An innovative data platform for multiple stakeholders to aid decision-makers with Knowledge, Education, and Governance in Groundwater resources management

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ABBREVIATIONS

AFD: *Agence Française de Développement*

ARESS: *Atelier pour les Ressources en Eaux Souterraines au Sahel*

BRGM: *Bureau des Recherches Géologiques et Minières*

GW : Groundwater

IFI: International Financial Institution

IO: International Organization

NGO: Non-Governmental Organization

OI: *Operative Intelligence*®

PPP: Private Public Partnership

ABSTRACT

The project supported by the More Water for Sahel Initiative (MW4S) aims to strengthen the capacity of multiple stakeholders involved in groundwater (GW) management in the Sahel to trigger and implement relevant improvements in knowledge of GW resources, in water science education, and water projects governance. The development and implementation of an innovative multi-data and multi-actor digital platform will help to reach this purpose.

In the most arid areas of the Sahel, the stakeholders and decision-makers concerned with water access have to adapt continuously rethinking current practices and act promptly and collectively. They need to be well informed in the three key areas of knowledge, training, and governance to:

- choose among the best political, strategic, and technical options while ensuring consistency at international, national, regional, and local framework;
- drive the implementation of actions in knowledge, training, and governance using in a global approach;
- align water development projects towards two major goals: an effective increase in the available water volume to vulnerable populations to water scarcity and awareness of resource limits.

This represents the rationale of the multi-data and multi-actor platform project illustrated here.

The project stands on three pillars: 1) the accurate characterization of water resources in the Sahel, 2) the promoted know-how sharing, and 3) the strengthening of governance. In this respect, the project adopts a transdisciplinary tool designed in a BlockChain type logic, which is *de facto* accessible to a large number of actors. With a scientific effort to aid in formulating best choices for GW education and governance and to ensure a long-term impact, the needs of each Sahel country will be addressed via

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an assessment on existing reserves tackling the GW renewability and sustainability, understanding the evolution of water balances, harmonizing data collection and sharing mechanisms, state of preservation of natural hydro systems, assessment of wastewater treatment, and so on.

To summarize, the project fosters the cooperation of multiple stakeholders for improving GW management and mitigating the instability in the Sahelian region.

1 INTRODUCTION

Confronted with multiple challenges, the "water" ecosystem in the Sahel must come out of a paradox i.e. the Executive Secretary of the Sahara and Sahel Observatory described: "the real paradox of the region is that, although it has a high water potential, it exploits only a very small part of it, thus allowing only a very low level of satisfaction of the needs".

The water stakeholders and the main decision-makers are encouraged to use the ever precise and readily available scientific knowledge to think and collectively act in a different way. Following the previous works of the More Water for the Sahel Initiative, the project is conceived to give all stakeholders the possibility of knowing and combining the implemented actions in the three key fields of knowledge, training and education, and governance for groundwater resource management.

The main objective of the project is to provide the necessary and relevant information to let stakeholders choose the most appropriate options at each political, strategical, and technical level. This requires that all the actors can guarantee the coherence of all actions undertaken, and to steer their implementation. In response to this requirement, the multi-data and multi-actor platform project based on the three pillars put science at its core with an approach in three distinct parts: 1) the improved characterization of the water resources in the Sahel 2) the better know-how sharing and 3) the governance enhancement.

With the support of the More Water for Sahel Initiative (MW4S), the project entails the designing of a transdisciplinary tool in a BlockChain type logic and making it *de facto* accessible to multiple stakeholders. On one hand, this applied science effort can be tailored to the needs of each Sahelian country ensuring transparency and impact overtime via an assessment of existing GW reserve detailing: renewability and sustainability, water balance evolution, data harmonization, sharing mechanisms, state of preservation state of natural hydro systems, wastewater treatment assessment, etc. On the other hand, the project empowers stakeholders to make the best decisions in terms of education and governance for the available GW resources.

The capacity to combine actions in the three key areas of Knowledge, Education and Governance is key in designing this project.

2 METHODS

Pillar I: Improving water resources knowledge in the Sahel

With regard to the knowledge component, most studies on Sahelian water resources are based on a geological knowledge that is still fragmentary and uneven when compared to the large scale of the Sahel. This despite the existence of reports, which are locally important for the reserves in large sedimentary basins.

