STUDY OF THE INCREASE IN THE WATER SUPPLY RATE IN THE ANDROY REGION, EXTREME SOUTH OF MADAGASCAR

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ABSTRACT

The study will eventually increase the water supply rate of many target villages in the Androy region by using a system operating system: solar pumping, piped water delivery, sharing by distribution networks water, desalination by nanofiltration, use of solar energy as a power source for electromechanical equipment, rehabilitation of boreholes with human power failure, realization of new deep boreholes in the neogene zone. This system is more economical and sustainable. The whole of Madagascar's Great South will thus be able to benefit economically from such a system.

Keyword *Androy Region, Drinking Water Supply, Hydrogeology, Hydraulics, Desalination, Solar Energy.*

1. CONTEXT OF THE STUDY AREA

The Androy Region is in the extreme south of Madagascar, it is divided into 04 districts, counting 767577 inhabitants in 2015. Its climate belongs to the semi-arid zone. It has two geological formations including the crystalline formation in the north and the sedimentary formation in the center to the south.

Currently, it is the least served region in terms of water supply, with a drinking water access rate of 13% (by CREAM 2013). Since 1952 to the present day, several studies in geology, hydrogeology and water supply infrastructure were made in Androy. In addition, many water supply infrastructures has already installed such as water drilling, pipeline, wells, water catchment tanks, as well as water distribution by tank trucks. Despite all its efforts in water supply, access to water is still the major problem and one of the factors blocking the development of the region.

The objective of this research is to improve the rate of water supply in Androy in the 2030 horizon. To achieve the objective of research and to clarify the problem, a multidisciplinary study integrating sociology, hydraulics, hydrogeology, geophysics, topography, and renewable energy was carried out in the framework of this study. These different approaches constitute the structure of this research.

1.1 Location of the Study Area

The region of Androy is geographically located in the extreme south of Madagascar. It occupies the territory between the rivers Mandrare in the east and Menarandra in the west. It is vast of 19,540 km2. It is bordered to the north by the foothills of the Bara Highlands and to the south by the Indian Ocean and the Mozambique Channel. It comprises four districts and 45 municipalities. The four districts are Ambovombe-Androy (5 829 km²), Beloha (4 669 km²), Bekily (5 097 km²) and Tsihombe (2 223 km²).

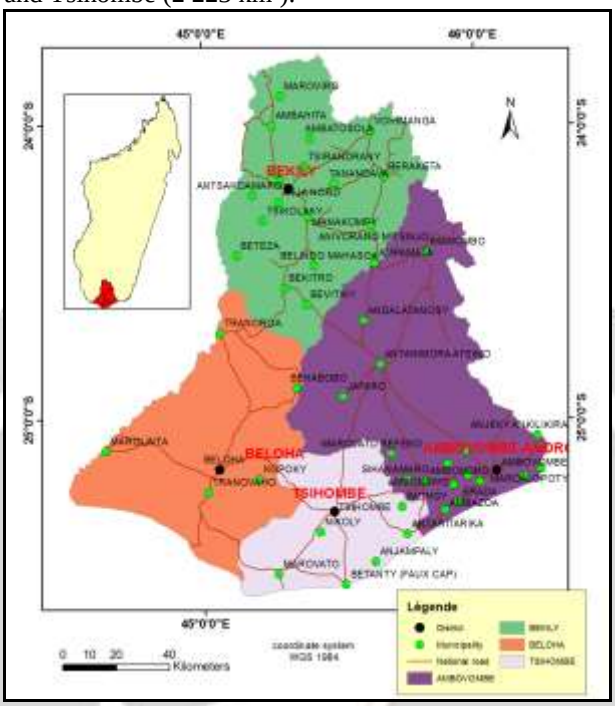

Fig -1: location study area

1.2 Climate context

Belonging to the sub-arid domain of southern Madagascar, the Androy Region is subject to semi-arid to arid tropical climate with two sliced seasons: wet season (summer) and dry season (winter).

Aridity increases from north and northeast to south and southwest of the region and is reflected in changes in plant landscapes and soils. This aridity is amplified by still high temperatures and strong, persistent and drying winds, especially on the southern coastal fringe of the region (Tsiok'Atimo).

