Complex Projects Modelling as a Tool to Establish a Cooperation Framework within Transboundary Aquifers

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ABSTRACT

Transboundary aquifers are a relatively new subject. In the particular cases when the resource is confined and its flow is relatively slow, parties tend to wait for the emergence of a problem to start cooperating. Nevertheless, the geological and hydrogeological specificities of transboundary aquifers prove them to be a less contentious resource than surface water and a great factor of cooperation. Unfortunately, the lack of anticipation of risks and uncertainties and the underestimation of the importance of stakeholders' management often leads to conflicts.

This article considers the creation of cooperation through the development and implementation of projects (taken in their broad sense). It explains how, by modelling the development of cooperation projects, it is possible to anticipate the risks and uncertainties which can give rise to conflicts and get over them in order to ensure the success of both project and cooperation. A study of transboundary cooperation water projects in ten different basins is reported here, with a focus on the "Guarani Aquifer System Project" (SAG) between Argentina, Brazil, Paraguay and Uruguay that ended in 2009. This study is based on the scientific application of Development Modeling© techniques that help defining, evaluating and classifying degrees of complexity in the management of large international projects.

The study allowed identifying three main concepts explaining sources of conflicts within transboundary aquifers: Innovation, Instability and Uncertainty. First, *the degree of innovation of project processes:* transboundary aquifers cooperation projects being a novelty on which stakeholders usually never worked, thus lacking of references concerning the working process. Second, *the degree of instability of project environment:* to be sustainable, a cooperation project at a transboundary scale has to go through a political dimension which is subject to many changes coming from the environment. Third, *the degree of uncertainty of project decision making:* The combination of degrees of Innovation and Instability reveals project elements that cannot be forecast accurately by stakeholders and project management teams. This can heavily impact the cooperation negatively.

This article shows that preparation is necessary for the cooperation project to be sustainable. Complex projects' modelling is one way to consider the system as a whole and to avoid conflicts, whatever their source. Nowadays, the durability of transboundary aquifers resources does not only depend on technical, but also managerial knowledge and behaviour, and there is a lot to learn from existing best practices.

Key words: Systems modelling, conflict anticipation, complexity, uncertainty, stakeholders' management

CAUSES AND IMPACTS OF CONFLICTS ON TRANSBOUNDARY AQUIFERS (TBAs)

Groundwater, and particularly Transboundary Aquifers (TBAs), have been exploited for a long time through private, public or industrial wells. Some aquifers contain important quantities of fresh water and represent for the population a consequent water supply. However, it's only recently that this resource began to be evaluated as such. Uses and exploitation have started faster than the legal and institutional framework, as well as the knowledge upon this resource, could go.

Groundwater is mobile. It is not stopped by political borders and forms a "pure common pool" resource for a variety of users (Giordano, 2003). Locally, neighbouring property owners' pump into the same resource while internationally, countries have sequential control of the shared water (Matthews, 2005). Disputes over common shared resources originate from two main causes: quality or quantity. At both international and local level, the resource has to face the conflicting demands of the different users. A proper management practice must, on the one side, ensure the equitable allocation of the resource within a context of increasing pressure on water demand (Taylor *et al*, 2010) and on the other side, limit the spread of polluted water throughout the aquifer.

Apart from quality and quantity reasons, some conflicts around TBAs are caused by the nature of those aquifers itself. Aquifers have hydrological and geological specificities that influence the way they are, and should be, managed. The studies into TBAs led by the Internationally Shared Aquifer Resources Management programme (ISARM) show that most of the TBAs are diffusive in nature: part of their water follows a flux. Consequently, any intervention in the aquifer at one location by a user "A" may have environmental and/or economic externalities upon user "B" at another location. This specificity increases the conflict potential degree around aquifers. However, no sweeping generalization can be made upon TBAs: if usually, the appropriation of groundwater is relatively easy, cheap, secure and clean and the water system is diffusive, the example taken in this article, namely the Guarani Aquifer System (SAG) - shared by Argentina, Brazil, Paraguay and Uruguay - shows the exact opposite. Hydrological and geological studies led between 2003 and 2009 through the "Environmental Protection and Sustainable Integrated Management of the Guarani Aquifer" project (SAG Project) show that, unlike most other aquifers, the SAG is confined, non renewable and compartmented. TBAs are not well known to policy makers. Their hidden nature associated to the lack of International law governing shared aquifers invite misunderstandings which may lead to conflicts. (Jarvis *et al*, 2005, Puri and Aureli, 2005)

