8.3.3 Results of Monitoring in Tsianaloka, Beroboka Sud, Bezezika and Analaiva

In Tsianaloka and Beroboka Sud, the villagers prepared gravel and sand for concrete base, and participated in the installation work of the pump. While in Bezezika and Analaiva, all these works were done by the Study Team with the participation of mechanics from the Water Association only.

Table 8.3.2 shows the water consumption from the water supply facility in each village. The measurement of water consumption was carried out in February 1996 during the rainy season.

Table 8.3.2 Average Water Consumption Rate in the Pilot Project Villages

(liters/person/day)

Group A (full participation of villagers)		Group B (partial participation of villagers)	
Tsianaloka	Beroboka Sud	Bezezika	Analaiva
Hand pump was broken	13.6	10.0	9.6

In Tsianaloka, the hand pump was broken after one month, and has been left unrepaired. In Beroboka Sud, Mandroatra River is situated 200 m away from the village center with a stable amount of water during all seasons. All villagers use the water from the river for washing and bathing. In Bezezika, the villagers also use the water from dug wells, Dabara canal and Mandeha River, both 500 m away. In Analaiva, there are many dug wells and the villagers use water from them in the same way as Dabara canal 500 m away.

It is considered that the water pumped in each village is used mainly for drinking. Villagers use water from rivers, canals and dug wells for washing and bathing even if these water sources are located farther than the hand pump. They may be afraid to cause trouble to the hand pump by using it too frequently, or it may be their habit and they feel more comfortable to go washing and bathing in water from those sources.

Table 8.3.3 shows the monitoring and evaluation in the villages.

In Tsianaloka, the hand pump broke down on January 1, 1996. The pump was guaranteed for six months by the supplier, so it was suggested to the villagers to request for the pump to be repaired to the supplier. The activities of the Water Association in Tsianaloka was very good, with an O/M fee collection of 100% in December 1995. It seems that they are well aware of the importance of the water facility and have a strong will to operate and maintain the well by themselves.

In Beroboka Sud, the hand pump was in good condition, but the Water Association in Beroboka Sud is not very active. Probably, the use of the hand pump in Beroboka Sud was much less frequent than in other villages.

In Bezezika, the axle bolt of the lever in the hand pump broke down after 1.5 month use. Villagers asked the Swiss Garage in Morondava, the car repair shop established by the Swiss cooperation, to repair it since the mechanics of the Water Association could not repair it. They paid FMG 20,000 from the Fund of the Water Association. The Water Association is not particularly active. All members are paying the O/M fee, and they elected four members to clean the surrounding area of the hand pump every Saturday.

In Analaiva, there was the same kind of trouble as in Bezezika and they asked the repair shop to repair it. The bolt was replaced temporarily by the mechanics of the Water Association but it did not fit. Only 13 households are registered as members and paid the O/M fee. According to the board members, the villagers do not want to be registered as members because the well is very far from their houses and they have dug wells.

All four villages do not use drained water, because it is not necessary during the rainy season.

Table 8.3.3 Monitoring and Evaluation in the Villages (February 1996)

	Group A		Group B	
	Tsianaloka	Beroboka Sud	Bezezika	Analaiva
1 Conditions of the hand pump	Hand pump has been broken since Jan. 1, 1996 after one month of use.	Good	Axle bolt of the lever in the hand-pump broke after 1.5 month of use.	Axle bolt of the lever in the hand-pump was broken.
1.1 If not good, did you try to repair it?			Yes, but couldn't. Bolt was replaced by Sues Garage.	Yes. Bolt was replaced but did not fit. The repair has been asked to SIRANALA.
2 Distance of the furthest house from the pump			600 m	300 m
3 Fence around the pump	Fully completed with gate and lock	Fully completed with gate and lock	Under construction	Not completed
4 Drainage canal		Waste water is drained to the road	Not good	Not good
5 Use of drained water		Not used	Not used. Plan for vegetable garden in dry season	Not used.
6 Other water source to be used	None	Mandroutra River	Dabara canal, Mandeha River, SAGRIM	Dabara canal, dug wells (for washing and bathing)
7 Need for other facilities		—	another 3 hand pumps	another 6 hand pumps
8 Bookkeeping				
8.1 List of participants	Made	Made	Made	Made
8.2 Number of participants	142 people over 18 years old	56 households	125 households	13 households
8.3 Fund charges	500 FMG	500 FMG	500 FMG	500 FMG
8.4 Period of collection of the Fund	Oct.'95 (all members) - Oct.'96 (25 members)	Oct. - Dec. '95	Nov. - Dec. '95	Dec. '95
8.5 Total amount of the Fund (FMG)	224,000	13,500 (-3,500 for wood for the fence)	50,900 (-20,000 for repair)	5,000
9 Remarks:				
9.1 Sanitary conditions around the pump	Clean	Clean	Not clean	Not clean
9.2 Activities of the Water Association	Very good	Not good	Very good	Not good
9.3 Leadership of the President	Very good	Not good	Very good	Not good
9.4 Collection of the Fund	Very good	Not good	Good	Not good

Table 8.3.4 shows the gender of the board members of the Water Associations. Some board members have changed since the establishment of associations. In Tsianaloka and Bezezika, the Presidents are women and they have good leadership skills. In Beroboka Sud and Analaiva, the Presidents are men and they do not have good leadership abilities. However, it is difficult to say that women are always better President of the Water Association than men, because the President of Tsianaloka is the wife of the village president and the President of Bezezika a teacher of the primary school, while the President of Beroboka Sud is the owner of a shop and the President of Analaiva is a farmer. It seems, however, that when the social position of the president is high, better management is attained.

Table 8.3.4 Gender of Board Members of the Water Associations (Feb. 1996)

	Group A		Group B	
	Tsianaloka	Beroboka Sud	Bezezika	Analaiva
President	woman	man	woman	man
Vice President	-	-	woman	-
Secretary	-	man	woman	man
Accountant	woman	woman	woman	woman
Sanitary Coordinator	woman	woman	-	woman
Mechanic	2 men	2 men	2 men	2 men
Responsible for cleaning	-	-	4 men	-

Table 8.3.5 shows the ratio of participation of the villagers and total amount of the Fund in the Water Associations as of February 1996. The highest ratio of participation is 87.4% in Bezezika, and the lowest is 3.1% in Analaiva. In Beroboka Sud, 56 households are members with 46.7% of participation, but only 12 members are paying O/M fee. It is estimated that the activities of the villagers for the hand pumps are good in Tsianaloka and Bezezika but not so good in Beroboka Sud and Analaiva.

Table 8.3.5 Ratio of participation of the villagers and total amount of the Fund in the Water Associations as of February 1996

	Group A		Group B	
	Tsianaloka	Beroboka Sud	Bezezika	Analaiva
Population of village	1,000	783	855	1,520
Households	109	120	143*	411
Population over 18 years old	327 *	--	--	--
Members (persons over 18 years old or households)	142 persons	56 households	125 households	13 households
Ratio of participation	43.4 %	46.7 %	87.4 %	3.1 %
Fund (FMG/month/member)	500	500	500	500
Members who have contributed at least 500 FMG	142	12	125	13
Total contribution as of February (FMG)	224,000	17,000	70,900	5,000

** estimated*

The differences between the four villages are summarized in Table 8.3.6. It is considered that the activities of the Water Associations have no relation with the education and income levels of the villagers. The table does not show a remarkable difference between groups A and B. Yet, the fence around the pump was completed with a gate and a lock in Tsianaloka and Beroboka Sud, but not completed in Bezezika and Analaiva. It probably means that the participation of the villagers in the work for the pump installation is an important factor for the enlightenment of villagers. Actually, the villagers of Beroboka Sud worked much harder than those of Tsianaloka for the pump installation although, for their defense, it is true that the Study Team could not make an appointment with the villagers beforehand because the delivery of the hand pump was badly delayed and, on that day, most of the villagers of Tsianaloka went out to work in rice fields far from the village .

In Tsianaloka, the existing water source is a pond 400 m away from the edge of the village. Water amount decreases in the dry season and the villagers dig a pit at the bottom of the pond. When they have enough time, they go to the large river 1.7 km away where the water looks more clean. It means that their needs for clean water is strong and the amount of the Fund clearly indicates this.

In Bezezika, they had six Water Associations for six dug wells, all headed by women, but the associations have become insubstantial since water of the dug wells became salty. These water associations still have the capacity to function and they convoked 50 women for the meeting with the Study Team during the field survey. This number is very high compared with others.

In Analaiva, it is estimated that the activities of the Water Association were not poor but they managed to handle the trouble with the hand pump well, asking the repair shop for the replacement of the parts temporarily by another one. It is thought that the main reason of the low contribution amount was that the location of the hand pump was not convenient for the villagers, as they had dug wells near the house. The administration of Analaiva is well organized and the president of the village proposed to offer a site for the establishment of a Morondava office of MEM, which is under planning, in the village. It is probable that the villagers of Analaiva are keen for the project implementation, awaiting for the piped water supply system.

The table shows a correlation between the number of attendants to the meeting with the Study Team and the activities of the Water Associations. There were more women attendants at the meeting than men in Tsianaloka and Bezezika. The high ratio of the participation might depend on the accessibility to the water source, because it is difficult to say that the women at Tsianaloka are more active than those of Beroboka Sud.

In summary, it is considered that the activities of the Water Associations for the hand pump wells depends on the following factors :

1. Accessibility to the existing water source that is stable in the dry season
2. Promotion of the participation of women
3. Leadership of the President of the Water Association
4. Participation in the work of facility construction.

Table 8.3.6 Summary of the differences among four Pilot Project villages

	Group A		Group B	
	Tsianaloka	Beroboka Sud	Bezezika	Analaiva
Living conditions				
Other water sources (condition in the dry season)	spring 400m away (reduced)	stream 200m away (stable)	6 dug wells, stream & canal 500m away (stable)	many dug wells, canal 500 m away (stable)
Teachers of the primary school	1	1	5	15
Teachers of the secondary school	0	0	0	7
Organizations	0	2 [1]	5 [2]	3 [3]
Averaged annual income per household (FMG)	500,000 - 600,000	350,000 - 450,000	500,000 - 600,000	700,000 - 800,000
Meeting with the Study Team (during the field survey)				
Women attendants	20	8	50	19
Men attendants	10	12	16	27
Water Association				
President	woman	man	woman	man
Leadership of the president	Very good	Not good	Very good	Not good
Women board members	3	2	4	2
Activities of Water Association	Very good	Not good	Very good	Not good
Fence around the pump	Completed	Completed	Under construction	Not completed
Ratio of participation	43.4 %	46.7 %	87.4 %	3.1 %
Members who have contributed at least 500 FMG	142	12	125	13
Total contribution as of February (FMG)	224,000	17,000	70,900	5,000

[1] Agricultural Association, Christian Association
[2] Agricultural Association, Christian Association, 6 Women's Water Associations, YMCA, YWCA
[3] Agricultural Association, Agricultural Water Management Association, Sport Club (Football)

9. GROUNDWATER DEVELOPMENT PLAN

The groundwater development potential in the Study Area is generally of sufficient level for domestic water supply use. As described in Section 5.2.4, the groundwater development potential per square kilometer ranges from 176 m^3/day (minimum in the Maharibo River basin) to 947 m^3/day (maximum in the Morondava River basin) in this area, which means that the potential per square kilometer is sufficient for supplying water to 8,800 people even in the minimum potential area, provided that the unit supply amount is fixed at 20 ℓ/c/d.

The areas where large quantities (61,800 m^3/day) of groundwater is pumped up for irrigation, industrial, and urban water supply use fall within an area with very high potential, the sub-basin of the Morondava River basin. The remaining capacity in this area is as much as 852 m^3/day/km^2 which is more than enough for rural water supply.

Consequently, sufficient quantities of groundwater can be obtained from anywhere in this Study Area. However two issues remain :

- Water quality: whether it is suitable for drinking
- Economic point of view: whether groundwater pumping is economically feasible or not, which is related to the required volume of water

With regard to quality, sea water intrusion is observed in most areas along the coast. Moreover, some parts of the coastal plain, even those that are further from the coast, are underlain with saline water aquifer interbedded with other beds containing fresh water, resulting in problems with saline water during the well drilling. At places close to dykes or fault lines, water quality may not be good enough for drinking due to dissolved substances from hot springs.

In consideration of the above, groundwater development should be carefully planned at each location, for example:

- Large-scale groundwater development should not be planned in areas along the coast in order to avoid sea water intrusion.
- Several extra drillings should be incorporated into the establishment of the well construction plan for coastal areas and where saline water aquifers are presumably interbedded.
- Well drilling should not be planned at points close to dykes or their related lineament in order to avoid hitting hot springs.

Regarding economic issues, the following measures have been taken into consideration in the planning of groundwater development.

- Borehole wells with manual pumps were planned for villages with a population less than 800 in order to minimize O/M costs.
- For the majority of the villages, with a population over 800 but not exceeding 3,000, a solar powered motor pump is to be introduced, for which fuel is not necessary (low operation costs).
- Introduction of motor pumps with diesel engine generators is limited to the villages whose financial capability (ability to pay) is adequate to cover O/M costs, and where there is a reliable fuel supply (access to fuel stations is possible, even during the rainy season).

9.1 Basic Concept for the Groundwater Development Plan

Since the groundwater development potential is sufficient in terms of quantity, as mentioned above, the volume to be developed shall be extrapolated from the water demand in the year 2005, that is, the unit supply amount (20 ℓ/c/d) multiplied by the estimated population in 2005 for each of the candidate villages. The developed groundwater is not for the purpose of supplementing existing water sources. Unsanitary domestic water sources in majority of the villages in the Study Area are to be replaced by safe water sources. This is the major concept of the groundwater development plan.

As for the project implementation schedule for groundwater development, villages with both high requirements for a safe water source and a comparatively good financial situation should be given priority (50 to 60 villages). The remaining listed candidate villages and the villages left off the list will follow the prioritized villages.

9.2 Groundwater Development Plan per Village

Table 9.2.1 presents the groundwater development plan in terms of quantity for each of the surveyed 81 candidate villages.

Electrical resistivity sounding was performed at 46 villages and test drilling at only 13 villages, but the overall hydrogeological analysis has made it possible to estimate the drilling depth required to hit an aquifer, and to estimate the production amount of each well. Resistivity sounding at the remaining 35 villages is necessary in order to determine the drilling depth more precisely before implementation of the project.

Table 9.2.1 Groundwater Development Plan (1/2)

Village		Population		Categorization (Prioritization)	Groundwater Development Plan				
					Target Drilling Depth	Expected Pumping Discharge	Amount to be Developed	Estimated Water Level	
No.	Name	in 1995	in 2005					S.W.L	D.W.L
						ℓ/min.	ℓ/min.	GL-m	GL-m
106	Malaimbandy # *	7,000	9,200	A A	250 m(6")	(>400)	380	30.00	(40.00)
103	Ankilizato # *	4,200	5,500	A A	170 m(6")	300	260	22.60	115.00
25	Befasy # *	2,000	2,600	A A	63 m(4")	560	140	5.57	9.98
104	Mandabe # *	2,000	2,600	A A	103 m(6")	350	140	9.80	13.90
67	Analaiva # *	1,520	2,000	A A	73 m(4")	715	110	3.70	4.81
23	Marerano *	1,100	1,400	A A	170 m(6")	300	80	15.00	30.00
109	Tsianaloka # *	1,000	1,300	A A	22 m(4")	70	70	13.17	14.49
110	Kiboy *	930	1,200	A A	130 m(6")	200	70	15.00	30.00
115	Ankotrofotsy *	908	1,200	A A	150 m(6")	350	70	15.00	25.00
107	Ampanotoka *	900	1,200	A A	200 m(6")	75	70	35.00	50.00
97	Bezezika # *	855	1,100	A A	48 m(4")	930	60	7.80	8.64
114	Ambatolahy # *	800	1,100	A A	93 m(6")	350	60	13.41	24.27
31	Beleo	800	1,100	A A	70 m(4")	500	60	6.00	12.00
93	Beroboka Atm. # *	783	1,000	A A	73 m(4")	767	60	2.95	5.21
46	Marofihitsa # *	750	980	A A	38 m(4")	524	50	4.12	4.46
99	Ankilimida *	600	790	A A	70 m(4")	600	40	15.00	30.00
5	Befamonty *	450	590	A A	70 m(4")	150	30	5.00	15.00
9	Ankoba	410	540	A A	70 m(4")	150	30	5.00	15.00
100	Ampanihy	742	970	A B	100 m(4")	500	50	5.00	15.00
83	Ampataka *	695	910	A B	50 m(4")	200	50	5.00	15.00
8	Nosibe *	600	790	A B	100 m(4")	150	40	5.00	15.00
17	Ambivy II *	500	660	A B	60 m(4")	350	40	5.00	15.00
20	Marolafika Atm. *	500	660	A B	100 m(4")	300	40	5.00	15.00
101	Benato	500	660	A B	70 m(4")	800	40	5.00	15.00
55	Ampananiha	420	550	A B	70 m(4")	500	30	10.00	20.00
26	Antevamena	360	470	A B	70 m(4")	500	30	7.00	14.00
10	Antseranandaka No.	342	450	A B	60 m(4")	150	30	5.00	15.00
27	Mitsitiky	340	450	A B	100 m(4")	500	30	15.00	30.00
3	Antaly *	327	430	A B	100 m(4")	150	20	5.00	15.00
102	Anolotsy	300	390	A B	70 m(4")	800	20	5.00	15.00
7	Nositonga	260	340	A B	48 m(4")	150	20	5.00	15.00
41	Farateny *	250	330	A B	100 m(4")	600	20	5.00	15.00
60	Tandrokosy	238	310	A B	70 m(4")	700	20	8.00	16.00
34	Croise. Besotroka	200	260	A B	70 m(4")	500	10	10.00	20.00
39	Antsamaka	150	200	A B	70 m(4")	400	10	10.00	20.00
76	Laijoby (Avaratra)	150	200	A B	60 m(4")	500	10	15.00	25.00
16	Ambivy I *	130	170	A B	150 m(6")	350	10	10.00	20.00
68	Betsipotika *	120	160	A B	70 m(4")	700	10	7.00	15.00
94	Ankilivalo *	2,960	3,900	B A	100 m(4")	800	220	10.00	15.00
52	Antsakamirohaka *	1,600	2,100	B A	50 m(4")	500	120	5.00	15.00
112	Tsimafana *	1,500	2,000	B A	100 m(4")	500	110	5.00	20.00

Test construction was made in this Study.
* Depth to aquifers have been estimated by conducting electric resistivity sounding.

Table 9.2.1 Groundwater Development Plan (2/2)

Village		Population		Categorization (Prioritization)	Groundwater Development Plan				
					Target Drilling Depth	Expected Pumping Discharge	Amount to be Developed	Estimated Water Level	
No.	Name	in 1995	in 2005			ℓ/min.	ℓ/min.	S.W.L GL-m	D.W.L GL-m
58	Bemanonga *	1,250	1,600	B A	100 m(4")	500	90	5.00	15.00
59	Marovoay *	1,247	1,600	B A	100 m(4")	700	90	5.00	15.00
113	Mananjaky	1,170	1,500	B A	30 m(4")	70	80	13.00	20.00
89	Ankaraobato	800	1,100	B A	70 m(4")	600	60	5.00	15.00
1	Andranopasy I # *	623	820	B A	30 m(4")	137	50	12.48	5.33
53	Androvakely *	550	720	B A	100 m(4")	500	40	5.00	15.00
40	Manomentimay *	436	570	B A	80 m(4")	500	30	5.00	15.00
82	Marofandiliha *	370	490	B A	80 m(4")	500	30	6.00	15.00
64	Andranomena A # *	210	280	A B	78 m(4")	402	20	+1.80	1.53
33	Misokotse *	800	1,100	B B	60 m(4")	500	60	7.00	15.00
70	Ampandra *	600	790	B B	80 m(4")	800	40	10.00	18.00
47	Ambararata # *	500	660	B B	73 m(4")	767	40	2.95	5.21
74	Tsinjorano *	450	590	B B	70 m(4")	800	30	10.00	20.00
36	Namakia	400	530	B B	60 m(4")	600	30	5.00	15.00
81	Malandirano	400	530	B B	60 m(4")	500	30	6.00	12.00
15	Miary *	365	480	B B	150 m(6")	350	30	10.00	20.00
48	Ankevo *	300	390	B B	80 m(4")	700	20	5.00	15.00
66	Croisement BST	204	270	B B	60 m(4")	700	20	8.00	18.00
18	Ambahia *	200	260	B B	80 m(4")	350	10	5.00	15.00
30	Bekininy Soarano	400	530	A C	70 m(4")	700	30	7.00	15.00
35	Amanga	400	530	A C	70 m(4")	500	30	5.00	15.00
4	Darika *	327	430	A C	100 m(4")	150	20	5.00	15.00
80	Analalava *	300	390	A C	60 m(4")	600	20	10.00	20.00
95	Ambohibary	300	390	A C	70 m(4")	800	20	5.00	15.00
79	Ambonio	270	350	A C	60 m(4")	500	20	10.00	17.00
65	Tanandava	250	330	A C	60 m(4")	500	20	5.00	15.00
11	Tsaramandroso	237	310	A C	60 m(4")	400	20	5.00	15.00
2	Andranopasy II	226	300	A C	70 m(4")	150	20	5.00	15.00
6	Ambatobe *	220	290	A C	60 m(4")	150	20	5.00	15.00
19	Besatrohaka *	210	280	A C	70 m(4")	150	20	5.00	15.00
29	Ankilatamahavelo	190	250	A C	70 m(4")	500	10	10.00	20.00
69	Amboloando	150	200	A C	60 m(4")	800	10	10.00	18.00
43	Andrananja	70	90	A C	60 m(4")	500	10	5.00	15.00
56	Antseranambondro	60	80	A C	60 m(4")	500	4	5.00	15.00
28	Andranovorisosotra	40	50	A C	70 m(4")	500	3	5.00	15.00
61	Bekonazy	40	50	A C	80 m(4")	700	3	10.00	18.00
50	Bevantaza	150	200	B C	70 m(4")	350	10	15.00	30.00
14	Tanambahiny	131	170	B C	100 m(4")	350	10	15.00	30.00
72	Antevamena II *	100	130	B C	70 m(4")	700	10	8.00	18.00
32	Anadabo	36	50	C C	60 m(4")	500	3	10.00	20.00

Test construction was made in this Study.
* Depth to aquifers have been estimated by conducting electric resistivity sounding.

10. PLAN ON WATER SUPPLY FACILITIES

10.1 Plan on Unit Supply Amount

The establishment of a water supply plan should always be based on two elements: "Unit Supply Amount" and "Population Served". There are two different ways in determining the unit supply amount in the South-western Region of Madagascar.