1.3 Geological Context

The crystalline basement characterised by granulite facies appears outcrop in the northern part of the Androy Region. It contains layers of various ultra-metamorphic rocks characterised by gneisses (sillimanite, cordierite, garnet, various types of mica), quartzites (garnet, magnetite, sillimanite or graphite), marbles and pyroxenites to micas, etc.

Its northeastern and eastern part is covered by the basalt and rhyolite of the Cretaceous volcanic massif of Androy, whose major axis about 80 km long is oriented North-South, the eastern zone of the massif is included in the district of Amboasary. The central and southern part of the region is covered by quaternary sedimentary formations and continental Pliocene (tertiary), which are based on the crystalline basement: limestone sandstone, marine sand and dunes, clayey sandstone, marls and clayey sand. In the beds and along the rivers (Mandrare and Menarandra) have deposited recent alluvium of sands and thick silts.

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1.5 Hydro Geological Context

The sedimentary basin of the extreme south between the rivers Mandrare in the East and Menarandra in the West. It is divided into two subregions by Tsihombe crystalline spur through which the bed of the Manambovo River passes. The first subregion is Beloha in the west. It comprises, in the south, the dune plateau of Karimbola, in the center the basin of Beloha now covered by deposits of white and red sands, the continental deposits of the Neogene to the north and north-west.

The second subregion is represented by the Ambovombe Basin. The red sand plateau of Beantara to the east, in between, is the Ampamolora depression, which continues in the north to the dry Bemamba valley to the south, perpendicular to the Ampamolora depression, the plateau of old quaternary dunes of South Sampoina.

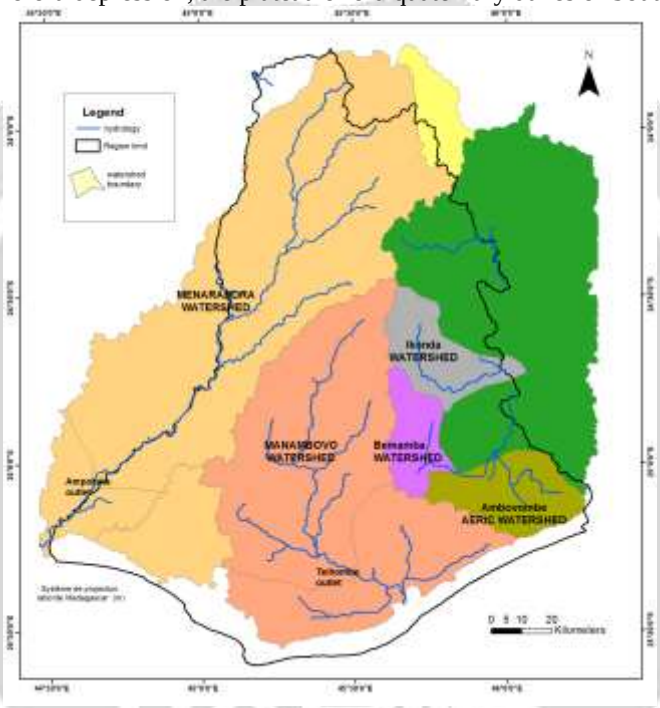

Fig -2: Hydrogeology map of the study area

2. METHODOLOGY

The methodology implemented involves the inventory of water resources, diagnosis of existing water supply systems as well as possibilities for exploiting solar energy for the supply of the Androy AEP system. It involves using different types of water supply and proposing a new technology: desalination by nano-filtration and solar energy as a source of power.

2.1 Diagnosis of existing Water Drilling

The amount of drill points inventory is 933. In total, 127 of them are not functional. The functionality rate is 86%. Bulk drilling has a water production capacity of more than 5m3 / h. The number of bulk boreholes inventory is 193.