Conflicts around TBAs can have irreversible impacts upon both the resource and the projects started around it. To name few, the competition towards the resource and over exploitation can lead to the exceeding of the practical sustained yield; conflicts among stakeholders can get the project to abort or have a lesser performance in terms of delay, cost or quality; and, in the broader extent, the dispute can block the whole cooperation process, impede the exchange of data and eventually provoke repercussions on other sectors.

GROUND AND BENEFITS OF SOUND COOPERATION

Be it for a quality or quantity reason, conflicts on TBAs still often appear before any planning scenario can be enforced in the basin. Naturally, stakeholders around TBAs tend to wait for a conflict to emerge to start cooperating. Interviews of thirty-five stakeholders working in the SAG area allowed the identification of two main causes for this issue: first, the stakeholders involved on groundwater in the area don't know on which subject they should start to cooperate; second, they don't see the point in cooperating if there is no problem to face and they place the TBA on a secondary level on their agenda. Moreover, the systems' theory shows that human beings, when facing a complex system, will tend to chose the wrong solution because complex systems behaviours are counter intuitive (Sterman, 2001). Shall stakeholders be willing to cooperate before the emergence of a conflict; they would meet difficulties in framing their initiative. And that is why it is mandatory to anticipate the cooperation but not before modelling it. The cooperation process will be even easier to implement when the TBA is still at its initiatory phase: when no structure has been created, no working process exists yet and not too many elements have to be taken into account (social, uses, juridical...). One prefers building a project on a sound basis rather than an unsuitable one.

Another ground for cooperation comes in with the nature of aquifers. Globally, groundwater is less contentious than surface water. Firstly, aquifers never tend to become legitimate borders. Uses are physically restricted by existing borders. Secondly, in most aquifers or at least in most parts of them, the flux is quite low so environmental and economic externalities have a weaker conflict potential degree. Additional sources of water are less often a source of conflict than scarcity. For the SAG, the groundwater resource was a great factor of coordination and unity between the four countries.

Whatever the hydrological or geological nature of the aquifer, cooperation will always result in a better situation than conflict. This is proved scientifically by the games theory (Von Neumann and Morgenstern, 1944) and the totality principle of the systems theory (Von Bertalanffy, 1968) showing that "The interaction between the parts will prove in a more performing result than the properties that the parts own separately". Taking examples in the field draws the same conclusions concerning the reasons and benefits of cooperation:

- *Financial and economic*: countries will only start cooperation when they are convinced that the cost of cooperation is less than the cost of non-cooperation (Feitelson, 2003). Cooperation has a cost, but it also generates higher benefits than non cooperation (economies of scale,…)
- *Mapping*: Countries cannot know if the aquifer is transboundary as long as they haven't studied it.
- *Networking*: Cooperation strengthens linkages among stakeholders, particularly technicians.
- *Systemic view*: By bringing a wider knowledge of the resource, its hydrological specificities and functions (depth, outcrop area, surface, water table,…) and its stakeholders, cooperation allows having a systemic view of the TBA and ultimately establishing common managerial instruments.
- *Uses*: Particularly when uses are not spread yet, collaboration helps their anticipation. Espacially for deep aquifers, it is mandatory to think years ahead as most of the water is non-renewable.

The SAG is already a source of disagreement between geologists and hydrologists. The first consider that groundwater should be managed separately when the latter believe that surface and groundwater should follow a common integrated approach. Who is in charge of managing groundwater in each country? And what is groundwater for each country? Countries sharing a unique groundwater resource will most probably face the same issues. Cooperation will help them in finding common answers.