One is to follow the government guideline for rural water supply covering the whole of Madagascar (20 ℓ/c/d), which is mentioned in Section 3.1. Another is to be based on the results of the evaluation survey on the Phase I Project, that is, a smaller unit supply amount (15 ℓ/c/d, for example), putting the emphasis on easier and lower cost maintenance in view of achieving sustainable conditions, as described in Section 7.2.

A thorough discussion was held on this matter between the JICA Study Team and the MEM Team at the meeting on the Interim Report, and as a result, the unit supply amount was decided at 20 liters on condition of the following, in order for the supply facilities to be effective and sustainable :

- MEM itself continues its effort to educate the inhabitants of the project area on the use of a safe water source and the payment for the services as the implementing body. Also, MEM appeals to the local authorities or the relevant ministries to do the same, as the coordinating body of the rural water supply sector.
- MEM strengthens its organization and system for the maintenance services, and educates the users on proper facility operation.

10.2 Service Population Plan

During the period of the Study in Madagascar, the local administration was reorganized in accordance with the "decentralization policy", as mentioned in Clause 2.2.1, resulting in the majority of the Project candidate villages becoming parts of new "Communes" which are now the smallest units of the local administrative organization.

However, it was confirmed during the meetings on the Progress Report and Interim Report that the villages for the Study will remain the same, and the objective area will not expand to cover the new communes. The groundwater development plan and the water supply plan, therefore, are to be established on the basis of the former "villages". Accordingly, the service population of each village is the projected population of the village in the target year of 2005.

Data on the population growth rate is not available in this area, therefore, the same rate as in the Phase I Project Area (2.76% per annum) is to be used. Assuming that the growth rate is constant, the projected population of the concerned villages in the year 2005 (after 10 years) is calculated as:

$$\text{Present population} \times (1 + 0.0276)^{10}$$

As a result, the population served at each candidate village is forecast to become about 1.3 times the present population. These values are to be used in determining the scale of each facility.

10.3 Supply Facility Plan

10.3.1 Type of Supply Facility

The types of water supply facilities applicable in this Study Area are the following:

a. Hand pump wells for comparatively small-scale villages with a population less than 800 (1,000 in case of scattered village), and for villages where the dynamic water level is higher than 30 meters below the ground level. The number of wells to be constructed will depend on the population to be served in the village.

b. Simple supply system composed of a distribution system with communal faucets and intake facility (well and motorized pump powered by diesel engine generator or photo-voltaic panels). This type of supply facility has been planned at comparatively concentrated villages with a population over 800. The energy source has been selected in accordance with the following conditions:

- Photo-voltaic (Solar energy) system ---- For villages where the population is not so large, and at places where the dynamic water level in the well is not so deep, because the generation of high energy requires a large amount of investment. However, for villages with poor access to a fuel station, introduction of this system seems inevitable regardless of the high investment cost.

- Electricity generated by diesel engine ---- For densely populated villages and where there is financial capability to pay for the operation cost. In addition, villages with relatively easy access to a fuel station throughout the year even during the rainy season.

10.3.2 Scale of Supply Facility

Based on the conditions mentioned above, the water supply facility for each of the candidate villages has been planned and tabulated in Table 10.3.1.

The scale of water supply facilities have been planned under the following conditions, based on the unit supply amount of 20 ℓ/c/d and the projected population in 2005.

a. Hand pump facility

- Water collection hours: 4 hours in the morning and 3 hours in the afternoon, totaling 7 hours a day

- Pumping rate: 15 ℓ/min during actual pumping, and 10 ℓ/min on average taking unused time into consideration, that is, 600 ℓ/hour and 4.2 m^3/day.

- Number of wells required in one village:

  Water demand (population served multiplied by 20 ℓ/c/d) is to be divided by 4.2 m^3/day.

b. Facilities equipped with motorized pump and communal faucets

Since this system is provided with a distribution tank, it is not necessary to consider water collection hours because the inhabitants can collect water at any time by opening the tap, so long as the tank is filled with water. The pumping rate and the capacity of the tank have been determined in conformity with water demand, which is within the range of groundwater development potential. In Table 10.3.1, the required pumping rates are also presented by fixing the pumping period at 6 hours a day.

10.3.3 Standard Design of Supply Facility

(1) Standard design of the well

The target depth of the well in each of the candidate village has been determined based on the hydrogeological analysis, especially on the result of the geophysical survey, and is tabulated in Table 9.2.1 along with the diameter of the wells.

The well screen should have an opening ratio of more than 3 % and a slot size of less than 1 mm, and must be installed at positions in relation with good aquifers. For the wells of high pumping rate at more than 300 liters per minute, it is better to use a screen with a larger opening ratio, i.e. 10 % or more.

The standard well design is presented in Fig. 10.3.1 (for a hand pump well) and Fig. 10.3.2 (for a motor pump well).

(2) Standard design of the supply facility

The number of hand pump wells (1 to 4 wells) in each of the candidate villages is tabulated in Table 10.3.1, and these are to be located in accordance with the distribution of houses and are to be separated by more than 100 meters each other.

The standard design of the concrete pump base is given in Fig. 10.3.3.

For the motor pumped supply system, the well is to be constructed at a comparatively high elevated site in the village, and a raised distribution tank is to be constructed within 10 meters from the well. Water pumped by the submersible motor pump is conveyed to the distribution tank also by the pump, and is delivered to several communal faucets through branch type distribution pipes by natural flow.

A pressure gauge shall be affixed at the bend connecting the riser pipe with the conveyance pipe to the tank, and the sluice and check valves on the conveyance pipe. The distribution tank and the end of the distribution pipes shall be equipped with drain valves. A generator house or solar panels are to be constructed near the well, in order to supply power to the pump. Figures 10.3.4 and 10.3.5 represent the schematic drawings of the total facility.

Table 10.3.1 Water Supply Facilities by Village (1/4) (Hand Pump Type)

Village No.	Village Name	Population in1995	Population in2005	Categorization	Well Diameter	Well Depth	Well S.W.L / D.W.L (GL-m / GL-m)	Well Q'ty	Hand Pump Capacity×Head	Hand Pump Q'ty
99	Ankilimida	600	790	A A	φ4"	70 m	(15.00 / 30.00)	4	15 ℓ/min× 30.0 m	4
5	Befamonty	450	590	A A	φ4"	70 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
9	Ankoba	410	540	A A	φ4"	70 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
83	Ampataka	695	910	A B	φ4"	50 m	(5.00 / 15.00)	4	15 ℓ/min× 15.0 m	4
8	Nosibe	600	790	A B	φ4"	100 m	(5.00 / 15.00)	4	15 ℓ/min× 15.0 m	4
17	Ambivy II	500	660	A B	φ4"	60 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
20	Marolafika Atm.	500	660	A B	φ4"	100 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
101	Benato	500	660	A B	φ4"	70 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
55	Ampananiha	420	550	A B	φ4"	70 m	(10.00 / 20.00)	3	15 ℓ/min× 20.0 m	3
26	Antevamena	360	470	A B	φ4"	70 m	(7.00 / 14.00)	2	15 ℓ/min× 14.0 m	2
10	Antseranandaka N.	342	450	A B	φ4"	60 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
27	Mitsitiky	340	450	A B	φ4"	100 m	(15.00 / 30.00)	2	15 ℓ/min× 30.0 m	2
3	Antaly	327	430	A B	φ4"	100 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
102	Anolotsy	300	390	A B	φ4"	70 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
7	Nositonga	260	340	A B	φ4"	50 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
41	Farateny	250	330	A B	φ4"	100 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
60	Tandrokosy	238	310	A B	φ4"	70 m	(8.00 / 16.00)	2	15 ℓ/min× 16.0 m	2
34	Croise. Besotroka	200	260	A B	φ4"	70 m	(10.00 / 20.00)	2	15 ℓ/min× 20.0 m	2
39	Antsamaka	150	200	A B	φ4"	70 m	(10.00 / 20.00)	1	15 ℓ/min× 20.0 m	1
76	Laijoby Avaratra	150	200	A B	φ4"	60 m	(15.00 / 25.00)	1	15 ℓ/min× 25.0 m	1
16	Ambivy I	130	170	A B	φ4"	150 m	(10.00 / 20.00)	1	15 ℓ/min× 20.0 m	1
68	Betsipotika	120	160	A B	φ4"	70 m	(7.00 / 15.00)	1	15 ℓ/min× 15.0 m	1
53	Androvakely	550	720	B A	φ4"	100 m	(5.00 / 15.00)	4	15 ℓ/min× 15.0 m	4
40	Manomentimay	436	570	B A	φ4"	80 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
82	Marofandiliha	370	490	B A	φ4"	80 m	(6.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
70	Ampandra	600	790	B B	φ4"	80 m	(10.00 / 18.00)	4	15 ℓ/min× 18.0 m	4
47	Ambararata	500	660	B B	(φ4" φ4"	73 m 75 m	(2.95 / 5.21) (3.00 / 5.00)	1) 2	15 ℓ/min× 5.0 m	3
74	Tsinjorano	450	590	B B	φ4"	70 m	(10.00 / 20.00)	3	15 ℓ/min× 20.0 m	3

Table 10.3.1 Water Supply Facilities by Village (2/4) (Hand Pump Type)

Village		Population		Categori-zation	Well					Hand Pump	
No.	Name	in1995	in2005		Diameter	Depth	S.W.L GL-m	D.W.L GL-m	Q'ty	Capacity×Head	Q'ty
36	Namakia	400	530	B B	φ4"	60 m	(5.00	/ 15.00)	3	15 ℓ/min× 15.0 m	3
81	Malandirano	400	530	B B	φ4"	60 m	(6.00	/ 12.00)	3	15 ℓ/min× 12.0 m	3
15	Miary	365	480	B B	φ4"	150 m	(10.00	/ 20.00)	2	15 ℓ/min× 20.0 m	2
48	Ankevo	300	390	B B	φ4"	80 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
66	Croisement BST	204	270	B B	φ4"	60 m	(8.00	/ 18.00)	2	15 ℓ/min× 18.0 m	2
18	Ambahia	200	260	B B	φ4"	80 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
35	Amanga	400	530	A C	φ4"	70 m	(5.00	/ 15.00)	3	15 ℓ/min× 15.0 m	3
30	Bekininy Soarano	400	530	A C	φ4"	70 m	(7.00	/ 15.00)	3	15 ℓ/min× 15.0 m	3
4	Darika	327	430	A C	φ4"	100 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
80	Analalava	300	390	A C	φ4"	60 m	(10.00	/ 20.00)	2	15 ℓ/min× 20.0 m	2
95	Ambohibary	300	390	A C	φ4"	70 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
79	Ambonio	270	350	A C	φ4"	60 m	(10.00	/ 17.00)	2	15 ℓ/min× 17.0 m	2
65	Tanandava	250	330	A C	φ4"	60 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
11	Tsaramandroso	237	310	A C	φ4"	60 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
2	Andranopasy II	226	300	A C	φ4"	70 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
6	Ambatobe	220	290	A C	φ4"	60 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
19	Besatrohaka	210	280	A C	φ4"	70 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
29	Ankitatamahavelo	190	250	A C	φ4"	70 m	(10.00	/ 20.00)	2	15 ℓ/min× 20.0 m	2
69	Amboloando	150	200	A C	φ4"	60 m	(10.00	/ 18.00)	1	15 ℓ/min× 18.0 m	1
43	Andrananja	70	90	A C	φ4"	60 m	(5.00	/ 15.00)	1	15 ℓ/min× 15.0 m	1
56	Antseranambondro	60	80	A C	φ4"	60 m	(5.00	/ 15.00)	1	15 ℓ/min× 15.0 m	1
28	Andranovorisosotra	40	50	A C	φ4"	70 m	(5.00	/ 15.00)	1	15 ℓ/min× 15.0 m	1
61	Bekonazy	40	50	A C	φ4"	80 m	(10.00	/ 18.00)	1	15 ℓ/min× 18.0 m	1
50	Bevantaza	150	200	B C	φ4"	70 m	(15.00	/ 30.00)	1	15 ℓ/min× 30.0 m	1
14	Tanambabiny	131	170	B C	φ4"	100 m	(15.00	/ 30.00)	1	15 ℓ/min× 30.0 m	1
72	Antevamena II	100	130	B C	φ4"	70 m	(8.00	/ 18.00)	1	15 ℓ/min× 18.0 m	1
32	Anadabo	36	50	C C	φ4"	60 m	(10.00	/ 20.00)	1	15 ℓ/min× 20.0 m	1

Table 10.3.1 Water Supply Facilities by Village (3/4) (Engine Generator Type)

Village No.	Village Name	Population in 1995	Population in 2005	Categorization	Well Diameter	Well Depth	Well S.W.L (GL-m) / D.W.L (GL-m)	Well Q.ty	Submersible Motor Pump Capacity×Head	Engine Generator	Reservoir Capacity	Public Faucet	Pipe Line φ4" (m)	Pipe Line φ3" (m)	Pipe Line φ2 1/2 (m)	Pipe Line φ2" (m)
106	Malaimbandy	7,000	9,200	AA	φ6"	250 m	(35.00 / 80.00)	1	340 ℓ/min × 95.0 m	55.0 KVA	40m³	22	600	400		400
103	Ankilizato	4,200	5,500	AA	φ6"	170 m	(25.00 / 115.00)	1	310 ℓ/min × 130.0 m	55.0 KVA	40m³	13	200	200		1,200
67	Analaiva	1,520	2,000	AA	φ4"	73 m	(3.70 / 4.81)	0	110 ℓ/min × 30.0 m	10.0 KVA	20m³	5		200	300	700
115	Ankotrofotsy	908	1,200	AA	φ6"	150 m	(15.00 / 25.00)	1	70 ℓ/min × 40.0 m	10.0 KVA	15m³	3				50
97	Bezezika	855	1,100	AA	φ4"	50 m	(8.00 / 9.00)	1	70 ℓ/min × 30.0 m	10.0 KVA	15m³	3				400
114	Ambatolahy	800	1,100	AA	φ6"	93 m	(13.41 / 24.27)	0	60 ℓ/min × 40.0 m	10.0 KVA	10m³	3				50
94	Ankilivalo	2,960	3,900	BA	φ4"	100 m	(10.00 / 15.00)	1	220 ℓ/min × 30.0 m	12.5 KVA	40m³	9	200	400	200	200
58	Bemanonga	1,500	2,000	BA	φ4"	100 m	(5.00 / 15.00)	1	100 ℓ/min × 30.0 m	10.0 KVA	15m³	4		200		400

Table 10.3.1 Water Supply Facilities by Village (4/4) (Solar Energized Type)

Village No.	Village Name	Population in 1995	Population in 2005	Categorization	Well Diameter	Well Depth	Well S.W.L (GL-m) / D.W.L (GL-m)	Well Q.ty	Submersible Motor Pump Capacity×Head	Solar Energized	Reservoir Capacity	Public Faucet	Pipe Line φ4" (m)	Pipe Line φ3" (m)	Pipe Line φ2 1/2 (m)	Pipe Line φ2" (m)
25	Befasy	2,000	2,600	AA	φ4"	63 m	(5.57 / 9.98)	0	200 ℓ/min × 25.0 m	2.38 KW	30m³	6				1,000
104	Mandabe	2,000	2,600	AA	φ6"	103 m	(9.80 / 13.90)	0	200 ℓ/min × 30.0 m	2.86 KW	30m³	6		200	200	800
23	Marerano	1,100	1,400	AA	φ6"	170 m	(15.00 / 30.00)	1	110 ℓ/min × 45.0 m	2.36 KW	15m³	3				50
109	Tsianaloka	1,000	1,300	AA	φ4"	35 m	(13.00 / 15.00)	1	100 ℓ/min × 30.0 m	1.43 KW	15m³	3				50
107	Ampanotoka	900	1,200	AA	φ6"	200 m	(35.00 / 50.00)	1	90 ℓ/min × 65.0 m	2.78 KW	15m³	3				50
110	Kiboy	930	1,200	AA	φ6"	130 m	(15.00 / 30.00)	1	100 ℓ/min × 45.0 m	1.99 KW	15m³	3				50
31	Belco	800	1,100	AA	φ4"	70 m	(6.00 / 12.00)	1	80 ℓ/min × 30.0 m	1.14 KW	10m³	3				50
93	Beroboka Atm.	783	1,000	AA	φ4"	70 m	(3.00 / 5.00)	1	80 ℓ/min × 20.0 m	0.75 KW	10m³	2				50
46	Marofihitsa	750	980	AA	φ4"	40 m	(4.00 / 5.00)	1	80 ℓ/min × 30.0 m	1.07 KW	10m³	2		3,000		50
100	Ampanihy	742	970	AB	φ4"	100 m	(5.00 / 15.00)	1	80 ℓ/min × 30.0 m	1.06 KW	10m³	2				50
52	Antsakamirohaka	1,600	2,100	BA	φ4"	50 m	(5.00 / 15.00)	1	160 ℓ/min × 30.0 m	2.28 KW	20m³	5				500
112	Tsimafana	1,500	2,000	BA	φ4"	100 m	(5.00 / 20.00)	1	150 ℓ/min × 40.0 m	2.86 KW	20m³	5				50
59	Marovoay	1,247	1,600	BA	φ4"	100 m	(5.00 / 15.00)	1	130 ℓ/min × 30.0 m	1.78 KW	20m³	4				500
113	Mananjaky	1,170	1,500	BA	φ4"	30 m	(13.00 / 20.00)	1	120 ℓ/min × 30.0 m	1.67 KW	15m³	4				500
89	Ankaraobato	900	1,100	BA	φ4"	70 m	(5.00 / 15.00)	1	80 ℓ/min × 30.0 m	1.14 KW	10m³	3				50
1	Andranopasy I	623	820	BA	φ4"	50 m	(7.00 / 15.00)	1	70 ℓ/min × 30.0 m	0.89 KW	10m³	2		5,000		500
33	Misokotsa	800	1,100	BB	φ4"	60 m	(7.00 / 15.00)	1	80 ℓ/min × 30.0 m	1.14 KW	10m³	3				600

