Global information and Knowledge Sharing on Transboundary Aquifers
- a discussion paper-

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ABSTRACT

This discussion paper is about generic benefit of transboundary aquifer assessments as carried out nowadays all over the world. The paper addresses relevance of assessed information & gained knowledge for others (than the involved aquifer states) in terms of replicability and lesson learned. Once the relevant knowledge is identified, it needs to be disseminated to the potential user in the most appropriate way. The paper discusses current practice and recommends further methodological development, harmonisation and use of contemporary information and communication technology.

Key words: transboundary aquifer assessment knowledge sharing

1. INTRODUCTION

During the last decade, with increase of general awareness about the importance of groundwater, an issue of transboundary aquifers (TBAs) has also started to receive more attention from international community. Very instrumental for this process were initiatives of UNECE (to conduct a first inventory of TBAs in Europe), of UNESCO & IAH (to set up an international program – ISARM), and of GEF (to include groundwater in its International Waters projects). In meantime, various TBA inventories and assessments have been conducted worldwide, producing valuable information and knowledge about this complex issue.

This paper addresses the following two questions:

- Which part of information & knowledge on a particular transboundary aquifer could be of practical use to others (than the involved aquifer states)?
- In which way should this specific information and knowledge be made available and accessible to potential users?

In order to discuss these questions, an overview of available TBA information is made, including among other its consistency, completeness and dissemination (the next chapter). The overview is followed by an analysis of generic TBA knowledge and its sharing (the third chapter). The article is rounded off with some conclusions and recommendations regarding TBA methodology and TBA knowledge sharing.

1. THE MAIN TBA ACTIVITIES AND THEIR GENERIC ADDED VALUE

This chapter gives a critical overview of the main TBA assessment activities conducted so far. Only the main regional and global TBA activities are included in the overview, namely: UNECE assessments, GEF TBA projects and ISARM Programme.

1.1. UNECE Inventory 1999

The first major step towards TBA assessment was made by UNECE in 1999 by organizing an inventory of transboundary groundwaters in Europe (UNECE Task Force on Monitoring & Assessment, 1999). The inventory report gives an overview of groundwater characteristics in 25 participating countries, identifying in total 89 transboundary aquifers. The questionnaire prepared for the inventory was quite comprehensive and contained mainly quantitative items, i.e. requesting numerical characterisation of aquifers (the subsequent

UNECE and ISARM questionnaires will be much more descriptive). The questionnaire forms were in most of the cases only partially filled out, showing the limited knowledge on TBAs. Moreover, the inventory team faced all the challenges of international data harmonization (language, classification, formatting, organizational and other differences). Finally, it became very clear that assessment of TBAs is much more challenging than the assessment of international surface waters. While the presence and extent of surface water is usually a given fact, in the case of (invisible) groundwater is that one of the main issues to be agreed upon between riparian countries. The same holds for all the other components of the assessment such as the status of the system, the future trends, measures to be taken, etc.

Generic added value of the 1999 inventory is its pioneering role in addressing TBAs, formulating their characteristics (the questionnaire) and providing a pan-European overview. Lesson learned, as briefly mention above, made a clear message about the importance and complexity of TBA assessment.

The UNECE inventory has lead to development of Guidelines on Monitoring and Assessment of Transboundary Groundwaters (UNECE Task Force on Monitoring & Assessment, 2000). An effort was made to generalise the findings of the inventory (and some other activities conducted at that time, namely about the use of models and indicators) in order to assist further assessment and management of TBAs in the region of elsewhere. Beside the monitoring and assessment issues, common management and institutional arrangements are briefly addressed as well. The guidelines are quite general but give a proper scope for further elaboration.

1.2. The first UNECE assessment 2007

After the 1999 TBA inventory, UNECE concentrated the TBA assessment at two following regions: South East Europe (SEE) and Caucasus and Central Asia (CACENA). The results of the assessment were presented in 'The first Assessment of Transboundary Rivers, Lakes and Groundwaters in UNECE region' (UNECE 2007). The groundwater assessment was carried out in cooperation with UNESCO, INWEB, IGRAC and other international organisations. For the SEE region, the main source of information was a TBA inventory & workshop from 2004 (INWEB, 2004) and the subsequent Thessaloniki workshop in 2007. For the CACENA region, the Almaty workshop in 2007 delivered the most of the aquifer data.

