



OBSERVATOIRE DU SAHARA ET DU SAHEL  

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SAHARA AND SAHEL OBSERVATORY



« Managing Hydrogeological Risk in the Iullemeden  
Aquifer System (IAS) »  
Mali - Niger - Nigeria

Policy elements for transboundary risks  
reduction of the Iullemeden Aquifer  
System (IAS)

*March 2008*

## 1 - INTRODUCTION

Within the framework of the project "Managing hydrogeological risks in the lullemeden Aquifer System (IAS)", Mali, Niger and Nigeria, sharing the IAS, combine their efforts to prevent and/or attenuate the potential risks which threaten their water resources in order to ensure their management. The lullemeden Aquifers System includes mainly the two aquifers of the Continental intercalary and the Continental Terminal. It covers a surface of 500,000 km<sup>2</sup>. The development of elements of policy for the reduction of the transboundary risks of the IAS, appeared as a need which consolidates these efforts and consolidates them.

The project "Managing hydrogeological risks in the lullemeden Aquifer System (IAS)" is financed by the Global Environment Funds (GEF) within the framework of the international Waters and implemented by the Observatory of the Sahara and Sahel (OSS), like an action making it possible the countries concerned to ensure a better management of these water resources for a durable development of the area.

The components of the project making it possible to work out the elements of policy of reduction of the transboundary risks of the IAS are as follows:

- identification of the transboundary risks;
- establishment of a tripartite mechanism of dialogue for the transboundary risk management;
- reinforcement of sensitizing, the participation and the communication.

The transboundary risks suitable for affect subsoil waters of the Continental Intercalary and the Continental Terminal were analyzed and evaluated through step TDA/SAP (Transboundary Diagnostic Analysis / Strategic Action Programme) recommended by the GEF for International Water adapted to transboundary subsoil waters of the Aquifers System of lullemeden.

In this case, the Transboundary Diagnostic Analysis (TDA) is an analysis based on the study of the scientific and technical facts relating to the aquifers and the conditions of use of their resources. The TDA, based on technical and scientific information available and checked, made it possible to examine the state of the water resources of the IAS as well as the major causes of their degradation.

In the framework of current project IAS, only the Transboundary Diagnostic Analysis was realized. It was carried out by the National Committees of Coordination and Follow-up of the activities of project (CNCS) through national consultations, on the basis of information and data existing and available in the countries. The CNCS is a framework of reflexion which was set up in each country, in order to ensure a national vision translating the position of the national partners concerned. It gathers the representatives of the national institutions concerned with the management of subsoil waters. This reflexion is the fruit of periodic meetings and contribution of the members of the committee to identify the risks which threaten the water resources of the IAS in the light of the orientations of the country for the development of these resources. The Committee was also charged to examine the investigations carried out by the national consultants and to discuss the results of their reports.

A document of the Transboundary Diagnostic Analysis of the IAS was produced by the OSS and was validated during a regional workshop held in Niamey February 06<sup>th</sup> and 07<sup>th</sup> 2008.

In addition, the OSS carried out the development with the active participation of the countries, of the management tools of the water resources of IAS (Database, GIS, and Model). The mathematical model of the IAS made it possible to present a better evaluation of its water

resources as well as conditions of the development of the abstraction in the future. Indeed, this model specifies the water assessment on the scale of the basin highlights the hydraulic relations between the aquifers and the Niger River and underlines the impact of the exploitation in each of the three countries out of the two others. It also highlighted the evolution of the taking away compared to the renewable resource whose threshold of overexploitation was crossed in 1995, year as from which the abstraction estimated at 152 million m<sup>3</sup> exceed the average recharge estimated at 150 million m<sup>3</sup> in 1970.

### **Object of the study**

The development of the elements of policy of reduction of the transboundary risks of the IAS like those of the strategy of development and conservation of water and the grounds of the IAS, must take into account the analysis and the evaluation of these transboundary risks identified as well as the results and products obtained within the framework of current project IAS.

The elements of policy and strategy to mitigate these risks integrate dimensions policy, socio-economic and environmental. These strategies include among other things, the programs aimed for the reduction of poverty (Strategy of the Reduction of Poverty), the management of the request for the suitable and efficient use of water and the grounds, the policy of the right (of access) to water and the ground taking of account the price of water and the aspects land, the intensification of the human activities in the zones of refill of the aquifers, the regulation and follow-up of the water points, the joint use surface water - subsoil waters, the harmonized policies of responsibility for the prevention (early alarm compared to the transboundary risks).