DEFINITION OF COMPLEXITY AND SCENARIOS FOR ITS MANAGEMENT

Once proven the necessity of cooperating around TBAs, one shall consider a management strategy for this cooperation. Now, cooperating on TBAs is not easy because TBAs are complex systems, therefore requiring a specific managerial approach. A project is a combination of various functional sub-systems (political, technical, legal, social...). All these systems can be classified in two different fundamental categories: "complicated" systems or "complex systems" (Le Moigne, 1977)There is complexity as soon as there is a high degree of uncertainty for the people involved in the project (managers, decision-makers, scientists…). Uncertainty is the result of two factors: instability and innovation (Daniel, 2010). Following the field of complexity management, hydrocomplexity arises from the "2I + U" (Instability, Innovation and Uncertainty) equation:

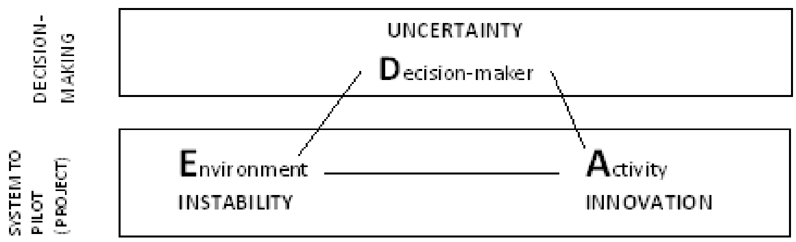

Fig.1 EAD triptych

There is INSTABILITY when the initial conditions of the project, its ENVIRONMENT, are totally or partially new. The degree of instability concerns the means, stakeholders, inputs and resources at the beginning of the project. TBAs involve a large number of stakeholders (well owners, industrial users, geologists,...) with different objectives and suffer from a lack of data. Finally, underground water is a new natural resource for most of the project stakeholders who had never worked on it before. All of these parameters add on the degree of instability of the project environment.

There is INNOVATION when the ACTIVITY carried out to achieve the project results, i.e. the transformation process, the tasks and methods, are totally or partially new. To take the example of the SAG Project, each of the four countries initially possessed its own technique to design a hydrological map of its portion of the aquifer. In order to create a common "mapabase", they had to adopt a common process that was novel for them. In the same way, the project team had to hire oil wells drilling companies instead of water wells drilling because the latter didn't have the ability to drill that deep. For the hired companies, dealing with water was an innovating process.

UNCERTAINTY results from the two previous parameters. As indicated in its name, uncertainty gathers elements that cannot be forecasted by stakeholders and project management teams because these project elements are revealed by the ENVIRONMENT and the ACTIVITY during the project life cycle. Depending on the degree of uncertainty of the project decision making (certainty, uncertainty, risk, unknown), the manager will have to adapt its decision making mode.

Hence, managers of groundwater resources, in order to know the degree of complexity of the concerned system and adopt appropriate strategies, can calculate the degree of instability of the project environment as well as the degree of innovation of the project processes, both resulting in the degree of uncertainty of the project decision making. The definition of "project" used in this article is the one developed by the Project Management Institute: "a project is a temporary endeavour undertaken to create a unique product, service or result" (PMI, 2004). We take here the word "project" in its broad sense, possibly taking the form of an infrastructure, a research, a treaty, an exchange of information, a network, in conclusion, any initiative that the stakeholders could take to cooperate around the TBA. Any form of cooperation must therefore go through a project.

The complexity of TBA's projects make them become highly potentially contentious. Most of the traditional approaches consider a successful cooperation as the absence of conflicts, hence waiting for the conflict to emerge to try and solve it. Chronologically, it places the use of those mediation, negotiation and resolution techniques during the project cycle, after the emergence of the dispute. The complex project modelling approach that will be presented now is one way to consider the system as a whole and a tool to anticipate and prevent conflicts before they appear. Complex project modelling can help in anticipating and driving the changes rather than undergoing them.

THE COMPLEX PROJECT MODELING APPROACH

Taken the fact that TBAs are complex systems, they will automatically follow the paradigm developed by Herbert A. SIMON (1989), according to which complexity exists but is difficult to manage. When facing it, human beings have to clarify it and represent it through an arborescence. Modelling is a way to depict the project. Particularly when considering complex projects for TBAs, it allows clarifying the project by drawing a clear representation of it. The objective of modelling is to name clearly the outputs that must be realized by the end of the project. The SAG project was confronted to the issue that any complex project can face: the whole process was much delayed at first because the Terms of References didn't explain clearly what each stakeholder's mission was. Hence the people involved in the project got confused about what they had to do. The outputs of the project shouldn't be hidden in excel pages of the framework, but rather exposed in bright light.

