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Governance of Groundwater Resources in Transboundary Aquifers (GGRETA) project

OVERVIEW AND RESULTS OF THE ASSESSMENT PHASE (2013–2015)

The River Lempa near Esquipulas, Guatemala © Andrea Merla

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This document was prepared by Mr Jac van der Gun (Senior Advisor to UNESCO-IHP and Former Director of the UNESCO IGRAC Centre) on the basis of the activities developed by the GGRETA case studies teams that are composed by international, regional and national experts.

The GGRETA project

Water is an important component of our physical environment and it is, above all, indispensable for life on Earth. Groundwater covers a significant part of the corresponding water demands, in particular in areas with a relatively dry climate. Until not very long ago, the invisible groundwater used to be taken for granted in most countries, but this attitude is no longer appropriate. Lessons have been learned during the last half of a century during which different types of pressures on the groundwater resources started and continued increasing steadily. If we want to benefit optimally from our precious groundwater resources and to ensure their sustainability, then we should govern and manage them carefully.

But practice has shown that groundwater management and protection tends to be very difficult. Groundwater is interacting with and affected by various other components of the physical environment; our knowledge of local groundwater systems and their behaviour is often very limited; in addition, each groundwater system has usually a very large number of users and other stakeholders, often with competing or conflicting interests. Adequate governance provisions – related to information systems, institutions, policy and different kinds of support – are required to enable effective groundwater management interventions.

Many groundwater systems around the world (or *'aquifers'*, as exploitable groundwater reservoirs are called) are *transboundary*, which means that they either extend over two or more administrative units inside a country or are crossed by international boundaries. Evidently, the latter condition adds special challenges to groundwater governance and management: governance of such transboundary aquifers requires harmonization and cooperation across the national borders among the various authorities in charge of groundwater, based on mutual trust and on transparency. World-wide there is not yet much experience on this subject. The GGRETA project ("*Governance of Groundwater Resources in Transboundary Aquifers*") aims at gaining experience in this respect, on the basis of three pilot studies of transboundary aquifer systems in different parts of the world: the Trifinio aquifer in Central America, the Stampriet aquifer system in Southern Africa and the Pretashkent aquifer system in Central Asia. These three pilots were selected to represent different major aquifer types and different transboundary contexts.

GGRETA is part of the *Water Diplomacy and Governance in Key Transboundary Hot Spots Programme* financed by the Swiss Agency for Development and cooperation (SDC) and is implemented by the UNESCO International Hydrological Programme (UNESCO-IHP) in close cooperation with the International Union for Conservation of Nature (IUCN), the UNESCO International Groundwater Assessment Centre (IGRAC) and local project teams.

The first phase of GGRETA (2013-2015) was designed as an assessment phase, with three major objectives:

- Focusing the attention of the international community on transboundary aquifers, and providing examples of their assessment and diagnostics
- Assessment of the transboundary aquifers and their context for the three pilot cases (Trifinio, Stampriet and Pretashkent)
- Fostering recognition of the shared nature of the groundwater resource and facilitating cross-border dialogue and technical exchanges

This brochure summarises activities and results of this phase, in particular by presenting the picture emerging from the assessment activities.

Governance of Groundwater Resources in Transboundary Aquifers (GGRETA) Project
Overview and Results of the Assessment Phase (2013–2015)

Pilot study 1: The Trifinio Transboundary Aquifer

Approach and main activities

The technical activities of this pilot study were executed by a local tri-national team coordinated by the UICN (*Unión Internacional para la Conservación de la Naturaleza*) that was the local implementing partner of UNESCO. A close cooperation was set with the *Plan Trifinio*[1]. Apart from compiling and analysing existing information (mainly limited to climate, geology and hydrogeology), the focal components of the pilot study were a geophysical survey (subcontracted to the company *Geofísica Aplicada*), a study of gender issues (in cooperation with municipalities) and the development of a geo-referenced database (supported by IGRAC). In addition, initial advocacies for a multi-actor consultation platform for sustainable groundwater management were made at the occasion of meetings with local authorities and personnel of the Plan Trifinio.

Location, delineation and aquifer type

What originally was called “Trifinio Transboundary Aquifer” – named after the zone where the three countries Guatemala, Honduras and El Salvador meet – is in fact composed of two relatively productive and laterally disjunct aquifer units located in the valley floor of the sub-basin of the Upper Lempa river (*Río Lempa*). As will be shown below, their delineation was enabled by GGRETA’s geological and geophysical surveys. The aquifer system is considered to be *representative for the groundwater setting in small alluvial valleys in mountainous areas around the globe, characterised by strong links between groundwater and surface water*, in this specific case the transboundary Río Lempa.

