CHAPTER 5 EXISTING INSTITUTION AND ORGANIZATION FOR WATER SUPPLY

5.1 Organization of AES and JIRAMA in the South Region

5.1.1 Organization of AES

The headquarters of AES is in the capital city of Antananarivo with a General Director and eighteen (18) staff in the office. AES also has a regional office in Ambovombe city serving the South Region with water supply as a center of the service area. To the regional office, a Technical Director and 114 staff in 2006, decreased from 120 in 2005, are assigned for operation and maintenance of the water services.

In the area of Beloha-Tsihombe pipeline water supply system, which was constructed under the water supply project with the official assistance of Japan in 1995 to 1997, there is an area office in Beloha city, and a liaison office in Tsihombe city. In the system, service staffs are arranged at each water supply station to sell the water from the reservoir along the pipeline. Additionally, the water is provided to the remote villages using water tank trucks operated by Beloha office and Tsihombe office. However, the drinking water is not sufficiently provided to the villages due to the shortage of water tank trucks and expensive water charge of AES. One bucket with 13liters of water costs 100Ar(5.6Yen), which is equivalent to 6,600Ar/m^3 (370Yen/m^3) and 16.5 times of JIRAMA's rate of 400Ar/m^3 (22Yen/m^3) in 2005.

Based on the previous studies by the Consultants from World Bank and the AES himself, the proposal for improvement of the AES has been deliberated by the MEM and concerned agencies since September 2005. The important symposium sponsored by MEM for the viability of drinking water supply in the South was held on the 24th and 25th March, 2006 in Ambovombe city to discuss the multiple solutions. It is possible to improve the present situations of AES technically and financially, however, for effective improvement, investment, technical improvement and managerial innovation of the existing system are indispensable. Currently, income of AES mainly from selling water is not sufficient due to technical and managerial difficulty. It was only 36,000 m^3/year (about 100 m^3/day) in 2005.

(1) Situation of AES

The AES has acted as a main agency for the water supply project cooperated with Japan and other donors in the South Region of Madagascar more than 25 years. Main water supply facilities belong to AES as follows:

1) Ambovombe water tank truck system
2) Pipeline system of 140km in Beloha to Tsihombe city
3) Groundwater supply in communes with solar pumping system namely 5 AEP Centers and groundwater development with handpump facilities assisted by World Bank and UNICEF

The main water supply facilities belonging to AES are operated insufficiently due to decrease in number of the water tank trucks and increase of diesel cost for operation. The number of water tank truck is only 2 tankers in Ambovombe office and 1 tanker in Beloha existing pipeline system. The two water tank trucks are run to supply water to the surrounding area of Ambovombe. However, Amboasary water treatment plant which is one of water sources for Ambovombe area has a larger capacity of water treatment than the current operation, and the another water source, groundwater in Ambovombe city, is only 38m^3/day.

Beloha existing pipeline is hardly working from February 2006 due to the high cost of diesel. The most of staffs of AES are in the suspension of the work at this part.

(2) AES Organization in 2005

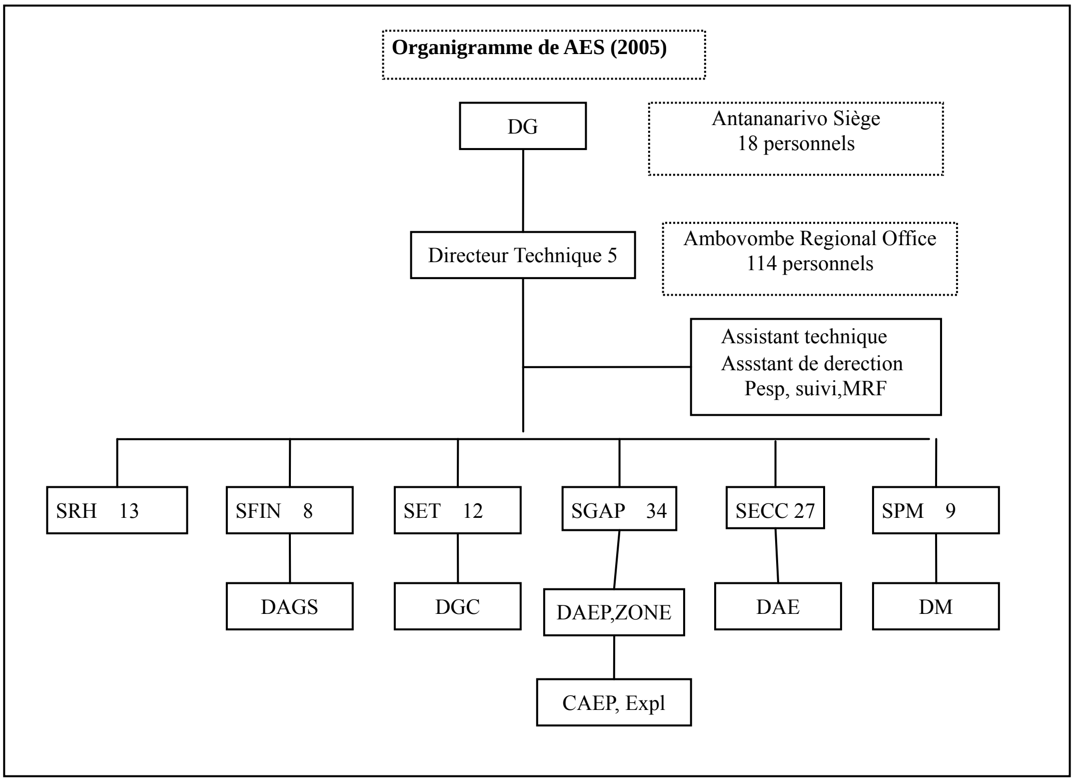

Figure 5.1.1 - 1 AES Organization Chart (2005)

(3) Financial Aspect of AES

Most of the current expenditure of AES is composed of operation cost for water tank trucks in the Ambovombe system, and the pipeline operation cost for Tsihombe and Beloha water supply system as shown Table 5.1.1-1 and Table 5.1.1-2. The total expenditure is about 251,329,333 Ar (14million Yen) in 2004. On the other hand, water charge income is 106,682,323 Ar (6million Yen) in 2004, and the current deficit is 144,647,010 Ar (8million Yen) in 2004.

The AES relied on about 320 million Ar (18million Yen) of subsidy from national budget which is about 63% of AES yearly current expenditure in 2000 and 2001. Recent total current expenditure of AES is shown in Table 5.1.1-1. The current deficit in 2005 is still high of 24.1% but has little improved after the subsidy termination. Table 5.1.1-2 indicates that the AEP center type of water supply management makes its balance of operation.

Table 5.1.1 -1 Financial Aspect of AES from 1999-2005 (in Ariary)

Year	Water charge	Operation Cost	Balance (1999-2004)	Subsidy from the State
1999	107,601,955	372,327,788	236,535,100	(63.5%)Subsidy
2000	190,421,539	495,501,068	312,719,400	(63.1%)Subsidy
2001	184,558,000	496,677,400	312,119,400	(62.8%)Subsidy
2004	**106,682,323**	**251,329,333**	**-144,647,010**	**- (57.6%)**
2005	**57,212,675**	**58,626,171**	**-1,413,495**	**- (24.1%)**

Data: AES, Annual Activities Report, February 2006

Table 5.1.1 -2 Financial Status of AES year 2004-2005

Supply system	Year	Initial balance	Expenditure	Income	Balance	
Ambovombe System	2004		**122,522,200**	**39,325,070**	**-83,197,130**	**(Ar)**
			48.75%	36.86%	57.52%	
	2005	5,976,128	272,051,595	277,874,582	153,141	(Ar)
5AEP Centres	2004		**39,365,889**	**39,906,952**	**541,064**	**(Ar)**
			15.66%	37.41%	-0.37%	
	2005	445,789	445,789	891,578	1,783,156	(Ar)
Pipeline System	2004		**89,441,244**	**27,450,301**	**-61,990,943**	**(Ar)**
			35.59%	25.73%	42.86%	
	2005	1,194,598	13,565,993	14,364,696	395,895	(Ar)
Total	2004		**251,329,333**	**106,682,323**	**-144,647,010**	**(Ar)**
			100%	100%	100%	
	2005	**7,616,515**	**286,063,377**	**293,130,856**	**2,332,192**	**(Ar)**

Production unit cost of Ambovombe and existing Pipeline System in 2005 is estimated in Table 5.1.1-3.

Table 5.1.1 - 3 Production unit cost of Ambovombe and existing Pipeline System in 2005

Items	Water Supply Amount(m^3/year)	Expense (Ar)	Income (Ar)	Supply Unit Cost (Ar/bucket)	Remarks
	A	B	C	B/A	
AES Total	**36,116 (98.9m^3/day)**	**293,130,856**	**286,063,377**	**105**	Including Subsidence (about 1/2 of total expense)
Brake down	Water Supply Amount	Production Expense	Water Charge	Production Unit Cost	Excluding personnel cost
Ambovombe System	7,266 (19.9m^3/day)	34,974,200	-	63	Including 6,612m^3/year : delivered by Water Truck
Tsihombe-Beloha Pipeline System	2,465 (6.8m^3/day)	37,116,021	14,061,738	196	
Sub Total	9,731 (26.7m^3/day)	72,090,221	-	96	
*Above two Systems at supply center				*(100)	
Other 5 AEP/AES	26,385 (72.3m^3/day)	63,300,592	54,489,605	32	

5.1.2 Situation of JIRAMA in Amboasary and Ambovombe

JIRAMA provides electricity and water supply services to the regional town of Amboasary and only power supply to Ambovombe, independently. Although electric power supply to Amboasary is currently in deficit due to high fuel costs, the water supply services using groundwater source near the Mandrare River is well managed.

Both tariffs of water and electricity are set by JIRAMA headquarter in Antananarivo, and generally national rates for water and electricity are applied. The water and electricity bill is issued based on the meter reading of the previous month. There is 8 days grace period for non-payment. If the user does not pay within 8 days, the line will be closed within a week.

(1) Situation in Amboasary

Groundwater is the source of water supply. The depth of borehole is 14.5m and water quality is in good condition. The water charge is set simply in two steps as the first 10 m^3/month is 195 Ar (11Yen) and more than 10 m^3/month is 440.6 Ar/month (25Yen/month). JIRAMA installed eighteen (18) public faucets but nine (9) faucets were stopped service due to installation of house connections. The remaining nine (9) faucets were contracted operation to the private water venders who sell the water of 10 litters by 20 Ar (1.1Yen)to make money and public water services in the town.

Table 5.1.2 -1 Financial Condition of JIRAMA in Amboasary (2004) (in Ariary)

Year		Revenue	Expense	Balance
2004	Water	16,130,400	1,600,000	130,400
	Electricity	79,075,600	126,897,200	-47,821,600

Table 5.1.2 -2 Outline of JIRAMA in Amboasary in 2005

JIRAMA in Amboasary (Water Supply and Electricity)		
1. Water supply:	Private connection	193
2. Water supply amount:	Production:	83,897 m^3/year (230 m^3/day)
	Accounted for water	57,732 m^3/year (68.8%)
	Water Loss	13%
3.Water quality:	EC: 104 mS/m, pH: 7.99, Turbidity 0.54, Cl: 156 mg/l ,	
4.Water charge (Average : 309.2 Ar/m^3)		
0-10m^3/month	195 Ar (11Yen) (constant)	
10 + m^3/month	440.6 Ar (25Yen) (constant)	
5. Electricity		
0-20 kWh/month	115 Ar (6.4Yen) (constant)	
20 + kWh/month	395 Ar (22Yen) (constant)	

The number of staff of JIRAMA in Amboasary is only 12. Organization chart of JIRAMA in Amboasary (2005) is shown as follows.

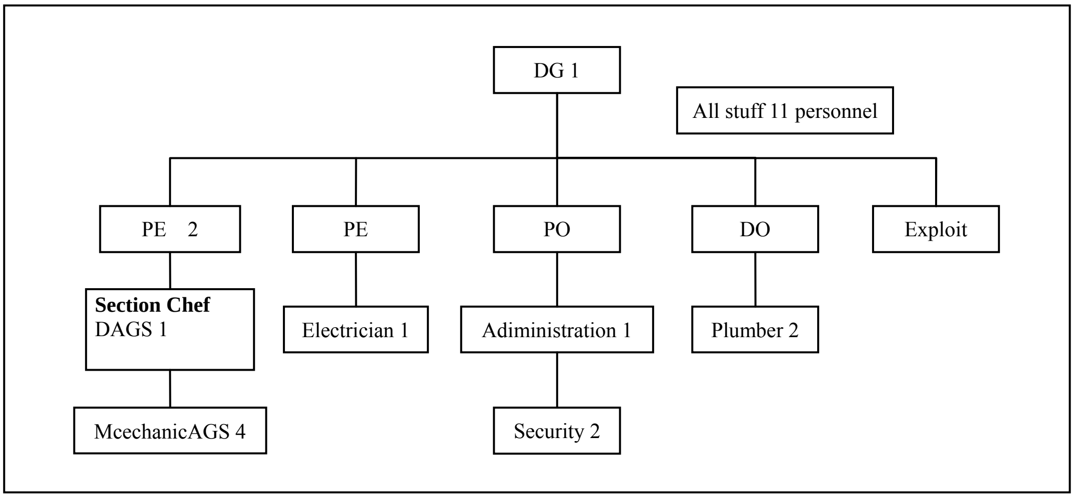

Figure 5.1.2 - 1 Organization chart of JIRAMA in Amboasary (2005)

(2) Situation in Ambovombe

The JIRAMA in Ambovombe was established recently in 1999. The duty is only for electric power supply in the urban. However, because of the cost inflation of fuel and purchase of new generator, the financial status is not stable as shown below.

Table 5.1.2-3 Financial Condition of JIRAMA in Ambovombe (in Ariary)

Year		Revenue	Expense	Balance	Remarks
2004 (monthly average)	Electricity	6,600,000	10,000,000	-4,000,000	-
2005 (March)	Electricity	7,037,000	16,991,000	-	Purchase: New Generator

Running the electric supply is making heavy loss, but still keeping 24 hours supply. The AES replaced the diesel pumping system to JIRAMA electric base as 38 m^3/day in 2005. This reduced operation cost.

5.2 Commune, Fokontany, and CPE

(1) Actual Water Supply Systems

Table 5.2-1 represents the actual water supply systems by commune in rainy and dry seasons.

In the rainy season, the most common way of getting water is public "impluvium", which is widely used by local people in all the communes except Sihanamaro. Private water tanks equipped with a gutter, public water tanks and shallow wells are also usable on certain conditions. AES water wagons distribute water to three communes. There are a lot of people who depend on natural water points such as ponds, 'rano vato' (water on rocks), puddles, rivers and so on.

In the dry season, all the 15 communes in the study area depend heavily on the AES water wagon system. However, local people, especially in remote villages far from Central Ambovombe, are obliged to seek for other means to get enough water, due to the fact that the water quantity distributed by the wagons is totally insufficient to meet their demand. They reluctantly buy expensive water carried from far away from their dwellings. Some of them go all the way to rivers or wells for muddy or saline water. Only one commune, Sihanamaro, has a totally different policy for the use of their impluvium: They don't use the water stocked in the impluvium during the rainy season and save it for the dry season.

Water shortage is an acute problem throughout the whole study area. Especially, people in the suburb hamlets are confronted with more serious situation than in the central town of Ambovombe or Ambondro. Particularly, the situation in the dry season is so miserable, indeed: They are forced to take pains to pay no less than 500 to 1,000 Ar (28-56Yen) for a bucket of water or drag their weary feet toward water points far away from their home.

Table 5.2-1 Actual Water Supply Systems in the Study Area (1/2)

Rainy Season－Saison des pluies

( ) : Rate for a bu

Commune	Water Wagon	Zebu Carriage	Impluvium (Pub.)	Impluvium (Private)	Public Tank	Tank with Gutter (Pub.)	Tank with Gutter (Private)	Deep Well	Shallow Well	Pond	Rano Vato (water on rock dents)	River
Ambanisarika	-	-	10 (100Ar)	-	-	-	(200 - 400Ar)	-	-	○	-	-
Ambazoa	-	-	5 (50Ar)	-	-	-	○	-	-	-	○	-
Ambohimalaza	-	-	8 (50Ar)	○	-	○	○	-	-	○ Artificial Sarimonto*Name of a pond	-	-
Ambonaivo	-	-	15 (50Ar)	-	Under construction	-	(250Ar)	-	-	For animals ○	○	-
Ambondro	-	-	2 out of 7 available (50Ar)	-	Solar (50Ar)	-	○	-	○	○	-	-
Ambovombe	Central town, poured into tanks (100Ar)	from wells nearby (100Ar)	23 out of 28 available, Periphery (50Ar)	-	Wagon (100Ar) Solar (20Ar)	(100Ar)	(100Ar)	○	○	○	○	-
Analamary	-	-	3 (50Ar)	-	-	-	(200 - 300Ar)	-	-	○	-	-
Antanimora	-	-	-	-	-	-	-	○ (AES Public faucet: 40Ar) (UNICEF Pump: 1400Ar/household/year)	-	-	-	-
Antaritarika	(100Ar)	-	9 (300Ar)	-	-	○ (Free)	○	-	-	-	○	-
Beanantara	-	-	2 out of three available (20Ar)	-	-	-	○	-	-	-	○	The Mandrare in case of necessity
Erada	-	-	6 (100Ar)	○	-	-	○	-	-	-	-	-
Maroalomainty	(100Ar)	-	10 (50 - 100Ar)	-	-	-	(200 - 500Ar)	-	-	-	-	-
Maroalopoty	(100Ar)	-	8 (50Ar)	-	-	-	(200Ar)	-	-	Artificial ○	-	-
Sihanamaro	-	-	-	-	-	-	-	-	○	○	○	-
Tsimananada	-	-	3 (50Ar)	-	-	-	(200Ar)	-	-	Natural Aritificial- (50Ar)	-	-

Table 5.2-1 Actual Water Supply Systems in the Study Area (2/2)

Dry Season－Saison sèche

( ) : Rate for a bu

Commune	Water Wagon	Zebu Carriage	Impluvium (Pub.)	Impluvium (Private)	Public Tank	Tank with Gutter (Pub.)	Tank with Gutter (Private)	Deep Well	Shallow Well	Pond	Rano Vato (water on rock dents)	River
Ambanisarika	(100Ar) Insufficient	(From Ambovombe－500Ar) (From Ambondro－500Ar)	-	-	-	-	-	-	-	-	-	-
Ambazoa	(100Ar) Insufficient	-	-	-	-	-	-	-	Saline water near the sea	-	-	The Manambovo (600Ar)
Ambohimalaza	(100Ar) Insufficient	From Ambovomve, Ambondro (600Ar)	1 out of 10 filled by AES (100Ar)	-	-	-	-	-	-	-	-	-
Ambonaivo	(100Ar, when fuel lacks 200 - 500Ar) Insufficient	Some of carriage owners are vendors. (500 - 500Ar)	-	-	-	-	-	-	-	-	-	-
Ambondro	15 Fokontany out of 23	(600 - 800Ar)	-	-	Solar (50Ar) Insufficient	-	(150 -200Ar)	-	600-800Ar (private)	-	-	-
Ambovombe	Central town, poured into tanks (100Ar)	(3000Ar/drum: Central Town) (6000Ar/drum: Periphery)	Rarely buy from AES (100Ar)	-	Wagon (100Ar) Solar (20Ar)	(300Ar)	Central town (150Ar) Periphery (300Ar)	○	○	-	-	-
Analamary	(100Ar) Insufficient	(From Ambovombeから－500Ar)	-	-	-	-	-	-	-	-	-	-
Antanimora	-	-	-	-	-	-	-	○ (AES Public faucet: 40Ar) (UNICEF Pump: 1400Ar/household/year)	-	-	-	-
Antaritarika	(100Ar)	○	-	-	-	-	-	-	-	-	-	The Manambovo (2,500 fmg)
Beanantara	(100Ar) Insufficient	From the Mandrare (600Ar)	-	-	-	-	-	-	-	-	-	The Mandrare
Erada	(100Ar) Insufficient	(300Ar)	-	-	-	-	○	-	-	-	-	-
Maroalomainty	(100Ar) Insufficient	(500Ar)	-	-	-	-	-	-	Saline water near the sea	-	-	-
Maroalopoty	(100Ar) Insufficient	(300Ar)	-	-	-	-	-	-	-	-	-	-
Sihanamaro	In case of insufficiency (50 out of 150Ar saved as communal profit)	From Ambondro (800Ar)	5 (20 - 50Ar, End of dry season, 200Ar)	-	-	-	-	-	○	-	-	The Manambovo (Not for sale)
Tsimananada	(100Ar) Insufficient	From Ambovombe (300Ar)	-	-	-	-	-	-	-	-	-	-

(2) Operation and Management of Water Supply

The actual O/M (Operation and Management) of water supply infrastructures by the authorities of commune or fokontany is described as follows.

(a) Impluvium

14 communes out of 15 have their own impluvia, which are wildly used by the public mainly during the rainy season. Table 5.2-2 shows the three ways of O/M for impluvium (except the Commune of Antanimora).

Table 5.2-2 Different O/M systems for Impluvium by commune

No.	Commune	Commission (Commune)	Commission (Fokontany)	CPE
1	Ambanisarika	X	-	-
2	Ambazoa	X	-	-
3	Ambohimalaza	-	X	-
4	Ambonaivo	-	-	X
5	Ambondro	-	-	X
6	Ambovombe-Androy	-	X	-
7	Analamary	-	X	-
8	Antanimora *Borehole	-	-	X
9	Antaritarika	-	-	-
10	Beanantara	-	X	-
11	Erada	X	-	-
12	Maroalomainty	X	X	X
13	Maroalopoty	-	-	X
14	Sihanamaro	-	X	-
15	Tsimananada	-	X	-
	Total	4	7	5

Generally, public impluvium are managed by one of the three organization in the above table. Only in Maroalomainty management system is different from one impluvium to another.

Usually, impluvium water is not free of charge. The rate of a bucket of water (13 liters) is from 50 to 100 Ar (2.8-5.6Yen) in the rainy season, and from 100 to 500 Ar (5.6-28Yen) in the dry season. Water rates are different from one commune to another.

Long time has passed since the construction of these impluvia. Certain impluvia have quite a few cracks on the concrete surfaces, which prevents an efficient water storing.

(b) Public Water Tank

There is a CPE (Water Point Committee) covering 1,500 househould in the center of the commune of Ambondro for distribution of water pumped by solar system. The committee consists of a president, a vice-president, a treasury, a secretary, an auditor, four advisers, two guards, and water vendors. Only guards and water vendors are paid for their daily tasks.

The rate was 10 Ar (0.6Yen) for a bucket of water in 2000. Since then it has been going up gradually. The rate is 50 Ar (2.8Yen) as for April, 2005.

All the facilities including solar panels are in good operation so far. According to the president of the committee, the actual water rate is quite enough for daily O/M, but, not enough to save for repairing or parts exchange.

In the rainy season, there is abundant water in the well. In the dry season, however, it is quite difficult to pump up enough water due to the decrease of water quantity. Therefore, people are compelled to buy water from private shallow wells at ridiculous rate (600 – 800 Ar(33.3-44.4Yen)).

(c) Borehole Equipped with a Hand Pump

It is good to know some information about the O/M system of the boreholes quipped with a hand pump in the commune of Antanimora adjacent to the study area.

In Antanimora, 150 boreholes were drilled and equipped with a hand pump named “India Mark II’, using the funds provided by UNICEF in the middle of 1990s.

At the beginning, a French NGO was responsible for monitoring of the project. Then, in May 2000, the local beneficiaries’ O/M organization, AAEPA (Association d’Alimentation en Eau Potable d’Antandroy) was created to take over the task. The organization chart is shown in Figure 5.2-1.

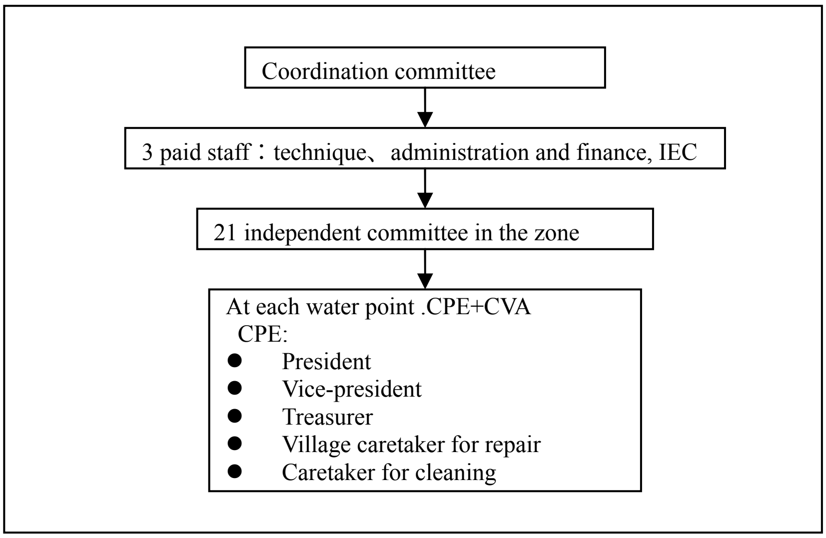

Figure 5.2-1 Organization Chart of the AAEPA

The coordination committee (Comité de coordination) occupies the highest top. This committee consists of a president, a vice-president, a treasury, and an advisor and controls the whole organization. The next lower branch is a three-person-group responsible for technical, administrative, and financial aspects such as well repairing and paper work on daily basis. Then, the O/M committee composed of the representatives from the 21 sub-zones comes. Under a sub-zone, each water point has its own CPE （Comité de Point d’Eau）and CVA（Comité Villageoise d ’Animation） that are in charge of daily O/M in the covering area. A CPE consists of a president, a vice-president, a treasury, two guard and two sanitation keepers.

According to one of the three staffers for technical, administrative, and financial aspects, the biggest problem which this O/M group is actually confronted with is a shortage of funds. The only income source is the payment from the beneficiaries. As the annual payment born by a household is only 1,400 Ar (78.4Yen), the total annual income for the AAEPA is no more than 5 million Ar(280,000Yen).

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CHAPTER 6 PILOT PROJECT

6.1 Plans and Objectives

In order to establish a self-management system at beneficiaries and appropriate to the socio-economic conditions in the study area, a test with a view to verify the impacts of raising population’s awareness, the Pilot-Project, has been carried out following the creation of CPE. Table 6.1-1 presents basic information on the five (5) sites selected as the subject of the Pilot-Project among the drilling sites showing positive results. The localization of each site is presented in Figure 6.1-1.

Table 6.1-1 Five sites of the Pilot-Project

No.	Identi-fication	Pilot-project site	Commune	Nb of villagers	Facility	Charge system
1	P009	Marobe Marofoty	Ambovombe	570	Rope pump	Volumetric 20 Ar/bucket
2	P010	Analaisoke	Sihanamaro	850	Rope pump	Contribution 100 Ar/month/household
3	F009	Lefonjavy	Ambohimalaza	630	Vergnet pump	Contribution 1000 Ar/month/household
4	F022	Anjira	Antaritarika	315	Vergnet pump	Volumetric 20 Ar/bucket
5	F006	Bemamba Antsatra	Antanimora	410	Solar pump	Contribution 1000 Ar/month/household

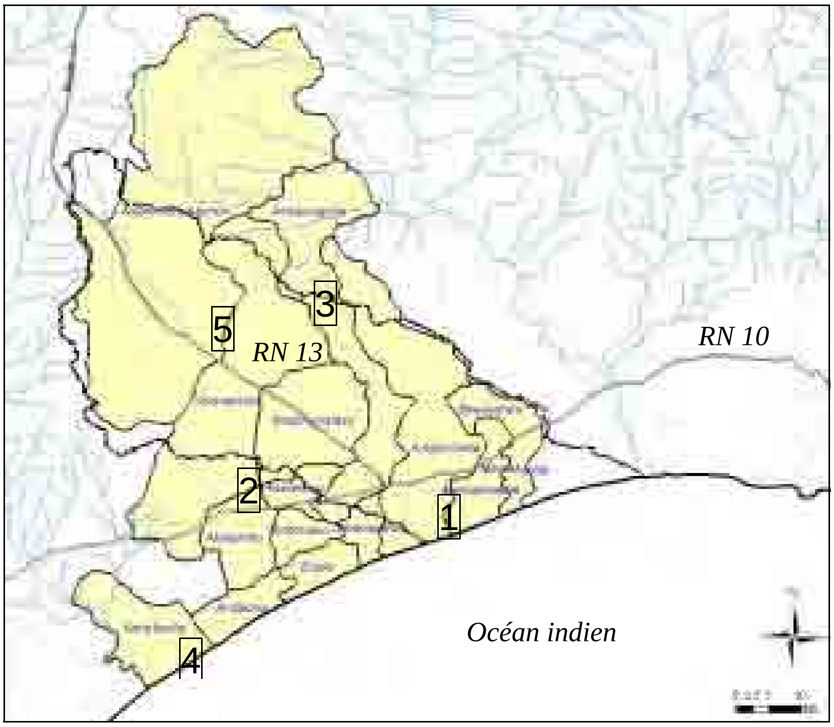


Figure 6.1-1 Location of the five sites (5) of the Pilot-Project

A sequence of activities of the Pilot-Project have been executed at the five drilling sites during 10 months, from the beginning of December 2005 to the end of September 2006, through a Malagasy NGO of which head office is located in Antananarivo. Details of the activities, the objectives and the contracts between the JICA Study Team and the NGO are presented in Table 6.1-2.

Table 6.1-2 Details of activities and contracts between JICA Study Team and the NGO

Sub-contract	Activities	Objective	Execution period
First stage (Contract 1)	Raising beneficiaries' awareness on the notion of water charge and the management and O/M system	- To create management and sanitary senses at the community population in rural area	December 2005 – March 2006
	Creation of CPE at the 5 Pilot-Project sites	- To create an organization of CPE for each Pilot-Project site	
Second stage (Contract 2)	Monitoring of the 5 Pilot-Project sites	- To verify the application state and the level of understanding of what the community population has learnt from the sessions of raising awareness - To make the community population recognize what is lacking to the management and to proceed to its capacity building	June – September 2006

6.2 Pilot Project Sites and Specification for Water Supply Facility

The following water supply facilities were constructed in the Pilot Project in this Study and shall be tested and monitored the operation and maintenance system with community participations.

(1) Solar Pumping System at one (1) site, F006, Antanimora (Groundwater Potential 30m^3/hr)
*Supply Population: 650
*Supply Capacity: 20 m^3/day
*Pump Capacity: 4.0 m^3/hr
*Total Head: 50m
*Water Tank: 10 m^3 x 2 units
*Public Faucet: 4 taps x 1 unit
*Solar pumping system is five (5) year guarantee.

(2) Pump Rope at two (2) sites, P009 in Ambovombe and P010 in Sihanamaro
*Static Water Level: about 10m to 20m
*Hand dug well

(3) Pump Vergnet at two (2) sites
* HPV-60 (Static Water Level: less than 60m) :F009 in Ambovombe
*HPV-100 (Static Water Level: less than 100m) :F022 in Antaritarika
*Maintenance tools

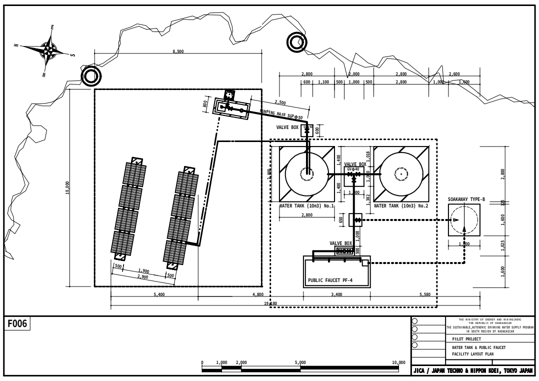


Figure 6.2-1 Solar Puming System facility layout

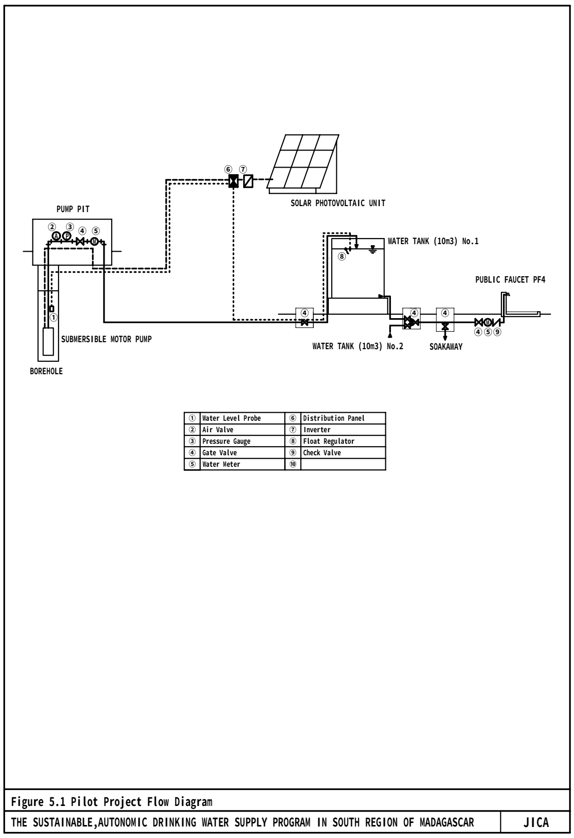


Figure 6.2-2 Solar Pumping System Flow Diagram

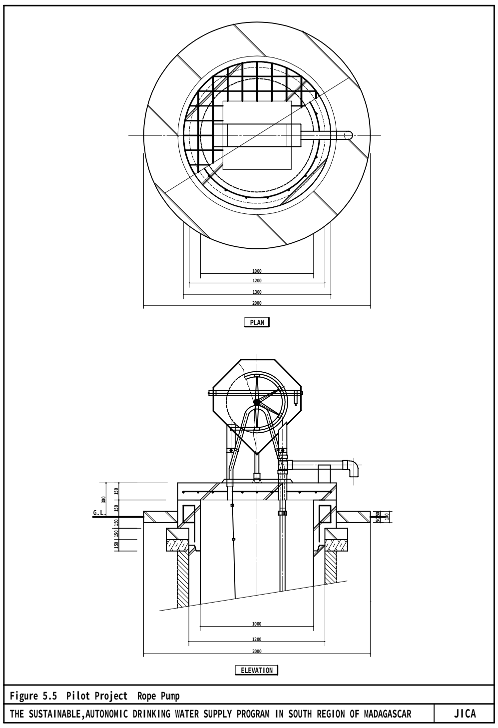


Figure 6.2-3 Rope pump

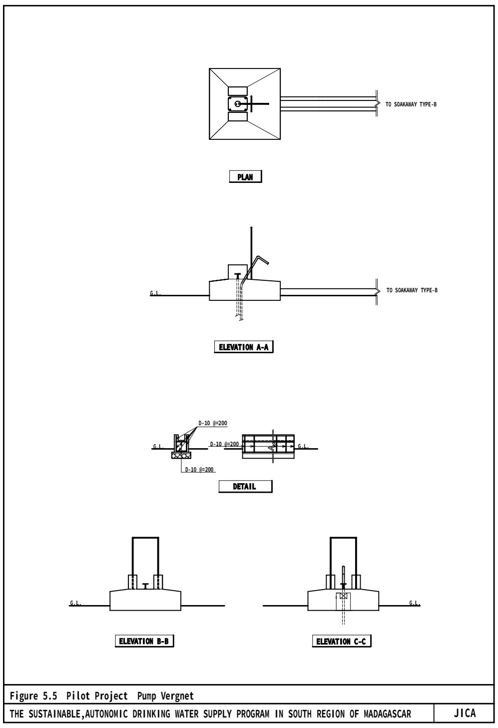


Figure 6.2-4 Vergnet pump

6.3 Socio-Economical Conditions of the Target Villages

6.3.1 Social Conditions of the Pilot Project Sites

Five sites among the test drilling sites were selected for the pilot project implementation. Each site is located in different five zones of AEP (drinking water supply) based on the hydro-geological division in the study area except Zone A.

With regard to the administrative position, each site lies under different conditions:

- Marobe Marofoty is in the urban area of Ambovombé town
- Analaisoke and Anjira, are in the centres of fokontany, and,
- Lefonjavy is a village which is one hour away by zebu cart from the fokontany centre.

More than 1,000 inhabitants live at Anjira, whereas less than 400 inhabitants live at Bemamba Antsatra: population of the other three sites is between 500 and 1,000 people. As it was recommended to users to fix the water charge based on the concept that all the water users contribute to maintain and manage the facility as well as to accumulate necessary funds for renewal of the installation, population size (number of pump users) influences directly not only on the necessary volume of water from the facility but also on the amount of water charge.

Regarding basic infrastructure, the conditions are as follows:

- Marobe Marofoty, Analaisoke and Anjira have primary schools
- Marobe Marofoty and Anjira have medical institutions
- Only Marobe Marofoty has weekly market and stores.
- All of them are accessible all the year, but roads to Bemamba Antsatra and Lefonjavy are narrow and difficult to pass through for heavy lorry during rainy season.

To sum up, compared to the other sites, Marobe Marofoty is relatively rich in social basic infrastructure.

The basic data of the project sites are summarized on the Table 6.3.1-1.

Table 6.3.1-1 Name, location, and commune of the pilot project sites

ID		F006	P010	P009	F022	F009
Name		**Bemamba Antsatra**	**Analaisoke**	**Marobe Marofoty**	**Anjira**	**Lefonjavy**
Zone		B (southern part of Antanimora)	C (Town and surrounding of Ambondro)	D (town and surrounding of Ambovombé)	E (coastal dune)	F (Ambovombé basin)
Commune		Antanimora	Sihanamaro	Ambovombé Androy	Antaritarika	Ambohimalaza
Population of fokontany		400	806	570	1,093	630
Social infra-structure	Primary school	-	Primary school	Schools in Ambovombé	Primary school	-
	Medical institution	-	-	Medical institutions in Ambovombé	CSB	-
	Market	-	-	Weekly market and stores in Ambovombé	-	-
	Road condition	Track, 3 km from RN 13	Minor road to commune centre	RN10 and RN13, local roads in the town	Local roads to commune centre	Track, 16 km from RN13

Source: JICA study team, 2006

6.3.2 Economic Condition of the Pilot Project Sites

(1) Income and Expenditure

A household of Lefonjavy earns 1,366,017 Ar in a year while that of Marobe Marofoty earns 328, 250 Ar per year. However, judging from direct observation of the village, it might be possible that some villagers replied their revenue in Fmg (former currency, equivalent to 0.2 Ar) instead of in Ariary.
Sources of income are agriculture, livestock, commerce and another activity such as temporary or seasonal migration to mining sites. The number of households who engage in these occupations is shown in Table 6.3.2- 1 Main income source of the pilot project sites.

Table 6.3.2- 1 Main income source of the pilot project sites

Number of household & average income		F006 Lefonjavy	F009 Bemamba Antsatra	F022 Anjira	P009 Marove Marofoty	P010 Analaisoke
Agriculture	Num. household	15	2	10	10	11
Livestock raising	Num. household	17	17	15	6	10
Commerce	Num. household	0	16	0	7	0
Other	Num. household	0	3	3	8	13
Average annual income		1,367,017	747,089	1,130,469	328,250	382,514
Average annual expenditure		458,806	299,589	1,092,506	231,317	322,503

Source: JICA study team 2006

6.3.3 Current Water Use

Current water use in the five project sites according to the interview to inhabitants is as follows:

(1) Volume of water: inhabitants draw daily is less than 10 liters in all 14 sites interviewed.
(2) Among the five project sites, residents of Analaisoke and Lefonjavy (Zone C and Zone F) know free water source. Residents of other sites buy water from wells, public fountains or water vendors.
(3) People pay for water in two modes: volumetric and contribution.
Amount of water charge is relatively low in the contribution mode than the volumetric mode.
In volumetric mode, a household of Anjira pays 46,000 Ar for water monthly to private water vendors and a household in Marobe Marofoty pays 12,667 Ar to private water vendors and public fountains. In the contribution mode, a household in Bemamba Antsatra pays only 1,400 Ar as annual water charge.
(4) Only the inhabitants of Bemamba Antsatra have experienced organizing themselves for the water source management. The inhabitants of Marobe Marofoty do not organize themselves, but they know the CPE established at the public fountains where they will fetch water.

Table 6.3.3- 1 Condition of current water use shows the summary of the condition of current water use of each Pilot Project site.

Table 6.3.3- 1 Condition of current water use

Item		P009 Marobe Marofoty	P010 Analaisoke	F006 Bemamba Antsatra	F009 Lefonjavy	F022 Anjira
Water source	Free	-	- Rainwater tank - Impluvium - *vovo* - Ponds	- River - Ponds - *vovo*	- River - Pond (water pool)	- River
	Charged	- Public fountain - *vovo*	-	- Public fountain	-	- Water vendor (river water)
Water sources	Association for water management	-	-	Residents belonging to a CPE	-	-
	Distance	- Public fountain : 1.5km - *Vovo* : 0.8km	- Well : on site - Impluvium : on site - Basin : on site	- River: 0.3km - Pond : 0.2km - Vovo : on site - Public fountains: 5 km	- River: 30 km - Ponds: 1 km and 6 km	- River : 12 km - Water vendor: on site
	Quantity of sources	- Insufficient	- Insufficient	- Insufficient (river, pond, vovo) - Average (public fountains)	- Insufficient	- Insufficient
	Quality of sources	- Average (public fountain - Bad (*vovo*)	- Bad	- Average (river, pond, vovo) - Bad (public fountain)	- Bad	- Bad
	Unit water charge	100 Ar/ bucket	-	1,400 Ar/ household/ year	-	300 – 400 Ar / bucket
Volume and expense of water	Quantity of draw water per capita (*average of 18 households surveyed in each site*)	6. 26 lit/pers./day	10.8 lit/pers./day	6.59 lit/pers./day	9.91 lit/pers./day	5.79 lit/pers./day
	Mode of water charge	Volumetric (20Ar/ bucket in general)	-	Contribution	-	Volumetric
	Total payment (*average of 18 households surveyed with each site*)	12,667 Ar/ household/ month	-	1.400 Ar/ household/ year	-	46,000 Ar/ household/ month

Source: Base line survey and socio-economic condition survey, JICA Study Team, 2005
Basic data collection of the 14 sites, JICA study team, 2006
In situ observation

6.4 Participation of the Community Population and Capacity Building of the CPE

(1) State Principle

In June 2005, the Ministry of Energy and Mining has elaborated the "Manual of Procedure for the establishment of water and sanitation projects" in order to set up and to manage components of water and sanitation in rural area of Madagascar. According to this manual, in rural area, community management should be applied for all water points equipped with manual pumps and for water, gravidity system and by pumping system.

(2) Raising Beneficiaries' Awareness

Conformingly with the State policy, the training of a CPE has been carried out at each pilot project site. The NGO has started to organize some training of raising awareness. These activities are about raising beneficiaries' awareness on the understanding plan for the value of the creation of a CPE and for the importance of the self-management of AEP system and the maintenance of good sanitary condition in the village area.

The activities of raising awareness comprise 2 following points:

- Recalling and re-enforcing of the beneficiaries' perception of the water scale price, the understanding of the maintenance system and the AEP management, and the necessity of creation of a CPE within the beneficiaries.
- Recalling and executing the beneficiaries' capacity building on controlling the sanitary condition of daily life.

6.5 Creation of CPE and Water Charge

6.5.1 Creation of CPE

The Water Point Committee (CPE) is the community structure of which goal is to make sure of the sustainability and the autonomy of the water point conveyance management. It ensures the following tasks:

(a) Representing the population

(b) Raising awareness and monitoring

(c) Financial management

Figure 6.5.1-1 presents the typical chart of a CPE and the assistants, and its detailed functions.

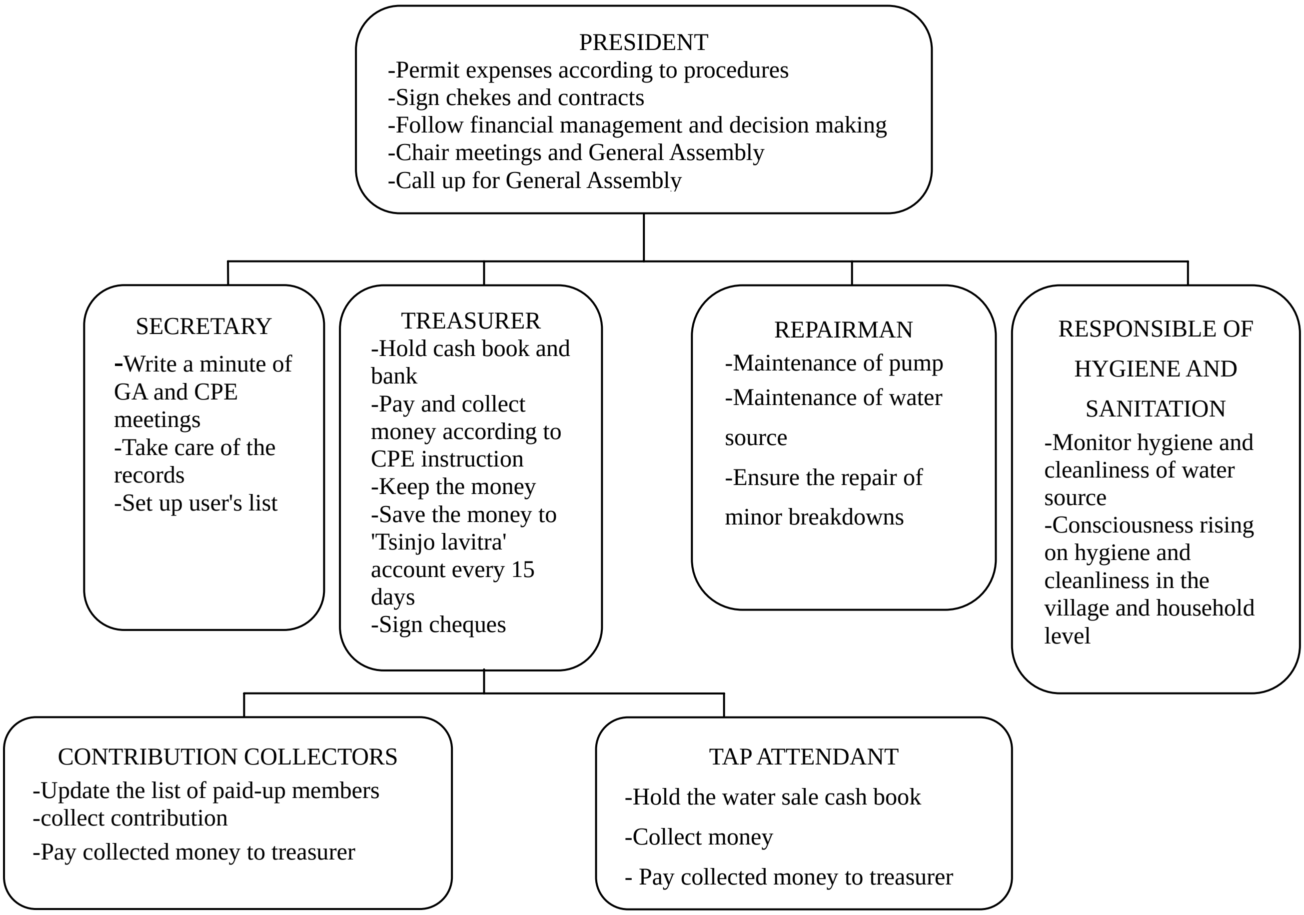


Figure 6.5.1-1 Typical chart of a CPE, the assistants and its detailed functions

A CPE has been created at each Pilot-Project site during February and March 2006. The procedure of creation of the CPE has followed the stages presented in Figure 6.5.1-2.