As a transboundary resource, TBAs are often managed by a team partly composed of politicians. This traditional approach to complex project management of TBAs attempts to mask oppositions in order to find a consensus as quickly as possible gained through ignorance. There is no real object to the discussion but rooms to manoeuvre and power created by uncertainty (Crozier and Friedberg, 1977). This approach is embodied when taking the example of transboundary surface water like the Nile River: the ten riparian countries are now trying to sign a treaty to share the water and one of the options considered to find an agreement is not to mention an exact quantity of water but rather let the contentious article 14.B. vague "Nile Basin States, agree, in a spirit of cooperation, to work together to ensure that all states achieve and sustain water security and not to significantly affect the water security of any other Nile Basin State". This political approach is commonly used nowadays in the field of international laws. It's a political paradigm in the sense that it aims at maintaining the power through hierarchy and top-down decision making.

On the opposite, the Complex Project Management Approach starts by enabling negotiation and makes room for potential conflicts to appear before the beginning of the project. It works through systems and networks and allows all stakeholders to be involved thanks to transversal decision making. This paradigm is based on facts rather than ideas and has for objective to go straight to results, performance indicators, costs and outputs in order to highlight concrete facts. On the opposite of the first approach that we call here "administrative management mode", this latest is called "pragmatic modelling mode".

Nowadays, most of the projects around underground and surface water, and more broadly dealing with development, follow the political approach. We think that we should let behind this paradigm to turn towards a more field oriented project management mode. Field interviews show that most of the stakeholders involved in such kind of project feel limited by the heavy weight of politics that let few margins to initiatives. Most of the time, politics take the gold seat at the project management table. Unlike the traditional approach, the pragmatic modelling mode places politics only as one portion of the whole system, along with others such as: social, cultural, financial, technical, media, academic... Each has results to achieve and all are interlinked: if one of the aspects is falling apart, the whole system will. In most of the projects led only by politics, the projects' outputs are governed by the funding: as soon as the latter stops, the sustainability of the project is threatened. To start the move towards a more systemic way of thinking, it's necessary to start managing projects with more realism, pragmatism and negotiation.

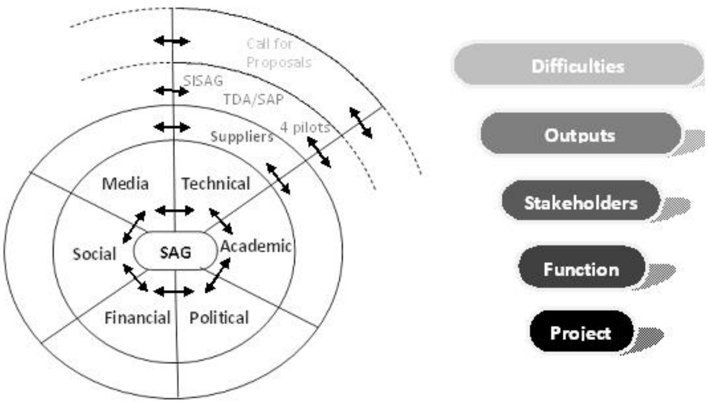

Fig.2 Project Systemic Wheel

Fig.2 shows an example of a more systemic representation of the SAG project. It illustrates the technical domain of the project, for which consortiums were asked to collect the hydrogeological data in the field to create an Information System (SISAG), and ultimately a Transboundary Diagnostic Analysis (TDA). Three main difficulties happened in the technical field: 1/ the Project Implementation Plan (PIP) suffered a 6-months delay that was passed on to all project outputs, including the technical ones; 2/ Because of negotiation issues with the only one company that answered to the first call for proposal, the company that answered to the second call for proposal was hired first but necessitated the outputs of the first one to work; 3/ Resulting of the two first difficulties, there was no time left for the implementation of the technical outputs that were made but never subsequently used by the stakeholders.