The first UNECE assessment was carried out following the structure of the "Driving Forces-Pressures-State-Impact-Responses (DPSIR) framework" adopted by the European Environmental Agency (EEA). This approach gives a quite clear regional overview of pressures (groundwater is exposed to), of current groundwater status (including the transboundary impact and management measures), and of future trends and prospects. Hence, this approach can be recommended for a regional assessment, certainly in terms of factors/characteristics to be taken in account/assessed. However, an assessment of individual aquifers asks for more elaborated methodological steps. During the first assessment, extent of aquifers is only partially delineated, and that mostly in the SEE region.

1.3. The second (on-going) UNECE assessment

The second UNECE assessment is on-going and it will be completed next year. This time, the intention in to assess surface- and groundwater in an integrated manner per catchment area. Practically, the second assessment of TBAs includes (next to SEE and CACENA) also Eastern European countries that are not a part of the European Union (EU). For the EU region, the second assessment will use the results of the EU Water Framework Directive (WFD) if those became available in meantime. Since the TBA activities in the second assessment are described in an other paper prepared (by A. Liponnen) for this conference, only a few lesson learned (so far) will be mentioned here:

- It is still difficult to implement a balanced integrated approach, especially in areas with large rivers where groundwater easily remains insufficiently addressed.
- EU WFD defines groundwater bodies (GWBs) rather than aquifers, causing the harmonisation difficulty at the borders of the EU. Moreover, the guidelines for definition (including delineation) of

GWBs are rather supple, leading to various interpretations across the Europe. Consequently, the GWBs within the EU are not harmonised yet. (It would be interesting to analyse the motivation behind various interpretations)
- The assessment remains politically very sensitive so that countries often hesitate to confirm the facts that are not completely obvious (which is often the case with invisible groundwater).
- So far, the assessment has not provided sufficient information on the role of groundwater in the changing world, regarding both anthropogenic impact and climate variability.

The second assessment is planned to be completed 2011; hence, there is still time for possible improvements.

1.4. GEF TBA Projects

In the last several years, Global Environment Facility (GEF) has initiated and co- financed several large TBA projects and encouraged inclusion of groundwater component in various surface water-related projects. The most important GEF TBA projects carried so far are:

- Groundwater and Drought Management in SADC
- Environmental Protection and Sustainable Integrated Management of the Guarani Aquifer
- Integrated Management of the Shared Nubian Aquifer
- Managing Hydrogeological Risk in the Iullemeden Aquifer System
- Protection of the North West Sahara Aquifer System (NWSAS)

These are large, long term projects, four of them located in Africa and one in South America. Also interesting for this discussion is the project 'Developing Renewable Ground Water Resources in Arid Lands: a Pilot Case - the Eastern Desert of Egypt', because of its replication objective and Protection and Sustainable use of the Dinaric Karst Aquifer System (DIKTAS), because of its hydrogeological specifics.

While the UNECE assessments provide a regional overview for dozens of TBAs and the countries, the GEF projects usually concentrate at one aquifer, allowing more in depth analysis. Besides, the GEF projects are not only about assessing but also about suggesting solutions. Each GEF International Water (IW) project comprises a Transboundary Diagnostic Analysis (TDA) and a Strategic Action Program (SAP). The TDA is actually a TBA assessment, including hydrogeological, ecological, socio-economical, organisational, legal and political facts relevant for actual or potential future disputes or conflicts. The SAP is primarily a joint suggestion for TBA management, including national ('baseline') and international ('incremental') activities. Noticeably, the GEF do not require a TDA to be conducted according to a prescribed elaborated procedure; a TDA content and the applied methodology are substantially defined by the specifics of the problem and by consensus of involved aquifer countries. GEF recommends use of experience from exemplary TDAs conducted elsewhere, which is useful (given the right selection of projects/cases) but not the most efficient way. Moreover, the aquifer countries (that are about to commence TDA) could have various opinions about experiences and recommendations made elsewhere.

At the moment, the TBA GEF projects are in various stages of execution and information about results already achieved is not equally available for all the projects. Nevertheless, some comparison and analysis of conducted TDAs can be done. It seems that hydrogeological part of TDA does not bring much novelties to be adopted elsewhere. From a hydrogeological point of view, it is certainly interesting to learn about some advanced implementation of satellite imagery or isotopes, but they are not specific for a transboundary context. Transboundary specifics can rather be found in data and information handling procedure, being not only a technical matter (differences in language, formats, references, classifications, software, etc), but also having its cultural, social-economical, organisational and political connotation. Nevertheless, experiences about transboundary data and information assessment and management could be used elsewhere, if made available in an adequate form. For instance, the Netherlands and a German state of North Rhine-Westphalia harmonised lithostratigraphical and hydrogeological classifications prior developing a common portal; that

allowed on-fly semantic translation of groundwater information in the portal (Kukuric & Belien, 2006). Info on both the process and the technology should be clearly communicated if intended to be replicated elsewhere.

