Sustainable Groundwater Management
Lessons from Practice

Case Profile Collection Number 7

Yacambu-Quibor — A Project for Integrated Groundwater and Surface Water Management in Venezuela

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This case profile presents the progress of an ambitious multi-purpose water-transfer scheme in the vicinity of Barquisimeto-Venezuela, which aims, by transferring water resources from the Yacambu catchment, to (a) increase the area of irrigated agriculture in the highly-productive Quibor Valley (b) recuperate the Quibor Valley Aquifer, whose groundwater availability and quality have seriously deteriorated by excessive exploitation, through the conjunctive use of surface water and groundwater and (c) provide additional bulk water supply to Hidrolara, the urban water-services utility. Within the overall implementation plan for this project, GW•MATE has advised on the institutional and legal framework for the administration of the surface water and groundwater resources. Additionally, the experience of this project is being used as a contribution to improve the national provisions for groundwater resources management, by way of suggestions to consolidate the new Water Law currently in the drafting process.

Quibor Valley – Groundwater & Agricultural Development

- The Quibor Valley in Lara State (Figure 1) constitutes an area of some 434 km^2 with semi-arid climate and rainfall of 400-500 mm/a. It is situated 25 km south of Barquisimeto, a city of some 1.0 million population, which is the largest food distribution center in Venezuela.

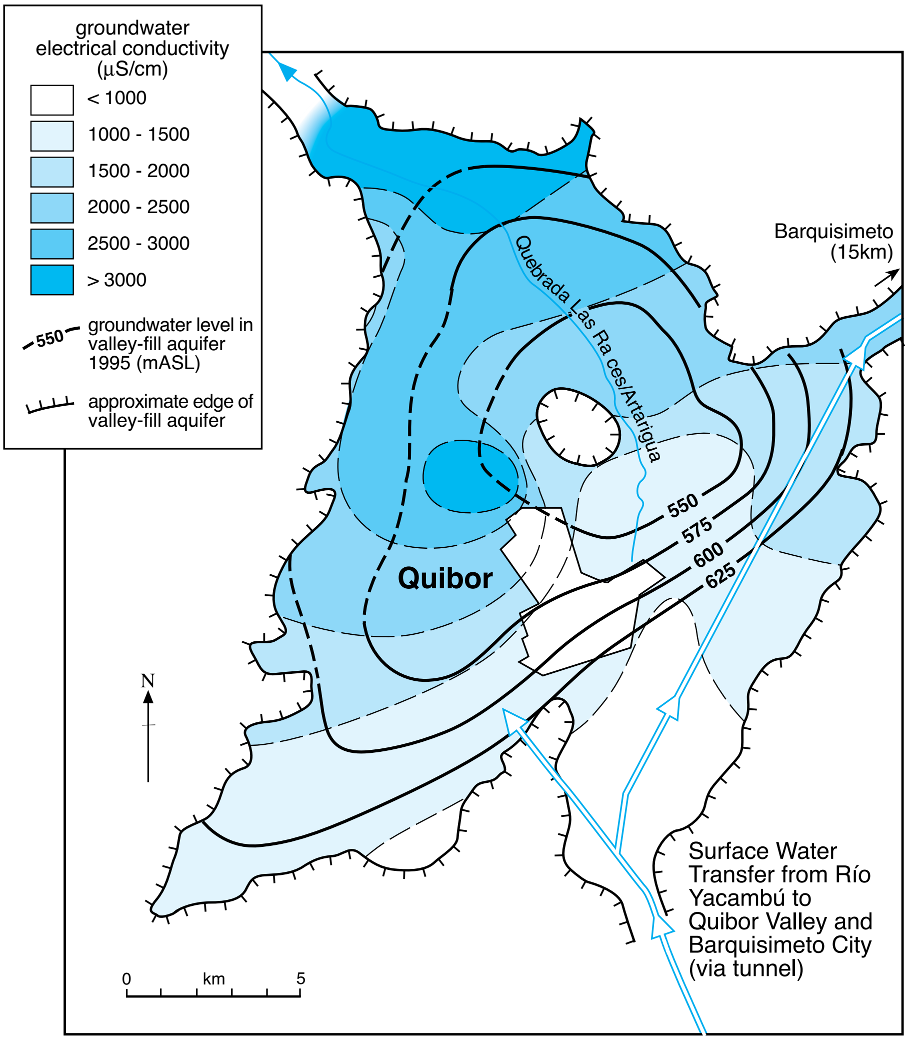
- The valley possesses exceptionally favorable conditions for vegetable, fruit and livestock production of high quality and economic value, but while some 21,500 ha of the valley have potential for cultivation under irrigation only about 3,000 ha are currently in production.