Table -1 Drilling in the Androy area

District	Drilling with flows	Number of Drilling	Non-Functional Drilling	Functionality Rate
Bekily	136	350	36	90%
Beloha	12	151	30	80%
Tsihombe	1	42	3	93%
Ambovombe	44	390	58	85%

District	Drilling with flows	Number of Drilling	Non-Functional Drilling	Functionality Rate
total	193	933	127	86%

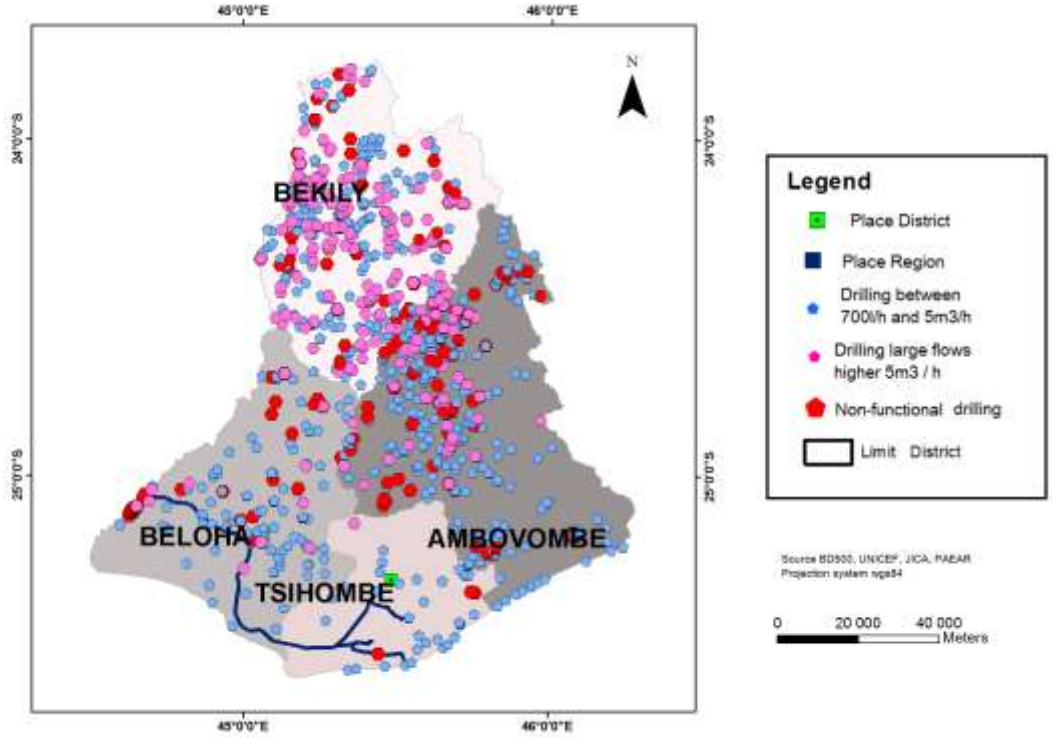

Fig -3 Androy drilling

2.2 Diagnosis of existing drinking water supply in the city center

The diagnosis of the water supply system is given in the table below.

Table -2: existing water supply situation

location	Situation	Water Adduction System
Ambovombe	a pipeline study was planned for the capture of the Mandrare River towards Sampoina and Ambovombe, this project was aborted	Pipeline project linking Mandrare – Sampoina and Ambovombe.
	drilling JICA F015 large flows exist but very mineralised	water supply project city Ambovombe
	A pipeline of capture right bank of bemamba was studied to supply the city of Ambovombe until Antaritarika. This project was abandoned due to insufficient flow of drilling	pipeline project linking Bemamba – Ambovombe - Antaritarika.
Beloha and Tsihombe	An existing thermal power pipeline, sometimes broken down due to generator maintenance and rising fuel prices	Pipeline linking Ampotaka - Beloha - Tsihombe
Bekily	water supply provided by JIRAMA	pumping water supply powered by thermal center
Tsihombe	Water supply provided by JIRAMA, but the water has a conductivity around 3000µS	Water abstraction through an underground Manambovo

location	Situation	Water Adduction System
		River Dam
Ambondro	residents get unsafe water from pools and traditional wells	JICA drilling F01 exists, but is not operated
Bekitro	the villagers draw water from the Manambahy River, which flows about 250 m from the village center	no infrastructure in drinking water
Beraketa	served by an AEP fed by two boreholes each having a usable flow of 10 m3 / h	functional water supply but drilling powered by thermal group
Andalatanosy	Has 02 drilling water, one equipped by generator and the other equipped with solar.	the water supply is out of order
Antanimora	Has 02 drilling water	pumping water supply powered by thermal group

2.2 Parameterization of the water requirement

Water needs must be sized to meet the needs until 2030. A population increase of 2.54% has been considered until. 2030. The consumption of the beneficiaries is 30 litres / person / day.