Replicability is often specified as one of the objectives in GEF TBA projects. 'Eastern Desert' was even not a TBA project and yet, the implementation of the in the project developed methodology to other regions and countries was one of the project objectives. Similarly, DIKTAS project addresses the assessment and management of a transboundary regional karst system and this unique experience is expected to be applied elsewhere. In order to achieve that, the relevant experience needs to be adequately described and conveyed, allowing for easy access to key information and necessary adaptation to a new situation. For instance, a standardised way of assessing/describing/presenting ecological or socio-economical impact of TBA problems would be very helpful.

Establishment of consultation and cooperation mechanisms is a part of each GEF TBA project, providing interesting approaches and solutions. These experiences could be sorted out with respect to relevant (cultural, political, organisational) conditions, allowing a better insight in their applicability elsewhere.

Suggested solutions included in the SAP (such as guidelines for community based management, training and outreach) could be very inspirational and instructive for other regions. Besides, some of the SAP solutions are already implemented or under implementation, bringing the reality check of their feasibility.

Two additional, on-going GEF project should be mentioned as well, being very relevant for improvement of TBA assessment and dissemination of results: Transboundary Water Assessment Programme (TWAP) and Enhancing the use of Science in International Waters Projects to Improve Project Results (SCIENCE). TWAP develops a methodology for a global assessment of five transboundary water systems (rivers, lakes, groundwater basins, large marine ecosystems and open ocean). The methodology will be used for assessing the changing conditions resulting from anthropogenic and natural causes. Development of the methodology is based on indicators derived from available measurements and proxy information. Hopefully, the global TWAP methodology will also bring more consistency in the assessment of individual TBAs. The GEF SCIENCE project is designed to recognize, capture, analyze and integrate the scientific findings from GEF International Waters projects and to disseminate them across the IW portfolio and beyond. The project includes activities such as documenting and understanding best practices and establishment of 'Science Learning Network'. Regardless whether the knowledge generated in TBA projects could be qualified as scientific of not, improvement of mechanisms for knowledge extraction, systematisation and dissemination is very much needed development.

1.5. ISARM

Internationally Shared Aquifer Resources Management (ISARM) initiative is UNESCO and IAH led multi-agency effort aimed at improving the understanding of transboundary aquifers. ISARM operates as an umbrella programme, (co)organising various TBA-related activities all over the world (ww.isarm.net). The most of ISARM engagements in the past was at regional level, contributing to inventories and regional (initial) assessments of TBAs (similar to UNECE assessments, but than world-wide). In 2001, ISARM produced a Framework Document, identifying the main TBA aspects, namely hydrogeological, legal, socio-economical, institutional and environmental. Each of these aspects has required elaboration and methodological approach. In meantime, a substantial progress has been made in describing a legal TBA aspect. The International Law Commission produced so-called Articles on the Law of Transboundary Aquifers (Yamada, 2008), to be used as a basis for an international guideline, convention or a law. The articles are the result of excellent cooperation between layers and hydrogeologists that was necessary to properly capture hydrogeological issues in a legal form. It has been noticed that the legal clarity on basic TBA issues is already alleviating the assessment and establishment of transboundary (legal) agreements in practice.

Likewise the legal, the hydrogeological TBA aspect has also been further elaborated since the ISARM Framework is produced. A methodology for hydrogeological assessment has been suggested by IGRAC (Kukuric et al, 2008), consisting basically of three steps:

- Delineation and description
- Classification, diagnostic analysis and zoning
- Data harmonisation and information management

Although IGRAC has been involved in practically all ISARM activities, its main contribution so far has been to the hydrogeological assessment. In the last several years, the mapping activities (delineation and description) are carried in various parts of the world (Americas, Africa, Asia, Europe), yielding precious information on aquifers presence and extent (IGRAC, 2009). Yet, not all transboundary aquifers are delineated and many aquifers are delineated in an approximate manner. Even when TBA boundaries precisely match the boundaries of outcropped hydrogeological units, no further info is available on aquifer extent (depth, inclination) under the surface. Besides, aquifer countries do not always agree about delineation criteria and there is no consistency in conducted inventories and aquifer descriptions.

Aquifer delineation and description need to provide information sufficient for subsequent classification, diagnostic analysis and zoning. There are very few examples found of systematic classification and zoning, whereas DPSIR (used by UNECE) and TWAP (under development by GEF) are the examples of regional diagnostic analysis. The last step of the hydrogeological assessment (i.e. data harmonisation and information management) is addressed in next chapter.