- Agricultural development in the Quibor Valley has been achieved through the exploitation of local groundwater resources, which occur in a Quaternary valley-fill comprising lenses of alluvial sand and gravel interbedded with lacustrine silts and clays. In the surficial layers of the central valley floor clay strata predominate which restrict the rates of diffuse infiltration to groundwater. Nevertheless, it is estimated that the Quibor Valley Aquifer is recharged at an average rate of 22 Mm^3/a, mainly as a result of seepage from permeable streambeds at the margin of the main intermontane valley.

- The rate of groundwater abstraction for agricultural irrigation has exceeded the replenishment over a period of almost 40 years, and currently stands at around 27 Mm^3/a. This has led to a major reduction in the potentially exploitable aquifer reserves from some 350 Mm^3 to 42 Mm^3, and in addition to continuously falling groundwater levels increasing groundwater salinity has also been observed (Figure 1) – both of which threaten the productivity and profitability of local agriculture.

- The existing water supply of the city of Barquisimeto is from wells in other local aquifers and from the Alto Tocuyo surface water system, but all of these sources (like those of the Quibor Valley) are proving insufficient to meet the increasing demand, both in the urban and agricultural sectors.

Figure 1: Hydrogeological sketch map of the Quibor Valley - Venezuela showing water-table depletion, groundwater salinity and locations of the Yacambu surface water-transfer scheme



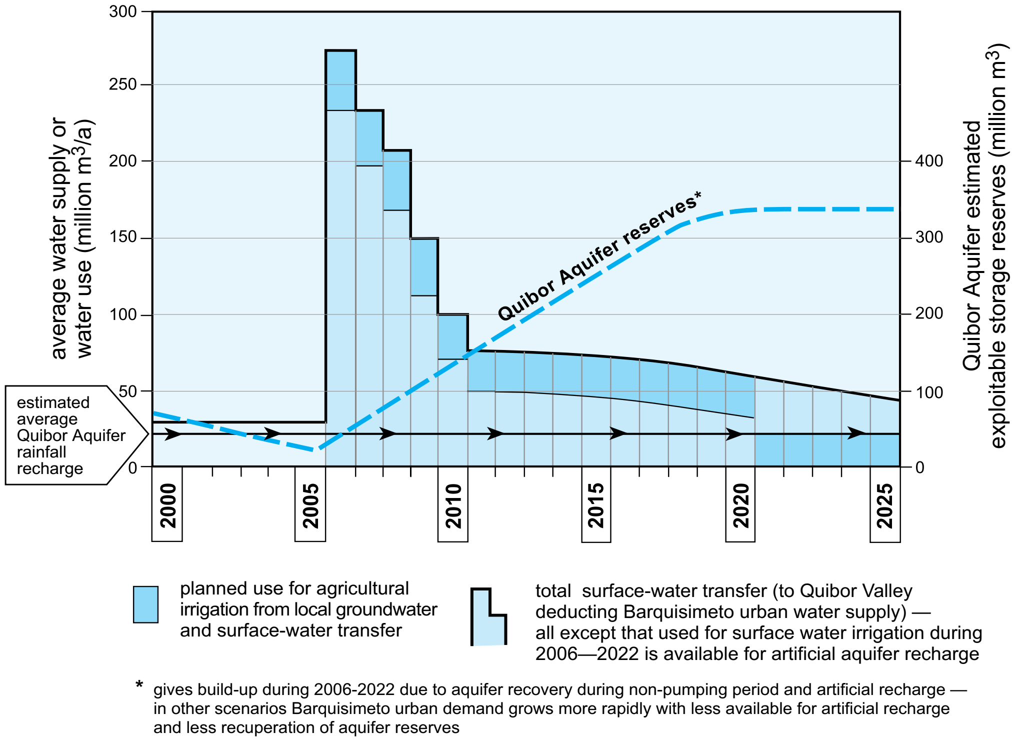
Technical Dimensions of Yacambu-Quibor Project

