Transboundary Aquifer Management: The Guarani

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Manohar R. Patole
mrp251@nyu.edu

NYU ROBERT F. WAGNER GRADUATE SCHOOL OF PUBLIC SERVICE

Abstract

Groundwater comprises 97% of the accessible freshwater reserves in the world, however its practice in international law is minimal and has its limitations. My work analyzes the struggles of governing The Guarani Aquifer System (GAS), the largest groundwater system in Latin America. The project approach and lessons learned can provide others with tools for successful regional planning for transboundary aquifers.

Figure 1: Environmental Protection and Sustainable Development of the Guarani Aquifer System Project. Adapted from the *Guarani Aquifer Strategic Action Plan 2009*

Background

PGAS is rooted in a project by regional universities in the 1990's looking to gain scientific and technical understanding of the GAS. Seeking advance the study, the Organization of American States (OAS) was approached to further the project. The OAS understood the potential impacts and brought in the World Bank (WB), Global Environment Facility (GEF), and UNESCO for additional financial, administrative, and technical support.

My interest in the Guarani Aquifer System stems from a research paper for an International Water Law class in 2009. I have continued my work on the topic and presented at several international conferences, including the 2015 IWRA World Water Congress in Edinburgh, Scotland.

Project Summary

In 2000, Argentina, Brazil, Paraguay, and Uruguay initiated the ***Environmental Protection and Sustainable Development of the Guarani Aquifer System Project*** (PGAS) , with the support of UNESCO's Internationally Shared (Transboundary) Aquifer Resource Management Program (ISARM), GEF, OAS and the WB to study and plan for the long-term management of the GAS . The aim of PGAS was to develop and implement a sustainable binding agreement for the management of the Guarani Aquifer System (GAS) to be administered cooperatively by the four nations of Argentina, Brazil, Paraguay and Uruguay based on appropriate technical, scientific, institutional, legal, economical and environmental guidance. The development and implementation of the PGAS was to have regional and international importance. Regionally, it would help develop the necessary tools and provide institutional strengthening to for better coordination and management of the GAS. For the international community, it would be the first comprehensive international framework on groundwater and for the WB it would aid in its policy development on international groundwater management.

Key Points

1. Population growth, pollution of accessible freshwater sources and climate variability will require cities to identify and utilize other freshwater sources, namely aquifers. Therefore, **all water resources available** to cities for agriculture, energy, industry and human development needs must always be closely linked with sustainable urban development and regional plans.

2. Aquifers, like surface waters, are a **fugitive resource** that does not conform to administrative or political boundaries, making them transboundary. However, law and policy for transboundary aquifer management has its limitations and its management has often been ignored in development or regional plans.

3. The confluence of **limited water resources** for a growing urban population**, transboundary aquifer management**, and **the environmental sustainability** movement led UNESCO to develop the Internationally Shared (Transboundary) Aquifer Resource Management Program (ISARM). The program identified six transboundary aquifers of regional importance, one of which was Guarani Aquifer System (GAS), named after the indigenous tribe living within the area of the aquifer which covers Argentina, Brazil, Paraguay and Uruguay.

4. **Environmental Protection and Sustainable Development of the Guarani Aquifer System Project (PGAS)** was developed and implemented, spanning 6 years from 2003 to 2009, comprised of 7 components and 4 pilots. It was precautionary in nature, with the purpose to study and plan for the long-term management of the GAS.