1 Plan Trifinio refers to the tri-national development plan for the area and the institution ensuring its execution

General features of the Upper Lempa area

Topographic map of the Upper Lempa sub-basin

As the topographic map shows, the Upper Lempa sub-basin is a mountainous area and includes territories of the three countries mentioned before. The sub-basin covers an area of 966 km^2 and surface elevations vary between 720 and 2,720 metres above mean sea level. The relatively flat and wide river valleys are called Valle de Esquipulas (Guatemala), Valle de Nueva Ocotepeque (Honduras) and Valle de Citalá (El Salvador). Geology is characterised by volcanic rocks – mostly of Tertiary age – outcropping over most of the area and covered by Quaternary alluvial sediments (gravel, sand, clay) in the main river valleys. Climate varies from temperate at the higher elevations to semi-arid tropical in the river valley zone, with mean annual temperatures of 23 to 25 °C and average annual rainfall of 1,200 to 2,000 mm depending on the location in the sub-basin. Most of the rainfall is concentrated during the period May-October.

Recent demographic data have not been collected, but the total population estimated in 2007 was around 100,000.

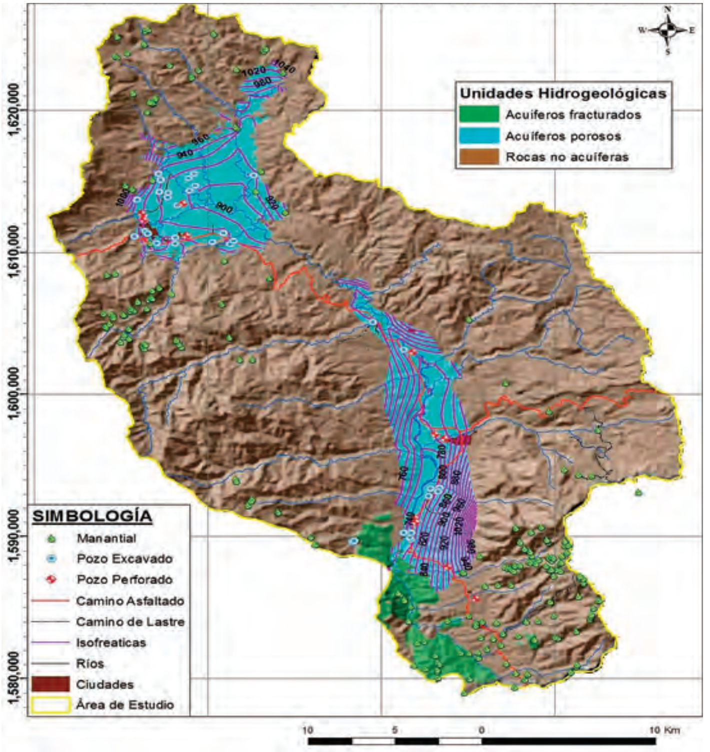
Water and water use in the area

The amounts of rainfall and their irregular distribution in time imply a considerable rainfall surplus during wet periods. Water balance calculations carried out by the project team suggest that in an average year this surplus adds up to values in the order of 300 mm (Valle de Nueva Ocotepeque), 700 mm (Valle de Esquipulas) and even more than 1,200 mm in elevated mountainous zones (Montañas del Macizo de Montecristo). This very significant surplus feeds the rivers in the area – Río Lempa and its tributaries – and recharges the groundwater reservoirs (aquifers). On the other hand, rainfall deficits occur during the dry part of the year and accumulate beyond the moisture storage capacity of the soils, resulting in net irrigation water requirements of 635 to 835 mm/year in the Valles de Esquipulas, Nueva Ocotepeque and Citalá.

The pilot study did not assess the regime of Río Lempa, nor did it define how much surface water and groundwater is supplied for domestic, agricultural and industrial uses in the area.

The aquifers of the Trifinio area

In this area only the Quaternary alluvial deposits form aquifers of more than local significance and potentially capable to produce transboundary impacts. Analysis of records of boreholes and wells, in combination with the geophysical survey, have improved the knowledge on the geometry and other properties of the aquifers. Field data have revealed, among others, that phreatic conditions prevail (free water-table), with relatively shallow water levels, and that groundwater flows generally towards the river, in downstream direction. In a hydraulic sense, the aquifers are only moderately productive, but they are abundantly recharged due to the considerable rainfall surplus during the rainy season and their favourable location as it comes to intercepting runoff from the surrounding mountainous zones. An important finding of the geophysical survey is that the Quaternary alluvial deposits form two separate spatial units, one in the Valle de Esquipulas and the other one in the Valle de Ocotepeque–Citalá. *Consequently, the only transboundary aquifer in the Trifinio area is the latter unit, shared by Honduras and El Salvador only, not by Guatemala.* It should not be overlooked, however, that all alluvial aquifer units in the sub-basin, also those in Guatemala, are hydraulically connected by Río Lempa.



