Water resources management for climate adaptation in Mali

Boubacar Sidiki Dembele (Authors' coordinator), with Sidi Konate, Mamadou Ouedraogo, Abdramane Soumaguel and Hamala Diakite

Part One: The Study of Ultimate Users of Water Resources and Dialogue with Communities

The sites selected for this study are Kiban (Koulikoro region), Diouna (Ségou region), and Massabla (Commune of Bougouni, Sikasso region).

1. Objective of the Study

Objectives assigned to the study are specifically aimed at:

- Determining, at the level of the three sites selected, the potential of surface and underground water resources (in quantity and in quality);
- Determining sectors that use the water resources;
- Determining water resources' ultimate users, their current, and future requirements over the next 25 years; and
- Using the WEAP 21 software for modeling the rational use of water resources, with a view to minimizing eventual conflicts.

2. Methodologies Used

In addition to experts' opinions, the methodological approaches that were used in this study are as follows.

Data collection was conducted in three phases:

- Documentary retrievals allowed for the collection of all documents likely to contribute to the document that takes into account all the elements of the terms of reference of the study. This data was collected for each locality.
- Holding of village assembly meetings: the consultants went to the sites to carry out dialogues with the water resource users. To this end, a general assembly meeting was held at each of the three sites in the presence of all social groups of the population, to collect data on potential water resources (underground and surface) and the population's essential needs from these resources.
- Analysis: data collection was followed by its analysis and a comparison of the data in order to select the most reliable data. The documentary analysis was made in three parts: climate data, agro-sylvo-pastoral data and socio-economic data. After documentation analysis, information collected during the general meetings held in villages, was also analyzed.

Starting from a baseline situation (the reference climate scenario) the average of the main climate parameters (temperature, rainfall, wind speed, etc.) over the period 1971 to 2000 were determined. The main elements for characterizing water resources (underground and surface) available in the three sites were determined. Then, an assessment of water requirements for the various socio-economic activities (agriculture, livestock, handicrafts, market-gardening, etc.) was carried out in the three sites. Finally, the comparison of each use of the available and potential water (underground and surface) and demands for meeting the main socio-economic requirements, suggested whether the existing potential supply met all the requirements and if yes, with what limitations.

This same approach was used in the case of a climate change scenario where the main meteorological parameters concerning the three sites stem from a climate change model built for Mali. This analysis allows for determining of this temporal horizon, and the impacts of the climate change scenario on water resources in the three sites.

Finally, the knowledge of the potential impacts of climate change will allow for formulation of the most appropriate adaptation options for each site in the field of water resources.

3. Results Obtained

3.1 Determining the water resource potential

For the purpose of the study and with the help of local populations, a rough estimation of the potential of the three sites for availability of surface water was made by using experts' opinions.

3.1.1 Availability of surface water in the three communes

Table 1: Surface water available through ponds and lowlands

Commune	Nature of water sources	Volume of water (m^3) mobilizable per	Presence of water retention structure
Diouna	A network for 9 contiguous ponds	50,000	No
Kiban	A big pond (river)	23,000	3 dams, the inadequacy of which causes the early drying up of the pond.
Masabla	Lowlands and the Mono river	10,000 30,000	No No

Source: Survey by the team on sites – 2006.

In each of the communes, there is a network of ponds and lowlands. Constraints and limitations related to the use of surface water resources are of three kinds:

- Irregularity of the rainfall and prevailing hydrological conditions (the average rainfall for the last 20 years is lower by 15 to 20% than that of the previous years); which cause a decrease in the flow rate of rivers and the fast drying up of ponds and lowlands.
- Whether rainwater drains away fast or not. An absence of small dams and lowlands management schemes allow for an accumulation of standing water.
- Almost all ponds and lowlands in the three localities are clogged; which made the populations of the three communes propose the deepening of ponds and the construction of micro-dams on the Mono River as priority adaptation options.

3.1.2 Quality of underground water used as a safe drinking water supply

During the village assembly meetings (Figure 1), the populations of the three communes were interviewed in relation to the quality of water and the status of water resources.

Figure 1: Assembly meeting in Diouna

a) The Water Issue

Water quality is considered poor when it is unsafe for human and livestock consumption meaning that it could be a source of diseases.