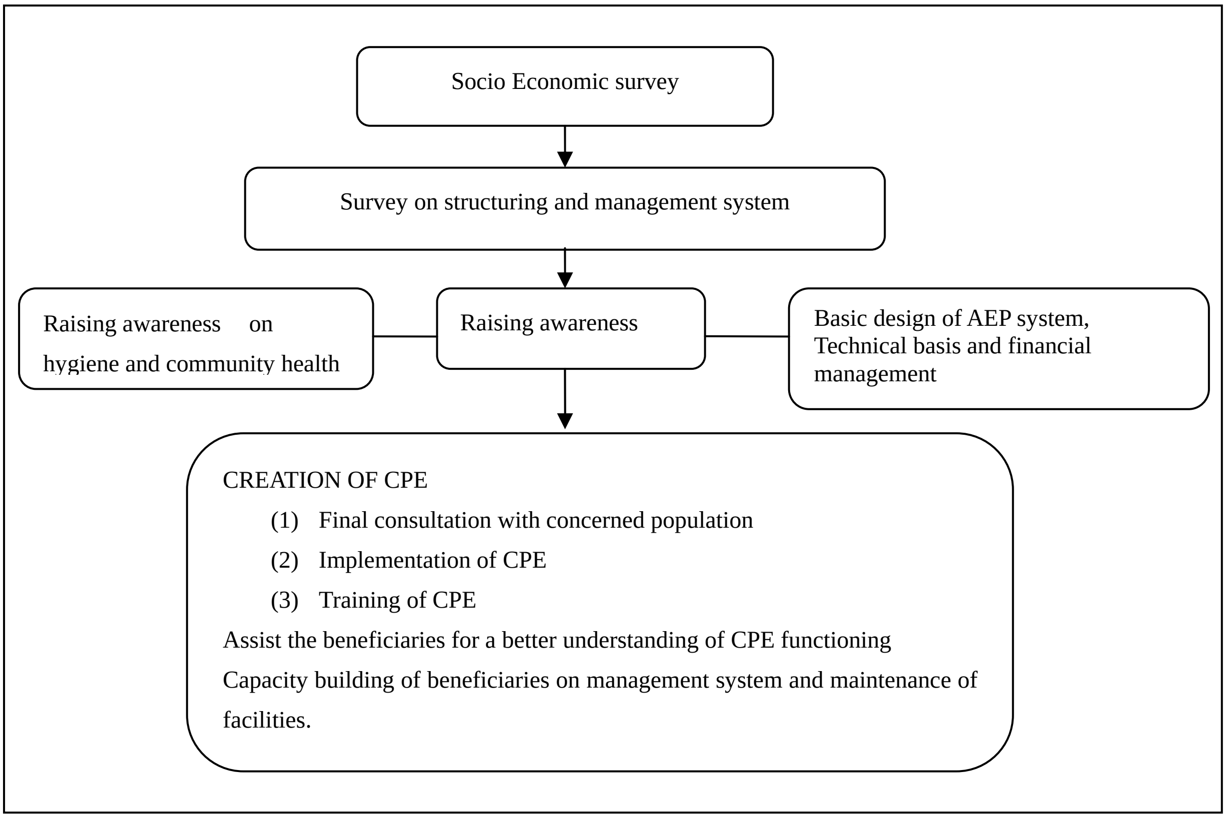


Figure 6.5.1-2 Procedure of creation of the CPE

6.5.2 Water Charge

(1) Charge System

Following the activity of raising awareness carried out by the NGO, the members of each newly created CPE have decided the charge of one bucket or the monthly contribution after considering everything. The charge system of each pilot site is presented in Table 6.5.2-1.

Table 6.5.2-1 Charge system of the 5 Pilot-Projects sites

No.	ID	Project-Pilot site	Commune	Nb of villagers	Water sale system	Payment membership fees	Water scale price for villagers	Water scale price for others (outside of the Fokontany)	For cattle watering
1	P009	Marobe Marofoty	Ambovombe	570	Volumetric	-	10Ar/small bucket 20Ar/medium size bucket 30Ar/big bucket	-	-
2	P010	Analaisoke	Sihanamaro	850	Contribution	-	100 Ar/month /household	-	-
3	F009	Lefonjavy	Ambohimalaza	630	Contribution	-	1,000Ar/month /household	-	-
4	F022	Anjira	Antaritarika	315	Volumetric	-	20Ar/bucket 50Ar/bucket in dry season	50Ar/bucket	-
5	F006	Bemamba Antsatra	Antanimora	410	Contribution	500 Ar	1,000Ar/month /household	1,000Ar/month /household	Membership fee : 1,200 Ar Monthly contribution : 1,000 Ar

(2) Basic Financial Management

The basic financial water management shall include at least the chart of the following figure 6.5.2-1.

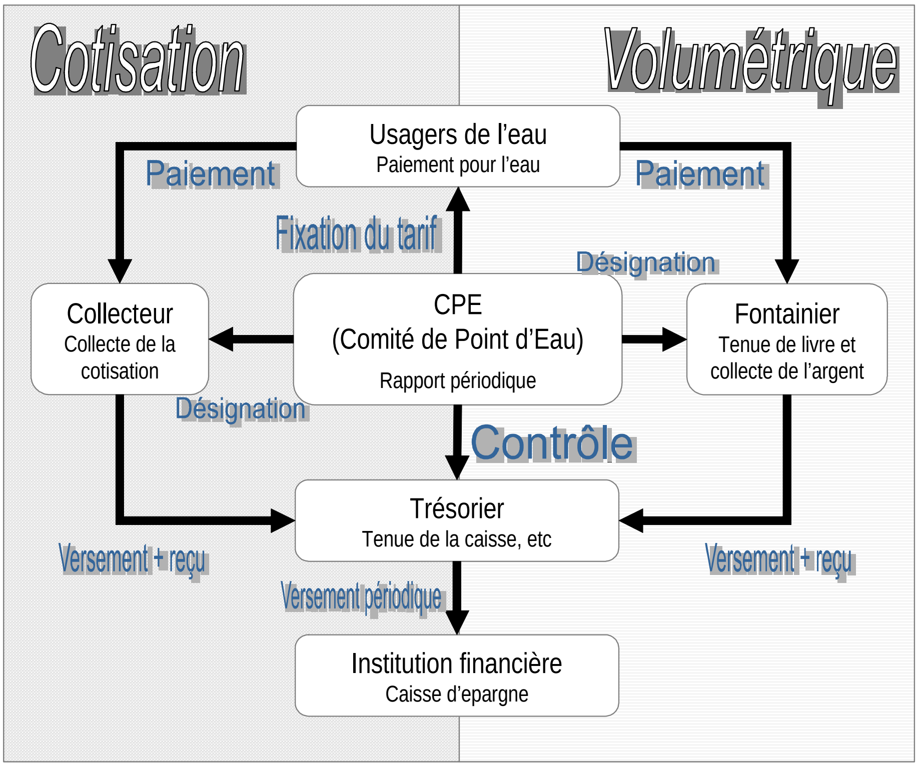


Figure 6.5.2-1 Concept chart of the basic management

(3) General Approximate Calculation of the Water Charge

The general approximate calculation of the water charge using the price scale method and according to the demographic scale is as follows. It is advisable to introduce the rope pump and the vergnet pump in a village populated of about 500 persons. However, the solar pumping system should be set up in a site where the number of beneficiaries would be less than 1,000.

1) Monthly contribution

Hypothetical criteria of the contributory charge are applied to the approximate calculation presented in Table 6.5.2-2 Hypothetical criteria of the contributory charge.

Table 6.5.2-2 Hypothetical criteria of the contributory charge

Criteria	Hypothetical figures
Average size of a household	6.4 persons
Normal life span of pump	8 years
Maintenance and management fees	5% of the cost of the pump

(a) Rope Pump

As shown in Table 6.5.2-3, considering the cost of the pump, the annual renewal, and the maintenance and management fees, beneficiaries in a village populated of 300 inhabitants should monthly contribute of 3,133 Ar, which would be the most costly case. In case of considering neither the cost the pump nor the annual renewal, the beneficiaries of a village populated of 1,000 inhabitants should only contribute 40 Ar per month.

Table 6.5.2-3 Hypothetical criteria of the contributory charge (using rope pump)

Item	Including cost of pump	Renewal	Management& Maintenance	Unit
Cost of pump	1,500,000	-	-	Ar
Cost of renewal		187,500	-	Ar/year
Management&Maintenance fees		75,000	75,000	Ar/year
Total cost		262,500	75,000	Ar/year
Contribution: Polulation = 300		467	133	Ar/household/month
Contribution: Polulation = 500		280	80	Ar/household/month
Contribution: Polulation = 1.000		140	40	Ar/household/month

(b) Vergnet Pump

Below Table 6.5.2-4 shows that in case of considering the cost of the pump, the annual renewal and the maintenance and management fees, the beneficiaries of a village populated of 300 inhabitants should monthly contribute 1,493 Ar, which would be the most expensive case. Nevertheless, in case of not taking into account the cost of the pump, the annual renewal and the maintenance and management fees, the beneficiaries of a village of 1,000 inhabitants should only contribute 128 Ar/month/household.

Table 6.5.2-4 Hypothetical criteria of the contributory charge (using Vergnet pump)

Item	Including cost of pump	Including renewal	Management& Maintenance fees	Unit
Cost of pump	4,800,000	-	-	Ar
Cost of renewal		600,000	-	Ar/year
Management&Maintenance fees		240,000	240,000	Ar/year
Total cost		840,000	240,000	Ar/year
Contribution: Polulation = 300		1,493	427	Ar/household/month
Contribution: Polulation = 500		896	256	Ar/household/month
Contribution: Polulation = 1.000		448	128	Ar/household/month

(c) Solar Pumping System

As shown in Table 6.5.2-5: Hypothetical criteria of the contributory charge (using solar pumping system), considering the cost of the pump, the annual renewal, the guarantee and operators' allowance, the beneficiaries of one with 300 inhabitants should contribute 27,464 Ar per month. However, without considering the cost of the pump, the annual renewal and the guarantee but taking into account the repairing fees, 1,000 persons should monthly contribute 672 Ar/household.

Table 6.5.2-5 Hypothetical criteria of the contributory charge (using solar pumping system)

Item	Including cost of pump	Including renewal	Including guarantee	Without any guarantee	Unit
Cost of equipment	54,000,000	-	-	-	Ar
Cost of renewal		3,388,235	-	-	Ar/year
Repairing fees		540,000	540,000	540,000	Ar/year
Guarantee of 5 years		10,800,000	10,800,000	-	Ar
Operator's allowance		720,000	720,000	720,000	Ar/year
Total cost		15,448,235	12,060,000	1,260,000	Ar
Contribution: Population = 300		27,464	21,440	2,240	Ar/household/month
Contribution: Population = 500		16,478	12,864	1,344	Ar/household/month
Contribution: Population = 1.000		8,239	6,432	672	Ar/household/month

2) Volume Charge

Hypothetical criteria of the volume charge applied to the approximate calculation are presented in Table 6.5.2-6 Hypothetical criteria of the volume charge.

Table 6.5.2-6 Hypothetical criteria of the volume charge

Criteria	Hypothetical figures
Daily consumption	10 litre/capita
Normal durability of pump	8 years
Maintenance and management fees	5% of the cost of the pump

(a) Rope Pump

As shown in Table 6.5.2-7 Hypothetical criteria of the volume charge (using rope pump), in case of not considering the cost the pump but taking into account the annual renewal, the maintenance and management fees, the liter charge becomes 0.146 Ar. In case of taking into consideration only the maintenance and management fees, the liter charge decreases to 0.042 Ar. For an average need of 10l/day/capita, and while considering only the maintenance and management fees, the price of one bucket is 0.54 Ar.

Table 6.5.2-7 Hypothetical criteria of the volume charge (using rope pump)

Item	Including cost of pump	Including renewal	Management&Maintenance fees	Unit
Cost of pump	1,500,000	-	-	Ariary
Cost of renewal		187,500	-	Ariary
Management&Maintenance fees		75,000	75,000	Ariary
Total cost		262,500	75,000	Ariary
Case of 500 inhabitants				
10 liter/day/capita		0.146	0.042	Ariary/liter
15 liter/day/capita		0.097	0.028	Ariary/liter
20 litre/jour/personne		0.073	0.021	Ariary/liter
30 liter/day/capita		0.049	0.014	Ariary/liter
10 liter/day/capita		1.9	0.5	Ariary/bucket

(b) Vergnet Pump

Below Table 6.5.2-8 Hypothetical criteria of the volume charge (using Vergnet pump), shows that in case on using Vergnet pump, and while considering the cost of the pump, the annual renewal and the maintenance and management fees, the price of the liter/day/capita is 0.5 Ar for the beneficiaries. On the contrary, in case of omitting the above-mentioned criteria but regarding the maintenance and management fees, the price of the liter becomes 1.7 Ar in case of consumption is 10l/day/capita.

Table 6.5.2-8 Hypothetical criteria of the volume charge (using Vergnet pump)

Item	Cost of pump included	Renewal included	Maintenance&Management Fees	Unit
Cost of pump	4,800,000	-	-	Ariary
Cost of renewal		600,000	-	Ariary
Management&Maintenance fees		240,000	240,000	Ariary
Total cost		840,000	240,000	Ariary
Case of 500 inhabitants				
10 liters/day/capita		0.5	0.1	Ariary/liter
15 liters/day/capita		0.3	0.1	Ariary/liter
20 liters/day/capita		0.2	0.1	Ariary/liter
30 liters/day/capita		0.2	0.04	Ariary/liter
10 liters/day/capita		6.1	1.7	Ariary/bucket

(c) Solar pumping system

Table 6.5.2-9 Hypothetical criteria of the volume charge (using solar pumping system) shows that with regards of the cost of the pump, the annual renewal, the repairing fees, the guarantee and operators' allowance, the price of the liter for 1,000 inhabitants is 4.3 Ar. While omitting just the cost of the pump, the price of the liter becomes 0.4 Ar. In case of considering the repairing fees, the guarantee and the operator's allowance, the price of the liter is 0.7 Ar. If only the repairing fees and the operator's allowance is taken into account, the price of a bucket for 1,000 inhabitants becomes 4.6 Ar in case the daily consumption is 10l/day/capita.

Table 6.5.2-9 Hypothetical criteria of the volume charge (using solar pumping system)

Item	Cost of pump included	Renewal included	Guarantee included	Without	Unit
Cost of equipment	54,000,000	-	-	-	Ar
Cost of renewal		3,388,235	-	-	Ar/year
Repairing fees		540,000	540,000	540,000	Ar/year
Guarantee of 5 years		10,800,000	1,080,000	-	Ar
Operator's allowance		720,000	720,000	720,000	Ar/year
Total cost		15,448,235	2,340,000	1,260,000	Ar
Case de 1000 habitants					
10 liters/day/capita		4.3	0.7	0.4	Ariary/liter
15 liters/day/capita		2.9	0.4	0.2	Ariary/liter
20 liters/day/capita		2.1	0.3	0.2	Ariary/liter
30 liters/day/capita		1.4	0.2	0.1	Ariary/liter
10 liters/day/capita		55.8	8.5	4.6	Ariary/bucket

6.6 Monitoring of the Pilot Project

6.6.1 Essential Plan for the Monitoring of the Pilot Project

(1) Objective

The monitoring of the Pilot Project aims at strengthening the capacity of self-management of the CPE members and the community population, at assessing the current situation compared with the expected results, and at drawing some useful lessons for the planning of a sustainable and autonomous AEP system in the future, especially concerning community management.

(2) Methodology and Content of the Activities

The activities of monitoring have been sub-contracted with an NGO of Antananarivo and the basic items are presented as follows:

1) Monitoring on the condition of maintenance of facilities and coaching targeting person in charge of operation
2) Monitoring on the management status at the level of CPE.
3) Monitoring on the level of improvement of activities related to sanitation at the local population.
4) Monitoring on the level of improvement of general water supply conditions at the local population.
5) Identification of crucial issues and measures to be taken
6) Coaching at sites to improve the condition encountered.

The NGO has executed such sequence of activities 1) – 6) two times on the five Pilot Project's sites about one month and half apart and has compared the results of the second session with those of the first session in order to set up some differences between both periods.

(3) Period

The activities of monitoring have been executed on site during the period included between July 2006 and mid-September 2006.

6.7 Lessons Drawn from the Pilot Project

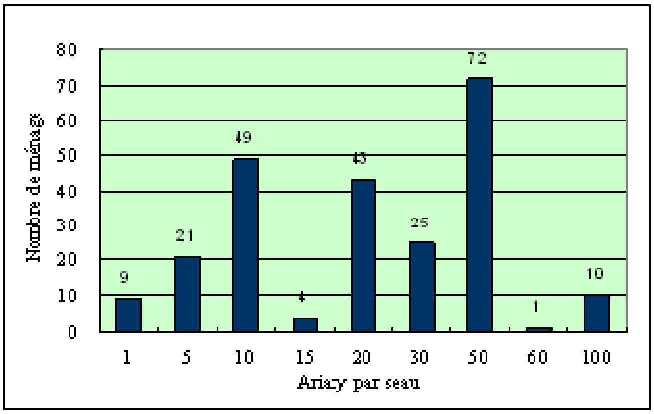
6.7.1 Maintenance Based on the Activities of the CPE

(1) Price of Water

The experience of a pilot project proves the approximate price range of an operated positive water cost that would ensure the durability of the AEP system, considering the expenditure made by the beneficiaries.

1) Analysis of figures obtained from a social survey

According to an additional social survey carried out at the fourteen (14) sites of boreholes at the end of December 2005, the scale of price which is acceptable by assumption by most of the local inhabitants varies from 1 to 100 Ar per bucket (Figure 6.7.1-1). In short, the community population in the study area would mean to pay at the maximum 29.6 Ar per bucket of 13 litres in average.



Nb. of sample	234
Maximum	100
Minimum	1
Median	20
Mode	50
Average	29,6

Unit: Ar / bucket

Source: Additional social survey

Figure 6.7.1-1 Distribution of the water charge range reasonable by assumption at the level of the beneficiaries

2) Water charge hypothetically acceptable for the community population

Consequently, the water charge, hypothetically acceptable for the community population, would be of the order of the figures in Table 6.7.1-1, following the charge system. However, it concerns the starting period of a water point newly established. It is highly probable that the increase of the water charge would be accepted by the population provided on one hand transparency on the accounting at the level of the CPE members and on the other hand, the beneficiaries may get clear incentive thanks to the AEP system applied.

Table 6.7.1-1 Water charge hypothetically acceptable for the community population

Charge system	Amount (Ar)	Unit
Volumetric	30 to 50	Ar/ bucket of 13 liters
Contribution	500 to 1 000	Ar/ household /month

(2) Framework of the management and maintenance system

1) Framework of the management and maintenance system

Figure 6.7.1-2 shows a basic cooperative system between three main actors concerning maintenance and management of a water point. As the autonomy of beneficiaries is considered crucial in terms of daily management, the CPE should occupy the core of this system. The other two actors, that is, public organizations or NGO, and equipment suppliers should offer technical and social assistance for the CPE so that this beneficiary group could be empowered. It is important that the CPE should seize the initiative in management (payment for water on daily basis) especially at the first stage that follows the installation of a new water supply system.

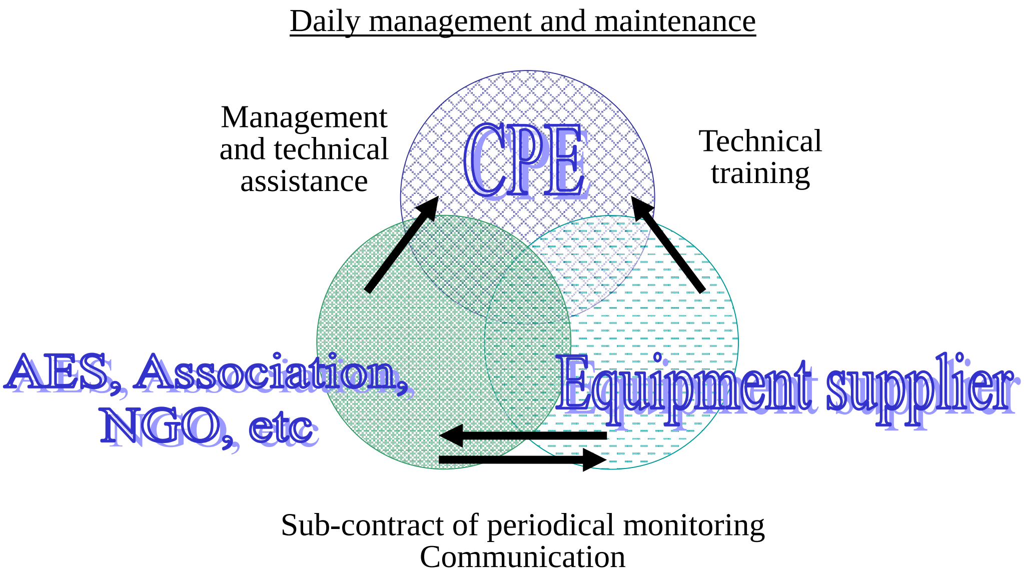


Figure 6.7.1-2: Basic cooperative system between the three major actors

2) Crucial points to ensure the sustainability of water supply system mainly managed by local community

The following are the important points to ensure the sustainability of water supply system mainly managed by local community.

(a) Leadership
(b) Transparency of accounting
(c) Training for CPE
(d) Collaboration with other major actors

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Chapter 7 GROUNDWATER POTENTIAL STUDY

7.1 Hydrogeological Potential Analysis

This study was prepared targeting groundwater developing because groundwater utilization was the most suitable to this remote area to minimize maintenance cost. The objectives to identify potential are summarized as follows;

- Connectivity between aquifer and sea water
- Aquifer in the limestone
- Static water level distribution inside of the basin
- Depth of basement
- Groundwater flow near boundary of the basin
- Permeability of aquifer
- High resistivity in the formation
- Calcareous geology
- Salinity in the formation

7.1.1 Analysis

(1) Connectivity between Aquifer and Sea Water

Groundwater outflow to the sea was a significant interest in this study because it clarify possibility of existence of fresh water at the coastal dune. The corrected information indicates that ground water flow out to sea directly through high permeable formation.
This existence of permeable formation extends to the centre of basin estimating by static water level gradient. This permeable formation can be permeable channel as alternative.

(2) Aquifer in the Limestone

1) Aquifer
Drilling result indicate that limestone or calcareous sandstone is distributed not only limited area, but covers all area and depth, at least, up to bottom of test hole.
But thickness of limestone is a few meters and horizontal extension is not identified. It can be concluded that ground water may flow though fissure in limestone, but can't store utilizable amount of water. Recharge from upstream also is not feasible because static water level is confirmed as close as sea water level. From above consideration, it can be concluded that perched fresh water aquifer in limestone don't exist at the coastal dune.

2) Calcareous Geology
It is observed that the calcareous grain and material is distributed in the sediment formation. The calcium
In some case the origin of grain of calcium can be particle of shell since formation in the sand near sea (above) include a lot of fragment of shell.

(3) Static Water Level inside Basin
Static water level of F018, F015, F014,F032 reveal static water level gradient is continuing to the sea without remarkable change of level. This time no test hole was drilled at the center of basin, but the old

drilling result which was done near Ampamolora at the north of Sarimonto, support this conclusion.

(4) Depth of Basement

Geophysical data is interpreted as depth of basement at shallower than 200m, but test hole does not reach to basement except F009 and hard rock area. Only a few of test drilling reached in the past. For example, the well at the Ferme d'Ambovombe hit marble at 172m depth which is equivalent to -50m height.

(5) Groundwater Flow near Boundary

Static water level follows topography with direction of N-S at western rim, but it is not clear at hill of the eastern rim. For example, the test hole at F030 doesn't reach to aquifer, which is lower than 24m (229m), while the static water level at F018 is 50.45m (203m). One of possibility is difference of depth of basement. Basement declines to the east.

(6) Hydraulic Conductivity of Aquifer

The most of test hole have low yield and low hydraulic conductivity even in the sedimentary formation from the result of pump test. However, hydraulic conductivity need be like value of F015 to achieve low gradient of static water level. Therefore, hydraulic conductivity of sediments is defined referring value of F015. It needs to be remarked that it doesn't match with one at any drilled boreholes.
The hydraulic conductivity is specifically defined at Chapter 7.3.2 Groundwater modelling and Chapter 7.3.3 Calibration, depending geology.

(7) High Resistivity in the Formation

The most of formation resistivity is very low as a result of geophysical survey, and it was considered that formation was consisted or consolidated with low permeable silt or clay. Selection of position of F032, F018, PM006 was referred to existence of high resistive zone at around 50m. If ground water exist, it is suitable for water supply system at village level.

(8) Salinity in the Formation

Mud resistivity during drilling varied drastically high indicating salinity in the formation. The change occurred even in the shallow depth as less than 10m. While sampled cuttings was dipped and mixed in the mineral water and is observed change of conductivity. conductivity changes higher immediately and continue to increase gradually as times pass. The characteristic of evolution is different from depth respectively.

7.1.2 Classification of Potential

As a result of above consideration, groundwater development potential is categorized as following map.

Zone A Basement rock area. Aquifer is targeted shallower depth. Aquifer targeted at weathered zone or fracture.

Zone B Northern part of the Ambovombe basin. Targeted aquifer has variation of depth 10-70m

Zone C Ambondro area. Only unconfined aquifer.

Zone D Ambovombe (urban) Most of well target unconfined aquifer or relatively lower saline groundwater near sea water level

Zone E Border of coastline & costal dune area, It needs to target near sea water level, aquifer have high salinity.

Zone F Central basin sometimes high saline perched aquifers exist. It needs to target aquifer near sea water level, but very saline. During rain season, a lot of seasonal pond come out

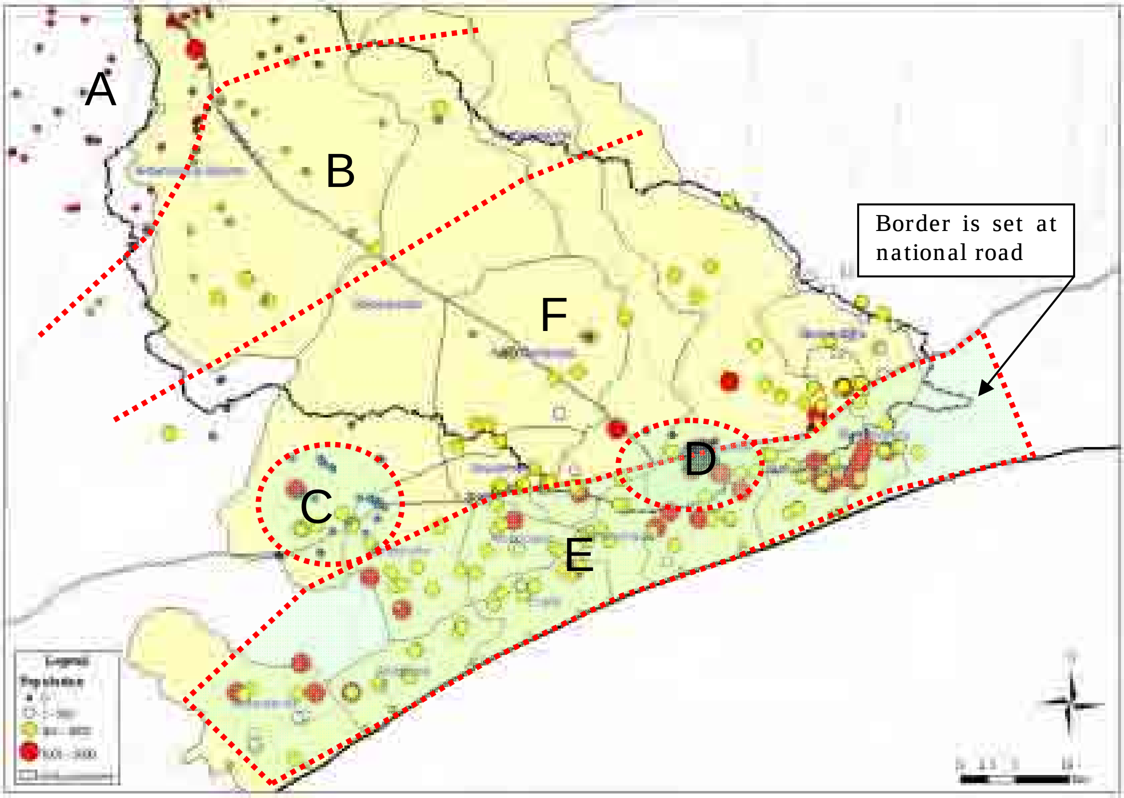


Figure 7.1.2-1Classified area by ground water potential

7.2 Water Balance and Ground Water Recharge

(1) Objective

To manage a groundwater basin, knowledge of the quantity of water that can be developed is a prerequisite. Determination of the available water within a basin requires evaluation of the elements constituting the hydrologic cycle[1].

Accordingly final goal of this study is to estimate the amount of element of hydrologic cycle and to evaluate the available amount of the groundwater within the basin.

(2) Study Area

From the calculation by the GIS application software, the area of Ambovombe Basin is obtained as 1,923km^2. Through this study this calculated area is used as Study Area.

(3) Hydrologic Cycle

Figure 7.2-1 shows presumed hydrologic cycle of Ambovombe basin. In terms of subsurface hydrologic cycle, as shown in the Figure 7.2-1, northern part of the basin which is composed of rock formation is acting as recharge area and groundwater flows through fissured or weathered layer of this rock formation. Then groundwater flows to the downstream of the basin through the aquifer which is composed of sedimentary formation, and finally it flows out to the sea.

Before the Study, there is possibility of existence of impermeable layer to close the Ambovombe Basin. However, according to the results of test well drilling survey of the Study, there is no impermeable layer at the bottom of dune which located along the seashore. Therefore it is confirmed that groundwater flows out to the sea through under the dune.

[1] Groundwater Hydrology; Second Edition, D.K.Todd, 1980

On the other hands, there is other small subsurface hydrologic cycle around Ambovombe urban located in the downstream of Ambovombe Basin. Through the Study, there are many shallow dug wells within Ambovombe urban. According to the results of monitoring of groundwater level for selected shallow dug wells within Ambovombe urban, groundwater level is confirmed throughout the year and it is almost stable even there is continuous pumpage of the water by the owner. If groundwaters of these shallow dug wells are derived only from the direct infiltration of the rainfall, some of the well shall be dried in the dry season due to insufficient supply. Therefore there is possibility of continuous recharge to this area throughout the year.

It is presumed that the Sarimonto marsh is one of the water sources which supply groundwater to the Ambovombe urban. Sarimont marsh is located downstream of Bemanba river which flows within Ambovombe Basin and it is acting as reservoir to store flood river flow especially in rainy season.

It is also presumed that such a stored water infiltrate into underground and it flows to Ambovombe urban. Shallow dug wells are confirmed by the Study Team around Sarimont marsh in November, at the time stored water is infiltrated and marsh is totally dried. Accordingly Sarimont marsh is thought as one of the source of recharge to Ambovombe urban. In addition, there may be other source of recharge along the northern part of the slope of dune to Ambovombe urban. In fact from the results of seasonal monitoring survey, there is the area of increment of groundwater level at the southern part of Ambovombe urban.

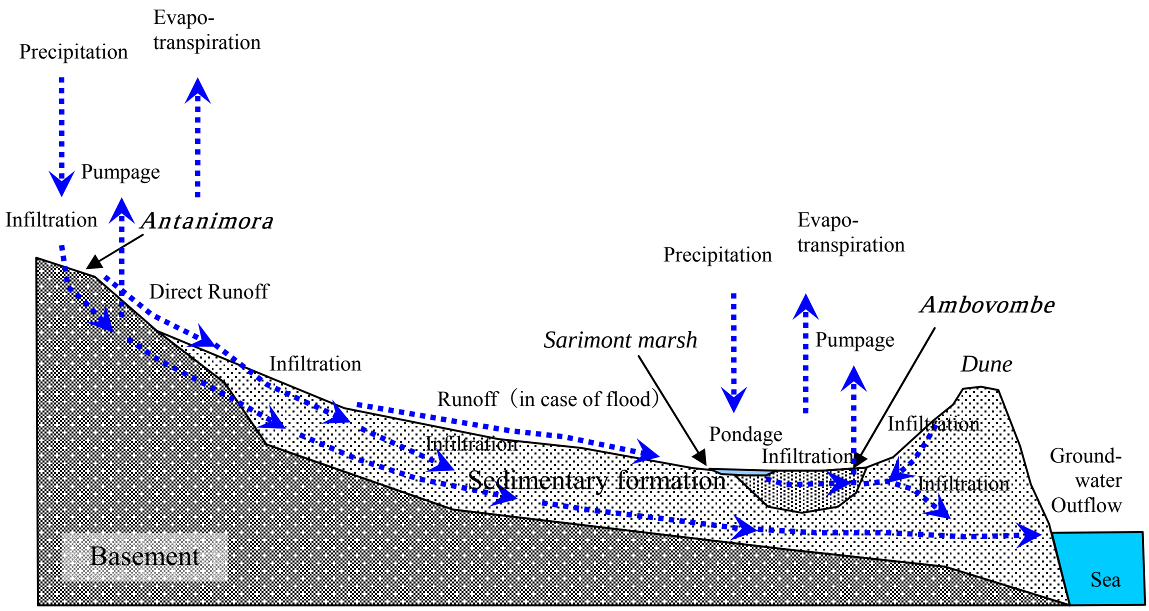


Figure 7.2-1 Hydrologic Cycle of Ambovombe Basin

(4) Equation of Hydrologic Equilibrium

Equation of hydrologic equilibrium for the hydrologic cycle shown in the Figure 7.2-1 is described as followings; Figure 7.2-2 shows elements for the equation.

$$P = E + R \text{ ....} (1)$$

$$R = Q + GWout \text{ ....} (2)$$

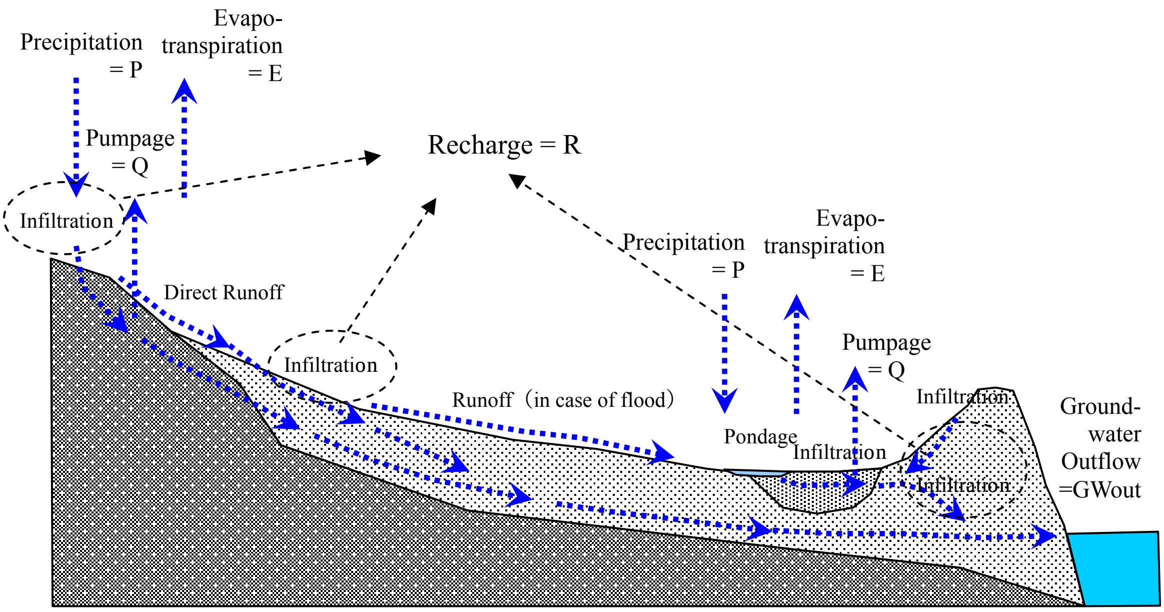


Figure 7.2-2 Elements for Hydrologic Cycle

(5) Calculation of elements for the equation

1) Precipitation

Thiessen polygon[2] is generated for rainfall gauge station within the Study Area.
As shown in the Table 7.2-1, 543mm/year is obtained as the amount of precipitation for the estimation.

Table 7.2-1 Calculated Precipitation (mm/year)

Station	(A); Thiessen Polygon area	(B); (A)/Total Area(%)	(C);Average Precipitation (mm/year)	(B)×(C)	(D); Calculated Precipitation (mm/year)
Antanimora	604	31%	720	226	(D)=Σ(B)×(C) = 543 (D)×1,923km^2= 1,044,189,000 m^3/year
Ambondro	317	16%	399	66	
Ifotaka	90.5	5%	507	24	
Ambanisarika	314	16%	481	79	
Ambovombe	496	26%	493	127	
Amboasary	101.5	5%	414	22	

2) Groundwater outflow

Groundwater outflow is estimated using Darcy's equation for groundwater flow at the end of the Basin. Figure 7.2-3 and 7.2-4 shows elements for groundwater outflow calculation.

[2] Thiessen polygon is generated by intersect of perpendicular bisector of neighboring two stations.

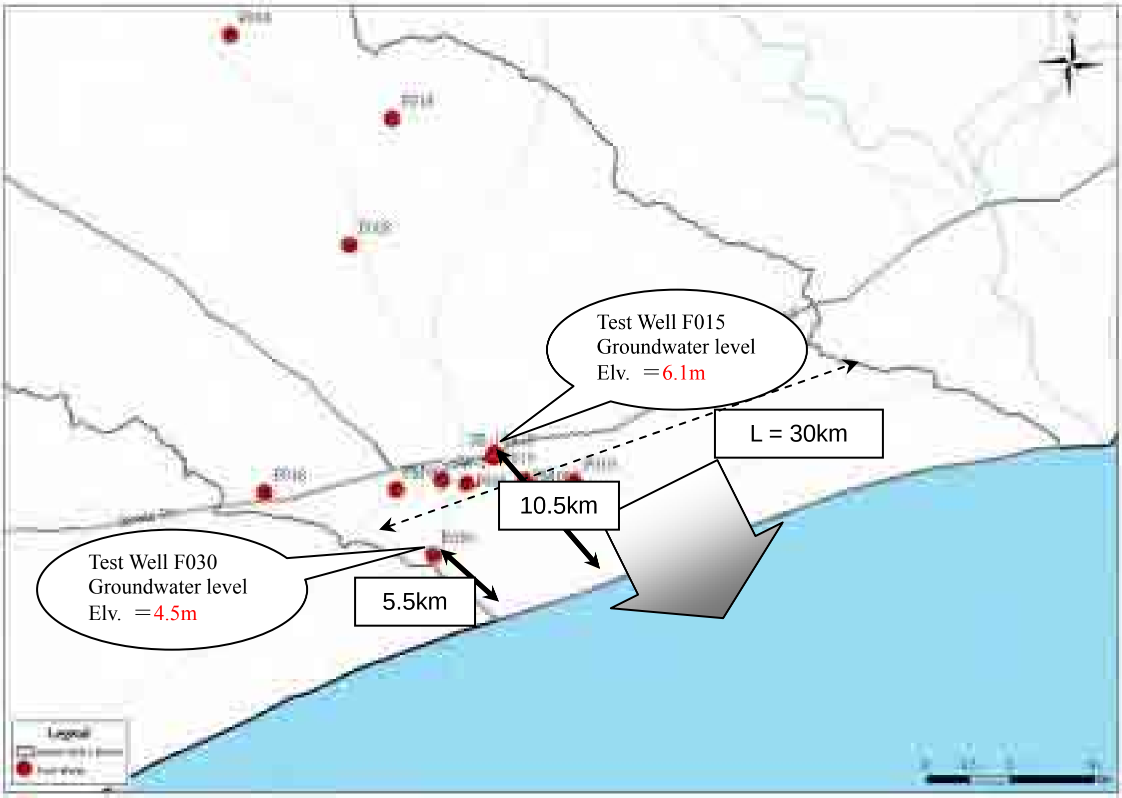


Figure 7.2-3 Elements for Groundwater Outflow Calculation (1)

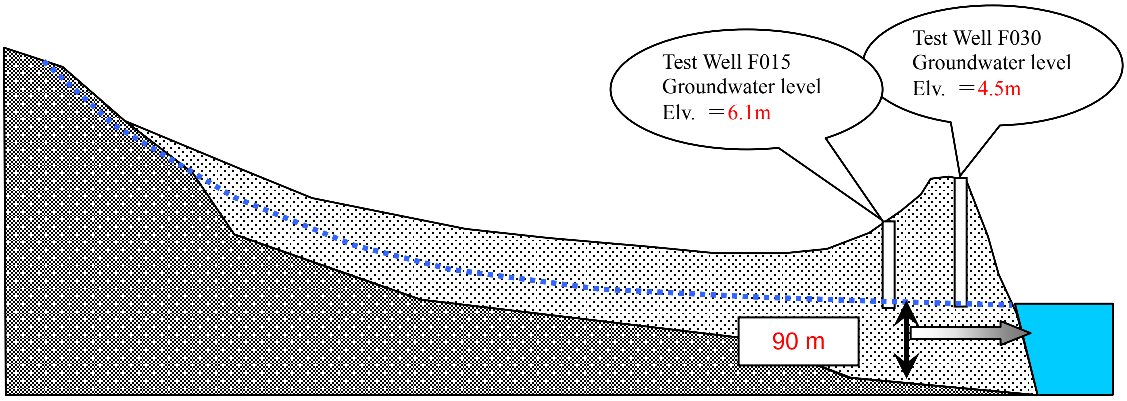


Figure 7.2-4 Elements for Groundwater Outflow Calculation (2)

Hydraulic gradient is estimated as shown in the Table 7.2-2 using the groundwater level elevation and length from sea for the test well F015 and F030.

Table 7.2-2 Calculated Hydraulic Gradient

Test Well No.	(A); Groundwater level Elv. (m)	(B); Distance from sea (km)	(C); Hydraulic gradient =(A)/(B)
F015	6.1	10.5	0.00058
F030	4.5	5.5	0.00082
			0.00070

From the results of pumping test (recovery test) for the test well No.F015, hydraulic conductivity is obtained as 9.2×10-2 cm/s and 6.8×10-2 cm/s (average of these values is 8.0×10-2 cm/s).
Width of the flow is estimated as 30km and thickness of the aquifer is estimated as 90m.

Finally groundwater outflow Q is calculated as followings;

$$GWout = T \times i \times L \times h = 0.08 \times 10^{-2} \times 0.0007 \times 30{,}000 \times 90 = 1.512\,(\mathrm{m^3/s}) = 47{,}682{,}432\,(\mathrm{m^3/year})$$

$GWout$: $GroundwaterOutflow(m^3/s)$
K : $HydraulicConductivity(cm/s)$
i : $HydraulicGradient$
L : $Width$ (m)
h : $Thickness$ (m)

Obtained *GWout* is divided by the area of the Basin (1,923km^2), then depth of groundwater outflow is calculated as 24.8mm/year.

3) Pumpage

It is difficult to confirm actual amount of groundwater abstraction within the Ambovombe Basin. Then pumpage is estimated using the results of existing well inventory whish is undertaken Phase-I of the Study.

a) Antanimora Area(Q1)

According to the results of inventory survey, there are 47 wells equipped with hand pump and 19 wells without pump. In addition there are two AES solar pump wells.
Table 7.2-3 shows calculation of total pumpage in Antanimora area.

Table 7.2-3 Estimation of pumpage in Antanimora area

Type of well	Pumping rate (m^3/day)	Number	Total (m^3/year)
Hand pump well	2.00	47	34,310
Without pump	0.50	19	3,468
Solar pump well A	18.2	1	6,643
Solar pump well B	20.7	1	7,556
		Total	51,977

b) Ambovombe Area(Q2)

According to the results of inventory survey, there are 75 wells without pump and 2 wells equipped with solar pump. In addition there are one AES electric motor pump wells.
Table 7.2-4 shows calculation of total pumpage in Ambovombe area.

Table 7.2-4 Estimation of pumpage in Ambovombe area

Type of well	Pumping rate (m^3/day)	Number	Total (m^3/year)
Vovo (dug well)	0.50	75	13,688
Solar pump well	5.00	2	3,650
Electric pump well	30.0	1	10,950
		Total	28,288

c) Total Pumpage(Q1+Q2)

Total pumpage is calculated as followings;
51,977m^3/year＋28,288m^3/year＝80,265 m^3/year

4) Recharge

Recharge is calculated as followings;

$$R = Q + GWout = 80{,}265 + 47{,}682{,}432 = 47{,}762{,}697 \text{ m}^3/\text{year}$$

Obtained R is divided by the area of the Basin (1,923km^2), then depth of groundwater outflow is calculated as 24.8mm/year. This amount is 4.6 % of total precipitation.

5) Evapotranspiration

Evapotranspiration is calculated as followings;

$$E = P - R = 1{,}044{,}189{,}000 - 47{,}682{,}432 = 996{,}506{,}568 \text{ m}^3/\text{year}$$

Obtained E is divided by the area of the Basin (1,923km^2), then depth of evapotranspiration is calculated as 518.2mm/year.

As shown in the Figure 7.2-2, there are elements of evapotranspiration from pondage in the hydrologic cycle. Strictly such element shall be separated from the total element of evapotranspiration. However due to insufficient information, it is difficult to estimate the exact amount.

7.3 Groundwater Modeling and Simulation

7.3.1 Objective

Objectives of the groundwater simulation are as followings;

- Evaluate impact on the condition of groundwater level and groundwater quality in case groundwater development plan will be introduced in Ambovombe Basin
- Propose optimized/modified groundwater development plan if possibility of negative impact on groundwater environment will be expected by the evaluation of existing plan.
- Estimate groundwater development potential without any negative impact on the groundwater environment.

7.3.2 Groundwater Modeling

(1) Modeling Area

Figure 7.3.2-1 shows the area for groundwater modeling including proposed groundwater development site (test well site of F006 and F015).