The elements of policy for the reduction of the risks must refer to a legal and institutional framework making it possible to work from the point of view of attenuation of the risks. An analysis of the legal and institutional instruments of the three countries was already carried out with the technical aid of FAO It led in particular to the production of groundwork of draft-agreement between the three bearing countries on the creation of the tripartite mechanism of dialogue for the management of the IAS.

During a regional workshop held in Tunis March the 10, and 11 2008 animated by the OSS and gathering the representatives of the countries, the broad outline and the principal elements of policies of reduction of the transboundary risks, are defined, by taking account of 1) hydrogeological and environmental, 2) socio-economic, and 3) legal and institutional (**Tabl. 1**).

**Table 1:** Matrix of problems for "the development of the elements of Policy of reduction of the transboundary risks of the lullemeden Aquifer System (IAS)"

	<b>Reduction of water resources</b>	<b>Water quality degradation</b>	<b>Impacts of Climate Change / Variability</b>
Hydrogeology and Environment	<p><u>Issues:</u></p> <ul style="list-style-type: none"> <li>• Ignorance of the water resources and the insufficiency of the monitoring of the resources.</li> <li>• Lower productivity of the works,</li> <li>• Absence of environmental impact study in the programs and the projects of realization of water points</li> <li>• Destruction of ecosystems</li> </ul>	<p><u>Issues:</u></p> <ul style="list-style-type: none"> <li>• Miss perimeter of protection on the level of certain fields of collecting</li> <li>• of purification</li> <li>• Pollution of groundwater and soils due to over use of pesticides used by agriculture</li> <li>• Solicitation of deep water fossils of bad qualities</li> </ul>	<p><u>Issues:</u></p> <ul style="list-style-type: none"> <li>• Reduction of rainfalls generating the recharge of the aquifers</li> <li>• Deforestation and degradation of land cover</li> <li>• Silting the hydrographic network</li> </ul>
	<p><u>Solutions suggested:</u></p> <ul style="list-style-type: none"> <li>• Improvement of knowledge of the water resources which result in the installation of a network of regular follow-up of the resources water as well as the determination of the hydrodynamic parameters of the aquifers of the SAI.</li> <li>• The actualization of the data on the resources to allow a better simulation of aquifers by the mathematical model known SAI.</li> <li>• The development of techniques of artificial refills of tablecloths using no conventional water (treatment and recycling of industrial water) and if possible starting from water of the Niger River.</li> <li>• The realization of environmental impact studies in any programme and project of execution of new water points.</li> <li>• The safeguarding of the wetlands through the plantation of the suitable forest species</li> <li>• The definition of the perimeters of protection of field of collecting of the water points</li> <li>• Conservation of the vegetable cover which supports the infiltration of water (CES/DRS)</li> </ul> <p>Rational management of the pastures</p>	<p><u>Solutions suggested:</u></p> <ul style="list-style-type: none"> <li>• management of solid waste and liquids</li> <li>• rational use of manures in agriculture and good management of their conservation</li> <li>• rational use of manures and pesticides in agriculture</li> </ul>	<p><u>Solutions suggested:</u></p> <ul style="list-style-type: none"> <li>• The development artificial recharge techniques of aquifers using no conventional water (treatments and recycling of industrial water and if possible from Niger River)</li> <li>• The preservation of the forests through the plantation of the suitable forest species</li> </ul>

**Table 1 (continued):** Matrix of problems for "the development of the elements of Policy of reduction of the transboundary risks of the Iullemeden Aquifer System (IAS)"

	<b>Reduction of water resources</b>	<b>Water quality degradation</b>	<b>Impacts of Climate Change / Variability</b>
Social and economic	<u>Issues:</u> <ul style="list-style-type: none"> <li>• impact of continual increase of the population which increases the demand for drinking water,</li> <li>• development of agricultural techniques of productions (irrigation): what increases the abstractions,</li> <li>• Increase in livestock which exploits the quantity to take.</li> </ul>	<u>Issues:</u> <ul style="list-style-type: none"> <li>• Negative impact of the increase in the population involving the development of the urbanization with for consequence production of solid waste and liquids degrading the quality of water, and generating risks of diseases</li> <li>• Development of the irrigation involving the use of the chemicals involving the contamination of subsoil water and surface.</li> </ul>	<u>Issues:</u> <ul style="list-style-type: none"> <li>• -The reduction of rainfall and desertification which generate the concentration of the populations at places favourable with their socio-economic activities (agricultures, breeding...)</li> <li>• Increase in the temperature, the gases (CFC) reduction of rainfall which involve problems of recharge of the aquifers with the increase in demand,</li> </ul>
	<u>Solutions suggested:</u> <ul style="list-style-type: none"> <li>• Use of suitable techniques and technologies</li> <li>• to save water (Crop varieties and vegetable consuming little water, use of effective techniques of irrigation),</li> <li>• rationalization of the use of drinking water</li> </ul>	<u>Solutions suggested:</u> <ul style="list-style-type: none"> <li>• waste treatments,</li> <li>• Use of bio-pesticides,</li> <li>• sensitizing of the populations</li> </ul>	<u>Solutions suggested:</u> <ul style="list-style-type: none"> <li>• Adaptation of the populations to the use of ground space of dwelling, agriculture</li> <li>• Use of cultures consuming little water,</li> <li>• Vulnerability assessment</li> </ul>