Hydrogeological map highlighting (in blue) the alluvial aquifer units of the Valle de Esquipulas and the Valle de Ocotepeque–Citalá

Río Lempa in low-flow conditions

Gender issues

A proposal has been developed and widely discussed for a strategy of integrating gender issues in planning in the Trifinio region, under the general objectives of recognizing the capacities of women and strengthening the position of women (as regards their roles, rights and involvement in decision-making). Components under this specific project are training, networking with other entities involved in gender and in Integrated Water Resources Management (IWRM) and monitoring. Specific activities carried out are workshops, validation of tools, as well as dissemination of validated tools and training regarding their implementation.

Main groundwater management challenges in the area

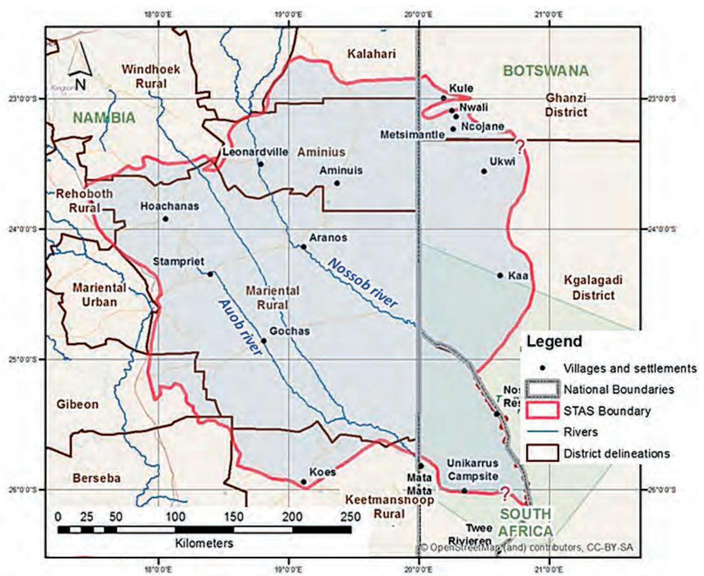
Pollution forms a major water resources management challenge in the area. A diversity of pollution sources is observed, such as domestic solid waste and waste water, chemicals used in agriculture (fertilizers, herbicides and pesticides), wastewater and solid waste from agro-industrial processing, and buried storage tanks of hydrocarbon products. Adequate sanitation is absent in many communities; wastewater and solid waste tend to be dumped untreated and uncontrolled to the environment, in absence of treatment facilities and controlled waste dumps; and many storage tanks are probably leaking. The alluvial aquifers – including the Ocotepeque–Citalá transboundary aquifer – are directly exposed and very vulnerable to pollution. Without effective pollution control, their groundwater is bound to become more and more polluted over time.

At first sight, the alluvial aquifer systems do not seem to be threatened by *groundwater quantity problems* (such as declining water levels and exhaustion), but careful monitoring over a longer period is needed to validate this impression and to anticipate potential groundwater quantity problems in the future. Other major challenges may become apparent after improving groundwater governance in the area. Their early identification may prevent problems from escalating beyond the levels where they still can be controlled.

Improving groundwater governance

The assessment has produced valuable information, but it is clear that information and knowledge are still limited; so, monitoring change over time and continued upgrading of information systems and knowledge are essential. Beyond assessment and monitoring, many other aspects need to be addressed to enhance groundwater governance and to enable sustainable management of the transboundary aquifer in the Trifinio area. This entails in particular institutional aspects, the main theme programmed for the second phase of GGRETA. Some preparatory activities have been carried out already during the first phase, notably the discussions on establishing a multi-actor groundwater management platform.

Pilot Study 2: The Stampriet Transboundary Aquifer System (STAS)



The area of the Stampriet Transboundary Aquifer System (STAS)

Approach and main activities

Assessment of the Stampriet Transboundary Aquifer System has been carried out by a team familiar to the area and composed of professionals of Namibia, Botswana and South Africa. Apart from collecting and studying relevant literature for assessment and diagnostics, the team has spent much attention to compiling basic data and to GIS mapping.

Location, delineation and type of aquifer

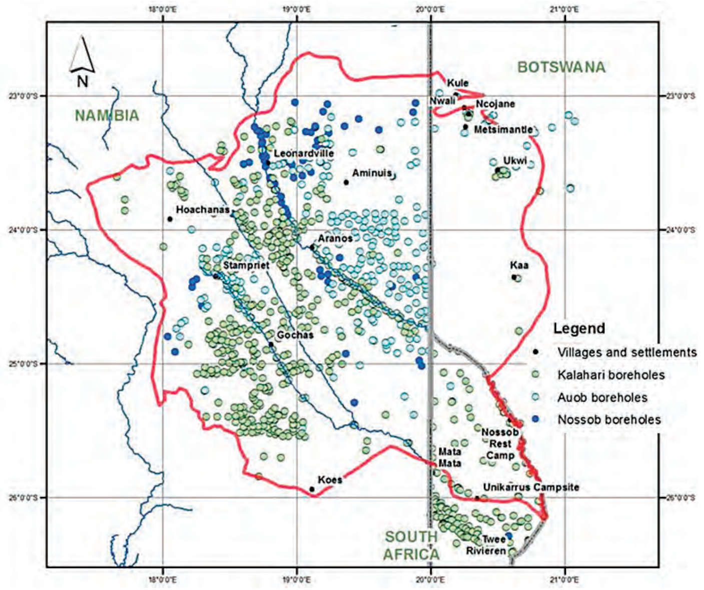
The Stampriet Transboundary Aquifer System (STAS) covers a large arid region stretching from Central Namibia into Western Botswana and South Africa's Northern Cape Province. It contains two confined sandstone aquifers and the overlying unconfined Kalahari aquifer units. The delineation of the STAS area follows the outer boundary of the so-called Ecca Group of geological formations within the catchments of the Auob and Nossob rivers. *The STAS is a very large transboundary aquifer system, receiving insignificant recharge, in a dry region without permanent surface water.*