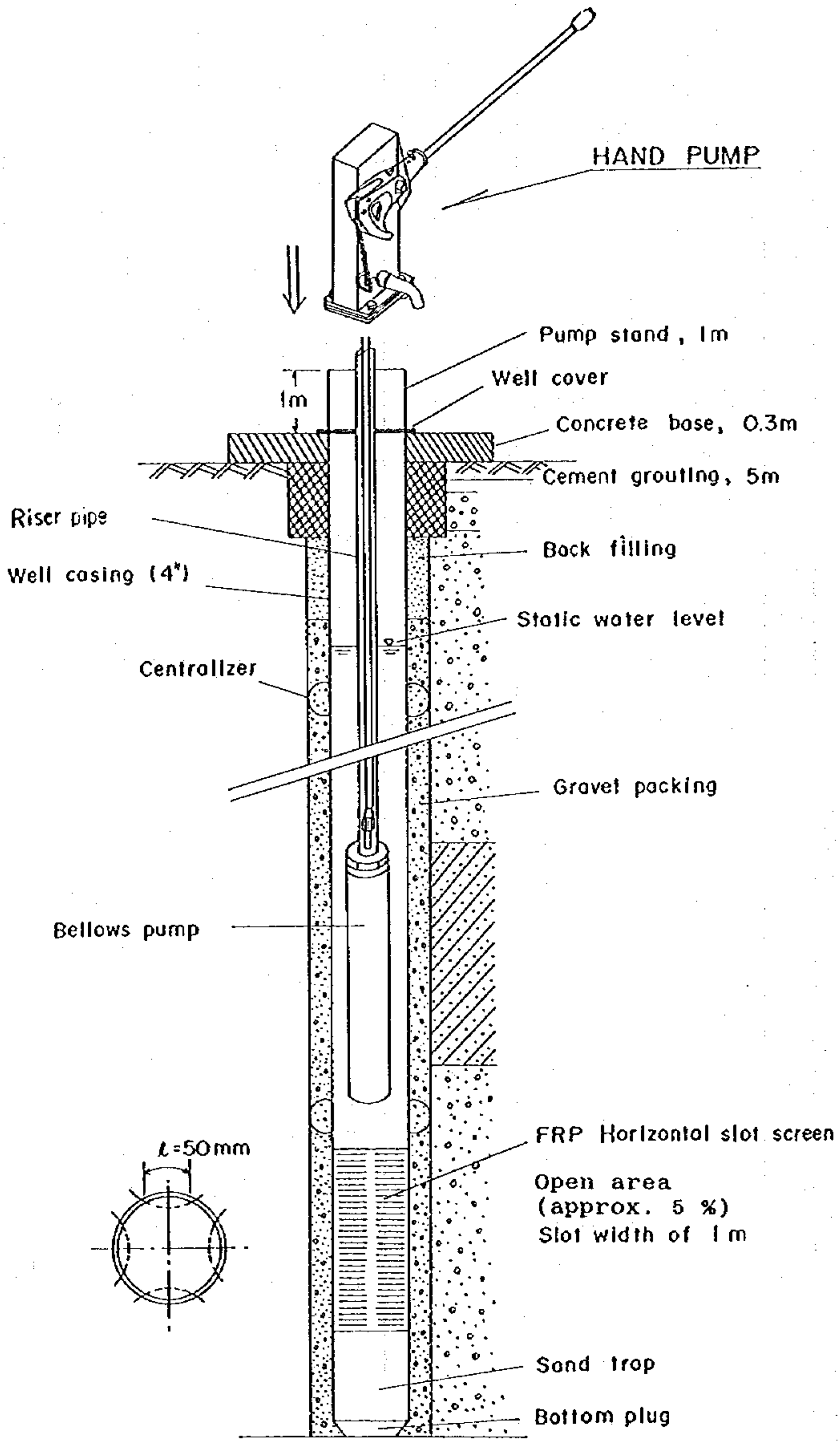


Fig. 10.3.1 Standard Well Design for Hand-pumped Well

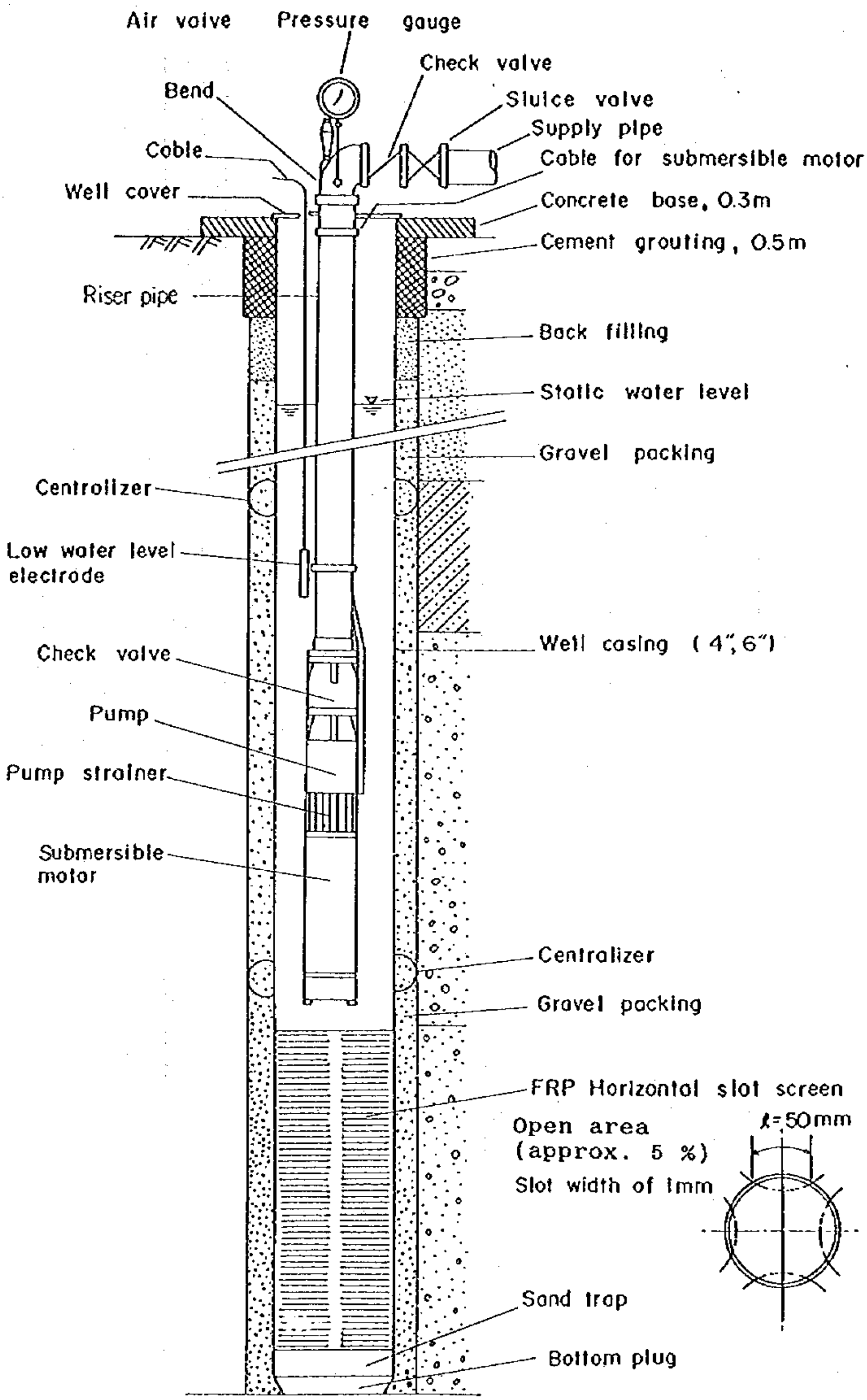


Fig. 10.3.2 Standard Well Design for Motor-pumped Well

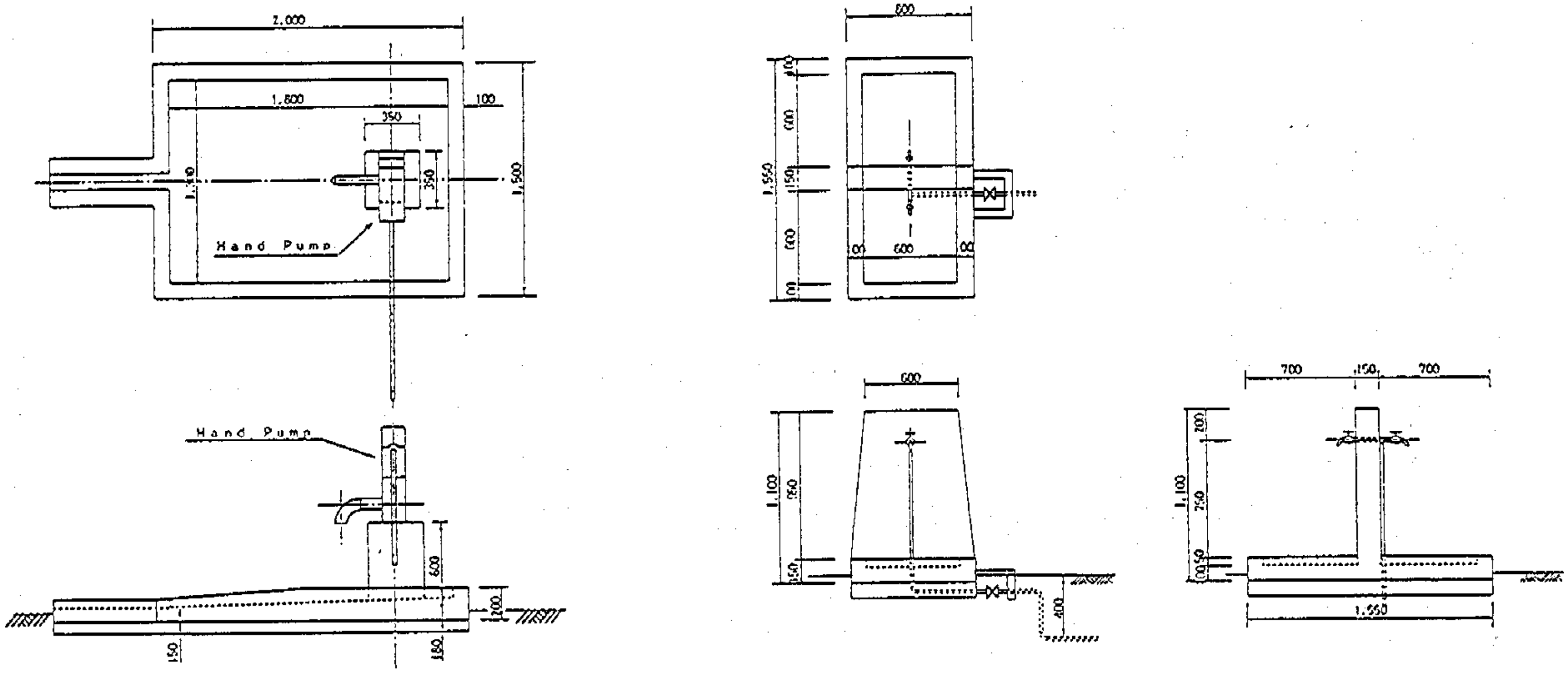
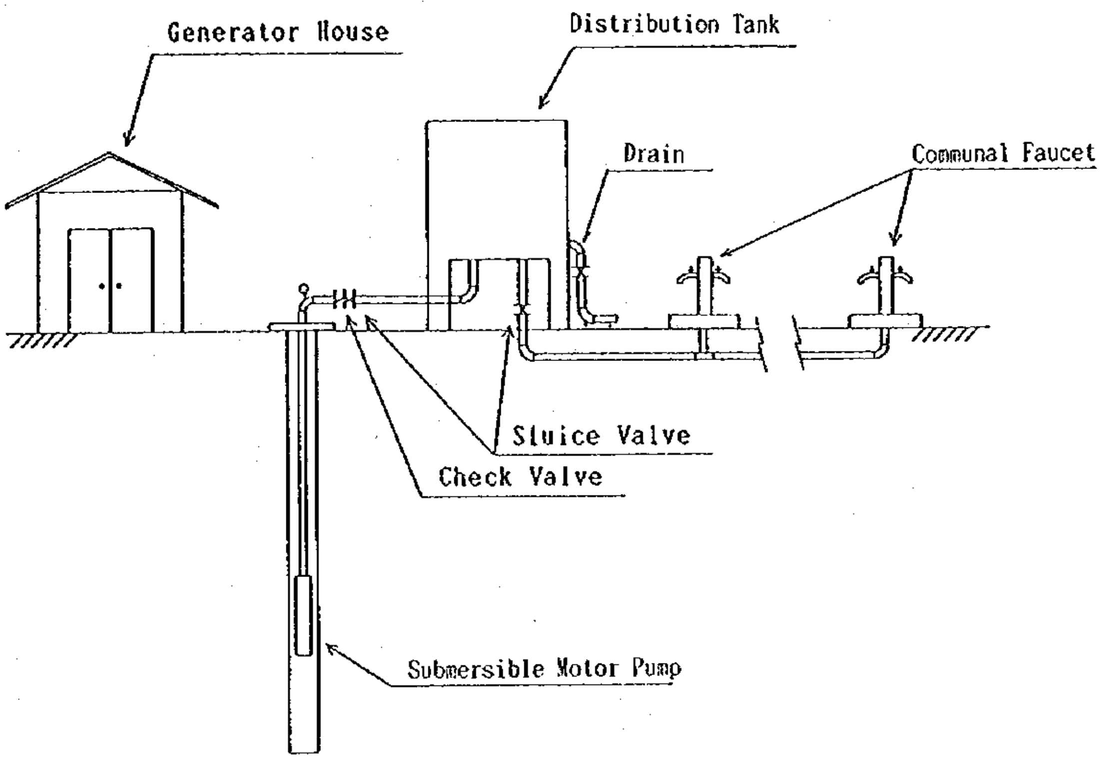


Fig. 10.3.3 Standard Design of the Concrete Pump Base and Communal Faucets



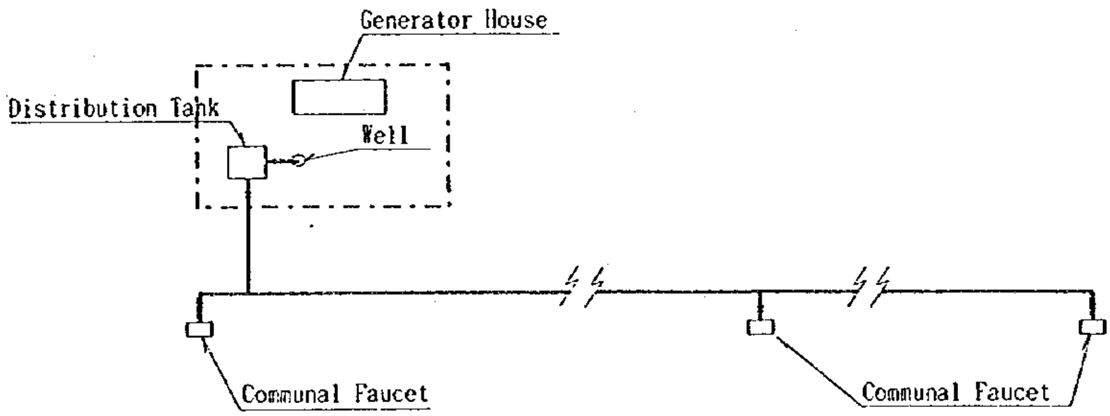


Fig. 10.3.4 Schematic Drawing of Water Supply System (with Pumping by Diesel Engine Generator)

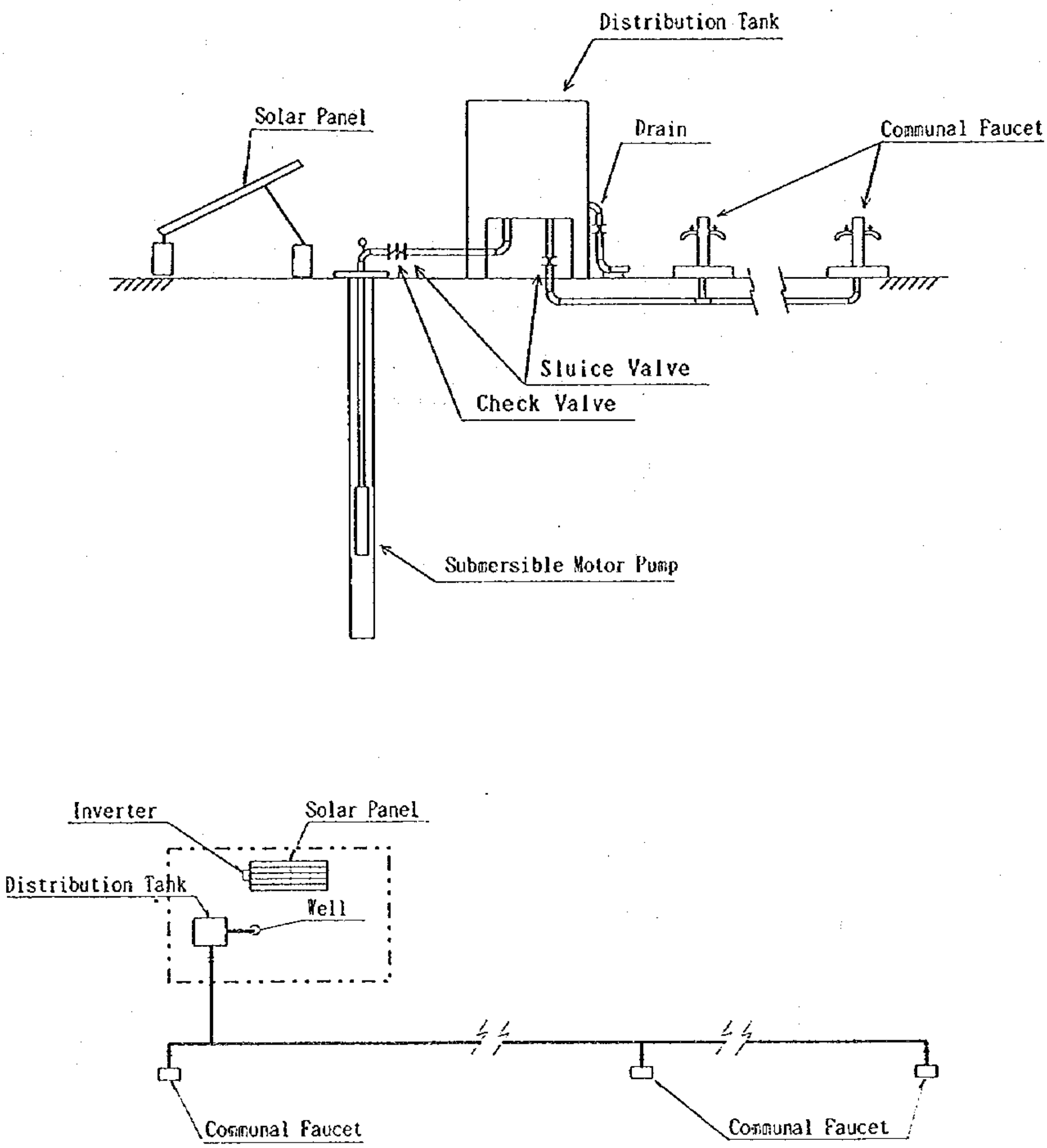


Fig. 10.3.5 Schematic Drawing of Water Supply System (with Solar Energized Pumping)

10.4 Estimation of Necessary Investment Cost

A cost estimation for the construction of water supply facilities has been done under the following conditions and assumptions:

- The facility construction cost shall include the cost for the establishment of the project management office in the Morondava area, since this office is believed to be vital in order to make the project sustainable. The office complex shall comprise an office building, combined warehouse, workshop, and garage. The cost for constructing the office also includes the necessary equipment and materials for the maintenance of the wells, vehicles and the tools for repairing the pump and generator.
- The unit construction costs and material costs for the water supply facility are assumed to be same as that of the Phase I Project, however, the contingency is estimated at 8 % for the foreign portion and 10 % for the local portion.
- The construction cost for the hand pumps consists of the cost of works and materials for 4-inch wells, concrete pump base, and hand pump installation with spare parts delivery.
- The cost estimation for the construction of the semi-urban type facilities is divided into that of intake and distribution system.

  The cost for the distribution system comprises the works and materials for the reservoir tank, distribution pipe and communal faucets. Their size and number depend on the type of facility and water demand of the villages.

  The intake system comprises a single well with a diameter of 4-inches or 6-inches equipped with a submersible motor pump; the well diameter depending on the volume of water to be pumped (outer diameter of the pump). The power source is a diesel engine generator accompanied by a generator house at 8 villages, and a set of solar panels at 17 villages. The power supply, that is, the capacity of the generator or number of solar panels depends on the water demand of the villages.

10.4.1 Construction Cost of Supply Facilities for 80 Villages

For all of the 81 villages surveyed, excluding the village of Andranomena where a well was constructed during the Study period, the facility construction cost is estimated at about US Dollars 7.54 million, as shown in Table 10.4.1.

Table 10.4.1 Facility Construction Cost for 80 Villages (Unit = US$)

Items	Foreign	Local	Total
Construction Cost		2,359,515	2,359,515
Equipment and Material Cost	4,064,791		4,064,791
Administration and Engineering Cost	325,184	188,761	513,945
Contingencies	351,198	254,827	606,025
Total	4,741,173	2,803,103	7,544,276

- Number of wells and their total length:

  4-inch wells : 135 wells totaling 10,025 m drilling

  6-inch wells : 6 wells totaling 1,070 m drilling

- Number of the supply facilities by type:

  Diesel Engine Generator Type 8 sets

  Solar Energy Type 17 sets

  Hand Pump Type 121 sets

With the addition of the cost to set up the Morondava management office, the construction cost for the works in the 80 villages totals about 9.43 million US Dollars as shown in Table 10.4.3.

10.4.2 Construction Cost for the Selected 60 Villages

In view of the ideal project implementation, that is, from the viewpoints of urgent necessity and a favorable socio-economic condition, the construction cost of the facilities in the 60 prioritized villages has been estimated, and presented in Table 10.4.2. The back data which was used to conduct the cost estimation are presented in the Supporting Report.

Table 10.4.2 Facility Construction Cost for 60 Selected Villages (Unit = US$)

Items	Foreign	Local	Total
Construction Cost		2,085,777	2,085,777
Equipment and Material Cost	3,552,457		3,552,457
Administration and Engineering Cost	284,197	166,862	451,059
Contingencies	306,932	225,263	532,195
Total	4,143,586	2,477,902	6,621,488

- Number of wells and their total length :

4-inch wells	:	103 wells,	totaling	7,795 m	drilling
6-inch wells	:	6 wells,	totaling	1,070 m	drilling

- Number of supply facilities by type :

Diesel Engine Generator Type	8 sets
Solar Energy Type	17 sets
Hand Pump Type	89 sets

With the addition of the cost for the setting-up of the Morondava management office, the construction cost for the 60 selected villages totals about US$ 8.5 million, as shown in Table 10.4.4. The cost of setting up the office includes the construction cost of the buildings and the equipment and materials for the maintenance of facilities:

. Borehole Logging, Equipment for Water Quality Analysis

. Pumping Test Equipment

. Vehicles

Cargo Truck with Crane 4 × 4	1 unit
4WD Station-wagon	1 unit
Pick-up Truck	1 unit

. Maintenance Tools	1 unit
. Well Service Machine	1 unit
. Spare Parts	L. S.

Table 10.4.3 Investment Cost (80 Villages)

(Unit=US$)

Item		Foreign	Local	Total
Project Management Office	Land and Construction Cost		174,512	174,512
	Equipment and Material Cost	1,438,495		1,438,495
	Administration and Engineering Cost	115,080	13,961	129,041
	Contingencies	124,286	18,847	143,133
	Sub-total	1,677,861	207,320	1,885,181
Well Drilling & Water Supply Facility	Construction Cost		2,359,515	2,359,515
	Equipment and Material Cost	4,064,791		4,064,791
	Administration and Engineering Cost	325,184	188,761	513,945
	Contingencies	351,198	254,827	606,025
	Sub-total	4,741,173	2,803,103	7,544,276
Total		6,419,034	3,010,423	9,429,457

Table 10.4.4 Investment Cost (60 Villages)

(Unit=US$)

Item		Foreign	Local	Total
Project Management Office	Land and Construction Cost		174,512	174,512
	Equipment and Material Cost	1,438,495		1,438,495
	Administration and Engineering Cost	115,080	13,961	129,041
	Contingencies	124,286	18,847	143,133
	Sub-total	1,677,861	207,320	1,885,181
Well Drilling & Water Supply Facility	Construction Cost		2,085,777	2,085,777
	Equipment and Material Cost	3,552,457		3,552,457
	Administration and Engineering Cost	284,197	166,862	451,059
	Contingencies	306,932	225,263	532,195
	Sub-total	4,143,586	2,477,902	6,621,488
Total		5,821,447	2,685,222	8,506,669

11. OPERATION AND MAINTENANCE

11.1 Establishment of Water Associations

Some of the villages in the Study Area have water associations for water source management, but are mostly irrigation related, only a few are for domestic water use. All candidate villages should have autonomous water management associations for the purpose of sustainable O/M of the water supply facilities prior to project implementation. Therefore, promotional activities for the organization of the water associations were undertaken by the Joint Study Team during the village inventory surveys. Also, trial water associations were established in the pilot project, as explained in section 8.1.1. Repeated discussions were held with the villagers to formulate water associations in the 6 villages of the pilot project.

The water associations were established in the following manner:

- A meeting was called by the village chief (president)
- The Joint Study Team explained the regulations of the water association and the roles of the executive members (president, secretary, accountant, sanitary coordinator, and mechanics).
- Election of the executive members by the villagers
- Detailed explanation on the management of the water association to the elected executive members, including bookkeeping.

The functions and duties of the executive members of the water association are as follows:

President:

- To call the inhabitants for a meeting once a month, regarding the situation of expenditures, for the collection of fees, diffusion of information, education and training.
- To make sure that the members are fulfilling their duties.
- To check the formulation and utilization of the Fund and sign the account book for revenue and expenses.
- To make a request to the authorities concerned with facility maintenance that are beyond the capacity of the water association.

Secretary:

- To support the President in his activities, and represent him during his absence.

- To take down notes during the meetings, prepare the Minutes of Meetings and write down the decisions made by the Water Association
- To help the Treasurer with the bookkeeping.

Treasurer

- To collect contribution fees from households with the help of the President and Secretary, and make a record of the contributions.
- To keep the book up-to-date (receipts and payments)
- To be responsible for the cash.

Sanitary Coordinator

- To enlighten the association members, emphasizing on the necessity of using safe water, especially during the rainy season
- To keep the well and its surrounding area clean.
- To monitor the hygiene of villagers.

Mechanic

- To check the functioning of the facilities daily, and to repair the troubled parts.
- To store the repairing tools and materials and maintain their condition.
- To report to the president if technical assistance by the authorities is necessary.

11.2 Economic and Institutional Aspects of the Operation and Maintenance

The economic aspect of operation and maintenance is one of the critical issues in a rural water supply project. Although motivation and participation of beneficiaries is important, the operation and maintenance of facilities do not function well without proper financial, technical and institutional background of the parties concerned. In this project, there are mainly three parties concerned for the operation and maintenance. They are MEM, local authorities and the water association of the beneficiary villages. In this section, the budgetary and institutional constraints of each party will be examined, thereby formulating a realistic operation and maintenance plan for the project.

11.2.1 Budgetary and Institutional Constraints of MEM

Since MEM is a major governmental institution in charge of rural water supply programs in Madagascar, it must play a central role to support the operation and maintenance program of this project. Without proper support from MEM, this project will lose its sustainability.