Table 2: Quality of water used for various uses

Commune	Population's consumption	Agriculture	Market-gardening	Drinking water for animals	Handicrafts
Diouna	Poor	Good	Good	Poor	Good
Kiban	Poor	Good	Good	More or less Good	-
Masabla	Good	Good	Good	Good	-

Source: Survey by the team on sites – 2006.

During their village general assembly meeting, the population of Diouna deemed that their water is of poor quality for human and livestock consumption. However, for agriculture and market-gardening, the quality is acceptable.

In Kiban, only 20 wells out of the 450 traditional wells counted there, do not dry up. The water-pumping devices for these 450 wells are hand-powered. Water from wells is of a poor quality. The drinking water for the population comes from the safe drinking water supply network but in the case of water shortage in the network, the population is compelled to drink water from wells. The quality of the river water is good enough for watering livestock during periods of high waters; that is to say during and at the end of the rainy season. As soon as the water level goes down significantly, water quality becomes poor and there is an increased risk of disease for livestock.

In the locality of Massabla, the river water is of good enough quality for watering livestock during periods of high waters. As soon as the water level goes down significantly, water quality becomes poor. When this happens the population gets their drinking water from the pumping system.

b) Water Requirements Coverage
The water requirements coverage for the three localities can be summarized as follows:

- *Commune of Diouna:* Following the village general assembly meeting, the current status of water requirements coverage was deemed by the population as not satisfactory because it does not reach their requirements.
- *Commune of Kiban:* The population deemed that there are deficits in all sectors of water supply.
- *Commune of Massabla:* The population is supplied with safe drinking water from the pump. Having just one watering point is insufficient and is the source of disputes within the population. The same problem was observed in the other sectors of water use as shown in Table 3. Apart from the pump installed in the borehole, all the other wells in the village dry up from February every year.

3.2 Determining the water use sectors

Water use sectors were grouped into three types: domestic, industrial and agricultural. The water use sectors on the three sites selected for the study were:

- Supplying the population with drinking water;
- Supplying drinking water for livestock;
- Agricultural supply;
- Supplying market-gardens and for the watering of gardens and plantations; and
- Supplying the fisheries.

3.3 Determining current and future water requirements

3.3.1 Estimation of water requirements in the case of the reference scenario

Because of the lack of statistical data, during village assembly meetings it was necessary for the villagers to make estimations with the support of consultants and communal authorities. These estimations are shown in Table 3. Estimations of water requirements for the agriculture sector in 2005 are indicated in Table 4.

Table 3: Water requirements (m^3) for the population and the livestock sector in 2005

Commune	Water requirements (m3) by the year 2005			
	Population		Livestock	
	Number	Requirements (m^3/day)	Number	Requirements
Diouna	1,051	23	4,780	105
Kiban	8,744	192	11,732	258
Masabla	1,595	35	338	7

Source: Survey by the team on sites – 2006

Table 4: Water requirements (m^3) for the agriculture sector in 2005.

Commune	Rice (m^3/year)	Market-gardening (m^3/year)	Cotton (m^3/year)	Ground-nut (m^3/year)	Maize (m^3/year)	Millet/Sorghum (m^3/year)
Diouna	0	60,000	0	1,394,250	2,666,800	7,735,000
Kiban	624,000	120,000	0	14,300,000	1,033,385	44,330,000
Masabla	208,000	36,000	680,000	107,250	226,678	728,000

Source: Survey by the team on sites – 2006

3.3.2. Estimation of future water requirements in the reference scenario case

From these elements, the population's needs for meeting the main socio-economic requirements were estimated and shown in Tables 5 and 6 below:

Table 5: The population's water requirements (m^3) for the livestock sector by 2025

Commune	Population		Livestock	
	Number	Requirements (m^3/day)	Number	Requirements
Diouna	1,400	75	11,245	337
Kiban	22,495	497	27,599	828
Masabla	3,407	31	795	24

Source: Survey by the team on sites – 2006

Table 6: Water requirements (m^3) for the agriculture sector by the year 2025

Commune	Rice (m^3/year)	Market-gardening (m^3/year)	Cotton (m^3/year)	Ground-nut (m^3/year)	Maize (m^3/year)	Millet/ Sorghum (m^3/year)
Diouna	0	108,367	0	2,518,171	4,816,537	13,970,270
Kiban	1,127,103	216,733	0	25,827,391	1,866,408	80,064,911
Masabla	375,671	65,020	1,228,156	193,705	409,406	1,314,849

Source: Survey by the team on sites – 2006

3.4 Use of Water Evaluation and Planning (WEAP) software for modeling water resource use

The main objective of using the WEAP is to see whether water availability in each of the sites allows for covering the main socio-economic requirements of the populations of these communes in two different climate situations.