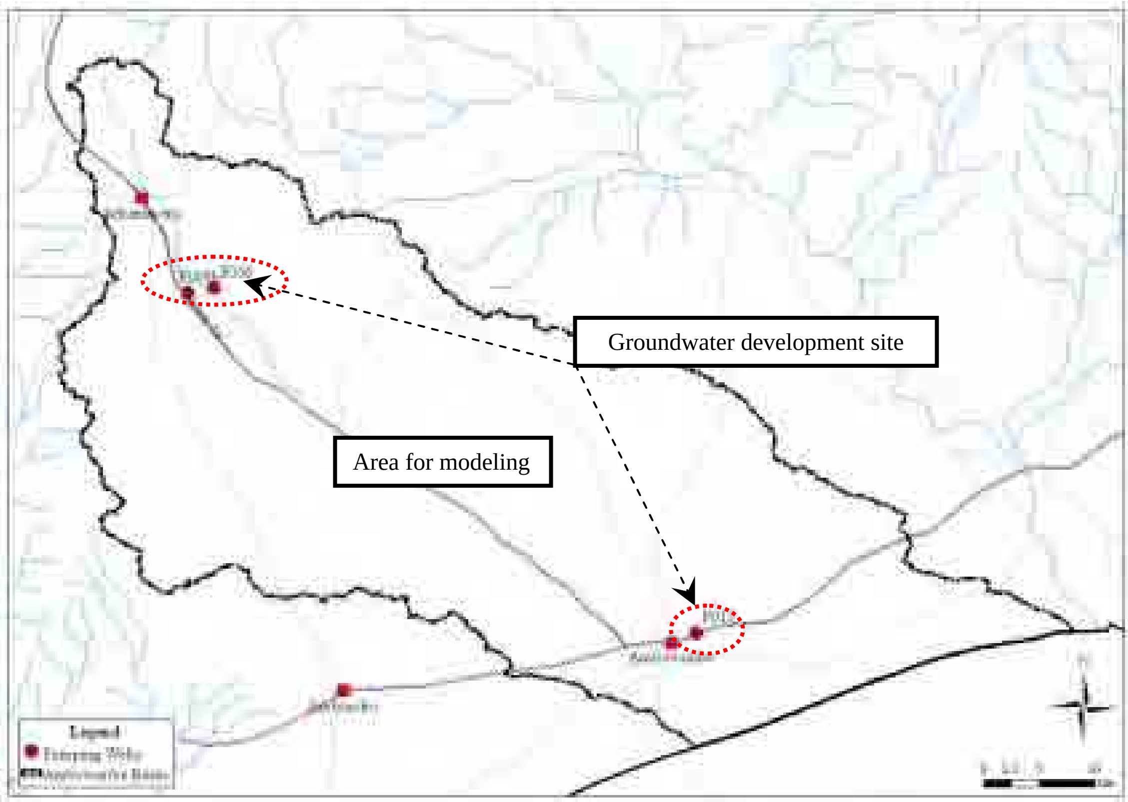


Figure 7.3.2-1Area for Groundwater Modeling

(2) Flow Model

SEAWAT (SEAWAT:A Computer Program for Simulation of Three-Dimensional Variable-Density Ground Water Flow) is used for the modeling. This model could simulate three-dimensional groundwater flow and also simulate variable-density flow as well. This model is developed by combining MODFLOW (Finite-different three-dimensional groundwater flow model) and MT3D (3-D Multi-Species Transport Model) to solve coupled flow and solute-transport equations.

(3) Modeling

1) Aquifer distributed area

Except the center of the Basin, existing wells are confirmed. This fact derive the fact that groundwater aquifer is distributed in all the region of the Basin.
Finally aquifer distributed area is defined on all the region of Ambovombe Basin.

2) Elevation of ground surface

Figure 7.3.2-2 shows contour map of elevation of ground surface. Elevation of ground surface is taken from the DEM (Digital Elevation Model) data for the Study Area.

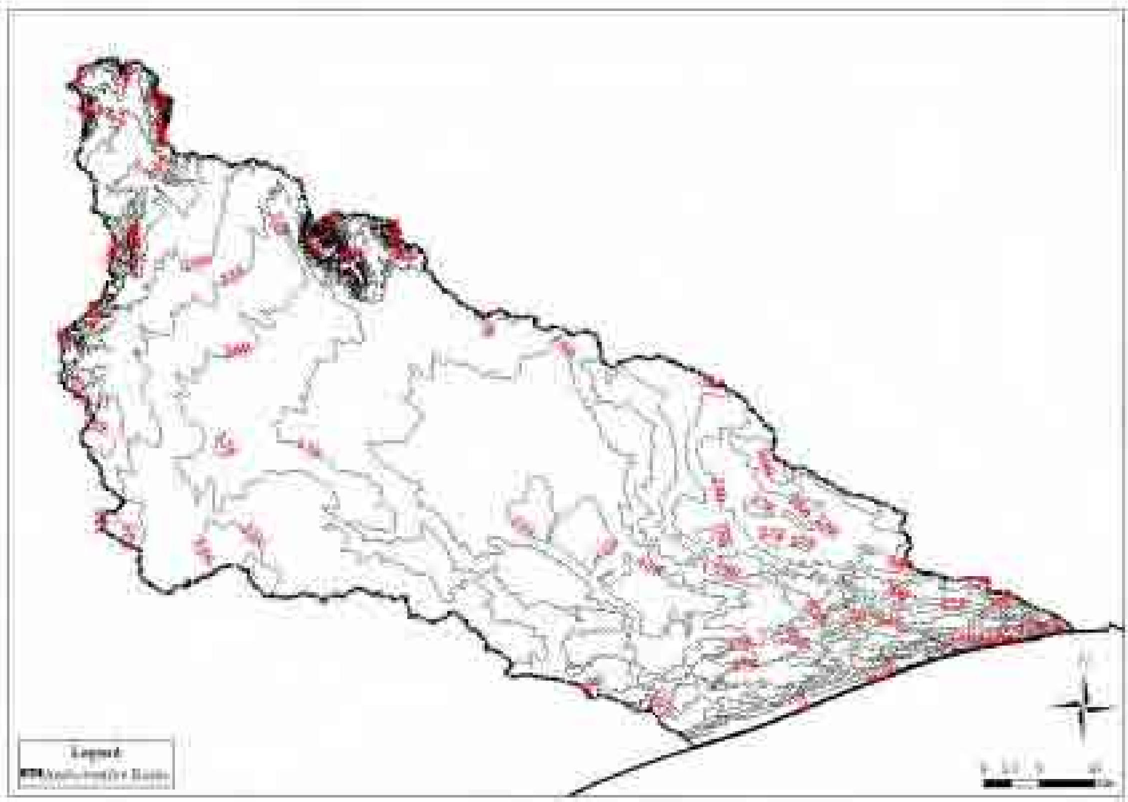


Figure 7.3.2-2 Contour map of ground surface elevation

3) Elevation of basement

Figure 7.3.2-3 shows contour map of elevation of basement. Elevation of the basement is taken from contour map of elevation of basement which is prepared by the JICA Study Team compiling with the results of geophysical survey and test well drilling survey.
However, for the region of northern rock formation distributed area, elevation of the basement is defined deducting the depth of test well F001 (80m) from the elevation of ground surface.

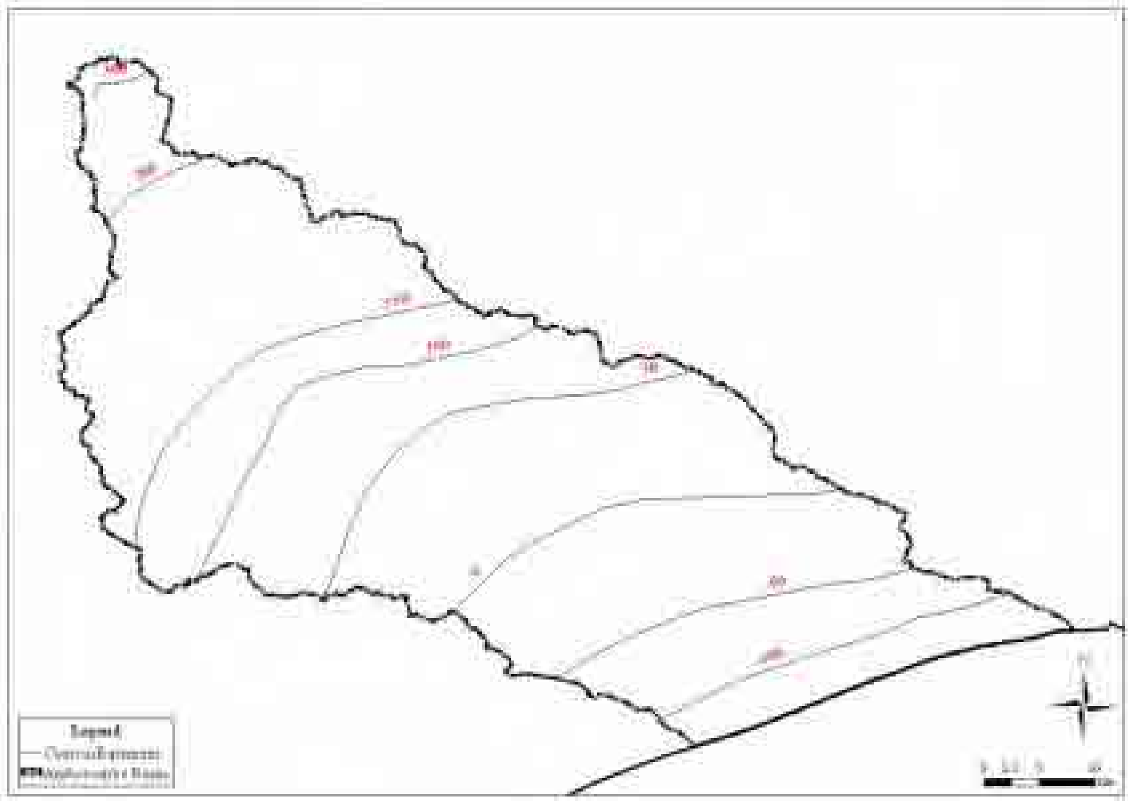


Figure 7.3.2-3 Contour map of basement elevation

4) Finite-different Grid

Figure 7.3.2-4 shows finite-different grid used for simulation. As shown in the Figure, modeling area (94.5km×40.0km) is divided by 500m x 500m grid.
For the sectional side, aquifer layer is divided into 6 layers to evaluate saline water intrusion in detail.

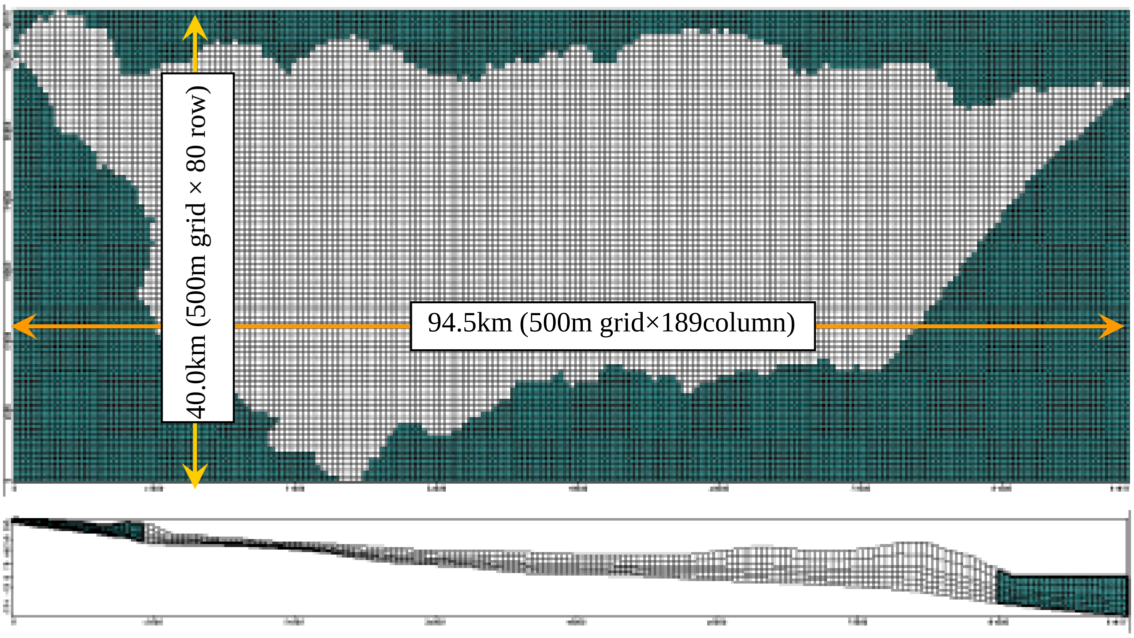


Figure 7.3.2-4 Finite different grid used for simulation

5) Hydrogelogical boundaries

Figure 7.3.2-5 shows hydrogeological boundaries for the modeling area. Hydrogeological boundaries are referred from existing hydrogeological map.
Hydrogeological boundaries are summarized into typical four type of units, such as Pre-cambrian rock formation, brown and white sand (tertiary deposits), dune sediments (quaternary deposits) and Alluvial deposits.

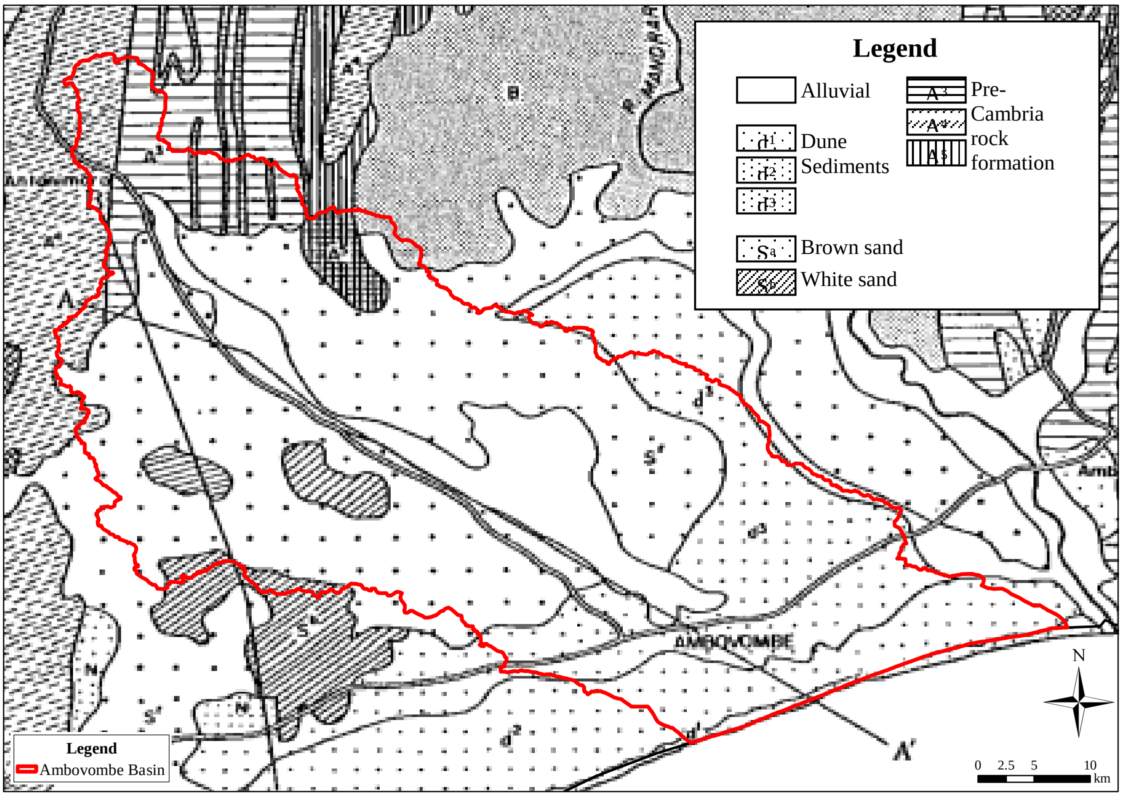


Figure 7.3.2-5 Hydrogeological boundaries

7.3.3 Calibration

(1) Calibration Procedure

Calibration of the model is executed by changing hydrogeological parameter (hydraulic coefficient) until calculated groundwater level distribution might be almost same as the actual groundwater level distribution which is obtained through groundwater monitoring survey in this Study.
Calculation is iterated until the differences between initial groundwater level and final groundwater level could be minimum.

(2) Flow Boundary Conditions and Initial Condition

1) Constant head boundary
Elevation 0m is applied at the coast line as a constant head boundary of sea.
And elevation 380m is also applied at the upper most part of the basin as a constant head boundary. This condition is based on the fact that there is constant discharge at the uppermost area even in the dry season.

2) Constant concentration boundary

Salt concentration is 35,000mg/lit is applied at the coast line as a constant concentration boundary of sea water.

3) Initial concentration property

Figure 7.3.3-1 shows distribution of measured electric conductivity for existing wells in November, 2005. From these Figures, water quality could be divided into two regions. The one region is upper stream region in rock formation distributed area with electric conductivity is les than 200 mS/m. The second region is down stream region in sediments formation distributed area with electric conductivity is higher than 200mS/m. Considering such a situation of the area, initial concentration is simply defined following above mentioned actual condition. For the model, initial concentration of the salt is obtained by exchanging electric conductivity value using the relationship between these values.

Figure 7.3.3-2 shows applied initial concentration boundary for the model. As shown in the Figure, electric conductivity of Region 1 is defined as 200 mS/m (1,000mg/lit of salt concentration) and electric conductivity of Region 2 is defined as 500 mS/m (2,500mg/lit of salt concentration).

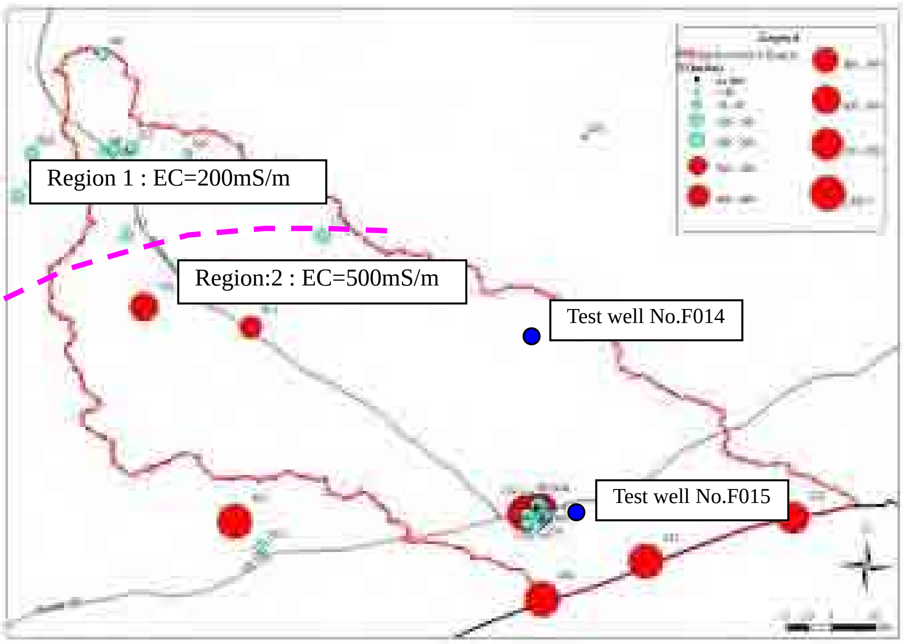


Figure 7.3.3-1 Distribution of electric conductivity of existing wells (November, 2005)

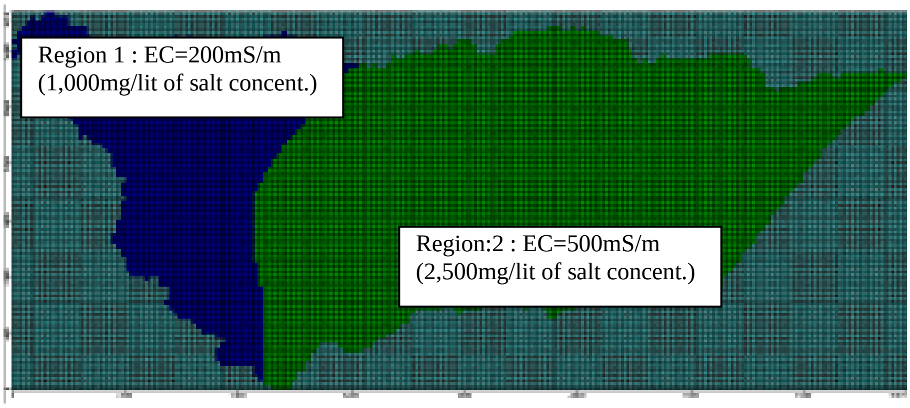


Figure 7.3.3-2 Initial concentration boundary

4) Recharge

Recharge value, 25mm/year, is used from the results of water balance study (chapter 7.2). Recharge concentration value is used the same as the initial concentration property because salt concentration of groundwater increase after infiltration of fresh rainfall by the effect of salt dissolution.

5) Dispersion property

Horizontal dispersivity value is defined as 0.1m and vertical dispersivity value is defined as 1m.

6) Hydraulic conductivity

Hydraulic conductivity is defined from the results of pumping test for the test wells.
Table 7.3.3-1 shows defined hydraulic conductivity.

Table 7.3.3-1 Hydraulic Conductivity Value

Hydrogeological Boundary	Applied Value	Referred Data
Pre-Cambrian rock formation	7.0×10^{-5} cm/sec	➢ Hydraulic Conductivity of test well F001=3.5×10^{-5}～6.6×10^{-5} (cm/sec)
Tertiary Sediment formation	3.0×10^{-4} cm/sec	➢ Hydraulic Conductivity of test well F014=1.0×10^{-4}～2.8×10^{-4} (cm/sec) ➢ Hydraulic Conductivity of test well F018=4.5×10^{-6}(cm/sec) ➢ Hydraulic Conductivity of test well F009=3.0×10^{-6} (cm/sec)
Dune Sand A	7.0×10^{-2} cm/sec	➢ Hydraulic Conductivity of test well F015=6.8×10^{-2}～9.2×10^{-2} (cm/sec)
Dune Sand B	7.0×10^{-1} cm/sec	➢ Identified from the calibration
Alluvial	1.0×10^{-4} cm/sec	➢ Hydraulic Conductivity of test well F006, F006b =4.9×10^{-5}～9.3×10^{-4} (cm/sec)

7) Effective porosity

Effective porosity is used as 0.15.

(3) Results of Calibration

Figure 7.3.3-3 shows results of calibration comparing calculated groundwater distribution and observed groundwater level of the test wells.

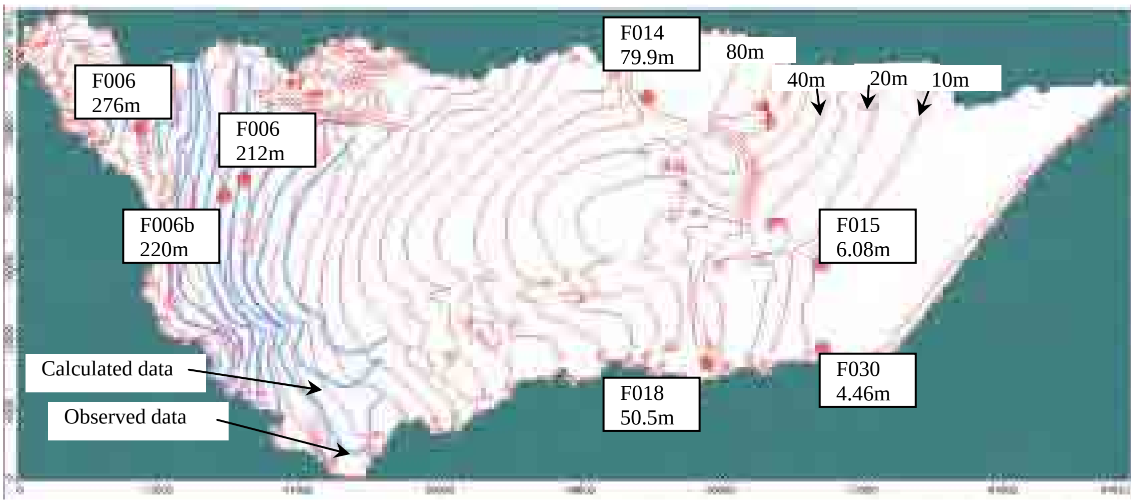


Figure 7.3.3-3 Results of calibration

7.3.4 Simulation

(1) Proposed Groundwater Development Plan

Table 7.3.4-1 summarizes proposed groundwater development plan for the study area.

Table 7.3.4-1 Proposed groundwater development plan

Case	Description	Well for the Development	Volume of groundwater development
Case-1	Groundwater is developed at the point of test well F015 and will be supplied to the Ambovombe city.	F015	230m^3/day (83,950m^3/year)
Case-2	Groundwater is developed at the point of test well F006 and will be supplied to the Ambovombe city.	F006	275m^3/day (100,375m^3/year)
Case-3	Groundwater is developed at the point of test well F015 and will be supplied to the Ambovombe city and Coastal Area.	F015	1,790m^3/day (653,350m^3/year)
Case-4	Groundwater is developed at the point of test well F006 and will be supplied to the Ambovombe city and Coastal Area.	F006	2,065m^3/day (753,725m^3/year)

(2) Methodology for the Simulation

To evaluate the impact from proposed groundwater development, following case study is executed as the simulation.

① Using calibrated model as the initial state of groundwater flow without any development program
② Introduce groundwater extraction at the point of test well F015 with changing the discharge from 1,000 to 5,000 m^3/day and observe the impact to the groundwater level and concentration of salt.
③ Introduce groundwater extraction at the point of test well F006 together with the extraction at the point of test well F015, with changing the discharge from 1,000 to 5,000 m^3/day and observe the impact to the groundwater level and concentration of salt.
④ Time for simulation is 10 years.

(3) Location of virtual observation well

To observe impact from groundwater development to the groundwater level and groundwater quality, virtual observation well is located from the point of pumping well F015 to the coast line. Level of observation well is the bottom of layer 4 on the grid layer. Figure 7.3.4-1 shows location of observation well.

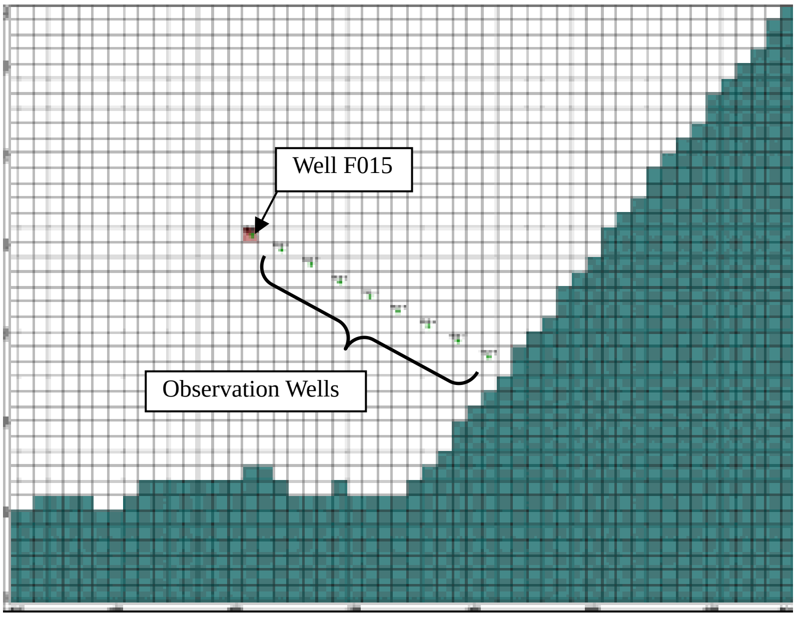


Figure 7.3.4-1 Location of virtual observation well

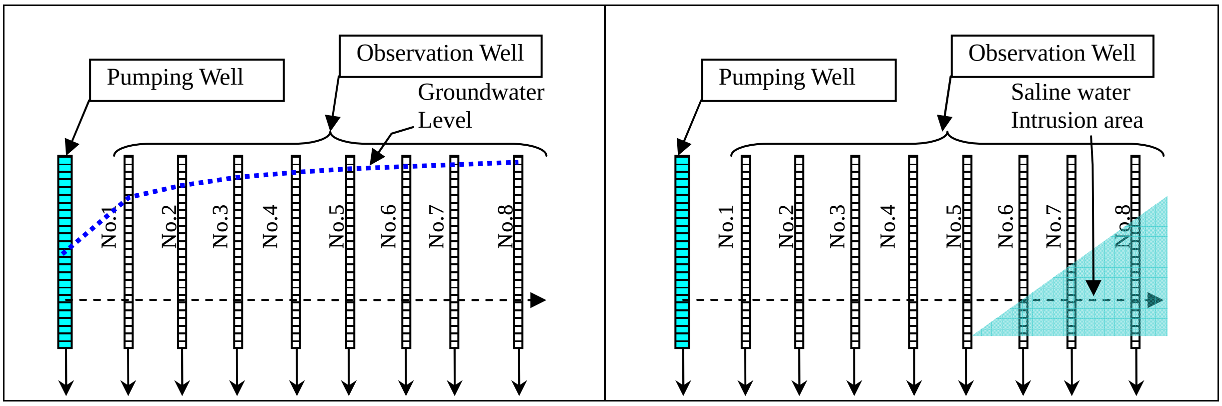
(4) Results of Simulation

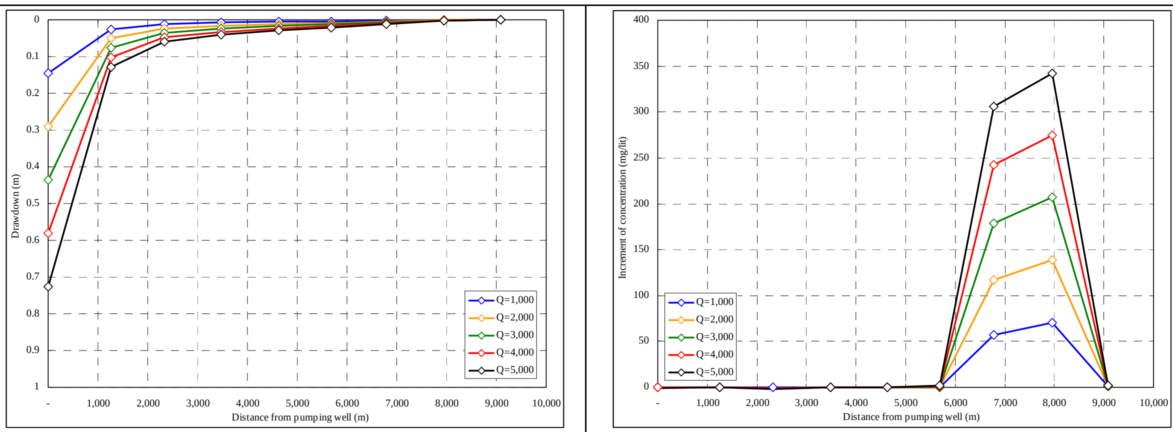
Figure 7.3.4-2 shows results of simulation in case pumping discharge of F006 well keeps 0 and pumping discharge of F015 well is changed from 1,000 to 5,000m^3/day. Figure 7.3.4-2 (a) shows the change of groundwater level for every observation well for five steps of the pumping discharge. From the Figure, there is a certain scale of drawdown at the observation well No.1 and No.2. However at the observation well No.3 to No.8, scale of drawdown is not so large even pumping discharge is 5,000m^3/day.

Figure 7.3.4-2 (b) shows the change of salt concentration for every observation well for five steps of the pumping discharge. From the Figure, there is a certain scale of increment of salt concentration at the observation well No.5 to No.8. However at the observation well No.1 to No.4, there is no apparent change of salt concentration even pumping discharge is 5,000m^3/day.

Then this result doesn't change when pumping discharge of well F006 is introduced.

Therefore it is confirmed that there will be no any negative impact for the groundwater environment when groundwater development plan is introduced for the Ambovombe Basin.





(a) Pumping discharge and Drawdown (b) Pumping discharge and salt concentration

Figure 7.3.4-2 Results of simulation

7.3.5 Evaluation of Groundwater Development Potential of the Well F015

(1) Objective

From the results of the test well drilling, electric conductivity of the most of the drilled borehole indicates high value, more than 500mS/m. However at the well F015, low electric conductivity layer, EC is less than 500mS/m, is found above the deep high electric conductivity layer. And during pumping test for the well F015, electric conductivity of pumped water is almost stable, around 300mS/m, even pumping discharge is 172m^3/day.

At the water supply plan of the Study, groundwater development plan is proposed at the well F015 because of possibility of sustainable pumping of low electric conductivity water.

Therefore evaluation of groundwater development potential of the well F015 is executed with the created groundwater simulation model.

(2) Boundary Conditions

1) Initial Concentration

Figure 7.3.5-1 shows vertical profile of electric conductivity of test well F015 and F030. From the figure, law electric conductivity layer could be seen at the upper aquifer of well F015.

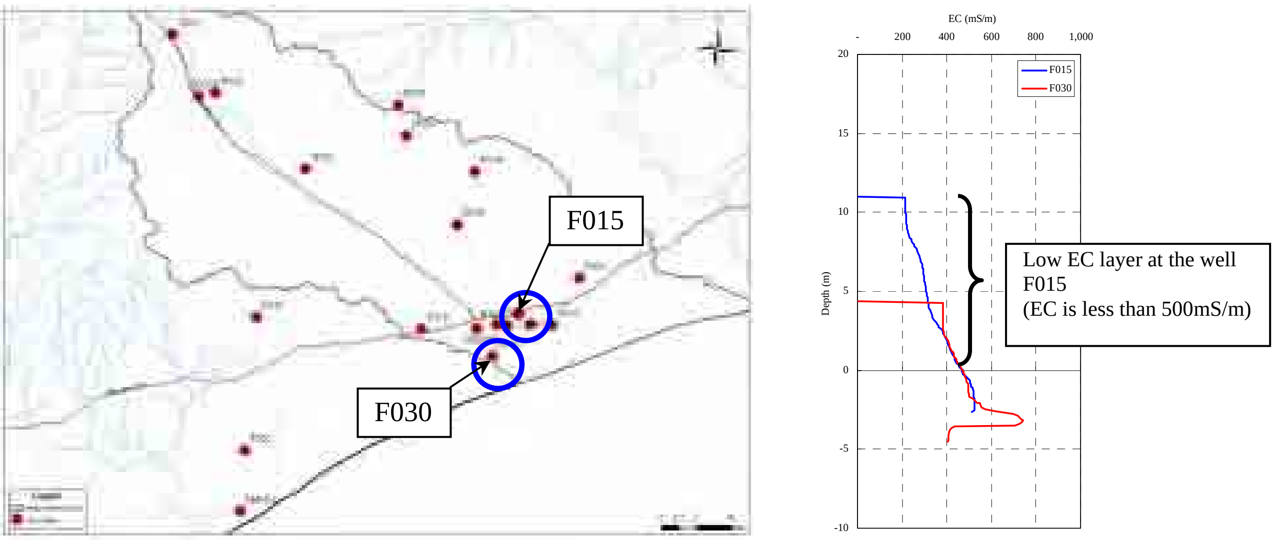


Figure 7.3.5-1 Vertical profile of electric conductivity at the well F015

The thickness of this layer is estimated around 10m and such low electric conductivity layer is not confirmed at the well F030. Then the area of distribution of this low electric conductivity is defined up to 5 km apart from F015 well.

Figure 7.3.5-2 shows defined initial concentration of the model. As shown in the Figure, salt concentration of the low electric conductivity area is defined as 1,500 mg/lit (EC=300mS/m). This low electric conductivity setting is applied only for the layer1, (top layer), to the layer4.

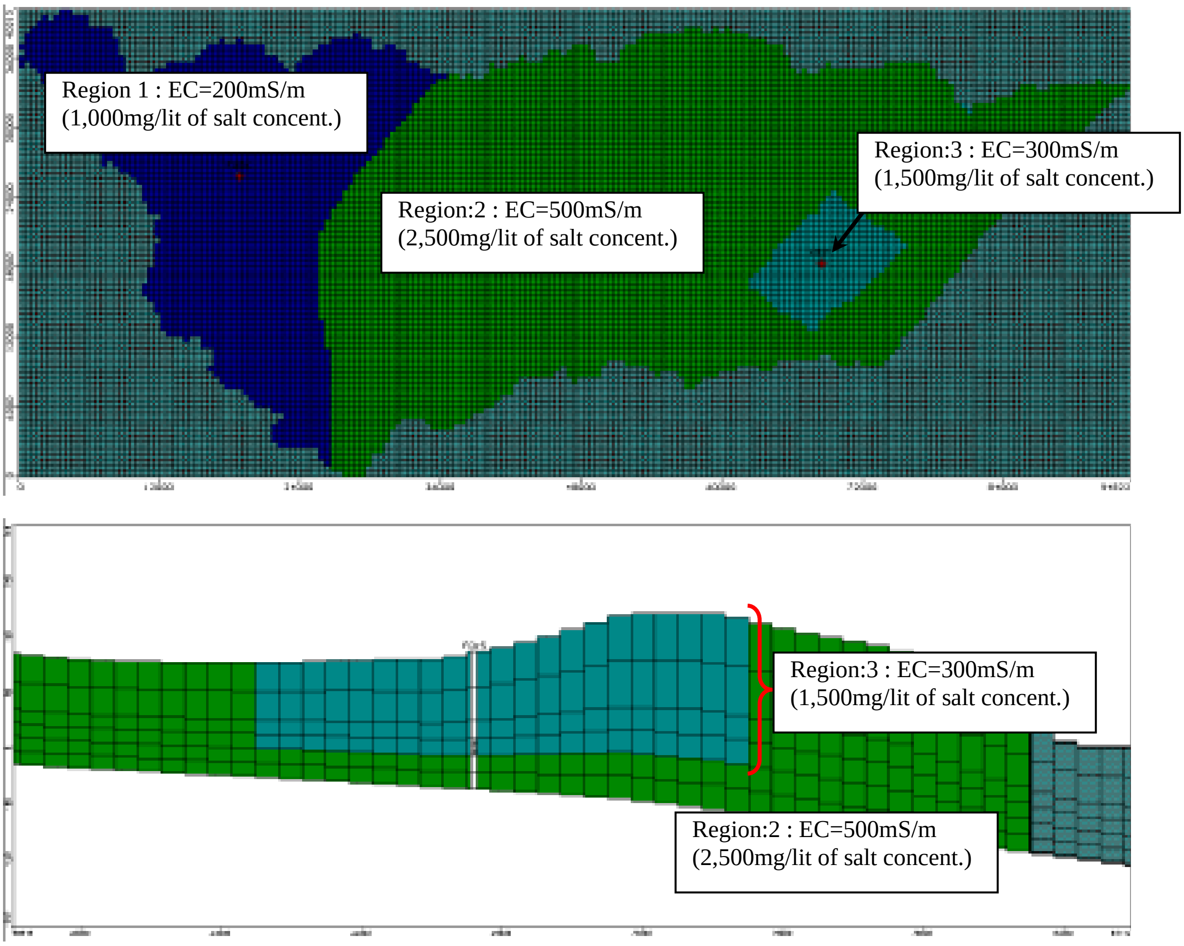


Figure 7.3.5-2 Initial concentration boundary

2) Recharge Concentration

Except low electric conductivity area, recharge concentration value is used the same as the initial concentration property because salt concentration of groundwater increase after infiltration of fresh rainfall by the effect of salt dissolution.

For the area of low electric conductivity, recharge concentration is defined as 500mg/lit (EC=100mS/m) considering the measured lowest electric conductivity at the hand dug well in Ambovombe city.

3) Observation point at the pumping well

To observe the change of electric conductivity at the well F015, virtual observation well is installed besides the pumping well as shown in the Figure 7.3.5-3.

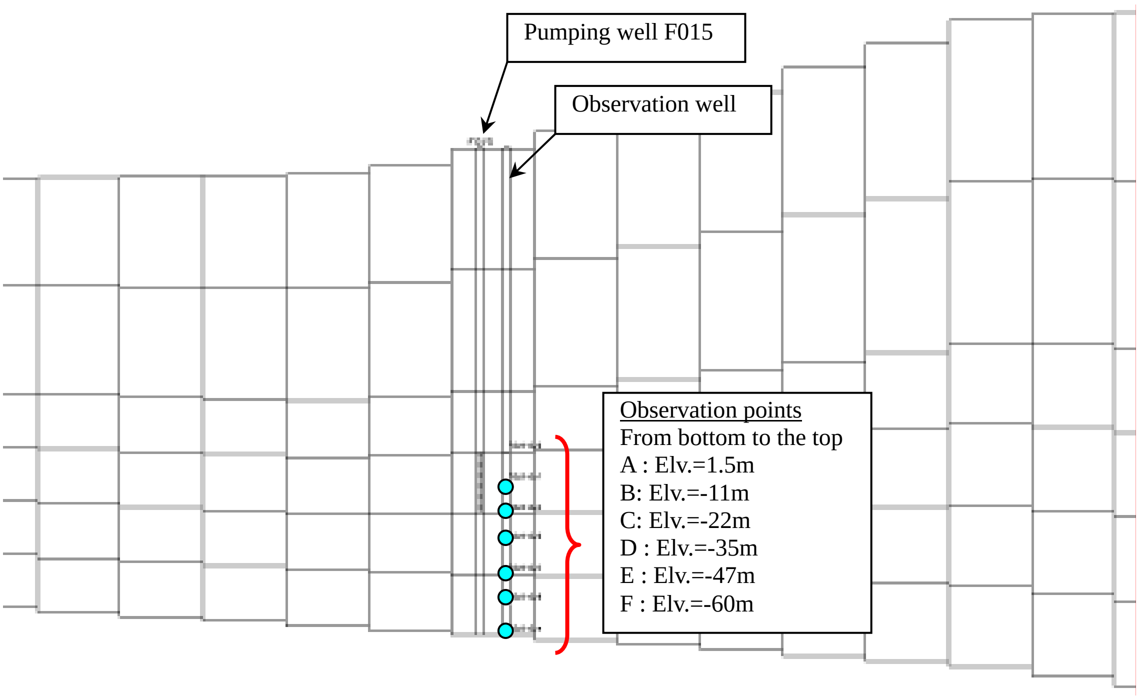


Figure 7.3.5-3 Virtual observation points at the observation well

(3) Results

Simulation is executed for 10 years using above mentioned boundary conditions. Figure 7.3.5-4 shows the results of simulation.

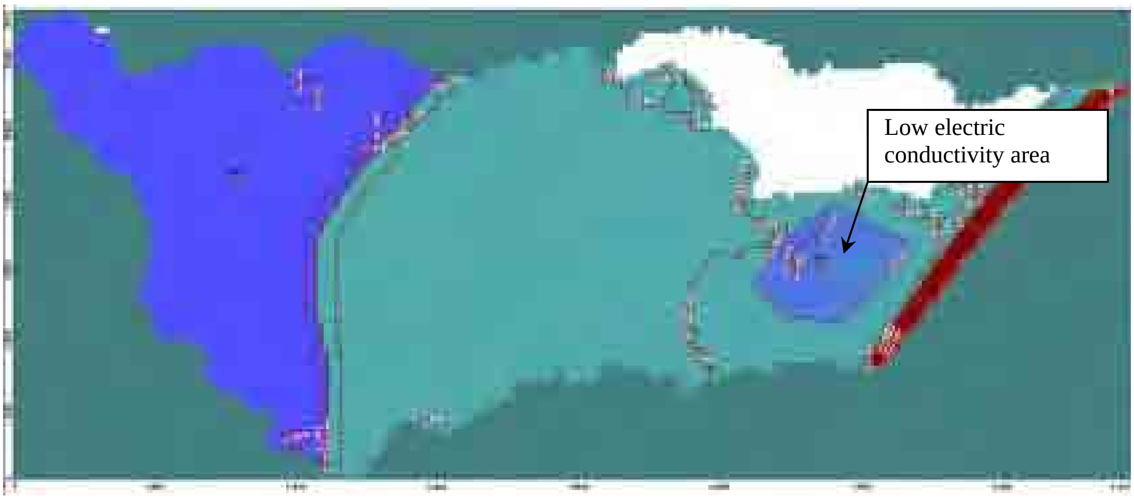


Figure 7.3.5-4 (a) Results of the simulation (layer 4)

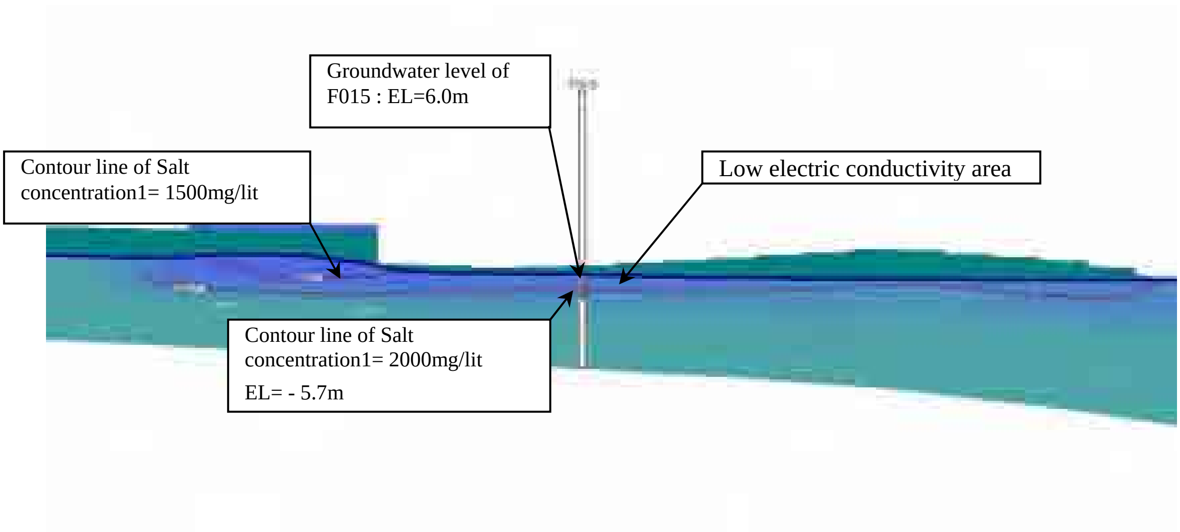


Figure 7.3.5-4 (b) Results of the simulation (cross section)

As shown in the Figure, low electric conductivity area with the thickness of 12m is created by the simulation. Figure 7.3.5-5 shows the time-series change of salt concentration at the observation points.

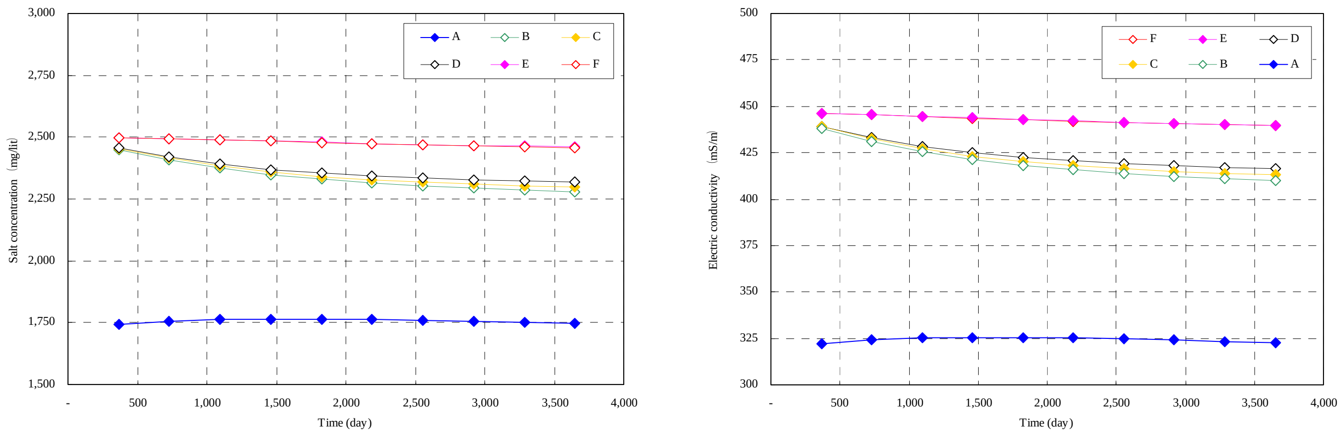


Figure 7.3.5-5 Time-series change of salt concentration at observation points

(4) Change of Water Quality with Pumping

1) Setting of pumping well

Change of water quality at the well F015 is observed. The screen at the well F015 is applied only at the layer 4 to get low electric conductivity water.