Table -3: Drilling in the Androy area

District	Population 2015	Population 2030	Requirement 2015 (m3/day)	Requirement 2030 (m3/day)
AMBOVOMBE	365 709	533 397	12 657	17 981
BEKILY	172 298	251 317	6 145	8 661
BELOHA	114 367	166 817	3 971	5 631
TSIHOMBE	115 203	168 016	4 032	5 702
Grand total for Androy	767 577	1 119 547	26 805	37 975

2.2 Parameterization of water supply networks

The hydraulic calculation of the networks was carried out by the application of Bernoulli's.

Bernoulli's Theorem (Drinking Water Supply, Mahmoud Moussa) is written as follows:

[Z + (P /ρg) + (V²/2g)] uphill = [Z + (P / ρg) + (V²/2g)] downstream + ΔH

With regard to the calculation of the linear pressure drop, the method used combines the Darcy and Colebrook formula with a coefficient k = 0.1.

The linear pressure drop according to Darcy's formula:

$$\Delta H = \lambda \frac{L}{D} \frac{\rho V^2}{2}$$

where the coefficient of loss of load according to the formula of Colebrook:

$$\frac{1}{\sqrt{\lambda}} = -2 \log\left(\frac{\frac{K}{D}}{3.71} + \frac{2.51}{Re\sqrt{\lambda}}\right)$$

Z: position energy
P / ρg: pressure energy
V² / 2g: kinetic energy
ΔH: total pressure loss which is equal to the sum of the linear and singular head losses.
with D : the diameter of the pipe (m);
L :the length of the pipe (m);
P : density (kg / m3)
Re :Reynolds number
V : the average speed of the liquid (m / s)

2.2 Solar Pump Sizing

Using solar energy has chosen for the study as a power source of electromechanical equipment. This is a renewable and free energy, easy to maintain and more sustainable.
The pumping system consists of a submersible pump powered by solar panels.
The power supply will be carried out with the wire of the sun which means that no accumulator is envisaged and the pumping will operate only in periods of sunshine.
The average sunshine value of 5.0 Kwh / m2 / day is considered as a reference for sizing.

The average daily and monthly hydraulic energy required from the relationship:

$$E_c = CH.Q.HMT/R_P$$

- Where Ec is expressed in kWh.
- Q: Flow rate (m3 / day)
- HMT: total head.
- CH: the hydraulic constant

The power of the pump is:

Pc = (Qj x HMT x2,725) / (HSP x R) with

- Qj: daily volume in m3
- H: manometric head of pumping in meter
- HSP: sunshine in the day in KWh / m²
- R: overall efficiency generator, electronics and electric pump taken at 40%

2.2 parameterisation of desalination by nanofiltration

Nanofiltration is a separation technique using a membrane that allows the fractionation of solutes, whose molar mass is between 200 and 1000 Daltons.

The necessary settings before sizing a nanofiltration plant are:

Jp = K*(ΔP-ΔΠ) avec **ΔΠ=i*C*R*T** ; $\Delta P=\frac{Pentrée-Psortie}{2}$; $Jp=\frac{Qp}{S}$

- Jp: permeate flow (L / h / m²)
- K: permeability of the membrane (L / h / m² / bar)
- ΔP: membrane pressure (bar)
- ΔΠ: osmotic pressure (bar)
- S: filtration area (m²)
- i: number of entities released per mole
- C: molar concentration (mol / L)
- R: perfect gas constant (L.bar/mol.K)
- T: temperature (K)

The dimensioning of the nano-filtration membrane on an industrial scale, according to the following formula:

$$QpS=K\times(\Delta P-\Delta\pi)$$

3. RESULT

The solutions provided for the reinforcement of the Androy drinking water exploitation are quoted in the following paragraph:

- Upgrading and solar system mobilisation of the electromechanical equipment of the Ampotaka - Tsihombe Pipeline - False cap.
- Implementation of the Antsira-Ambon Solar Pipeline powered by solar system.
- Implementation of the Bemamba Pipeline - Ambovombe - Antaritarika powered by solar system.
- Construction of solar pumping water supply from rural town centers to municipalities: Antanimora - Andalatanosy - Beraketa - Bekitro - Maroaloky Erakoky.
- Construction of the gravity gravitational water supply of Manakoliva.
- Implementation of solar pumping water supply on large boreholes of 29 sites, coupled with desalination units powered by solar system.
- Rehabilitation of 127 boreholes equipped with pump motors.