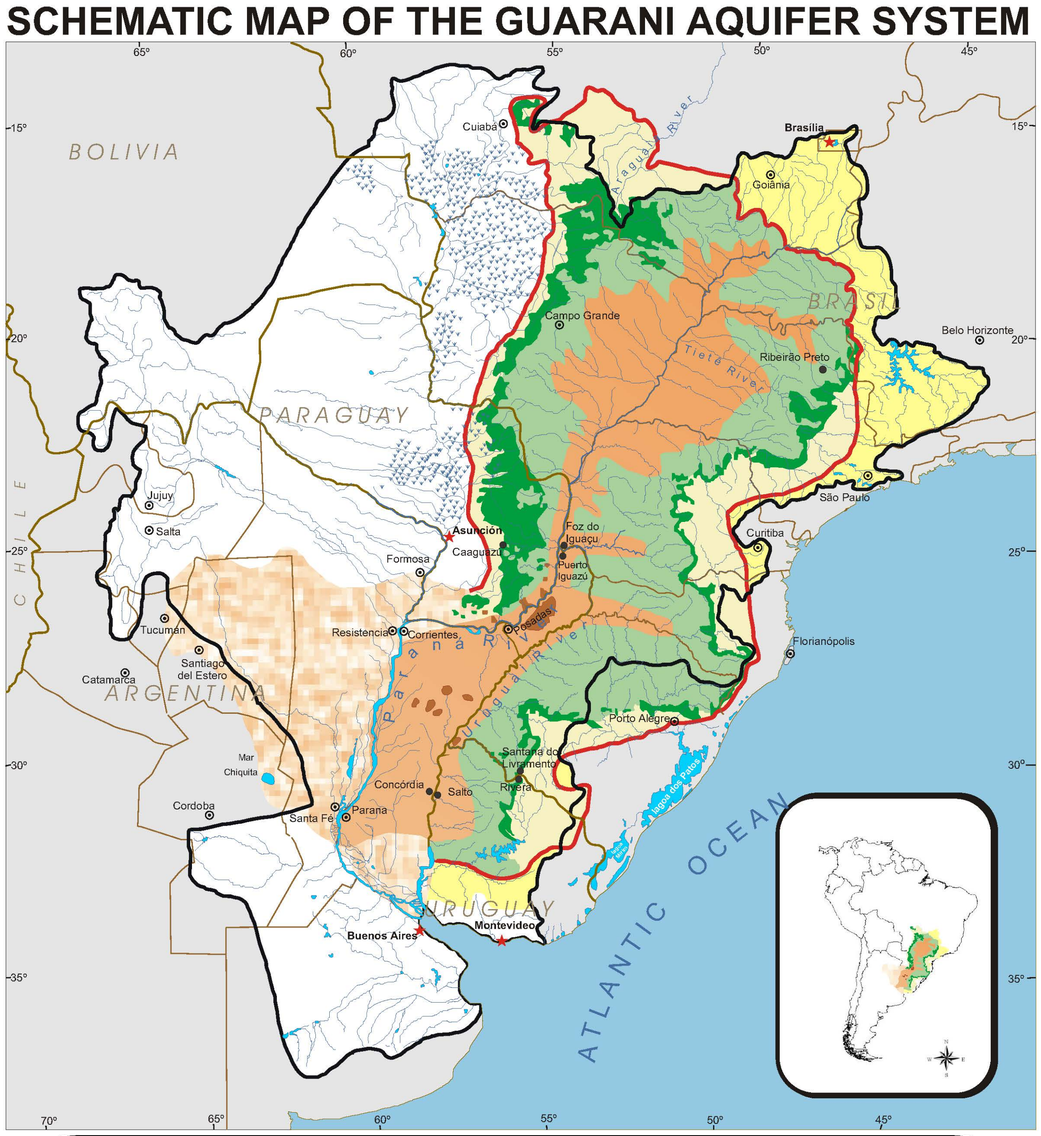
5. The end of the project in 2009 did not result in a binding agreement between the 4 nations over the GAS. However, the project provided significant contributions to scientific and technical knowledge of the GAS, as well as laying the foundation for the subsequent Guarani Aquifer Agreement in 2010.

6. Analysis shows the impacts of the project reached beyond the confines of the GAS: fostering cooperation through fact-finding to reduce information asymmetry, the importance of harmonizing institutions for transboundary water resources management, furthering the the study of transboundary aquifer management, and managing for uncertainty can mitigate future "hot" conflicts.

Water Resources Cooperation Timeline

April 1969: La Plata Basin Treaty → April 1973: Treaty of Itaipu → March 1991:Treaty of Asunción → May 1997: UNGA Adopts Convention on the Law of the Non-Navigational Uses of International Watercourses

SCHEMATIC MAP OF THE GUARANI AQUIFER SYSTEM



LEGEND

- Drainage water do not related to the Guarani (no belonging to the system)
- Potential Indirect rechage areas
  - From surface runoff
  - from underground flows
- Potential direct recharge areas
  - porous regime: Guarani outcrops
  - fractured/porous regime: basalts and sandstones
- Potential discharge areas
  - porous regime:Guarani outcroppings
  - fractured/porous regime: basalts and sandstones
  - fractured/porous regime (relation to Guarani to be defined)
- Prata watershed basin limit
- Paraná geological basin limit
- Rivers
- Wetlands
- International Boundaries
- State/Provincel Boundaries
- Cities
- State/Province Capitals
- National Capitals

Approximated Scale: 1:13.600.000

0 100 200 300 km

Notes:
- Schematic map produced by CAS/SRH/MMA (UNPP/Brazil) approved by the Project Steering Committee - Project for the Environmental Protection and Sustainable Development of the Guarani Aquifer System (Argentina, Brazil, Paraguay, Uruguay - GEF/World Bank - OAS).
- Colored portions represent the areas which, potentially, belong to the Guarani Aquifer System. The aquifer limits are not completely defined in Argentina and Paraguay.