2) Pumping discharge

Pumping discharge is changed in eight steps, such as 250, 500, 1,000, 1,500, 2,000, 3,000, 4,000, 5,000 m^3/day.

3) Results

Figure 7.3.5-6 shows results of observation of salt concentration at the observation point A on the well F015. As shown in the Figure salt concentration increase in accordance of increasing of pumping discharge. However, salt concentration converges to the specific value, 2,200mg/lit (400mS/m in electric conductivity), in case pumping discharge is more than 3,000m^3/day.

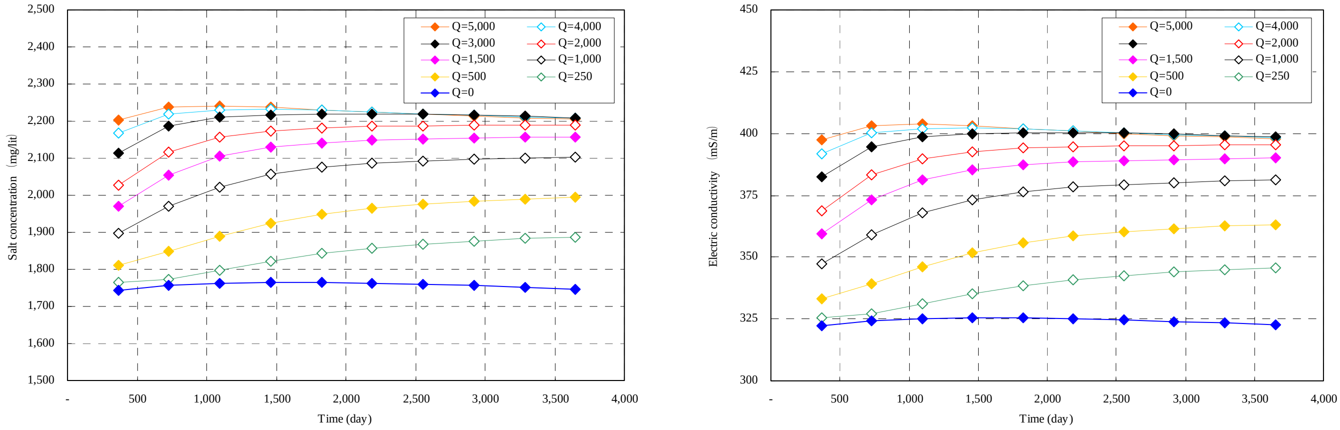


Figure 7.3.5-6 Results of observation of salt concentration and electric conductivity at obs. point A

(5) Case Study I (Reduction of low electric conductivity area)

Several case studies are executed using the same groundwater flow model with changing boundary conditions. For Case Study I, area of low electric conductivity is reduced in half area. Figure 7.3.5-7 shows applied initial concentration boundary for Case Study I.

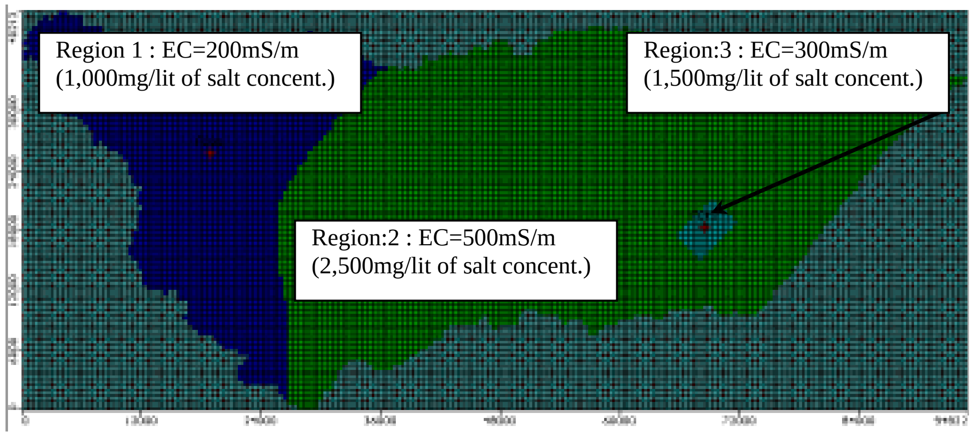
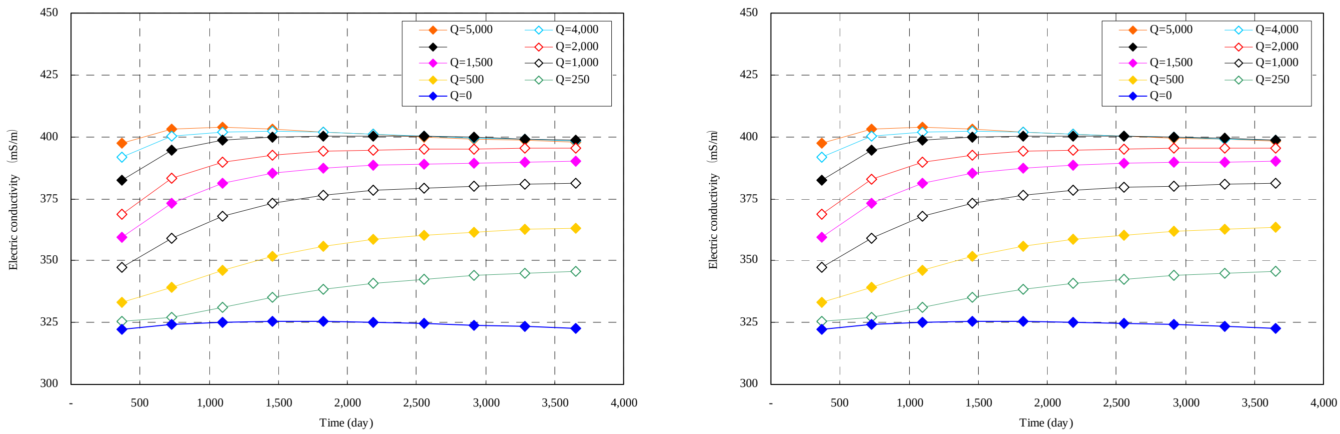


Figure 7.3.5-7 Initial concentration boundary in Case Study I

Figure 7.3.5-8 shows results of salt concentration at the observation point A.

As shown in the Figure there is slight increase of salt concentration. However, the change is negligible, and water quality of pumping well is thought to be same condition as before.

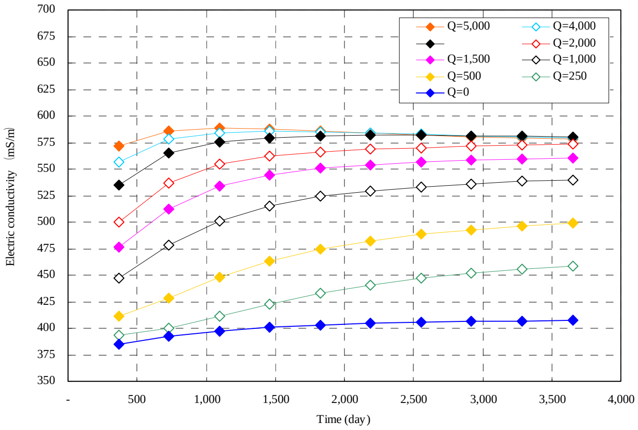


Before reduction of the area After reduction of the area

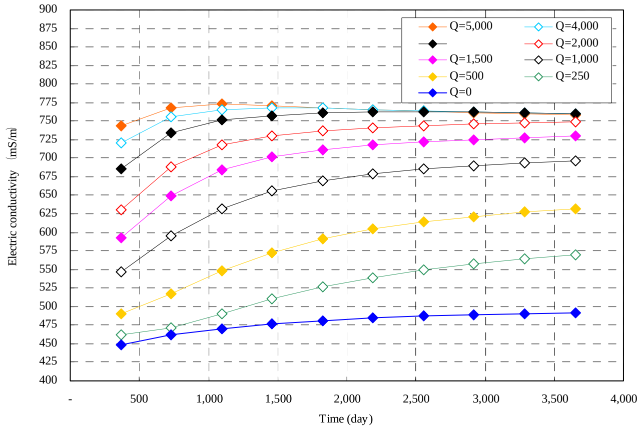
Figure 7.3.5-8 Results of observation of electric conductivity at point A of observation well

(6) Case Study II (Change of salt concentration under low electric conductivity layer)

For Case Study II, salt concentration of Layer 5,6 under the low electric conductivity layer is changed to 4,000mg/lit and 5,500mg/lit from the initial concentration of 2,500mg/lit. Figure 7.3.5-9 shows results of salt concentration at the observation point A. As shown in the Figure, salt concentration at point A of observation well changes drastically following to the increment of salt concentration in Layer 5 and 6. This result indicate if salt concentration will increase at deeper part of the area of well F015, pumping water quality may influenced drastically and salt concentration of pumped water will increase. So it is very important to monitor the actual distribution of water quality of the region around well F015 before the development.



Salt concent. Layer 5,6 = 4,000 mg/lit (EC=750mS/m)



Salt concent. Layer 5,6 = 5,500 mg/lit (EC=1000mS/m)

Figure 7.3.5-9 Results of observation of electric conductivity at point A of observation well

7.4 Groundwater Monitoring Plan

(1) General

Monitoring of groundwater is very important for the management of groundwater resource. Impact on the groundwater environment is evaluated by the execution of groundwater simulation. However observation of actual change of groundwater environment will provide important data to verify the results of simulation.

(2) Proposed Monitoring Plan

Through the study, groundwater level and groundwater quality have been monitored by the Study Team together with local expert. Furthermore, automatic level and quality gauges were installed for the test wells.

Then it is strongly recommended to utilize such previously installed monitoring equipment.
Figure 7.4-1 and 7.4-2 shows location of wells equipped with monitoring equipment. Utilizing these wells monitoring should be undertaken by the local expert in Ambovombe and the monitored data should be stored in the MEM in Antananarivo.

Figure 7.4-3 shows recommended organization chart for the groundwater monitoring.

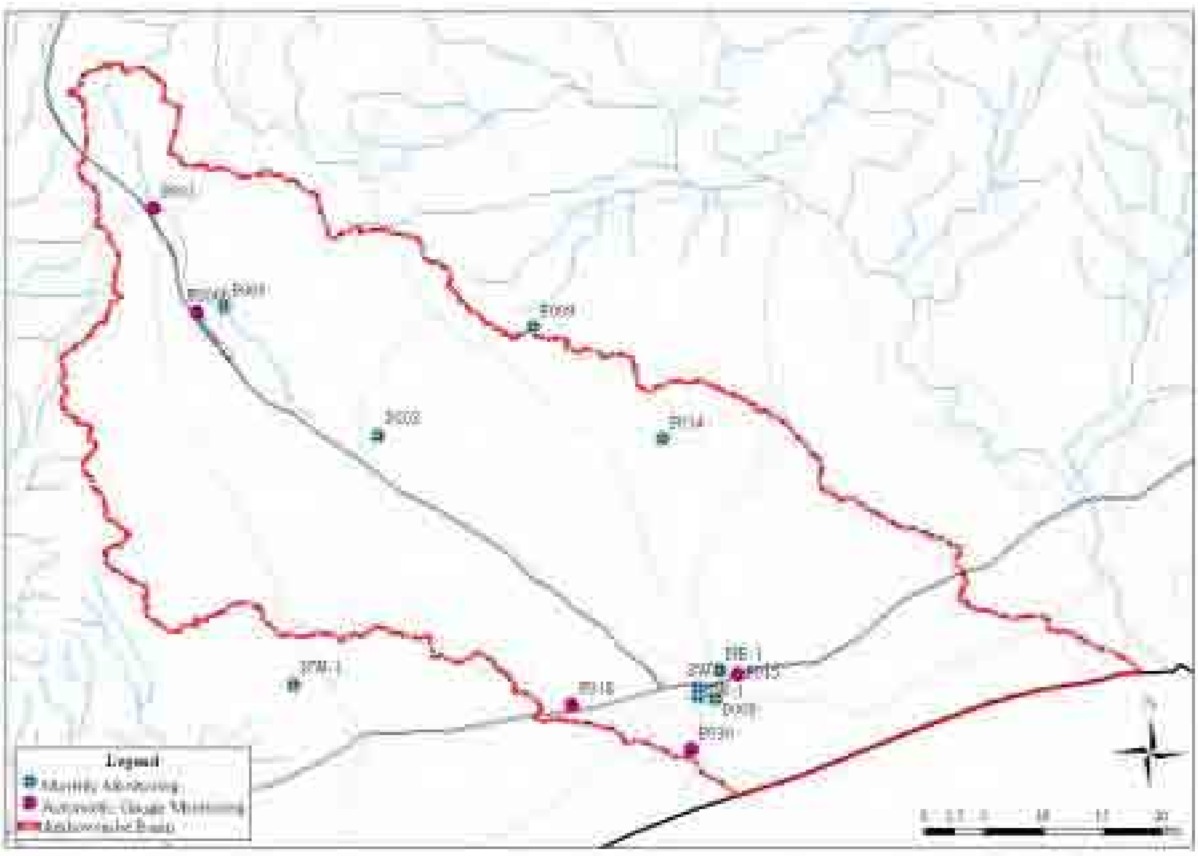


Figure 7.4-1 Location map of groundwater level monitoring well

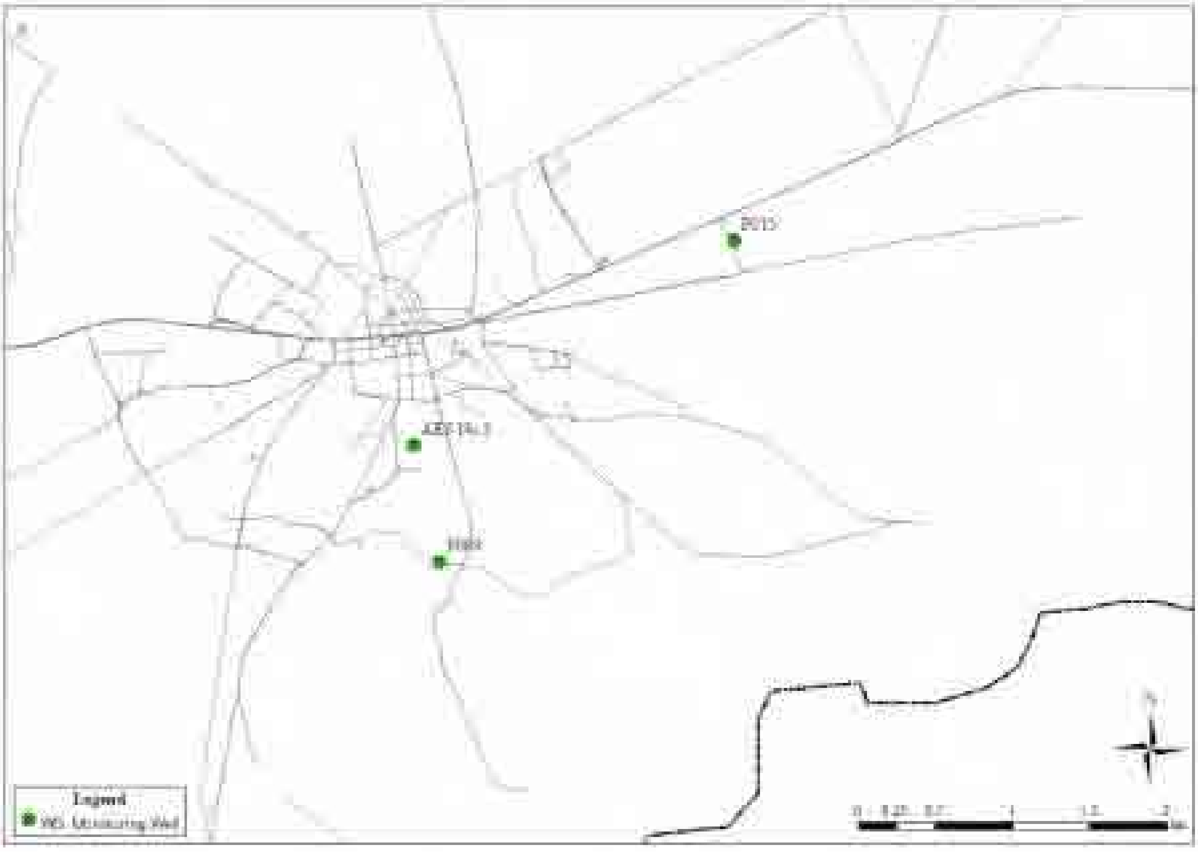


Figure 7.4-2 Location map of groundwater quality monitoring well

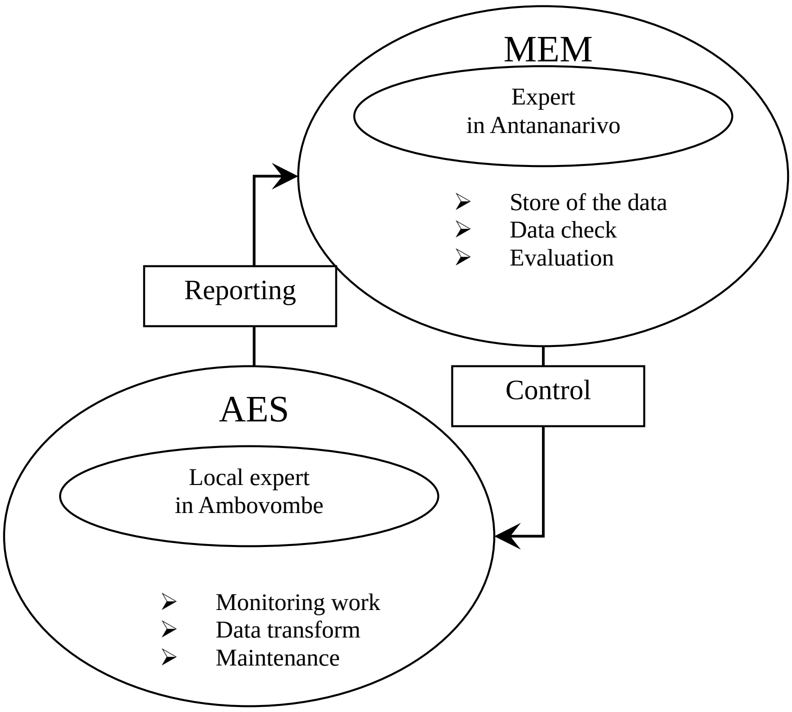


Figure 7.4-3 Organizaion chart for monitoring

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CHAPTER 8 WATER SUPPLY PLAN

8.1 Basic Conditions

8.1.1 Water Supply Area

The water supply area in this Study is divided into two categories namely as city of Ambovombe Commune and other Communes of rural villages as follows:

(1) The city of Ambovombe Commune
  1) Population in 2005 : 38,213 of 58 fokontanys

(2) Other Communes of Rural Villages excluding Ambovombe Commune
  1) Population in 2005 : 239,767 of 332 fokontanys
  2) Number of Villages and Population :Surveyed by JICA Study Team in 2005
     Ideal facility
     - Population less than 300: 1,183 villages: Hand Pump Facility
     - 300 to less than 1,000 : 164 villages : Hand Pump Facility/Solar Pumping System
     -1,000 to less than 2,000 : 3 villages : Solar Pumping System
  3) Water source should be groundwater in the village with safe quality for drinking.

Figure 8.1.1 - 1 Water Supply Area

8.1.2 Water Demand

(1) Supply Population

The total population of 15 target communes with 390 fokontany is 277 980 based on the latest population census carried out during February to April 2005, Region of Ambovombe –Androy, as follows.

Table 8.1.2-1 List of Target Communes and Population, Number of Fokontany

No.	Commune	Number of fokontany	Population 2005	Population 2015	Water Demand (m^3/day)	Fokontany surveyed
1	Ambanisarika	12	11 112	16 592	166	11
2	Ambazoa	20	15 168	22 648	226	20
3	Ambohimalaza	15	13 395	20 000	200	14
4	Ambonaivo	15	9 001	13 440	134	13
5	Ambondro	23	18 556	27 706	277	22
6	Ambovombé-Androy	58	38 213	42 000	420	50
7	Analamary*	15	10 509	15 691	157	14
8	Antanimora	38	22 725	33 931	339	19
9	Antaritarika	24	14 037	20 959	210	23
10	Beanantra	26	12 404	18 521	185	22
11	Erada	17	10 799	16 124	161	17
12	Maroalomainty	32	32 645	48 743	487	32
13	Maroalopoty	50	36 394	54 340	543	41
14	Sihanamaro	28	20 120	30 041	300	12
15	Tsimananada*	17	12 902	19 264	193	16
	Total sauf/ without Antaritarika	366	263 943	366 609	3 661	303
	Total	**390**	**277 980**	**40 000**	**4 000**	**326**

Note: Analamary and Tsimananada became independent in 2003 from Ambanisarika and Ambohimalaza, and from Ambovombe respectively. Source: Region of Androy (2003, 2005), SAP (2001-2002)

(2) Target Year

The target year for water supply facilities is the year of 2015 due to the year of Millennium Development Goals (MDG).

(3) Population Growth Rate

It is possible to compare the population between years at the District level, though the increase rate reflects the change of data collection method. Between 2002 and 2005, population of District of Ambovombe-Androy has increased by 16,388 persons or 6.1% and that of Tsihombe has increased by 19,568 persons or 27.5%. While the population increase rate of this period in Ambovombe-Androy is comparatively low, the increase rate of the 15 target communes is high with the figure of 35.5%.

The population in the Study area is estimated using Logistic Curve forecasting calculation method and the population in the Study area in 2015 will be about 400,000. The population growth will be about 3.7 times in ten years. The present population in Ambovombe Commune in 2005 is 38,200 from the result of this Study, and is estimated as 42,000 in 2015.

(4) Water Consumption

The Study was planed to supply clean water 10 litters/day/capita when groundwater source confirmed.

(5) Water Demand

The water demand in Ambovombe Commune is estimated as 420 m^3/day and 3,580 m^3/day in 2015 according to the demand of 10 litter/day/capita.

Table 8.1.2-2 Population in the Study area and the Water Demand

Items			Present Population	Demand Projection
Year			2005	2015
1. Total Population in Study (supply) area			278,000	400,000
1-1) Population in study (supply) area excluding Ambovombe commune			239,800	358,000
1-2) Ambovombe Commune			38,200	42,000
2. Total Demand in Study (supply) area			(m^3/day)	
	10	Litter/day/cap.	2,780	4,000
2-1) Demand in Study area excluding Ambovombe commune				
	10	Litter/day/cap.	2,398	3,580
2-2) Demand in Ambovombe Commune				
	10	Litter/day/cap.	382	420

8.1.3 Water Source and Water Supply Zone

The safe water source in the Study area is the confined groundwater from borehole due to the less contamination from the surface and stability even in dry seasons. The Study area is situated in a flat area of Ambovombe basin which is covered with thick sediments from Quaternary Alluvium deposits to the basement rocks. Clay, sand, gravel, sandstone and conglomerate layers form the most common unconfined aquifers. On the other hand, Pre-Cambrian weathered granites and gneiss build up the hill where good semi-confined and confined aquifers are found in the northern part of the Basin namely Antanimora Atsimo to Manave At the same time, water supply area has been zoning namely A, B, C, D, E, and F. The main water supply area is the city of Ambovombe, zone D, and the coastal area of zone E.

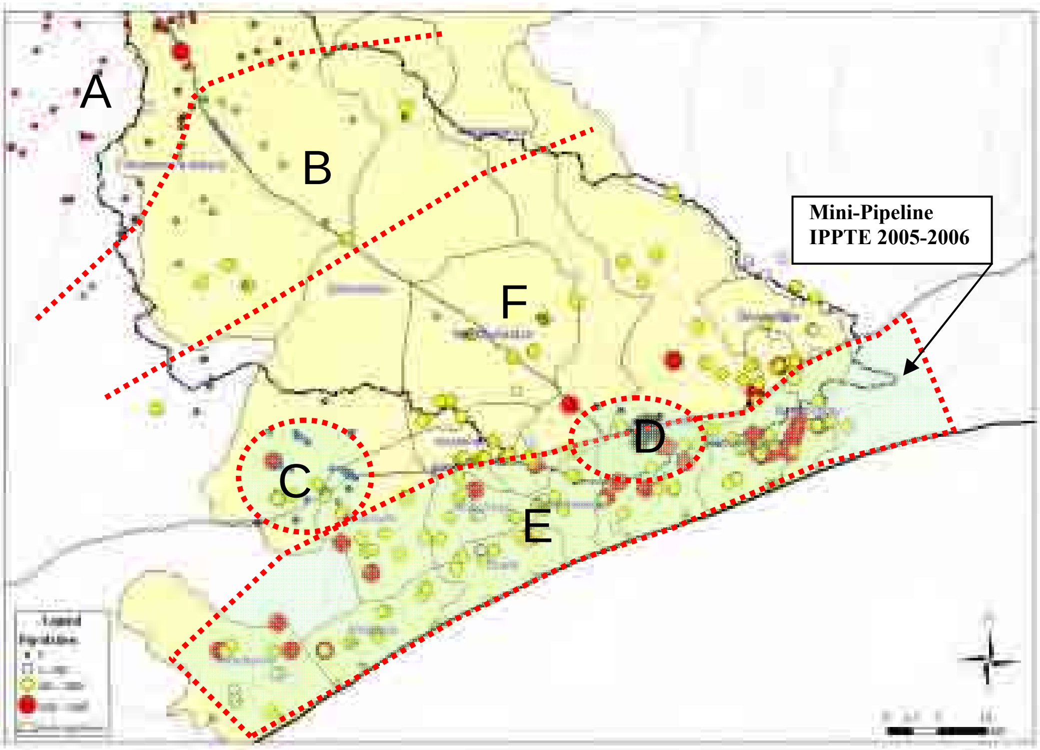


Figure 8.1.3-1 Zoning of Water Supply Area

8.2 Water Supply Alternative Plan

8.2.1 The Description of Alternative Plans

The water resource study was made to secure the stable and safe water supply throughout the year round in the target area. The test drilling study was made at 5 hand-dug well sites and 20 borehole sites aiming at "one water source per village" in the study area. And water supply facilities were constructed at 5 sites utilizing successful test drilled wells to implement the pilot project. The stable, safe water sources (with groundwater potential) that the test drilling study had made clear were limited to the following 2 sites:

- The suburbs of Ambovombe City (F015: domestic water)
- Antanimora area (F001, F006 and F006B: drinking water)

[D: Drinking Water Supply Plan]

The water supply alternative plan (**D1** – **D3**) is intended to utilize the water source (domestic water) in the suburbs of Ambovombe, while the plan (**D4** – **D6**) is limited to the use of water source (drinking water) in Antanimora area (F001, F006 and F006B). Therefore, the water supply plan was formulated taking the following points into consideration:

① The operation and maintenance is available in the present technical level of AES.
② The water cost based on the facilities renewal cost for sustainable operation and maintenance is less than Ar100/13ℓ bucket at present and the water facilities can be independently operated (on a self-supporting basis).
③ The water cost range is Ar50 to Ar100/13ℓ bucket that the residents are willing to pay.
④ The South Region Water Supply Agency (AES) established in the 1980's had some problems in the aspects such as boost of fuel cost, slash of subsidy and operation and maintenance, and the water cost is Ar100/13ℓ bucket at present, but the cost was Ar150 to Ar500/13ℓ bucket in July 2005.
⑤ The alternative plan to this program (**D1** – **D6**) obtained the result of trial estimation that the cost is Ar30 to Ar50/13ℓ bucket.

The water supply alternative plan (**D1** – **D2**) is intended to use the water source (F015) in the suburbs of Ambovombe City to supply water to the Ambovombe and its surrounding area (zone D) that have a high population density and the highest priority. The difference between (**D1**) and (**D2**) is that (**D1**) is of self-completion type using Diesel power generation as the power source while (**D2**) using the commercial power available from JIRAMA. The commercial power capacity of JIRAMA cannot be used in a full scale because of its insufficient allowable quantity, but it is so advantageous from the viewpoint of the maintenance cost that the plan (**D1**) will be shifted to the plan (**D2**) in future.

Plan (**D3**) will use the water source (F015) in the suburbs of Ambovombe City and supply water to the coastal sand-dune zone (zone E). The water will not be used for drinking water, but for domestic water

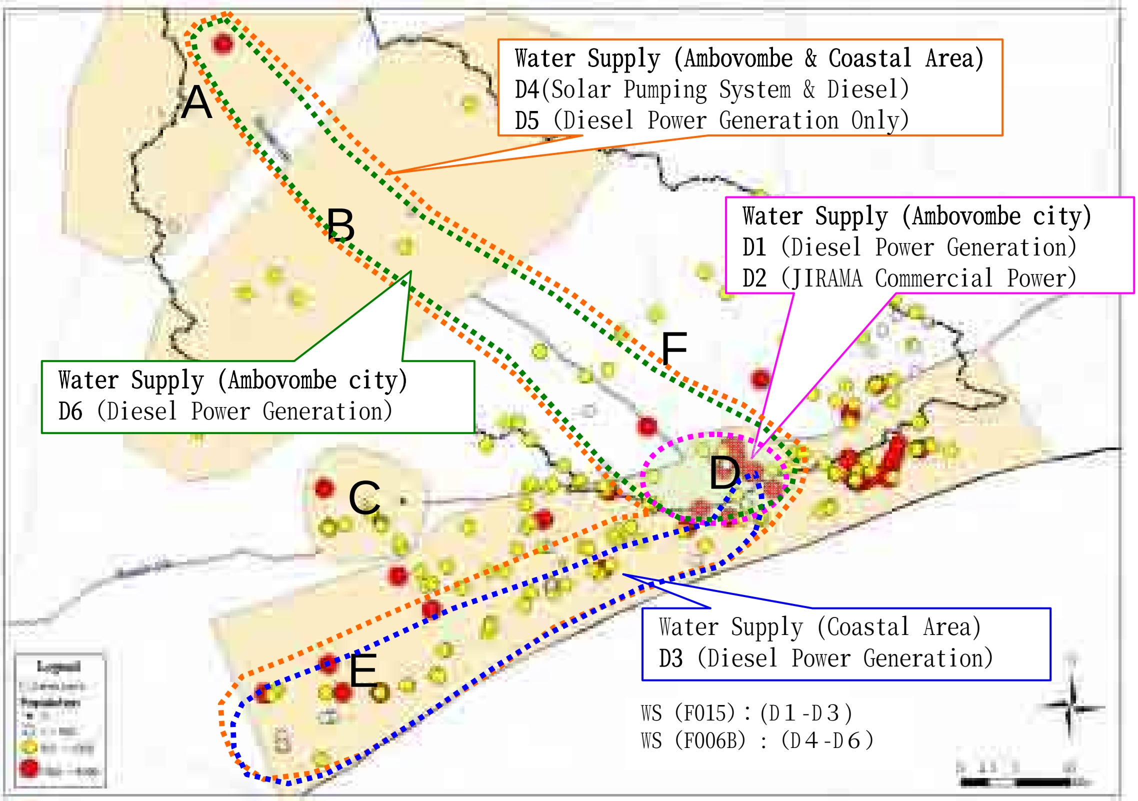


Fig.8.2.1-1 Water Facilities Deployment Layout in Water Supply Alternative Plan (D1 to D6)

Table 8.2.1-1 Comparison of Basic Items in Water Supply Alternative Plan (D1 – D6)

	Water Source	Population of Beneficiaries	Direct Work Cost	Cost per Beneficiary	Production Cost (13ℓ bucket) & Minimum Production		Operation & Maintenance Cost
			Billion¥	¥/person (Ar/person)		m^3/day	million /d
D1	Ambovombe Suburbs (F015)	40,000	¥0.13	¥3,250 (Ar55,000)	Ar20 ¥1.1	400	¥1.04 (Ar18.5)
D2	Ambovombe Suburbs (F015)	40,000	¥0.13	¥3,250 (Ar54,000)	Ar25 ¥1.4	400	¥0.78 (Ar13.9)
D3	Ambovombe Suburbs (F015)	179,000	¥1.1	¥6,145 (Ar108,000)	Ar20 ¥1.1	400	¥1.20 (Ar23.1)
D4	Antanimora Area(F006B)	206,500	¥2.3	¥11,380 (Ar198,000)	Ar15 ¥0.83	700	¥1.36 (Ar24.2)
D5	Antanimora Area (F006B)	206,500	¥2.3	¥11,380 (Ar198,000)	Ar25 ¥1.4	700	¥2.26 (Ar40.4)
D6	Antanimora Area (F006B)	84,500	¥1.3	¥15,300 (Ar270,000)	Ar25 ¥1.4	400	¥1.29 (Ar23.1)

On the other hand, the water for (**D4** – **D6**) will be transported from the water sources of the Antanimora area where the water quality is compliant with the standard for drinking water. For this, it is necessary to provide the long-distance service pipeline of approximately. 60km from a water source to the water supply target area, Ambovombe City and further approximately. 50 and several km to Antaritarika, the final point of the coastal sand-dune zone. However, there is a topographic advantage that the water transmission to the final point of Antaritarika can adopt gravity flow by utilizing an altitude difference of approximately. 80m from the water source point.

Plans (**D4** and **D5**) are the consistent water supply project for the almost entire water supply area from the water source to the final point. The implementation work period requires about five (5) years, namely a short period (2008-2012). Therefore, it is necessary to implement the project by dividing the entire period into phases that have individual completeness with the priority for supply of the most demanded drinking water.

1) Plan (**D4**), the water supply systems using solar power will be installed at four (4) sites or more with the consideration for reduction of the fuel cost and the operation and maintenance cost.
2) Plan (**D5**) is intended to use Diesel power generation as the power source and concentrate pumping plants on three (3) sites in order to reduce the initial investment and improve the efficiency of operation. (Refer to Table 8.2.1-1)

Plan (**D6**) is intended to supply water from safe and stable drinking water source in Antanimora to Ambovombe City that is the most important zone in the study area.

Plans (**D1** – **D6**) were formulated assuming that the water cost is lower than the current cost of Ar100/13ℓ bucket considering the facilities renewal cost for the sustainable maintenance and operation, and in order to ensure the independent operation (to obtain the independent profitability). For this purpose, it is necessary to reinforce the maintenance and operation system to realize the above viewpoints in implementation of each plan. For the operation system, there are options, namely the use of existing AES and the establishment of a new independent organization (privatized). As the result of the study, it would be most appropriate to reform and reinforce the organization using the experience of the existing AES that has been making the comprehensive study of the water issues in the study area, Therefore, it is necessary to start the urgent (2007) plan (**D1**) and simultaneously the technical cooperation (**S1**) for the project for the technical and operational support of AES in order to improve the operation by the efficient use of the water revenue available from the water supply to Ambovombe City. In addition, the concrete plan (**D4**) should be discussed in details with the related agency (MEM), aiming to the realization of the water supply improvement program for the target area after 2008. This program will also be promoted through the active cooperative relationship with organizations making activities in the area including municipalities, EU, African Development Bank and NGOs. The integrity with many projects implemented in the area and the technical support programs (**S1**, **S2** and **S3**) concerned with the total management will also be required. MEM completed the Mini-Pipe (Amboasary-Sampona) and started supply water in November 2006. Therefore, we include an additional Alternative Plan (S4) such as technical assistance for the extension of Mini-Pipe to Antaritarika of coastal area via Ambovombe city for drinking water supply.
Concretely, these include the following:

1) Adjustment and promotion of the gravity feeding pipeline program with the impluvium
2) Support to reinforce the operation and organization for executing the water cost within the water cost range (Ar50 to Ar100/13ℓ bucket) that the residents are willing to pay.
3) Support for the urgent improvement for the technical, operational and organizational reinforcement of the existing pipeline (of 140km between Tsihombe and Beloha).
4) Consideration of technical assistance for the extension of Mini-Pipe (Amboasary-Sampona) as Plan (S4)

The highest priority for installing an impluvium will be given to the zone at 10km or more distant from a zone where a permanent water supply system or a groundwater source is located.

1) Priority order 1: Zones at 10km or more distant from a pipeline having a little benefit from it.
   A total of 164 impluviums will be constructed: Analamary (12 units), Maroalopoty (43 units), Maroalomainty (29 units), Beanantara (25 units), the Northwest of Sihanamaro (17 units) and the central to the northern part of Ambovombe (38 units).
2) Priority order 2: Zones in the coastal sand-dune area where no pipeline will be constructed: A total of

64 units will be constructed: Antaritarika (27 units), Ambazoa (15 units), Erada (14 units), Tsimananada (8 units)

3) Priority order 3: A total of 53 units will be constructed in 4 Communes except the zones as conditioned above.

The installation sites will be selected depending upon the distance from a water source including the existing impluvium. One unit of impluvium will be installed for each distance of 5km from an existing water source in turn in order to fill the dead zones.

Plan (**D7**) is a construction of large impluviums is in the high priority order even in the study of demand at each Commune for formulation of the Development Plan implemented in 2006, and it is required in the situation that there is no other water source, even though there is a seasonal limitation.
However, the impluviums should be installed for the temporary and emergency use in the areas where no safe, stable water is supplied and the system durability is not guaranteed because there is no water in such tanks during a certain period.

As the system scale is large, this project including the soft assistance for hygienic education will have been implemented by the final goal year of 2015.

1) Priority order 1: 164 units (for 4 years from 2007 to 2010) in the zones (fokontany) that are located at 10km or more distant from a service pipeline and having a little benefit from it.
2) Priority order 2: 64 units (for 3 years from 2011 to 2013) in the zones (fokontany) where no water pipeline is constructed in the coastal sand-dune area.
3) Priority order 3: 53 units (for 2 years from 2014 to 2015) in 4 Communes (fokontany) except the zones as conditioned above.

Plan (**D8**) is intended to construct rainwater collection systems with the standard volume of $10m^3$ using the roofs of the public facilities as the water collecting part (approximately. $100m^2$).

Plan (**D9**) is intended to construct the rainwater collection systems of the HDPE type tank which collect rainwater using the roof of each house, and ensure the residents to construct the water collection system independently.

Plan (**D10**) relates to underground storage tanks to be constructed to collect rainwater in water channels in an artificial storage space using impermeable sheets. The construction of this type of tanks is simple because concrete is only used in a part of it.

Plans (**D11** and **D12**) relates to the use of sterilizing agents or anti-septic agents to protect the water for drinking from the rainwater collection systems as described in Plans (**D7** – **D10**) above.

Plan (**D13**) is concerned with the discussions on water tank trucks.

Plan (**D14**) is a solution to the area having an groundwater potential, if it is limited, and this area covers the north of Antaritarika in the west to the south of Ambondro and the groundwater level is about 20m in altitude.

Plan (**D15**) relates to desalination system to change the water with a high salinity into fresh water, which requires the drive power for pressure generation and the replacement of filters and other parts for the maintenance and operation of it.

Plan (**D16**) focuses on promotion of water boiling to secure safe drinking water.

[DM: Domestic Water Supply Plan]

Plan (**DM1**) relates to the use of hand pumps and is being implemented with two (2) types of rope pump and Vergnet pump as a pilot project.

Plan (**DM2**) relates to the use of depressed land.

[P: Power Generation Plan For Water Supply]

Plan (**P1**) relates to the introduction of wind power generation.
Plan (**P2**) relates to the micro power generation using the head of water in service pipelines.

[L: Administrative Action To Support Water Supply Improvement]

Plan (**L1**) relates to the legislation for sale of water. The registration system is applied to water vendors in the city area of Ambovombe City, but there is no regulation for water selling prices.

Plan (**L2**) deals with the problems of existing wells and the solutions to improve them, as follows:

- Foreign objects enter well because there are not covers. The covers are made of wooden plates, but there are some wells over which it is difficult to install their covers because their apertures are heavily broken. If the obligation of installing a cover is defaulted, it is an issue how the obligation is forced to fulfill.
- The toilets are of pit latrine, there is risk that the groundwater in the densely populated residential areas may be contaminated with excreta.
- The drain water penetrate into the ground and then return to the well because washing is done near a well.

Plan (**L3**) is partly overlapped with the plan (**L2**) above, but focuses on the well location regulation. The water quality is safe and there are few residential houses at present in the southeast of Ambovombe City, but it will be required to enforce the policy for water source protection against contamination from the ground surface along with the future increase of the population.

Plan (**L4**) relates to the water transportation to remote areas through the service pipelines constructed. The water transportation by zebu carts depends actually upon the incentive that water can be sold at a high price or upon the mutual voluntary activities, but water is not absolutely supplied efficiently to remote areas.

Plan (**L5**) is a plan to implement the water supply project by introduction of private sector vitality, but the concrete detailed works including selection of companies in charge have been slow, and the existing AES is also an indispensable entity.

Comprehensive evaluation of the improvement for the independent sustainable drinking water supply to the poorest areas through the use of various assistance schemes:
The planned target area is the poorest area in the Madagascar. Aiming at attaining the 2015 millennium development goal, it is necessary to make a flexible, quick solution to meet the needs in this area to the overall reduction of poverty, particularly the drinking water supply issue in considering any grant aid such as professional technical assistance and community development assistance grant aid.

Table 8.2.1-2 List of Water Supply Systems In The Study Area(1/3): Facility Specification

No.	Main target	Water supply facility	Water supply plan	Service area (Service population 2015)	Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Service Population	Construction cost /beneficiary population
D1	**Domestic** water (Virtually drinking)	Water supply system to urban Ambovombe utilizing water source at the outskirts of Ambovombe (Diesel generator method)	2 Deep well(8", Depth 150m, Capacit300m^3/d x 2=600m^3) Water supply facility (Submersible pump, Generator, Ground level water tank 300m^3, Urban pipeline10km, Public Faucet 20)	Ambovombe residents 23,000+surroundings=40,000; Water supply quantity 10L/d/person (400m^3/d)				1	*		40,000	130million yen/40,000 =3.3thousand yen/person
D2	Domestic water (Virtually drinking)	Same as above (JIRAMA Commercial electricity method)	Same as above, but for the power source JIRAMA electricity shall be utilized.	Same as above				1	*		40,000	130million yen/40,000 =3.3thousand yen/person
D3	Drinking water (Virtually)	Water supply system to coastal area utilizing water source at the outskirts of Ambovombe (Diesel generator method)	・/5 deep well(8", Depth 150m, Capacity 600m^3/day) ・Water supply facility (Submersible pump, Generator, Ground level type collection water tank 200m^3, Booster pump, Ground level type water tank100m^3, Distribution tank 600m^3, 100m^3, 50m^3, Transmission pipeline6km, Distribution pipeline52km, Public faucet 36) If, as a result of groundwater simulation the well capacity is proved to be reasonable, then 10 wells are needed.	Villagers scattered in the coastal dune area 179,000, Water supply quantity 10L/d/person (1,790m^3/d)					1		179,000	1,100mill. Yen/179,000 =6.1thousand/person
D4	Drinking water	Water supply system utilizing the groundwater in Antanimora to Ambovombe and the coastal dune area. (Solar pumping system + Diesel pumping system)	・6 Deep well (6", Depth 63m, Capacity 600m^3/d/well, Solar pumping capacity100m^3/day) ・GFS system (Antanimora - Ambovombe 300mm, L=62km, Q=66m^3/hr, Ambovombe - Antaritarika 200mm, L=52km, Q=37m^3/hr) ・Water supply facility (Elevated water tank 50m^3, Urban pipeline 10km, Ground level type collection water tank 800m^3, 300m^3x2, Distribution tank 50m^3x4, 100m^3x5, Public Faucet 20) (Solar pumping system 4, Diesel generator system 2)	1) Ambovombe Residents 23,000, 2) Coastal area villagers 179,000, 3) Antanimora water source vicinity 4,500 Total 206,500 4) Water supply capacity 10L/d/person (2,065m^3/d)		1		1	1		206,500	2,300mill Yen/206,500 =11thousand Yen /person
D5	Drinking water	Water supply system utilizing the groundwater in Antanimora to Ambovombe and the coastal dune area. (Diesel pumping system)	・Same as above, ・3 deep wells, (If the power source is diesel generator, operational hours of the GFS transmission can be extended to 12 hours with the elevated control tank being 150m^3 to properly utilize the pumping capacity of 600m^3/d.) Deep well(6", depth 63m, Diesel powered pumping capacity Q=50m^3/hrx12hr=600m^3/day/well,)	1) Ambovombe Residents 23,000, 2) Coastal area villagers 179,000, 3) Antanimora water source vicinity 4,500 Total 206,500 4) Water supply capacity 10L/d/person (2,065m^3/d)		1		1	1		206,500	2,300mill Yen/206,500 =11thousand Yen /person
D6	Drinking water	Water supply system utilizing the groundwater in Antanimora to Ambovombe. (Diesel pumping system)	・2 Deep wells (8", Depth 63m, Diesel powered pumping capacity 600m^3/day/well, elevated control water tank150m^3) ・Gravity force pipeline system (Ambovombe - Antanimora 300mm, L=62km, Q=50m^3/hr) ・Water supply facility (Elevated water tank 100m^3, Urban pipeline system 10km, Distribution line 10km, Public faucet 35)	1) Ambovombe Residents 23,000, 2)Amboihmalaza villagers 57,000, 3) Antanimora water source vicinity 4,500 Total 84,500 4) Water supply capacity 10L/d/person (2,065m^3/d)		1		1		1	84,500	1,300mill. Yen/84,500 =15thousand yen/person
D7	Drinking water	Impluvium 1 Public, large scale	・Improve the water supply in rainy season + 1 month (Total 5 months). ・Fokontany level: Water collection area 1,000m^2, Tank volume 120m^3	281 Fokontanys without wells or existing impluviums			1		1	1	approx. 140,500 (Assuming ave. population of one fokontany to be 500)	10mill. yen/500persons =20 thousand yen/person
D8	Drinking water	Impluvium 2 Public, medium scale	・A 10m^3 volume tank using the roof of public facilities. Water collection area 100m^2.	Same as above. Differentiation between the above shall be considered later on. As above, many have already been constructed by NGOs			1		1	1	The surrounding population of the construction site shall be the beneficial population, which is around 500/site. The number of the site will be dependant on the number of requests	1mill. Yen/ 500 persons = 20 thousand yen / person
D9	Drinking water	Impluvium 3 Shared, small scale	Water collection area of the private roof: 50m^2, tank volume 5m^3. Includes improvement of the roof	All areas except Ambovombe			1		1	1	one basin per 2 to 3 households	600thousand Yen/7persons =90 thousand Yen/person
D10	Drinking water	Impluvium 4 Public, large scale	・Construct water storage space underground, and store rainwater. ・Already constructed in school yards. ・Water collection area 1,00m^2, water storage tank 120m^3.	281 Fokontanys without wells or existing impluviums			1		1	1	approx. 140,500 (Assuming ave. population of one fokontany to be 500)	13million yen /500persons =26thousand yen / person
D11	Drinking water	Education of using sterilizer	Hygiene education for prevention of water deterioration using Sur eau	All areas without water source except Ambovombe			1		1	1	231,831	The cost depends on the contents of the program itself.
D12	Drinking water	Education of using antiseptic	Prevention of water decay and hygiene education.	All areas except Ambovombe			1		1	1	231,831	The cost depends on the contents of the program itself.
D13	Drinking water	Water service truck 1	・Construction of pipeline between Antanimora and Ambovombe is a prerequisite. ・Change the system of water source from Amboasary to Ambovombe. ・Procurement of 6m^3 water service truck.	All areas except Ambovombe					1	1	6,000 beneficiaries with 1 truck	8.54mill Yen /6000persons =1423 Yen
D14	Drinking water	Handpump in the vicinity of Antaritarika	・HPV100 with head water of 100m shall be set in villages having population over 100. Because of the limit of the head, these will be set in areas under 100m. ・110m well, supplementary facilities, establishment of pump accessories sales system, repair work system.	Imongy、Antaritarika North、Mananbovo River basin					1		16,259	7540 thousand yen /200 person =38万thousand yen /person
D15	Drinking water	Desalination facility	・Remove the salinity in high saline water. ・Set desalination facility in water supply systems of wells, elevated water tank, public faucet. Construct solar power source for pumps and desalination facility.	All areas where salinity is high.			1	1	1	1	252,830	Shall be clarified after the concrete plan
D16	Drinking water	Hygiene education on boiling water.	・Spread the boiling water method as a means of securing safe water.	All areas			1		1	1	231,831	Shall be clarified after the concrete plan
DM1	Domestic water	Hand pump in the seaside areas	・Install manpower pumps able to pump 100m expecting EC3,000 to 10,000μS/cm. Target areas is limited to areas up to 100m above sea level, thus the areas are above the cliffs along the seashore or valleys between the sand dunes.	Low areas along the sea side, population being around 1/10 of the population of the coastal areas.	1		1	1	1	1	・25fokontany at coastal area ・30fokontany at eastern ・10fokontany around Ambaliandro	7540 thousand yen /200 person =38万thousand yen /person
DM2	Domestic water	Construction of small reservoir	In the coastal areas, it is hard to obtain even the water for cattle even in rainy season because ponds or marshes are not formed. Paste mud in the depression areas to enable to reserve water.	Only in coastal areas where natural ponds are not formed.					1		Coastal area	Shall be clarified after the concrete plan
P1	Power Source	Utilization of wind-power	Wind pump and wind generator	Coastal areas and all areas	1	1	1	1	1	1	270,560	Shall be clarified after the concrete plan
P2	Power Source	Pumped hydropower (Micro hydropower)	Micro hydropower utilizing the altitude difference and flow rate of distribution line.	Point from Antanimora to Ambovombe and Point from Ambovombe and Antaritarika				1	1		183,584	Shall be clarified after the concrete plan
L1	Legist ration	Stabilize the water price which becomes high when water is scarce.	All water sellers who sell water from the AES constructed facilities should be licensed, and prohibit the selling of water above the controlled price.	-			1	1	1	1	252,830	The cost depends on the contents of the program itself.
L2	Legist ration	Proposal of sanitary vovo design	・Sanitary guidelines around the wells. ・Guidelines for the well caps and well surroundings	Ambondro、Ambovombe			1	1			38,684	The cost depends on the contents of the program itself.
L3	Legist ration	Guidelines for well construction and regulation on pollution source.	・Set the water source area and regulate the construction of houses. ・Prohibit using the well from which diseases broke out. ・Pollution may be caused that there is no well cap, so legalize on well caps.	Ambovombe, in particular			1	1			38,684	The cost depends on the contents of the program itself.
L4	Legist ration	Organize the carts to optimize the water transportation.	All water sellers who sell water from the AES constructed facilities should be licensed, and prohibit the selling of water above the controlled price. Also, if the water is to be sold far away, the wholesale price is discounted.	Ambovombe, in particular			1	1	1	1	252,830	The cost depends on the contents of the program itself.
L5	Legist ration	Support on transparent of AES	・Relocation of staff. ・Disclosure of accounting report (to Donors and district) ・Support until the management of project constructed facilities get into orbit.	-			1	1	1	1	252,830	The cost depends on the contents of the program itself.