- The design of the Yacambu-Quibor water transfer scheme was initiated as long ago as 1973, with the object of supplementing Barquisimeto water supply and increasing the area of Quibor Valley under irrigation. It has a capacity to carry 330 Mm^3/a, of which about 30% was designated for urban water supply and the balance would be used to irrigate the 21,000 ha of agricultural land available.
- However, it is now predicted that for somewhere between 5 and 30 years there would be a potential excess of transfer water available, because (a) the full irrigation demand is unlikely to mature until 2011 and (b) Hidrolara (the Barquisimento water supply utility) would phase-out existing water supply sources gradually and thus would not take-up its full quota directly. This presents an opportunity for using excess transferred water, suspending current groundwater pumping for agricultural irrigation and allowing recuperation of the Quibor valley aquifer. A further consideration is that the Yacambu dam has 80% regulation capacity, which implies that under flood runoff conditions it should be able to generate an additional supply of 83 Mm^3/a part of which could also be used for artificial aquifer recharge.

- A simplified water demand-supply simulation (Figure 2) shows that, when the surface water transfer becomes available during 2006, the current groundwater pumping for irrigated agriculture would cease and be substituted by transferred water allowing:
  - full recuperation of aquifer reserves to 350 Mm^3 by 2020 if Hidrolara continues using its existing sources
  - recuperation of aquifer reserves to 102 Mm^3 if Hidrolara uses only transfer water from 2011

  In both scenarios large volumes of transfer water would be available over a short number of years, with very high peak volumes for short periods in some years. While it should be feasible for part of the excess transfer water to be used for artificial aquifer recharge, it may not be feasible to achieve sufficient infiltration to utilize the peak flows, and other uses of this resource need to be identified.

Figure 2: Water demand-supply prediction for the Quibor Valley-Venezuela during 2000-25 showing potential recuperation of aquifer storage reserves using excess water from the Yacambu transfer scheme



- It is also evident in Figure 2 that, should the current rate of groundwater abstraction be maintained, almost total depletion of aquifer reserves would occur and the agricultural production of the valley could collapse. It is, therefore, very urgent to promote a consensus among irrigators to reduce abstraction to a level commensurate with the average rate of replenishment, and this would be all the more critical if the water transfer project should suffer any further construction delays.

- It is important to consider all potential artificial recharge options for the Quibor Valley aquifer – including such techniques as infiltration lagoons or trenches, seepage from (normally dry) riverbeds, injection in abandoned wells, etc. Given the size of probable excess surface water transfers, some of these options may have constraints, but their theoretical potential is such as to warrant technical and economic feasibility studies at pilot level, prior to proceeding to full-scale operations.

- It is also important to make a more detailed assessment of the current processes of groundwater salinization, which could:
  - reduce the future value of groundwater for irrigation if not carefully managed
  - influence the preferred approach to aquifer artificial recharge.

- It will be essential to implement soil and water conservation measures not only in the Yacambu catchment generating the new water supply (where some successful measure have already been implemented), but also in the Quibor Valley (Quebrada Las Raices catchment) whose aquifer will receive additional recharge and will need improved protection against pollution.