1) Budgetary Constraints

The public investment program (hereinafter referred to as PIP) is a basic budgetary program on public investment including rural water supply project, which is allocated under the control of the Ministry of Finance. The table below is the PIP allocated for the Water Department of MEM during the financial years 1994-1996.

Table 11.2.1 PIP for the Water Department of MEM in 1994-1996 Financial Year

Financial Year	Allocated Amount (million FMG)	Growth Rate (%)
1994	14,542.0	n.a
1995	16,644.9	14.5
1996	20,135.9	21.0

Source: PIP 1994-1996

Since PIP includes official development assistance, it fluctuates every year in accordance with the scale of assistance. Furthermore, it is important to notice here that PIP is an investment program and does not cover the operation and maintenance cost of past investment programs. Consequently, MEM cannot depend on PIP for the operation and maintenance costs.

Accordingly, the regular administrative budget of MEM should be reviewed. The table hereafter shows the regular administrative budget allocated for the Water Department and Toliara Office in the financial year 1995.

Table 11.2.2 Regular Administrative Budget of MEM in Financial Year 1995

Unit: FMG

Budget Item	Water Department	Toliara Office
Personnel and Administration	666,000,000	94,000,000
Fuel and Spare Parts & Others	129,500,000	56,800,000
Regular Budget Total	795,500,000	140,800,000

Source: MEM

It clearly shows that the personnel and administrative items occupy 83.7 % and 66.7 % of all the regular budget in the Water Department and in Toliara Office, respectively, indicating that the Water Department as well as the Toliara Office can not afford to sufficiently allocate operation and maintenance cost, such as fuel and spare parts, for on-going rural water supply projects.

In summary, since the operation and maintenance program for rural water supply cannot be covered by PIP, an increase in the regular budget of MEM is absolutely necessary, and this increase should be to a large extent allocated for the operation and maintenance of rural water supply projects.

2) Institutional Constraints of MEM

The institutional constraints of MEM are closely related to budgetary constraints. Without proper allocation of the budget, MEM is incapable of keeping highly qualified staff. It is obvious that the most serious institutional constraint of MEM is lack of manpower in its Toliara regional office. The number of personnel is not enough to cover the whole area of the former Toliara region. The following table indicates the number of personnel by category.

Table 11.2.3 Number of Personnel by Kind of Staff in MEM

Categories of Staff	MEM Total	Water Department	Toliara Office
Administrative	154	25	6
Engineer	90	12	2
Assistant Engineer	45	9	2
Driller	10	7	0
Assistant Driller	56	30	0
Mechanic	20	4	1
Laborers	350	52	38

Source: MEM

It is clear that the number of engineers is not sufficient to cover the whole area of the former Toliara region including the Study Area. Moreover, there is only one mechanic stationed who is capable of repairing of hand pumps and generators.

The lack of mobility is another serious constraint in the Toliara office. Since access from Toliara to Morondava is very difficult, it is almost impossible to regularly contact the villages in the Study Area.

In summary, it is necessary for the MEM to increase its manpower, especially, the number of mechanics, and it is absolutely imperative to set up the Morondava branch office of MEM regional office, which shall be conveniently located for regular contact with the villages in the Study Area. Without the Morondava office, the maintenance of facilities will almost be impossible.

11.2.2 Budgetary and Institutional Constraints of Local authorities

A local authority is another institution to support villages. The Departemanta, the middle unit of local authority, is the most realistic institution to support the project, if possible.

1) Budgetary Constraints

The local authority, such as departemantas, is financially subsidized by the central Government through the Ministry of Interior. However, the budget is extremely limited, and the allocation of the budget for the operation and maintenance program is very scarce. The table below indicates the budget of Morondava Departemanta in 1994.

Table 11.2.4 Budget of Morondava Department in the Financial Year 1994

Budgetary Item	Total Budget (FMG)	Composition Rate (%)
Administration	42,081,750	11.2
Investment	332,700,500	88.8
Total	374,782,250	100.0

Source: Morondava Department

It is obvious that although the budget is concentrated on the investment program, there is little capacity to allocate their budget to support the operation and maintenance program of the project. What is worse, the fact is that the budget for the operation and maintenance, such as fuels and spare parts, in the same financial year is only FMG 9,570,140, which occupies 22.7 % of the administrative budget and only 2.6 % of the total budget. Thus, local authorities cannot allocate their budget for the operation and maintenance program of the project, and therefore it is not realistic to depend on financial support from the local authorities.

2) Institutional Constraints

Since the Departemanta is purely an administrative unit, the staff of which are dispatched by the Ministry of Interior, the administrative office of Departemanta is incapable of supporting the operation and maintenance of facilities.

The local development committee is run by officials from the regional offices of the various ministries concerned, however, since MEM has no office in the departemantas in the Study Area, there are no engineers or mechanic except some civil engineers, their function is limited to advising on technical issues.

11.2.3 Budgetary and Institutional Constraints of the Water Associations of Villages

1) Budgetary Constraints

Since the village is not an official administrative unit and has no budgetary resources, the sole financial resource will be the operation and maintenance fee collected by water associations. It is easily estimated that this amount of fee cannot cover the capital cost for major repairs such as replacement of hand pumps and generators and re-drilling of boreholes.

2) Institutional Constraints

Even if a water association is initially set up, there are mainly three major institutional constraints in villages. The first one is lack of communication and mobility, the village has no communication and transportation means in case they require support from MEM. The second one is lack of simple technology to repair minor breakdowns of the facilities. The third is lack of financial planning so that villagers are apt to spend the operation and maintenance fee without proper financial management. Thus, long-term training such as successive seminars will be necessary.

11.2.4 Demarcation of Responsibilities for Operation and Maintenance

Since neither of the above three parties concerned is not sufficiently endowed with budgetary and institutional resources, each party must cooperate to share the burden of the operation and maintenance by mobilizing the available resources. It is needless to say that MEM has the primary burden of operation and maintenance. The important point here is that the operation and maintenance should be planned not ideally but more realistically. In this sense, the realistic demarcation of responsibilities for the operation and maintenance are planned as below.

1) MEM

The most realistic demarcation of responsibilities of the Morondava office of MEM are:

a) to manage and control the overall operation and maintenance program

b) to conduct periodical patrols in villages and check the problems of facilities

c) to technically support the minor repair of facilities

d) to repair the medium-sized breakdowns at the cost of villages. (The medium-sized repair includes the replacement of batteries and the repair of hand pumps.)

e) to repair the major breakdowns at its own costs and personnel. (The major repair includes the replacement of pumps and generators, and rehabilitation or re-drilling of boreholes.)

f) to plan and conduct the periodical seminars for training on the minor repair of facilities by repair kits and training on the financial management of water associations.

As mentioned before, setting up the Morondava office is a basic condition for the above demarcation of responsibilities for MEM. It is important to plan the annual time table for the periodical patrol and training seminars.

2) Local Authorities

The most realistic demarcation of responsibilities of local authorities are:

a) to assist communication with villages in case of needs (Departamenta office)

b) to give the technical advise to villages (local development committee)

Since the office of Departemanta is the center of the community in rural areas, the office is in a position to assist communication from villages to the Morondava office of MEM in case of necessity. Each office of Departemanta to which a candidate village belongs will convey the message to the Morondava office through their telephone equipment immediately upon request of the villagers. The date and contents of the communication should be recorded.

The office of Departemanta will also convey the message from the Morondava office to villages in such a case as notifying the date for seminars. If a office of Departemanta has no telephone equipment, the office will transmit messages to police stations nearby with wireless communication systems.

When the Morondava office is set up, the MEM representative will be a member of the Morondava local committee. As a result, the representative will make a technical transfer on facilities O/M to other members of the committee so that they will be able to technically advise the villagers when required.

3) Water Association

The most realistic demarcation of responsibilities of the water association of villages are:

a) to manage the water association properly.

b) to collect the operation and maintenance fee regularly and equitably.

c) to operate the facilities properly.

d) to repair minor breakdowns of facilities at their own costs and personnel.

e) to report medium-sized breakdowns of facilities to the MEM or JIRAMA, and apply for immediate repair at their own cost. (The medium-sized repair includes the replacement of batteries, repair of pumps and/or generator, re-development of wells, etc.)

f) to report major breakdowns of facilities to the Morondava office of MEM and apply for immediate repair. (The major repair includes the replacement of pumps and generators, and re-drilling of boreholes.)

g) to cooperate with in the seminar conducted by the MEM

The important point for the operation and maintenance is equity and sustainability of water associations of villages. Equity will be maintained by the negative incentives for non-payers. In case that a household is reluctant to pay for the operation and maintenance fee in spite of its affordability to pay, the use of facilities should be suspended. The association will neutrally decide this suspension after some warning period.

Sustainability of the water association shall be maintained by positive incentives for the executive members of water associations. The executive members of the water association should be compensated for the proper amount of wage for its assignment, which is publicly and neutrally decided by the association. However, these monetary incentives are mandatory measures, and the most crucial issue is improvement of people's awareness of the importance of operation and maintenance of facilities.

11.2.5 Action Plans for Operation and Maintenance

The above basic demarcation of responsibilities should be more concretely formulated in the form of an action plan for each party concerned. The first step is to clarify the demarcation of responsibilities of each party. Table 11.2.5 below is a sample of the demarcation of the responsibilities of each party. All the parties concerned must have mutual understandings of this table, thereby taking immediate actions when they are required.

Table 11.2.5 Demarcation of Responsibilities in Each Party

Party	Regular Operation	Periodical Patrol	Minor Repair	Medium Repair	Major Repair	Seminar
MEM	T	M, F, P, T	T	M, P, T	M, F, P, T	M, F, P, T
Department		C	C	C	C	C
D. Committee	T	T	T	T	T	T
Village	M, F, P		M, F, P	F		M, P

Note: M, F, P, T and C symbolizes responsibility for Management, Finance, Personnel, Technical assistance and Communication assistance, respectively.

The second step is to concretely formulate the action plan required for each party. In order to assume its responsibilities, each party should make a resource mobilization table, and the table should be filled with the correct figure, considering the type and number of facilities. The table below is a sample of the resource mobilization table. The concrete figures of the available units and financial value of resources required will be clear based on this table.

Table 11.2.6 Example for Resource Mobilization Table of Each Party

Kind of Resources	Required (Unit)	Available (Unit)	Gap (Unit)
Vehicle			
Fuel			
Spare Parts			
Staff			
Kind of resource	Required (FMG)	Available (FMG)	Gap (FMG)
Vehicle			
Fuel			
Spare Parts			
Equipment			
Wage			

The gap between the required resources and the available resources must be replenished by other resources. The gap will be the amount of financial resources required. For MEM, the necessary amount of budget to be newly allocated will be concretely calculated. For water associations of villages, the needed amount of fee will be concretely calculated. The overall package of these action plans will be formulated in advance to the implementation of the Project.

11.2.6 Future O/M management Plan for Rural Water Supply

MEM is planning to establish a semi-governmental company for the better management of the rural water supply projects.

Similar to JIRAMA, which manages the urban water supply under MEM, new enterprises, "EPIC (Public Establishment with Industrial and Commercial Characteristics)", shall cover the management of the rural water supply.

However, unlike in urban areas, income is not expected from the rural water supply projects, hence the enterprises are to be subsidized by the government.

One example of an "EPIC" is the "AES (Water Supply for the South)", which was transferred from the Presidential Secretariat to the MEM in 1994. The rural water supply project in the southern area of Madagascar is being funded by foreign financial assistance, and upon completion of the facilities, the operation and maintenance is to be managed by the AES, not by the Toliara Regional Office of MEM.

As for the Phase I Project in the South-western region, it is now under the direct management of MEM through the Toliara Regional Office, but it will be transferred to a new EPIC in the near future. The coming project, namely the Phase II Project in the South-western region, will be managed by the Morondava branch of the Toliara Regional Office initially, then the management will be shouldered by an EPIC.

Thus, the new management bodies will be established one by one and cover all Madagascar.

11.3 Estimation of Operation and Maintenance Cost

The total operation and maintenance cost is estimated at FMG 281.7 million (US$ 70,912) per year, assuming a project life is 30 years, however, cost increase due to inflation is not included in the calculation.

The maintenance cost is divided into two. Firstly, the burden of the project management office comprising : running costs of the office, cost for periodic patrol, and the rehabilitation or redevelopment services of the wells (2 to 4 years per well). And secondly, the burden of individual water associations formed in the villages where the project was implemented, comprising: running costs of the facilities, and the cost for overhaul and replacement of the pumping and generating equipment.

11.3.1 Operation and Maintenance Cost Covered by MEM

The average annual operation cost mostly borne by the project management office :

Salary and allowances	FMG 12,600,000
Fuel and lubricants for vehicles	FMG 3,280,000
Repair and overhaul of equipment	FMG 8,563,000
Well rehabilitation and vehicle replacement	FMG 16,842,000
Other expenses	FMG 1,200,000
Total	FMG 42,485,000 (US$ 10,696)

It is assumed that there will be one person per position in the project management office.

- Manager	FMG	300,000 / month
- Secretary	FMG	150,000 / month
- Water Supply Facility Technician	FMG	250,000 / month
- Driver	FMG	200,000 / month
- Guard	FMG	150,000 / month
Total	FMG	1,050,000 / month

The cost for the well rehabilitation and vehicle replacement is shown in the following Table.

Table 11.3.1 Cost for Well Rehabilitation and Vehicle Replacement

(Unit: US$)

Year	Well Maintenance	Vehicle Replacement
1	0	0
2	1,269	0
3	0	0
4	5,077	0
5	0	0
6	1,269	0
7	0	0
8	5,077	0
9	0	0
10	1,269	27,171
11	0	0
12	5,077	0
13	0	0
14	1,269	0
15	0	0
16	5,077	0
17	0	0
18	1,269	0
19	0	0
20	5,077	27,171
21	0	0
22	1,269	0
23	0	0
24	5,077	0
25	0	0
26	1,269	0
27	0	0
28	5,077	0
29	0	0
30	1,269	27,171
Sub total	45,691	81,513
Total	127,204	
Average / year	$ 4,240	

11.3.2 Operation and Maintenance Cost Covered by the Water Association

The annual operation and maintenance costs borne by the water associations differ according to the type of facility.

1) The annual O/M cost for the hand pump type facility for 35 villages totals about FMG 59 million/ year, with an average per village of about FMG 1.69 million/ village/ year. The monthly amount borne by household ranges from FMG 900 to FMG 2,000/ month/ household.

   The monthly O/M cost per village is presented in Table 11.3.2.

2) The annual O/M cost for the solar powered type facility for 17 villages totals about FMG 37 million/ year, with an average of about FMG 2.18 million/ village/ year. The monthly amount borne by household ranges from FMG 400 to FMG 1,500/ month/ household.

   The monthly O/M cost per village is presented in Table 11.3.3.

3) The annual O/M cost for the diesel engine generator facility for 8 villages totals about FMG 143 million/ year, with an average about FMG 17.89 million/ village/ year. The monthly amount borne by household ranges from FMG 1,400 to FMG 4,000/ month/ household.

   The monthly O/M cost per village is presented in Table 11.3.4.

Table 11.3.2 Monthly Operation and Equipment Maintenance Cost for 35 Villages (H/P)

(FMG/month)

No. Village	Population		No. of Pump	Salary	Maintenance	Total
	in 1995	in 2005				
3 Antaly	327	430	2	50,000	72,100	122,100
5 Befamonty	450	590	3	50,000	108,200	158,200
7 Nosilonga	260	340	2	50,000	72,100	122,100
8 Nosibe	600	790	4	50,000	144,200	194,200
9 Ankoba	410	540	3	50,000	108,200	158,200
10 Antseranandaka N.	342	450	2	50,000	72,100	122,100
15 Miary	365	480	2	50,000	72,100	122,100
16 Ambivy I	130	170	1	50,000	36,100	86,100
17 Ambivy II	500	660	3	50,000	108,200	158,200
18 Ambahia	200	260	2	50,000	72,100	122,100
20 Marolafika Atm.	500	660	3	50,000	108,200	158,200
26 Antevamena	360	470	2	50,000	72,100	122,100
27 Mitsitiky	340	450	2	50,000	72,100	122,100
34 Croise. Besotroka	200	260	2	50,000	72,100	122,100
35 Amanga	400	530	3	50,000	108,200	158,200
36 Namakia	400	530	3	50,000	108,200	158,200
39 Antsamaka	150	200	1	50,000	36,100	86,100
40 Manomentimay	436	570	3	50,000	108,200	158,200
41 Farateny	250	330	2	50,000	72,100	122,100
47 Ambararata	500	660	2	50,000	72,100	122,100
48 Ankevo	300	390	2	50,000	72,100	122,100
53 Androvakely	550	720	4	50,000	144,200	194,200
55 Ampananiha	420	550	3	50,000	108,200	158,200
60 Tandrokosy	238	310	2	50,000	72,100	122,100
66 Croisement BST	204	270	2	50,000	72,100	122,100
68 Betsipotika	120	160	1	50,000	36,100	86,100
70 Ampandra	600	790	4	50,000	144,200	194,200
74 Tsinjorano	450	590	3	50,000	108,200	158,200
76 Laijoby Avaratra	150	200	1	50,000	36,100	86,100
81 Malandirano	400	530	3	50,000	108,200	158,200
82 Marofandiliha	370	490	3	50,000	108,200	158,200
83 Ampataka	695	910	4	50,000	144,200	194,200
99 Ankilimida	600	790	4	50,000	144,200	194,200
101 Benato	500	660	3	50,000	108,200	158,200
102 Anolotsy	300	390	2	50,000	72,100	122,100
Total (35 Villages)			88	1,750,000	3,173,200	4,923,200

(US$ 1,239)

Table 11.3.3 Monthly Operation and Equipment Maintenance Cost (Solar Type)

(FMG/month)

No. Village	Population		Salary	Maintenance	Total
	in 1995	in 2005			
1 Andranopasy I	623	820	100,000	79,400	179,400
23 Marerano	1,100	1,400	100,000	79,400	179,400
25 Befasy	2,000	2,600	100,000	79,400	179,400
31 Beleo	800	1,100	100,000	79,400	179,400
33 Misokotsa	800	1,100	100,000	79,400	179,400
46 Marofihitsa	750	980	100,000	79,400	179,400
52 Antsakamirohaka	1,600	2,100	100,000	79,400	179,400
59 Marovoay	1,247	1,600	100,000	79,400	179,400
89 Ankaraobato	800	1,100	100,000	79,400	179,400
93 Beroboka Atm.	783	1,000	100,000	79,400	179,400
100 Ampanihy	742	970	100,000	79,400	179,400
104 Mandabe	2,000	2,600	100,000	114,100	214,100
107 Ampanotoka	900	1,200	100,000	79,400	179,400
109 Tsianaloka	1,000	1,300	100,000	79,400	179,400
110 Kiboy	930	1,200	100,000	79,400	179,400
112 Tsimafana	1,500	2,000	100,000	79,400	179,400
113 Mananjaky	1,170	1,500	100,000	79,400	179,400
Total	18,745	24,570	1,700,000	1,384,500	3,084,500

(US$ 776)

Table 11.3.4 Monthly Operation and Equipment Maintenance Cost (E.Generator Type)

(FMG/month)

No. Village	Population		Salary	Fuel & Oil	Maintenance	Total
	in 1995	in 2005				
58 Bemanonga	1,250	1,600	100,000	530,600	118,000	748,600
67 Analaiva	1,520	2,000	100,000	530,600	118,000	748,600
94 Ankilivalo	2,960	3,900	100,000	663,300	161,000	924,300
97 Bezezika	855	1,100	100,000	530,600	118,000	748,600
103 Ankilizato	4,200	5,500	100,000	2,547,100	347,000	2,994,100
106 Malaimbandy	7,000	9,200	100,000	3,820,600	347,000	4,267,600
114 Ambatolahy	800	1,100	100,000	530,600	118,000	748,600
115 Ankotrofotsy	908	1,200	100,000	530,600	118,000	748,600
Total	19,493	25,600	800,000	9,684,000	1,445,000	11,929,000

(US$ 3,003)

12 PROJECT EVALUATION

The Project is designed to supply potable water for the villagers in the South-western Region of Madagascar, thereby meeting the basic human needs in the rural areas where water shortage is so alarming as it significantly increases the incidence of waterborne diseases, and the major objectives of the project evaluation are:

1) to economically evaluate the Project in terms of the cost-benefit analysis;
2) to financially evaluate the Project in terms of the cost recovery analysis, and
3) to socially evaluate the Project in terms of the social impacts on beneficiaries from the Project.

12.1 Economic Evaluation

12.1.1 Methodologies

The major objective of the economic evaluation of the Project is to verify the economic viability of the Project, attempting to assess the overall impact of the Project in achieving the national economic objectives of Madagascar. The impact of the Project is assessed in the context of the national economy rather than in the context of the project entity. The basic methodology employed in the economic evaluation is the cost-benefit analysis which employs EIRR (Economic Internal Rate of Return) as a criterion to judge the economic viability. It is widely believed that the Project benefit accrued from a groundwater development project is the reduction in waterborne diseases, and the benefit is rather difficult to be converted into monetary terms.

However, in this study, the reduction in waterborne diseases will be quantified in the form of monetary value by means of the Disease Impact Analysis (DIA) method. The DIA method quantifies project benefits through the following methodologies:

(1) to identify the mortality rate from waterborne diseases due to the absence of potable water.

(2) to identify the project benefit in the form of the reduction in the mortality rate from waterborne diseases by the Project.

(3) to convert the reduction in the mortality rate into monetary value.

12.1.2 Parameters for Economic Evaluation

The following parameters are employed as basic assumptions for the economic evaluation of the Project.

(1) Project Life

The duration of the project life for the economic evaluation shall be 30 years after a 3-year design and construction period. Consequently, the Project will commence from the fiscal year 1996, and will end by the fiscal year 2028.

(2) Case of Non Implementation of the Project

It is expected that the situation of waterborne diseases will be slightly improved even without the implementation of the Project. The present situation is regarded as the case of non implementation of the Project.

(3) Currency and Exchange Rate

The currency for the economic evaluation will be based on the US dollar, and the exchange rate to convert it into the local currency will be FMG 4,000 against one US dollar.

(4) Sunk Cost

The sunk costs related to the Project shall not be taken into account for the cost estimate, since the value is too small to be included in the cost estimate.

(5) Residual Value

The residual value related to the Project shall not be taken into account for the benefit estimate, since the value is too small to be included in the benefit estimate.

(6) Prices and Conversion Factors

The financial prices in all the related project costs and benefits shall be expressed in the price level as of the end of February 1996. The conversion factors are basically meant to be used in converting domestic prices of non-tradable outputs into equivalent border prices. Tradable goods can be valued directly in terms of border prices, but since the conversion factors for non-tradable outputs are derived on the basis of the conversion factors of closely related substitutes and complements, it is necessary to have conversion factor for tradable goods.