Firstly, the model is operated by introducing meteorological parameters from 1971 to 2000 which correspond to the reference scenario, also referred to as the baseline scenario. The assumption is that this climate scenario will be repeated in the future, from the year 2005 until the year 2025, but that there will be an increase in requirements, associated with population growth.

Secondly, meteorological parameters are taken from the climate scenario that was elaborated for Mali. The reference year retained is 2005 and the upper time limit of the simulation is 2025. The projections of meteorological parameters and requirements evolve regularly for the period between 2005 and 2025 (population, livestock, orchards, kitchen-gardens, etc.). In general, this climate scenario implies that the normal precipitation is going to decrease by about 0.5%/year whereas the normal temperature is going to increase by about 0.2%/year.

In case water requirements are not met, scenarios for adaptation to the harmful effects of climate change will be worked out.

Finally, the results of these various scenarios (reference and climate) and eventually those of the adaptation scenario can be compared by the WEAP which makes it possible to know whether there is stagnation, acceleration or mitigation of the unmet water requirements.

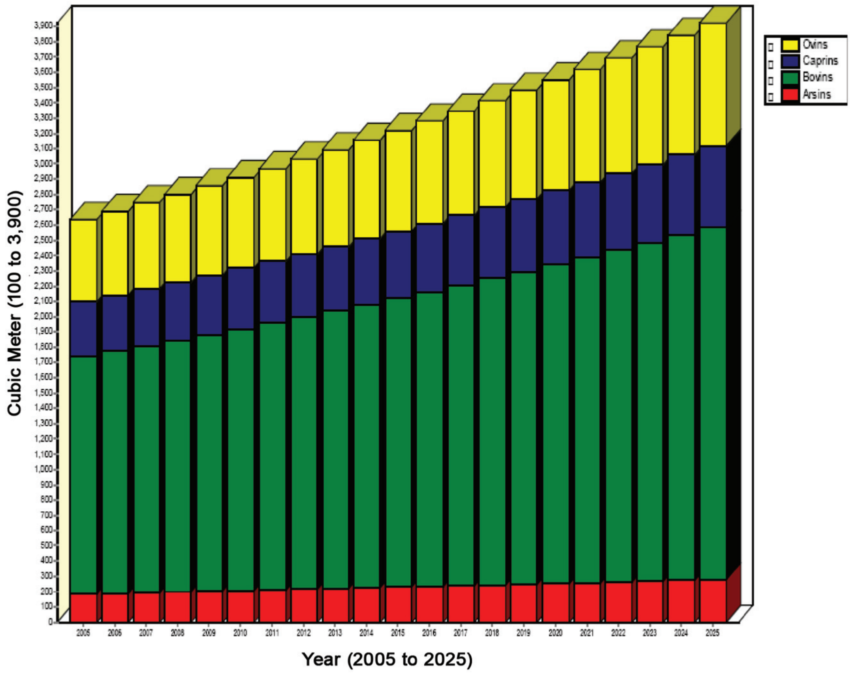

Figure 1: WEAP profile of water requirements for livestock from 2005 to 2025 in Massabla