IGRAC has also made an initial step to elaborate the remaining (socio-economical, institutional and environmental) TBA aspects (IGRAC, 2009). ISARM activities, as conducted so far, usually do not provide sufficient insight in these aspects in order to allow some methodological suggestions. On the other hand, various TBA conferences (e.g. Tripoli 2002, 2008, Ciudad Real 2006, Thessaloniki 2008) and symposia have generated relevant information that needs to be processed, together with experiences coming from GEF projects and UNECE assessments. That would lead to further methodological developments regarding economical, institutional and environmental TBA aspects.

2. GENERIC TBA KNOWLEDGE AND ITS SHARING

A number of TBAs activities conducted in the last decade is substantial. The results of these activities could be relevant elsewhere (i.e. outside of the activity region) by:

- contributing to the development of common methodology
- addressing (hydrogeological, socio-economic, etc.) specifics recognisable elsewhere

There is still no generally accepted TBA methodology; UNECE uses a rather descriptive DPSIR based framework for a regional diagnostics and GEF is currently developing indicator-based methodology for a regional/global assessment. At the aquifer level, GEF is using generally defined TDA, whereas IGRAC has elaborated the hydrogeological aspect of the ISARM framework. The necessary foundation for the legal assessment has been provided, but the same is still lacking for other (economical, institutional and environmental) TBA aspects.

Like in any other field, critical (sufficient) amount of information (produced) and experience (gained) is necessary for a mature methodological development. In that respect, international groundwater community has been making a tremendous progress during last ten-eleven years, carrying out numerous TBA activities and producing plenty of new pieces of information. Yet, since ISARM Framework Document (2001), no comprehensive guidelines have been produced addressing the complex assessment issue. Consequently, information produced is often not consistent in content and/or format, making it more difficult to comprehend, compare and accept elsewhere.

The other precondition for a methodological development and for use of experience gained elsewhere is information accessibility. The importance of conferences and symposia for exchange of experience is indispensable. In order to bridge the gaps between the face-to-face meetings, internet-based communities or fora are often introduced. A successful example is a Global Groundwater Forum, set up (by UNESCO and

IGRAC) to bridge two GEF conferences (2005 and 2007). General lack of interest to join a TBA forum could be partially explained by sensitivity of the issue, but this should not be decisive for the exchange of experience.

Although UNECE water website http://www.unece.org/env/water/ is not particularly conveniently arranged, UNECE is publishing all the information collected/generated during the assessment process, including meeting minutes, presentations, background documents, etc. This transparency is very relevant for the TBA process and the document repository alleviates the consistency of the assessment. On the other hand, only the final inventory and assessment reports provide to external user a clear insight in the implemented procedure and achieved results.

Accessibility of GEF initial project documents was always good, whether through GEF project database (http://www.gefonline.org/) of databases of GEF implementing agencies (such as World Bank and UNEP). However, the project sites needed more time to develop. Moreover, the sites contain mostly general project information and less descriptions of project results. Since the start up of IW-Learn initiative (www.iwlearn.net), visibility of GEF project activities has increased. Via the IW-Learn platform, GEF projects can use Website Toolkit, that substantially increases the consistency of published information. The toolkit contains a dynamic content management system that is rather easy to use and efficient. It also provides a possibility to generate RSS feeds and share news with other sites. The IW-Learn platform offers also templates for Experience Notes, a sort of lesson learned, nowadays a standard part of each GEF project.

The ISARM site (www.isarm.net) is a portal to information on the ISARM programme and various regional TBA activities. The portal provides a link to the IGRAC's Global Groundwater Information System (GGIS). The GGIS contains a TBA Global Overview, an interactive global map, connected with TBA indicators and related project organisations and documentation. A country-based Global overview connects to 70 attribute values (per country) and hundreds of documents and addresses. That is unfortunately not a case with TBA Global Overview (Fig.1). The main obstacle is a lack of harmonisation. Information collected through various regional ISARM enquiries needs to be harmonised prior storage in a common GGIS database. Only then the GGIS search mechanism can be employed to identify similar situation and reuse the knowledge gained elsewhere.