The conversion factor for each specific commodity can be computed in the following formula.

$$CF = (M + X) / \{(M+TM) / (X+TX)\}$$

Where, CF = Specific Commodity Conversion Factor, M = Value of Imports of Specific Commodity, X = Value of Exports of Specific Commodity, TM = Value of Taxes on Imports of Specific Commodity, and TX = Value of Taxes on Exports of Specific Commodity

Standard conversion factor (SCF) and consumption conversion factor (CCF) can be worked out by aggregating all commodities and grouping consumption commodities in the above formula, respectively.

Table 12.1.1 indicates SCF from the trade statistics, denoting that SCF in the Malagasy economy is estimated at 0.824, and Table 12.1.2 indicates CCF from the trade statistics, showing that CCF in the Malagasy economy is estimated at 0.853. Accordingly, the various conversion factors for the use of the economic evaluation are estimated below.

Cost Item	Calculation Method	Conversion Factor
Traded Goods	= 1.000	1.000
Non-traded Goods	SCF	0.824
Skilled Labour	CCF	0.853
Unskilled Labour	CCF x 0.500	0.427
Transferred Value	= 0.000	0.000

12.1.3 Project Cost

(1) Financial Cost of the Project

The project costs are classified into investment cost, operation and maintenance cost, and replacement cost.

The investment cost of the Project shall be roughly divided into 1) the investment cost for Morondava office, 2) the investment cost for well drilling and 3) contingencies. Two cases are set up for the cost estimate in accordance with the number of candidate villages to be developed. Case A is assuming that the number of candidate villages to be developed is all the 80 accessible villages, and Case B is assuming that the number of candidate villages to be developed is the highly prioritized 60 villages.

In Case A, the total investment cost for the Morondava office and well drilling of all the 80 accessible villages is estimated at US$ 9,429,457, and, in Case B, the total investment cost for the Morondava office and facilities construction for the highly prioritized 60 villages is estimated at US$ 8,506,669, respectively. The details of the estimate of the financial investment cost for both Case A and Case B are as shown in Table 12.1.4 and Table 12.1.5, respectively.

The operation and maintenance cost for the Project includes *1)* the salary and allowances, *2)* the cost for fuel and lubricants, *3)* the cost for the maintenance and repairs and *4)* other general expenses of the Project. The total operation and maintenance costs for both Case A and Case B are estimated at US$ 6,456, and the details of the estimate of the financial operation and maintenance cost for both Case A and Case B are as shown in Table 12.1.4 and Table 12.1.5, respectively.

The replacement cost for the Project includes *1)* replacement of the equipment for wells and *2)* the replacement of vehicles for the Morondava office. The replacement cost for the minor equipment for wells is estimated at US$ 1,269 in every 2 years, that for the major equipment for wells is estimated at US$ 3,808 in every 5 years, and that for vehicles of the Morondava office is estimated at US$ 27,171 in every 10 years.

(2) Conversion Factors

Using the conversion factors for traded goods, non-traded goods, skilled labour, unskilled labour and transferred value, the conversion factors for each cost item are calculated as below. The details of the calculation of the conversion factors are as per Table 12.1.3.

Cost item	Conversion Factor
Investment Cost	0.711
Operation and Maintenance Cost	0.689
Replacement Cost	0.827

(3) Economic Cost of the Project

By using the above conversion factors for each cost item, the financial costs are converted into economic costs for the purpose of conducting the economic evaluation.

In Case A, the total investment cost for the Morondava office and well drilling of all the 80 accessible villages is converted into the economic cost at US$ 6,713,852 by the conversion factor of 0.711, and, in Case B, the total investment cost for the Morondava office and well drilling for the highly prioritized 60 villages is converted into the economic cost at US$ 6,059,628 by the conversion factor of 0.711. The details of the estimate of the financial investment cost for both Case A and Case B are as shown in Table 12.1.4 and Table 12.1.5, respectively.

The financial operation and maintenance cost for both Case A and Case B is converted into the economic cost at US$ 4,452, and the details of the estimate of the financial operation and maintenance cost for both Case A and Case B are as shown in Table 12.1.14 and Table 12.1.5, respectively.

As a result, the financial and economic costs for the investment, operation and maintenance, and replacement are shown below.

(Unit: US$)

Case / Cost Item	Investment	Operation & Maintenance	Replacement
Case A (Financial)	9,429,457	6,456	5,077
Case A (Economic)	6,713,852	4,452	4,199
Case B (Financial)	8,506,669	6,456	5,077
Case B (Economic)	6,059,628	4,452	4,199

(4) Investment Schedule

The schedules for the disbursement of the financial investment costs for both Case A and Case B are as per Table 12.1.6.

(Unit: US$)

Case	1st Year	2nd Year	3rd Year
Case A	5,017,000	3,489,669	922,788
Case B	5,017,000	3,489,669	0

In Case A, the disbursement shall be completed within 3 years from 1996 to 1998, and, in Case B, the disbursement shall be completed within 2 years from 1996 to 1997.

12.1.4 Project Benefit

(1) Beneficiaries

In the Case A, the number of beneficiary villages is 80, and the total number of population who will benefit from the Project is 54,962. In the Case B, the number of beneficiary villages is 60, and the total number of population who will benefit from the Project is 51,255.

In addition to the above actual number of the beneficiaries, a considerable number of people passing through the beneficiary villages and residents of nearby villages will benefit from the Project. Accordingly, the actual number of beneficiaries will significantly increase.

(2) Project Benefit

To supply potable water for rural villages where water shortage is so acute is self-explanatory. It is obvious that the implementation of the Project will significantly mitigate mortality from waterborne diseases, and, at the same time, in this kind of BHN (Basic Human Needs) type project, the benefit is often not quantified. However, since it is desirable that the project benefit is quantified in monetary terms, the project benefit will be calculated through the following procedures based on the DIA method.

a) Identification of the Reduction in the Mortality Rate by Waterborne Diseases

In the Study Area, due to the absence of potable water, the major waterborne diseases such as diarrhea typhoid, amebiasis, hepatitis and so forth are seriously prevailing. According to the bulletin by the Ministry of Health in 1994, as Table 12.1.7 shows, the average occupation rate in all the mortality from 1991 to 1993 occupies 12.3%, and diarrhea is the primary cause of mortality with an average occupation rate of 9.8%.

Consequently, as Table 12.1.8 and Fig. 12.1.1 shows, while the male mortality rate in the Study Area ranges from 6.36 per 1,000 persons at the age of ten to 222.36 per 1,000 persons at the age of seventy five, the female mortality rate ranges from 5.88 per 1,000 persons at the age of ten to 198.53 per 1,000 persons at the age of seventy five. Especially, infants under the age of five are a relatively vulnerable group of the population.

b) Identification of the Project Impact on the Reduction of Mortality

The reduction in waterborne diseases by the groundwater development will significantly mitigate the mortality rate from diseases. Table 12.1.9 and Fig. 12.1.2 illustrate that the project impact on the reduction in the mortality rate, showing that supplying potable water to the beneficiary villages significantly mitigates the mortality rate. For instance, the reduction in the mortality rate at birth by the Project is 4.53 per 1,000 persons for boys, and 3.91 per 1,000 persons for girls, respectively.

c) Conversion of the Reduction of Mortality Rate into the Monetary Value

The above project impact on the mortality will be converted into monetary value in the form of the saved life expectancy. Table 12.1.10 and Fig. 12.1.3 illustrate life expectancy in Madagascar, showing that the male life expectancy at birth is estimated at 54.23 years, and the female life expectancy at birth is estimated at 59.26 years. To extend these life expectancies is the basic concept of the project benefit.

On the other hand, Table 12.1.11 and Fig. 12.1.4 illustrate the estimated population structure of all the 80 beneficiary villages in Case A, and Table 12.1.12 and Figure 12.1.5 illustrate the estimated population structure of 60 highly prioritized beneficiary villages in Case B. By using the above data for the life expectancy and the population structure for both men and women, the total saved life expectancy for both Case A and Case B is estimated based on the condition that the saved life expectancy will be utilized as an economically active population. The details of the calculation of the benefit are as per Table 12.1.13 to Table 12.1.16 and Fig. 12.1.6 to Fig. 12.1.9.

Case	Annual Saved Life Expectancy (Years)	Annual Monetary Project Benefit (US$)
Case A (Male)	4,229	141,459
Case A (Female)	3,860	129,003
Case A Total	**8,089**	**270,462**
Case B (Male)	3,944	131,929
Case B (female)	3,600	120,320
Case B Total	**7,544**	**252,229**

As a result, the annual project benefit in Case A is estimated at US$ 270,462, and that in Case B is estimated at US$ 252,229.

12.1.5 Economic Internal Rate of Return

Using the above economic costs and benefits, the economic internal rate of returns (EIRR) for Case A and Case B were calculated together with EIRR for the project risk cases, where the project will encounter several project risks such as uncertainty of the cost increase and the benefit decrease, 6 EIRRs for the following combination of 2 project cases (Case A and Case B) and 3 project risks (no risk, cost 10% up risk, and benefit 10% down risk) were calculated. The details of the cash flow for each case is shown in Table 12.1.17 to Table 12.1.22. Fig. 2.1.10 and Fig. 2.1.11 illustrate the transition of the cumulative net benefit for both Case A and Case B, respectively.

Case / Risk	No Risk (Case 1)	Risk 1 (Case 2)	Risk 2 (Case 3)
Case A	1.27%	0.63%	0.56%
Case B	1.48%	0.84%	0.77%

The results show that although all the EIRRs recorded positive figures, they are relatively low compared with the opportunity cost of capital, indicating that the benefits of this kind of BHN type project are not completely quantified.

12.1.6 Summary and Limitations of Economic Evaluation

The results clearly show that the economic viability of the Project is not so high compared with other cash-generating projects. Therefore, grant aid or soft loans with an extremely high grant element shall be required for the implementation of the Project.

The economic evaluation of the Project has the following limitations.

1) Since the project benefit is theoretical and is based on the condition that the reduction in mortality from waterborne diseases is to be converted into economically active population, the project benefit is to some extent uncertain.

2) In order to significantly mitigate the mortality rate by waterborne diseases, it is necessary to improve the sanitary education of beneficiaries.

Table 12.1.1 Standard Conversion Factor from Trade Statistics

(Unit: Million US$)

No	Item	1988	1989	1990	1991	1992	Average of 5 Years
1	1) Total Imports of Goods & Services (CIF)	762.0	757.0	1016.0	857.0	877.0	853.8
2	1) Total Exports of Goods & Services (FOB)	415.0	482.0	528.0	489.0	506.0	484.0
3	2) Total Custom Duties & Import Taxes	342.9	307.2	294.6	214.3	204.3	272.7
4	2) Total Export Taxes	0.0	0.0	0.0	0.0	0.0	0.0
5	2) Total Export Subsidies	32.0	24.0	5.0	0.0	0.0	12.2
6	1 + 2	1177.0	1239.0	1544.0	1346.0	1383.0	1337.8
7	1 + 2 + 3 - 4 +5	1551.9	1570.2	1843.6	1560.3	1587.3	1622.7
8	Standard Conversion Factor SCF = 6/7	0.758	0.789	0.837	0.863	0.871	0.824

Sources : 1) IMF, International Financial Statistics, 1994
2) Ministry of Finance, Trade Devision

Table 12.1.2 Consumption Conversion Factor from Trade Statistics

(Unit: Million US$)

No	Item	1988	1989	1990	1991	1992	Average of 5 Years
1	1) Total Imports of Goods & Services (CIF)	268.0	242.0	286.0	278.0	298.0	274.4
2	1) Total Exports of Goods & Services (FOB)	342.0	378.0	423.0	405.0	399.0	389.4
3	2) Total Custom Duties & Import Taxes on Consumption Goods	103.3	100.4	122.3	89.9	92.3	101.6
4	2) Total Export Taxes on Consumption Goods	0.0	0.0	0.0	0.0	0.0	0.0
5	2) Total Export Subsidies on Consumption Goods	32.0	24.0	5.0	0.0	0.0	12.2
6	1 + 2	610.0	620.0	709.0	683.0	697.0	663.8
7	1 + 2 + 3 - 4 +5	745.3	744.4	836.3	772.9	789.3	777.6
8	Consumption Conversion Factor CCF = 6/7	0.818	0.833	0.848	0.884	0.883	0.853

Sources : 1) IMF, International Financial Statistics, 1994
2) Ministry of Finance, Trade Devision

Table 12.1.3 Conversion Factors for Investment, Operation & Management and Replacement Cost

Cost Items	1 Share(%)	Traded Good & Services	Non-traded Good & Service	Skilled Labour	Unskilled Labour	Transferred Values	2 Conversion Factor for Each Cost Item	1 X 2
		1.000	0.824	0.853	0.427	0		
Investment Cost	100.0	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	0.711
(1) Morondava Office	1.9	5.0	15.0	10.0	60.0	10.0	100.0	
Land and Construction	n.r.	0.050	0.124	0.085	0.256	0.000	0.515	0.010
(2) Morondava Office	15.3	60.0	0.0	10.0	20.0	10.0	100.0	
Material	n.r.	0.600	0.000	0.085	0.085	0.000	0.771	0.118
(3) Morondava Office	1.4	0.0	0.0	80.0	10.0	10.0	100.0	
Administration & Engineering	n.r.	0.000	0.000	0.682	0.043	0.000	0.725	0.010
(4) Well Drilling	25.0	25.0	15.0	10.0	40.0	10.0	100.0	
Construction	n.r.	0.250	0.124	0.085	0.171	0.000	0.630	0.158
(5) Well Drilling	43.0	60.0	0.0	10.0	20.0	10.0	100.0	
Material	n.r.	0.600	0.000	0.085	0.085	0.000	0.771	0.331
(6) Well Drilling	5.5	0.0	0.0	60.0	30.0	10.0	100.0	
Administration & Engineering	n.r.	0.000	0.000	0.512	0.128	0.000	0.640	0.035
(7) Contingencies	7.9	25.0	15.0	10.0	40.0	10.0	100.0	
	n.r.	0.250	0.124	0.085	0.171	0.000	0.630	0.050
Operation & Maintenance Cost	100.0	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	0.689
(1) Salary & Allowances	49.1	0.0	0.0	40.0	50.0	10.0	100.0	
	n.r.	0.000	0.000	0.341	0.214	0.000	0.555	0.273
(2) Fuel and Oil	12.8	70.0	5.0	5.0	10.0	10.0	100.0	
	n.r.	0.700	0.041	0.043	0.043	0.000	0.827	0.106
(3) Maintenance and Repairs	33.4	70.0	5.0	5.0	10.0	10.0	100.0	
	n.r.	0.700	0.041	0.043	0.043	0.000	0.827	0.276
(4) Other General Expenses	4.7	25.0	50.0	5.0	10.0	10.0	100.0	
	n.r.	0.250	0.412	0.043	0.043	0.000	0.747	0.035
Replacement Cost	100.0	70.0	5.0	5.0	10.0	10.0	100.0	
	n.r.	0.700	0.041	0.043	0.043	0.000	0.827	0.827

Table 12.1.4 Financial & Economic Project Cost (Case A / 80 Villages)

(Unit: US$)

Cost Items	Financial Cost	Conversion Factor	Economic Cost
Investment Cost			
(1) Morondava Office / Land & Construction	174,512	0.515	89,874
(2) Morondava Office / Material	1,438,495	0.771	1,109,080
(3) Morondava Office / Engineering	129,041	0.725	93,555
(4) Well Drilling / Construction	2,359,515	0.630	1,486,494
(5) Well Drilling / Material	4,064,791	0.771	3,133,954
(6) Well Drilling / Engineering	513,945	0.640	328,925
(7) Contingencies	749,158	0.630	471,970
Total	9,429,457	0.711	6,713,852
Operation & Maintenance Cost			
(1) Salary & Allowances	3,172	0.555	1,760
(2) Fuel & Oil	826	0.827	683
(3) Maintenance & Repairs	2,156	0.827	1,783
(4) Other General Expenses	302	0.747	226
Total	6,456	0.689	4,452
Replacement Cost			
Total	5,077	0.827	4,199

Table 12.1.5 Financial & Economic Project Cost (Case B / 60 Villages)

(Unit: US$)

Cost Items	Financial Cost	Conversion Factor	Economic Cost
Investment Cost			
(1) Morondava Office / Land & Construction	174,512	0.515	89,874
(2) Morondava Office / Material	1,438,495	0.771	1,109,080
(3) Morondava Office / Engineering	129,041	0.725	93,555
(4) Well Drilling / Construction	2,085,777	0.630	1,314,040
(5) Well Drilling / Material	3,552,457	0.771	2,738,944
(6) Well Drilling / Engineering	451,059	0.640	288,678
(7) Contingencies	675,328	0.630	425,457
Total	8,506,669	0.711	6,059,628
Operation & Maintenance Cost			
(1) Salary & Allowances	3,172	0.555	1,760
(2) Fuel & Oil	826	0.827	683
(3) Maintenance & Repairs	2,156	0.827	1,783
(4) Other General Expenses	302	0.747	226
Total	6,456	0.689	4,452
Replacement Cost			
Total	5,077	0.827	4,199

Table 12.1.6 Investment Schedule

Item	Cost	1st Year	2nd Year	3rd Year	Total	1st Year	2nd Year	3rd Year	Total
Case		Case A (80 Villages)				Case B (60 Villages)			
(1) Morondava Office	F	174,512	0	0	174,512	174,512	0	0	174,512
Land & Construction	E	89,874	0	0	89,874	89,874	0	0	89,874
(2) Morondava Office	F	1,438,495	0	0	1,438,495	1,438,495	0	0	1,438,495
Material	E	1,109,080	0	0	1,109,080	1,109,080	0	0	1,109,080
(3) Morondava Office	F	129,041	0	0	129,041	129,041	0	0	129,041
Engineering	E	93,555	0	0	93,555	93,555	0	0	93,555
(4) Well Drilling	F	1,058,803	1,026,974	273,738	2,359,515	1,058,803	1,026,974	0	2,085,777
Construction	E	667,046	646,994	172,454	1,486,494	667,046	646,994	0	1,314,040
(5) Well Drilling	F	1,606,620	1,945,837	512,334	4,064,791	1,606,620	1,945,837	0	3,552,457
Material	E	1,238,704	1,500,240	395,010	3,133,954	1,238,704	1,500,240	0	2,738,944
(6) Well Drilling	F	213,234	237,825	62,886	513,945	213,234	237,825	0	451,059
Engineering	E	136,470	152,208	40,247	328,925	136,470	152,208	0	288,678
(7) Contingencies	F	396,295	279,033	73,830	749,158	396,295	279,033	0	675,328
	E	249,666	175,791	46,513	471,970	249,666	175,791	0	425,457
Total	F	5,017,000	3,489,669	922,788	9,429,457	5,017,000	3,489,669	0	8,506,669
	E	3,584,395	2,475,233	654,224	6,713,852	3,584,395	2,475,233	0	6,059,628

Table 12.1.7 Structure of Disease On-set Rates in Madagascar

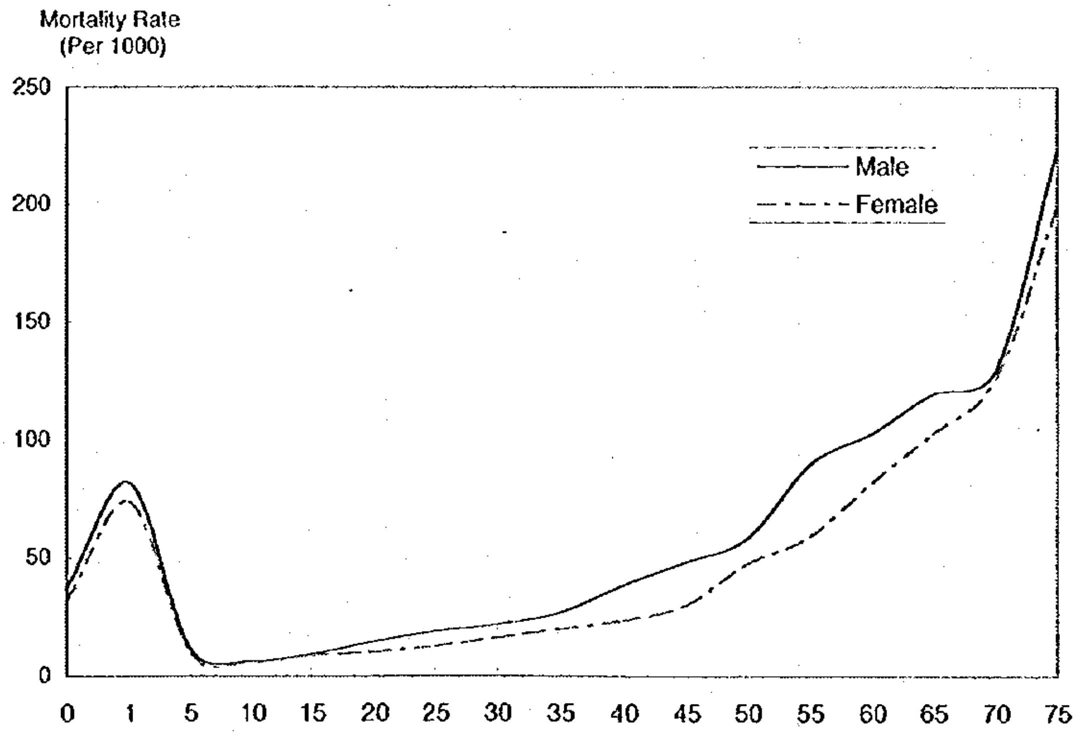
Name of Diseases	Number of Death Cases				Composition (%)			
	1991	1992	1993	1991-93 Average	1991	1992	1993	1991-93 Average
Diarrhees	573	482	592	549	10.8	8.9	9.7	9.8
Typhaid	33	37	24	31	0.6	0.7	0.4	0.6
Amibiasis	32	36	23	30	0.6	0.7	0.4	0.5
Hepatite Virale	16	15	13	15	0.3	0.3	0.2	0.3
Parasit	52	38	55	48	1.0	0.7	0.9	0.9
Muscles	11	21	11	14	0.2	0.4	0.2	0.3
Water-born Diseases	**717**	**629**	**718**	**688**	**13.5**	**11.6**	**11.8**	**12.3**
Tuberculose	117	157	150	141	2.2	2.9	2.5	2.5
Peste	12	12	17	14	0.2	0.2	0.3	0.2
Diphterie	3	0	3	2	0.1	0.0	0.0	0.0
Coqueluche	5	4	13	7	0.1	0.1	0.2	0.1
Tetanos	7	6	8	7	0.1	0.1	0.1	0.1
Poliomyelite	0	1	0	0	0.0	0.0	0.0	0.0
Rougeole	32	7	85	41	0.6	0.1	1.4	0.7
Paludisme	198	233	216	216	3.7	4.3	3.5	3.9
Tumeurs	236	241	241	239	4.5	4.5	3.9	4.3
Mal. Endocr. & Diabete	72	51	69	64	1.4	0.9	1.1	1.1
Carences Nutritionnelles	304	315	384	334	5.7	5.8	6.3	6.0
Maladies du Metabolisme	60	32	43	45	1.1	0.6	0.7	0.8
Maladies du Sang	25	14	24	21	0.5	0.3	0.4	0.4
Troubles du Alcool	73	82	83	79	1.4	1.5	1.4	1.4
Systeme Nerveux	90	109	139	113	1.7	2.0	2.3	2.0
Mal. Oreille Dont Otite	1	3	3	2	0.0	0.1	0.0	0.0
Mal. Hypertensives	91	98	112	100	1.7	1.8	1.8	1.8
Cardiopathies Ischemiques	27	58	56	47	0.5	1.1	0.9	0.8
Insufficancecardiaque	369	354	423	382	7.0	6.5	6.9	6.8
Mal. Vascul. Cereblates	391	442	500	444	7.4	8.2	8.2	7.9
Circulatoire	226	207	179	204	4.3	3.8	2.9	3.7
Pneumonie, Aigues	557	531	668	585	10.5	9.8	10.9	10.4
Respiratoire	124	115	125	121	2.3	2.1	2.0	2.2
Mal. Appareil Digestif	246	296	302	281	4.6	5.5	4.9	5.0
Mal. Organes Genito-urin.	90	125	138	118	1.7	2.3	2.3	2.1
Gros. Aboutis. Avortement	36	34	44	38	0.7	0.6	0.7	0.7
Complic. Liees a Gross.	6	9	14	10	0.1	0.2	0.2	0.2
Complic. Travail Accouch.	8	12	16	12	0.2	0.2	0.3	0.2
Complic. Suites de Couches	10	13	7	10	0.2	0.2	0.1	0.2
Premat. Poids Insuffisant	100	86	99	95	1.9	1.6	1.6	1.7
Hypoxie	66	43	55	55	1.2	0.8	0.9	1.0
Anomalies Congenitales	222	237	269	243	4.2	4.4	4.4	4.3
Senilite	158	142	112	137	3.0	2.6	1.8	2.5
Autres Etats Mal Definis	248	330	379	319	4.7	6.1	6.2	5.7
Traumatismes	367	387	409	388	6.9	7.1	6.7	6.9
Other Diseases	4577	4786	5385	4916	86.5	88.4	88.2	87.7
Total	5294	5415	6103	5604	100.0	100.0	100.0	100.0