In a context characterized by excessive local demands and by unsuitable resources consumption, much effort would be worthwhile vis à vis the GW recharge knowledge and the renewable resources assessment. As a consequence, the following actions are recommended:

1. To characterise different geological environments of the aquifers,
2. the understand the emplacement of sedimentary deposits considering past environments
3. To characterise sedimentary deposits in terms of flow and transport (vertical transport in particular);
4. To identify water paths from the surface to the outlet areas even when outside the borders of a country;
5. To understand the flow dynamics of both surface water and groundwater;

6. To modelize current flow and also of the past dynamics, with paleoclimates on aquifer recharge. The flow in the future will account for e.g. climate change on aquifer dynamics
7. To identify possible contamination enhancing also the know-how on water tracing;
8. To capitalize on the basin knowledge derived by the oil industry.

In all these fields, the latest technological and scientific advances, the resulting exhaustiveness of the range of tools available[5] and the possibility to work on more suitable geographical scales are all opportunities to be seized when the situation evolves positively.

As a consequence, The More Water for Sahel Initiative[6] (MW4S) has advocated successfully that the *Atelier pour les Ressources en Eaux Souterraines au Sahel* (ARESS) - a project under the supervision of AFD with the participation of BRGM and numerous public and private actors - manages, over the next decade, the work to be carried out in terms of knowledge around the seven identified major themes[7]: 1) Observation networks, 2) Large-scale mapping, 3) GW recharge, 4) Satellite image input, 5) Geophysical prospecting, 6) Numerical modelling, 7) Databases.

Since numerous collected GW data remain scattered and/or difficult to access e.g. for the large aquifers (mainly transboundaries[8]), we put particular emphasis on the last selected theme, the database, to better structure, protect, and operationalize data collection, and, when necessary, the know-how sharing. Hence, the project ultimate objective is to set-up an effective collective database for the knowledge of water resources at full scale in the Sahel.

Within this framework, the main actions to be carried out to achieve this interactive database are the following:

1. To carry out an inventory for an analysis of existing data, while ensuring their compatibility;
2. To identify all stakeholders, and national and transnational programs working on databases and exchange platforms;
3. To survey all existing projects;
4. To compare the tools, methods and procedures used to identifying possible pitfalls (feedback),
5. To formulate recommendations using a common language, while ensuring consistency and coherence;
6. To advocate more advanced data standardisation
7. To formalize a comprehensive digital strategy capitalizing on big data processing tools and the integration of the measurement-data conversion;
8. To establish a reference model for data storage;
9. To implement devices offering calibrated provision of validated data.

[5]Examples include the exploitation of spatial imagery and geophysical data acquired by satellites or airborne, the cross-referencing of seismic and magnetic data with radar data, the development of proton magnetic resonance, digital tools for the simulation of 4D flows, geochemical and isotopic tracers.

[6] www.morewaterforsahel.com

[7]Knowledge 1: Observation networks: the aim is to determine which dedicated hydro-climato-geophysical-geochemical observation networks using direct methods (drilling, in situ measurements and sampling) and indirect methods & use/development of innovative methodologies should be set up and put into action:

Knowledge 2: Large-scale cartography: the aim is to determine what complementary cartographic programs the Sahel needs and whether new cartographic programs should be envisaged.

Knowledge 3: Groundwater recharge: the aim is to estimate the renewable resources of the Sahelian aquifers with the current state of knowledge.

Knowledge 4: Contribution of satellite images: the aim is to evaluate the contribution and the limits of the interpretation of satellite images in the search for water in the Sahel?

Knowledge 5: Geophysical prospecting: this involves assessing how to design and carry out multi-method airborne geophysical exploration campaigns.

Knowledge 6: Numerical modelling: this involves identifying aquifers suitable for numerical modelling, acquiring the relevant data and establishing these models.

Knowledge 7: Database: the aim is to structure, protect and operationalise the collection, processing and, where necessary, the sharing of data and knowledge. Note: the development of this axis is at the origin of this project.

[8]In 2017, OSS recalled that of the 608 transboundary aquifers identified in the world, 83 are in Africa and shared between two or more countries.

Besides these perspectives for understanding the water potential in the Sahel, it is necessary to reflect on the best way to gather knowledge, to capitalize on it, and to pass it on to the next generations.