Sources:
- South America Hydrogeological Map, 1996, DNPM/CPRM/Unesco.
- Guarani Aquifer Hydrogeological Map, 1999, Campos H.C.
- Map of Geological Integration of the Prata Basin, 1998, Mercosul/SGT2.
- Map of hydrogeological integration of the Prata Basin, in elaborating, Mercosul/SGT2.
- Geological Map of Brazil, 2nd Edition, 1995, MME/DNPM.
- Geological Map of Rio de la Plata Basin, 1970, OEA.

Figure 2: Schematic Map of the Guarani Aquifer System. Adapted from the *Guarani Aquifer Strategic Action Plan 2009*

Objectives

The PGAS had four main objectives to achieve during its implementation between 2003-2009

1. To enhance and enlarge a technical knowledge of the Guarani Aquifer System.
2. To implement a permanent Well Monitoring Network and an Information System for the whole GAS (SIGAS)
3. To elaborate the Strategic Action Plan (SAP) and the Transboundary Diagnostic Analysis (TDA).
4. To develop a proposal for a coordinated management framework, harmonizing water policies and management tools among the four participating countries, reducing future qualitative and quantitative threats to the GAS.

In addition to the four main objectives, PGAS was comprised of seven interconnected components, designed to facilitate understanding of the morphology and behavior of the GAS, its use and conservation, and its relationship with communities and institutions. Furthermore, the information gained will assist in the development of the necessary systems and tools for coordinated management of the GAS. (WB PAD 2002)

1) ***Expansion and Consolidation of the Current Scientific and Technical Knowledge Base on the Guarani Aquifer System*:** Synthesize, analyze, and expand the knowledge base on the GAS.

2) ***Joint development and implementation of the Guarani Aquifer System Management Framework*:** Develop a framework for the coordinated management (technical, institutional, financial and legal) of the GAS.

3) ***Public and stakeholder participation, education and communication*:** Promote and support the participation and involvement of the public; foster environmental and water resources education, social communication, and the dissemination of knowledge.

4) ***Project Monitoring and Evaluation, and Dissemination of Project Results*:** Create and implement a system for recording and analyzing progress achieved during the Project implementation period.

5) ***Development of Management and Mitigation Measures within Identified "Hot Spots"*** : Design, apply, and evaluate the costs and feasibility of good management practices at specific sites within the GAS region.

6) ***Assessment of Geothermal Energy Potential*:** Evaluate the geothermal potential of the GAS.

7) ***Project Coordination and Management*:** Provide organizational and administrative support.

PGAS Pilot Projects

Ribeirão Preto (Brazil)
Localized pollution and over-drafting in densely populated areas.

Itapúa (Paraguay)
Agricultural impacts on aquifer quality.

Rivera (Uruguay) / Santana do Livramento (Brazil)
Management and protection within an unconfined portion of the aquifer.

Concordia (Argenitina) / Salto (Uruguay)
Development tourism around thermal waters.

As part of Component V to identify hotspots, the four pilot projects design, apply and evaluate the costs and feasibility of good management practices at specific sites within the GAS region, with the aims of establishing measures for the appropriate management and sustainable use of the aquifer. The main foci of these pilots was the prevention of potential point and non-point sources of pollution and over-drafting in critical GAS recharge/discharge areas or areas of high user/uses concentration.

