Transboundary Guarani Aquifer System and Groundwater Management Mechanisms

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ABSTRACT

The Guarani Aquifer resources are public in all four involved countries: Argentina, Brazil, Paraguay and Uruguay. In general legal differences are applicable to mineral and water resources in those countries, and in both cases management is under national or state or local specific law and institutions. In absence of groundwater management schemes, national and state legislations tried to adapt for groundwater the same approaches valid for surface water. Aspects related to time and space scale are the main problems which occur and must be considered on the definition of adequate laws and management structures. For this reason hydrogeologists did not want to adopt surface water resources management structures and regulation. Using the umbrella of watershed committees or involving communities from both sides of national boundaries some groundwater local committees have been implemented and succeed. In fact those small structures are much more applicable to the scale of conflicts related to well field interference between some specific users. Groundwater use conflicts and environmental protection actions can be efficiently locally addressed with the support of national and subnational governments. Regional aspects of groundwater management and land use development strategies have also to be considered on cooperation strategies. According to the results of Environmental Protection and Sustainable Development of the Guarani Aquifer System Project (2003-2009) main aspects of the aquifer characteristics and functioning can be evaluated and related to current water management schemes. Consequently some guidelines and orientations can be proposed to enable new advances on groundwater management in the region. Those suggestions just confirm how suitable is the maxim "think global, act local" on groundwater protection and management.
Key words: Guarani Aquifer, Groundwater management, management local committees

1. INTRODUCTION

Argentina, Brazil, Paraguay and Uruguay agreed to execute the Environmental Protection and Sustainable Development of the trans-boundary Guarani Aquifer System (GAS) Project (Fig. 1: GAS localization). Significant part of the resource (US$13M) was provided by the Global Environment Facility (GEF), with the support of the World Bank, as implementation agency, and the Organization of the American States, as regional execution agency. The four beneficiary countries provided an active institutional participation as counterparts that reached more than donated amount (US$15M). The German Geological Survey and the International Atomic Energy Agency supported some specific studies. Based on a participatory process and knowledge development, the project allowed the countries to elaborate a Strategic Action Program (SAP), which was approved by the Project Steering Committee.

The project was executed in the period from March 2003 to January 2009 and all objectives were reached. A Quality Control Process was implemented by institutions of the four countries. All technical basic information was published in 26 volumes available in some bibliotheca in the region.

The Strategic Action Program (SAP) is the main project document that summarizes relevant management developments and priorities based on different knowledge advances. Its elaboration process involved directly more than 300 institutional representatives and experts from different areas. National representatives (water resources and environmental institutions, universities, civil society and NGOs) participated in the execution process through Project National Execution Units (including sub-

national levels), that were established in each country to support execution process and promote integration of dispersed information from different institutions dealing with groundwater.

Into the SAP process Argentina, Brazil, Paraguay and Uruguay defined a list of national priorities to improve groundwater management; developed Guarani aquifer tailored made management instruments and finally agreed a cooperation structure to integrate all necessary efforts and to support technical instruments functioning and maintenance. The main treats of national and sub-national institutions now are the implementation of all Guarani management instruments, the priorities in national and sub-national level to strength groundwater and water resources management and cooperation framework proposed. The cooperation framework will support local, national, sub-national and regional priorities implementation and to develop an effective integration between different technical institutions responsible to groundwater management. August 2010, Argentina, Brazil, Paraguay and Uruguay signed the Guarani Aquifer Agreement and parliamentary approval is required in all countries. The agreement shows the way to strength Guarani Aquifer management and setup countries to proceed to the SAP implementation process.

Figure 1: GAS localization

2. BASIC KNOWLEDGE FOR MANAGEMENT

Main knowledge advances are related to a more precise definition of the limits and characteristics of the aquifer system; groundwater flow regimes; recharge and discharge areas; and changes in the use of water and soil in the region, extensively changed in recent decades. Knowledge internalization was promoted since project beginning through a comprehensive training and support program participation of institutions for water management in the countries and states. A quality control program included also representatives of technical scientific community in countries.