**Table 1 (end):** Matrix of problems for "the development of the elements of Policy of reduction of the transboundary risks of the Lullemeden Aquifer System (IAS)"

	<b>Reduction of water resources</b>	<b>Water quality degradation</b>	<b>Impacts of Climate Change / Variability</b>
Legal and Institutional	<p><u>Issues:</u></p> <ul style="list-style-type: none"> <li>• Absence of framework of dialogue on the scale of the basin of the SAI</li> <li>• Insufficiency of regulations of the management of water,</li> <li>• Ignorance of the regulation</li> </ul>	<p><u>Issues:</u></p> <ul style="list-style-type: none"> <li>• Lack and/or not application of legal and institutional instruments relating to discharge and rejection of industrial and domestic waste in the rivers and the groundwater aquifers,</li> </ul>	<p><u>Issues:</u></p> <ul style="list-style-type: none"> <li>• Slowness in implementing the three international conventions (CCC, CBD, Desertification)</li> <li>• Difficulty of application of the legal and institutional instruments related to the climatic risks of variabilities</li> </ul>
	<p><u>Solutions suggested:</u></p> <ul style="list-style-type: none"> <li>• To finalize and approve the project of draft-agreement relating to the mechanism of dialogue between the 3 countries.</li> <li>• Drafting of legal texts founding of the authorizations of taking away of water and realization of hydraulic works,</li> <li>• To elaborate / finalize and/or implement the policies and strategies regarding transboundary risk management</li> <li>• To develop principle of IWRM,</li> </ul>	<p><u>Solutions suggested:</u></p> <ul style="list-style-type: none"> <li>○ To found the principle pollutant-payer,</li> <li>○ To take legislative and administrative notes founding authorizations of discharges and rejections of waste,</li> <li>○ Founding suitable measurements of exploitation of the mining careers,</li> </ul>	<p><u>Solutions suggested:</u></p> <ul style="list-style-type: none"> <li>• To create and/or implement the legal and institutional frameworks relating to the National Action Plans of Adaptation to the climatic changes,</li> <li>• To develop an early alarm system on the scale of the basin</li> </ul>

## 2 - RECALL OF THE PRINCIPAL TRANSBOUNDARY RISKS

Through the knowledge acquired and reinforced by the various products of the project (reports of the consultants and the national coordination and follow-up, hydrogeological model and produced committees database and GIS), the regional document of the Transboundary Diagnostic Analysis was produced and validated at the time of the regional workshop held in Niamey (Niger) from the 06 to February 08, 2008.

This document makes the synthesis of the principal hydrogeological risks identified in the IAS by adopting step TDA/PAS recommended by the (GEF) as approaches analysis and evaluation of the environment considered as well as the causes of its degradation. This analysis was carried out in a transect way while being focused on the transboundary problems without being unaware of the national concerns and priorities.

The list of the risks identified for the IAS, in the countries, according to this represented process: 14 risks in Mali, 8 in Niger and 24 in Nigeria. These risks were subjected to an analysis which makes it possible to be ensured of:

- the transboundary nature of the identified risk,
- the range of the risk compared to the national priorities and regional and international conventions as well as the various world initiatives,
- impacts of the risk on the economy, the environment and human health,
- anticipated profits with the examination of the risk.