Social Organization among Irrigation Community

- The 'irrigation culture' of the Quibor Valley pre-dates Spanish colonization. Since 1950, with the arrival of new immigrants from the Canary Islands, this culture has broadened to become 'water scarcity conscious', with the unreliable surface runoff being stored in lagoons of various sizes, the introduction of more water-efficient irrigation technology and improved water management at field level.

Table 1: Summary of agriculture irrigation infrastructure and crop types in the Quibor Valley – Venezuela

CLASS OF PRODUCER	FARM (ha)	NO OF FARMS	FARM WATER SUPPLY WELLS %	No.	LAGOONS %	No.	AREA CULTIVATED (ha)	CROP TYPES T	M	C	P	O	V
I+II	<10	1277	0.4	5	30.1	419	n/a	x	x	x			x
III with	10-50	274	6.2	19	64.2	268	260				x	x	x
IV land	50-200	103	20.4	29	83.5	237	300				x	x	
V	>200	41	36.6	28	70.7	150	3120				x	x	
V without		150					70	x	x				
VII land		40					936				x	x	

Key to crop types T = tomato M = maize C = cucumber P = pepper O = onion V = various others

- Today there are 48 large-scale producers (with land holdings of more than 200 ha), 1,230 irrigators with medium-sized land holdings and a number of landless farmers who are cultivating fields of 5-20 ha on a cooperative or tenant basis. In addition, there are some 3,000 agricultural laborers (representing 45% of the economically-active population of the valley) involved in land-based employment, whose socio-economic position is especially precarious. An indication of the type of agricultural production involved is indicated from a 1988 study (Table 1). A more recent survey (Table 2) shows that, while there is continuing interest in vegetables (especially onions), fodder grass is increasingly becoming a preferred crop. This pattern, with significant areas dedicated to relatively low-value and high-water consuming crops, is contributing to the aquifer stress.

Table 2: Recent survey of crop types in the Quibor Valley - Venezuela

CROP TYPE	AREA CULTIVATED	%
onion	2,102	50
other vegetables	905	21
fodder grass	616	15
maize	446	11
sugar cane	96	2
miscellaneous fruits	56	1

- The average energy cost for groundwater pumping is currently US $0.03/kwh and the average water pumping cost almost US $0.08/m^3. In Table 3 this energy tariff is compared to Mexican values, albeit that in both cases rural electrical energy is still subsidized. While the Mexican tariffs show that energy prices may be used to reduce groundwater abstraction, the Venezuelan case shows they may be used to reduce non-beneficial evaporation during the day.

Table 3: Comparison of present rural electrical energy tariffs in Venezuela and Mexico

COUNTRY	ENERGY TARIFF (US $/kwh) for irrigation pumping		for domestic use	
VENEZUELA	day irrigation	0.04	minimum	0.01
	night irrigation	0.02	maximum	0.06
MEXICO	permitted abstraction	0.03	minimum	0.05
	excess abstraction	0.05	maximum	0.18

- Various community-based organizations exist in the valley to undertake very specific functions, such as the provision of agricultural materials at discounted prices, the distribution of irrigation water to plot level, etc. As a result of water scarcity, experience with the latter is extremely important, since it has resulted in a high value being assigned to water resources by the local community, with careful use of even the smallest of sources. This has to be taken carefully into account in the design of the future scheme for conjunctive use of surface water transfers and local groundwater for irrigation.

- In relation specifically to the Quibor Valley aquifer, a Technical Commission for the Control of Well Pumping & Lagoon Use was established in 1977 and dissolved in 1984. In 2002 a new Technical Commission for the Soil & Water Conservation was constituted from representatives of the corresponding public bodies and of the user communities, with the function of advising MARNR and other competent agencies on management policy and measures.

Legal & Institutional Framework for Water Management

- The organization Sistema Hidraulico Yacambu-Quibor (SHYQ) was designated a public company in September 1989. The following strategies subsequently pursued by the company proved to be of great importance for the successful implementation of the water transfer project:
  - adopting an inclusive posture with stakeholders and thus gaining community respect
  - fostering a respectful relationship with agricultural producers of all scales to achieve consensus on the need for a sustainable approach to water resources
  - using a participative approach to establishing the presence of the company within the population, as a basis for mounting effective campaigns for Yacambu catchment soil and water conservation for Quibor Aquifer groundwater management and quality protection.