For the first time in the region, an integrated basic map was prepared with 191 topographic maps of the SAG in the countries, using a common projection and coordination system. The Guarani Aquifer System - SAG was defined jointly by stratigraphy specialists of the four countries as underground sandstone layers of the sedimentary basin of Parana-Chaco deposited. The development of the hydrogeological map of the Guarani Aquifer System resulted in the reduction of its total area to 1,087,879 km^2, of which approximately 21% in Argentina, 68% in Brazil, 8% and 3% in Paraguay in Uruguay. In outcrops of sandstones located at the edges of the SAG region with an area of 124,650 km^2, there are both recharge (83,500 km^2 or 67%) and groundwater discharge areas (33%), significant difference with respect to prior knowledge.

The static water reserves were calculated as higher than 29,551 km^3 (4,000 km^3 ±), but the deep recharge in 1.4 km^3/ano, indicating the occurrence of mining water in confined areas. The exploitable volumes were calculated in 2,014 km^3 (± 270 km^3), or 6% of SAG reserves, considering the maximum drawdown of water levels by pumping as 400 m. If current exploitation was maintained at 1.04 km^3/ano, through the 1,800 wells that reach the SAG (a total of 8,000 known wells in the region), available reserves could be exploited by more than 2,000 years at current patterns of consumption.

Mathematical models were developed to predict the behaviour of the aquifer in pilot areas considered as critical. In the thermal area of Concordia-Salto, municipalities border Argentina and Uruguay, the model simulates the construction of seven new wells will lead to a strong interference between the flows and water temperatures in local thermal wells over a period of 40 years. The model in Rivera-Santana do Livramento (border of Uruguay and Rio Grande do Sul) oriented the migration from wells toward an area protected in the western portion of municipal areas.

Based on regional studies carried out were established in seven major GAS areas that should guide the use and management of groundwater. Internally, each area presents special characteristics of flows, naturally slow through the rock pores and fissures. In the transition between the northern and southern areas, the groundwater flow is limited by the occurrence of deep tectonic movement (Arc de Rio Grande-Assumption) and were estimated between 45,000 and 405,000 m^3/day, less than 1% of the average flow of Parana River (173 million m^3/day). Other barriers smaller like lava dykes make wells on one side and other shows natural different features, as in Parana State. In confined areas, water is extracted from wells more than a thousand m deep and temperatures that can reach 50°C.

Regional studies were also supported on environmental isotopes behaviour and dating of water in the aquifer. The range of the water age is from recent in the outcrop area to max 38,000 years in Santa Catarina. In Mato Grosso do Sul as well as in Paraguay waters range is 4,000-28,000 years, where basalts windows allow direct recharge to the aquifer that feeds some springs flowing into Pantanal wetland.

Currently, 87% of water use from GAS occurs in Brazilian territory. In general, the main use of the waters of GAS is for public supply (66%). The industrial use (refrigerators, sugar/alcohol plants, etc.) reaches 16%, while in the countryside it is only 5%. Recreational uses in thermal areas have reached 13%, and 100% of the water in Argentina are intended for tourist use. In Paraguay and Uruguay more than 90% of GAS water is used to supply urban areas. In general, main concentrated threats on water quality of the SAG are related to the risk of manmade contamination in the outcrop zones. Regarding water availability greater risks are interference between wells and mining waters from areas under intensive use.

The assessment of changes in land use occurred between the years 1973 and 2007 and shows a continuous replacement of areas of dense forest and degraded (initially 42%) to agriculture (which now affects 47% of total area). The areas without cultivation remained virtually stable (reducing from 23 to 19%) and are concentrated in areas of Argentina, Uruguay and Rio Grande do Sul State.

The SAG is not a feature at risk of imminent exhaustion or contamination, despite being localized conflicts and problems that need support to be properly managed. However, the combination of increased water use, lack of adequate sanitation and amendment of land use can lead to a rapid modification of the current situation and the emergence of new critical areas.