Table 8.2.1-2 List of Water Supply Systems In The Study Area(2/3): Cost

No.	Construction cost				Water price		Operation and maintenance			
	①Direct construction cost	②Indirect construction cost	①+②	Cost basis	Ar/13L	Base	Ar	Base	Main repair items	O & M Difficulty
D1	130million yen			Estimation by local company	Ar30 (Yen1.7)	(Operational ＋Maintenance＋Renewal costs)÷Pumping rate	Ar27,700,000/month (Yen1,540,000/month) 400m^3/day	(Fuel cost＋Operator fee＋Fue	Generator+Pumping equipment	Difficulty is medium level, however key management organization such as AES is necessary.
D2	130million yen			Estimation by local company	Ar20 (Yen1.1)	(Operational ＋Maintenance＋Renewal costs)÷Pumping rate	Ar18,500,000/month (Yen1,030,000/month) 400m^3/day	(Fuel cost ＋ Operator fee ＋ Fuel transportation cost)	Pumping equipment	Difficulty is easy level, however key management organization such as AES is necessary.
D3	1,100mill. Yen			Estimation by local company	Ar30 (Yen1.7)	(Operational ＋Maintenance＋Renewal costs)÷Pumping rate	Ar27,700,000/month (Yen1,540,000/month) 400m^3/day	(Fuel cost ＋ Operator fee ＋ Fuel transportation cost)	Generator+Pumping equipment	Difficulty is slightly difficult level, however key management organization such as AES is necessary.
D4	2,300mill. Yen			Estimation by local company	Ar25 (Yen1.4)	(Operational ＋Maintenance＋Renewal costs)÷Pumping rate	Ar40,400,000/month (Yen2,240,000/month) 700m^3/day	(Fuel cost ＋ Operator fee ＋ Fuel transportation cost)	Invertors +pumping equipment	Difficulty is medium level, however key management organization such as AES is necessary.
D5	2,300mill. Yen			Estimation by local company	Ar30 (Yen17)	(Operational ＋Maintenance＋Renewal costs)÷Pumping rate	Ar148,500,000/month (Yen2,690,000/month) 700m3/day	(Fuel cost ＋ Operator fee ＋ Fuel transportation cost)	Generator+Pumping equipment	Difficulty is medium level, however key management organization such as AES is necessary.
D6	1,300mill. Yen			Estimation by local company	Ar35 (Yen2.0)	(Operational ＋Maintenance＋Renewal costs)÷Pumping rate	Ar32,300,000/month (Yen1,790,000/month) 400m^3/day	(Fuel cost ＋ Operator fee ＋ Fuel transportation cost)	Generator+Pumping equipment	Difficulty is medium level, however key management organization such as AES is necessary.
D7	10mill. Yen	30%	13mill. Yen	Assuming the cost will rise proportionally according to size based on the unit cost of 1981 BD report	100	Set repair period to 15 years, divided the repair fee and maintenance fee with the sell quantity of 360m^3.	Allowance 1,584,000 Ar/yr Repair 15,480,000 Ar/yr	・Maintenance cost 89,000yen/year ・1.1mill. Yen/15years = 74thousand yen/year	・Allowance of maintenance staff ・Repair cracks in the water tank	・Difficulty is high. It is hard to completely stop the leakage even after the repair. In this case, the contractor cannot correspond for the re-repair. It is highly possible that the advance payment will be wasted. ・It is top priority to organize the construction contractor who can deal with full responsibility, but difficult to organize considering the area's capability.
D8	1mill. Yen	30%	1.3mill. Yen	Adding the expected labor cost to the material costs	83	Amount of water sold shall be proportional to the above meaning the price shall be the same.	repair: 1,080,000Ar/year	5% of the construction cost	・repair of the trough, cracks on the roof and/or reconstruction of the roof.	・Medium level. It might be hard completely stop the leaks, however because the water tank is at the ground level, many other treatments can be taken. ・It is top priority to organize the construction contractor who can deal with full responsibility which, actually, shall be difficult.
D9	.5mill. Yen	30%	.65mill. Yen	Adding the expected labor cost to the material costs	83	Amount of water sold shall be proportional to the above meaning the price shall be the same.	repair: 565,000Ar/year	5% of the construction cost	・Repair cracks in the water tank	・Low, rebuy a new tank. ・Transportation of the tank from the seller may cause trouble, but it is not a technical difficulty.
D10	10mill. Yen	30%	13mill. Yen	From the unit cost per m3 if Japan.Transportation cost, Technician dispatch cost, civil works cost, sheet construction cost and drainage cost is not included, thus assuming that these cost double of the estimated cost.,	32	Renewal cost is calculated on the basis that the durable years is 20, annual sales amount is assumed as 360m^3.	-	-	Impossible to repair, only complete renewal is possible	・Impossible to repair
D11	NA	NA	NA	NA	NA	NA	9000Ar/HH(6 people)	Water usage 20L/day/person	purchase only	・Already circulated in market and easy to purchase.
D12	NA	NA	NA	NA	NA	NA	882,000Ar/HH(6people)	Water usage 1L/day/person	purchase only	・Since not yet in market, first thing needed is to set market system. ・Expensive
D13	6.57mill. Yen	30%	8.54mill. Yen	Base of the calculation for depletion expenses	No renewal 178Ar Renewal 233Ar	・Transport 18m^3 water per day ・Run 250km ・Repair and maintenance fee.	?	Base truck price is set at 6.57mill.Yen	Fuel, repair, maintenance	・Repair works is already undergone thus possible. ・As the existing trucks were not renewed, it is difficult with the current structure.
D14	・Well drilling 5mill. Yen ・facilities 500 thousand yen ・Setting of pump 300 thousand Total 5.8 million yen	30%	7.54mill. Yen	Construction fee of the South west project	6.1	・Stated in Interim Rep. ・Consideration of pump renewal cost ・10Litter/day/person	840,000Ar	Including pump renewal cost	・Commodities such as packing ・Allowance to the repair man	・Exchange of the commodities is possible in the residents' level. ・If there is need to raise the pump and check the function, personnel who is used to handling with the repair works is needed. ・There is need to establish pump repair man system and commodities sales shop.
D15	Shall be clarified when planned out, after evaluation of test operation				Shall be clarified when planned out, after evaluation of test operation		Shall be clarified when planned out, after evaluation of test operation			・Understanding of the function and electrical technology is necessary. ・There may be situations when nobody other than the supplier can handle.
D16	Shall be clarified when planned out, after evaluation of test operation				Shall be clarified when planned out, after evaluation of test operation		Shall be clarified when planned out, after evaluation of test operation			-
DM1	・Well drilling 5mill. Yen ・Facilities 500 thousand yen ・Setting of pump 300 thousand Total 5.8 million yen	30%	7.54mill. Yen	Construction fee of the South west project	6.1	・Stated in Interim Rep. ・Consideration of pump renewal cost ・10Litter/day/person	840,000Ar	Including pump renewal cost	・Commodities such as packing ・Allowance to the repair man	・Exchange of the commodities is possible in the residents' level. ・If there is need to raise the pump and check the function, personnel who is used to handling with the repair works is needed. ・There is need to establish pump repair man system and commodities sales shop.
DM2	Shall be clarified when planned out, after evaluation of test operation				Shall be clarified when planned out, after evaluation of test operation		Shall be clarified when planned out, after evaluation of test operation			・If the supervising bodies are clear, removal of residuals in the ponds are simple tasks and possible for the residents to do so.
P1	Shall be clarified when planned out, after evaluation of test operation				Shall be clarified when planned out, after evaluation of test operation		Shall be clarified when planned out, after evaluation of test operation			Difficult because it's not common in the country.
P2	Shall be clarified when planned out, after evaluation of test operation				Shall be clarified when planned out, after evaluation of test operation		Shall be clarified when planned out, after evaluation of test operation			Difficult because it's not common in the country.
L1	NA	NA	NA	NA	NA	NA	NA	NA	NA	If the supply amount is enough there should be no problem.
L2	NA	NA	NA	NA	NA	NA	NA	NA	NA	Difficulty is high unless penalty is applied.
L3	NA	NA	NA	NA	NA	NA	NA	NA	NA	Difficulty is high unless penalty is applied.
L4	NA	NA	NA	NA	NA	NA	NA	NA	NA	Since there is close relationship between the sales custom and the utilization, the difficulty is high if the water sellers do not increase.
L5	NA	NA	NA	NA	NA	NA	NA	NA	NA	Depending on the political power of the government

Table 8.2.1-2 List of Water Supply Systems In The Study Area(3/3): Evaluation

No.	Comments from the study team			Status of Madagascar side				Japan's cooperation						Construction	Environmental
	Advantages	Disadvantages	Others	Resp. Org.	Autonom.	Sustain.	Urgency	Priority	loan	grant	tech. corp..	Grass root	NGO	Duration	Impacts
D1	Operational costs for the water supply facility is the most economical since the water source (F015) is close to the target water supply area of urban Ambovombe. This plan should serve as an urgent improvement of water supply, and with the stable income source, reform of the AES shall be possible.	Water quality is at the level of the Madagascar standard of 3,020 S/m, so the water shall be utilized for domestic use only. SWL is 134m which is too deep to utilize solar power.	Organized management body is necessary. AES, Ambovombe local government or a financially independent new organization can be a candidate, but should make full use of the experience of AES. On the other hand, water selling at public faucet can be entrusted to private bodies.	AES	High	High	High	◎		○	○			1year	None in particular
D2	Using the JIRAMA commercial electricity bears lower costs and easier maintenance than the diesel generator method. Possible to urgently improve the domestic water supply utilizing the nearby water source(F015).	The capacity of the existing JIRAMA power station is 1,400kW/day which is short of the required capacity, and the power supply is unstable. Improvement of the current status is a necessity.	Negotiation with JIRAMA (Ambovombe) on improvement of power supply capacity is necessary, and assurance on stable power supply is needed through the implementing agency (MEM).	AES	High	High	High	◎		○	○			1year	None in particular
D3	It is possible to distribute domestic water to the coastal dune area where there is a shortage of drinking water. Possible to shorten the pipe length and distribute by the gravity force system.	Water quality is at the level of the Madagascar standard of 3,000 S/m, so the water shall be utilized for domestic use only. Revision of the well capacity (600m^3->300m^3) was needed due to evaluation of the groundwater potential.	Organized body such as AES is necessary to be the main management organization, but selling water at public faucet can be entrusted to private bodies or communes	AES	High	High	Medium	○	○	○				3years	Monitoring on water quality
D4	Possible to supply stable and good quality water to Ambovombe and the coastal areas. With the introduction of solar pumping system, fuel cost should be minimized. Co-financing with the African Development Bank (BAD) is possible for the construction of the water supply system in the coastal area.	Few or more years are needed for construction, thus not suited for urgent improvement. Phasing of construction period is necessary. Solar energy is clean but the operational hours are restricted to 6 hours and the capacity is limited to 100m^3/day/facility.	Organized body such as AES is necessary to be the main management organization, but selling water at public faucet can be entrusted to private bodies or communes	AES	High	High	Medium	○	○	○				5years	Consideration to the vegetation in the areas of the pipeline and the water rights of the water source area.
D5	Possible to supply stable and good quality water to Ambovombe and the coastal areas. The diesel generating method makes it possible to control the operational hours to obtain the necessary pumping rate.	Few or more years are needed for construction, thus not suited for urgent improvement. Phasing of construction period is necessary. The price of diesel as the fuel of power source is soaring to Ar1,740/L=Yen102.3/L.	Organized body such as AES is necessary to be the main management organization, but selling water at public faucet can be entrusted to private bodies or communes	AES	High	High	Medium	○	○	○				5years	Consideration to the vegetation in the areas of the pipeline and the water rights of the water source area.
D6	Possible to supply stable, good quality drinking water to Ambovombe and the villages along the pipeline.By using the gravity force, able to supply water effectively . With the stable income, improvement of the operational management system of AES shall be possible.	Distribution pipeline extending 62km is needed since the water source is situated far from the supply area.	Organized body such as AES is necessary to be the main management organization, but selling water at public faucet can be entrusted to private bodies or communes	AES	High	High	High	◎	○	○				3years	Consideration to the vegetation in the areas of the pipeline and the water rights of the water source area.
D7	･There is almost no need for maintenance fee except for repair works.	･If the cracks occur as a whole, complete repair works for the leaks shall be very difficult. ･There is need to secure company for repair works. ･The implementing agency is reluctant on this scheme because of fears of sanitary problems. ･Does not function during droughts, and this occurs often.	･This plan does not match the needs of the executing agency, thus consideration of the Japan's policy is necessary. ･In theory, repair works of every 15 years can be conducted with affordable water price. ･However, once the payment is fallen into arrears, the repair cost is too expensive to be done.	Fokontany	Middle	Low	Middle	Middle		△	○	○	○	3mths /impluvium	Land acquiring of 50m x 50m
D8	･The number of user will be limited and shall be easy to maintain. ･Ground level tank shall make repair works to be easier.	･Unable to balance the number of users and usable amount.	･Already constructed in most of the facilities, and the NGOs are already in implementation ･In theory, repair works of every 15 years can be conducted with affordable water price.	Fokontany	Middle	Low	Low	Low			○	○	○	1mth /impluvium	None in particular
D9	･The distance from the water source shall be minimum in the rainy season for the people. ･Managing responsibility shall be clear.	･Those non self-reliant shall be abandoned.	･The project shall not be standard one since the program is targeted to individuals. ･In theory, repair works of every 15 years can be conducted with affordable water price. ･The situation is the same all over the southern region, thus there might be feelings of unfairness if the program is targeted to individuals. ･It depends on the intension of the users, but replacement of new one shall be few.	Fokontany	Middle	Low	Middle	Low			○	○	○	Half mth /impluvium	None in particular
D10	･Some of the impurities will be removed, since the water will be stored in sealed underground. ･Plastics instead of concrete shall be main structural materials. ･Hard to be worn out since it's built underground.	･Cannot be repaired. ･Because the water does not percolate but rather be induced, the function must be checked beforehand.	･Has to be constructed on Japanese experience.	Fokontany	Middle	Low	Middle	Low		○	○	○	○	mth/impluviu	None in particular
D11	Already in market, thus no activity is needed other than to residents.	At public water tanks it is necessary to continuously add chemicals to maintain the hygienic condition, thus there is a lot of waste. Also, even if theoretically proven that there is no health problem, there still leaves some doubt.	･There is doubt if it meets the residents' needs .･Further study on by-products such as tri-halo methane is needed.	M. of Health / Local government	Low	Low	Low	Low			○	○	○	1-2 years	None in particular
D12	･No construction works. ･Enables long term preservation of water.	･The amount consumed should be limited since its costly. ･Market is not yet set up, thus, distribution system is needed to be established.	･There is doubt if it meets the needs of the residents. ･Enables long time preservations of water, however because it's costly this is only for emergency use. ･Desirable to use with the cheaper EauSur	M. of Health / Local government	Low	Low	Low	Low			○	○	○	1-2 years	None in particular
D13	･No construction cost occurs. ･In areas where demand prediction is difficult, it enables to respond to the demands not secured.	･Fuel fee is needed, thus it is costly compared to pipeline distribution as far as operational cost is concerned. ･Water service trucks renewal is needed.	･Transportation fees shall be cut by half since the transportation to and from Amboasary is lessened. ･Unless the truck renewal plan is submitted from the Madagascar Gov., the same shall be repeated.	AES	Low	Low	Low	Low		○				Set with the pipeline	None in particular
D14	･O & M cost is minimum.	･At present there is no parts shop nor repair man system, thus establishment is needed. ･Salinity is high with EC above 3,000μS/m.	･O & M is the most sure, but coverage area is small, and most of the area is out of coverage.	MEM	Middle	Middle	High	Middle		△		○	○	2Weeks/se	None in particular
D15	･Possible to secure water at the supply targets.	･Necessary to change the filter, and commodity cost is required. ･Electricity cost is required. ･Not distributed in Madagascar, thus any trouble occurs must seek overseas.	･Although there are suppliers who say its free of maintenance, the fact that its not in general use states that it is difficult to be in operation.	AES	Low	Low	Low	Low					○	Few years	None in particular
D16	･No need for new facilities. ･Definitely able to disinfect.	･Hard to secure fuel since vegetation is scarce. ･Danger of expanding forest logging to secure fuel.	･Important to secure tree plantation.	Ministry of Health	Low	Low	Low	Low					○	Long term	Tree logging
DM1	･O & M cost is cheap. ･No more need to go down the sea cliffs.	･At present there is no parts shop nor repair man system, thus establishment is needed. ･Too high salinity to use for drinking. ･Depends on person's liking, it might not be used.	･Need to conduct few pilot projects and see how much it is needed. ･This alternative can be applied to the Tulear District also.	MEM/AES	Middle	Middle	Middle	Low				○	○	2Weeks /set	None in particular
DM2	･O & M cost is cheap.	･Used by cattle, so hygienic usage is not possible.	･The cattle move for their food as well, so they move if their food is run out, even if the water is there ･Unable to keep hygienic state, thus necessity is low. ･Prevention of leaks is unclear thus experiments are needed.	Commune /Residents	High	Middle	Low	Low				○	○	Few mths /set	Vegetation degradation
P1	The potential of wind power is high.	Wind pumping has already been implemented for the shallow aquifers in the 1970s, but there are none that is still working.	There is no record of wind power generation in the district, but the potential in the coastal area is high, and since the machine effectiveness has been improved, there are rumors that of plans in the area.	AES/MEM	Low	Middle	Low	Low			○			One year	Renewable clean energy
P2	There is potential of Micro hydropower using the GFS water flow.	･There is no other micro hydropower system in the country, thus there is uncertainty on the maintenance and operation. ･Construction of the pipeline is necessary	The power potential assuming the GFS from Antanimora and Ambovombe with the line length 62km, altitude difference 150m, pipe diameter 300mm, distribution flow rate 66m3/hr can be calculated as:Pth=9.8ｘ0.0183m3/sｘ(150-5)＝２６kW	AES/MEM	Low	Low	Low	Low			○			One year	Renewable clean energy
L1	The rate of the poor acquiring the water shall increase.	･The demand which has been suppressed due to high cost might burst, and the supply plan might have to be reexamined if it succeeds. ･The motivation of the water sellers might go down which will disbenefit the residents as a result.	･Supply system exceeding the demand is a necessity.	District	Middle	Low	Low	Low			○		○	1year	None
L2	･Able to upgrade the quality of drinking water.	･For the residents, many work shall occur, so recognition of necessity is needed. ･Some construction occur, so cost is borne.	It would be difficult for the residents to accept the administrative guidance unless there is penalty.	District	Low	Low	Low	Low			○		○	1year	None
L3	･Enables to manage the sustainability of the groundwater source.	･There are some residents who disbenefit from the regulation.	･Site location control shall be the main issue. ･It would be difficult for the residents to accept the administrative guidance unless there is penalty.	District	Middle	Middle	High	High			○			1year	None
L4	･Minimize the facility construction which the initial cost is high, and exclude the causes of raising the O & M costs. ･Increase of employment opportunity.	･Doesn't congruent with the traditional way of usage of bull-carts. ･Water sellers become active as the cost of water rises. Therefore, inhibition of the water price and organization of water sellers is a conflicting issue.	It would be difficult for the residents to accept the administrative guidance unless there is penalty.	District	Middle	Middle	Low	Low			○		○	1year	None
L5	Decrease the wasteful spending, and lower the sustainable cost break point.	None	･Even at this point of time when the involved parties recognize that the political intervention should be cleared out this cannot be realized.	MEM	Middle	High	High	Middle			○			Few years	None

Table 8.2.1-3 Water Supply Alternative Plan 1/25

ID	D1	Category of Plan : Facility Level 2 type	
Implementation	Emergency = 1 Year (2007)		
Water source	Ambovombe east part	Type of water source	Groundwater (F015)
Target area	Ambovombe residents 23,000 +surroundings=40,000	Population in 2015	40,000
Main goal	The urgent domestic non-commercial water supply to the Ambovombe citizen		
Others	Diesel power generator (Fuel economies type)		
Water supply plan	2 Deep well(8”、Depth 150m、Capacit300m^3/d) Water supply facility (Submersible pump, Generator, Ground level water tank 300m^3, Urban pipeline10km、Public Faucet 20)		
Construction cost	Direct construction cost Overhead	¥130,000,000	¥3,250
	Total	¥130,000,000	¥3,250
Management cost (Ar/bucket)	Running cost Maintenance cost Update expenses Reserve fund	20.0 5.0 5.0	Detail at the Table 8.2.1-2
	Total	30.0	
The minimum water fee	Update expense preparation	It includes.	It doesn't include.
(Ar/ bucket)	Metered rate	Ar30.0-	Ar25.0-
(Ar/month/family)	Period	-	-
Construction period	1 year		
Degree of difficulty of the maintenance management	Ordinariness		
Maintenance management system	Management organization	AES/AEP	
	Maintenance organization	AES/AEP	
	It is necessary to review about the organization improvement, too.		
Gathers Advantage:	-Operational costs for the water supply facility is the most economical since the water source (F015) is close to the target water supply area of urban Ambovombe. -This plan should serve as an urgent improvement of water supply. - This plan achieve a stable income source, reform of the AES shall be possible.		
Disadvantage:	-Water shall be utilized for domestic use only, need safe and stable water.		
Constrain	-Water quality is at the level of the Madagascar standard of 3,020 S/m. -SWL is 134m which is too deep to utilize solar power. -Organized management body is necessary. AES, Ambovombe local government or a financially independent new organization can be a candidate.		
Environmental Impacts	None in particular		
Others	It is possible for there to be completeness and to set urgently.		

Table 8.2.1-3 Water Supply Alternative Plan

ID	D2	Category of Plan : Facility	
Implementation	Emergency = 1 Year (2007)	Level 2 type	
Water source	Ambovombe east part	Type of water source	Groundwater (F015)
Target area	Ambovombe residents 23,000 +surroundings=40,000; Water supply quantity 10L/d/person (400m^3/d)	Population in 2015	40,000
Main goal	The domestic water supply to the citizen		
Others	JIRAMA Commercial electricity method (but, current capacity of power is not enough)(*)		
Water supply plan	-2 Deep well(8”、Depth 150m、Capacit300m^3/d) -Water supply facility (Submersible pump, Generator, Ground level water tank 300m^3, Urban pipeline10km、Public Faucet 20)		
Construction cost	Direct construction cost	¥130,000,000	¥3,250
	Overhead		
	Total	¥130,000,000	¥3,250
Management cost (Ar/month)	Running cost (Each of the facilities 30 persons) Maintenance cost Update expenses Reserve fund		Detail at the Table 8.2.1-2
	Total	18.5	
The minimum water fee	Update expense preparation	It includes.	It doesn't include.
(Ar/ bucket)	Metered rate	20.0Ar-	15.0Ar-
(Ar/month/family)	Period		
Construction period	1 year		
Degree of difficulty of the maintenance management	Ordinariness		
Maintenance management system	Management organzation	AES/AEP	
	Maintenance organzation	AES/AEP	
	-With the regular water fee income, it is possible to improve the management system of AES of the present situation, too.		
Gathers Advantage:	-This plan should serve as an urgent improvement of water supply. - This plan achieve a stable income source, reform of the AES shall be possible.		
Disadvantage:	-The capacity of the existing JIRAMA power station is 1,400kW/day which is short of the required capacity, and the power supply is unstable.(*) -Water shall be utilized for domestic use only, need safe and stable water.		
Constrain	-Negotiation with JIRAMA (Ambovombe) on improvement of power supply capacity is necessary.(*) -Water quality is at the level of the Madagascar standard of 3,020 S/m.		
Environmental Impacts	None in particular		
Others	-It is possible for there to be completeness and to set urgently. -Power supply option is utilization of JIRAMA commercial and diesel gneration. (*) -the switchover to D2 or the use type is proper from the plan of D1		

Table 8.2.1-3 Water Supply Alternative Plan

ID	D3	Category of Plan : Facility	
Implementation	Short-Term(2008-2010)	Level 2 type	
Water source	Ambovombe eastern part	Type of water source	Groundwater (F015)
Target area	Village at the seashore dune band	Population in 2015	179,000
Main goal	The domestic water supply to coastal area utilizing water source at the outskirts of Ambovombe		
Others	Diesel generator method		
Water supply plan	-5 deep well(8”、Depth 150m、Capacity 300m^3/day) -Water supply facility (Submersible pump, Generator, Ground level type collection water tank 200m^3, Booster pump, Ground level type water tank 100m^3, Distribution tank 600m^3, 100m^3, 50m^3, Transmission pipeline 6km、Distribution pipeline 52km、Public faucet 36、PE pipe materials 20km) -If, as a result of groundwater simulation the well capacity is proved to be reasonable, then 5 wells are needed.		
Construction cost	Direct construction cost (Each of the facilities 30 persons) Overhead	¥1,100,000,000	¥6,145
	Total	¥1,100,000,000	¥6,145
Management cost (million Ar/month)	Running cost Maintenance cost Update expenses Reserve fund		Detail at the Table 8.2.1-2
	Total	27.7	
The minimum water fee	Update expense preparation	It includes.	It doesn't include.
(Ar/ bucket)	Metered rate	30.0Ar-	25.0Ar-
(Ar/month/family)	Period		
Construction period	2～3 year		
Degree of difficulty of the maintenance management	It rather is a difficulty.		
Maintenance management system	Management organization	AES/AEP	
	Maintenance organization	AES/AEP	
	Because the soaring of fuel is moving ahead, the running cost tends to become expensive.		
Gathers Advantage:	-It is possible to distribute domestic water to the coastal dune area where There is a shortage of drinking water. possible to shorten the pipe length and distribute by the gravity force system.		
Disadvantage:	-Water quality is at the level of the Madagascar standard of 3,000 S/m, so the water shall be utilized for domestic use only. -Revision of the well capacity (600m3->300m3) was needed due to evaluation of the groundwater potential.		
Constrain	-Water quality is at the level of the Madagascar standard of 3,020 S/m.		
Environmental Impacts			
Others	-Monitoring on water quality -There is possibility of the cooperation support with Africa development bank, too.		

Table 8.2.1-3 Water Supply Alternative Plan 4/25

ID	D4	Category of Plan : Facility	
Implementation	(Emergency,Short-Term,Middle-Term)	Pipeline + Level 2 type	
Water source	Antanimora southern part	Type of water source	Groundwater (F006B)
Target area	Ambovombe urban and the seashore dune band	Population in 2015	206,500
Main goal	Water supply to the village and the citizen in Antanimora to Ambovombe and the coastal dune area.		
Others	Solar pumping system 4sets + Diesel pumping system 2sets		
Water supply plan	-6 Deep well (6”, Depth 65m, Capacity 600m^3/d/well, Solar pumping capacity100m^3/day) -Gravity force pipeline system (Antanimora - Ambovombe, Ambovombe - Antanimora) -Water supply facility (Elevated water tank 50m3, Ground level type collection water tank 300m^{3}x2 800m^3, Distribution tank 50m^{3}x4, 100m^{3}x5, Public Faucet 20)		
Power source	-Diesel pumping system (2sets 600m3/d/well x 2wells -Solar pumping system (4sets 100m3/d/well x 4 wells		
Construction cost	Direct construction cost (Each of the facilities 30 persons) Overhead	¥2,300,000,000	¥11,138.000
	Total	¥2,300,000,000	¥11,138.000
Management cost (Ar/month)	Running cost Maintenance cost Update expenses Reserve fund		Detail at the Table 8.2.1-2
	Total	40.4	
The minimum water fee	Update expense preparation	It includes.	It doesn't include.
(Ar/ bucket)	Metered rate	20.0-	15.0-
(Ar/month/family)	Period		
Construction period	2〜3 year		
Degree of difficulty of the maintenance management	Ordinariness		
Maintenance management system	Management organization	AES/AEP	
	Maintenance organization	AES/AEP	
	Reduction of operation cost is achieved by introduction of solar pumping system.		
Gathers Advantage:	-Possible to supply stable and good quality water to Ambovombe and the coastal areas. -With the regular water fee income, it is possible to improve the management system of AES of the present situation, too.		
Disadvantage:	-Few or more years are needed for construction, thus not suited for urgent improvement.		
Constrain	-Gravity feeding system is efficient, but it requires large amount of investment due to length (120km)		
Environmental Impacts	None in particular		
Others	-Water supply system which the enforcement organization wants most The drinking water supply which was stable to the seashore dune band -Co-financing with the African Development Bank (BAD) is possible for the construction of the water supply system in the coastal area.		

Table 8.2.1-3 Water Supply Alternative Plan 5/25

ID	D5	Category of Plan : Facility	
Implementation	(Emergency,Short-Term,Middle-Term	Pipeline + Level 2 type	
Water source	Antanimora southern part	Type of water source	Groundwater (F001,F006B)
Target area	Ambovombe city and the seashore dune band	Population in 2015	206,500
Main goal	Drinking water supply to the Ambovombe citizen and the seashore village		
Others	Diesel pumping system		
Water supply plan	- 3 deep wells, (6”, depth 65m, capacity 600m^3) - Water supply facility (Elevated water tank 50m^3, Ground level type collection water tank 300m^{3}x2 800m^3, Distribution tank 50m^{3}x4, 100m^{3}x5, Public Faucet 20)		
Power source	-Diesel pumping system (2sets 600m3/d/well x 3wells 1,800m3/d		
Construction cost	Direct construction cost (Each of the facilities 30 persons) Overhead	¥2,300,000,000	¥11,138
	Total	¥2,300,000,000	¥11,138
Management cost (Ar/month)	Running cost Maintenance cost Update expenses Reserve fund Total	48.5	Detail at the Table 8.2.1-2
The minimum water fee	Update expense preparation	It includes.	It doesn't include.
(Ar/ bucket)	Metered rate	30.0-	25.0-
(Ar/month/family)	Period		
Construction period	2～3 year		
Degree of difficulty of the maintenance management	Ordinariness		
Maintenance management system	Management organization	AES/AEP	
	Maintenance organization	AES/AEP	
	The running cost tends to become expensive due to disel generation power,but, operation can be efficient minimizing number of water source.		
Gathers Advantage:	-possible to supply stable and good quality water to Ambovombe and the coastal areas. the diesel generating method makes It possible to control the Operational hours to obtain the necessary pumping rate. -With the regular water fee income, it is possible to improve the management system of AES of the present situation, too.		
Disadvantage:	-Few or more years are needed for construction, thus not suited for urgent improvement. -Phasing of construction period is necessary.		
Constrain	-Gravity feeding system is efficient, but it requires large amount of investment due to length (120km)		
Environmental Impacts	None in particular		
Others	-It is the watering system which the enforcement organization wants most.It is putting expansion into the seashore dune band, too, in view. -Co-financing with the African Development Bank (BAD) is possible for the construction of the water supply system in the coastal area.		

Table 8.2.1-3 Water Supply Alternative Plan

ID	D6	Category of Plan : Facility	
Implementation	Short-Term(2008-2010)	Pipeline + Level 2 type	
Water source	Antanimora southern part	Type of water source	Groundwater (F006B)
Target area	Antanimora southern part- Ambovombe city	Population in 2015	84,500
Main goal	Drinking water supply to the citizen of Ambovombe and the village		
Type of the facilities	Diesel pumping system		
Water supply plan	-2 Deep wells (8", Depth 63m, Diesel powered pumping capacity 600m3/day/well) -Gravity force pipeline system (Ambovombe - Antanimora L=63km) -Water supply facility (elevated control water tank 100+150m^3,Distribution tank 100m^{3}x5, Urban pipeline system 10km、 Distribution line 10km、Public faucet 20)		
Power source	-Diesel pumping system (2sets 600m3/d/well x 3wells 1,800m3/d		
Construction cost	Direct construction cost (Each of the facilities 30 persons) Overhead	¥1,300,000,000	¥15,300
	Total	¥1,300,000,000	¥15,300
Management cost (Ar/month)	Running cost Maintenance cost Update expenses Reserve fund Total	32.3	Detail at the Table 8.2.1-2
The minimum water fee	Update expense preparation	It includes.	It doesn't include.
(Ar/ bucket)	Metered rate	30.0-	25.0-
(Ar/month/family)	Period		
Construction period	2〜3 year		
Degree of difficulty of the maintenance management	Ordinariness		
Maintenance management system	Management organization	AES/AEP	
	Maintenance organization	AES/AEP	
	The working which put the improvement of the management maintenance control system of AES in view is possible.		
Gathers Advantage:	-Possible to supply stable, good quality drinking water to Ambovombe and the villages along the pipeline. By using the gravity force, able to supply water effectively . With the stable income, improvement of the operational management system of AES shall be possible.		
Disadvantage:	-Distribution pipeline extending 62km is long enough to escalate construction cost.		
Constrain	-System is the most effecient, but pipeline is long to escalate construction cost then financial assistance is required. -Operating system is simple but, diesel generation system costs high for running system.		
Environmental Impacts	None in particular		
Others	-watering facilities are the handiest and are efficient but need compatible with cost of fuel.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D7	Category of Plan : Facility	
Implementation	-	Impluvium 1 Public, large scale	
Water source	Rainwater	Source of water	The rainfall
Target area	281 Fokontanys without wells or existing impluviums	Population in 2015	281village=about 140,000
Main goal	Improve the water supply in rainy season + 1 month (Total 5 months).		
Others	Fokontany level: Water collection area 1,000m^2, Tank volume 120m^3		
Water supply plan			
Construction cost	Direct construction cost Overhead	¥10,000,000 ¥3,000,000	30% of direct cost
	Total	¥13,000,000	
Management cost par year	Detail shall be referred at table 8.2.1-2	¥163,000	
	Total	¥163,000	
The minimum water fee	Metered rate (Ar/bucket) Period	100 n.d.	
Construction period	4 months		
Degree of difficulty of the maintenance management	Maintenance of the daily life is simple but as for the repair of the water tank, the degree of difficulty is high.		
Maintenance management system	Management organization	CPE/Fokontany	
	Maintenance organization	CPE/Fokontany	
	O & M Difficulty	･Difficulty is high. It is hard to completely stop the leakage even after the repair. In this case, the contractor cannot correspond for the re-repaire. It is highly possible that the advance payment will be wasted. ･It is top priority to organize the construction contractor who can deal with full responsibility, but difficult to organize considering the area's capability	
Gathers Advantage:	･There is almost no need for maintenance fee except for repair works.		
Disadvantage:	･If the cracks occur as a whole, complete repair works for the leaks shall be very difficult. ･There is need to secure company for repair works. ･The implementing agency is reluctant on this scheme because of fears of sanitary problems. ･Does not function during droughts, and this occurs often.		
Constrain	･This plan does not match the needs of the executing agency, thus consideration of the Japan's policy is necessary. ･In theory, repair works of every 15 years can be conducted with affordable water price. ･However, once the payment is fallen into arrears, the repair cost is too expensive to be done.		
Priority	low	When there is not the source of water	
Environmental Impacts	The agricultural land in the sloping ground must be requisitioned at some area.		
Others	･ The exception area is an area within 10 km, the area where there is a groundwater source from the pipeline. It depends and the inland area, Anlamary, the eastern region become priority. ･ It selects a priority area for the final goal to get to become number facilities to 1 Fokontany but for the number of the construction to become enormous and it constructs it.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D8	Category of Plan : Facility	
Implementation	-	Impluvium 2 Public	
Water source	Rain water	Source of water	The rainfall
Target area	It excludes the area where there is a groundwater source.	Population in 2015	500 person / 1 system
Main goal	It improves watering only in the rainy season when the source of water which can be used over year-round can not be secured. +1 months of the rainy seasons (5 months in amount)		
Others	A 10m^3 volume tank using the roof of public facilities. Water collection area 100m^2.		
Water supply plan			
Construction cost	Direct construction cost	¥1,000,000	
	Overhead	¥300,000	30% of direct cost
	Total	¥1,300,000	
Management cost	Maintenance cost Detail shall be referred at table 8.2.1-2	¥65,000	(5% of construction cost)
	Total	¥65,000	
The minimum water fee	Metered rate (Ar/bucket)	83Ar	
	Period	n.d.	
Construction period	2 months		
Degree of difficulty of the maintenance management	Maintenance of the daily life is simple but as for the repair of the tank, the degree of difficulty is high.		
Maintenance management system	Management organization	CPE/Fokontany	
	Maintenance organization	CPE / Fokontany, Virtually private own	
	O & M Difficulty	・It might be hard completely stop the leaks, however because the water tank is at the ground level, many other treatments can be taken.	
Gathers Advantage:	・The number of user will be limited and shall be easy to maintain. ・Ground level tank shall make repair works to be easier.		
Disadvantage:	・Unable to balance the number of users and usable amount.		
Constrain	・Already constructed in most of the facilities, and the NGOs are already in implementation ・In theory, repair works of every 15 years can be conducted with affordable water price. ・It is top priority to organize the construction contractor who can deal with full responsibility which, actually, shall be difficult.		
Priority	low.	When there is not the source of water	
Environmental Impacts	None in particular		
Others	・ It is necessary to select for the facilities which are easy to construct most for the NGO immediately before the construction candidate site implementation. ・ Because the possibility that the other organization constructs oppositely is high, the necessity to implement specially as the Japan support is low.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D9	Category of Plan : Facility	
Implementation		Impluvium 3,small scale	
Water source	Rainwater	Source of water	The rainfall
Target area	It excludes the area where there is a groundwater source.	Population in 2015	2-3 family / 1 system
Main goal	It improves watering only in the rainy season when the source of water which can be used over year-round can not be secured. +1 months of the rainy seasons (5 months in amount)		
Others	Water collection area of the private roof: 50m2, tank volume 5m3. Includes improvement of the roof		
Water supply plan			
Construction cost	Direct construction cost	¥500,000	
	Overhead	¥150,000	30% of direct cost
	Total	¥650,000	
Management cost pay year	Maintenance cost (10%) Detail shall be referred at table 8.2.1-2	¥32,500	(5% of construction cost)
	Total	¥32,500	
The minimum water fee	Metered rate (Ar/bucket)	83	
	Period	n.d.	
Construction period	2 weeks		
Degree of difficulty of the maintenance management	Because the maintenance of the daily life is simple but is strong in the wind of the salinity implication, the repair of the roof material and the gutter occurs frequently.		
Maintenance management system	Management organization	CPE/indivisual	
	Maintenance organization	CPE/indivisual	
	O & M Difficulty	･Transportation of the tank from the seller may cause trouble, but it is not a technical difficulty.	
Gathers Advantage:	･The distance from the water source shall be minimum in the rainy season for the people. ･Managing responsibility shall be clear.		
Disadvantage:	･Those non self-reliant shall be abandoned.		
Constrain	･The project shall not be standard one since the program is targeted to individuals. ･In theory, repair works of every 15 years can be conducted with affordable water price. ･The situation is the same all over the southern region, thus there might be feelings of unfairness if the program is targeted to individuals. ･It depends on the intension of the users, but replacement of new one shall be few.		
Priority	low	When there is not the source of water	
Environmental Impacts	None in particular		
Others	There are a way of making the colony which is composed of number family equal to or more than for some purpose priority by the tendency every family and so on in the forming of a colony.		