Table 12-1-8 Mortality Rate in Madagascar

Unit: persons per 1,000 persons

Age	Male Mortality Rate	Female Mortality Rate
0	36.84	31.80
1	81.71	73.94
5	11.14	9.34
10	6.36	5.88
15	9.24	8.72
20	14.46	10.13
25	18.74	12.44
30	21.54	15.89
35	26.74	19.72
40	38.28	23.39
45	48.12	29.96
50	58.17	47.37
55	89.25	59.00
60	102.58	81.73
65	119.34	102.58
70	128.97	125.58
75	222.36	198.53

Figure 12-1-1 Mortality Rate in Madagascar



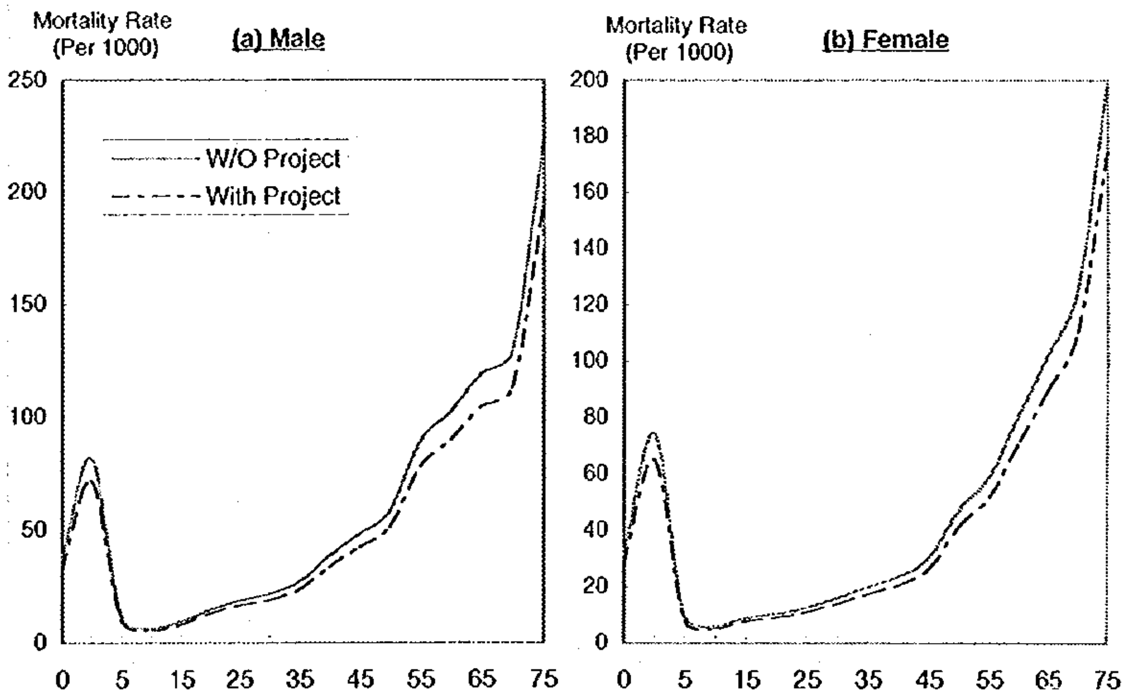
Sources: Indicateurs de Sante - Premiers Resultats 1990 - 1993, Ministere de La Sante

Table 12-1-9 Impact on Mortality Rate by Project

Unit: persons per 1,000 persons

Age	Male			Female		
	W/O Project	Impact	With Project	W/O Project	Impact	With Project
0	36.84	4.53	32.31	31.80	3.91	27.89
1	81.71	10.05	71.66	73.94	9.09	64.85
5	11.14	1.37	9.77	9.34	1.15	8.19
10	6.36	0.78	5.58	5.88	0.72	5.16
15	9.24	1.14	8.10	8.72	1.07	7.65
20	14.46	1.78	12.68	10.13	1.25	8.88
25	18.74	2.31	16.43	12.44	1.53	10.91
30	21.54	2.65	18.89	15.89	1.95	13.94
35	26.74	3.29	23.45	19.72	2.43	17.29
40	38.28	4.71	33.57	23.39	2.88	20.51
45	48.12	5.92	42.20	29.96	3.69	26.27
50	58.17	7.15	51.02	47.37	5.83	41.54
55	89.25	10.98	78.27	59.00	7.26	51.74
60	102.58	12.62	89.96	81.73	10.05	71.68
65	119.34	14.68	104.66	102.58	12.62	89.96
70	128.97	15.86	113.11	125.58	15.45	110.13
75	222.36	27.35	195.01	198.53	24.42	174.11

Figure 12-1-2 Impact on Mortality Rate by Project

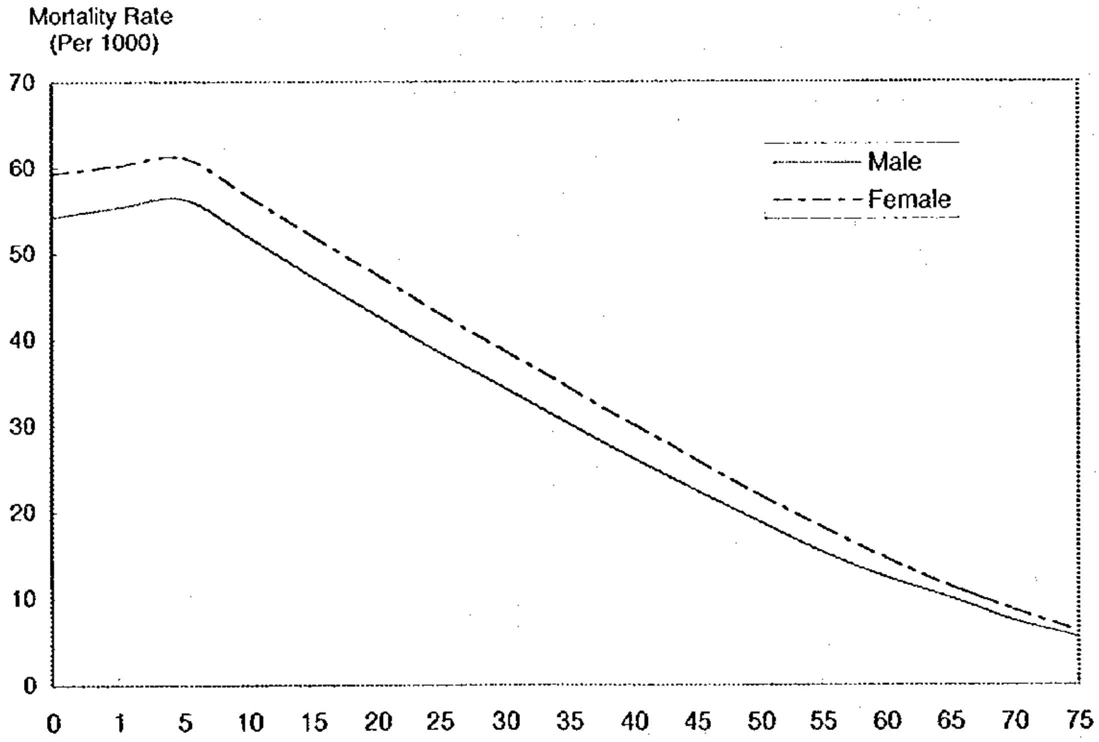


Sources: Indicateurs de Sante - Premiers Resultats 1990 - 1993, Ministere de La Sante

Table 12-1-10 Life Expectancy in Madagascar

Age	Male Life Expectancy (years)	Female Life Expectancy (years)
0	54.23	59.26
1	55.30	60.20
5	56.29	61.06
10	51.97	56.68
15	47.34	52.04
20	42.82	47.54
25	38.52	43.07
30	34.34	38.66
35	30.20	34.35
40	26.15	30.13
45	22.39	25.94
50	18.78	21.87
55	15.29	18.16
60	12.40	14.58
65	10.02	11.31
70	7.40	8.63
75	5.49	6.09

Figure 12-1-3 Life Expectancy in Madagascar

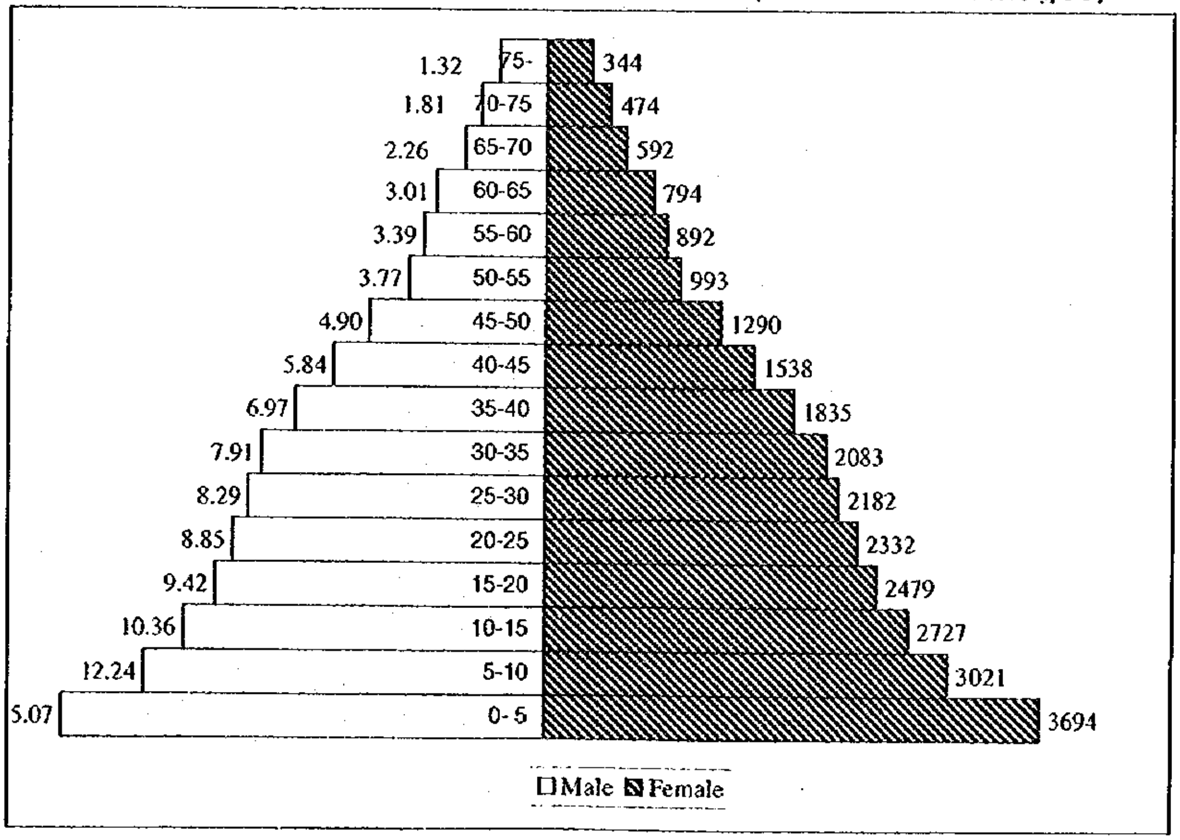


Sources: Indicateurs de Sante - Premiers Resultats 1990 - 1993, Ministere de La Sante

Table 12-1-11 Estimated Population Structure (Case A / 80 Villages)

Age Range	Number of Samples (persons)		Composition (%)	
	Male	Female	Male	Female
0- 5	3663	3694	13.23	13.55
5-10	3034	3021	10.96	11.08
10-15	2733	2727	9.87	10.00
15-20	2498	2479	9.02	9.09
20-25	2365	2332	8.54	8.55
25-30	2249	2182	8.12	8.00
30-35	2149	2083	7.76	7.64
35-40	1878	1835	6.78	6.73
40-45	1590	1538	5.74	5.64
45-50	1324	1290	4.78	4.73
50-55	1022	993	3.69	3.64
55-60	911	892	3.29	3.27
60-65	825	794	2.98	2.91
65-70	612	592	2.21	2.17
70-75	487	474	1.76	1.74
75-	352	344	1.27	1.26
Total	27692	27270	100.00	100.00

Figure 12-1-4 Estimated Population Structure (Case A / 80 Villages)

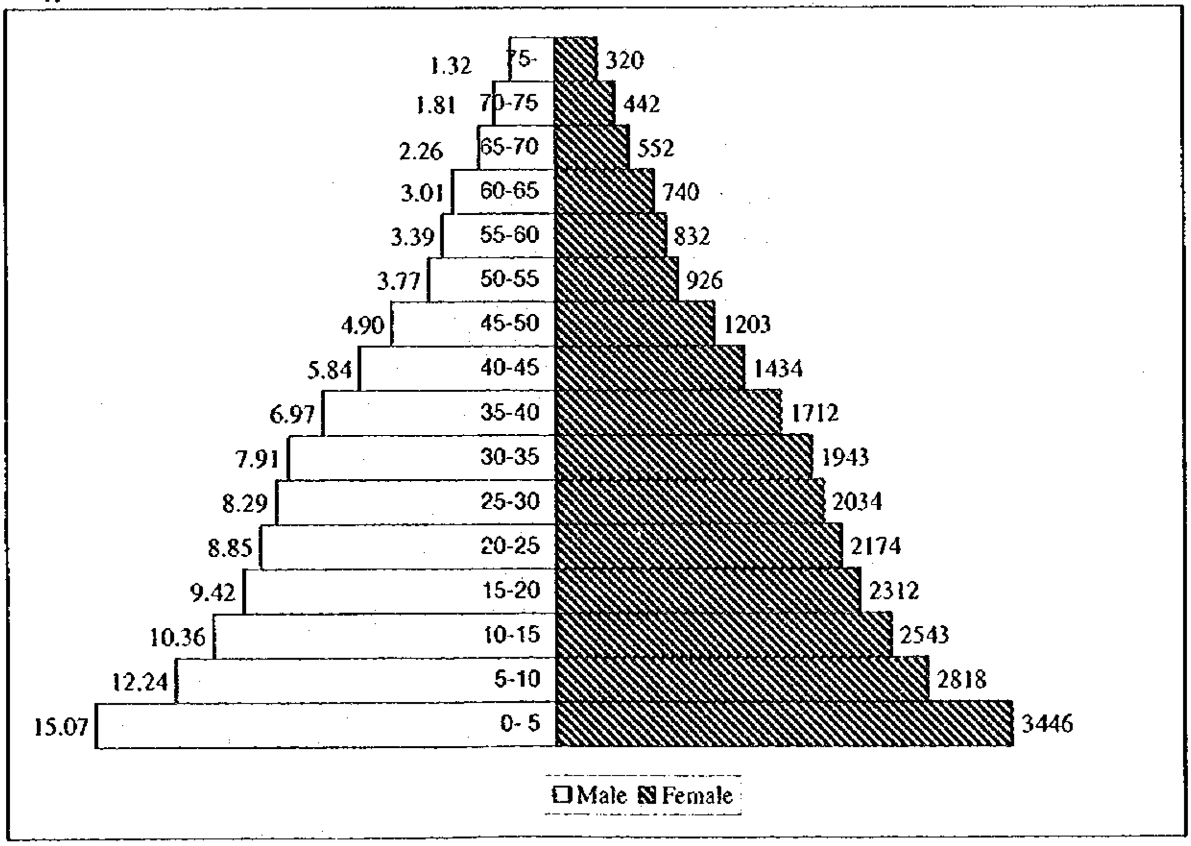


Sources: Indicateurs de Sante - Premiers Resultats 1990 - 1993, Ministere de La Sante

Table 12-1-12 Estimated Population Structure (Case B / 60 Villages)

Age Range	Number of Sanmples (persons)		Composition (%)	
	Male	Female	Male	Female
0- 5	3417	3446	13.23	13.55
5-10	2829	2818	10.96	11.08
10-15	2549	2543	9.87	10.00
15-20	2329	2312	9.02	9.09
20-25	2205	2174	8.54	8.55
25-30	2097	2034	8.12	8.00
30-35	2004	1943	7.76	7.64
35-40	1751	1712	6.78	6.73
40-45	1482	1434	5.74	5.64
45-50	1234	1203	4.78	4.73
50-55	953	926	3.69	3.64
55-60	850	832	3.29	3.27
60-65	770	740	2.98	2.91
65-70	571	552	2.21	2.17
70-75	455	442	1.76	1.74
75-	328	320	1.27	1.26
Total	25824	25431	100.00	100.00

Figure 12-1-5 Estimated Population Structure (Case B / 60 Villages)



Sources: Indicateurs de Sante - Premiers Resultats 1990 - 1993, Ministere de La Sante

Table 12-1-13 Project Benefit by Mortality Rate Reduction (Case A / Male)

Age Range	Population in the Study (persons)	Mortality, w/o Project (per 1,000)	Impact on Mortality (per 1,000)	Mortality, with Project (per 1,000)	Average Life Expectancy (years)	Number of Saved Persons (persons)	Saved Life Expectancy (years)	Annual Average Income (US$)	Annual Project Benefit (US$)
0-5	3663	81.71	10.05	71.66	54.23	36.81	1,996	33.68	67238
5-10	3034	11.14	1.37	9.77	56.29	4.16	234	35.93	8407
10-15	2733	6.36	0.78	5.58	51.97	2.13	111	38.50	4265
15-20	2498	9.24	1.14	8.10	47.34	2.85	135	39.58	5336
20-25	2365	14.46	1.78	12.68	42.82	4.21	180	38.78	6990
25-30	2249	18.74	2.31	16.43	38.52	5.20	200	37.87	7578
30-35	2149	21.54	2.65	18.89	34.34	5.69	196	36.74	7185
35-40	1878	26.74	3.29	23.45	30.20	6.18	187	35.39	6604
40-45	1590	38.28	4.71	33.57	26.15	7.49	196	33.68	6596
45-50	1324	48.12	5.92	42.20	22.39	7.84	175	31.50	5528
50-55	1022	58.17	7.15	51.02	18.78	7.31	137	28.57	3921
55-60	911	89.25	10.98	78.27	15.29	10.00	153	24.50	3747
60-65	825	102.58	12.62	89.96	12.40	10.41	129	24.50	3163
65-70	612	119.34	14.68	104.66	10.02	8.98	90	24.50	2206
70-75	487	128.97	15.86	113.11	7.40	7.72	57	24.50	1400
75-	352	222.36	27.35	195.01	5.49	9.63	53	24.50	1295
Total	27692	—	—	—	—	—	4,229	—	141459

Figure 12-1-6 Project Benefit (Male)

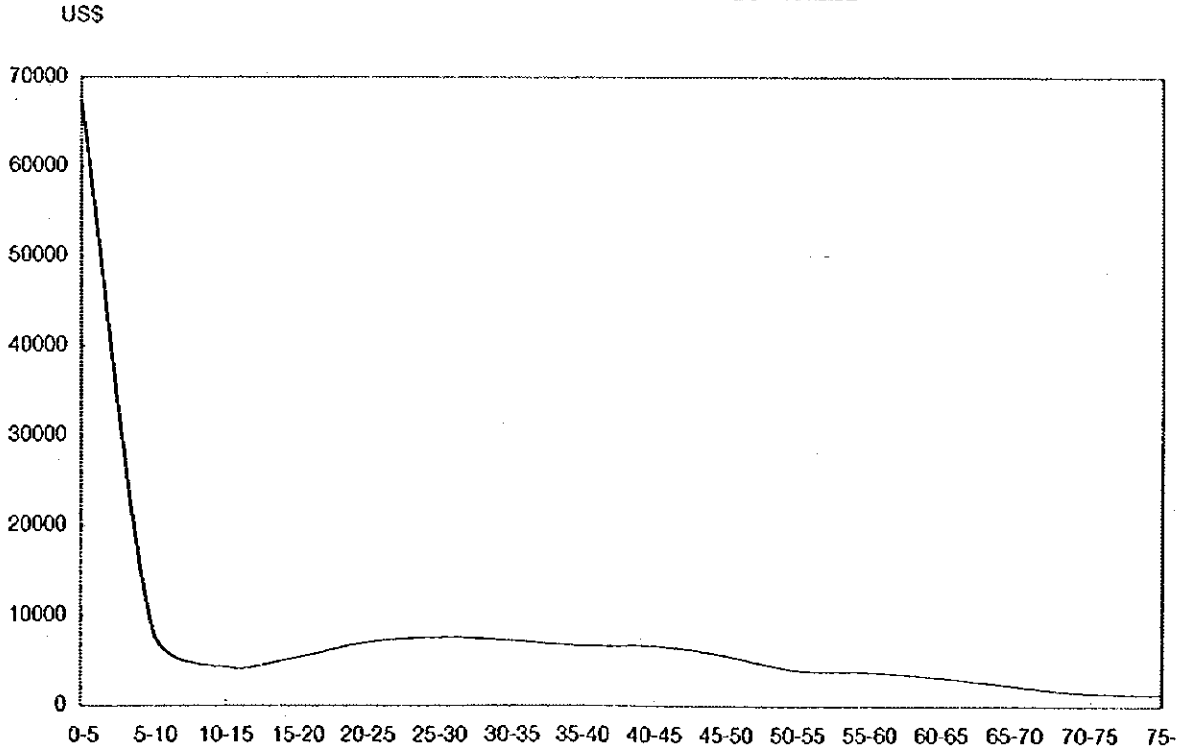


Table 12-1-14 Project Benefit by Mortality Rate Reduction (Case A / Female)