General features of the STAS area

The STAS area is 86,647 km^2 in extent and has a generally flat topography, gently sloping from NW to SE, between 1,500 and 900 m above mean sea level. It has a hot and dry climate, with an annual mean temperature of 19-22 °C and mean rainfall ranging from 140 mm/yr in the SW to 300 mm/yr along the northern and north-eastern border. During the period May through September there is hardly any rainfall. The Namibian sector of the area covers approximately two-thirds of the area and is almost completely in use as agricultural land. The Botswana sector occupies 18% and includes from North to South three distinct land use zones: agricultural land (mainly in Ghanzi district), wildlife management area and national park. The South African sector (7%) is entirely used as national park. With an estimated population of nearly 50,000 – more than 90% of which in Namibia – the area is sparsely populated. Major settlements are Aranos and Koes, but their population is less than 5,000; all other settlements have less than 2,000 inhabitants. Commercial industrial and mining activities are absent.

Water and water use in the area

Given the climatic and other geographic features, there are no permanent rivers in the STAS area. Apart from the ephemeral rivers Auob and Nossob that provide some water during the rainy season, there are surface water pans scattered over the area that collect and store water for livestock watering; these reserves can last a few months after the rains. The only permanent and dependable water resource in the area is groundwater. Groundwater is withdrawn from the Kalahari, Auob and Nossob aquifers, by means of dug wells and boreholes (see below). It is estimated that at least 20 million cubic metre per year is abstracted; 65% of this volume comes from Kalahari aquifers, 33% from the Auob aquifer and 2% from the Nossob aquifer. The breakdown of overall water use is as follows: 52% for irrigation, 32% for stock watering and 16% for domestic use.



Location of boreholes in the STAS area (showing the aquifers tapped)

Dune area stretching from the Auob to the Nossob river

A horticulture drip-irrigation farm close to Stampriet

Cattle drinking at a small dam situated in a pan in Kgalagadi North

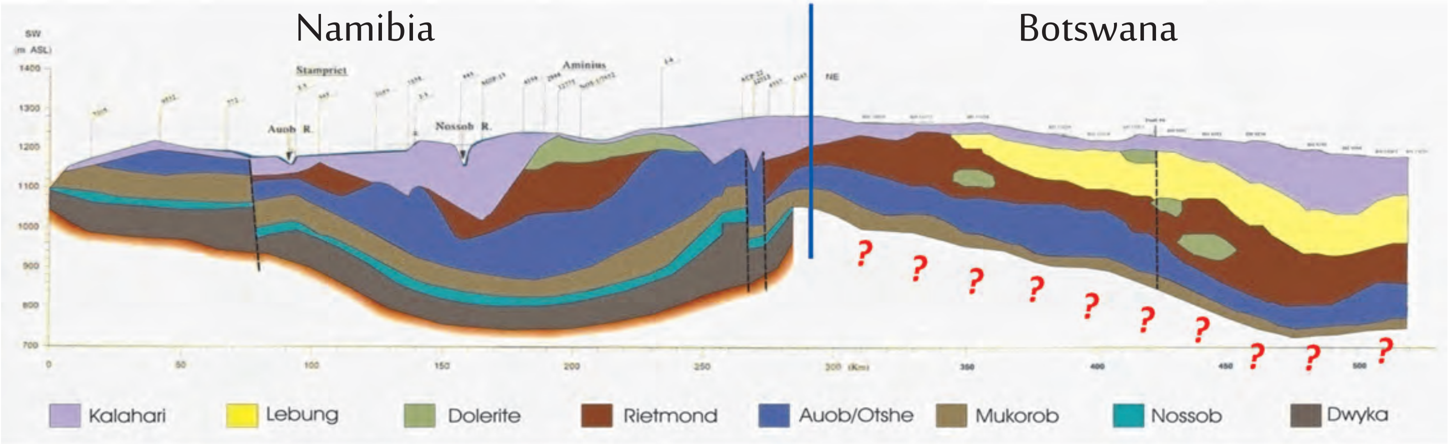
In general, the urban centres and villages receive water from governmental and parastatal water supply corporations. Private land owners usually have their own wells.