Table 8.2.1-3 Water Supply Alternative Plan

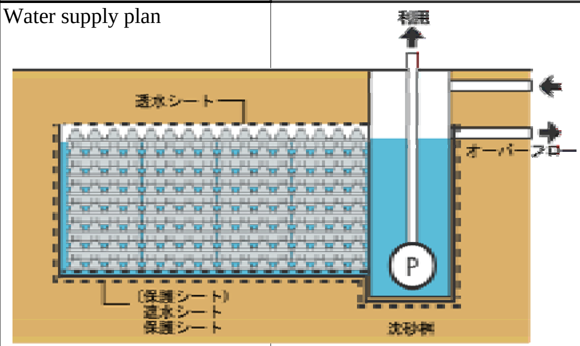
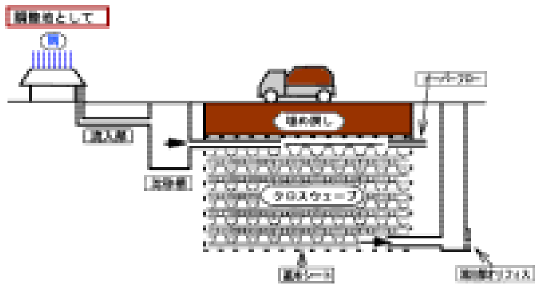
ID:	D10	Category of Plan : Facility	
Implementation	-	Impluvium 4,Public, large	
Water source	Rainwater	Source of water	The rainfall
Target area	It excludes the area where there is a groundwater source. 281 Impluvium, Fokontany	Population in 2015	1 system / 1 fokontany
Main goal	It improves watering only in the rainy season when the source of water which can be used over year-round can not be secured. +1 months of the rainy seasons (5 months in amount)		
Water supply facility	･Construct water storage space underground, and store rainwater. ･Many systems are constructed in school yards in Japan. ･Water collection area 1,00m2, water storage tank 120m3.		
Water supply plan			
Construction cost	Direct construction cost	¥10,000,000	
	Overhead	¥3,000,000	30% of direct cost
	Total	¥13,000,000	
Management cost pay year	Maintenance cost Detail shall be referred at table 8.2.1-2		
The minimum water fee	Metered rate (Ar/bucket)	32	
	Period	n.d.	
Construction period	4 months		
Degree of difficulty of the maintenance management	･ It is impossible to repair.		
Maintenance management system	Management organization	CPE/Fokontany	
	Maintenance organization	CPE/Fokontany	
	O & M Difficulty		
Gathers Advantage:	･Some of the impurities will be removed, since the water will be stored in sealed underground.		
Disadvantage:	･Cannot be repaired.		
Constrain	･Has to be constructed on Japanese experience. ･Because the water does not percolate but rather be induced, the function must be checked beforehand.		
Priority	low	When there is not the source of water	
Environmental Impacts	The site must be requisitioned at some area.		
Others			

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D11	Category of Plan : Soft	
Implementation	-	Hygiene education using sterilization drug	
Water source	All water	Source of water	All the source of water
Target area	It excludes the area where there is a groundwater source.	Population in 2015	232.000
Main goal	Sanitation education by the sterilization which used equal Sur eau		
Others	Distribution of sterilization drug like Sur Eau and establishiment of network to sell		
Water supply plan			
Construction cost	Purchasing cost	9000Ar（500yen）	annual expenses / family
	Total	9000Ar（500yen）	
Management cost (dix mille yen par mois)	Purchasing cost Detail shall be referred at table 8.2.1-2	9000Ar（500yen）	annual expenses / family
	Total	9000Ar（500yen）	
The minimum water fee	Metered rate (Ar/seau)	n.d.	
	Period	n.d.	
Construction period	-		
Degree of difficulty of the maintenance management	Difficile		
Maintenance management system	Management organzation	Beneficiary	
	Maintenance organzation	Beneficiary	
	O & M Difficulty	･It already exists in market and is easy to purchase.	
Gathers Advantage:	It already exists in market, thus no activity is needed other than to residents.		
Disadvantage:	-		
Constrain:	･There is doubt if it meets the residents' needs ･Further study on by-products such as tri-halo methane is needed.		
Priority	low	When there is not the source of water	
Environmental Impacts	None in particular		
Others	-Because the problem in this area is that there is not water itself, not being the pollution of water, it is different from the needs of the resident.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D12	Category of Plan : Soft	
Implementation	-	Hygiene education on sterilization / antiseptic	
Water source	Rainwater storage of tank	Source of water	All the source of water
Target area	It excludes the area where there is a groundwater source.	Population in 2015	232,000
Main goal	Water rot prevention and the sanitation education		
Others	・The distribution of the sterilization drug and the service of the sales network ・The sanitation education guide		
Water supply plan			
Construction cost	Purchasing cost	882000Ar(49,000Yen)	annual expenses / family
	Total	882000Ar(49,000Yen)	
Management cost	Purchasing cost Detail shall be referred at table 8.2.1-2	882000Ar(49,000Yen) 0	annual expenses / family
	Total	882000Ar(49,000Yen)	
The minimum water fee	Metered rate (Ar/seau)	n.d.	
	Period	n.d.	
Construction period	-		
Degree of difficulty of the maintenance management			
Maintenance management system	Management organzation	Beneficiary	
	Maintenance organzation	Beneficiary	
	O & M Difficulty	・Since not yet in market, first thing needed is to set market system. ・Expensive	
Gathers Advantage:	・No construction works.		
Disadvantage:	・The amount consumed should be limited since its costly.		
Constrain	・There is doubt if it meets the needs of the residents. ・Enables long time preservations of water, however because it's costly this is only for emergency use. ・Desirable to use with the cheaper SurEau		
Priority	low	When there is not the source of water	
Environmental Impacts	-		
Others	-Because the problem in this area is that there is not water itself, not being the pollution of water, it is different from the needs of the resident.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D13	Category of Plan : Purchasing equipment	
Implementation	-	Water track	
Water source	Groundwater	Source of water	Water that raw water transmission was done with the pipeline
Target area	It excludes the area where there is a groundwater source.	Population in 2015	t is the benefit of 200 family (two cups of buckets) in one 6m3.
Main goal	・It changes to the system the source of water of which was Ambovombe from Ambossary. ・The watering to the area which left a pipeline		
Ohers	･Change the system of water source from Ambossary to Ambovombe. ･Procurement of 6m3 water service truck.		
Water supply plan			
Construction cost	Direct construction cost Overhead	¥6,600,000 ¥1,980,000	$6m^3$ water tank truck 30% of diect cost
	Total	¥8,580,000	
Management cost	Maintenance cost Detail shall be referred at table 8.2.1-2		
The minimum water fee	Metered rate (Ar/seau) Period	233 Ar n.d.	
Construction period	6 months		
Degree of difficulty of the maintenance management	･Repair works is already undergone thus possible.		
Maintenance management system	Management organzation	AES	
	Maintenance organzation	AES	
	O & M Difficulty		
Gathers Advantage:	･No construction cost occurs. ･In areas where demand prediction is difficult, it enables to respond to the demands not secured. ･Transportation fees shall be cut by half since the transportation to and from Ambossary is lessened.		
Disadvantage:	･Fuel fee is needed, thus it is costly compared to pipeline distribution as far as operational cost is concerned. ･Water service trucks renewal is needed.		
Constrain	･Unless the truck renewal plan is submitted from the Madagascar Gov., the same shall be repeated. ･Construction of pipeline between Antanimora and Ambovombe is a prerequisite.		
Priority	low		
Environmental Impacts	None in particular		
Others	It is necessary to service a road, too, because the road condition leads to the car trouble badly.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D14	Category of Plan : Facility	
Implementation		Borehole equipped with hand pump	
Water source	Groundwater	Source of water	Groundwater
Target area	Western part of the study area (Antaritarika North, Imongy)	Population in 2015	16,000
Main goal	It constructs the source of water which year-round can be used for in the area where there is not the source of water.		
Water supply facility	･HPV100 with head water of 100m shall be set in villages having population over 100. Because of the limit of the head, these will be set in areas under 100m. ･110m well, supplementary facilities, establishment of pump accessories sales system, repair work system.		
Water supply plan			
Construction cost	Direct construction cost	¥5,800,000	
	Overhead	¥1,740,000	30% of direct cost
	Total	¥7,540,000	
Management cost	Maintenance cost Detail shall be referred at table 8.2.1-2	¥47,000	
	Total	¥47,000	
The minimum water fee	Metered rate (Ar/seau)	6.0Ar	
	Period	n.d.	
Construction period	2week / unit		
Degree of difficulty of the maintenance management	･Exchange of the commodities is possible in the residents' level.		
Maintenance management system	Management organization	CPE	
	Maintenance organization	AES/CPE	
	O & M Difficulty		
Gathers Advantage:	･O & M cost is minimum.		
Disadvantage:	･At present there is no parts shop nor repair man system, thus establishment is needed.		
Constrain	･Salinity is high with EC above 3,000 μS/m. ･O & M is the most sure, but coverage area is small, and most of the area is out of coverage.		
Priority	Middle		
Environmental Impacts	None in particular		
Others	･If there is need to raise the pump and check the function, personnel who is used to handling with the repair works is needed.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D15	Category of Plan : Facility	
Implementation		Desalination facility	
Water source	Groundwater with high salinity	Source of water	Groundwater
Target area	All the areas	Population in 2015	250,000
Main goal	It removes the salinity of water with high salinity and it makes an use in drink possible.		
Others	desalination facility, elevated water tank, public faucet, solar power source for pumps and desalination facility.		
Water supply plan			
Construction cost	Detail shall be referred at table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	-		
Degree of difficulty of the maintenance management	･Understanding of the function and electrical technology is necessary.		
Maintenance management system	Management organzation	AES/CPE	
	Maintenance organzation	AES/CPE	
	O & M Difficulty		
Gathers Advantage:	･Possible to secure water at the supply targets.		
Disadvantage:	･Necessary to change the filter, and commodity cost is required. ･Electricity cost is required.		
Constrain	･Not distributed in Madagascar, thus any trouble occurs must seek overseas. ･Although there are suppliers who say its free of maintenance, the fact that its not in general use states that it is difficult to be in operation.		
Priority	low		
Environmental Impacts	None in particular		
Others			

Table 8.2.1-3 Water Supply Alternative Plan

ID:	D16	Category of Plan : Soft	
Implementation		Hygiene education focusing boiling water	
Water source	It is the water which isn't hygienic.	Source of water	All water
Target area	All the areas	Population in 2015	230,000
Main goal	It does the popularization of the boiling as the safe drink securing.		
Others	Spread the boiling water method as a means of securing safe water.		
Water supply plan			
Construction cost	Detail shall be referred at table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	-		
Degree of difficulty of the maintenance management	Boiling water is one of daily activity.		
Maintenance management system	Management organization	Ministry of health	
	Maintenance organization	Ministry of health	
	O & M Difficulty	The securing of fuel becomes a problem.	
Gathers Advantage:	･No need for new facilities.		
Disadvantage:	･Hard to secure fuel since vegetation is scarce. ･Danger of expanding forest logging to secure fuel.		
Remark:	･Important to secure tree plantation.		
Priority	low		
Environmental Impacts	it connects with the felling of vegetation.		
Others	It isn't possible to promote in the being limit which doesn't have an aim about the supply and the influence over the environmental destruction for the securing of fuel to become a problem.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	DM1	Category of Plan : Facility	
Implementation		Handpupmp in the vicinity of Imongy	
Water source	Groundwater	Source of water	Groundwater
Water supply type	Handpupmp in the vicinity of Imongy		
Target area	To be limited to the area to the 100 m water level of the seaside and the eastern part, it assumes about 1/10 of the seaside population.	Population in 2015	16,000
Main goal	t expects water with degree of 000?S/cm from 000 EC3, to 10 and it constructs the source of water which year-round can be used for in the area where there is not the source of water.		
Water supply facility	Install manpower pumps able to pump 100m expecting EC3,000 to 10,000μS/cm. Target areas is limited to areas up to 100m above sea level, thus the areas are above the cliffs along the seashore or valleys between the sand dunes.		
Water supply plan			
Construction cost	Direct construction cost	¥5,800,000	
	Overhead	¥1,740,000	30% of direct cost
	Total	¥7,540,000	
Management cost	Maintenance cost Detail shall be referred at table 8.2.1-2	¥47,000	
	Total	¥47,000	
The minimum water fee	Metered rate (Ar/seau) Period	6.0Ar n.d.	
Construction period	2week / unit		
Degree of difficulty of the maintenance management	･Exchange of the commodities is possible in the residents' level.		
Maintenance management system	Management organization	CPE	
	Maintenance organization	AES/CPE	
	O & M Difficulty		
Gathers Advantage:	･O & M cost is cheap. ･No more need to go down the sea cliffs.		
Disadvantage:	･At present there is no parts shop nor repair man system, thus establishment is needed.		
Remark:	･Too high salinity to use for drinking. ･Need to conduct few pilot projects and see how much it is needed. ･This alternative can be applied to the Tulear District also.		
Priority	Middle		
Environmental Impacts	None in particular		
Others	To verify the utilization rate of the resident, it is necessary to construct on a trial basis at about 10 sites. As for making 10 sites, because the condition depends on the site, to make an installed base clear, the number of the degrees becomes necessary.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	DM2	Category of Plan : Facility	
Implementation		Construction of small reservoir	
Water source	Rainwater	Source of water	Rainwater
Target area	Seaside area	Population in 2015	16,000
Main goal	At the seaboard, it lacks even about livestock water for irrigation because a pond and a marsh aren't formed about the clearness, too, in the rainy season. It makes it possible to be and to store water as it sets up mud to the hollow, and so on.		
Others	Paste mud in the depression areas to enable to reserve water.		
Water supply plan			
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	-		
Degree of difficulty of the maintenance management	･If the supervising bodies are clear, removal of residuals in the ponds are simple tasks and possible for the residents to do so.		
Maintenance management system	Management organzation	CPE	
	Maintenance organzation	CPE	
	O & M Difficulty	The securing of clay becomes a problem about the construction, the maintenance.	
Gathers Advantage:	･O & M cost is cheap.		
Disadvantage:	･Used by cattle, so hygienic usage is not possible.		
Remark:	･Unable to keep hygienic state, thus necessity is low. ･Prevention of leaks is unclear thus experiments are needed.		
Priority	low		
Environmental Impacts	Vegetation degradation		
Others	To verify the utilization rate of the resident, it is necessary to construct on a trial basis at about 10 sites. As for making 10 sites, because the condition depends on the site, to make an installed base clear, the number of the degrees becomes necessary.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	P1	Category of Plan : Facility	
Implementation	-	Pumping system utilizing wind power generation	
Water source	-	Source of water	Groundwater
Target area	Seaside area	Population in 2015	183,000
Main goal	The source of power of the groundwater with deep water level that the pump rises and also the power pump to do raw water transmission to the eastern part and the seaside with high altitude		
Others	Wind pump and wind generator		
Water supply plan			
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	-		
Degree of difficulty of the maintenance management	・Because it isn't general, it becomes order from the foreign countries such as the parts.		
Maintenance management system	Management organization	AES/MEM	
	Maintenance organization	AES/MEM	
	O & M Difficulty	Difficult because it's not common in the country.	
Gathers Advantage:	･The potential of wind power is high.		
Disadvantage:	･Wind pumping has already been implemented for the shallow aquifers in the 1970s, but there are none that is still working.		
Remark:	･There is no record of wind power generation in the district, but the potential in the coastal area is high, and since the machine effectiveness has been improved, there are rumors that of plans in the area.		
Priority	low		
Environmental Impacts	Vegetation degradation		
Others	The operation percentage and the repair frequency and so on must be verified.		

Table 8.2.1-3 Water Supply Alternative Plan

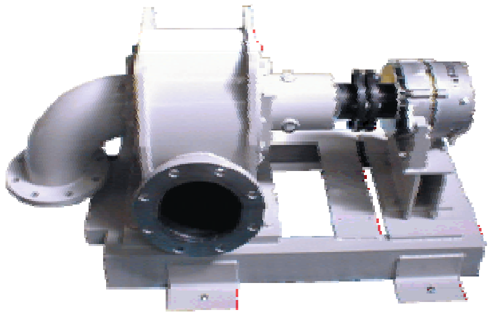
ID:	P2	Category of Plan : Facility	
Implementation	-	Micro hydropower generation system	
Water source	Any water	Source of water	Water flowing transmission line
Target area	Ambovombe	Population in 2015	183,584
Main goal	The generated power is utilized for pumping system to transmit water to the eastern part and the coastal area or to pump up groundwater from deep aquifer.		
Water supply facility	The power potential assuming the GFS from Antanimora and Ambovombe with the line length 62km, altitude difference 150m, pipe diameter 300mm, distribution flow rate 66m3/hr can be calculated as:Pth=9.8ｘ0.0183m3/ｓｘ(150-5)＝２６ｋW		
Water supply plan			
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	NA (several months)		
Degree of difficulty of the maintenance management	・Because it isn't general, it becomes order from the foreign countries such as the parts.		
Maintenance management system	Management organization	AES/MEM	
	Maintenance organization	AES/MEM	
	O & M Difficulty		
Gathers Advantage:	・There is potential of Micro hydropower using the GFS water flow.		
Disadvantage:	・There is no other micro hydropower system in the country, thus there is uncertainty on the maintenance and operation. ・Construction of the pipeline is necessary		
Remark:	・Construction of the pipeline from Antanimora and Ambovombe is necessary. ・Application is limited because the capacity of generation is small.		
Priority	low		
Environmental Impacts	Vegetation degradation		
Others			

Table 8.2.1-3 Water Supply Alternative Plan

ID:	L1	Category of Plan : Soft	
Implementation		Regulation: Stabilization of water price	
Water source	-	Source of water	-
Target area	All the area where there is not the source of water	Population in 2015	252,000
Main goal	Stabilization of water price during water shortages		
Water supply facility			
Water supply plan	Introduction of licensing system to re-sell water of AES to control water price.		
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	NA		
Degree of difficulty of the maintenance management	Securing enough amount of water and system of distribution		
Maintenance management system	Management organzation	Prefecture	
	Maintenance organzation	Prefecture	
	O & M Difficulty		
Gathers Advantage:	･Increasing of chnace to buy water for even poor rsidenets.		
Disadvantage:	･The demand which has been suppressed due to high cost might burst, and the supply plan might have to be reexamined if it succeeds. ･The motivation of the water sellers might go down which will disbenefit the residents as a result.		
Remark:	･Supply system exceeding the demand is a necessity.		
Priority	low		
Environmental Impacts			
Others			

Table 8.2.1-3 Water Supply Alternative Plan

ID:	L2	Category of Plan : Soft Regulation: Introduction of guideline for well construction to improve sanitation	
Implementation	-		
Water source	Shallow groundwater	Source of water	Dug Well
Target area	Existence Dug Well (Ambovombe、Ambondro)	Population in 2015	38,000
Main goal	Design proposal at the Dug Well facilities for the sanitary conditions improvement		
Others			
Water supply plan	･Sanitary guidelines around the wells. ･Guidelines for well construction, for instance, well caps and structure.		
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	NA		
Degree of difficulty of the maintenance management	Difficult		
Maintenance management system	Management organization	Prefecture	
	Maintenance organization	Prefecture	
	O & M Difficulty		
Gathers Advantage:	･Able to upgrade the quality of drinking water.		
Disadvantage:	･For the residents, many work shall occur, so recognition of necessity is needed. ･Some construction occur, so cost is borne.		
Constrain:	It would be difficult for the residents to accept the administrative guidance unless there is penalty.		
Priority	low		
Environmental Impacts	None in particular		
Others	Because it requires to obey, enforcement of guidelines is difficult unless penalty is applied.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	L3	Category of Plan : Soft	
Implementation		Regulation: Introduction of guideline to protect water resources from polution	
Water source	Shallow groundwater	Source of water	Existence Dug Well
Target area	Existence Dug Well (Ambovombe、Ambondro)	Population in 2015	38,000
Main goal	The guideline to protect water resources from polution.		
Others			
Water supply plan	・Set the water source area and regulate the construction of houses. ・Prohibit using the well from which diseases broke out. ・Pollution may be caused that there is no well cap, so legalize on well caps.		
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	NA		
Degree of difficulty of the maintenance management	Difficult		
Maintenance management system	Management organzation	Prefecture	
	Maintenance organzation	Prefecture	
	O & M Difficulty		
Gathers Advantage:	・Enables to manage the sustainability of the groundwater source.		
Disadvantage:	・There are some residents who disbenefit from the regulation.		
Constrain:	・Location control shall be the main issue. ・It would be difficult for the residents to accept the administrative guidance unless there is penalty.		
Priority	low		
Environmental Impacts	None in particular		
Others	Because it requires to obey, enforcement of guidelines is difficult unless penalty is applied.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	L4	Category of Plan : Soft	
Implementation		Regulation: Improvement of efficiency of water selling	
Water source	Shallow groundwater	Source of water	Dug Well
Target area	Existence Dug Well (Ambovombe、Ambondro)	Population in 2015	250,000
Main goal	Improve efficiency fo existing water selling system by organizating zebucart water sellers		
Water supply facility	All water sellers who sell water from the AES constructed facilities should be licensed, and prohibit the selling of water above the controlled price. Also, if the water is to be sold far away, the wholesale price is discounted.		
Water supply plan			
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	NA		
Degree of difficulty of the maintenance management	Difficult		
Maintenance management system	Management organzation	Prefecture	
	Maintenance organzation	Prefecture	
	O & M Difficulty		
Gathers Advantage:	･Minimize the facility construction which the initial cost is high, and exclude the causes of raising the O & M costs. ･Increase of employment opportunity.		
Disadvantage:	･Doesn't congruent with the traditional way of usage of zebu-carts. ･Water sellers become active as the cost of water rises. Therefore, inhibition of the water price and orginazation of water sellers is a conflicting issue.		
Constrain:	･It depends on concensus with residents		
Priority	low		
Environmental Impacts	None in particular		
Others	･It would be difficult for the residents to accept the administrative guidance unless there is penalty.		

Table 8.2.1-3 Water Supply Alternative Plan

ID:	L5	Category of Plan : Soft	
Implementation		Regulation: Support on improvement of management capability of AES	
Water source	AES	Source of water	Water supplied by AES
Target area	All the areas	Population in 2015	250,000
Main goal	Support of reinforcement on management capability of AES		
Others			
Water supply plan	･Relocation of staff assignment. ･Disclosure of accounting report (to Donors and district) ･Support until the management of project constructed facilities get into orbit.		
Construction cost	Detail shall be referred to the table 8.2.1-2		
Management cost			
The minimum water fee			
Construction period	NA		
Degree of difficulty of the maintenance management	Difficult		
Maintenance management system	Management organization	MEM	
	Maintenance organization	MEM	
	O & M Difficulty	Depending on the political leadership of the government	
Gathers Advantage:	･Decrease the wasteful spending, and lower the sustainable cost break point.		
Disadvantage:	･Repelling from holders of vested interests		
Constrain:	･Reform is not yet enough although stakeholders recognize that the political intervention should be removed.		
Priority	low		
Environmental Impacts	None in particular		
Others	—		

8.2.2 Methodology of the Selection of Alternative Water Plan

As a result of the test drilling, it was found that the only groundwater source which was potentially favorable both in quantity and quality was at Antanimora. Therefore, upon the consideration of long list of alternatives, water sources other than groundwater were also considered, in order to improve the water supply situation of the area. From the evaluation of the long list, the alternatives were refined to a short list, which was then prioritized. The diagram below shows the method.

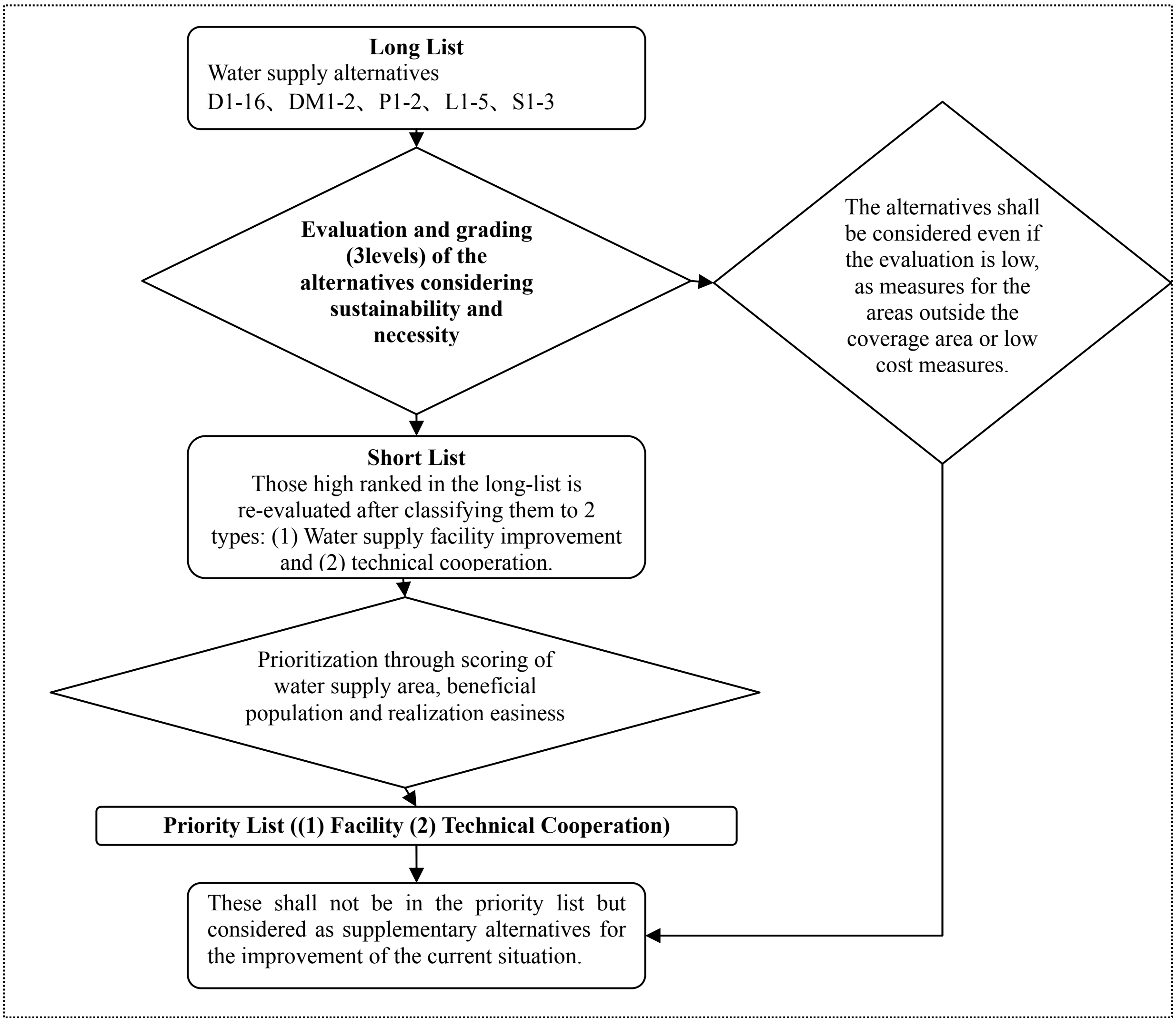


Fig.8.2.2-1 Flow Chart of the Alternative Selection

8.2.3 The Long List

Since the target area is facing water shortage problems even in the wet season, there shall be great improvement of the situation even if the water supply system is targeted on domestic use only (at the level of the Madagascar Water Quality standard). Thus, a long list of alternatives was considered for all situations, not limiting to potable water (at the level of WHO guideline). In addition, improvement of power system, which is one of the important issues upon the pumping of water, shall be also considered as one of the alternatives. Also, because the usable water is very limited in the target area, the water is developed and used disorderly. Therefore, a support through laws and regulations is also effective. Figure 8.2.3-1 shows the categorization of the alternatives.

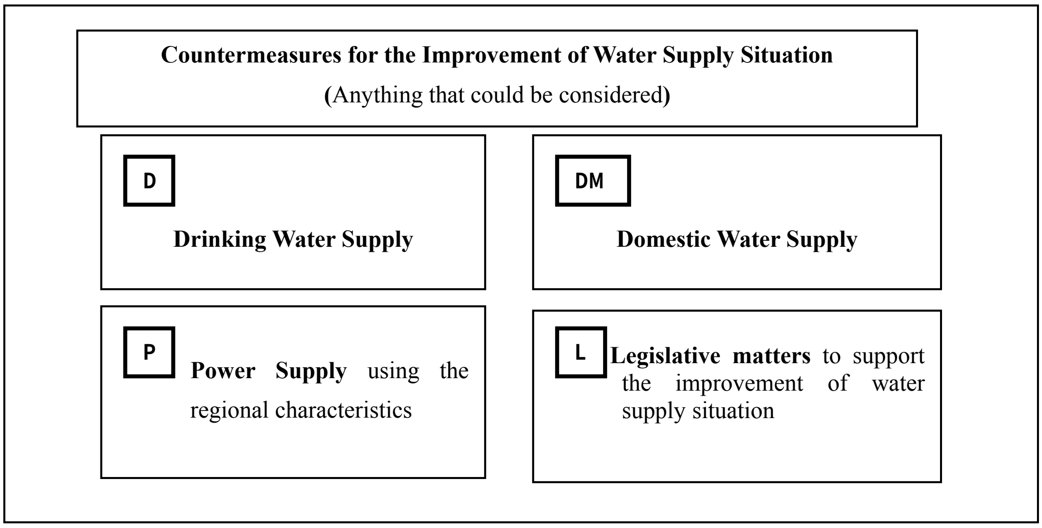


Fig 8.2.3 -1 Categorization of the Alternatives

A long list of alternatives which can be applied in the target area is shown in Table 8.2.3-1. Each of the alternatives is evaluated on sustainability and necessity as shown below. In addition, these alternatives are classified as either (1) facility (improvement of water facility) or (2) soft program (technical cooperation) for priority determination.

Sustainability: Able to operate and maintain with only the domestic resources, without the support of any donors after construction. In addition, the alternative has effects not only to the water supply conditions of the area, but ripple to the Madagascar's other regions or similar fields.

- High：Operation and maintenance is possible as long as the infrastructure is ready; economic effects are also high
- Middle: Some doubts on the self-reliance of the operation and maintenance, but economic effects are high
- Low：Support such as from donors is a prerequisite.

Necessity: There would be benefit to the people in implementing the project as soon as possible
- High: There would be benefit to the regional society or the economy
- Middle: There might not be change in the regional society, but there would be improvement in the people's life.
- Low: There are requests in the society.

Table 8.2.3 – 1 Alternative Plans of the Water Supply in the Area (Long List)

	Main Objective	Water Supply Facility	Water Supply Plan	Sustainability	Necessity	Facility/ Soft
D1	Domestic Water (virtually drinking water)	Level 2 Water supply facility	Water supply system to urban Ambovombe utilizing water source at the outskirts of Ambovombe (Diesel generator method)	High	High	Facility
D2	Domestic Water (virtually drinking water)	Level 2 Water supply facility	Same as above (JIRAMA Commercial electricity method)	High	High	Facility
D3	Domestic Water (virtually drinking water)	Pipeline system	Water supply system to coastal area utilizing water source at the outskirts of Ambovombe (Diesel generator method)	Middle	Middle	Facility

	Main Objective	Water Supply Facility	Water Supply Plan	Sustainability	Necessity	Facility/ Soft
D4	Drinking water	Pipeline + Level 2 water supply facility	Water supply system utilizing the groundwater in Antanimora to Ambovombe and the coastal dune area. (Solar pumping system + Diesel pumping system)	Middle	Middle	Facility
D5	Drinking water	Pipeline + Level 2 water supply facility	Water supply system utilizing the groundwater in Antanimora to Ambovombe and the coastal dune area. (Diesel pumping system)	Middle	Middle	Facility
D6	Drinking water	Pipeline + Level 2 water supply facility	Water supply system utilizing the groundwater in Antanimora to Ambovombe. (Diesel pumping system)	Middle	High	Facility
D7	Drinking water	Rain water collecting system 1 Public, large scale	Improve the water supply in rainy season + 1 month (Total 5 months). Fokontany level: Water collection area 1,000m^2, Tank volume 120m^3	Low	Middle	Facility
D8	Drinking water	Rain water collecting system 2 Public, medium scale	A 10m^3 volume tank using the roof of public facilities. Water collection area 100m^2.	Low	Low	Facility
D9	Drinking water	Rain water collecting system 3 Shared, small scale	Water collection area of the private roof: 50m^2, tank volume 5m^3. Includes improvement of the roof Sustainability & Necessity is middle evaluation because O/M depends on private household and needs health education and rainwater only rainy season.	Middle	Middle	Facility
D10	Drinking water	Rain water collecting system 4 Public, large scale	・Construct water storage space underground, and store rainwater. ・Already constructed in school yards. ・Water collection area 1,00m2, water storage tank 120m^3.	Low	Middle	Facility
D11	Drinking water	Education of using sterilizer	Hygiene education for prevention of water deterioration using Sur eau (Included also in the Plan S3)	Low	Low	Soft
D12	Drinking water	Education of using antiseptic	Prevention of water decay and hygiene education. (Included also in the Plan S3)	Low	Low	Soft
D13	Drinking water	Water service truck 1	・Construction of pipeline between Antanimora and Ambovombe is a prerequisite. ・Change the system of water source from Amboasary to Ambovombe. ・Procurement of 6m^3 water service truck.	Low	Middle	Facility
D14	Domestic Water (virtually drinking water)	Hand pump in the vicinity of Imongy	・HPV100 with head water of 100m shall be set in villages having population over 100. Because of the limit of the head, these will be set in areas under 100m. ・110m well, supplementary facilities, establishment of pump accessories sales system, repair work system.	Middle	High	Facility
D15	Drinking water	Desalination facility	Remove the salinity in high saline water. Set desalination facility in water supply systems of wells, elevated water tank, and public faucet. Construct solar power source for pumps and desalination facility.	Low	Low	Facility
D16	Drinking water	Hygiene education on boiling water.	Spread the boiling water method as a means of securing safe water.	Low	Low	Soft
DM1	Domestic water	Hand pump in the seaside areas	Install manpower pumps able to pump 100m expecting EC3,000 to 10,000μS/cm. Target areas is limited to areas up to 100m above sea level, thus the areas are above the cliffs along the seashore or valleys between the sand dunes.	Middle	Middle	Facility
DM2	Domestic water	Construction of small reservoir	In the coastal areas, it is hard to obtain even the water for cattle even in rainy season because ponds or marshes are not formed. Paste mud in the depression areas to enable to reserve water.	Middle	Low	Facility

	Main Objective	Water Supply Facility	Water Supply Plan	Sustainability	Necessity	Facility/ Soft
P1	Power Source	Utilization of wind-power	Wind pump and wind generator	Middle	Low	Facility
P2	Power Source	Pumped hydropower (Micro hydropower)	Micro hydropower utilizing the altitude difference and flow rate of distribution line.	Low	Low	Facility
L1	Legislation	Stabilize the water price which becomes high when water is scarce.	All water vendors who sell water from the AES constructed facilities should be licensed, and prohibit the selling of water above the controlled price.	Low	Low	Soft
L2	Legislation	Proposal of sanitary vovo design	･Sanitary guidelines around the wells. ･Guidelines for the well caps and well surroundings	Low	Low	Soft
L3	Legislation	Guidelines for well construction and regulation on pollution source.	･Set the water source area and regulate the construction of houses. ･Prohibit using the well from which diseases broke out. ･Pollution may be caused that there is no well cap, so legalize on well caps.	Low	High	Soft
L4	Legislation	Organize the carts to optimize the water transportation.	All water vendors who sell water from the AES constructed facilities should be licensed, and prohibit the selling of water above the controlled price. Also, if the water is to be sold far away, the wholesale price is discounted.	Middle	Low	Soft
L5	Legislation	Support on transparency of AES	･Reorganization of the staffs. ･Disclosure of accounting report (to Donors and district) ･Support until the management of project constructed facilities get into orbit.	Middle	High	Soft
S1	Technical Assistance	Technical and management assistance to AES	･Technical and management assistance with linkage with the water supply plan conducted by the Japanese side ･Technical guidance to the manager of the water supply facility operation and maintenance as well as water price, and support on the improvement of the management.	High	High	Soft
S2	Technical Assistance	Follow up assistance (modification assistance)	･Modification of the existing facility (pipeline + water treatment plant) and operation and maintenance ･General and technical follow-up assistance on operation and management including modification of the intake point broken from the cyclone in 2005.	High	High	Soft
S3	Technical Assistance	Technical assistance on the utilization of rainwater	･Construction of impluvium to satisfy the request of the local government and the residents, and technical assistance of the organization using the NGO ･Since there is a need for adjustment with MEM (executing agency), need to plot out a master plan, conduct pilot project, monitor and check the beneficial effects.	Middle	Middle	Soft
S4	Technical Assistance	Technical assistance on the utilization of existing pipeline and extension	･Technical assistance for extension of existing Mini-Pipe from Sampona to Antaritarika via Ambovombe city ･Monitoring and evaluation of operation and maintenance for Mini-Pipe from Amboasary to Sampona	Middle	High	Soft

8.2.4 The Short List

The evaluation of each alternative of the long list can be summarized to figure 8.2.4–1 (Facility) and figure 8.2.4-2 (Soft)

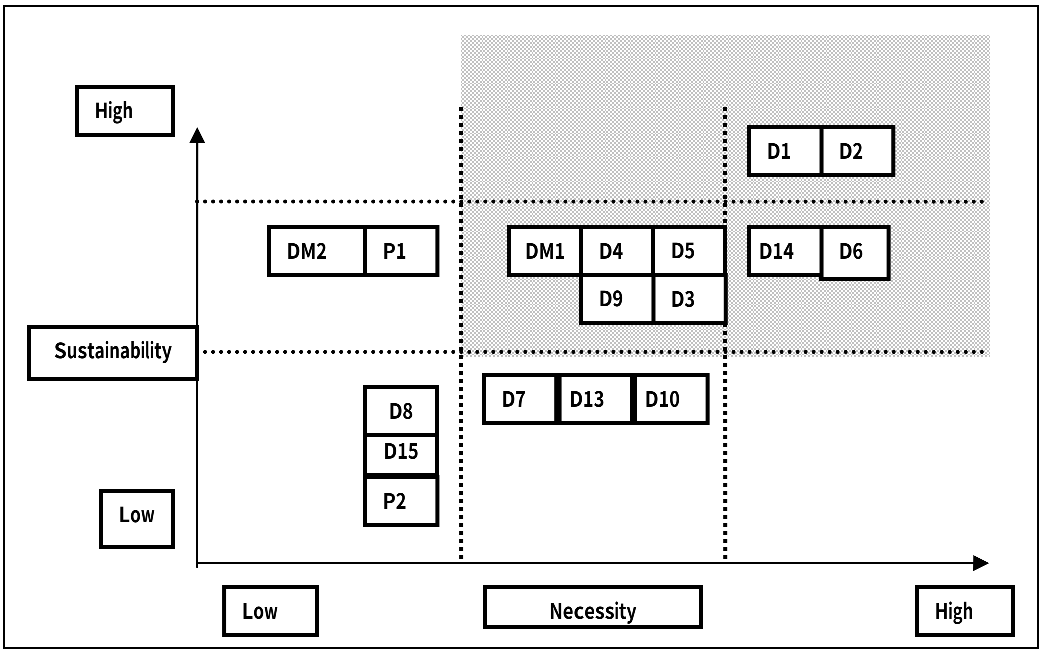


Fig. 8.2.4-1 Evaluation of the Long List (Facility)

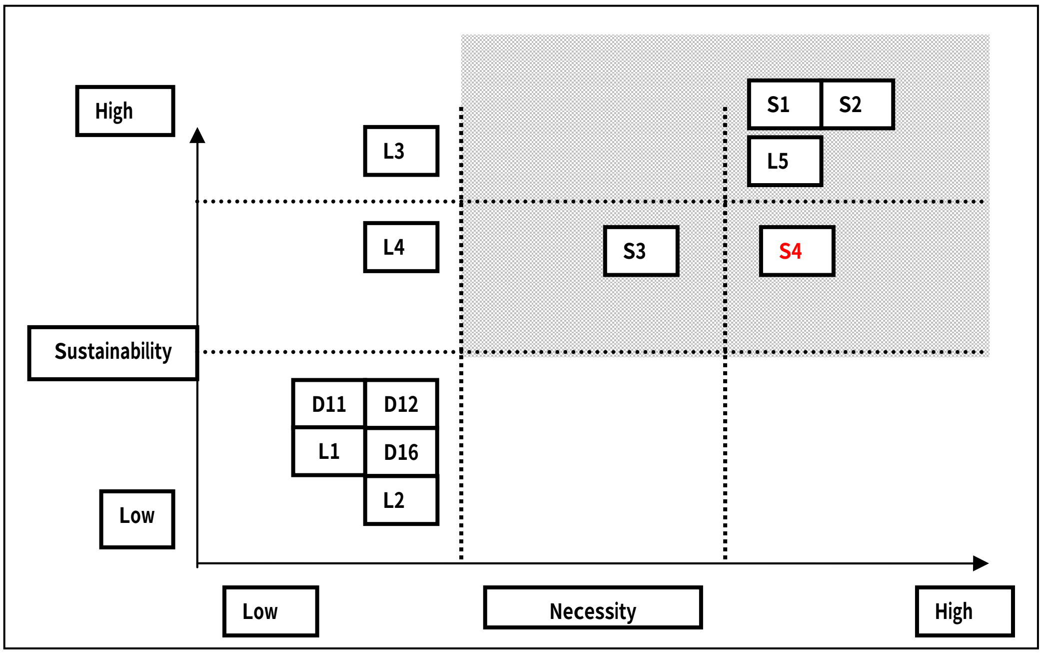


Fig. 8.2.4-2 Evaluation of the Long List (Soft)

9 out of 18 facility plans and 5 out of 12 soft plans which are evaluated as middle or high for both the sustainability and necessity is screened on the short list, and are then re-evaluated on the more detailed point of view. In addition, plans for construction of impluviums (D 7, D 8, D 9), which are actually being constructed in the target area, shall be analyzed as special consideration facilities. The short list is listed on Table 8.2.4-1 (Facility) and Table 8.2.4-2 (Soft).

Table 8.2.4–1 Alternative plans screened for consideration of priority (Facilities, Short List)

	Main Objective	Water Supply Facility	Sustainability	Necessity
D1	Domestic Water (virtually drinking water)	Level 2 Water supply facility(Diesel)	High	High
D2	Domestic Water (virtually drinking water)	Level 2 Water supply facility(JIRAMA)	High	High
D3	Domestic Water (virtually drinking water)	Pipeline system	Middle	Middle
D4	Drinking water	Pipeline + Level 2 water supply facility	Middle	Middle
D5	Drinking water	Pipeline + Level 2 water supply facility	Middle	Middle
D6	Drinking water	Pipeline + Level 2 water supply facility	Middle	High
D9	Drinking water	Rainwater collecting system [3] Shared, small scale	Middle	Middle
D14	Domestic Water (virtually drinking water)	Hand pump in the vicinity of Imongy	Middle	High
DM1	Domestic water	Hand pump in the seaside areas	Middle	Middle

Table 8.2.4–2 Alternative Plans screened for Consideration of Priority (Soft, Short List)

	Main objective	Soft program	Sustainability	Necessity
L5	Legist ration	Support on transparency of AES	High	High
S1	Technical Assistance	Technical and management assistance to AES	High	High
S2	Technical Assistance	Follow up assistance (modification assistance)	High	High
S3	Technical Assistance	Technical assistance on the utilization of rainwater	Middle	Middle
S4	Technical Assistance	Technical assistance on the utilization of existing pipeline and extension	Middle	High

8.2.5 Determination of order of priority

The order of priority is determined by totaling the score evaluated through the below criteria (criteria for the facilities are shown on Table 8.2.5-1 and criteria for the soft program are shown on Table 8.2.5-2)

Table 8.2.5-1 Priority Order Scoring Criteria for the Facilities

	Criteria	5 points	3 points	1 point
1.	Quality of water	WHO standard	Madagascar Std.	Domestic use only
2.	Beneficial population	Over 100,000	Over 10,000	Under 10,000
3.	Construction cost per capita	Under 10,000 Yen	Under 30,000 Yen	Over 30,000 Yen
4.	Profitable water price (per 13L bucket)	Under 50Ar	Under 100Ar	100Ar and over
5.	Impact area	Over 5km	Around 3km	Around 1km
6.	O&M organization	No need for improvement	Need improvement	Need new organization
7.	Recurring management cost	Under 200,000 Yen / month	Under 500,000 Yen / month	Over 500,000 Yen/month
8.	Budgetary feasibility	Under 200 million Yen	Over 200 million Yen	Over 3,000 million Yen

Table 8.2.5-2 Priority Order Scoring Criteria for the Soft Program

	Criteria	5 points	3 points	1 point
1.	Is the program aimed at improvement of water quality?	WHO standard	Madagascar Std.	Domestic use only
2	Beneficial population	Over 100,000	Over 10,000	Under 10,000
3	Cost for hygiene	Under 10,000 Yen	Under 30,000 Yen	Over 30,000 Yen
4	Consideration concerning profitable water price?	Consideration of water price	Consideration of economy	No consideration
5	Impact area	Over 5km	Around 3km	Around 1km
6	Effectiveness of O&M organization strengthening	Drastic improvement	Improvement	Not much change
7	Synergic effect with the facility construction	Very large	There is some effect	No synergic effect
8	Feasibility and effectiveness	Feasible and large effect	Normal	Difficult and small effect

The scores corresponding to each alternative for the water supply facility improvement is shown below:

Table 8.2.5- 3 Scoring Results (Facility)

	Main objective	Water supply Facility	Quality	Pop.	Constr. cost	Water price	Impact Area	Organi-zation	Manag. Cost	Feasi bility	Total	Priority order
D1	Domestic Water (virtually drinking water)	Level 2 Water supply facility	3	3	5	5	3	3	3	5	**30**	**2**
D2	Domestic Water (virtually drinking water)	Level 2 Water supply facility	3	3	5	5	3	3	5	5	**32**	**1**
D3	Domestic Water (virtually drinking water)	Pipeline system	3	5	3	5	5	1	1	3	**26**	**4**
D4	Drinking water	Pipeline + Level 2 water supply facility	5	5	3	5	5	1	5	3	**32**	1
D5	Drinking water	Pipeline + Level 2 water supply facility	5	5	3	5	5	1	1	3	**28**	**3**
D6	Drinking water	Pipeline + Level 2 water supply facility	5	3	3	5	5	1	5	3	**30**	**2**
D9	Drinking water	Impluvium [3] Shared, small scale	1	1	3	1	5	5	5	5	**26**	**4**
D14	Domestic Water (virtually drinking water)	Hand pump in the vicinity of Imongy	3	1	5	1	1	3	5	5	**24**	**5**
DM1	Domestic water	Hand pump in the seaside areas	1	1	5	1	1	3	5	5	**22**	**6**

As a result of the scoring, priority order is determined as below.

1) Priority 1: Plan **D2** is aimed at improving the domestic water of the 40,000 people living in Ambovombe. However, power supply from JIRAMA is a necessary condition. If this is not possible, the plan should be changed to the same as **D1,** which is utilizing the diesel generator at first, and when the JIRAMA power supply has increased, the operational cost shall be reduced.
   - The water source shall be using F015, at the outskirts of the urban area
   - The water quality is not up to the standard of drinking, but domestic use only.
   - For the operation and maintenance, AES, with many experiences, shall be in charge. However, strengthening in both technically and management point of view is necessary, the effect shall increase if combined with technical assistance on such as water price and legal system (**L5**, **S1**).
2) Same as Priority 1: Plan **D4** is aimed to improve the current water supply situation of the 210,000 people living in the whole target area, including Ambovombe and the coastal villages, utilizing the gravity force system. Reduction of operational costs by the solar pumping system shall be a pre-requisite.
3) Priority 2: Plan **D6** is aimed to improve the water supply situation of 85,000 people living in Ambovombe and those living along the transmission pipeline, by utilizing the gravity force system. However, because the beneficial population is medium scale in comparison with the other plans, and because the pumping is conducted by diesel generator, the project cost is reduced. The pipeline is the same as plan D4 until Ambovombe, excluding the water supply to the coastal dune area.
4) Priority 3: Plan **D5** is aimed to improve the current water supply situation of the 210,000 people living in the whole target area, including Ambovombe and the coastal villages, utilizing the gravity force system. The difference from Plan D4 is the application of diesel power supply for the pumping system.
5) Priority 4: Plan **D3** is aimed to improve the water supply situation of 180,000 people living in the coastal dune area, utilizing the water source in the outskirts of Ambovombe. Application of gravity force system is considered, but the pumping is conducted by diesel generator.
6) Same as Priority 4: Plan **D9** is a rainwater collection system, and although this is not a stable water supply system which can be used throughout one year, it shall serve as countermeasures to the area beyond 10km from the distribution pipeline where it is too far to expect an improvement. Therefore, this plan shall not be conducted alone, but should be conducted in combination with Plan **S3** including hygiene and health education.
7) Priority 5 and 6: Plan **D14** and **DM1** is a hand pump system utilizing the point groundwater source

found in the coastal dune areas. Currently, pilot project is undergoing, and it is found that even if the water quality is above the Madagascar standard, the water is used for domestic use.

The scores of the soft program are shown in the table below. As for plans L5 and S1, because these are the same in that both are assistance to the AES, the two shall be scored together.

Table 8.2.5-4 Scoring Results (Soft Program)

	Main objective	Water supply Facility	Quality	Pop.	Cost	Water price	Impact Area	Organiz ation	Manag. Cost	Feasibil ity	Total	Priority order
L5	Legist ration	Support on transparency of AES	5	3	5	5	3	5	5	3	**34**	**1**
S1	Technical Assistance	Technical and management assistance to AES										
S2	Technical Assistance	Follow up assistance (modification assistance)	5	3	3	5	5	5	3	3	**31**	**2**
S3	Technical Assistance	Technical assistance on the utilization of rainwater	3	3	3	5	3	3	5	5	**30**	3
S4	Technical Assistance	Technical assistance on the extension of existing Mini Pipeline	5	5	3	3	5	3	3	3	**30**	3

8.2.6 General Evaluation and Other Considerations

(1) General

As a result of scoring, for the improvement of the domestic water supply, implementation of **D1** and **D2** is the most prioritized plan, and if soft program **L1** and **S1** is implemented simultaneously, the water supply situation shall surely improve. However, to improve the drinking water situation, implementation of **D4** is necessary. Actually, what is going to be implemented depends on the budgetary funding, and if there is enough budget in either the executing agency (MEM) or donors such as the Japanese Government, **D4** and **L1, S1** should be implemented. Furthermore, the repair work of the existing facilities through **S2** and technical cooperation on rainwater collection system with hygiene and health education **(S3)** should be urgently conducted. An additional technical assistance **(S4)** is required urgently because Mini-Pipe from Amboasary to Sampona started water supply in November 2006. The extension of Mini-Pipe shall be supplied drinking water by natural gravity to the coastal area of Antaritarika via Ambovombe city.

Currently, reform of AES, which is in charge of water supply in this district, is on going. Therefore, if the technical strengthening of AES, in terms of management and operation of water supply facilities including water tariff system, can be done simultaneously, the improvement effect shall be even greater (plans **L5**, **S1**). According to the results of analysis of the annual report of AES of 2005, the water sales, which is one of the important income resources, averaged to only 100m^3/day (Western pipeline:7m^3/day, Ambovombe water tank truck: 20m^3 and AEP independent water supply center 73m^3/day) . The planned water sales at the point of grant aid by the Japanese Government were assumed to be 200m^3/day. Thus, recovery of the water sales as an income source is a pre-requisite for the improvement of the management status which cannot be achieved with only downsizing of manpower. Therefore, there is a need to newly construct or to do repair work of existing facility (Follow-Up) to ensure enough income (**S2**). Plans **D1** and **D2**, which can be constructed with little money, enables average water sales of 400m^3/day to Ambovombe Commune and the outskirts.