This analysis reveals that certain of these risks are its causes or consequences and/or impacts. Other transboundary risks interest especially the natural resources of surface and particularly the loss of the biological biodiversity. A specific analysis of these risks, in the regional vision, emphasizes three principal risks which can be regarded as a concern major common to the three countries and for which the efforts of only one country could not find a solution remediable and durable. These risks are:

- **reduction in the water resources:** it is due to the combined effects of the progressive taking away, and the reduction in the refill of the aquifers because of the climatic change in the area. This type of risk is characterized by the modification of the subsoil water potential in terms of reduction or scarcity of the resource. This reduction can be due to the combined effects 1) of the progressive taking away, and 2) of the reduction of the recharge of the aquifers because of the reduction in rainfalls.
- **water quality degradation:** it is identified with the pollution of the aquifers because of the infiltration of the water discharges used under conditions which do not meet the standards of quality, and with the abnormally mineral-bearing subsoil water call (fluorides)
- **impacts of climate and variability changes:** The climatic risk itself appears by its randomness because of the occurrence of the climatic extremes (droughts, floods) during the years and the decades to come. The climatic total models are more developed for surface water (in particular rain) than groundwater.

The type of risk related to the impacts of variability and/or climate changes is characterized by 1) the stranding of the hydrographic network of the Niger river which reduces its food by groundwater resulting from the aquifers of Ci and the CT and supports increasingly frequent floods, 2) the installation of the sandunes in the surfaces of recharge and on vegetable cover reducing the infiltration of rainwater in

particular, 3) the adjustment of the wetlands by the populations having migrated from the desert zones.

On the basis of thorough analysis of the three transboundary major risks as well as the matrix of the problems whose development by the countries was facilitated by the OSS, the three countries were appropriate of the structure of the regional document to produce in order to develop the elements of policy to reduce these three transboundary risks. The following chapters present these elements resulting from the points of view of each country.

### **3 - POLICY ELEMENTS FOR THE REDUCTION OF MAINS RISKS**

The elaboration of the elements for the policy of reduction of the major risks faced by the IAS water resources is an attitude that must be shared by the involved countries concerned with the exploitation of these Resources. This attitude reflects a common awareness of the question and the necessity of mitigating them or overcoming them if possible. This attitude can be achieved only if we are convinced of the scope of the measures to be undertaken and their efficacy. It is through a good knowledge of the aquifer system and its reactions that such predisposition is expected from the various stakeholders involved in the management of the IAS water resources.

The three countries have developed national water policies (Niger 2001, Mali 2004, Nigeria 2004 draft) which take these policies into consideration reducing risks through the following major points:

Improving knowledge of and controlling water resources

- improving coverage of water needs of the population and livelihood through the setting up of new water points and a programme for the rehabilitation and maintenance of existing works
- ensuring the active participation of the populations in the conception and realisation of works, improving the operation of the infrastructure and clarifying and respecting the roles of the different partners (State, Communities, Sectors, Private operators, benefiting Communities) and securing the exploitation rights.
- ensuring the protection of the population and property against aggressive actions as well as the protection of water resources against the various forms of pollution.
- promoting sub regional and international cooperation for the management of transboundary waters in order to avoid conflicts arising from their uses
- generally the three countries have set as national objectives ensuring socio-economic development through the development of water resources. To this end the Integrated Management of Water Resources (IMWR) has been adopted as an approach for the management of this sector with as objective the rationalisation of its use and avoiding competition between the sectors.

This approach adopted in each country requires consultation efforts and planning in order to preserve the resources and at the same time achieve the objective of the National plans.

Within the framework of the IAS the current situation, for the use of water resources reflects the beginning of a uncontrolled abstraction between the three involved countries. It is for this reason that setting up a common vision for the reduction of risks threatening the water resources at the level of the IAS Basin, should seek to analyse the risks and the means of the mitigation within broader global consultation framework



### **3.1 - Reducing risks related to the dropping availability of Resources**

#### **3.1.1 - Hydrogeological and environmental aspects**

The exploitation of waters using high flow works leads to the modification of piezometric heads because of the creation of concentric depression cones. These depression cones spread in all directions across international borders threatening the ultimate water resources in the low development regions.

Within the framework of the numerous hydraulic programmes realised in the basin, many artesian drillings have witnessed remarkable drop in the artesianism.

It was equally noted that general drying is affecting the IAS ponds caused by climatic changes. These ponds have generally been affected by siltation. This gradual drying up of the ponds has resulted in the extinction of important fauna and flora varieties and species.