The Stampriet Transboundary Aquifer System

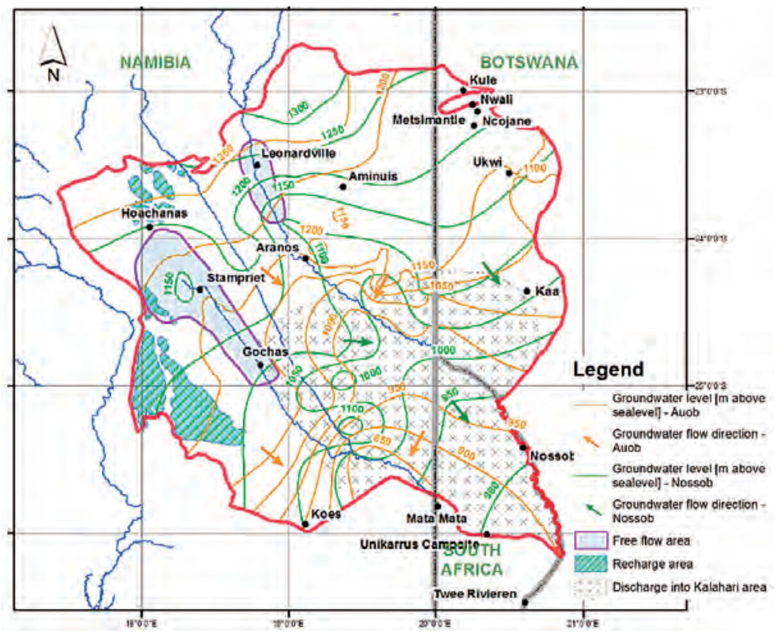
From a geological point of view, the STAS area is part of a huge sedimentary basin in which a thick sequence of layers has been deposited. The layers of Carboniferous through Jurassic age are together known as *Karoo Supergroup* and contain mainly sandstones, shales, mudstones, siltstones and limestone. They are covered by a blanket of sediments of the *Kalahari Supergroup*, of Tertiary-Quaternary age and consisting predominantly of sand, calcrete (duricrust), gravel, clayey gravel, sandstone and marl.

The Kalahari sediments contain phreatic aquifers (free water table), easily within reach of the local inhabitants. Their lateral extent is limited, hence they form local aquifers, and the Kalahari sediments as a whole do not constitute a transboundary aquifer system. By drilling a deep borehole in 1912 near Stampriet, a deeper aquifer was struck – the Auob aquifer– that produced a free-flowing or artesian well. This aquifer is laterally continuous across the international borders, like the deeper located Nossob aquifer. Both aquifers are confined sandstone aquifers, producing truly artesian conditions in parts of the depressed valleys of the Auob and Nossob rivers, which prompted the name Stampriet Artesian Basin (SAB).

The confined Auob and Nossob aquifers, and the overlying discontinuous phreatic Kalahari aquifers, form the Stampriet Transboundary Aquifer System. Conceptually, the physical processes taking place in this system are reasonably understood, but quantification is still limited –in spite of many efforts made over a long period of time. What is known on the groundwater quantity processes of the confined aquifers is summarized in simplified form on the map of the conceptual model shown on the next page. Apart from diffuse recharge by downward seepage from the Kalahari aquifers, there are a few recharge zones in the Western part of the STAS area where sinkholes facilitate concentrated recharge during rare wet years. The mean annual recharge rate for these confined aquifer units is likely to be significantly less than that of the Kalahari aquifers, for which rates of around 1 mm/year, averaged over the area, have been estimated. The general direction of groundwater flow is from NW to SE. In the South-Eastern quadrant of the area, groundwater massively seeps upward from the confined



Geological SW-NE cross-section through the STAS area, showing the position of the main aquiferous units (Kalahari, Auob and Nossob) aquifers and discharges into the Kalahari formations, from where it evaporates. Groundwater salinity in this zone – known under the name Salt Block – therefore is rather high.



Conceptual model – Auob and Nossob transboundary aquifers

Main groundwater management challenges in the area

Lack of monitoring data (climate, groundwater abstraction, water levels, water quality) seriously hampers a systematic diagnostic analysis. Nevertheless, the findings and combined experiences of the assessment team have revealed a number of challenges.