Age Range	Population in the Study (persons)	Mortality, w/o Project (per 1,000)	Impact on Mortality (per 1,000)	Mortality, with Project (per 1,000)	Average Life Expectancy (years)	Number of Saved Persons (persons)	Saved Life Expectancy (years)	Annual Average Income (US$)	Annual Project Benefit (US$)
0-5	3694	73.94	9.09	64.85	59.26	33.58	1,990	33.68	67018
5-10	3021	9.34	1.15	8.19	61.06	3.47	212	35.93	7622
10-15	2727	5.88	0.72	5.16	56.68	1.96	111	38.50	4285
15-20	2479	8.72	1.07	7.65	52.04	2.65	138	39.58	5464
20-25	2332	10.13	1.25	8.88	47.54	2.92	139	38.78	5374
25-30	2182	12.44	1.53	10.91	43.07	3.34	144	37.87	5445
30-35	2083	15.89	1.95	13.94	38.66	4.06	157	36.74	5769
35-40	1835	19.72	2.43	17.29	34.35	4.46	153	35.39	5421
40-45	1538	23.39	2.88	20.51	30.13	4.43	133	33.68	4495
45-50	1290	29.96	3.69	26.27	25.94	4.76	123	31.50	3890
50-55	993	47.37	5.83	41.54	21.87	5.79	127	28.57	3617
55-60	892	59.00	7.26	51.74	18.16	6.48	118	24.50	2881
60-65	794	81.73	10.05	71.68	14.58	7.98	116	24.50	2850
65-70	592	102.58	12.62	89.96	11.31	7.47	84	24.50	2070
70-75	474	125.58	15.45	110.13	8.63	7.32	63	24.50	1548
75-	344	198.53	24.42	174.11	6.09	8.40	51	24.50	1253
Total	27270	–	–	–	–	–	3,860	–	129003

Figure 12-1-7 Project Benefit (Female)

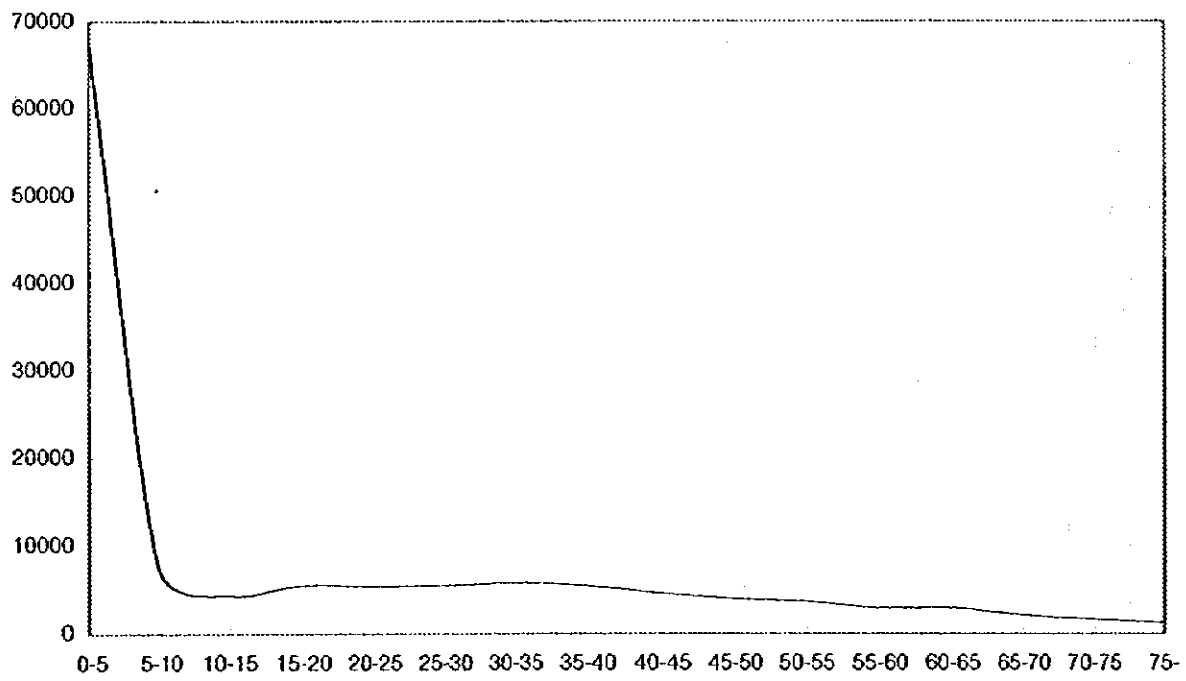


Table 12-1-15 Project Benefit by Mortality Rate Reduction (Case B / Male)

Age Range	Population in the Study (persons)	Mortality, w/o Project (per 1,000)	Impact on Mortality (per 1,000)	Mortality, with Project (per 1,000)	Average Life Expectancy (years)	Number of Saved Persons (persons)	Saved Life Expectancy (years)	Annual Average Income (US$)	Annual Project Benefit (US$)
0-5	3417	81.71	10.05	71.66	54.23	34.34	1,862	33.68	62722
5-10	2829	11.14	1.37	9.77	56.27	3.88	218	35.93	7836
10-15	2549	6.36	0.78	5.58	51.97	1.99	103	38.50	3978
15-20	2329	9.24	1.14	8.10	47.34	2.66	126	39.58	4975
20-25	2205	14.46	1.78	12.68	42.82	3.92	168	38.78	6518
25-30	2097	18.74	2.31	16.43	38.52	4.84	187	37.87	7066
30-35	2004	21.54	2.65	18.89	34.34	5.31	182	36.74	6700
35-40	1751	26.74	3.29	23.45	30.20	5.76	174	35.39	6157
40-45	1482	38.28	4.71	33.57	26.15	6.98	183	33.68	6148
45-50	1234	48.12	5.92	42.20	22.39	7.31	164	31.50	5152
50-55	953	58.17	7.15	51.02	18.78	6.81	128	28.57	3656
55-60	850	89.25	10.98	78.27	15.29	9.33	143	24.50	3496
60-65	770	102.58	12.62	89.96	12.40	9.72	120	24.50	2952
65-70	571	119.34	14.68	104.66	10.02	8.38	84	24.50	2058
70-75	455	128.97	15.86	113.11	7.40	7.22	53	24.50	1308
75-	328	222.36	27.35	195.01	5.49	8.97	49	24.50	1207
Total	25824	—	—	—	—	—	3,944	—	131929

Figure 12-1-8 Project Benefit (Male)

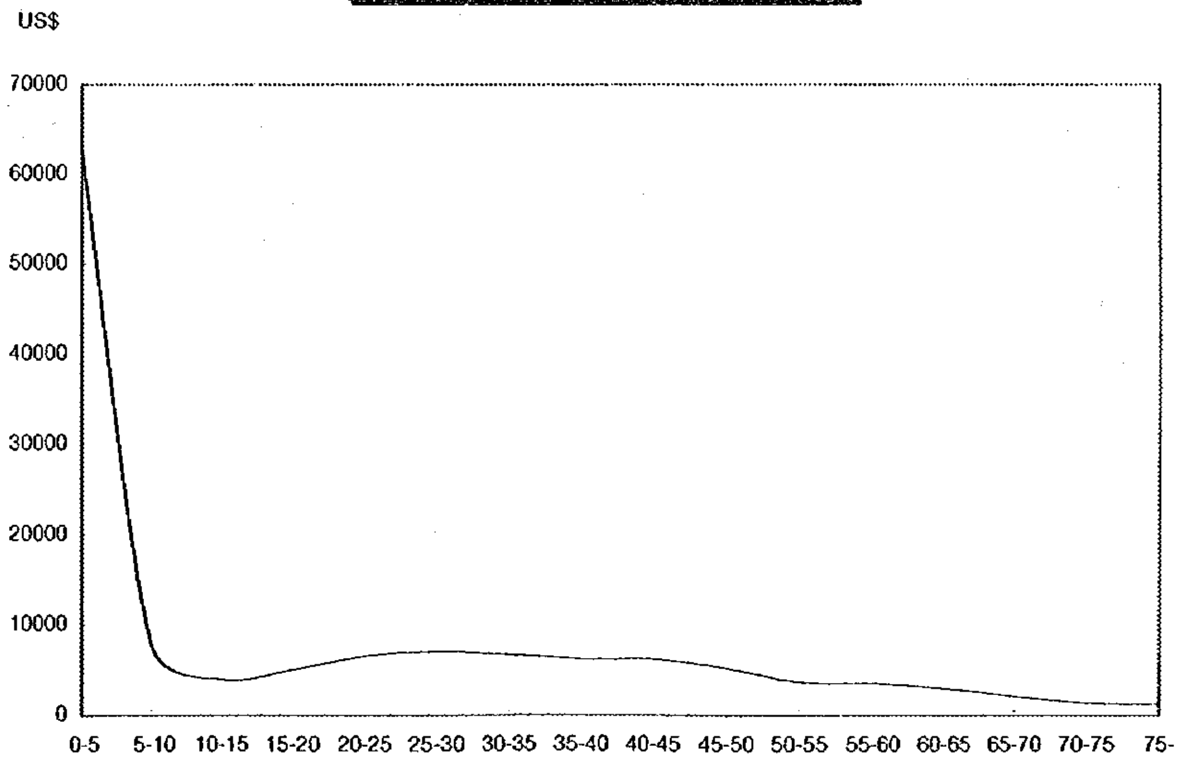


Table 12-1-16 Project Benefit by Mortality Rate Reduction (Case B / Female)

Age Range	Population in the Study (persons)	Mortality, w/o Project (per 1,000)	Impact on Mortality (per 1,000)	Mortality, with Project (per 1,000)	Average Life Expectancy (years)	Number of Saved Persons (persons)	Saved Life Expectancy (years)	Annual Average Income (US$)	Annual Project Benefit (US$)
0-5	3446	73.94	9.09	64.85	59.26	31.32	1,856	33.68	62519
5-10	2818	9.34	1.15	8.19	61.06	3.24	198	35.93	7110
10-15	2543	5.88	0.72	5.16	56.68	1.83	104	38.50	3995
15-20	2312	8.72	1.07	7.65	52.04	2.47	129	39.58	5095
20-25	2174	10.13	1.25	8.88	47.54	2.72	129	38.78	5010
25-30	2034	12.44	1.53	10.91	43.07	3.11	134	37.87	5076
30-35	1943	15.89	1.95	13.94	38.66	3.79	146	36.74	5382
35-40	1712	19.72	2.43	17.29	34.35	4.16	143	35.39	5057
40-45	1434	23.39	2.88	20.51	30.13	4.13	124	33.68	4191
45-50	1203	29.96	3.69	26.27	25.94	4.44	115	31.50	3627
50-55	926	47.37	5.83	41.54	21.87	5.40	118	28.57	3373
55-60	832	59.00	7.26	51.74	18.16	6.04	110	24.50	2687
60-65	740	81.73	10.05	71.68	14.58	7.44	108	24.50	2657
65-70	552	102.58	12.62	89.96	11.31	6.97	79	24.50	1930
70-75	442	125.58	15.45	110.13	8.63	6.83	59	24.50	1444
75-	320	198.53	24.42	174.11	6.09	7.81	48	24.50	1166
Total	25431	–	–	–	–	–	3,600	–	120320

Figure 12-1-9 Project Benefit (Female)

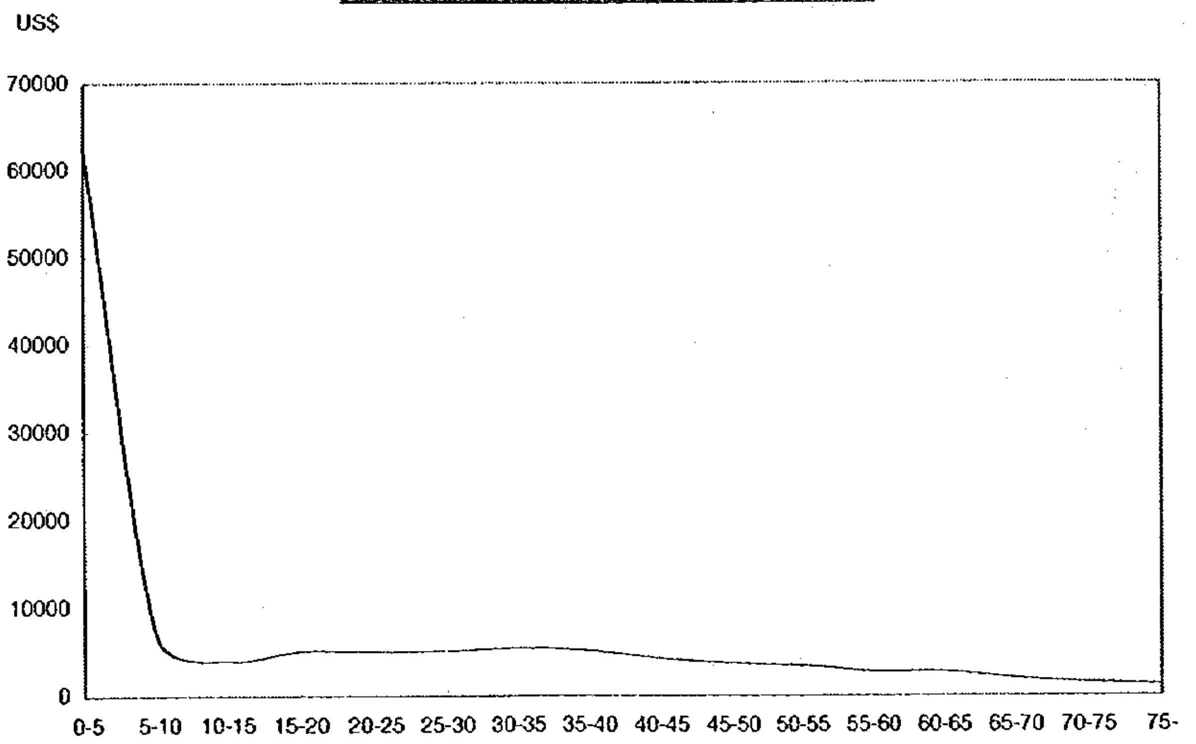


Table 12.1.17 Economic Internal Rate of Return (Case A-1)

EIRR = 1.27%

Project Year	Financial Year	Investment Cost ①	O & M Cost②	Cost ③=①+②	Benefit ④	Net Benefit ⑤=④-③	Cumulative Net Benefit
1	1996	3,584,395	0	3,584,395	0	-3,584,395	-3,584,395
2	1997	2,475,233	4,452	2,479,685	78,786	-2,400,899	-5,985,294
3	1998	654,224	5,501	659,725	252,233	-407,492	-6,392,786
4	1999	0	4,452	4,452	270,462	266,010	-6,126,776
5	2000	0	8,651	8,651	270,462	261,811	-5,864,965
6	2001	0	4,452	4,452	270,462	266,010	-5,598,955
7	2002	0	5,501	5,501	270,462	264,961	-5,333,994
8	2003	0	4,452	4,452	270,462	266,010	-5,067,984
9	2004	0	8,651	8,651	270,462	261,811	-4,806,173
10	2005	0	4,452	4,452	270,462	266,010	-4,540,163
11	2006	0	27,972	27,972	270,462	242,490	-4,297,673
12	2007	0	4,452	4,452	270,462	266,010	-4,031,663
13	2008	0	8,651	8,651	270,462	261,811	-3,769,852
14	2009	0	4,452	4,452	270,462	266,010	-3,503,842
15	2010	0	5,501	5,501	270,462	264,961	-3,238,881
16	2011	0	4,452	4,452	270,462	266,010	-2,972,871
17	2012	0	8,651	8,651	270,462	261,811	-2,711,060
18	2013	0	4,452	4,452	270,462	266,010	-2,445,050
19	2014	0	5,501	5,501	270,462	264,961	-2,180,089
20	2015	0	4,452	4,452	270,462	266,010	-1,914,079
21	2016	0	31,121	31,121	270,462	239,341	-1,674,738
22	2017	0	4,452	4,452	270,462	266,010	-1,408,728
23	2018	0	5,501	5,501	270,462	264,961	-1,143,767
24	2019	0	4,452	4,452	270,462	266,010	-877,757
25	2020	0	8,651	8,651	270,462	261,811	-615,946
26	2021	0	4,452	4,452	270,462	266,010	-349,936
27	2022	0	5,501	5,501	270,462	264,961	-84,975
28	2023	0	4,452	4,452	270,462	266,010	181,035
29	2024	0	8,651	8,651	270,462	261,811	442,846
30	2025	0	4,452	4,452	270,462	266,010	708,856
31	2026	0	27,972	27,972	270,462	242,490	951,346
32	2027	0	4,452	4,452	270,462	266,010	1,217,356
33	2028	0	8,651	8,651	270,462	261,811	1,479,167
Total		6,713,852	251,860	6,965,712	8,444,879	1,479,167	1,479,167

Table 12.1.18 Economic Internal Rate of Return (Case A-2)

EIRR = 0.63%

Project Year	Financial Year	Investment Cost ①	O & M Cost②	Cost ③=①+②	Benefit ④	Net Benefit ⑤=④-③	Cumulative Net Benefit
1	1996	3,942,835	0	3,942,835	0	-3,942,835	-3,942,835
2	1997	2,722,756	4,897	2,727,654	78,786	-2,648,868	-6,591,702
3	1998	719,646	6,051	725,698	252,233	-473,465	-7,065,167
4	1999	0	4,897	4,897	270,462	265,565	-6,799,602
5	2000	0	9,516	9,516	270,462	260,946	-6,538,656
6	2001	0	4,897	4,897	270,462	265,565	-6,273,091
7	2002	0	6,051	6,051	270,462	264,411	-6,008,680
8	2003	0	4,897	4,897	270,462	265,565	-5,743,115
9	2004	0	9,516	9,516	270,462	260,946	-5,482,169
10	2005	0	4,897	4,897	270,462	265,565	-5,216,605
11	2006	0	30,769	30,769	270,462	239,693	-4,976,912
12	2007	0	4,897	4,897	270,462	265,565	-4,711,347
13	2008	0	9,516	9,516	270,462	260,946	-4,450,401
14	2009	0	4,897	4,897	270,462	265,565	-4,184,836
15	2010	0	6,051	6,051	270,462	264,411	-3,920,425
16	2011	0	4,897	4,897	270,462	265,565	-3,654,861
17	2012	0	9,516	9,516	270,462	260,946	-3,393,915
18	2013	0	4,897	4,897	270,462	265,565	-3,128,350
19	2014	0	6,051	6,051	270,462	264,411	-2,863,939
20	2015	0	4,897	4,897	270,462	265,565	-2,598,374
21	2016	0	34,233	34,233	270,462	236,229	-2,362,145
22	2017	0	4,897	4,897	270,462	265,565	-2,096,581
23	2018	0	6,051	6,051	270,462	264,411	-1,832,170
24	2019	0	4,897	4,897	270,462	265,565	-1,566,605
25	2020	0	9,516	9,516	270,462	260,946	-1,305,659
26	2021	0	4,897	4,897	270,462	265,565	-1,040,094
27	2022	0	6,051	6,051	270,462	264,411	-775,683
28	2023	0	4,897	4,897	270,462	265,565	-510,118
29	2024	0	9,516	9,516	270,462	260,946	-249,173
30	2025	0	4,897	4,897	270,462	265,565	16,392
31	2026	0	30,769	30,769	270,462	239,693	256,085
32	2027	0	4,897	4,897	270,462	265,565	521,650
33	2028	0	9,516	9,516	270,462	260,946	782,596
Total		7,385,237	277,046	7,662,283	8,444,879	782,596	782,596

Table 12.1.19 Economic Internal Rate of Return (Case A-3)

EIRR = 0.56%

Project Year	Financial Year	Investment Cost①	O & M Cost②	Cost ③=①+②	Benefit ④	Net Benefit ⑤=④-③	Cumulative Net Benefit
1	1996	3,584,395	0	3,584,395	0	-3,584,395	-3,584,395
2	1997	2,475,233	4,452	2,479,685	70,907	-2,408,778	-5,993,173
3	1998	654,224	5,501	659,725	227,010	-432,715	-6,425,888
4	1999	0	4,452	4,452	243,416	238,964	-6,186,924
5	2000	0	8,651	8,651	243,416	234,765	-5,952,159
6	2001	0	4,452	4,452	243,416	238,964	-5,713,196
7	2002	0	5,501	5,501	243,416	237,915	-5,475,281
8	2003	0	4,452	4,452	243,416	238,964	-5,236,317
9	2004	0	8,651	8,651	243,416	234,765	-5,001,552
10	2005	0	4,452	4,452	243,416	238,964	-4,762,588
11	2006	0	27,972	27,972	243,416	215,444	-4,547,145
12	2007	0	4,452	4,452	243,416	238,964	-4,308,181
13	2008	0	8,651	8,651	243,416	234,765	-4,073,416
14	2009	0	4,452	4,452	243,416	238,964	-3,834,452
15	2010	0	5,501	5,501	243,416	237,915	-3,596,537
16	2011	0	4,452	4,452	243,416	238,964	-3,357,574
17	2012	0	8,651	8,651	243,416	234,765	-3,122,809
18	2013	0	4,452	4,452	243,416	238,964	-2,883,845
19	2014	0	5,501	5,501	243,416	237,915	-2,645,930
20	2015	0	4,452	4,452	243,416	238,964	-2,406,966
21	2016	0	31,121	31,121	243,416	212,295	-2,194,672
22	2017	0	4,452	4,452	243,416	238,964	-1,955,708
23	2018	0	5,501	5,501	243,416	237,915	-1,717,793
24	2019	0	4,452	4,452	243,416	238,964	-1,478,829
25	2020	0	8,651	8,651	243,416	234,765	-1,244,064
26	2021	0	4,452	4,452	243,416	238,964	-1,005,101
27	2022	0	5,501	5,501	243,416	237,915	-767,186
28	2023	0	4,452	4,452	243,416	238,964	-528,222
29	2024	0	8,651	8,651	243,416	234,765	-293,457
30	2025	0	4,452	4,452	243,416	238,964	-54,493
31	2026	0	27,972	27,972	243,416	215,444	160,950
32	2027	0	4,452	4,452	243,416	238,964	399,914
33	2028	0	8,651	8,651	243,416	234,765	634,679
Total		6,713,852	251,860	6,965,712	7,600,391	634,679	634,679