Many hydrogeological studies have revealed an important interference between the tapping of the aquifers and the quality of the river waters supplied by these aquifers. In the case of the IAS this interference is reflected in the running of Continental Terminal and Continental Hamadien waters into the Niger River. (Tirat, Greigert, UNDP/DTC etc). The Niger river and its tributaries in IAS part, with the reduced flows from the source even, are not capable any longer of diluting and are causing the biodegradation of the effluents of the neighbouring communities whose drainage is never perfect. Guaranteeing a minimum flow capable of ensuring the quality of surface waters. This is an objective that could be assigned to ground waters of the IAS. The discharge through the many spring lines constitute therefore a quality source for the entire hydro system.

Rather than preserving a flow, we may equally choose to maintain a piezometric level. Maintaining the activity of natural wetlands, particularly those recognised by Ramsar Convention (W Park, many forests reserves in IAS areas) are equally part of the objective of our policy in reducing environmental risks.

Other consequences include soil erosion engendered by the degradation of the vegetation cover as well as major environmental problems (drought, desertification) and the low income of the population limiting increases in agricultural production.

To reduce the above mentioned hydrogeological and environmental risks, the following measures are recommended;

- Reconnaissance studies involving geological, geophysical and hydrogeological areas within the framework of elaborating regular synthesis of the totality of the knowledge of the basin as a whole.
- Setting up an optimal network for the quantitative measurement of water resources
- Assess renewable and exploitable resources at the local level for each of the aquifers.
- Map the Aquifer recharge zones and restrict the attribution of housing licences at the level of these recharge zones and provide preventive measures to the inhabitants.
- Define and ensure the respect of regulation standards related to the tapping of water by the setting up of a water police, applying the principle of user/payer.
- Systematise impact studies within the framework of setting up surface water retention works upstream the aquifer recharges require that water point management committees, water users associations, water exploitation and supply companies, agricultural users, industries and mines which tap important amounts of ground waters submit regularly the amounts of water tapped or exploited.
- Carry out reliable systematic estimations of tapped waters by the concerned technical departments for exploitation drills, village and pastoral wells not equipped with meters.
- Link the common data base through a map server interconnecting the three countries.

- Promote meetings of water resources experts so as to exchange experiences and data.
- Promote the recharge of aquifers through a better infiltration of water using dams, planting trees, and protecting banks, etc
- Sensitise, inform and train all stakeholders
- Shut down or rationally use all artesian drills which are causing the dropping Aquifer water resources
- Generalise over the entire basin the implementation of authorising setting up high flow water works.
- The only means of maintaining the piezometric level is limiting or totally suppressing non controlled or useless tapping of water in the CT and CH water sheets.
- Combine the simultaneous use of surface waters with ground waters in order to reduce pressure on ground waters.
- Carry out Environment Impact Studies before the implementation of major development projects
- Recycle waste waters and capitalise their new uses

### **3.1.2 - Socio economical aspects**

The majority of the population in the IAS lives in the rural areas and makes its income essentially from agriculture and livestock.

Low rainfall conditions and continuous population growth gives rise to large water demand that will lead to increased abstractions, thereby influencing water availability in the basin. A reduction of water resources in the IAS basin will generate several consequences among which are migration and social conflicts.

In urban areas human habitation entails a reduction of surface infiltration and that, in turn, results in a decrease of recharge and an increase in solid and liquid wastes production.

Groundwater in the IAS is both a natural and an economic resource: this duality generates conflicts and makes the management complex, politically.

Though water has an economic value it cannot be considered as merchandise in the basin. Because of the socio-economic implications of its decreased availability, the management of the groundwater in the IAS requires cooperation among the sharing countries.

To satisfy the needs of all users (villager, urban, industrial and pastoral), the States in the basin must set up an institutional framework to guarantee sustainable management of the waters of the system.

Already, the States of the basin are experiencing the GIRE as strategy.

On the socio-economic side, the following propositions are made in order to reduce the risks of resource reduction:

- to ensure that water development programs have a positive impact on the environment and the population
- to exploit water resources rationally
- to encourage the involvement of the private sector in the management of water resources

- to fight against water waste by optimising water use (technique of tastes to tastes) while recycling used water and reducing water leakage in irrigation works and water delivery systems;
- to establish a planed scheme of management of groundwater on a long-term basis;
- to carry out research and development that will provide sufficient knowledge on trans-boundary waters for decision making;
- to discontinue fallow practices particularly in recharge zone fields;
- to discontinue use of organic manure and bio pesticides particularly in recharge zones;

### **3.1.3 - Legal and Institutional aspects**

For a long time, in some countries, the environment was limited to the forestry resources. But in 1980's a holistic approach that took into consideration the global dimension of the environment came into play.

The conflicts related to the natural resources exploitation arise mainly from the exploitation of the resources (land, forest, water and pastoralism) for various purposes.