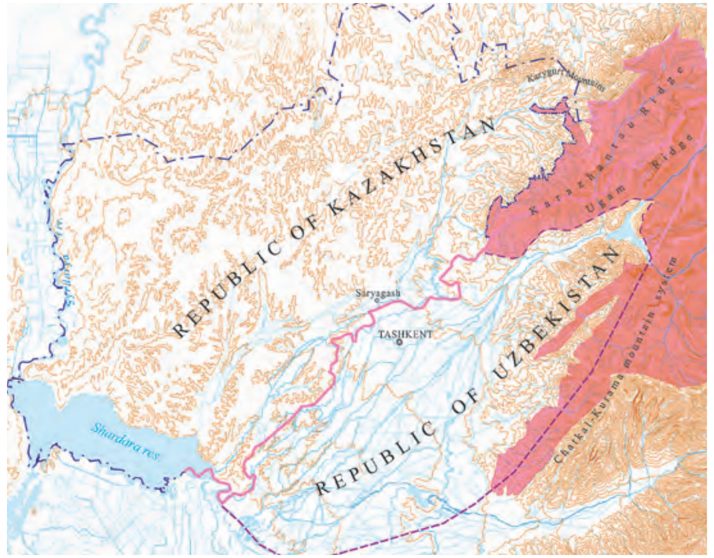
As regards *groundwater quantity*, real stress is not yet being observed. Lack of monitoring may be an explanation, but the exceptionally low intensity of groundwater withdrawal certainly plays a major role. If for some reasons (population growth, economic development, etc) the demand for water in the region would increase significantly, then very soon the groundwater resources may run short of meeting these demands. Therefore it is very important to initiate effective control of groundwater quantity, e.g. by some initial practical steps such as solving the problem of water spillage by leaking boreholes in the Auob aquifer and preventing future problems by improved regulation of drilling.

Groundwater quality has its natural variations. Most notable are generally poor conditions in or near the Salt Block zone. Pollution, however, may also lead to groundwater quality degradation elsewhere in the area. The confined transboundary aquifers have very low vulnerability to pollution, but they will experience higher withdrawal pressures if overlying Kalahari aquifers become polluted. The more shallow and usually phreatic Kalahari aquifers are vulnerable to pollution; in particular in the Namibian sector the pollution risk is often medium to high due to irrigated agriculture (using fertilizers and pesticides) and environmentally unfriendly sanitation and waste disposal practices. Partly from the groundwater management point of view and partly for health reasons, there is scope for enhancing water supplies and even more for improving sanitation in the entire area.

Improving groundwater governance

Given the fragility of the aquifer system and the fact that groundwater is the only permanent source of water in this huge area, it is evident that the Stampriet Transboundary Aquifer System should be governed and managed wisely. A large part of the provisions and interventions to be considered are of a local nature, but transboundary cooperation will be very useful by sharing information, exchanging experience and by harmonizing interventions across the international boundaries. At the level of the assessment, *the three countries have already proven to be willing and capable to cooperate effectively.*

Pilot study 3: The Pretashkent Transboundary Aquifer (PTBA)



The Pretashkent aquifer, shared between Kazakhstan and Uzbekistan

Approach and main activities

Although the Pretashkent Transboundary Aquifer (PTBA) covers parts of both Kazakhstan and Uzbekistan, the latter republic considers sharing its information in this stage not yet opportune. Therefore, this pilot study –a synthesis and interpretation of existing information – was carried out by a team of Kazakhstani scientists and technical specialists only and, apart from a few contextual features, it does not describe the Uzbekistani part of the Pretashkent Aquifer, but merely addresses the Kazakhstani part.

Location, delineation and aquifer type

The Pretashkent Transboundary Aquifer is located at considerable depth under a relatively flat area of piedmont and alluvial plains bordered by the Shardara reservoir and Syrdarya river in the South and West, and by spurs of the Tian Shian and Chatkalo-Kuramin mountain systems to the North-East and East. This area includes three administrative districts of southern Kazakhstan and thirteen districts in the adjoining part of Uzbekistan (including the capital Tashkent). The aquifer delineation is based on geological formation boundaries and the location of the aquifer's main discharge zone. *The Pretashkent Transboundary Aquifer is an example of medium-sized deeply buried artesian aquifers with negligible recent recharge.*

General features of the Pretashkent area

The area underlain by the Pretashkent Transboundary Aquifer measures approximately 17,000 km^2, of which 10,840 km^2 in Kazakhstan. The elevation of the area ranges from 214 m above mean sea level at its Western border to slightly over 1,000 m in the East. The Eastward bordering mountain ridges, outside the PTBA area, rise to more than 3,600 m. The area has a continental dry climate, with hot summers (mean July temperature 25 to 30 °C) and a relatively warm winter (mean January temperature -4 to 0 °C). Precipitation falls mainly during the period November-May – during winter mostly in solid form, during other seasons in the form of rains – and varies from year to year between 200–350 mm/year in the South-West (Shardara) to 350–360 mm/year more North-Eastward (Kazygurt), and to even some 20% more at the Eastern border. The area's climate is characterised by a precipitation deficit.

Some 92% of the population of 5.5 million lives in Uzbekistan, thus the population density in the Uzbekistani sector (which includes the Tashkent capital territory) is more than one order of magnitude higher than in the Kazakhstani sector. This difference in population density is reflected in the dominant categories of economic activities: mainly agriculture and food industries in the Kazakhstani sector, versus engineering, chemical industries, metallurgy and agriculture in the Uzbekistani sector.