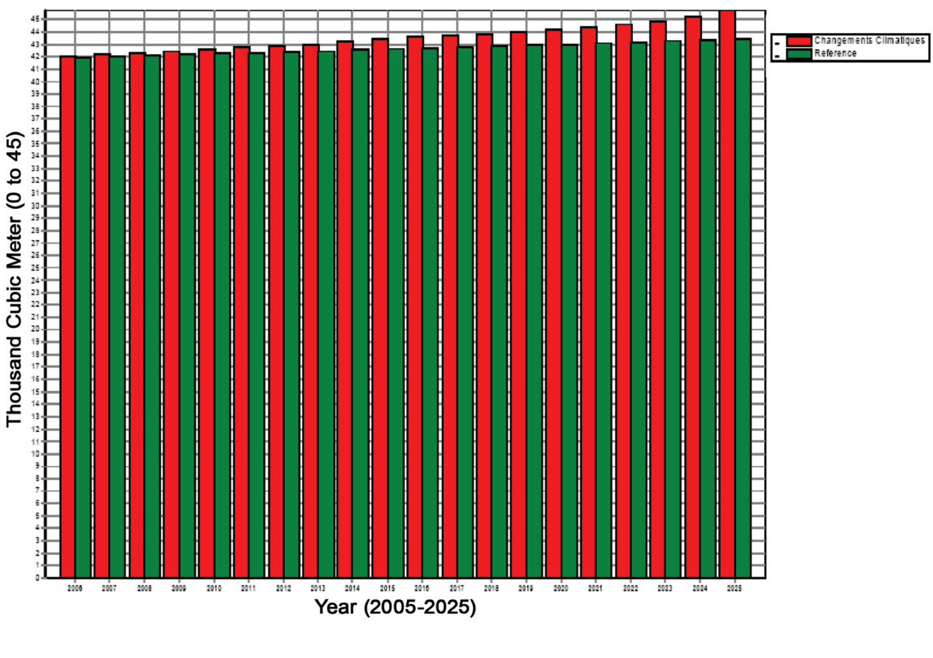

Figure 2: Unmet requirements in Massabla in the case of the reference and climate scenarios (*Red:* Climate change, *Green:* Reference)

At the level of the three communes, we have the same types of water requirements and the same water availability (underground and surface water).

For the commune of Massabla, we added an additional water requirement: irrigation. In fact, the Mono River crosses most of Massabla. In this case the priority adaptation option that was formulated by the population is achieved, as use of the Mono River would offer the possibility of irrigating 15ha of rice according to DNH estimations. By integrating this possibility and by assuming that a micro-dam will be constructed on the Mono River in 2005, we changed the rice growing area from 1ha in 2005 to 15ha in 2025. The WEAP model operated with data from the two climate scenarios.

As with the commune of Massabla, using the WEAP model for Kiban and Diouna reveals a deficit when one takes into account issues such as the drying up of ponds three months after the rains stop and the drying up of wells around March and April.

Generally, water resources available in these three sites are not sufficient for meeting the water requirements of these populations.

4. Recommendations

Following this study, it was recommended that low cost structural changes were carried out, such as:

- The deepening of the ponds in Kiban and Diouna and the construction of water retention dams;
- The construction of a micro-dam on the Mono River in Massabla; and
- The realization of new drinking water supply systems and the repair or replacement of faulty equipment.

To protect pond beds from silting up with sand, evaporation, and for timber production, ponds are surrounded with a 50ha forest belt of trees that doesn't need too much water and a 100ha controlled area that will strengthen the carbon sink and prevent land degradation around the ponds.

The implementation of these adaptation measures will cost 350 million Francs for constructing the micro-dam and 150 million Francs for the deepening of each pond and its maintenance.

In summary it is recommended that:

- Community elected leaders need to adopt such environmental projects into their local development plans and get in touch with the ANICT for their funding. This agency offers up to 95% of the costs of funding environmental projects;
- Access to safe drinking water and to sanitation systems is improved through the promotion of photovoltaic solar energy;
- Agricultural water resources are used sustainably through small-scale irrigation development;
- Water resource availability is increased through constructing water mobilization structures; and
- Appropriate water management technology is needed in order to keep costs down.

Part Two: The Identification and Selection of Appropriate Water Resource Management Technologies

5. Purpose

Objectives assigned to this study, carried out in the localities of Massabla, Diouna and Kiban, are specifically aimed at:

- Making an inventory of the technology used in the field of the adaptation of water resources to climate change;
- Identifying and selecting the most appropriate technology;
- Proposing better technology if necessary; and
- Proposing a technology transfer methodology.

6. Methodology

The methodological approach can be summarized as follows:

6.1 Bibliographical study

- Documenting the climate scenario envisaged for Mali and predicting the impacts on water resources in the study zone;
- Collecting of water resource management both in Mali and worldwide; and
- Gathering relevant socio-economic data as well as the costs of existing technology.

6.2 Site visits and surveys

Site visits were carried out in order to obtain a better knowledge of the physical and human environments in the study zones. Data collection took the form of interviews or discussions in groups or general assembly meetings with the population, local authorities and development organizations operating in each zone.