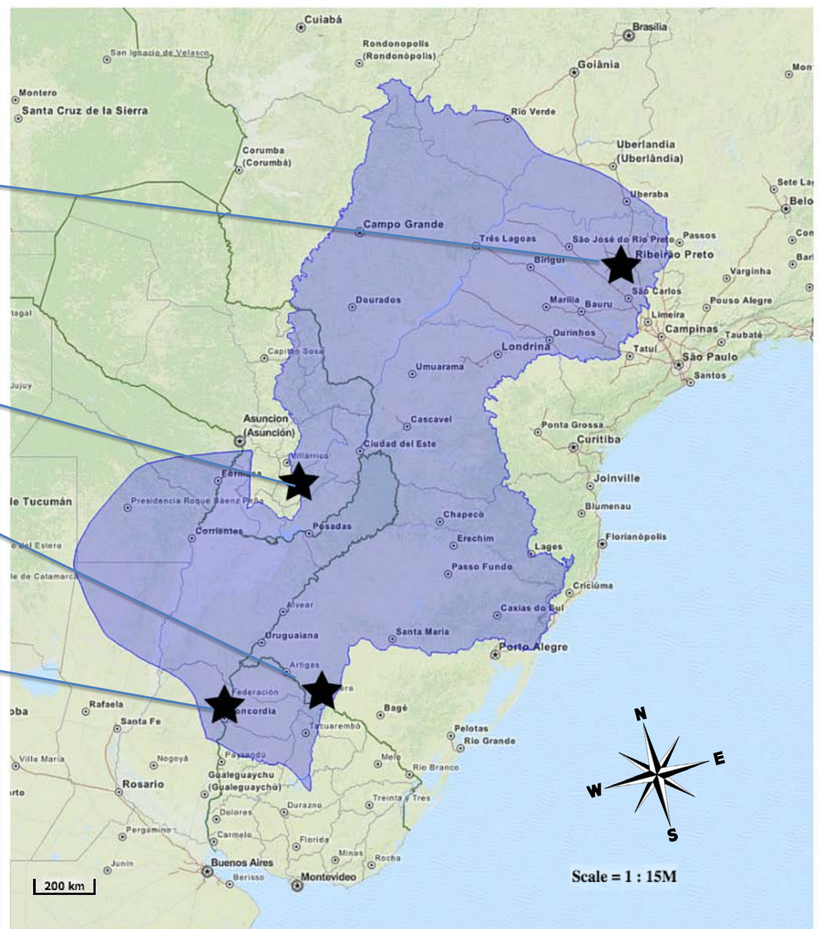


Figure 3: Location of PGAS Pilot Projects.

January 2000: Project Appraisal Document (PAD) Approved

September 2000: 1st Meeting of the Project Steering Committee

May 2003: Project Implementation Plan Approved Commencing the PGAS

June 2003: Pilot Projects Begin

January 2005: Transboundary Diagnostic Begins

Bibliography / Acknowledgements

Figures and Tables:

Figure 1 - PGAS (2009). *Report on the Project for the Environmental Protection and Sustainable Development of the Guarani Aquifer System: Strategic Action Plan.* Montevideo: World Bank and Organization of American States.

Figure 2 - PGAS (2009). *Report on the Project for the Environmental Protection and Sustainable Development of the Guarani Aquifer System: Strategic Action Plan.* Montevideo: World Bank and Organization of American States.

Figure 3 - Map of Guarani Aquifer System created by Manny Patole - International Groundwater Resources Assessment Centre: Global Groundwater Information System (GGIS) (last accessed March 24, 2016, http://www.un-igrac.org/global-groundwater-information-system-ggis)

Table 1 – Data obtained from World Bank (2009). *World Bank Project No. 068121, Environmental Protection and Sustainable Development of the Guarani Aquifer System: Implementation and Completion Results Report No. ICR00001198.* Washington D.C.: World Bank. July 31, 2009

SAG Logo adapted from PGAS (2007). *Project for the Environmental Protection and Sustainable Development of the Guarani Aquifer System: Transboundary Diagnostic Analysis*. Montevideo: World Bank and Organisation of American States.

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					TOTALS
Area (km2)	225,500	839,800	71,700	45,000	1,182,000
% of Total	20.98	61.65	8.05	3.32	N/A
% of Country	8.1	8.7	21.5	19.5	N/A
Annual Abstraction Volume (m3)	13,421,524	973,032,362	22,937,184	29,735,995	1,039,127,065
% Abstract by Country	1.3	93.6	2.3	2.8	100
Population within Area	7,947,667	80,141,145	3,263,318	724,768	92,077,168
% of National Population	20.59	42.99	55.91	21.92	N/A
% Population within GAS Area	8.64	87.04	3.54	0.78	100

Table 1: Basic characteristics of the GAS.