All these elements are then placed in the roadmap following the time frame:

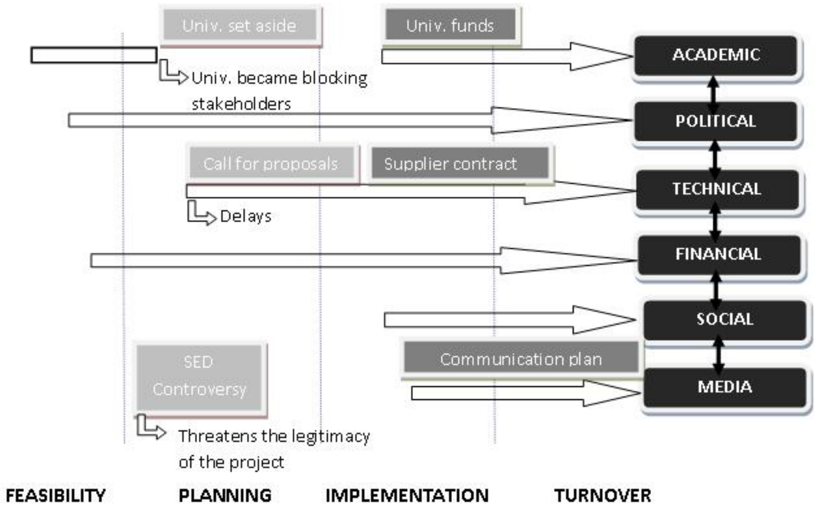

Fig.3 Roadmap

All elements need to be managed simultaneously and have to be integrated from the beginning until the end not to unbalance the whole project. If some aspects are prioritized upon others, it might affect the equilibrium of the system. *Figure 3* shows a simplified roadmap for the Guarani project. The technical issues mentioned above can be found in the technical line. Had a census of the potential companies that answered to the criteria of the call for proposal be made earlier, there wouldn't have been such delays in the realisation of the technical outputs. This issue threatened the whole project as it nearly stopped when the conflict cropped up. Finally the company contract terms were renegotiated, yet preventing the total achievement of the objectives of the technical part of the project.

Concerning the academic domain, the issue is similar. Universities were involved during the feasibility phase of the SAG but then put aside when the planning phase began. Realizing that they were pushed out of the way, some scientists began to challenge all the academic outputs of the project, trying to get the project to lose its credibility. The fourth phase includes again the academic aspects thanks to a fund provided to universities for specific researches. The interruption of the academic timeline provoked troubles that could have been avoided, had universities been included throughout the four phases. Finally, the media domain went through a harsh difficulty when international journalists launched a controversy, partly through a documentary called "*Sed, invasión gota a gota*", saying that the aim of the project was for the Americans to appropriate the groundwater of the Guarani Aquifer. As the communication manager was planned to be hired only halfway during the life of the project, the project manager had to face the controversy. Had communication started earlier, the diffusion of erroneous information about the project would have been avoided.

This representation clearly shows that the domains that were underestimated at some point of time favoured the appearance of difficulties and conflicts. Modelling the project' system allows decision-makers to have a clear representation of all domains and stakeholders and anticipate conflicts.

CONCLUSIONS AND RECOMMENDATIONS FOR THE MANAGEMENT OF TBAS

Complex project modelling is a way to depict uncertainty and guide decision-makers in the management of transboundary groundwater resources. Complexity cannot be represented objectively but it can be simplified to facilitate its comprehension and governance by the stakeholders involved in the project. Some recommendations can be drawn from this methodology and the field study made on the Guarani Aquifer. Many transboundary projects include project management as a component of the project. Instead, piloting the project is a role incumbent upon the project team that needs to be made during the preparation phase of the project, not its realisation. It's important to anticipate and take time to formalize the structure of the project before its launching. Complex project modelling is a tool that assists decision makers in planning their activities by forecasting potential conflict. Nevertheless, public consultations are a key of success to ensure that none will subsequently block the realization of the project. Without cooperation, even the project with the best framework and the best experts cannot reach its goal. So far, project management is often seen by managers as a reporting duty towards bilateral donors. On the contrary, it should help them guiding the project and make sure that no parameter or stakeholder has been underestimated. This way will ultimately tend to a pragmatic modelling and multidisciplinary approach. Needs have now been identified concerning TBAs: need for legislation, need for transboundary institutions, need for data; those needs can be modelled and clarified to ensure the durability of both transboundary aquifers' resources and projects' results.

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