6.3 Water requirements analysis, assessment of their potential, and resource management simulation

Water requirements were assessed from the data collected in the field and their management according to the expected climate changes was the subject of simulation with the WEAP.

6.4 Analysis of technology offers, definition of selection criteria and proposal for appropriate technology for the study zones

By taking account of the economic conditions and the possibility of ownership of this technology by the communities, it was possible to propose new technology suitable for the environment as well as a methodology for the transfer of the technology.

7. Results Obtained

Gradually the effects of the various adaptation options were simulated. Adaptation options to overcome the water deficit in Massabla were as follows:

- The construction of 40 modern boreholes; and
- A doubling of their capacity from 8 m^3/day to16 m^3/day.

7.1 Impact of climate change scenarios on water resources

Results of climate change scenarios

In the three localities, an average air temperature increase of between 0.7°C and 1.5°C is predicted by the year 2025. It is also predicted that the rainfall will drop by between 3% and 10%. The maximum deficit is predicted at between 19 and 23mm in the dry season.

Sensitivity of water resources to climate change

a) Locality of Diouna:

Ponds (Figure 4) which are the main source of surface water (Table 7) in the commune will be the most sensitive to climate change. The pond in Diouna plays a crucial role in the development projects of the commune such as off-season cropping, fish-breeding, supplying drinking water to livestock, etc.

Figure 4: Pond site in Diouna

Table 7: Water resource sensitivity to climate change in Diouna

	Increase in temperatures	Decrease in rainfall	Indicator
Ponds	4	5	9
Traditional wells	3	4	7
Modern wells	2	3	5
Bore holes	1	2	3
Impact indicator	10	14	-

The most exposed underground water resources are wells, with boreholes being the least sensitive to climate change.

(b) Locality of Kiban:
Safe drinking water mainly comes from wells and boreholes. The other sources for basic activities such as off-season cropping, supplying drinking water to livestock, fish-breeding or household work, are rivers and ponds. These sources of surface water to the commune are the most sensitive to climate change risks. The climate change forecast will be very important in the commune of Kiban, given the primary role played by the Dehara, Lambakoré, Lambaguilé and Souralanibine Ponds in the main livelihood activities of livestock breeding, market-gardening and fish-breeding.

The most exposed sources of underground water are wide-diameter wells, of which there are many in the commune. Boreholes which are less sensitive to climate change are of more of a benefit to the commune.

(c) Locality of Massabla:
This zone has the greatest diversity of water resources of all the communes studied although the impact indicators are highest. There are many lowlands which are highly vulnerable to climate change. Next are the rivers, which are at a fairly high risk. The other water sources in the zone present vulnerability ranging from average to low depending on the extent of the climate change.

In conclusion, on all three sites an increase in temperature and a decrease in rainfall have been observed. The consequences of these changes are as follows:

- A decrease in farm yields;
- The appearance of rangelands;
- The annual drying up of water courses and other areas of surface water (the Mono River is the main surface water resource and is drying up);
- The drying up of traditional wells;
- Yields of rain-fed crops becoming increasingly low;
- More intense heat;
- Difficulties in finding firewood; and
- An increase in the frequency of strong winds.

7.2 Identification of technology used in the study zone

On the various sites, underground water is collected through boreholes, and traditional or modern wells.

Modern wells and boreholes are generally meant for supplying safe drinking water to the population. However, in Massabla, the only existing borehole is used for all purposes during the period of the year when water courses and even the many traditional wells have dried up. The technology, techniques, practices and even the procedures encountered on the sites or related to the establishment and exploitation of infrastructures are described below.

Very little technology was developed to aid with the collection of surface water on the various sites of the study outside Kiban where two micro-dams were constructed on the Lambaguilé, Lambakoré, Dehara and Souralanibine lowlands.

For the better management of water, for the benefit of natural plants, dry-farming, supplying water-beds, and soil erosion control, the following practices are measures for adapting water resources to climate changes:

- Draught farming with ridges that are perpendicular to the highest slope of the land;
- The use of organic manure and crop varieties selected according to their resistance to drought, their place in the farming cycle and the nature of the soil;
- Agro-forestry practiced in the Diouna zone; and
- The localized use of chemical and organic fertilizers in Diouna.