Outcomes

★ Scientific and technical studies identified hydrogeological characteristics of the GAS (see Table 1). The recharge of Guarani aquifer is estimated to 5 billion m^3/year, with a total reserve (active and static) of 30 trillion m^3. These studies were shared and disseminated, furthering understanding of the GAS, and will assist in its future management.

★ Data from the four pilot projects found that current and potential transboundary effects of the GAS are restricted to a narrow strip of territory of no more than a few dozen kilometers, depending upon local specific hydrodynamic conditions. The results were encouraging and further follow-up was deemed necessary to enhance local management. However, GAS was determined not to have geothermal energy potential beyond tourism and home heating.

★ Investigation of GAS found it to be an economical source of public water supply, but not for irrigation use given other alternative water sources. However, as technologies become more efficient, the development of water-intense activities can impact land-use patterns, especially in replenishment zones. These zones are potential areas for specific cooperation and dialogue between the countries.

★ Development and implementation of Guarani Aquifer Information System (SIGAS) to serve as decision-support system for the four countries of the GAS considered to be strategic for the management and protection of the GAS.

★ The Transboundary Diagnostic Analysis (TDA), led to the development of the Strategic Action Programme (SAP). The SAP summarized the short and medium-term strategic actions and its long-term objective to implement coordinated and sustainable management of the GAS after the conclusion of the PGAS.

★ The SAP assigned specific responsibilities to the four countries to continue future cooperation: **Argentina** will be responsible for the SIGAS; **Brazil** for conceptual and mathematical model maintenance and further development; **Paraguay** will coordinate training and capacity improvement activities, and **Uruguay** will house the newly reorganized coordination unit. It also advised the localization of management integrated with the respective national line agencies.

Impacts

The PGAS was the most ambitious groundwater initiative in South America, and perhaps the world.

Alternative to Conflict: The project occurred in a politically neutral atmosphere – it was not prompted through any political conflicts. Through the gathering and sharing of scientific and technical data, it increased awareness of the GAS's characteristics and stimulated debate on groundwater management within the four countries at national, provincial, and community levels. As a result, the project demonstrated an alternative to the traditional "conflict-resolution-cooperation" paradigm and illustrated an option that empowers civil society, scientific and international organizations, further promoting conditions that create common ground.

Think Regionally, Act Locally: Localization of international development agendas is a significant concern. PGAS emphasized local administration, real stakeholder participation and dissemination of information. This promotion of local/regional ownership made the overall effort more effective in realizing project objectives.

Out of Sight, Out of Mind: Although 97% of the available freshwater is underground, most resource planning and management has focused solely on the other 3% - surface waters. Prior to the PGAS, groundwater management lacked political visibility in the region and globally. Much of the population, including the formal schooling systems and civil society, had no access to consistent information on aquifers, groundwater or the GAS. In the sector of water resources management and planning, the project drew attention to the importance of transboundary aquifers regionally and internationally.

Law and Order: There are over 450 international water courses around the world, and they are almost all governed by bi- or multi-lateral agreements. Of the over 200 transboundary aquifers, only three are considered part of any agreement. PGAS concluded in 2009, and in August of 2010 the four countries drafted the Guarani Aquifer Agreement (GAA). As of 2016, the power of the GAA remains limited and further action is required. The member states have yet to ratify the agreement nor do they agree on a dispute resolution mechanism. The PGAS built upon the work of inter-governmental and non-governmental organizations, setting a precedent for international legal cooperation and transboundary aquifer management.

Lessons Learned

Fact-finding not only addresses the problem of information asymmetry but it also fosters management coordination among parties through the identification of common principles and instruments

Agreements made on a regional or international scale will increase their chance of adherence if there is horizontal communication between sub-national governments and an emphasis of localization.

Regional planning needs to consider more than the 3% of surface waters when it comes to freshwater resource planning. The other 97% (aquifers) should be included in regional water resource plans.

Neither aquifers nor the impacts of their misuse respect political boundaries. If individual actors (whether cities, states, countries) exploit the resource for their own social and economic gains, their behavior is contrary to the common good of all users by depleting that resource.

The end of a project does not mean the end of cooperation.

January 2007: Pilot Projects End → March 2007: Transboundary Diagnostic Analysis Completed → January 2009: PGAS Concludes; Strategic Action Plan Approved → August 2010: Guarani Aquifer Agreement Drafted but not ratified by PGAS countries → December 2011: UNGA Adopts Law of Transboundary Aquifers → August 2014: International Watercourses Convention enters into force but no PGAS countries accept