- The Yacambu-Quibor Project for the conjunctive use of surface water and groundwater resources has already become something of a model in its integrated approach at Venezuelan national level.

- The National Constitution of 1999 modified the earlier 1961 provisions and designated all natural waters (both surface and underground) as of public domain, allowing the State to take necessary measures for their efficient management. In practice, however, water resource regulation still remains dispersed in a number of legal instruments, and recently a program for a new Water Law was approved by the National Assembly. Significantly, this is expected to incorporate a number of general recommendations which derive from the experience of the Yacambu-Quibor Project (Table 4).

Table 4: Principal Recommendations from the Yacambu-Quibor Scheme for Incorporation in the National Water Law

CONJUNCTIVE USE OF SURFACE WATER AND GROUNDWATER • include aquifers within the definition of catchments • specifically address groundwater issues and opportunities in catchment planning
WATER-USER PARTICIPATION • anticipate water-user participation when defining catchment agency membership • define catchment agency and water-user responsibility in case of surface water transfers • ensure that the water-user associations have a 'judicial personality' • waterwell drilling permits should require that contractors are appropriately qualified
AUTHORITY OF REGULATORY AGENCY • provide mechanisms for the regulatory agency to act as mediator, conciliator or referee in conflicts between water users • mobilize the assistance of water users when dealing with violations of water law
IMPLEMENTATION PROCESSES • develop the water law as a framework, and leave operational details for subsequent regulation • in parallel with the water law project, prepare a national water policy and strategy, together with appropriate instruments for its implementation • establish an 'implementation team' that assumes role of putting the water law into practice (even if still in draft form) with the object of creating feedback on solving implementation difficulties

Yacambu-Quibor Project Implementation Strategy

- The basic elements of the project strategy are as follows:
  - reinforce the 'irrigation culture' of the Quibor Valley, bearing in mind the existing land tenure jointly with other issues such as productivity, equity and infrastructure investment
  - explore irrigation distribution schemes that favor its efficient use but equitable access, recognizing the fact that water is the limiting factor in agricultural production
  - align the role of state institutions as (a) promoter of irrigation system development (b) regulator ensuring that development of the natural resource base is sustainable (c) protector of agricultural areas against 'urban invasion' and 'environmental degradation'
  - favor the formation of cooperative associations of small-scale farmers for supply of agricultural materials and sale of agricultural crops
  - design an organizational structure that clearly separates the management of water resources from the provision of urban and irrigation water supply
  - establish water resource charges that, in addition to the recovery of costs, provide an incentive for users not to pump groundwater during certain periods to permit aquifer recuperation.

- There is high expectation that the consistency and continuity necessary to make the project a long-term success exist because:
  - SHYQ is dedicated to project promotion, for example by having signed an agreement with the Quibor Valley agricultural producers association to consolidate the basis for stakeholder participation in project management
  - financial resources are under negotiation to support stakeholder participation in general and to provide for capacity building.

- To support the implementation strategy further research is needed in the following areas:
  - field investigation of aquifer recharge enhancement options
  - better understanding of groundwater salinization processes
  - appropriate drought resistant crops.

- The following institutional issues should be addressed in order to ensure implementation:
  - given uncertainty over the operational date for the water-transfer infrastructure, negotiation with users to reduce groundwater pumping is essential and urgent
  - a productive acceptable scheme to address the land tenure issues in the valley should be negotiated
  - scheme for distribution of surface irrigation water an irrigation water users' organization should be established very soon to take full advantage of the new transfer water.

Publication Arrangements

The GW•MATE Case Profile Collection is published by the World Bank, Washington D.C., USA. It is also available in electronic form on the World Bank water resources website (www.worldbank.org/gwmate) and the Global Water Partnership website (www.gwpforum.org).

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