Thus, an uncontrolled management, as well as, excessive exploitation of groundwater resources depletes its availability. Also, only a good policy at the level of the basin and a regulation of water usage (national norms, regional and international agreements and conventions) will lead to an equitable and sustainable management of the resource of the basin.

In the countries of the IAS, as everywhere else, the policies concerning management of resources like water take into account the international policies to which they subscribe.

The roadmap to achieving developmental objectives of the IAS must take in account the following solutions:

- coordination at the sector level;
- improvement of the monitoring and evaluation at the sector level;
- tools of programming and financing;
- governance in the water sector;
- Integrated Water Resources Management (IWRM)
- creation of an institutional framework assigned to monitor/assess the implementation of policies and laws in the sector.
- to regulate by authorization and concession the realizations and withdrawals of underground water subject to present a danger for reduction of the resource and harm the stream flow of water;
- to submit all activity linked to the use of underground water to an environmental impact assessment study;
- To make all stake holders (planners, decision makers) participate in the formulation, the implementation and the assessment of the national water policies
- to manage problems linked to water at the basin level by implementing the Integrated Water Resources Management (IWRM);
- to elaborate legal texts rationalizing water use for all utilisations;
- to prevent and to manage conflicts linked to the resource use at the basin level;

- to support legal processes and institutional reforms concerning the management of water resources at State level;
- finalise and approve the MoU project related to agreement mechanism between the three countries of the IAS;
- to harmonize national legislations related to water by taking into account the international water conventions;
- to decentralize the responsibilities and expertises so that the decisions are taken at the level where problems are risen and the involvement of all users;
- to sensitize, inform and to train actors on the legislative texts, and laws;
- to implement an observatory of basin
- to assure the durability of the projects
- to promote an equitable and sustainable development without compromising the future generations,
- a clear definition of functions and responsibilities of each actor for implementing different activities in water sector at the basin level.

### **3.2 - RISK OF THE DETERIORATION OF THE QUALITY**

#### **3.2.1 - Hydrogeological and Environmental aspects**

The groundwater resources of lullemeden Aquifer System are threatened with the deterioration of their quality compromising the access to drinking water to the populations and the achievement of some Objectives Millennium Goals for Development.

In the IAS zone, groundwater is exposed to two major causes for their quality degradation. It is due to pollution from various origins and the abstraction of groundwater with bad quality.

The pollution is generated by human activities. This pollution is caused by waste waters (urban, industrial) in the aquifers because of the growth of the urban populations and to the weak rate of expansion of sewerage network, to the evacuations of raisings, the use of the chemical manures and the products of pesticides treatment.

The deterioration of groundwater quality also comes from the conditions of structure of the aquifer. Thus, in the thick and heterogeneous aquifers, water quality is not constant according to the depth. During the weariness, the quality of water also deteriorates in the lower horizons.

The deterioration of water quality of the aquifer in exploitation can also result from an exchange (leakance) between several aquifer superimposed (or multilayered) of which some have waters with bad quality.

Mali, Niger and Nigeria, to protect their water resources in order to guarantee to the populations acceptable quality water, have defined clear and common appropriated measures to this effect. These measures are as following:

- to define and map areas of vulnerability to the pollution of the aquifer in the IAS;
- to monitor the use of fertilizers and pesticides;
- to monitor the quality of water during the exploitation of aquifers;
- -to protect the areas of recharge of the aquifers against pollution;
- to install protective perimeters around water points to preserve them from pollution
- to sensitize and train all actors on the risks of pollution of the aquifers;

- to advocate for the good management of liquid and solid waste;
- to monitor water quality using chemical, bacteriological and isotopic techniques ;
- to establish a public and private partnership for the protection of the water resources quality;
- to respect the waste water guidelines for the prevention of the deterioration of water resources quality
- to apply the principle of “ polluter pays”;
- to sensitize the population on the use of recycled waters and to control the losses of water through leakages
- to create and/or to reinforce the national reference laboratories for water quality monitoring,
- to control water abstractions.

### **3.2.2 - Socio-economic aspects**

In order to avoid the deterioration of the water quality in the basin, a policy concerning purification and water quality monitoring must be put in place.

Rapid growth of population in urban centres leads to depletion of resources of the towns and consequently a decrease in the incomes of the dwellers. In addition, the urban centres produce enormous quantities of waste for which the present systems of collection, evacuation and treatment prove deficient to handle.