3. MANAGEMENT INSTRUMENTS DEVELOPED

Developed management mechanisms need to be implemented and security measures enhanced to prevent the inappropriate use and harm same portions of the aquifer in a not too distant future. The resources of the SAG ensure superb opportunities to countries where it occurs. However, users and local communities must be engaged on rational use, as well as national governments, state and local authorities should strengthen the management and protection measures of groundwater in order to prevent emerging conflicts.

From a set of results and products developed and made available to countries, four specific tools have been selected and prioritized by countries, two technical, one to support local management and other to promote knowledge dissemination and capacity building on groundwater management. Each instrument should have the guidance of an Advisory Committee of Experts, established by countries. According to the Strategic Program of Action approved, each country will be responsible for providing the support needed to operate a management tool.

Geographic Information System of the Guarani Aquifer System (SISAG): The objective of SISAG is to make information available of more than 8,000 wells to all different users in the region of the

SAG. The System is comprised of 32 workstations that were delivered to the government responsible institutions for water resources management in countries, states and provinces and local authorities as well as water supply companies). The information provided by the responsible country is automatically shared with other countries and shall be accessed by stakeholders through web (i.e. www.ana.gov.br). A Technical Advisory Committee was integrated by the institutions responsible for water information and support to the operation of SISAG will be provided by Argentina, which placed a support structure in the National Board of Yaciretá dam. In Brazil SISAG is integrated with Groundwater Information System (SIAGAS) developed by CPRM (Federal Geological Survey) and adopted by States for inclusion of data.

Network Monitoring and Mathematical Modelling (M & M): were initially selected and sampled 180 wells with static levels of data, exploitation and water quality in order to support the management of the Guarani aquifer by national institutions and responsible sub-national states. Additionally, mathematical models for simulation and prediction of changes in use of groundwater have been developed in regional and local levels in selected pilot areas. The national monitoring network under implementation by the Brazilian government, including State of Sao Paulo network will be completely integrated to the regional network. Brazil will be responsible for providing all required support to operate the instrument and to support the Network Technical Advisory Committee of Experts created by the countries.

Local Management Support Committees: In order to support the development of appropriate mechanisms for the protection of SAG in areas where significant impacts occur, the creation of Local Management Support Committees should be encouraged. The experience of the creation of local committees has been very positive in the pilot areas, as in Ribeirao Preto where the community has proposed and the State Water Resources Council approved zoning measures like protection areas and controlled use zones of groundwater in the county, to deal with water lowering in the aquifer (60 m occurred in the last 30 years in the downtown area). In Concordia (Argentina) - Salto (Uruguay) countries anticipated the definition of minimum distance between wells to avoid water level and temperature interference. Local committees in Ribeirao Preto and Itapúa shall be supported by Brazil and Paraguay respectively. The transboudary committees of Concordia (Argentina) - Salto (Uruguay) and Rivera (Uruguay) - Santana do Livramento (RS) shall be supported by Argentina and Uruguay respectively.

Capacity Building for Groundwater Management and Knowledge Dissemination: The importance of knowledge dissemination and empowerment of involved institutions have often been aspects highlighted by all country representatives to develop a better management of groundwater and Guarani aquifer resources. The Project provided a fruitful process of involving national responsible institution press officers, environmental journalists from general media, NGOs and academic sectors that formed a base for communicational necessary actions implementation. In the first phase the commission involved only the press officers of the national responsible institutions and need to be strengthened for a more comprehensive and decisive action. Paraguay will support the implementation of planned procedures, which can count on with the support and expertise of agencies and national institutions.