The consideration of other plans including the ones screened off from the short list, taking in line the moves of the African Development Bank and the status of the facilities constructed by the Japanese side, are shown below:.

(2) If the establishment of management organization is on-going

1) Plans to be considered 1: Hand pump construction aimed to domestic use such as plans **D14** or **DM1**.
   - It should be noted that the suitable point is limited.

2) Plans to be considered 2: Assistance on the rainwater utilization technology as well as hygiene practices and commune development should be immediately conducted. (**S3**)
   - Some of the impluvium construction (plans **D7**, **D8**, **D9**) should be started as a pilot project and prove the effectiveness of the impluviums (large, medium, small) with the help of EU and NGOs.
   - Through the proof of the effectiveness and monitoring and evaluation of the impluviums, assistance on formulation of long-term enforcement plans to realize the goals should be conducted.
   - The construction of impluvium is based on the requests from the communes or residents of Fokontany, and not from the requests of the executing agency (MEM), so technical assistance and usage of NGOs is appropriate.
   - If the impluviums prove to be inappropriate to as a stable water source, another alternative scheme should be considered within the assistance.

3) Plans to be considered 3: The existing pipeline and the water treatment plant is in a critical situation and needs urgent repair works along with reform of the management of the AES including the reconsideration of the water tariff. (**S2**)
   - Need to conduct general improvement measures such as F/U (Follow-up) assistance, community development assistant or project-type technical assistance.

4) Plans to be considered 4: Construct the water supply facilities to the coastal dune area using co-finance with other donors such as African Development Bank (which is committing to the area since March 2006), and in the meanwhile the Japanese side alone commits for the realization of Plan **D6**, which is the plan utilizing the water source at Antanimora, supplying the water to Ambovombe.
   - The length of the gravity flow distribution line to Ambovombe is 60km.
   - The total project cost is relatively high (1.3billion Yen) as with plan D4.
   - Because the water supply area is smaller than D4, the priority order is lower.
   - Since there is no water supply system to the coastal dune areas, the construction cost shall be lower than plan D4.

8.3 Proposed Water Supply Plan

As a result of scoring, for the improvement of the domestic water supply in the Study area, the alternative plan **D1** and **D2** is the most prioritized plan, the water supply situation shall surely improve. However, to improve the drinking water situation, implementation of **D4** is necessary. Actually, what is going to be implemented depends on the budgetary funding, and if there are enough budgets the plan **D4** should be implemented. Furthermore, the improvement work of the existing facilities through plan **S2** with follow-up technical cooperation should be urgently conducted.

Currently, reform of AES, which is in charge of water supply in this district, is on going. Therefore, if the technical strengthening of AES, in terms of operation and management of water supply facilities including water tariff system, can be done simultaneously, the improvement effect shall be even greater (plans **L5**, **S1**). Plans **D1** and **D2**, which can be constructed with little budget coppering with Plans **D3**, **D4**, **D5** and **D6**, enables average water sales of 400m^3/day to Ambovombe Commune and the outskirts. Therefore, at first we show that 1) the design concept and 2) the integrated evaluation of basic indexes have carried out as follows.

8.3.1 Evaluation of Basic Index for Water Supply Alternative Plans

(1) Evaluation of Alternative Plan D1 to D6 and Plan D7 of existing pipeline

Table 8.3.2 -1 shows the evaluation of alternative water supply plans which proposed the priority Plan D1 to D6 and Plan S2 of existing pipeline. The evaluation was made based on the basic indexes were shown as follows.

1) **Water Source:** The water source was considered depend on the location. There are 2 proposed groundwater sources namely as Ambovombe city, F015 and Antanimora, F006B, and the existing water source at Ampotaka, Menarandra river.

2) **Supply Population**: The population served of Plan D1 & D2, Ambovombe city is 40,000, and Plan D4 & D5 is 206,500. On the other hand, the Plan S2 of rehabilitation of existing pipeline is 80,000.

3) **Construction Cost:** There are 2 indexes such as actual construction cost and construction cost per beneficiaries. The most economical water supply is the Plan D1 & D2 for the Ambovombe city of 40,000 population using groundwater source, F015 in the suburb of supply area. The construction cost is ¥0.13 billion Japanese yen (Ar2.3 billion) and ¥3 thousand yen (Ar54 thousand) per beneficiaries. On the other hand, the construction of Plan D4 & D5 for Ambovombe city and coastal area of 206,500 population using Antanimora groundwater source by pipeline 120km is ¥2.3 billion Japanese yen (Ar41.4 billion) and ¥11 thousand yen (Ar198 thousand) per beneficiaries. The construction of Plan S2 for Beloha-Tsihombe area of 80,000 population using groundwater from Ampotaka, Menarandra river by pipeline 140km is ¥2.1 billion Japanese yen (Ar37.8 billion) and ¥26 thousand yen (Ar468 thousand) per beneficiaries.

4) **Production Cost:** This is the most important factor to determine the priority plan for actual profitable operation. Considering the water supply plan and operation and maintenance cost, the minimum profitable amount and the production cost excluding facility renewable cost was simulated. Assuming the profitable supply of 400m^3/day at Ambovombe city water supply the production unit cost is Ar1,539/m^3 (¥84.6/m^3) and /or Ar20/bucket (¥1.1/bucket) of 13litters. On the other hand, assuming the profitable supply of 700m^3/day for Ambovombe city and coastal area water supply the production unit cost is Ar1,154/m^3 (¥63.9/m^3) and /or Ar15/bucket (¥0.83/bucket) of 13litters.

   For our Study Plan S2 of Beloha-Tsihombe existing pipeline 140km was supplied only 7m^3/day in 2005. The production unit cost was estimated Ar30,769/m^3 (¥1,723/m^3) and/or Ar400/bucket (¥22/bucket) of 13litters. This is the 4 times of official cost of Ar100/bucket (¥5.6/bucket) of 13litters. Therefore, we proposed the rehabilitation of existing facilities using solar pumping system to reduce the operation cost. Assuming the profitable supply of 50m^3/day the production unit cost is expected Ar6,154/m^3 (¥345/m^3) and /or Ar80/bucket (¥4.5/bucket) of 13litters.

5) **Water charge:** This production cost of simulation is not included in the facility renewable cost, therefore actual water charge should be added the renewable cost. The Chapter 8.6 of Water Charge discusses the new water charge including facility renewable cost. The new water charge is concluded based on the above production cost is Ar30 to Ar40/bucket at Plan D1, Ar20 to Ar40/bucket at Plan D4 and Ar80(excluding renewal cost) to Ar130/bucket (including renewal cost)at Plan S2**.**

Pleasantry it is judged that the facilities renewal in the self-supporting accounting system is difficult so that the water charge may become about Ar130/bucket (including renewal cost) in S2 that exceed the affordability of payment hope price of the residents in the existing facilities repair plan of S2.

At the stage of facilities renewal, new low water charge setting that is unified and took average on the whole of the water supply system in this area or new government assistance (subsidy) is needed in the future in consideration of the distinctiveness of the difficulty in this district.

Table 8.3.1-1 Reference: outline of waterworks corporate accounting

Items of waterworks corporate accounting		Contents	
1. Revenue expenditure and receipt (Profit surplus and loss carried forward)		**Profit surplus：** apply in an accumulated fund for expansion plan and improvement of facilities such as superannuated pipes up-date etc. by profit disposal （transferred by this project by financial reserve）	
		loss carried forward (amount of deficit)	
	1) Revenue receipt (Current receipts: （An income with an ordinary administrative action）	**Income of water charge**, new costumers admission fee income. Contributions of new member connection fee.	
		other accounts transfer **(subsidy)**, and land disposal income etc.	
	2) Revenue expenditure (current expenditure: Expenditure with an ordinary administrative action）	**Personnel expenses**	
		Charge collection overhead	**(power costs and water treatment costs (disinfection)**
		Non personnel expenses	
		Facilities improvement expense (maintenance works and repair expense)	
		Payment interest expense and depreciation expenses	
1. Capital expenditure and receipt (income from enterprise **bond, and** expenditure for expansion work, improvement of facilities, and enterprise bond)		Capital: Property	
	1)Capital receipt	Enterprise bond （amount of construction close including donation by this project）	
		money of financial reserve balance **(facilities renewal cost** by financial reserve**, for the facilities constructed by this project)**	
		General account money transferred, and others caused from net profit (subsidy etc.)	
	2) Capital expenditure	Amount of enterprise bond repayment Profit-and-loss account reserved capital (Depreciation expenses etc. without cash expenditure)	

The bold character is an item which relates to this project.

Table 8.3.1 -2 Evaluation of Basic Index of Alternative Water Supply Plans (Plan D1 to D6 and Plan S2, S4) (1¥＝18Ar, Diesel Oil 3,000Ar/litter)

Items	Water Source	Supply Population (10/day/ Capita)	Construction cost		Operation/Maintenance Cost (Excluding renewable cost)					Remarks
			Construction Cost (Excluding Overhead)	Construction Cost Per Capita by benefit	① Water Production Cost (Based on the Minimum Profitable Supply Amount)		Current Expenditure	Charge Income	②Minimum Profitable Supply Amount income=expense)	
							①x②x30days			
			Billion yen	Thousand Yen/Capita	1 bucket /13ℓ	m^3	Million Yen /month		m^3/day	
Plan D1	**Ambovombe City (F015)**	**40,000**	**¥0.13**	**¥3**	**Ar 20 ¥1.1**	**Ar 1,539 ¥84.6**	**¥1.03**	**¥1.03**	**400** (m^3/day)	Diesel
D2	Ambovombe City (F015)	40,000	¥0.13	¥3	Ar 15 ¥0.83	Ar 1,154 ¥63.9	¥0.77	¥0.77	400 (m^3/day)	JIRAMA Ambovombe
D3	Ambovombe City (F015)	179,000	¥1.1	¥6	Ar 25 ¥1.4	Ar 1,923 ¥108	¥1.28	¥1.28	400 (m^3/day)	Diesel
Plan D4	**Antanimora (F006B)**	**206,500**	**¥2.3**	**¥11**	**Ar 15 ¥0.83**	**Ar1,154 ¥63.9**	**¥1.35**	**¥1.35**	**700** (m^3/day)	**Solar and Diesel**
D5	Antanimora (F006B)	206,500	¥23	¥11	Ar 25 ¥1.4	Ar1,923 ¥108	¥2.24	¥2.24	700 (m^3/day)	Diesel
D6A	**Antanimora (F006B)**	**84,500**	**¥1.3**	**¥15**	**Ar 25 ¥1.4**	Ar1,923 ¥108	**¥1.28**	**¥1.28**	**200** (m^3/day)	**Solar**
*D6B	Antanimora (F006B)	84,500	¥1.3	¥15	Ar 10 ¥0.56	Ar 769 ¥42.7	¥0.51	¥0.51	*400 (m^3/day)	Solar
*D6C	Antanimora (F006B)	84,500	¥13	¥15	Ar 13 ¥0.72	Ar 1,000 ¥90	¥0.67	¥0.67	*400 (m^3/day)	Diesel
Plan S2 (Exist.Pipe-line)	Existing Pipeline (BD) 1995	80,000	¥2.1	¥26	Ar 50 ¥2.8	Ar 3,846 ¥214	¥1.8	¥1.8	280 (m^3/day)	Diesel
	2005 Actual Operation in 2005	80,000	¥2.1	¥26	Ar 400 ¥22.2	Ar 30,769 ¥1,709	¥0.36	¥0.18	7 (m^3/day)	Diesel
	Improvement Plan	**80,000**	**¥00.5**	**¥0.6**	**Ar 80 ¥4.4**	**Ar 6,154 ¥341**	**¥0.51**	**¥0.51**	**50 (m^3/day)**	**Solar(1set/place)**
Plan S4	**Amboasary (Mini-Pipe)**	**20,000**	**¥0.13 Ar2.3**	**¥7**	**Ar 150 ¥8.3**	**Ar 11,538 ¥641**	**¥1.923**	**¥1.923**	**100** (m^3/day)	Diesel (Sampona)

Note: 1) AES expense was Ar288 million(¥16million)/year in 2005. The amount of accounted for water was 99m^3/day in 2005.

(2) Design for Alternative Plan D1 and Plan D4

The above water supply alternative plans are designed based on the location of water sources confirmed by test drilling in 2005/2006 in this Study. There are two main alternative sources namely Plan D1 and D4.

1) Plan D1: Ambovombe groundwater source: F015, and
2) Plan D4: Antanimora groundwater source: F006B as follows

1) Plan D1: Ambovombe Groundwater Source: F015

The water supply area of Plan D1 is targeted the highest priority area of Ambovombe city and the beneficiaries are about 40,000 population. The water source is located in the suburb of supply area of Ambovombe city. Therefore, it is the most effective and economical water supply system in the Study area. However, water source of groundwater has the limit of Madagascar water quality standard that Electric Conductivity (EC) is 3,000μS/cm. The District city of Ambovombe has no steady water supply system, then there is serious shortage of water. Therefore the development of groundwater and supply water system solves the problems for cocking, washing, showering and other purposes, except for drinking. The estimated new cost of water by 13 litters of bucket is 30 to 40 Ar/ bucket considering water supply of 400m^3/day including cost of operation and maintenance and 15 yeas renewable cost. The water supply facility and daily water supply rate is designed based on the unit water consumption of 10 l/day/capita. The Plan I is the sustainable and autonomic water supply plan due to the water charge including the cost of operation and maintenance and 15 yeas renewable cost within the consumers' willingness to pay of 50 to 100 Ar/ bucket against the present cost of 100 Ar/ bucket.

2) Plan D4: Antanimora Groundwater Source: F006B

The water supply area of Plan D4 is targeted the highest priority area of Ambovombe city and the coastal areas, and the beneficiaries are about 265,000 population. The water source is located in Antanimora sites of F006 and F006B, the 60km northwest of Ambovombe city. Therefore, it is possible to plan by the gravity flow pipeline system in the Study area. The water source of groundwater confirmed at F006B is good quality of water within the WHO water quality standard that Electric Conductivity (EC) is about 100mS/m. There are also serious shortage of drinking water without any steady water supply systems, therefore the development of groundwater and supply water solves the problems for drinking, cocking, washing, showering and other purposes of water in the coastal area and Ambovombe city. The estimated cost of water by 13 litters of bucket is the 35 to 40 Ar/ bucket in Ambovombe city considering water supply of 200m^3/day, on the other hand the 20 to 30 Ar/ bucket in coastal area considering water supply of 500m^3/day including cost of operation and maintenance and 15 yeas renewable cost. The water supply facility and daily water supply rate is designed based on the unit water consumption of 10 l/day/capita and in the area. The Plan D4 is the sustainable and autonomic water supply plan due to the water charge including the cost of operation and maintenance and 15 yeas renewal cost within the beneficiaries' willingness to pay of 50 to 100 Ar/ bucket against the present cost of 100 Ar/ bucket. However, there are disadvantage of long pipeline at about 120km from the water source of Antanimora to the supply area of Antaritarika via Ambovombe city. The water supply system is divided into two stages namely Antanimora to Ambovombe city and Ambovombe city to Antaritarika about 65km pipeline and 55km, respectively. Figure 8.3.2-1 shows the outline of the water supply system of Plan D4 based on the topographic survey in 2006.

3) Rehabilitation of Existing Pipeline: Plan S2:

The existing water supply system with 142km pipeline from Ampotaka to Tsihombe city was completed by the Japanese cooperation in 1997 to 1999. However, it is in the hard situation for operation and maintenance of the existing pipeline system due to increasing fuel cost and lack of water tank trucks to sell the drinking water to the villages. Therefore, the rehabilitation of the existing pipeline system including improvement of pumping system for solar generation due to decrease the fuel cost.

The design of existing water supply system with pipeline in 1997 is as follows:

1) Supply population: 80,437 population
2) Supply capacity: 284 m^3/day
3) Water treatment plant at Ampotaka with 142km pipeline: pipe diameter φ74 mm to φ160 mm

The proposed rehabilitation plan S2 is included as follows:

1) Rehabilitation of 5 pumping stations:
   Installation for 5 sets of new solar pumping system, the capacity 50 m^3/day by 6 hours operation
2) Repair and maintenance of existing diesel generators at 4 stations of 8 generators
3) Maintenance of existing pipeline for protection and leakage
4) Embankment at water intake point to protect from erosion at Ampotaka

The water charge is officially settled by AES at 100 Ar/bucket of 13 litters in 2006, but it is expensive for villagers to buy water. The annual report of AES in 2005 indicates the water supply amount from existing pipeline system is only 2,465 m^3/year (6.8 m^3/day). It is very small water supply amount. On the other hand, the production cost was reported Ar37,116,000 excluding manpower cost, therefore the unit production cost is 196 Ar/bucket of 13 litters excluding manpower cost, and 392 Ar/bucket of 13 litters including estimated manpower cost against the selling water charge of 100 Ar/bucket of 13 litters in 2006. Production cost is the 4 times of selling cost,

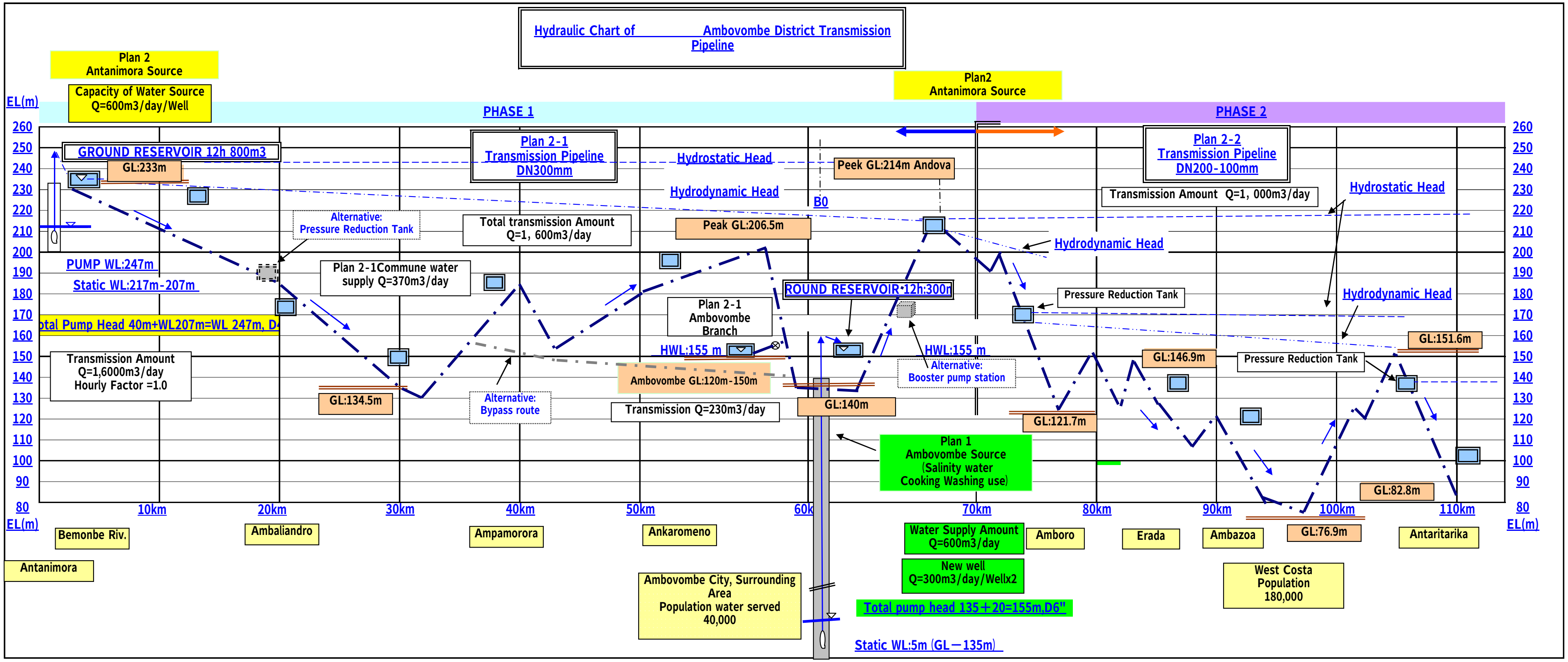


Figure 8.3.1-1 Hydraulic Chart of transmission pipeline

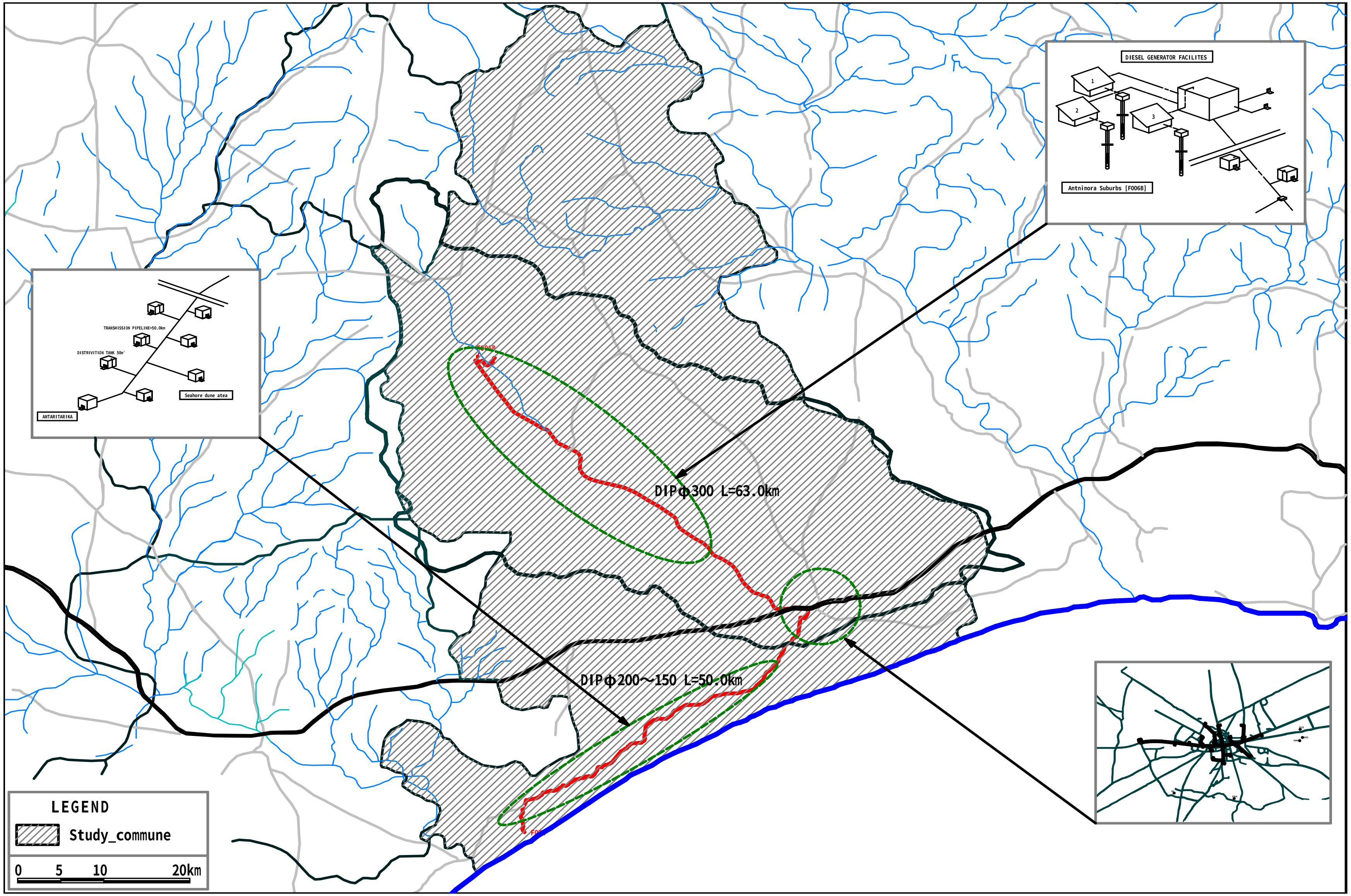


Figure 8.3.1-2 Antanimora Suburbs[F006B]/Ambovombe City+Seshore dune Area Water Supply Plan

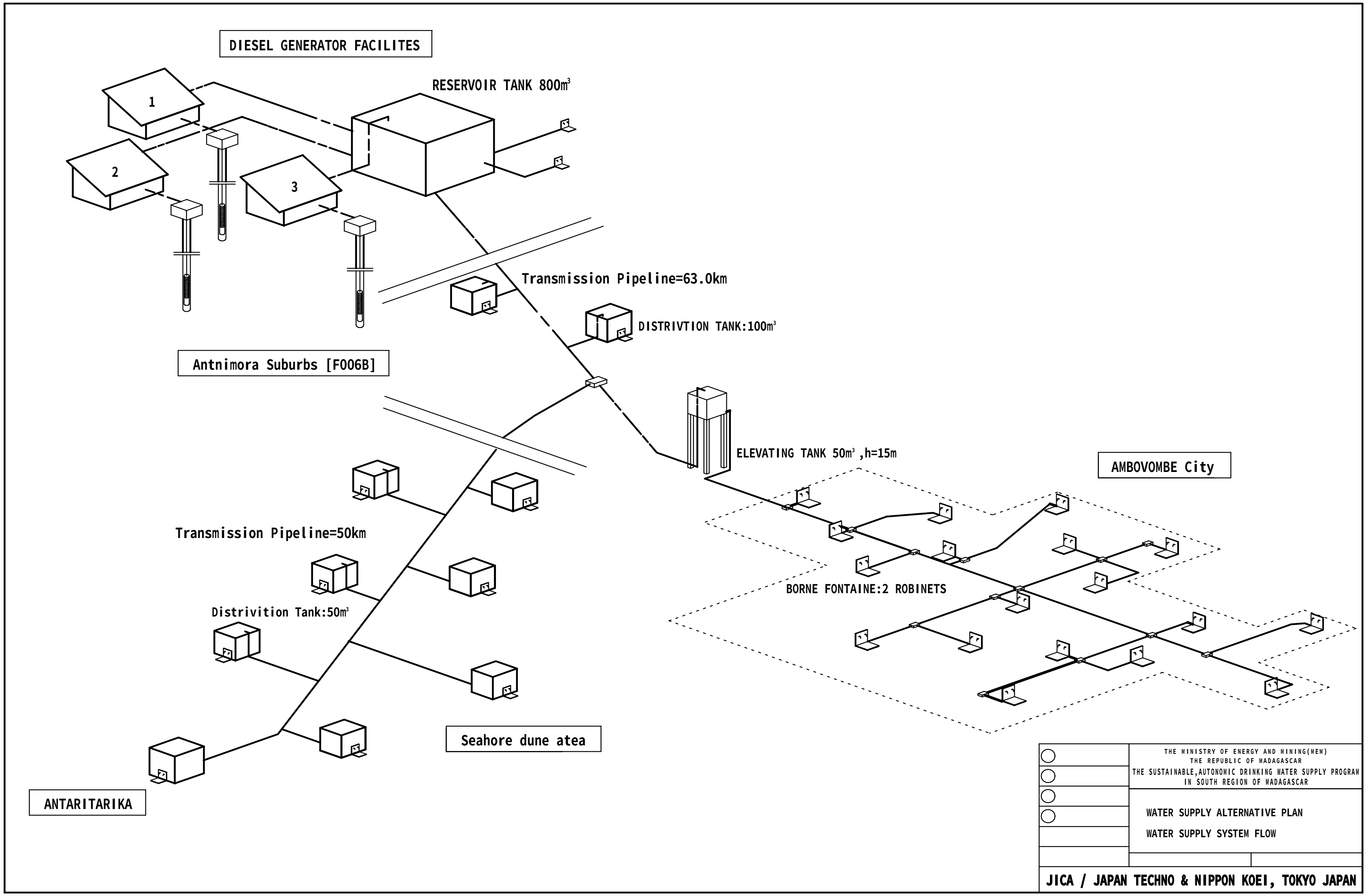


Figure 8.3.1-3 Antanimora Suburbs[F006B]/Ambovombe City+Seshore dune Area Water Supply Plan System Flow

8.4 Cost Estimation

The rough cost estimation of water supply facilities for each of alternative Plan are shown in the following table. The cost is only direct construction cost excluding overhead and indirect cost.

Table 8.4 -1 Cost Estimate of Plan D1, Plan D4 and Plan S2

Plan	Facility	Specification	Daily Maximum Supply Capacity	Total Cost	Production Cost	OM Cost(Monthly production cost)
Plan D1	Borehole (F015)	Ambovombe city (Level 2)	600 m^3/day	Ar2,340millon ¥130,million	Ar1,539/m^3 ¥86/m^3	Ar16.5million ¥920,000/month
Plan D4	Borehole (F006B)	Pipeline 120km to Antaritarika	1600 m^3/day	Ar41,000million ¥2,300million	Ar1,154/m^3 ¥64/m^3	Ar16.2million ¥900,000/month
Plan S2	Rehabilitation	Pumping station (F/U) by solar	50 m^3/day	Ar900million ¥50millioon	Ar6,154/m^3 ¥341/m^3	Ar.9.2million ¥510,000/month

8.5 Project Implementation Program

The project implementation program is shown in Figure 8.5 – 1.
The alternative plan will eventually require the implementation of the project, based on the priority of politically and financially. At the same time, we are strongly recommended to the support of AES technical and management and Follow up (F/U) works.

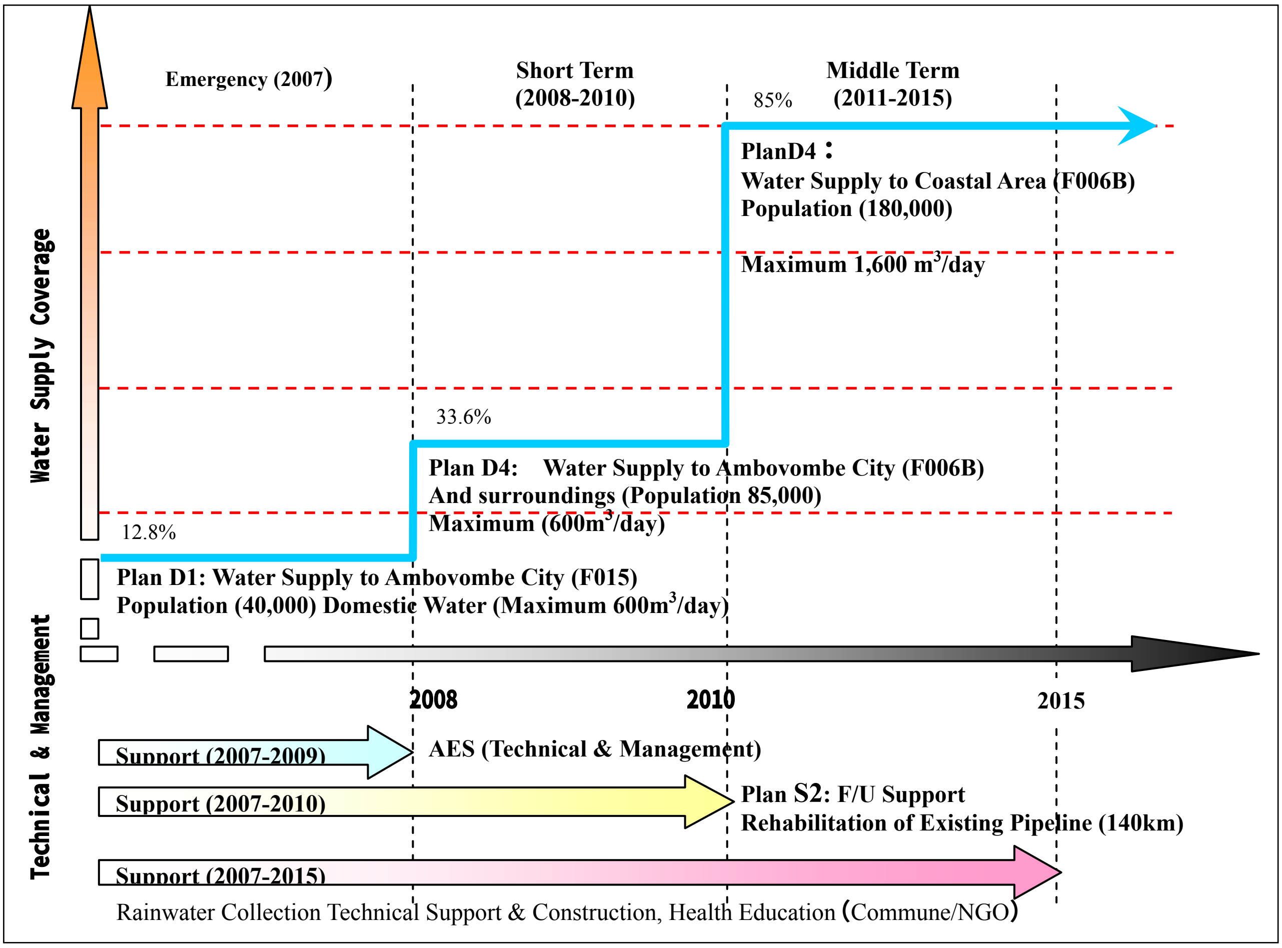


Figure 8.5-1 Water Supply Master Plan (2007—2015)

Table 8.5-1 The Population Water Served and Water Supply Amount

		Emergency	Short- Medium-term		Remarks
		D1	D4-(1)	D4-(2)	
		Ambovombe Ground Water Source	Antanimora Ground Water Source		
Target Unit Daily Average Water Consumption per Capita (l/day/cap.)		10	10	10	
Population in Administrative District	Part of Antanimora		5,000		
	Village on the way		57,000		
	Ambovombe City, Surrounding area	40,000	23,000		
	Costa			180,000	
	Total	40,000	85,000	180,000	
Water served ratio		100%	50%	50%	
Population water served		40,000	43,000	90,000	
Daily Average Water Consumption (m3/day)		400	590	900	A.
			133,000		
Daily Average Water Supply Amount	B. Effective Ratio	90%	90%	90%	Leakage ratio (10%)
	(m3/day)	440	430	900	
Daily Maximum Water Supply Amount	C. Load Factor	70%	70%	70%	Rainy season: 30%
	(m3/day)	D. 630	D. 690	D. 1,430	D=A/(BxC)
			D. Total 2,120		
Capacity of Transmission Pipe (m3/day)		E. 600	E. 1,600 Due to DN300mm Transmission pipeline capacity		Max. of water supply amount
Capacity of Water Source (m3/day)		600 Due to Max. capacity of wells	600	1,000	Same as capacity of the Transmission Pipeline
			1,600 Same as Capacity of Transmission Pipe		
Deficit Amount (m3/day)		30	520		D-E
Population Covered by Maximum Water Supply Amount		38,000	380	63,000	ExCxB/10 (l/day/cap)
			101,000		

8.6 Water Charge

8.6.1 Evaluation of Water Charge in 2005

When we consider the new water charge we should review the present water charge and production cost. Table 8.6.1-1 shows the sold water and cost for the production in 2005. The AES activities consist of three different categories as follows.

1) The Ambovombe system mainly for water tank trucks to supply water
2) The Tsihombe -Beloha pipeline system
3) The 5 water supply centers of AEP/AES

1) The Ambovombe System by Water Tank Trucks

The Ambovombe office supplies the water by water tank trucks which procured by Japanese grant assistance in 1990's. At that time, it was 24 water tank trucks procured, but only 2 water tank trucks worked and supplied water of 6,612m^3/year (18m^3/day) in 2005. The estimated production cost is 126Ar/bucket of 13 litters against the official water charge of 100Ar/bucket. On the other hand, it is also sold the water by a unit of water tank truck of 6m^3 estimated as 75,000Ar/unit (168Ar/bucket) in 2006 due to increase the cost of fuel. The fuel cost was 347FMG/litter (31¥/litter) in 1990, 1,700Ar/litter (94¥/litter) in 2005, and 2,200Ar/litter (122¥/litter) in 2006. The Amboasary treatment plant with water tank trucks, about 35km away from Ambovombe city, supplied water at about 200m^3/day in 1990's, however it is main water source in Ambovombe city by AES dug well of about 40m^3/day capacity by motorized pump in 2006.

2) The Tsihombe-Beloha Pipeline System

The Tsihombe-Beloha pipeline system consisting of water treatment plant with 142km pipeline was constructed by Japanese grant assistance in 1997 to 1999, supplied water about 280m^3/day for 80,000 beneficiaries in the early 2000's. The 7 years average of water supply amount after the completion of the system by pipeline with 7 water tank trucks was 70m^3/day in 2005. On the other hand, recent water supply in 2005/2006 was only 7m^3/day with 2 water tank trucks due to increased fuel cost and reduced water tank trucks. The estimated production cost is 392Ar/bucket of 13 litters against the official water charge of 100Ar/bucket.

3) The 5 Water Supply Centers of AEP/AES

The water supply amount of the 5 centers of AEP/AES namely Antanimora, Andalatanosy, Beraketa, Isoanala and Tsivory supplied groundwater to the 5 towns was 26,385m^3/year (72m^3/day) in 2005. The estimated production cost is 64Ar/bucket of 13 litters against the official water charge of 100Ar/bucket. It is profitable water due to including house connection, solar pumping system with groundwater sources excluding the water service trucks. Therefore, AES tried the individual water supply management system same as individual AEP/AES supply center.

Table 8.6.1-1 Water Production Unit Cost of AES in 2005

A) Total Supply Unit Cost (AES Total: Including Subsidy about 50% of total expense of AES which is nearly equal of the manpower cost; Including manpower cost)					
Items	Water Supply (Amount) (A)	Total Expense (B)	Total Income (C)	Production Unit Cost (B/A)	Remarks
	(m^3/year)	(Ar)	(Ar)	(Ar/bucket)	
	36,116	293,130,856	28,063,377	**105**	

B) Brake down of Production Unit Cost					
Items	Water Supply Amount (A)	(*Production Expense) (B) (Excluding manpower cost)	Water Charge Receipt (C)	(*Production Unit Cost) (D=B/A) (Excluding manpower cost)	Estimated Production Unit Cost (D*2) (Including manpower cost)
Ambovombe System	7,266 (Including 6,612m^3 delivered by Water Tank Truck)	34,974,200	-	63	126
Tsihombe-Beloha Pipeline System	2,465	37,116,021	14061738	196	392
Sub Total	**9,731**	72,090,221	-	96	**192**
*Above two Systems at supply Center					*(100)
5 AEP/AES	26,385	63,300,592	54,489,605	32	64

8.6.2 Consideration of Water Charge for the Alternative Plans

The profitable line of water charge is estimated as follow based on the minimum water supply amount, less than the 10% of daily average water supply amount, and operation and maintenance cost.

Table 8.6.2-1 New Water Charge by Alternative Water Supply Plan

Items	Plan- D1 AMBOVOMBE SOURCE	Plan- D4 ANTANIMPRA SOURCE		Plan- S2 REHABILITATION OF EXISTING PIPELINE	Remarks
1. Daily Max Water Supply Amount (m^3/day)	630	2,040		50 (Capacity: 1unit Solar generation)	Water Consumption: 10 l/day/cap
2.Daily Average Water Supply Amount (m^3/day)	440	**690**	**1,430**	*50	Daily average: 70% of Max. supply amount
3.Daily Maximum Water Supply Amount (m^3/day)	600 (Capacity: 1well)	**600** 1,600(Capacity: pipeline of DN300mm)	**1,000**	*50 (Capacity: 1unit Solar generation)	Amount: due to the capacity of the facilities
Pump operation time in Average	Diesel operation：8 hour/day or less Solar pumping operation：6 hour/day or less				Daily Operation
Minimum Water Supply Amount for profitable line of water supply (m^3/day)	400	200	500	*50	Set Amount of Minimum profitable line of the water supply
A Case A – Charge of Profitable line (Ar/Bucket)	20	23	15	80	Excluding facility renew cost
B Case B – Charge of Profitable line (Ar/Bucket,)	25	35	20	130	Including facility renew cost (Pump, and generator)
C Other overhead (Ar/Bucket,)	5-10	0-5	0-5	-	
New Water Charge (Profitable line) (Ar/Bucket,)	**30-40**	**35-40**	**20-30**	**80-100** Present charge=100	(Excluding Existing Pipeline System)
Note	Self-support accounting is available.	Self-support accounting is available.		*Self-support accounting is not available	*Due to Small amount of Solar generation
Available Population water served	**38,000**	**101,000** **38,000**	**63,000**	**80,000 (Design population)**	Due to hydraulic condition

Note) Facility renew cost is including only Pump and Generator.
Note) Facility renew cost is including only Pump and Generator.

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Chapter 9 ENVIRONMENTAL AND SOCIAL CONSIDERATION

9.1 Background

9.1.1 JICA Guidelines for Environmental and Social Consideration

To correspond with the growing concern for environmental and social consideration in development towards sustainable society, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), has established in April 2004 "the Japan International Cooperation Agency Guidelines for Environmental and Social Considerations" (hereinafter referred to as "JICA guidelines"). From the date of its validation, all development studies, preliminary studies of grant aid projects and technical cooperation projects conducted by JICA must take the procedures stipulated.
The procedures are stipulated according to the types of projects, and each project is categorized into Categories A, B and C depending on the impact prospected. The type of this study is a Development Study (Master Plan), and is categorized to Category B.

9.1.2 EIA System in Madagascar

The Madagascar Government enacted "la mise en compatibilité des investissements avec l'environnement" (Decree No. 99-954, hereinafter refer to as MECIE) in December 1999 which establishes the procedures of the Environmental Impact Assessment (EIA) system in the nation. In 2004, the decree was modified through decree No. 2004-167.
The types of projects and their scale stipulated to be targeted for EIA or EEP are defined in detail in Appendices I and II accordingly, and, among others, the projects concerned with this study (Master plan) is given in the table below.

Table 9.1.2 -1 Types and scales of projects for EIA and EEP concerned with this study

Type	Scale of project for EIA	Scale of Project for EEP
All activities	Any installation, work and activity in sensitive areas*	-
All activities	Any plan, program or policy potentially altering the natural environment or the use of natural resources, and/or the quality of the human environment in urban and/or rural areas	-
Excavation of earth	Over 20,000m^3	-
Pumping of water	Exceeding 30m^3/h	-

*note: sensitive areas are defined in Decree No.95-377 and 92-326, and among others, areas which have possibility of being targeted in this study is: arid or semi-arid areas which might be decertified.

9.1.3 Results of Consultation with ONE

(1) Date and the personnel whom consulted
- Date: 24-5-2005
- Personnel: ANDRIANAIVOMAHEA Paul, Director of the Environmental Evaluation, ONE
- Attendant: Razanmihaja M E RAKOTOMAHARO, Director of the Water and Sanitation, MEM
  Marcel RAKOTOMAVO, MEM

(2) Results
- Summary of the project along with the draft scoping was submitted.
- Taking into consideration that the area of the development is limited within the target area, and also that the objective of this project has highly social needs, it was decided that there are no needs for the Environmental Permit, and thus, EIA as stipulated in the MERCIE.

9.1.4 Principal on the Environmental and Social Consideration in this Study

As stated above, it was decided that EIA bas stipulated on the MECIE is not needed to be conducted for this plan. Therefore, full-scale EIA shall not be conducted for the environmental and social consideration in this study, but conduct an IEE level consideration instead.

9.2 Summary of the Master Plan

9.2.1 Background of the Plan

The target area, which is southern region of Madagascar, is suffering from lack of drinking water, due to very arid climate (annual precipitation being 400-500mm) and non-existence of water resources such as rivers and wells. In particular, in the coastal areas south of Ambovombe people are forced to buy expensive water from the water venders, because there are almost no groundwater resources, very little rain, and the public water trucks are broken time and time again.

9.2.2 Objectives of the Plan

The objectives of the plan is to formulate a water supply plan which supplies safe water, sustainable and autonomously.

9.2.3 Target area of the Plan

(1) The target water supply area is Ambovombe and the surroundings as well as south of National Route 10 between Ambovombe and Tsihombe to the coastal areas. 15 communes are involved, with the target population being 277,980 (as of 2005)
(2) Groundwater development area is the target area as well as along the National Route 13, towards Antanimora.

9.2.4 Summary of Water Supply Plan

Summary of water supply plan alternatives is shown on the table below.

Table 9.2.4-1 Summary of water supply plan alternatives

Plan	Summary	Water Source	Water Supply Area
D1	・Water supply facilities to supply urban Ambovombe utilizing water source in the outskirts of Ambovombe (Using diesel generator)	Borehole in the outskirts of Ambovombe (near F015)	Urban Ambovombe
D2	・ Same as above, but utilizing JIRAMA electricity	Same as above	Same as above
D3	・Water supply facilities to supply coastal dune area utilizing water source in the outskirts of Ambovombe (Using diesel generator)	Same as above	Coastal dune area
D4	・Water supply facilities to supply urban Ambovombe and the coastal dune area utilizing water source at Antanimora (Using solar pumping system)	Borehole at Antanimora (near F006, F006B)	Urban Ambovombe and the coastal dune area
D5	・ Same as above (Using diesel generator)	Same as above	Same as above
D6	・Water supply facilities to supply urban Ambovombe utilizing water source at Antanimora (Using diesel generator and gravity force)	Same as above	Urban Ambovombe

9.3 Current situation of the Target Area

9.3.1 Natural Environment

(1) Climate and Hydrology

The target area is in the most arid region of Madagascar.

To the east of the target area flows the Mandrare River, and to the west flows the Mananvovo River, but there are no continuous river flowing throughout the season within the Ambovombe Basin or the coastal dune area.

(2) Topography, Geology, Hydrogeology

The altitude of the Ambovombe ranges from 120 ~250m above sea level and it is gradually undulating down towards south west. The altitude at Ambovombe is the lowest in the area, showing 130 ～136m a.s.l. In the south, along the coastal area, lays sand dune with altitude ranging from 150 – 300m.

The geology of this area can be classified into 3 types: Pre-Cambrian basement zone in the north, thick young sediments in the Ambovombe Basin and coastal sand dune in the south.

Hydrogeologically, in the basement rock area around Antanimora, there is relatively good confined water, and on the other hand, in Ambovombe basin and costal dune areas where thick sediments are deposited, there is highly saline unconfined water.

(3) Ecosystem

The target area is in the most arid region of Madagascar, and the soil is sandy and dry, meaning that it is bad condition for the plants to grow. However, even under this crucial condition, some plants adapted to the environment and there grows many unique plants which are endemic to this area. Because of this uniqueness, the whole Southern Madagascar (including the target area) is designated by the WWF as one of the Global200 (238 ecosystems are selected around the world for its importance).