The Syrdarya river in high-water season

Piedmont plain in spring

Water and water use in the Kazakhstani sector

Permanent rivers in the area are the Syrdarya river (along the area's Western border) and the Keles river (running parallel and close to the boundary with Uzbekistan). Both are meanly fed by snow-melt and their mean annual discharge volumes are 37 and 0.96 km³, respectively. Other surface water bodies in the area include two ephemeral rivers, the transboundary Keles irrigation canal (flow of 8 m³/s in the Saryagash district) and the Shardara reservoir (900 km² in size). All these surface water sources are used for irrigation and watering of pastures. The Shardara reservoir is in addition a wetland of national significance, famous for various endangered and rare species of swimming birds.

Groundwater is present in a complex sequence of superimposed geological formations. Groundwater is fresh in some of these formations, but in others it is brackish. Shallow groundwater tables (less than 3 m deep) are found mainly near the rivers and along the Shardara reservoir.

Almost 99% of all water withdrawn is for agriculture (mainly for irrigation) and most of the remaining 1% is for domestic and public water supply. Bottling and other industrial uses account for less than 0.06%. Representing only 5.1% of all water withdrawn, groundwater seems at first glance an insignificant source of water, but this is not the case, since only groundwater meets drinking water quality standards. Therefore, the population depends for drinking water almost entirely on groundwater. Most groundwater used for domestic purposes (90%) and all water used for bottling comes from the Pretashkent Transboundary aquifer, while groundwater used for agricultural purposes is withdrawn from overlying non-transboundary aquifers.

Water demands and water use are likely to increase in the future, in response to population growth (mean annual growth rate was 2.6% over the period 2005–2014), to economic development (although the area of arable lands tends to decrease) and perhaps also to climate change.

Water withdrawal in the Kazakhstani sector of the PTBA area in 2013 (in million m³/year)

Category of use	Surface water	Groundwater	Total
Utility and drinking water	0.36	4.63	4.99
Bottling	–	0.27	0.26
Industrial water	0.03	–	0.03
Agriculture	488.69	21.35	510.04
TOTAL	*489.08*	*26.24*	*515.32*

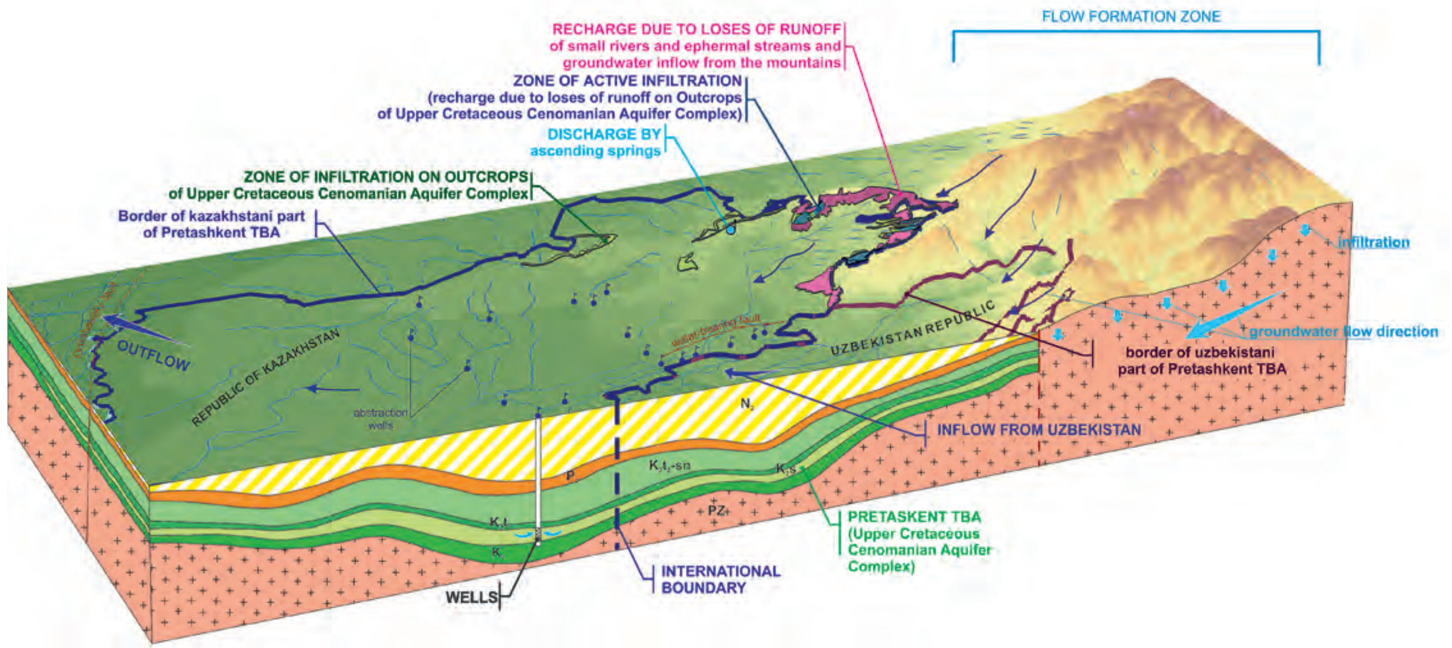
The Pretashkent Transboundary Aquifer

The area considered forms part of a depressed geological structure where a more than 2,000 m thick sequence of sediments has accumulated during the last 140 million years. These sediments – sandstones, sands, conglomerates, gritstones, gravels, boulders, silts, clays, argillites and limestones – are arranged in sub-horizontal layers (slightly tilted and folded) that produce an alternation of permeable layers (aquifer beds) and layers that offer resistance to groundwater flow (aquitards).