7.3 Levying and distribution technologies

Underground water

Regional boreholes are equipped with man-powered pumps with the following trade marks:

- *Vergnet* in Massabla in a poor operating condition;
- *India Mali* in Kiban in an average operating condition; and
- *India Insala* in Diouna in a poor operating condition.

In Kiban, a drinking water supply is achieved through a borehole equipped with a solar pump.

With buckets made out of old rubber inner-tubes, people draw water from wells for market-gardening, supplying livestock with water and even for household purposes, including human consumption. Animal-powered water-raising systems are also practiced in pastoral areas in the communes of Diouna and Kiban.

Surface water

There are no surface water pumping systems on the various sites, apart from water levied by using buckets, wash-basins, and casks for purposes such as watering gardens, or for use in households or for handicrafts requirements.

7.4 Technology used for adapting water resources to climate change

The technology identified on the sites is generally conventional. However, the use of this technology, in particular in rural areas of Mali, caused some difficulties ranging from high costs to the problems of maintaining the pumps. To collect underground water, boreholes, wells and cistern tanks were thought to be the best choice.

To collect surface water resources, a large range of technology is available. The ones that are deemed the most appropriate with regard to adaptation to climate change and in the socio-economic, cultural, and environmental context of our study zones in particular, and in Mali in general are outlined below.

7.5 Proposals for the most appropriate new technologies on the sites of the study zone.

7.5.1 Technological proposals for drinking water supply

In addition to proposals by the Malian administration, this project makes new proposals with a view to supplementing and/or strengthening these choices or making them more accessible to users in terms of cost investment for ownership and sustainability:

- Introduction and research on adaptation of low-cost drilling technology (manual or mechanical);
- Introduction and research on adaptation of low cost water raising systems mainly:
    - » Nicaraguan type rope-pump (man-, animal- or wind-powered or with high output moto-pump); or
    - » PVC pump (Flexi MAS Nicaragua type).
- With the prospect of climate change in line with the proposed climate scenario for Mali, a special emphasis should be placed on the introduction, research on adaptation, and dissemination of man-powered pumps for deep and very deep boreholes mainly:
    - * *India Mark II* (80m to 90m),
    - * *Busch Pump Zimbabwe* (80m to 90m),
    - * *Afridev with Bottom* (80m to 90m).

7.5.2 Agriculture and irrigation

Three main sources of water are available for irrigation in Mali: perennial surface water; nonperennial surface water; and shallow underground water. In our study sites, efforts were made to mobilize the only sources of water available for irrigation i.e. non-perennial surface water and/or shallow underground water (down to 10m for cereal crops and 20m for market-garden crops). For that purpose, it was suggested,

In a first stage:

- The introduction and use of manual drills jointly with shallow water pedal pumps (4m to 7m) of improved Bangladesh types (ANIP), and with low irrigation cost and low water pumps (Californian Network, Pepsi Drip, Nica Drip, Easy Drip etc.) in Kiban and Massabla;
- Further study of water resources and water-raising devices suitable for irrigation in the physical, socio-economic and cultural environment in Diouna where water beds are at an average depth of 32m and surface flows are non-existent is necessary.

Technological proposals to be tested for their socio-economic viability would be:

- Natural ponds to be deepened or artificial ponds to be built for irrigation and other practices such as fish-breeding, supplying livestock with water, feeding waterbeds etc;
- Drilling technology (manual or mechanical) together with low cost water-raising systems (Nicaraguan type rope-pump with appropriate traction systems, PVC pump etc.).

Technology would also be introduced and/or intensified to allow for optimizing water availability for dry-farming and for feeding waterbeds, previously identified on the study sites or identified from relevant experiences worldwide (lowlands and/or watershed area management schemes, water and soil conservation management schemes, organic manure, farming techniques and technical itineraries, variety selection etc.).

In a second stage:

- The population would need to be taught to use the technology outlined above in order to ensure its sustainability. The socio-economic feasibility of each technology or technology system should be proved so that it can be used sustainably.

7.5.3 Livestock

For livestock, water supply needs to be ensured. In Kiban and Massabla this would be from ponds and small dams. In Diouna, the deepening of ponds is the only water harnessing technology possible, provided that the socio-economic feasibility is proven. That could be done jointly with water and soil conservation technologies to ensure their sustainability. However, the overgrazing and overexploitation of underground water that can be harmful to the environment needs to be avoided.