In the Ambovombe basin, in particular on both sides of national route 13 from Antanimora to Ambovombe, semi-arid forest dominated by Didieraeceae family (endemic family in Madagascar) such as *Allaudia procera, A. dumosa, Diderea Trollii*, as well as Euphorbiaceae family typified by *Euphorbia plagiantha, E. stenocrada* can be seen. *Cederelopsis grevi (Ptaeroxylacae)*, although it is not a dominant species, should be listed as the common shrub in the area. This kind of semi-arid forest should have been a dominant type of vegetation before, but because these trees are useful resources to the people, in that these can be used as fuel wood, charcoal for commercial purposes, and timber for construction use, now these spiny semi-arid forest remains only in small areas. As far as the target area is concerned, relatively dense and mature forest spreads along the NR13 especially to the south-east of Antanimora, and along the secondary road toward Ambondro. Fig. 9.3.1-1 shows the area where this relatively dense semi-arid forest distribute, based on the ground survey and the satellite images.

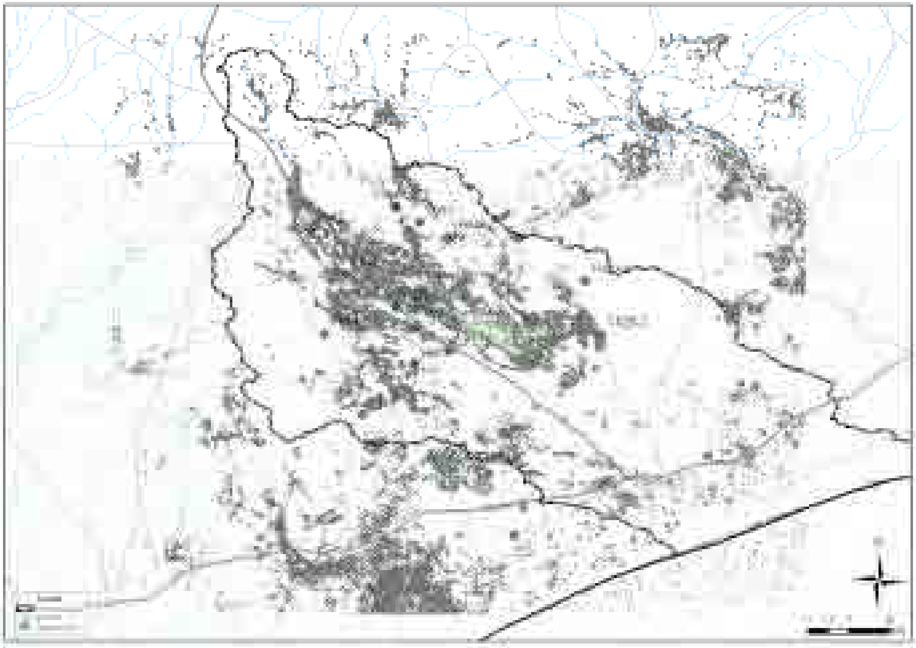

Fig. 9.3.1-1 Distribution of dense semi-arid spiny forest in the Target area

It should be noted that during the survey, many groups of Verrreaux's Sifaka (*Propithecus verreauxi*) were observed, and on other occasion, Ring-tailed Lemur (*Lemur catta*) was seen, both within this dense forest. Both of these species are ranked "vulnerable" in the IUCN Red List of threatened species. As such, it can be easily evaluated that this forest is very important for the ecosystem in the area.

On the other hand, the coastal sand dune area is mostly covered by either bare land or cultivated land, but in such areas as around the cemetery, natural vegetation (semi-arid forest) are well-preserved accordingly by the local customs.

9.3.2 Social Environment

(1) Administration System and Population

The target area is consisted of 1 Province, 1 Region, 2 Districts and 15 Communes. As of 2005, the total population of the area is 277,980 and of these 38,213 is living in the Ambovombe Commune, which is the central town of the area.

Also, the population growth of the target 15 Communes is 35.5% for the past 3 years, which is higher than the growth rate of the whole region. According to the logistic curve analysis, it is predicted that the population is expected to grow to 306,000 by 2015.

(2) Society and Culture

The dominant ethnic group in the area is the Antandroy. Main religion is Christianity, constituting about 60% of the population if 3 main groups (Protestant, FLM and Catholic) are combined. However, traditional belief is still important religion, with about a quarter of the population following the belief.

The land ownership in the area is in general legally owned by the state, but practically village leaders or clam chief (*olom-be*) decides land distribution for cultivation. Therefore, upon deciding the position of the borehole, it is important to consult with the village leader beforehand. In addition, there are lands such as cemetery or sacred forest that is forbidden to do any kind of activities, meaning a need to take extra care in using land for such as boreholes or water supply facilities.

Although it is changing in the recent years, women are generally seated at the back of the meeting place and have little chance to say their opinions. Drawing water is principally woman's job if the water source is within walking distance, but if the water source is far away from the village and needs oxen cart to fetch, then it's a man's job.

(3) Economy

The main occupation of people in the target area is agriculture of root crops, followed by fishing in the coastal dune area.

Also, though not a main industry in the area, the existence of water venders in the area should be of a big concern when considering water supply plan in the area. Water venders are especially important for the people in the dry season. Many people depend on the water from the water venders in the dry season. Although some water venders depend completely on this occupation for living, most have other occupation such as agriculture, and water selling is only a secondary earning. Water venders are not organized at all, and they are not on a permissive basis from the government.

(4) Current Situation of Water Supply in the Area

The target area is in the most arid region of Madagascar, thus the water supply is in general in a very bad condition. The main water source in the area can be grouped into these groups, that is: Artificial structure using the rainwater (Bassin, impluvium, artificial pond), usage of groundwater (borehole, hand dug well, vovo), usage of surface water (Rivers, ponds, puddles) and usage of water supply services (Water tank trucks of AES, water venders).

According to the results of the social survey, 43% of the villages in the area use groundwater as the main water source, followed by rivers and rainwater. However, it should be noted that because of severe condition of water supply in the area, people tend to use any source of water that come in hand, so for example water puddles in the surroundings are used as important water source by the local people.

9.4 Results of Environmental and Social Consideration

9.4.1 Regional Economy (including employment and livelihood)

Plan No.	Possible Effects	Mitigation
D1 D2 D3 D4 D5 D6	・If the pipeline is completed and public faucets installed in the area, and people can obtain water cheaper and easier than from the water venders, then the activities of the water venders shall be definitely effected. However, because most of the water venders are not fully dedicated to this profession (most of them are farmers), there shall be only few who will go completely out of work.	・Since full time water venders are only few, there is no need to take any measures to save the water vender's job. However, as there will be new type of work such as keeper of public faucets, these are expected to be the new job opportunity for the jobless water venders.

9.4.2 Social Capital and Local Decision Making Institutions

Plan No.	Possible Effects	Mitigation
D1 D2 D3 D4 D5 D6	・When deciding the position of the well, pipeline or other facilities, approval from the village leader is a necessity. Without his approval, there can be no cooperation from the local people. ・As far as the test well sites are concerned, they have already been approved by the village leader.	・Consultation with and approval from the village leader before deciding the position of a new well, pipeline or other facilities is a necessity. In particular, special precaution is needed not to construct any facility within cemetery or sacred forests.

9.4.3 The Poor, Indigenous and the Ethnic Minorities

Plan No.	Possible Effects	Mitigation
D1 D2	・These plans are set to supply water only to urban areas of Ambovombe, meaning other areas, especially the poor areas in the coastal zone have still shortage of water.	・In the long run there is a need to construct pipeline to the coastal areas, but in a short term there needs to construct impluvia to improve the water supply status of the coastal areas.
D3 D4 D5	・There may be some unequal distribution of benefit depending on the arrangement of the public faucets.	・Arrange the public faucet to avoid inequity as much as possible.
D6	Same as D1,D2	Same as D1,D2

9.4.4 Inequitable Distribution of Adverse Impacts and Benefits.

Plan No.	Possible Effects	Mitigation
D1 D2	• These plans are set to supply water only to urban areas of Ambovombe, meaning other areas, especially the poor areas in the coastal zone have still shortage of water.	• In the long run there is a need to construct pipeline to the coastal areas, but in a short term there needs to construct impluvia to improve the water supply status of the coastal areas.
D3 D4 D5	• There may be some unequal distribution of benefit depending on the arrangement of the public faucets.	• Arrange the public faucet to avoid inequity as much as possible.
D6	Same as D1,D2	Same as D1,D2

9.4.5 Conflict of Interest Among the Stakeholders

Plan No.	Possible Effects	Mitigation
D1 D2 D3	• There shall be no conflicts among stakeholders since the water source and the supply area is the same.	• None in particular
D4 D5 D6	• While the water source is in Antanimora, the main supply area spreads from Ambovombe to the south. Therefore, there could be possibility of conflict between the water source area and the supply area. However, because already there is considerable amount of wells constructed in the area, and also in this project there shall be public faucet set at the source point, there is little chance of conflict raised.	• Before construction there should be explanation and agreement with the people of Antanimora area.

9.4.6 Gender

Plan No.	Possible Effects	Mitigation
All	• Since the water supply area spreads further, it can be predicted that the woman's labor shall be eased. However, there are fears that the woman's participation shall not be enough when deciding the operational and maintenance procedures.	• Upon deciding the O&M procedures, there should be enlightenment program for woman's participation beforehand.

9.4.7 Water Rights

Plan No.	Possible Effects	Mitigation
D1 D2 D3	• There shall be no conflicts of water rights since the water source and the supply area is the same.	• None in particular
D4 D5 D6	• While the water source is in Antanimora, the main supply area spreads from Ambovombe to the south. Therefore, there could be possibility of conflict of water rights between the water source area and the supply area. However, because already there is considerable amount of wells constructed in the area, and also in this project there shall be public faucet set at the source point, there is little chance of conflict raised.	• Before construction there should be explanation and agreement with the people of Antanimora area.

9.4.8 Groundwater

Plan No.	Possible Effects	Mitigation
D1 D2 D3 D4 D5 D6	• With the utilization of groundwater, there are fears of lowering of water level of the surrounding existing shallow wells such as *vovo*s. However, since the depth of the existing shallow wells are under 20m compared with the depth of the planned borehole of 60 – 150m, the target aquifer is different, so there can be no lowering of water level.	• None in particular

9.4.9 Hydrological Regime of Rivers, Lakes and Inland Waters

Plan No.	Possible Effects	Mitigation
All	• As the water source is groundwater, there shall be no effect on the surface waters	• None in particular

9.4.10 Biota/Ecosystems

Plan No.	Possible Effects	Mitigation
D1 D2	・Because this supply plan is drawing water from Ambovombe to Ambovombe, there will be no effect to the surrounding ecosystem.	・None in particular
D3	・There are only little forest remaining between Ambovombe and Antaritarika, but there still remains some endemic forest around the cemetery or sacred forest. Thus, planned pipeline or water tank might be on these forests.	・Avoid these forests upon construction as much as possible, and no development should be allowed in the taboo areas such as around the cemetery or sacred forests.
D4 D5	・There are possibility of cutting the trees of the remaining good forest between Antanimora and Ambovombe.	・The main pipeline should be laid along the National Road, to minimize the cutting. Also, it is inevitable to some extent for cutting down some parts of the remaining forest between the water source and the National Road, but the area of cutting down should be minimized as much as possible.
D6	・Between Antanimora and Ambovombe the same as D4, D5 ・Between Ambovombe and Antaritarika the as D3.	・Between Antanimora and Ambovombe the same as D4, D5 ・Between Ambovombe and Antaritarika the as D3.

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CHAPTER 10 INSTITUTION FOR OPERATION AND MAINTENANCE

10.1 Operation and Maintenance of Water Supply Systems

10.1.1 Establishment of Community-based Organization

Under the Pilot Project in this Study in 2005/2006, the Water Point Committee (CPE) was established and operated the water facilities such as solar pumping system, pump rope and pump Vergnet. The JICA Study Team assisted the village to formulate the CPE through the local NGO and to explain the operation and maintenance by the beneficiaries and to pay water charges for themselves. As the results of monitoring of the activities for CPE in 2006, the Study Team concluded that it was very important for the villagers to operate and maintain the water facility themselves at the same time the experienced organization of AES supplying water in the area was most suitable organization for the operation and maintenance of water supply system for direct and/or indirect support to the CPE water supply facilities in the area.

10.1.2 Organization of AES

The AES was established in 1982 operating water supply in the Study area, having office in capital city of Antananarivo and the regional office in Ambovombe city in the center of the South Region of Madagascar. The technical office of Ambovombe gives operation and maintenance for water supply in the area. Moreover, the AES has an area office in Beloha city, and a liaison office in Tsihombe city in the water supply area of Beloha-Tsihombe pipeline system that was established by the assistance of the government of Japan in 1995 to 1999.

The AES has acted as a main agency for the water supply project in the South Region of Madagascar more than 25 years. Main water supply facilities belong to AES and maintenance support as follows:

1) Ambovombe water tank truck system
2) Pipeline system of 140km in Beloha to Tsihombe city
3) Groundwater supply in communes with solar pumping system namely 5 AEP Centers
4) Maintenance support at 7 villages of CPE solar pumping systems
5) Groundwater development with handpump facilities assisted by World Bank and UNICEF

Based on the studies of the Consultants of World Bank and the AES himself, the proposal for the improvement of the AES was discussed many times together with the MEM and concerned agencies from September 2005. The important symposium sponsored by MEM for the viability of drinking water supply in the South was held on the 24th and 25th March, 2006 in Ambovombe city to discuss the multiple solutions. It is possible to improve the present situations of AES, technically and financially, but it is impossible without any investment and/or technical improvement and innovation of management of the existing system due to the main income coming from the sold water by AES. It is only 36,000m^3/year and/or about 100 m^3/day in 2005. Therefore, the new project and/or rehabilitation of existing water supply facilities gives impact in the area and any other operation and maintenance shall be managed by AES.

Therefore, the AES is the most important organization for water supply and operation and maintenance in the South Region of Madagascar, now and in future. The AES has more than 25 years experienced in various types of water facilities to operate and maintain in the Study area.

10.1.3 Financial Aspect of AES

The most current expenditure of AES is composed of operation cost of water tank truck in the Ambovombe and Tsihombe - Beloha pipeline systems. The current financial balance is shown below the Table 10.1.3-1. The financial aspect from 1999 to 2005 became recently batter situation than the before. Table 10.1.3-2 shows the water production unit cost by AES in 2005.

Table 10.1.3 -1 Financial Aspect of AES from 1999-2005 (in Ariary)

Year	Water charge	Operation Cost	Balance (1999-2004)	Subsidy from the State
1999	107,601,955	372,327,788	236,535,100	(63.5%)Subsidy
2000	190,421,539	495,501,068	312,719,400	(63.1%)Subsidy
2001	184,558,000	496,677,400	312,119,400	(62.8%)Subsidy
2004	**106,682,323**	**251,329,333**	**-144,647,010**	**- (57.6%)**
2005	**57,212,675**	**58,626,171**	**-1,413,495**	**-(24.1%)**

Data: AES, Annual Activities Report, February 2006

The AES water supply amount in 2005 was 36,116m^3/year (98.9m^3/day) and the average supply unit cost was 105 AR/bucket of 13 litters excluding manpower cost in 2005 as shown Table 10.1.3-2.

1) Ambovombe water tank truck system supplied water 7,266m^3/year (19.9m^3/day) to the area , and the estimated production cost was 63 AR/bucket excluding manpower cost in 2005.
2) Tsihombe-Beloha pipeline system supplied water 2,465m^3/year (6.8m^3/day), and the estimated production cost was 196 Ar/bucket excluding manpower cost in 2005.
3) The 5 AEP/AES water supply center supplied water 26,385m^3/year (72.3m^3/day) , and the estimated production cost was 32 Ar/bucket excluding manpower cost in 2005.

Due to the increasing the fuel cost, however the AES endured the operation and maintenance for water supply in their hand, but the only the income came from the water production of 36,116m^3/year (98.9m^3/day). Therefore, the AES needs more water production.

Table 10.1.3.-2 AES Water Production and Unit Cost in 2005

Items	Water Supply Amount (m^3/year)	Expense (Ar)	Income (Ar)	Supply Unit Cost (Ar/bucket)	Remarks
	A	B	C	B/A	
Total in 2005	**36,116 (98.9m^3/day)**	**293,130,856**	**286,063,377**	**105**	Including Subsidy (about 50% of total expense)
Brake down	Water Supply Amount	Production Expense	Water Charge	Production Unit Cost	Excluding personnel cost
1) Ambovombe System	7,266 (19.9m^3/day)	34,974,200	-	63	Including 6,612m^3/year (18.1m^3/day) delivered by Water tank truck
2)Tsihombe-Beloha Pipeline System	2,465 (6.8m^3/day)	37,116,021	14,061,738	196	
Sub Total	9,731 (26.7m^3/day)	72,090,221	-	96	
Supply Service Center				*(100)	
3)The 5 AEP/AES	26,385 (72.3m^3/day)	63,300,592	54,489,605	32	

Data: AES, 2005 Annual Activities Report, February 2006

10.1.4 Recommendation to AES for Improvement and New Institution in the Area

The AES is the experienced good institution for water supply and operation and maintenance of water supply facilities in the South Region of Madagascar. The followings are the recommendation to AES for improvement of the institution.

When new water supply project starts, AES selects and forms the working group individually depend on the scope of project. The AES new management of the project working together with donor and/or himself is requested. The proposed sustainable, autonomic drinking water supply program in the south region of Madagascar shall recruit the intelligent manager, at first from AES and organize the project team working together with Japanese team based on the experiences of this Study. After the completion of the project for water supply in the south region of Madagascar, the trained AES team shall be worked operation and maintenance for the project. The plan of staff arrangement and rule of new water facilities is shown Table

Table 10.1.4-1 Plan of Staff arrangement and the roles for the new facilities

Place		Kind of occupation	No of Staff	Role	Organization
Steering Committee		Committee/Auditing officer		Commitment/Auditing	Government: MEM, District, Commune
HQ: Ambovombe		Water Supply Engineering and Assistant staff	Several person (including General Manager)	Overall control of the Management /Engineering	Government: AES
		Secretary	Several person	General Affairs and assistance of the General Management	
		Technician: Plumber, Mechanic and Electrician	Several person	O/M of the facilities (Operation, repairing, patrol of the facilities, leakage control)	
		Accounting Section	Several person	Accounting	
		Human resources	Several person	Labor control/ training of the staff	
		Material Management	Several person	Management/procurement of Materials/equipment	
		Service Section	Several person	Overall control/accounting of Water sale and collection of the charge.	
		Other staff	Several person	Driver, security, other roles	
Water Source Office		Operator, Leakage Control	Several person/place	O/M of the facilities (wells, pumps, reservoir pipeline)	Government: AES or Consignment
Supply Center	Ambovombe City	Water sales	Same as No of supply place=(1 chief and about 20staff and consigners)	Water sale and collection of the charge. O/M of the Service Facilities	Government: AES or Consignment
	Commune/ Fokontany	Water sales :Sell on consignment	Same as No of the supply place= (20staff)	Water sale O/M of the Service Facilities	Water committee of Commune/Fokontany or Consignment
Others(AEP)		O/M of the Existing facilities	Adjust with new organization		

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CHAPTER 11 PROJECT EVALUATION

11.1 Economic and Financial Evaluation

In this Study the water supply alternative plans are designed to satisfy the basic human needs (BHN) and reduction of poverty of villagers and level up the their living standard especially for water environment, who are mostly living in the remote area from the water sources and the dryness area of southern part of Madagascar. A total of 5 sites in the Study have been constructed three types of water supply facilities namely the solar pumping system, pumps vergnet and pumps rope. Similar to the Pilot Project sites, the villagers received a variety of direct as well as indirect benefits as follows:

The direct benefits include, among others, the followings.
1) Increased the volume of water in a day
2) Sanitation and health improvement
3) Time savings to carry water from outside the village
4) Reduced the hard work to carry water
5) Save the money to buy high cost of water from water vender

Furthermore, the expected indirect benefits can be lists as follows.
1) Increase in economic development owing to more time and greater opportunities for cash generation such as horticulture and livestock activities
2) Reduction in morbidity and mortality of children as a result of improvements in sanitation and increased time for women to care the children
3) Increased activities of the rural population for community development as a result of organized water committee

On the other hand, proposed water supply plans including pipeline system were evaluated technically and financially. And economic evaluation confirms that the economic benefit will exceed the cost if the water supply system is run properly. The review of existing water supply condition in South Region of Madagascar, AES sold the water actually 36,116m3/year at about 100m3/day in the area in 2005. There is serious shortage of water in Ambovombe city and coastal area, therefore the first alternative plan proposed supply capacity of 400m3/day assuming the economic benefit and reducing water charge of 100AR/bucket of 13litters. The water charge is expected 50AR/bucket against official rate of 100AR/bucket in 2006.

Moreover, it is assumed that improvement of water supply service will bring larger positive effects socially than the economic one. It is expected to contribute to development activities in the area and favorable economic effect caused by this development would spread further.

11.2 Environmental Evaluation

This study is the groundwater development and alternative sources for water supply systems. Considering environmental points of view the water supply project for Ambovombe city and coastal area is not huge project to affect the environments, seriously due to groundwater development and installation of pipeline. However the water supply system should be sustainable operated and managed in the long terms more than 10 years. Therefore, the four items consisting of groundwater pumping and construction of pipeline shown as follows should be monitored.

1) The influence for existing boreholes of water level changes by the groundwater pumping
2) The saline water intrusions and/or water quality changes by groundwater pumping
3) The land subsidence by groundwater pumping for water supply system
4) The damage of natural environment by construction of pipeline

On the other hand, considering Ambovombe city water supply there are no serious environmental affects by the implementation and operation for the project. However, the stable water supply to the city and surrounding villages is increasing wastewater in the area, therefore the environmental sanitation should be considered by the inhabitants themselves. Positive impacts of this project such as improvement of the living conditions increasing multi purposed water to the people and the reduction of labour work of women and children to carrying water, provision of stable and safe drinking water, and encouragement of economic activities in the areas are considerable while negative impacts are not counted.

11.3 Evaluation on Organization and Institution

Concerning water supply services in the Study area AES/MEM has been making effort to improve the service continuously. Financially AES has to be a self-contained status and making an appropriate profit for the support of CPS/Commune and Fokutan are heavily depending on water supply from AES. When the entire institution of AES and/or new organization, if any is focused, it is observed that more efficient service and more effective contact with the beneficiaries are encouraged under the organization’s strategy. In this Study the Study team recommended to existing AES to promote the water supply services as new systems due to his long experiences in the problematic area.

The Pilot Project was implemented to confirm the feasibility of the village level water supply policy for operation and maintenance. During implementation of the Pilot Project the problems are verified and the applied water point committee organization & institution were evaluated. The Water Point Committee (CPE) hardly had this kind of operation and maintenance experience to start up a brand new water supply system due to the remote area from city and beyond their knowledge, and Study Team/MEM that was in charge of this Study implementation of this Pilot Project was a good opportunity to get valuable knowledge and experience. Especially the applied approach holding open discussions with the stakeholders such as the CPS/Commune and Fokutan and villagers in the workshop and/or individual meetings during the planning and implementation stages through the sub-contracted local NGO. It is considered that these knowledge & experience were absorbed within AES.

Existing water supply organization of AES has basically a technological ability on the level of the management and operation of the water supply facilities in this region.
However, AES has relied on subsidy from the central government for years because AES assumed to operate water tank trucks as a main duty of the water supply activity for this region that compels to high cost water supply(water transportation) with short durability of water tank trucks.
Therefore a water supply with self-support accounting system as a public enterprise has not able to been achieved for AES. AES subjects to ameliorate the organization into a public enterprise based on the self-supporting accounting for further development of the organization
At the same time, it is necessary to clarify a role of the government and to establish a new system to secure the stability of water supply against unexpected economy and a social change for this district, because water supply in this region has highly public responsibility for the government and the people.
Moreover, to continue stable water supply in this region, AES should formulate water supply plan to meet resident's demand, and deepen continuous communications with the residents.
It should be opened to public water supply, the residents should participate the management, and the water

charge from resident appropriately be collected with resident's cooperation and relation.
On the other hand, it is hoped enough technical cooperation on the management and maintenance with AES side and assistant side (donor) in the future aimed to manage stable water supply including long pipeline route.

11.4 Technological Evaluation Concerning Water Supply Facility

(1) Technological evaluation

The evaluation concerning the water supply facility of the Pilot Project is shown below. Data concerning the tendency to the water pumping and consumption at solar pumping system is accumulated by recording the diary report by CPE, and the water charge for operation and maintenance collected by the CPE. The operation is excellently done as for each site of water supply facilities namely solar pumping system and pump rope and pump vergnets, and a more efficient operation will be expected based on the monitoring results and the support from AES/MEM in the future. Based on the experiences of construction, operation and management of Pilot Project especially solar pumping system, the proposed water supply plan including pipeline system shall be implemented technically well in the area using existing technology and experiences. The 6 solar pumping systems are working in the Study area from 1999 maintained by AES, and this Pilot Project indicates the improvement of technology supported by the local contractor who installed solar pumping facility with 5 years guarantee, now. Therefore, this technology for solar pumping system shall be recommended to reduce the operation cost for fuel and sustainable maintenance.

(2) Construction Work

The duration of the construction works in this Pilot Project was implemented from the late October 2005 to the middle March 2006. Although the works were done in accordance with the planned schedule, the factors, which affected the construction works in this Pilot Project, are summarized below.
1) A little delay of customs clearance and legal processes for tax exemption for solar pumping equipment
2) Deteriorated conditions of the access roads due to rainy season
3) The delay of transportation of the materials and the equipment to sites due to the bad weathers
4) The land issues, especially private opinions and attitudes by the villagers, and so forth.

The following points should be considered before the start of project.
1) To avoid rainy seasons for the construction works and allow enough time in the schedule,
2) To pay high attentions to the access roads, and ask appropriate agencies immediately in case there are some negative factors,

The construction of water supply system which we proposed in the conditions of South Region of Madagascar where there are often unpredictable factors. So far the progress of the construction works has not been diverted from the initial schedule seriously, but comprehensive plans are required to precede the rest of the schedule.

11.5 Economic Evaluation

The water supply plan proposed by this study is intended for the poorest population in Madagascar, suffering from the most adverse water conditions. In addition, the organization in charge of water supply is having financial difficulties. This is why the plan puts importance on the improvement of the living conditions of the inhabitants and the financial status of the organization concerned.

(1) Effects to be achieved through implementation of the proposed projects

1) Effects of implementation of the projects

The implementation of the priority projects D1-D6 will bring about better health conditions for all the beneficiaries through supply of good-quality water. This will result in an increase in the time of healthy state and a reduction in medical expenses. Lower water charges will also be effective for the inhabitants of Ambovombe city and the seashore district.

2) Reduction in water charges

A reduction in water charges is one of the important objectives of the plans. The priority plans, i.e. D1-D6, estimated water charges between 20 and 40 Ariary per bucket of 13 liters (see Table 8.6.2-1), which are less expensive than the current prices offered by AES and private water vendors. The beneficiaries will be inhabitants of the cities and the seashore district. However, it is necessary to consider the existence of the free water sources. Water is free at 37% of the 1,204 water sources such as rivers and ponds. For the inhabitants who use these water sources, consequently, the effect of implementation of the projects is expected to be negative. Moreover, it should be noted that a person draws and consumes water from more than one water source at prices that vary from 0 Ariary to a few hundred Ariary per bucket.

3) Improvement in water quality

An improvement in water quality is another important objective of the plans. In the priority plans, two water sources, providing groundwater of good quality from deep layers, are selected. The water currently consumed by the inhabitants is not only contaminated by E. coli but also saline. Generally, it is not appropriate as drinking water according to the standards of Madagascar and the WHO. Therefore, the implementation of the projects will bring about better conditions of drinking water for all the beneficiaries. This will in turn bring about improvement of their health and result in a reduction in medical expenses.

4) Reduction in water drawing time

Currently, the inhabitants go to the water sources more than 1 km away from their houses, which cause them to lose time. The water sources proposed by the plans, however, are not allocated to each village or each fokontany. According to the plans, a water source is 10 km away from a house at the maximum and cannot be said to bring about significantly positive effects for the beneficiaries.

(2) Improvement in the financial state of AES

According to the Annual Report of AES, its balance sheet of 2005 marked a deficit of about 1,4 million Ariary mainly due to a limited quantity of water sold. The implementation of the project D1 or D2 (conveyance of water from F015) will supply more than 600 tons of water per day at the maximum. Thus, the revenue of AES is expected to reach 1.35 million Ariary per day if it sells 440 m^3 of water at 40 Ariary per 13-liter bucket (including the renewal costs for pumps and generators) as planned. This amount is supposed to improve the above-mentioned financial difficulties of AES.

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CHAPTER 12 TECHNOLOGY TRANSFER

12.1 Technology Transfer

Technology transfer is the one of the objectives in this Study as follows.

Table 12.1 -1 Contents of the Technology Transfer

Target	Contents of Technology Transfer	
Technical Services	1.Socio-economic and household survey	1) Field survey and discussion with local agencies of district, commune, fokontany and villages 2) Household survey at village level
	2. Groundwater Potential Study and Development, and Water Resources Management Survey	1) Geophysical survey such as VES survey, IP survey and TEM survey for the selection of test drilling points 2) Hydrogeological survey and water resource inventory survey 3) Supervision of test drilling, borehole logging, pumping test & evaluation of groundwater potential 4) Water quality analysis 5) Water level measurements together with water quality changes for monthly and seasonally 6) Water quality profiling
	3.Design of Water Supply Facilities	1) Survey of existing water supply facility 2) Survey of operation and maintenance of water supply facilities 3) Survey of water treatment plan with pipeline including water source and intake facility 4) Monitoring of AEP/AES solar pumping system
	4.Operation and Maintenance (O/M)	1) Discussion of sustainable operation and maintenance for water supply facilities and alternative water supply facilities
Operation and Maintenance	Operation and Maintenance (O&M)	2) Operation and maintenance of water supply facilities at village level 3) Monitoring of Pilot Project for operation and maintenance and water charge collection at CPE level 4) Discussion of daily record and report for O & M at CPE level and technical assistance from MEM/AES 5) Discussion of water charge for O & M including renewable cost record and report the daily data

12.2 Implementation of the Seminar for Technology Transfer

The Seminar for Technology Transfer is held at the capital city of Antananarivo on 17th October, 2006 and the southern town of Ambovombe to explain the technology for the Studies executed in Phase I and II, and implementation of the Pilot Project to the counterparts participating from the MEM, AES and other concerned agencies to exchange knowledge and experiences and understanding between each other. others.

12.3 Instructions for the CPE at Village Level Concerning Pilot Project

Instructions and suggestion are given to the CPE member at Pilot Project sites as well as the Technical Services of AES/MEM throughout the construction, operation and maintenance, and monitoring. The instructions include how to operate and maintain the water supply facilities.

The contents of the instructions for the O&M are as follows.

1. Outline of the water supply systems and the facilities
2. How to operate and maintain the submersible motor pumps
3. How to operate and maintain the power sources, i.e. the solar pumping system.
4. How to operate and maintain the hand pumps namely pump rope and Vergnet
5. How to collect water charge and deposits
6. How to make action when problems happen
7. How to record daily operation, maintenance and management include water charge

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CHAPTER 13 CONCLUSION AND RECOMMENDATION

13.1 Conclusion

Based on the series of technical discussions between the Study Team, the MEM/DEA and JICA the conclusions and recommendations obtained throughout the Study in Madagascar and Japan. The results of the Study concerning the sustainable, autonomic drinking water for the people of Ambovombe and surrounding area carried out through the Phase I and Phase II Study from January 2005 to October 2006 in Madagascar and Japan the following facts were revealed.

1) The Baseline Study included hydrogeological survey, socio-economic survey, geophysical survey, well inventory survey, water level measurement survey and water quality survey, which have been completed in close cooperation with the MEM, DEA and their counterpart personnel, with emphasis on technology transfer, the AES and concerned agencies for the cooperation and assistance in the field survey, especially in Ambovombe and surrounding area.

2) The Study area in the South Region of Madagascar is characterized by the dryness and the problem of the lack of drinking water for the people due to the very arid climate and the non-existence of water resources. According to the AES annual report in 2005 the targeted water supply for the Ambovombe Commune and its surrounding villages is in a very serious condition that the AES could not supply enough water to the population of 278,000 including Antaritarika in the area in 2005. The supply capacity was only 36,116m^3/year (99 m^3/day), about 0.4 lit/cap/day in 2005 due to the lack of the water tank trucks and increase in the fuel costs from 694 Ar/lit in 2004 to 1,680 Ar/lit in 2005 and 2,200 Ar/lit in 2006.

3) During the survey, the flood of the Mandrare River caused by the cyclone in March 2005 affected the water treatment plant, which was constructed by the Japanese Assistance in 1990. There was an urgent need for countermeasures to protect the plant from serious destruction, and this had been requested in 2005. On the other hand, the treatment plant in Ampotaka constructed by the Japanese Assistance in 1995 to 1999 was seriously damaged by the same cyclone in March 2005 so this too needs urgent repair and protection measures. Under the alternative plan the rehabilitation of existing pipeline are also recommended to improvement the system especially generation system due to increase the fuel cost and decreasing water tank trucks. In 2005 only 7m^3/day of water was sold by this system. There is no more profitable level of operation because the production water cost is estimated 15,057Ar/m^3 (837¥/m^3) in 2005. Therefore, rehabilitation of the system should be included the solar pumping system and the 50m^3/day is the minimum profitable level.

4) The population of the Study area of Ambovombe is 146,078 in 1993 by Census, 277,247 in 2000 by EDF, and 207,419 in 2004 by regional office in Ambovombe. On the other hand, the population of Ambovombe and the coastal area collected by the Study team in 2005 is 277,980 and estimated to be 400,000 in 2015, the year of Millennium Development Goals (MDGs), analyzed through Logistic Curve forecasting calculation model.

5) The supply condition of Ambovombe has little improved since AES Ambovombe commenced supplying water by water tank trucks, about 30 to 40 m^3/day in capacity, using the submersible pump run by the Ambovombe JIRAMA electricity in 2005 to 2006. The AES water supply amount in 2005 was 36,116m^3/year (98.9m^3/day) consisting of Ambovombe water tank truck system 7,266m^3/year (19.9m^3/day) ,Tisihombe-Beloha pipeline system 2,465m^3/year (6.8m^3/day), and the 5 AEP/AES water supply center 26,385m^3/year (72.3m^3/day) . Therefore, the people of 277,980 in the Study area was supplied water only 0.4 litters/day/capita by AES due to lack of water source and water tank trucks. The 5 AEP/AES water supply center was managed well and sold 73% of AES water in 2005.

6) Groundwater potential of unconfined aquifer in Ambovombe commune is not bad based on the previous study by JICA in 1990.

The other area having groundwater potential is the outcropped and weathered Pre-Cambrian rocks in Antanimora to Manave, about 50 to 60 km northwest of Ambovombe commune where good quality of confined aquifer have already been developed by the MEM, AES, UNICEF and World Bank projects. The groundwater potential of the Pre-Cambrian basement rocks could be 80 m^3/day/well based on the analysis of MEM's information.

7) The Test Drilling in 2005 to 2006 in this Study was carried out in Antanimora area such as F001, F006 and F006B. It was successful results that the groundwater discharge was ranging from 15 to 30 m^3/hr/well and good quality of water. The Electric Conductivity (EC) shows 77mS/m to 122mS/m, and groundwater level is ranging from 14m to 17m in shallow depth from the ground. The elevation of the successful boreholes is about 250m to 300m above mean sea level against the Ambovombe city of about 150m above mean sea level. Therefore, the villages in Ambovombe basin could be supplied drinking water by natural gravity from the above groundwater in Antanimora. The groundwater potential was confirmed 500 m^3/d/well to 600 m^3/d/well by the pumping test, and to utilize for drinking water supply in Ambovombe city and other Study area including costal area. The Pilot Project of solar pumping system was installed in 2006 and working well at successful borehole of F006, Antanimora.

On the other hand, the Test Drilling was also carried out in Ambovombe commune. There are 5 boreholes drilled in the depth ranging from 50m to 200m. The only one borehole was success and the discharge was 300m^3/day with 302 mS/m, the limit of water quality standard in Madagascar. The static water level was 134m of unconfined aquifer. This is a good water source for Ambovombe commune, and possible to be supplied to the Coastal dune area.

8) The water supply main target is the Ambovombe commune and the costal area where many rural villages scattered due to the agricultural and fishery potentials, and a little water for drinking coming from only rainwater in the rainy season. The Test Drilling were carried out, however there were a little potential with saline. Therefore, the water source should be come from outside of Antanimora and/or Ambovombe.

9) The AEP is the point of water supply services center managed by the AES. Now there are five (5) centers, but it is individually operated and maintained in a sustainable manner, in such centers as Antanimora, Andalatanosy, Beraketa, Isoanala and Tsivory. On the other hand, the solar pumping system for water supply services is utilized in the village level and operated and managed by the CPE with the partnership of FONDEM of France and AES from 1999 to 2001. Therefore, this Study was recommend this operation, maintenance & management systems for the Pilot Project to extend the sustainable and autonomic

methods of CPE and AEP, and the plan for the improvement of the water supply in the Study area.

10) The water supply capacity by the solar pumping system in the Study area is ranging from 8 m^3/day to 44 m^3/day managed by village level CPEs. The water supply population is about 320 to 3,600 and has been maintained with the support of AES for more than 5 years without any serious problems. The guarantee period for equipment procured by the project is one year unless otherwise specified. As pointed out in a case study about operation and maintenance of solar pumping system more than 5 to 10-year guarantee period for solar pumping system due to the system renewable concept by the beneficiary communities. Stable water supply is thus assured for villagers, while water charge can be collected among villagers and saved for maintenance costs. This will sustain a long-term operation of the system. Therefore, this guarantee period for equipment was 5 years adapted this Pilot Project, and the capacity of solar pumping system for 20 m^3/day was installed to follow the management style of village level CPE and AEP.

11) The donor insures for more than 10 years operation for the water supply facility. During the guarantee period, these communities can raise operation and maintenance fund to collect water charge, which assumedly enables a long-term operation (15-20 years) of the system. The solar pumping system includes a selected pump, solar panels, inverter, water tank, and a control device. For the Pilot Project, the above 5 years guarantee by local supplier/contractor of TENEMA for operation and maintenance system combined with the solar pump equipment was implemented to monitor the operation for water supply at F006, Antanimora in the Study area.

12) Manual pump was selected in view of the readiness of spare parts and easiness to repair in this region. Considering the existing type of manual pumps in this area, two (2) types of manual pump were installed for this Pilot Project as follows.
   a) Pump Rope : 2 sites such as P009 and P010
   b) Pump Vergnet : 2 sites such as F009 and F022

Operation and maintenance system for manual pump was carried out in the village level taking on the CPE style. Study team coordinated with the local NGO of TARATRA to implement the community participation and capacity building for operation and maintenance by the villagers themselves. Existing operation and maintenance system prepared by the projects of UNICEF and World Bank has been monitored in view of sustainable and autonomic. Through the Study with MEM, the Study Team was carried out the evaluation of water charges for the operation and maintenance by village level CPE to monitor the management of the existing CPE together with Pilot sites in September 2006.

13) Currently, there are 12 sites of solar pumping system within the Study area operated by the CPE and AEP. These were constructed from 1999 to 2001. The seven (7) systems managed by CPEs of the concerned villages with the maintenance support from AES. The water charge and water service to the people are each in different levels and are managed by CPE and AEP/AES.

Table 13.1-1 Existing Solar Pumping System Maintained by AES, Ambovombe

Year	Village Name	Capacity	Population	Water Charge	Managed
1999	Ambondro Nanahera (Ambovombe)	22 m^3/day x 2	3,600	20 Ar/15 lit	CPE
2001	Mahavelo Mitsangana (Ambovombe)	10 m^3/day	1,000	20 Ar/15 lit	CPE
2001	Toby Mahavelo (Ambovombe)	8 m^3/day	360	20 Ar/15 lit	CPE
2001	Ifotaka (Amboasary Sud)	18 m^3/day	1,820	200Ar/m/Family	CPE
2001	Lovasoa Ranopiso (Fort Dauphin),	12 m^3/day	320	20Ar/15 lit	CPE
2003	Antanimora (Ambovombe)	19 m^3/day	2,000	40Ar/15 lit	AEP/AES

14) Drinking water is the essential for the human life. The shortage of water and luck of water is in the whole world due to the poverty, arid and semi-arid climates, drought, and global climate changes. Water supply is the most effective approach and is the Gateway for the poverty reduction program due to the essential factors included such as people awareness, participation, ownership, education, capacity building and establishment of close cooperation, operation, management and maintenance. The beneficially is the women and children due to their works to fetch the drinking water for family everyday from morning to the night. The key of successful water project should be sustainable, autonomic drinking water supply, and the water charge shall be pained with willingness by the people.

Concerning the point of poverty reduction view, the well organized water project should be pay attention to any supplementary advice for a little cash income to pay for the water in the rural poverty villages. The Study team requests the Steering Committee and concerned agencies to assist the rural poverty villages for the various specific fields getting a little cash income to pay for drinking water.

13.2 Recommendation

The recommendations obtained from this Study is as follows.

1) As the results of the full-dress study on groundwater development in Ambovombe basin and surroundings conducted in this Study, 20 boreholes and 5 hand dug wells were completed successfully within the schedule. However, the drinking groundwater was found only Antanimora, the 60km northwest of Ambovombe city, and the domestic water with the limit of water quality standard of Madagascar was found in the suburb of Ambovombe city.

2) Therefore, we recommended the water supply facility with 120km pipeline from Antanimora to Antaritarika via Ambovombe city for more than 400,000 populations including the city of Ambovombe and coastal area. There are many advantages against the long pipeline for drinking water supply by gravity flow from the start of Antanimora to the end of Antaritarika. The groundwater potential of test drilling F006B is high as 600m^3/day/well with 10m drawdown and shallow static water level at about 14.4m with 62m depth of borehole. The water quality is 100mS/m with WHO standard. Groundwater level is suitable for solar pumping system at about 100m^3/day/well with 6 hours operation. The profitable water charge is calculated 15-23Ar/bucket of 13 litters (0.83-1.3Ar/bucket) assuming the minimum profitable supply amount of 700m^3/day using combination power sources of solar pumping system and diesel generator due to decrease initial water facility cost.

3) On the other hand, it is also recommended urgently the development of successful groundwater source at the suburb of Ambovonbe city, test drilling of F015. We recommended the water supply facility for the city of Ambovombe about 40,000 populations. There is serious shortage of water. And this is the

most economical water supply facility from the nearest water source to the main supply area. The groundwater sustainable yield is high as 300m^3/day/well with 1m drawdown, but deep static water level at about 134m with 150m depth of borehole. The water quality is 302mS/m with the limit of Madagascar water quality standard. Therefore, groundwater is not suitable for drinking supply but for domestic water namely cooking, washing and other purposes. And the groundwater level is not suitable for solar pumping system due to very deep static water level, but for diesel engine pumping system. The profitable water charge is calculated 30-40Ar/bucket of 13 litters (2,308Ar/m^3 = 129Yen/m^3) assuming minimum profitable supply amount of 200m^3/day using power sources of diesel generator, but for JIRAMA electricity in future due to the limit of present capacity.

4) The AES has the technical office in Ambovombe city and sell the water 100Ar/bucket of 13 litters in 2006, and the supply capacity is only 20m^3/day in the area and 100m^3/day of whole AES operation area by water tank trucks, existing pipeline of 140km, and 5 AEP/AES water service centers. Therefore, the steady water supplies of 400m^3/day in Ambovombe city make the great improvement of the shortage of water in the area and financial management of AES.

5) In the Pilot Project implemented at 5 sites in the Study area the solar pumping system, pump rope, and pump vergnet was constructed, and the completed water supply facilities were handed over to the village CPE/MEM, counterpart agency. Also the technology transfer in sustainable operation and maintenance was done during the Pilot Project through sub-contracted local NGO. This is the most sustainable and autonomic drinking water supply program when we developed groundwater in the target sites, the population ranging from 500 to several thousands of population. Unfortunately in the Study area, the suitable drinking water was not discovered in each target village because the groundwater potential in the Ambovombe basin and coastal area is the mostly negative with a little potential with salinity. However, we recommend the stile of this Pilot Study is the most appropriate manners in rural water supply in the nation-wide Madagascar.

6) Consideration and attention to the poverty deduction in the Study area, the water and community participation are important keywords in the Study, and therefore, viewpoint of sociology was focused with respect throughout the Study. The rural population of developing countries, who used to be passive as recipients of the donor-funded projects, is now active actors in the development with participatory approaches. Especially water supply service in the District, commune and/or Fokontany level in South Region of Madagascar has been provided at free as one of the public services by the government. However, due to financial constraints of the government the water supply service in even in rural area has been discontinued. Restoring the water supply service and re-establishing the operation, management and maintenance of water supply service based on the “User-Pay-Policy” are necessary to secure the sustainable and autonomic management. For this purpose understanding of the concept among the local stakeholders like District local-level governments, communes, Fokontany and villagers are essential. Several workshops to encourage their participation were held during the Pilot Project through the sub-contracted local NGO together with Study team and the above-mentioned keywords were focused accordingly. Organization of community, villagers’ willingness to pay for water, set-up of capable management of water supply facility and support from local government and AES/MEM were the issues in the existing management system.

7) Utilization of the procedures used and lessons learned in this Study for groundwater development and water supply planning by the counterpart agency is recommended to expect for improvement of poor water supply coverage (around 3%) through upgrading of water supply in the district city of Ambovombe, at first and rural villages based on the proposed plans. At the same time, the urgently

requested rainwater collection facilities by local district and commune level are recommended to involve the Study team and/or NGOs for the construction together with health education due to available water limited in rainy season.

8) For the sustainable operation and maintenance of the water facilities constructed in the Pilot Project more guidance and support are required and dispatching short-term experts for this purpose is suggested. As the community-based activity through the NGOs is also necessary to promote operation, management and maintenance of solar pumping system and hand pump, education on health and sanitation and capacity building of villagers, introducing the "Community Empowerment Program" effectively is a possibility. This short-term experts and/or technical team support the integrated manners to improve the poverty reduction to pay attention for villagers' cash income.

9) In the occasions of workshop and seminar for technology transfer in order to avoid duplication of the project and to share the lessons learned with other donors and NGO that are working for water supply improvement exchange of ideas and presentation of the cases were carried out in the Study. For the onward development establishing closer cooperation and coordination with the other organizations are required.

10) Development of water supply using groundwater is recommended for rural water supply with population of several thousands to ten thousands, depend on the groundwater potential. But, attentions on water quality problems namely salinity of groundwater shall be taken in case of coastal area. For this development study of the team to carry out the different tasks such as groundwater potential study like geophysical survey, test drilling, monitoring of groundwater aquifer, etc. is recommended to require properly due to monitoring and management equipment to hand over the concerned agencies. The MEM's present approach shall be keep cooperation with the AES while training their own staff to be the groundwater development experts who know water supply planning as well shall be required.

11) Concerning rural water supply in South Region of Madagascar the AES shall take leadership toward improvement of water supply services in the Study area. In the Pilot Project technical, social (community participation and sensitization), financial, economic (provision of subsidy) and legal measures were introduced as a model of this kind of activity. Further extension of this kind of activities for actual implementation of national-wide water supply improvement program is expected.For the purpose of urging water supply improvement program in rural towns and villages MEM/AES shall proceed its on-going institutional reform to set up more efficient organization to promote new water supply systems of commercial basis and/or getting a little support from the Central, Provincial and District-level Governments. And also cross-subsidization to assist the financially vulnerable rural water supply from the financially strong systems in provincial cities and villages under the management of MEM can be considered.

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