Finally, the industrial units and other unsanitary establishments built in urban environments constitute real sources of pollution of the surface and groundwater, while there is lack of adequate treatment plants.

At the end of the installation of water schemes, water quality must be controlled and monitored.

To remedy these problems, some solutions are proposed:

- to avoid water quality deterioration in the basin, a sanitation policy and quality monitoring is implemented.
- to solve these problems, some solutions are proposed:
- to adequately distribute water schemes cover population and livestock needs;
- to make amenities around the water points and in cities to evacuate the wastewater (liquid garbage)
- to transform solid and liquid waste for their reuse;
- to carry out environmental impacts assessment studies when installing big works (Mines, roads, oil etc.);
- to identify and to restore zones affected by pesticides
- to encourage community and private management of water points
- to encourage local manufacture of water delivery equipments and chemical treatment of water in the basin
- to reinforce the training of the actors in water delivery
- to adopt a cost shared approach for investment, functioning and maintenance in national policies for water delivery and sanitation

- to enhance national capacities to run and manage water delivery and water sanitation systems
- to define quality norms for all water uses in the IAS (while taking into account WHO norms for drinking water).
- to monitor the performance of the sector to ensure a good development policy in drinking water delivery and sanitation systems
- to establish the principle of 'polluter pays'.

### **3.2.3 - Legal and Institutional aspects**

The water Resources Management in the basin in general, and sanitation in particular, are the concerns of the different countries for which a political consultative mechanism has to be put in place.

To reduce the water quality degradation, it is necessary to do the following arrangements:

- to create consultative bodies (national Council, regional and local Council, basins Committees and sub-committees) which give opinions and make propositions in water resources management and planning projects;
- to set a Coordination Committee of Water Sector and sanitation (CCSEA) the basin level;
- to do a common thinking and dialogue mechanisms to warn, arbitrate conflicts and the damages linked to pollution;
- to apply the principle 'polluter pays' to mobilize financial resources on one hand and to push users to reduce pollution
- to regulate polluting activities in vulnerable zones to preserve water quality
- to keep and protect environment against water degradation
- to control exploitation of water resources
- to encourage watershed management
- to control water quality
- to require Environmental impact assessment Studies for the installation of water schemes
- to define protective zones in order to preserve water quality and overexploitation,
- to put in place a mechanism for conflict resolution.

## **3.3 - RISKS LINKED TO CLIMATIC CHANGES AND VARIABILITIES**

### **3.3.1 Hydrogeological and environmental aspects**

In the IAS zone, the climatic changes had generated a rainfall decrease during these last 30 years.

These climatic changes appear mainly by a tendentious decrease (11 to 43%) of the rainfall since the end of sixties, with recurrent droughts that affected significantly the regime of watercourses, lakes and ponds as well as the aquifers. On the period 1950-2001, the curves of evolution of the total yearly rainfalls of the main stations show remarkable breaks to the years 1972-1973 and 1983-1984.

In the absence of human actions to inverse effects, it entailed a decrease of the recharge of the vulnerable transboundary aquifers of the basin. For example, a tendency to the decrease of the piezometric levels (4 to 7 meters during the last 10 years) has been observed in some

shallow aquifers. The consequences of this situation result in a decrease of the productivity or even the total drying up of some boreholes in 1990. In the same way, in the central zone of the basin some springs known the sixties disappeared practically nowadays. These decreases of rainfall generated a drastic reduction of the recharge rate.

The following solutions are considered for the reduction of the risks related to climate changes and variability in the hydrogeological and environmental aspects.

- to guarantee a safe environment and a sustainable development by carrying out environmental impact assessment at the time of the conception of the projects;
- to encourage the cultivation of drought resistant plants and the raising of animal adapted to the climatic conditions;
- to encourage capacity building of technical staff at local and state levels;
- to encourage the infiltration of rain for the recharge of aquifers by the construction of dams, barrages, “zai”, etc.;
- to preserve the vegetation cover by managing the forests, reforestation, and combating bush fires,
- to carry out dredging of rivers.
- groundwater and surface water monitoring to improve knowledge of water resources ;
- the setting up of a master plan for sustainable management of water resources
- the development and the setting up of relevant and integrated policy to combat climate adversity;
- to control the exploitation of the resource,
- to institute measures to reduce the pollution of water,
- conjunctive use of surface and ground waters in order to reduce the pressure on the ground waters,
- -define the exploitation zone in order to prevent groundwater quality degradation
- environmental impact studies must be achieved before the implementation of water resources development projects,
- to encourage the growth of drought resistant plants.