The upper aquifer beds (of which the uppermost one has a free water-table) tend to be non-transboundary and several of them contain brackish water. The so-called Upper-Cretaceous Cenomanian Aquifer Complex, in the lower part of the sedimentary sequence (see the conceptual model presented below as a block diagram), however, is continuous in the region and transboundary, and is called the *Pretashkent Transboundary Aquifer (PTBA)*. It is the most important aquifer in the area, contains fresh water and it is in artesian conditions, characterised by flowing wells. Although the PTBA is located at great depth (mean depth 1,064 m), there is substantial information available on its hydrogeological and hydraulic properties.

Gender issues (Kazakhstani sector)

Analysis of gender issues in Southern Kazakhstan revealed, among others, the female share in economic activities to be 43.8%. High male mortality rates in the age range of 40–45 cause shortages of family income, with negative impacts on living conditions, education opportunities, health, etc of widows and children. Gender equity is government policy.



Conceptual model of the Pretashkent Transboundary Aquifer (the pale green layer overlaying the lowest green layer depicts the PTBA)

Main groundwater management challenges

Due to its predominantly great depth and the hydraulic protection by an overlying regional aquitard, the PTBA is not vulnerable to pollution. Climate change will not have a significant direct impact (since the aquifer resources are virtually non-renewable), but there may be an indirect impact by potentially increasing water demands in the area.

The main problem offered by the PTBA is the *unavoidable depletion of groundwater storage in response to groundwater withdrawal.* After a certain period of exploitation, currently flowing wells will be no longer artesian and will need to be pumped; while on the long run, groundwater levels will drop below technically or economically maximum exploitable depths. Reduction of the groundwater pressures will quickly expand laterally, also across the international border.

Potential degradation of groundwater quality is another major concern. As far as the PTBA is concerned, only its recharge zones – very limited in size – are exposed to pollution. Nevertheless, progressive drops of water levels in the TBA may trigger invasion of brackish and saline groundwater from overlying strata. Pollution of shallow local aquifers, finally, may result in substitution of their exploitation by withdrawals from the TBA.

Improving groundwater governance

Governing the PTBA evidently should take into account the interaction with other aquifers and also with surface water, thus an integrated water resources management approach is appropriate.

Groundwater governance and management span different levels: the local (domestic) level, and the international (transboundary) level. Many of the already identified options for enhancing groundwater governance (legislation and regulations, awareness raising, capacity building, gender equity issues, etc.) can be addressed to a large extent at the domestic level. Nevertheless, cooperation between Kazakhstan and Uzbekistan will make a difference for developing and implementing effective policies aiming to control processes with significant transboundary components. *Developing and implementing a joint management strategy for exploiting the PTBA is a key challenge in this respect.* A mathematical simulation model designed to explore alternative exploitation strategies can only produce reliable results if sufficient information from both sectors of the aquifer is available. And it goes without saying that the overall benefits to be derived from the PTBA will increase if exploitation policies and measures for control are harmonized across the international border.

A look forward

It will be clear that good groundwater governance is a 'must' in each of the pilot studies described above. If the main groundwater management challenges are not adequately addressed, then potential benefits will be forgone, problems may emerge and degeneration eventually may become the fate of the aquifers and their resources. It is important to observe that the local context matters, thus tailor-made approaches and solutions are required. Hence, approaches to improving groundwater governance and to developing groundwater management need to be area-specific, not only because of different groundwater management challenges, but also because of the unique socio-economic and political setting of each area. Developing such approaches is by no means an easy task.

What the three pilot areas do have in common, however, and what has been demonstrated by the pilot studies is the transboundary dimension. This forms a complicating factor in groundwater governance, but it is a challenge addressed by GGRETA. *The key to successful management of transboundary water resources systems is smooth cooperation between the neighbouring countries involved.* The assessment phase undoubtedly has contributed already to improved transboundary cooperation, but more is needed. During the next phase, GGRETA therefore widens its scope, in particular by pursuing the development of frameworks and tools for enhanced cross-border dialogue and cooperation, and by capacity building in groundwater governance, hydro-diplomacy and gender.

This project is executed by the UNESCO-IHP within the framework of the Swiss Agency for Development and Cooperation (SDC) "Global Programme Water Initiatives (GPWI) – Water Diplomacy" activities.

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