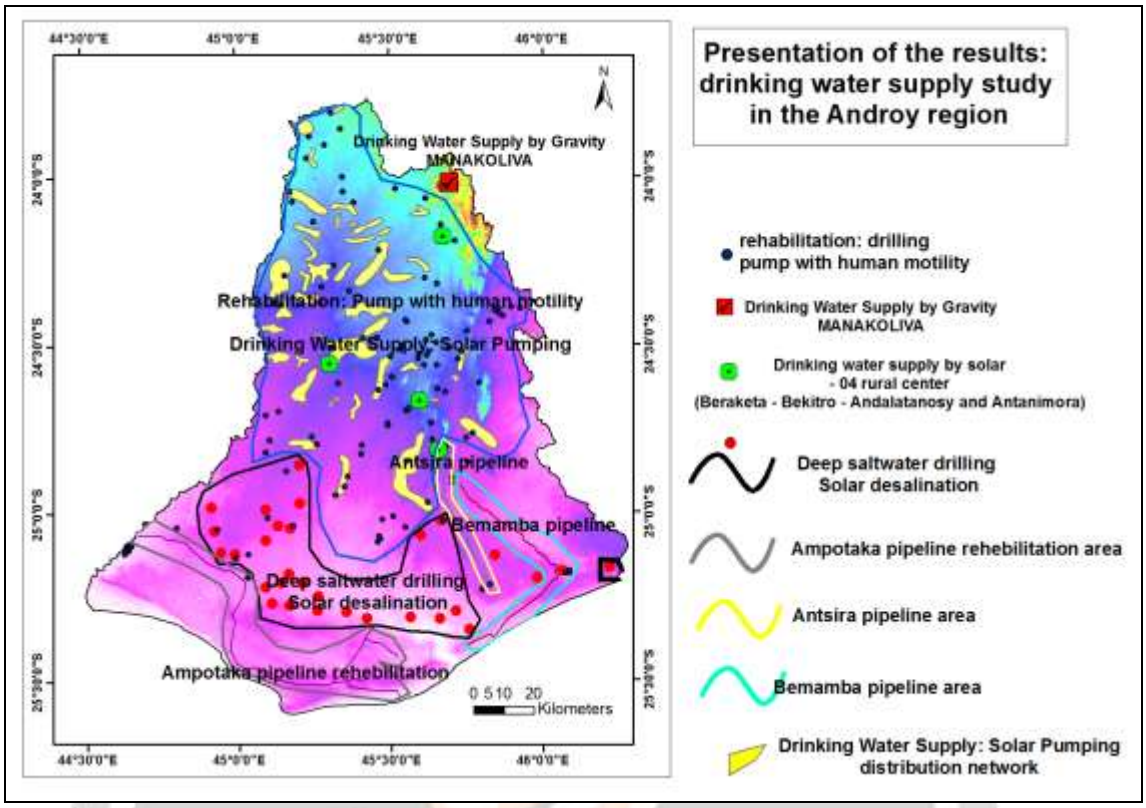

Fig -4: water supply proposal from Androy

Applying the result, the water access rate is the ratio between the number of the population served and the beneficiary 2030 (698,847 / 1,119,547), this is 62%.

Table -4: Drilling in the Androy area

water supply system	beneficiary	access rate
2030 water supply study	512697	45.8%
JIRAMA Bekily	6000	0.5%
functional drilling	150150	13.4%
other water partner	30000	2.7%
total		62%

4. CONCLUSIONS

The study will eventually increase the water supply rate of 62% of many target villages in the Androy Region using a system operating system, solar energy, more economical and sustainable.
The entire Greater South Madagascar will benefit from spin-offs socio-economically of such a system.

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