4. REGIONAL COOPERATION AND LOCAL MANAGEMENT CHALLENGES

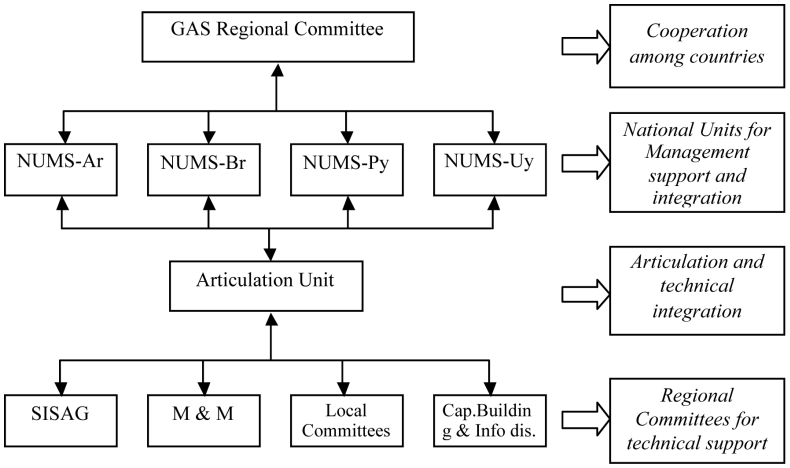
The development of the Guarani aquifer management tolls depends on responsible countries integration efforts. The Strategic Action Program of the Guarani Aquifer established different priorities for national, state and local management development in the country and improved mechanisms for regional cooperation and adequate functioning of management tools developed.

All established priorities shall be incorporated into the actions of water resources management institutions in the various fields of public administration. Actions at country level must be integrated by a National Unity for Management Support to gate and integrate the efforts of all institutions, till now acting in a dispersed and fragmented manner in the use, management and protection of SAG. In

the case of federal countries such as Argentina and Brazil, should be created Units of State management support, considering groundwater domain and necessities. At local level, institutional articulation shall be promoted by the Local Management Support Committees established in the pilot areas and those places where a real problem in groundwater use occurs.

As the National Units Management Assistance are installed by country and the Technical Advisory Committees by thematic managerial instruments, with experts from all countries, an Articulation Unit of technical nature was proposed to integrate actions, facilitate communication and support decision making process (Figure 2: Regional Cooperation Framework). According to the Guarani Aquifer Agreement signed in 2010 a Commission comprised by the four countries, shall coordinate the cooperation efforts. The commission will be established into the River Plate Intergovernmental Coordination Committee (CIC) level under the umbrella of the Treaty of the River Plate Basin (1969).

Figure 2: Regional cooperation framework



The Office of the Articulation Unit was installed in Montevideo with the support of Uruguay. After Guarani Aquifer Agreement countries are able to put office and integration efforts forward to support groundwater and Guarani Aquifer management at regional level.

5. CONCLUSIONS AND RECOMMENDATIONS

With the objective to support the decision making process for sustainable use and protection of the Guarani Aquifer national institutions have been installed groundwater management instruments in the countries. Correct functioning and up date process of those regional instruments necessarily depends on the cooperation and support institutional framework to be implemented in the next cooperation phase. The cooperation phase was recently launched by countries with the Guarani Aquifer Agreement signed on August, 2010. Set up all necessary coordination process to support the Strategic Action Program implementation in the countries is next main challenge.

The implementation of the four management instruments and SAP main actions will need to reach the lowest governmental level to be effective. The next implementation phase necessarily depends on well data collection, validation, analysis and dissemination of the information. Community in pilot and critical areas has to participate to make all information useful for users and all society. Considering all national available legislation different countries could consider to develop or detail some technical norms to support managerial process.

As compared to water resources in general, groundwater movement is very slow and interference scales are space and time limited. Despite of main instruments are the same, sustainable use and protection strategies of the Guarani Aquifer have to be adapted to be implemented at local scale. Very

successful measures were implemented in the local project pilots (i.e. Ribeirao Preto, Concordia-Salto). Capacity building to social empowerment and local institution strengthening will be a key element to prepare the implementation of effective actions to the management and protection process of the Guarani Aquifer.

The Project serves as an excellent example for other trans-boundary aquifers. The basis of those aquifer developments must be technical to have an understanding of the resource. The management instruments: Geographic Information System of the Guarani Aquifer System, Monitoring Network and Mathematical Modelling, Local Management Support Committees and Capacity Building for Groundwater Management and Knowledge Dissemination are necessary for any decision making process and further developments. A peaceful integrated political decision can only be reached on such management base.

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