Pillar II: Strengthening education and training on GW issues

During the work carried out by the More Water for Sahel Initiative, it became clear the need to own the above mentioned subjects, and the need to strengthen the education and training component. However, actual ownership is always difficult, even when a project is developed as close as possible to the beneficiaries[9]. The ownership of sustainable solutions and infrastructures are closely linked to feelings of national ownership, and actual technical and financial independence. As a consequence, there is an urgent need to strengthen university cooperation, and to provide further and better training in water science. It is necessary to improve the capacity of national services and administration in the field of GW knowledge to protect and to manage GW resources effectively and efficiently.

Within this framework, this project supports an innovative effort in terms of knowledge and know-how transfer through the "Education/Training" component of the multi-actor multi-data platform project. This will benefit in particular local actors, a *sine qua non* condition to ensure actual ownership of water subjects.

This effort constitutes the priority axis of the project, which could cover the following actions:

1. To provide support for training in hydrogeology in the affected countries;
2. To strengthen the institutional capacity of sub-Saharan states and their ability to bring transformation as a key factor for a long-term development;
3. To involve academic and technical players from European countries (universities and consultancy firms) in a vast program of scientific cooperation between universities and research organisations;
4. To set-up higher education courses for all subjects of interest and to welcoming students at Master level and Ph.D students from the G5 Sahel countries;
5. To empower Sahelian students in hydrogeology providing them an international-level experience in European universities, and integrating them in an international network of tutors and qualified experts;
6. To reinforce a continuous professional education curriculum on water issues.

Over a sufficient long period of time, those actions will allow positive progress both for the knowledge of water resources in the Sahel, and for the advancement of the know-how transfer. This advancement could be measured using four key indicators:

1. Number of trained people;
2. Level of knowledge effectively transmitted;
3. Quality of the provided training courses;
4. Evolution in competences and skills.

However, to ensure a positive evolution of the entire water ecosystem, these actions should integrate the governance dimension of the multi-data and multi-actors platform project.

3 RESULTS

Pillar III: Improve governance

The water projects governance requires accounting for all water dimensions and for all known factors to prioritize the best lines of action to implement under knowledge (pillar I), and education and training (pillar II). Informed decisions allow identifying the best project areas[10], and the funds to be used for the water projects.

[9]Reference is made to the very numerous WASH projects carried out by NGOs and implemented without the intervention of local institutions.

[10] The general idea of the Project Area concept is indeed to place the "water" ecosystem and the actors concerned under the constraint of duly quantifiable results in a zone ranging from 10 000 km2 to 500 000 km2 , where it would be possible, under the direction of the competent local authorities in the matter, and after a precise analysis of the critical spots (zones of approximately

In this respect, pillar III can be seen as the result of actions carried out under pillars I and II. It should be considered as a decision-making tool to design, plan, and implement comprehensive approaches and to identify the right priorities at the right place and moment in time. As an example, this tool should empower relevant actors to select the appropriate actions and chosen among the six axes defined in the framework of the ARESS work co-facilitated by BRGM and the More Water for the Sahel initiative[11].

The main advantages of the proposed project are the followings:

- Mitigating excessive compartmentalization of fields of activity;
- Connecting all relevant experts and actors at local, regional, national, and international levels;
- Putting current and past actions in a multi-scale, multi-level, multidisciplinary, and multi-temporal logics;
- Identifying demands for new and/or complementing actions;
- Informing and shedding light on various issues to aid decision-makers.

A further project added value is to capitalize on high-performance digital tools to build a unique and high-performance integrated information system, which enables stakeholders and decision-makers to think and to act in a logic of "*operative intelligence*®"[12]. New Information Technologies de facto allows us to think differently about the architecture of the Sahelian water ecosystem and to manage its evolution

5 000 to 10 000 km2 characterised by a water availability lower than the WHO minima) to integrate all the actions envisaged within the framework ".framework of "Water Peace Operations" ("Water Peace Operations") and thus combine the planning and implementation dimensions in the three key dimensions of Knowledge, Education and Governance. This is the added value brought by the global approach put forward in this project. The choice of project areas can be subjected to the sieve of five key criteria:

1) the multidisciplinarity of the project teams (do the responses to be provided require a coordinated pooling of multiple expertise and diverse know-how, and de facto the implementation of collective approaches),

2) the degree of innovation required to succeed (is it relevant to innovate or not in the answers?) ,

3) their sustainability (are the ongoing or planned actions sustainable?) ;

4) their impact in the short, medium and long term (will the planned actions contribute, for the most exposed populations, to an effective improvement in the level of accessible water) ;

5) the feasibility of the projects (is groundwater available in the long term, can it be mobilised and at what cost? Are there sources of funding).