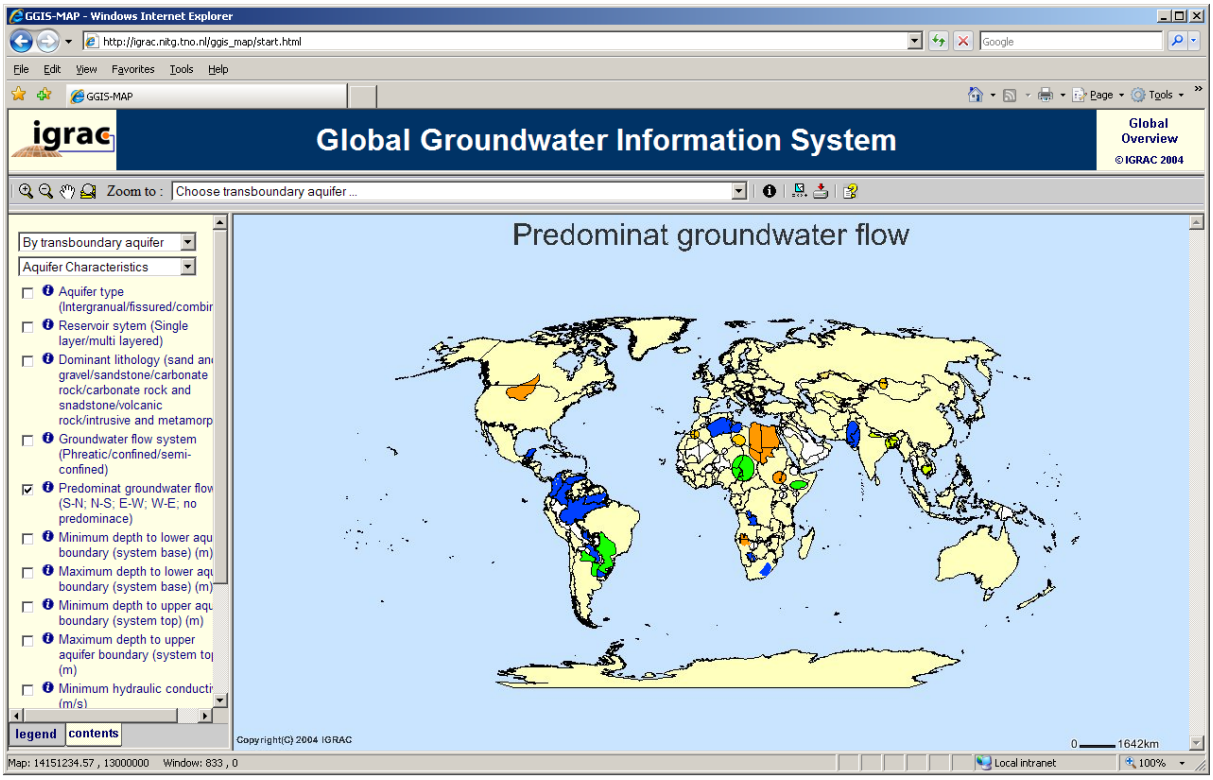

Figure 1. Transboundary Aquifer View (in GGIS - Global Groundwater Information System)

Harmonisation of TBA information is a difficult issue, not only concerning the content of collected information but also aquifer delineation. The experience of EU WFD shows that simple guidelines (EU WFD, 2003) lead to various interpretations and considerable delay in accomplishing the assessment. Consequently, WISE (Water Information System Europe) does not contain TBA information yet. ICT is not an obstacle any more and development of distributed and even real-time TBA information systems is already possible (Kukuric & Belien, 2006). The main obstacle is a lack of cooperation.

3. CONCLUSIONS

Amount of information on TBAs has been rapidly increasing during the last decade. The accessibility of information is gradually improving, also due to GEF, UNECE and ISARM activities and ICT advancements. However, TBA info if often collected, processed and disseminated in a way that do not allow easy comparison and possible reuse elsewhere.

A considerable progress has been made in shaping up a common TBA assessment methodology, especially regarding hydrogeological and legal aspect of TBAs. Yet, the other aspects (ecological, socio-economical, organisational) need to be elaborated as well. Use of common methodology would ensure higher consistency of information content and format, alleviating knowledge transfer and reuse. The ISARM core group needs to play a more active role in further methodological developments.

GEF IW-Learn initiatives such as experience notes and website toolkit (with RFF feed) also lead to better knowledge sharing. Contemporary ICT provides broad possibilities for web-based storage and processing of global TBA information that is relevant for reuse elsewhere and for policy analysis and planning. The main obstacle remains general unwillingness of aquifer countries to publish information that is not obvious or not easily confirmable (invisible groundwater). Fortunately, this is also a subject to gradual change, mostly due to unavoidable (and in this case positive) globalisation.

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