### **3.3.2 - Socio-economic aspects**

Droughts combined with human activities, lead to desertification and deterioration of natural resources and also to reduction of agricultural and pastoral productions. These have social and economic consequences such as reduced livestock production in the Sahel decreasing by half and the disappearance of some export crops.

Climate change and variability have socio-economic impacts which must be taken into account in the process of development of the countries. Therefore, it is very important to know the impact of climate change and variability in order to take adequate precautions.

Rainfall reduction leading to waters shortage has negative consequences on all social and economic activities of populations living in the lullemeden basin. Thus, to reduce these risks, it is necessary to take the following measures:

- to control migration and diseases;
- to develop short cycle varieties and techniques to conservation water moisture in soil;

- to build a seasonal forecasting model for production, dissemination, water withdrawal allowing the competent services to make decisions concerning water uses;
- to improve existing cropping systems through the runoff catchments;
- to develop communication systems to better inform, sensitize and advise populations on a better use of available water resources;
- to reduce wood consumption by use of improved equipments and substitution products;
- to minimize climatic changes adaptation management costs, and assure a large diffusion of the adaptation strategies,
- to decrease domestic consumptions of fire wood and fossil fuel,
- reduction of greenhouse gas effect;
- to protect most vulnerable community members notably women, children and aged people while improving incomes by creating income generating activities.

### **3.3.3 - Legal and institutional aspects**

Rainfalls are already insufficient, uncertain and unquantifiable, for some years now, and together with advancing desertification, make well conceived projects often fail in several countries of the Sahel.

Different solutions considered for the reducing of risks related to climatic changes and variability are:

- the improvement and the development of the numerous traditional methods of vegetable cropping, permit to increase production and to consolidate means of existence of rural farmers: traditional wells, traditional irrigation;
- the construction of stone rows permitting rainfall to infiltrate in soil, rather than to runoff;
- the deep digging around plants and bared spaces to conserve runoff water.
- the construction of vegetal contours (known as "Kalinbo", local plant), in some regions where desertification increases, to stop desertification and permit regeneration.
- the creation of earthy bands at hill and terraces hedge;
- establish practices that permit the regeneration of the plant cover in the fields;
- encourage choosing adapted crops to semi-arid and semi - desert conditions, to reduce effect on groundwater resources;
- Institutionalization of an early warning system (SAP);
- to define and respect authorized norms of fire wood cutting and charcoal to prevent risks of deforestation by applying forest legislation;
- to set up concerted bodies for natural resources management;
- to set up an adequate legal and institutional framework in the basin;
- to promote private sector and the civil society participation;
- to develop information and the knowledge on water;
- harmonization and adaptation of legal texts relative to the IAS.
- judicious use of water resources in the basin,
- to promote an equitable and sustainable development without compromising future generations in the basin,



- to assure monitoring and control of drillings,
- to institute some incentive measures for controlling waste,
- to support governmental actions for better controlling and an equitable and efficient distribution of water resources in a sustainable development context.

#### **4 - TOWARD A SUB-REGIONAL POLICY FOR RISK REDUCTION**

Following the resolutions of the World Summit of Rio de Janeiro and Dublin the 3 countries have adopted integrated water resources management in their national water policies..

This process is concretized by the setting up of the national water partnership.

The three countries are engaged in a process of integrated water resources management with a view to reducing risks of water resource availability; quality degradation and climatic changes and variability threatening the IAS groundwater.

Besides the three countries have established action plans to adapt climate change policies in conformity with United Nations convention on climate changes.

These countries established their national water policies based on the

Therefore to sustainably manage groundwater resources shared by the countries within the framework of the IAS the following measures are to be taken:

- Mitigate environment deterioration and erosion,
- Anticipate climate changes and variability impacts.
- Establish a consultation framework to finalise and approve the MOU ;
- member States to work in synergy with other development agencies
- Ensure common project implementation
- Ensure monitoring of projects and that standards are complied with
- Establish a database in order to ensure updating of water resources information.

#### **5 - RECOMMENDATIONS (STRATEGIC ORIENTATIONS)**

At the end of this investigation, the countries agreed on the following points:

- Inform m and sensitise the decision makers of the three countries about the risk in the IAS
- Finalise and adopt the consultative mechanism of the IAS
- Pursue capacity building of the actors in the IAS
- Increase the budget for IAS monitoring network
- Develop communication, information and consultation between water managers in the countries sharing the IAS.
- Update national legislations on water in order to take into consideration international conventions related to water.

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