[11]Governance 1: Protecting and rehabilitating the resource: Water quality is threatened or even deteriorated in certain sectors (saline intrusions, nitrates, heavy metals, etc.). How can vulnerable zones and contaminated sectors be identified and how can water quality be restored over time?

Governance 2: Increasing the resource: Among the tools to increase the mobilizable resource, is artificial recharge conceivable in the Sahel? Is the recycling of wastewater for aquifer recharge relevant and under what conditions?

Governance 3: Access to the resource: In certain sectors, particularly in the basement zone, the failure rates of water drilling are high. What methods can be used to reduce them?

Governance 4: Sharing the resource: How can knowledge and management of transboundary aquifers be improved?

Governance 5: Project design, monitoring and post-evaluation: How to improve project design, monitoring and post-evaluation?

Governance 6: Access in the areas concerned: How can the scientific world be given back the possibility to operate in safety in these areas and be guaranteed the necessary freedom of action?

[12] Combining collective intelligence, strategic sense and capacity to implement a project, *Operative Intelligence*® is a concept formalised by Emmanuel de Romémont, after having been practised in many operational contexts. Thinking and developing *Operative Intelligence*® answers a simple purpose: to link the conception and the operationalisation of strategies, while optimising the use of the resources required for this and reducing the time required to reach the defined goals. *Operative Intelligence*® is based on a quadruple requirement: 1) A permanent alignment of the strategy with its execution, 2) The convergence of all the actions carried out, 3) A deep understanding of the underlying dynamics, 4) The integration of the different plans, periods of time, fields of action and stakeholders. In other words, *Operative Intelligence*® allows both to guarantee that the execution accurately reflects the strategic decisions and to simultaneously adjust the strategy according to the feedback on the execution, to think about the transformation of an environment, to apprehend the underlying dynamics, to adjust the information flows, to shape the fields of action, to then facilitate decision-making and finally to architect and pilot the execution, all this while fully exploiting the relevant leverage effects. By choosing both what to do and what not to do, by widening the room for manoeuvre and avoiding counter-productive compartmentalisation *Operative Intelligence*® tends to reduce as much as possible the gaps between Thinking, Deciding and Acting, to combine several know-hows and skills: Designing a strategy and operationalizing its execution in an agile, coherent and efficient way, with adjusted information flows, applied systemic thinking and reinforced collective intelligence.

for the interested populations. This project seizes this opportunity connecting experts specialized in the analysis of decision-making processes, and the design, construction, and implementation of complex digital projects.

The digital platform will provide a predictive knowledge of the evolution of GW resources, and allow a transparent analysis of various issues to aid stakeholders in the adjustment of goals, modalities, and means. Decision-makers will have the instruments to align undertaken actions for two major goals: the effective increase of the available water volume for populations exposed to water scarcity and raising awareness on the limits of these resources.

Conclusions

Convergence knowledge represents the keyword of the illustrated project. Since the state of the art of Information and BlockChain Technologies enables considerable progress in managing data and complex programs, we advocate for a combination of a well-adapted digital GW data strategy to design and implement an encompassing multi-data and multi-actor digital platform.

This pioneering approach will represent a remarkable asset for decision-makers offering greater visibility on Sahelian GW resources and various ongoing and planned projects. Furthermore, easy, secure, and calibrated data access to multiple stakeholders - Sahel countries, scientific communities, donors and companies, IFIs, Public-Private Partnerships, etc.- will be ensured. The shared knowledge will help identify new virtuous pathways to ameliorate agriculture, to foster economic development, and to improve population living conditions in the most arid and least secure areas of the Sahel. Finally, it will facilitate cooperation and foster joint actions among stakeholders, including transnational cooperation, to bring new positive perspectives in GW management.

In conclusion, the project presented in this article enhances trust and transparency yielding to relevant, streamlined, sustainable infrastructure and technical assistance investments, and a positive impact on the economies via e.g. sustainable water solutions in large cities. The innovative data platform focusing on knowledge, education, and governance in GW resources management will contribute ultimately to the stability in the Sahelian region.

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