Table 12.1.20 Economic Internal Rate of Return (Case B-1)

EIRR = 1.48%

Project Year	Financial Year	Investment Cost ①	O & M Cost②	Cost ③=①+②	Benefit ④	Net Benefit ⑤=④-③	Cumulative Net Benefit
1	1996	3,584,395	0	3,584,395	0	-3,584,395	-3,584,395
2	1997	2,475,233	4,452	2,479,685	78,802	-2,400,883	-5,985,278
3	1998	0	5,501	5,501	252,249	246,748	-5,738,530
4	1999	0	4,452	4,452	252,249	247,797	-5,490,733
5	2000	0	8,651	8,651	252,249	243,598	-5,247,135
6	2001	0	4,452	4,452	252,249	247,797	-4,999,338
7	2002	0	5,501	5,501	252,249	246,748	-4,752,590
8	2003	0	4,452	4,452	252,249	247,797	-4,504,793
9	2004	0	8,651	8,651	252,249	243,598	-4,261,195
10	2005	0	4,452	4,452	252,249	247,797	-4,013,398
11	2006	0	27,972	27,972	252,249	224,277	-3,789,121
12	2007	0	4,452	4,452	252,249	247,797	-3,541,324
13	2008	0	8,651	8,651	252,249	243,598	-3,297,726
14	2009	0	4,452	4,452	252,249	247,797	-3,049,929
15	2010	0	5,501	5,501	252,249	246,748	-2,803,181
16	2011	0	4,452	4,452	252,249	247,797	-2,555,384
17	2012	0	8,651	8,651	252,249	243,598	-2,311,786
18	2013	0	4,452	4,452	252,249	247,797	-2,063,989
19	2014	0	5,501	5,501	252,249	246,748	-1,817,241
20	2015	0	4,452	4,452	252,249	247,797	-1,569,444
21	2016	0	31,121	31,121	252,249	221,128	-1,348,316
22	2017	0	4,452	4,452	252,249	247,797	-1,100,519
23	2018	0	5,501	5,501	252,249	246,748	-853,771
24	2019	0	4,452	4,452	252,249	247,797	-605,974
25	2020	0	8,651	8,651	252,249	243,598	-362,376
26	2021	0	4,452	4,452	252,249	247,797	-114,579
27	2022	0	5,501	5,501	252,249	246,748	132,169
28	2023	0	4,452	4,452	252,249	247,797	379,966
29	2024	0	8,651	8,651	252,249	243,598	623,564
30	2025	0	4,452	4,452	252,249	247,797	871,361
31	2026	0	27,972	27,972	252,249	224,277	1,095,638
32	2027	0	4,452	4,452	252,249	247,797	1,343,435
33	2028	0	8,651	8,651	252,249	243,598	1,587,033
Total		6,059,628	251,860	6,311,488	7,898,521	1,587,033	1,587,033

Table 12.1.21 Economic Internal Rate of Return (Case B-2)

EIRR = 0.84%

Project Year	Financial Year	Investment Cost ①	O & M Cost②	Cost ③=①+②	Benefit ④	Net Benefit ⑤=④-③	Cumulative Net Benefit
1	1996	3,942,835	0	3,942,835	0	-3,942,835	-3,942,835
2	1997	2,722,756	4,897	2,727,654	78,802	-2,648,852	-6,591,686
3	1998	0	6,051	6,051	252,249	246,198	-6,345,488
4	1999	0	4,897	4,897	252,249	247,352	-6,098,136
5	2000	0	9,516	9,516	252,249	242,733	-5,855,403
6	2001	0	4,897	4,897	252,249	247,352	-5,608,052
7	2002	0	6,051	6,051	252,249	246,198	-5,361,854
8	2003	0	4,897	4,897	252,249	247,352	-5,114,502
9	2004	0	9,516	9,516	252,249	242,733	-4,871,769
10	2005	0	4,897	4,897	252,249	247,352	-4,624,417
11	2006	0	30,769	30,769	252,249	221,480	-4,402,937
12	2007	0	4,897	4,897	252,249	247,352	-4,155,586
13	2008	0	9,516	9,516	252,249	242,733	-3,912,853
14	2009	0	4,897	4,897	252,249	247,352	-3,665,501
15	2010	0	6,051	6,051	252,249	246,198	-3,419,303
16	2011	0	4,897	4,897	252,249	247,352	-3,171,951
17	2012	0	9,516	9,516	252,249	242,733	-2,929,218
18	2013	0	4,897	4,897	252,249	247,352	-2,681,867
19	2014	0	6,051	6,051	252,249	246,198	-2,435,669
20	2015	0	4,897	4,897	252,249	247,352	-2,188,317
21	2016	0	34,233	34,233	252,249	218,016	-1,970,301
22	2017	0	4,897	4,897	252,249	247,352	-1,722,949
23	2018	0	6,051	6,051	252,249	246,198	-1,476,751
24	2019	0	4,897	4,897	252,249	247,352	-1,229,399
25	2020	0	9,516	9,516	252,249	242,733	-986,667
26	2021	0	4,897	4,897	252,249	247,352	-739,315
27	2022	0	6,051	6,051	252,249	246,198	-493,117
28	2023	0	4,897	4,897	252,249	247,352	-245,765
29	2024	0	9,516	9,516	252,249	242,733	-3,032
30	2025	0	4,897	4,897	252,249	247,352	244,320
31	2026	0	30,769	30,769	252,249	221,480	465,799
32	2027	0	4,897	4,897	252,249	247,352	713,151
33	2028	0	9,516	9,516	252,249	242,733	955,884
Total		6,665,591	277,046	6,942,637	7,898,521	955,884	955,884

Table 12.1.22 Economic Internal Rate of Return (Case B-3)

EIRR = 0.77%

Project Year	Financial Year	Investment Cost ①	O & M Cost②	Cost ③=①+②	Benefit ④	Net Benefit ⑤=④-③	Cumulative Net Benefit
1	1996	3,584,395	0	3,584,395	0	-3,584,395	-3,584,395
2	1997	2,475,233	4,452	2,479,685	70,922	-2,408,763	-5,993,158
3	1998	0	5,501	5,501	227,024	221,523	-5,771,635
4	1999	0	4,452	4,452	227,024	222,572	-5,549,063
5	2000	0	8,651	8,651	227,024	218,373	-5,330,690
6	2001	0	4,452	4,452	227,024	222,572	-5,108,118
7	2002	0	5,501	5,501	227,024	221,523	-4,886,595
8	2003	0	4,452	4,452	227,024	222,572	-4,664,023
9	2004	0	8,651	8,651	227,024	218,373	-4,445,650
10	2005	0	4,452	4,452	227,024	222,572	-4,223,077
11	2006	0	27,972	27,972	227,024	199,052	-4,024,025
12	2007	0	4,452	4,452	227,024	222,572	-3,801,453
13	2008	0	8,651	8,651	227,024	218,373	-3,583,080
14	2009	0	4,452	4,452	227,024	222,572	-3,360,508
15	2010	0	5,501	5,501	227,024	221,523	-3,138,985
16	2011	0	4,452	4,452	227,024	222,572	-2,916,413
17	2012	0	8,651	8,651	227,024	218,373	-2,698,040
18	2013	0	4,452	4,452	227,024	222,572	-2,475,468
19	2014	0	5,501	5,501	227,024	221,523	-2,253,945
20	2015	0	4,452	4,452	227,024	222,572	-2,031,372
21	2016	0	31,121	31,121	227,024	195,903	-1,835,469
22	2017	0	4,452	4,452	227,024	222,572	-1,612,897
23	2018	0	5,501	5,501	227,024	221,523	-1,391,374
24	2019	0	4,452	4,452	227,024	222,572	-1,168,802
25	2020	0	8,651	8,651	227,024	218,373	-950,429
26	2021	0	4,452	4,452	227,024	222,572	-727,857
27	2022	0	5,501	5,501	227,024	221,523	-506,334
28	2023	0	4,452	4,452	227,024	222,572	-283,762
29	2024	0	8,651	8,651	227,024	218,373	-65,389
30	2025	0	4,452	4,452	227,024	222,572	157,184
31	2026	0	27,972	27,972	227,024	199,052	356,236
32	2027	0	4,452	4,452	227,024	222,572	578,808
33	2028	0	8,651	8,651	227,024	218,373	797,181
Total		6,059,628	251,860	6,311,488	7,108,669	797,181	797,181

Figure 12.1.10 Transition of Cumulative Net Economic Benefi (Case A)

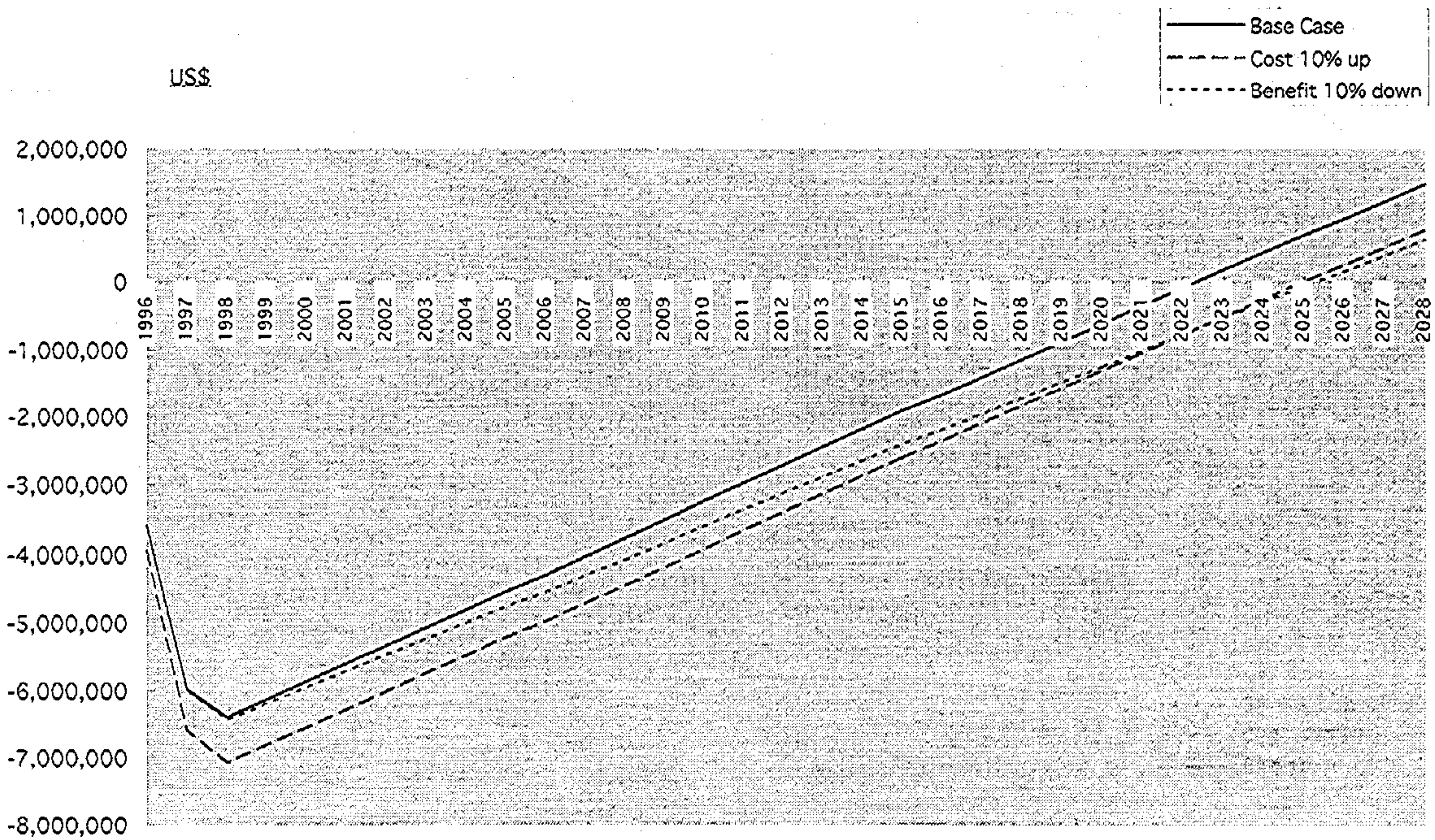
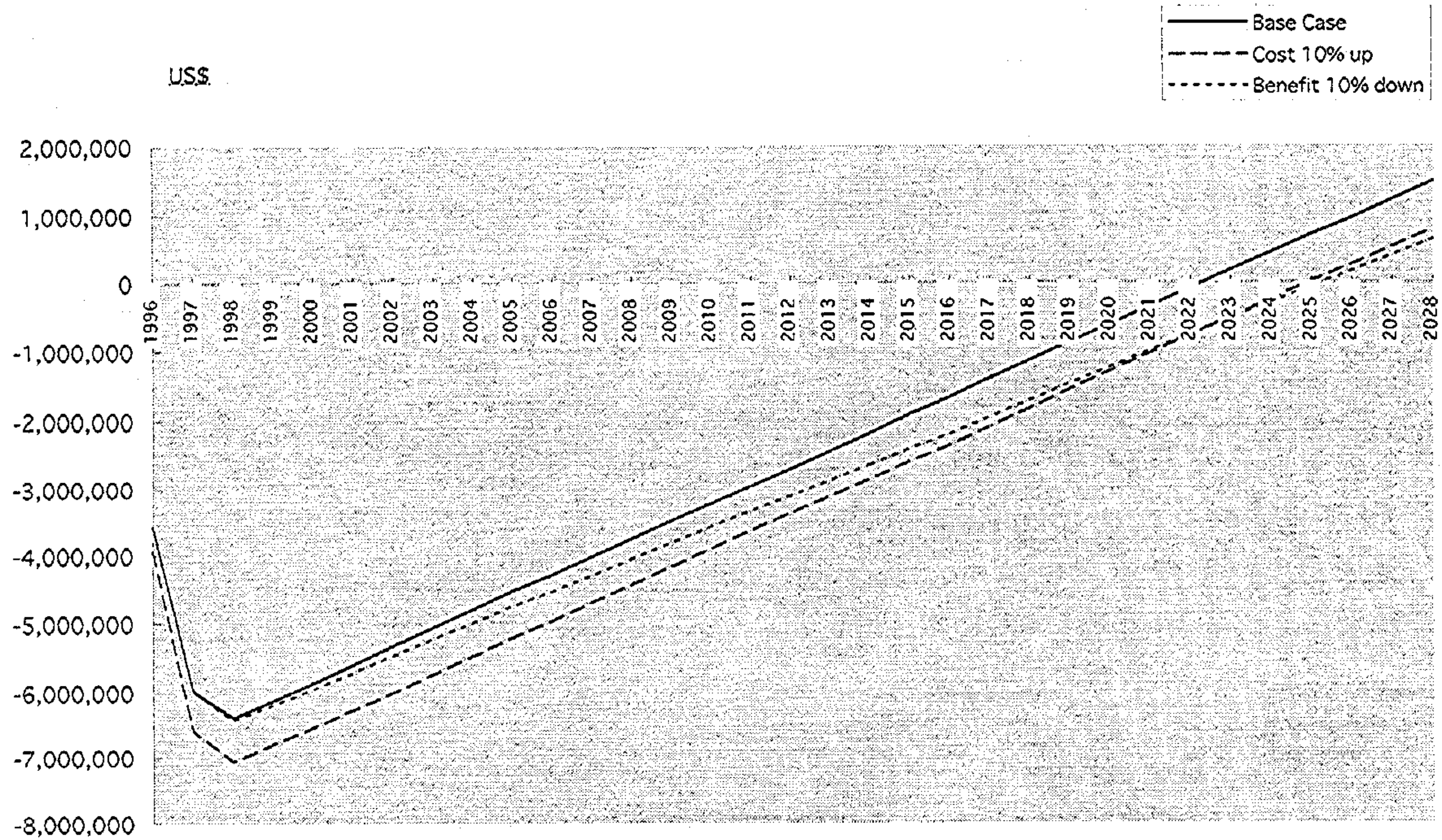


Figure 12.1.11 Transition of Cumulative Net Economic Benefit (Case B)



12.2 Financial Evaluation

12.2.1 Methodologies

The major objective of the financial evaluation of the Project is to verify the financial viability of the Project, attempting to assess the commercial viability of the Project from the viewpoint of project entities. The financial viability of the Project shall be evaluated in terms of two project entities. The first project entity is a beneficiary village which will financially be responsible for the operation and maintenance of the facilities through a water association. The second project entity is the Government of Madagascar which will financially be responsible for repaying foreign loans. The former financial soundness will be judged by the cost recovery analysis of water associations, and the latter financial soundness will be gauged by the foreign loan disbursement schedule.

12.2.2 Cost Recovery

(1) Cases and Parameters

In accordance with the type of facilities projected, the cost recovery analysis will be conducted in the case of *1)* hand pump type, *2)* generator type and *3)* solar type. The following parameters are employed as basic assumptions for the cost recovery analysis in the financial evaluation of the Project.

(a) Number of Households

The number of households which will pay water fees in each case is estimated below.

(Unit: Households)

Case / Year	1st Year	2nd Year	3rd Year and Later
Hand Pump Case	1,398	2,155	2,806
Generator Case	0	3,249	3,249
Solar Case	1,279	3,124	3,124

(b) Water Fee

As discussed in Chapter 6, the proper level of the water fee to be collected is FMG 500 per month per household, and this level of fee will be applicable to the revenue estimate for each case.

(c) Collection Rate

Although the level of water fee to be collected at FMG 500 per month per household is a proper rate, it is anticipated that some of beneficiary households cannot afford to and

/ or is reluctant to pay for the water fee. Consequently, the collection rate of the water fee will not be 100%. The collection rate of the water charge is fixed at 70% in the case of hand pump type and solar type, and is fixed at 80% in the case of generator type well.

(d) Prices and Currency

In the financial analysis for the village association, the prices are expressed in the local currency as of the end of February, 1996.

(2) Cost

Ideally, in the groundwater development which benefit the rural communities, 100% of the operation and maintenance cost as well as the capital cost of the Project should be covered by the contribution from beneficiaries. However, according to the survey by the World Bank on the cost recovery level of the rural water supply projects in 122 developing countries, the fact is that only 6% of the past projects could cover all the costs, and 58% of them could not cover even operation and maintenance costs.

Cost Recovery by User Contribution	Percentage of Countries Surveyed
All Costs (O & M plus Capital)	6 %
O & M Cost plus Part of Capital Cost	16 %
O & M Cost Only	20 %
Part of O & M Cost	30 %
No Cost Recovery	28 %

Considering the above reality, it is reasonable that the target of the cost recovery in this Project is to cover the operation and maintenance cost including the replacement cost of facilities. The financial operation and maintenance cost required for each case are estimated below based on the number of households in use of each facilities.

(Unit: Thousand FMG)

Case / Year	2nd Year	3rd Year	4th Year and Later
Hand Pump Case	3,169.3	4923,2	7,077.3
Generator Case	0.0	11,929	11,929
Solar Case	1,253.7	3,079.2	3,079.2

(3) Revenue

The revenues from the collection of water fee are estimated in each case based on the number of households and collected water fee.

(Unit: Thousand FMG)

Case / Year	2nd Year	3rd Year	4th Year and Later
Hand Pump Case	1398	2155	2806
Generator Case	0	3249	3249
Solar Case	1279	3124	3124

(4) Cost Recovery Analysis

Table 12.2.1 indicates the cost recovery table of the hand pump case, showing that:

1) the annual cash balance during the project life ranges from minus FMG 1,500.3 thousand to FMG 4,707.9 thousand;

2) neither of the project years during the project life will face deficit, and

3) the maximum cumulative cash balance during the project life will be FMG 90,695.8 thousand at the last year of the Project, which is equivalent to the amount of 12.8 times as much as the annual operation and maintenance cost.

Table 12.2.2 indicates the cost recovery table of the generator case, showing that:

1) the annual cash balance during the project life ranges from minus FMG 3,552.8 thousand to FMG 3,666.2 thousand;

2) neither of the project years during the project life will face deficit, and

3) the maximum cumulative cash during the project life will be FMG 45,431.2 thousand at the last year of the Project, which is equivalent to the amount of 3.8 times as much as the annual operation and maintenance cost.

Table 12.2.3 indicates the cost recovery table of the solar case, showing that:

1) the annual cash balance during the project life ranges from FMG 5,371.8 thousand to FMG 13,120.8 thousand;

2) neither of the project years the project life will face the deficit, and

3) the maximum cumulative cash during the project life will be FMG 256,343.7 thousand at the last year of the Project, which is equivalent to the amount of 83.3 times as much as the annual operation and maintenance cost.

In summary, in every case, the water fee collected will successfully cover the operation and maintenance cost, and the replacement cost, generating accumulated cash balance sufficient to cover even a small part of the capital cost. Especially, in the case of villages with solar powered pumps, which is almost maintenance-free in the operation of facilities, the water associations of these villages are more financially sound than other cases.

Figure 12.2.1 to Figure 12.2.3 illustrate the transition of the annual cash balance and the cumulative cash balance of each case, showing the above results.

12.2.3 Loan Disbursement

(1) Cases and Parameters

Since the Project is a BHN type project, the project shall not be financed from the commercial sector but from the public budget of the government of Madagascar or foreign borrowings. Accordingly, the financial viability of the Project shall be evaluated from the viewpoint of the governmental loan disbursements. Observing the financial situation of the government of Madagascar, it is realistic to finance the Project by borrowing foreign loans such as a soft loan from IDA (International Development Association) and AfDB (African Development Bank).

Case A is assumed to be that the concessionality level is low with the high interest rate, with a short grace period and repayment term, Case B is assumed to be that the concessionality level is moderate with a moderate interest rate, grace period and repayment term, and Case C is assumed to be that the concessionality level is high with a low interest rate, and long grace period and repayment term.

Case	Interest Rate	Grace Period	Repayment Term
Case A	7.0%	5 years	20 years
Case B	3.0%	10 years	30 years
Case C	0.75%	10 years	40 years

The basic parameters for the loan disbursement is same as those for the economic evaluation of the Project.

(2) Results

In Case A, where the concessionality level is low with a low grant element of 18.89%, the maximum payment of both interest payment and amortization falls on the 6th year at US$ 866,484, which is approximately 0.48% of the recurrent budget of the government of Madagascar in 1994. The details of the project loan disbursements and repayments in the Case A is as per Table 12.2.4.

In Case B, where the concessionality level is moderate with a moderate grant element