Therefore the following technology is recommended:

- Deep boreholes with low cost technology;
- Man-powered pumps for deep and very deep boreholes; and
- Nicaraguan type-rope pumps depending on the environment.

7.6 A proposed methodology for technology transfer

The proposed methodology will be based on the approach referred to as the "product and/or market creation approach". It is worth mentioning that this approach has already proved effective in Asia, Latin America and even in some African countries in the framework of pedal-pumps for small scale irrigation.

The 5 key factors for the establishment of viable and perennial distribution chains are:

- An adequate offer, characterized by (i) the function (the product fulfils the functions for which it was designed); (ii) the price (acceptable for the consumer); (iii) the place (the product is available in sufficient quantity in the required places); (iv) the quality (the product is of a good enough quality); and (v) the promotion, and information available to the consumers.
- Effective incentives for entrepreneurs, the primary motivation being undoubtedly profit, but social motivations can be also important (such as increasing the production of poor farmers).
- An effective information flow between the stakeholders of the chain because information sharing can increase the profit and performances, and reduce individual risks.
- An effective management of the chain: mainly constructing relationships between partners by creating opportunities for meetings by giving partners an overview of the chain and of the product; and by creating an enabling environment that allows for collaboration by the partners.
- An enabling environment: mainly a stable macro-economic situation; an open system of participation of the private sector; access to credit by the formal sector or the unorganized sector. The impact of legislation and tax on small- and medium-sized enterprises and well developed transport and transmission networks. Furthermore, the small private sector takes advantage of the existence of enterprise development services which provide knowledge and training required for assisting small- and medium-sized enterprises in developing. Therefore, it is essentially through these key factors that external agencies can contribute to developing reliable and perennial distribution chains.

This dissemination methodology is based on commercial manufacturing of the technology, without subsidies.

In the first stage, "practical research" is carried out in the field in a way to design technology meeting the following criteria:

- Technically effective;
- Financially affordable by target-clients;
- Economically profitable (rapid return on investment, technical sustainability of the product); and
- Locally manufacturable, as close as possible to clients (ultimate users).

In a second stage, the product is marketed in compliance with rules that will guarantee the sustainability of the product involved:

- The product is primarily meant for a clientele of small private entrepreneurs earning their living from their work, and investing themselves in the product;
- The product is made by local manufacturers taking advantage of the manufacturing and selling of their products;
- Product awareness is ensured by publicizing the name and the use of the new product, and by establishing a commercial relationship between the manufacturer and the client who is also a producer practicing irrigation;
- A "quality control system" is put in place both at the manufacturing and the use levels to make the product known and advertise the image of the product. This "quality control" is necessary to reach a "point of non-return", a time when the image of the product is established; and
- A step-by-step approach is necessary, to prevent a lack of information on its maintenance or on its conditions of use, for example which would lead to bad publicity.

This approach guarantees the sustainability of the manufacturing, the selling and the use of the technology involved. Nonetheless, there exist risks, such as:

- The subsidy to technology, by some structures, can destabilize the approach based on the purchaser's logic of entrepreneurship; and
- The lack of after-sale counseling service close to users.

8. Recommendations Made

An analysis of water resource availability, its evolution, and the demand from all sectors, confirmed the existence of a supply higher than demand. Nonetheless, deficits essentially related to mobilization, water-raising and management were observed on all the sites. These deficits, despite the risks of their increase related to climate change, can be reduced, and even made up through the actions below:

- Joint use of surface and underground water. In fact, the static levels of underground water (lower than 20m in Kiban and Massabla) allow for using them for household purposes, for supplying livestock with drinking water etc. whilst surface water can be used for market-gardening;
- A wide dissemination of low cost technologies (harvesting, pumping, distribution);
- A wide distribution of water and soil conservation technologies (ridge farming, organic manure, agro-forestry);
- The use of water resources planning, prediction and management tools such as the WEAP; and
- The strengthening of agro-meteorological assistance to the rural world, considered today a fundamental element of the strategy for adaptation to climate change in Mali, should in the long run contribute to a better utilization of water resources.

9. Conclusion

The identification and selection of appropriate water resource management technology raises the issue of adaptation (at the technical and financial level) to this technology hence the need for the study on the elaboration of strategies for adaptation to climate change.