in an ever-growing field of international relations (international waters) also for its significance for sustainable development and climate change.

However, in these two cases, the entry into force of the GAA is not just a question of reputation, but of aiding the four countries in meeting international obligations, they have subscribed to. Starting with sustainable development and the SDGs, there is an apparent link between TBA cooperation and SDG 6 (access to clean water and sanitation), but also with many other SDGs for which groundwater and transboundary collaboration over groundwater resources is essential (Sindico, 2016b). The entry into force of the GAA has the potential to lead to better transboundary management of the GAS through increased funding, exchange of good management practises and, more generally, a drive towards better cross-border cooperation thanks to an effective institutional structure. If the promises stemming from the entry into force of the GAA are kept, the four countries sharing the GAS will find it easier to meet SDG 6 and other SDGs that relate directly or indirectly with good groundwater governance, especially with its transboundary dimension.

There is a further more direct and specific reason why the entry into force of the GAA will benefit the GAS countries in their SDG policies. SDG 6.5 requires States "by 2030 [to] implement integrated water resources management at all levels, including through transboundary cooperation as appropriate". The agreed indicator for SDG 6.5.2 reads as follows: "Proportion of transboundary basin area with an operational arrangement for water cooperation". "The GAA falls clearly under the category of 'arrangement', which includes both legally binding and non-legally binding instruments. It also seems, from the latest developments on indicator 6.5.2 that the GAA would most likely fall under the category of "operational" arrangement (Sindico, 2016b), mainly if it were to include regular meetings of the four countries within the operation of its intuitional structure as suggested earlier in this paper.

When it comes to climate change, groundwater becomes particularly important. In fact, the more climate change threatens surface water through droughts and salinization; the more it becomes necessary to better understand and better manage groundwater resources (Margat and van der Gun, 2013). The latter, in fact, can become an adequate buffer against the climate change impacts on surface water. The good governance of groundwater resources becomes, hence, a strategy to adapt to climate change and promote resilience in many countries. Against this background, groundwater has a role to play also in the measures that all States need to adopt to implement and comply with the Paris Agreement. In fact, the Nationally Determined Contribution (NDC) that all States are obliged to prepare and submit according to the Paris Agreement needs to include also a section on adaptation. With the entry into force of the GAA and the potential leverage of TBA cooperation between the four countries, climate change adaptation will be strengthened. Groundwater related efforts linked to climate change adaptation could be included by the four nations in their NDCs establishing the formal link between the entry into force of the GAA and the Paris Agreement.

In conclusion, the entry into force of the GAA has the potential of reaping multiple benefits. Some are linked directly to the future management of the GAS, others are reputational, putting the four countries at the forefront of international environmental governance in the field of international waters, and finally other benefits relate to the positive interplay between the entry into force of the GAA and the implementation of the SDGs and the Paris Agreement.

6. Conclusions

This article has tracked the last fifteen years of transboundary cooperation over the GAS. It has highlighted a turbulent story with two clear periods and a third one potentially emerging in this previous year. In the first period (2002–2010) the four countries moved forward the cooperation agenda and thanks in particular, but not only, to the Guarani project and its SAP, a real momentum was also built. This first period culminated with the signature of the GAA in August 2010. The second period goes from 2010 to 2017 and it has been characterized by a regression of the GAS transboundary cooperation. Three of the four countries have ratified the GAA and despite some informal efforts to continue cross-border cooperation, usually in border areas, the momentum that had been developed

in the first period has not been sustained. 2017 may well be the year in which a third and crucial period begins for the GAS transboundary cooperation. With the recent ratification of the agreement by Brazil, all attention is focused on Paraguay and the date in which the GAA enters into force may be closer.

The article does not only take the reader through a historical journey of the last fifteen years of the GAS transboundary cooperation. It also highlights the advantages in boosting the latter through the GAA. The merits of pushing for a speedy entry into force of the agreement can be summarised as follows. Firstly, the scientific understanding of the GAS as a whole has been stalled and would benefit from a continuous monitoring and data sharing system, which could be enhanced through increased funding that could stem from an enforce GAA. Secondly, the entry into force of the GAA could promote regular exchange of practices in the management of the aquifer (via the La Plata Basin Commission acting as a clearinghouse). The past experience (Guarani Project and others) is in a position to provide useful good practices that can feed into the implementation of the GAA, especially from an institutional perspective. Thirdly, potentially the agreement could put the GAS again on the agenda and promote cooperation in cities that were not reached by the Guarani project, such as Pedro Juan Caballero and Ponta Porã for example.

Overall, considering the past and current practices in the transboundary management of the GAS, the entry into force and the implementation of the GAA "promises" to lead to more efficient cross-border cooperation.

Conflict of interest

None.

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