CHAPTER 5. HYDROGEOLOGY

Hydrogeological map of the Study Area is shown in Fig.5.1.1.

5.1 Aquifer of the Study Area

The main aquifers in the Study Area are considered to be formed with next layers and rocks:

- Laterite Layers (mother rock : Tertiary sedimentary layers)
- Bedrock (surface weathered part of the Precambrian bedrock)

The laterite layers are underlain with the Precambrian bedrock.

(1) Laterite Aquifer

The mother rock of the laterite layers is the Tertiary system which is composed of yellow claystone intercalated with sandstone and conglomerate and it covers all of the Study Area. The Tertiary system turned into lateritic clay, lateritic clayey sand and lateritic clayey gravel because of severe weathering action under the tropical condition. The thickness of the laterite aquifer is around 50m in average and more than175m around the airport.

(2) Bedrock Aquifer

The bedrock consists of quartzite sandstone, quartz schist and limestone. In general case, the aquifer is formed in the surface weathered part of the bedrock which is fractured by the weathering action. The thickness of this part is around 30m according to the results of the exploratory well drilling. Another type of the aquifer is formed along the fault in the bedrock which is highly fractured. The productivity of the latter aquifer is much greater than the former one.

5.2 Hydrogeological Structure

(1) Fault and Depression

Three major faults is inferred as shown in the hydrogeological map based on the results of the hydrogeological surveys which are geophysical prospecting and exploratory well drilling. These fault are running in NNW-SSE direction. The faults form main groundwater path in the bedrock aquifer.

These faults dislocated the bedrock and formed depression which is passing through the Bangui city area. The depth of the depression is 100m to 180m and its width is about 2km according to the hydrogeological cross sections. The depression is buried with

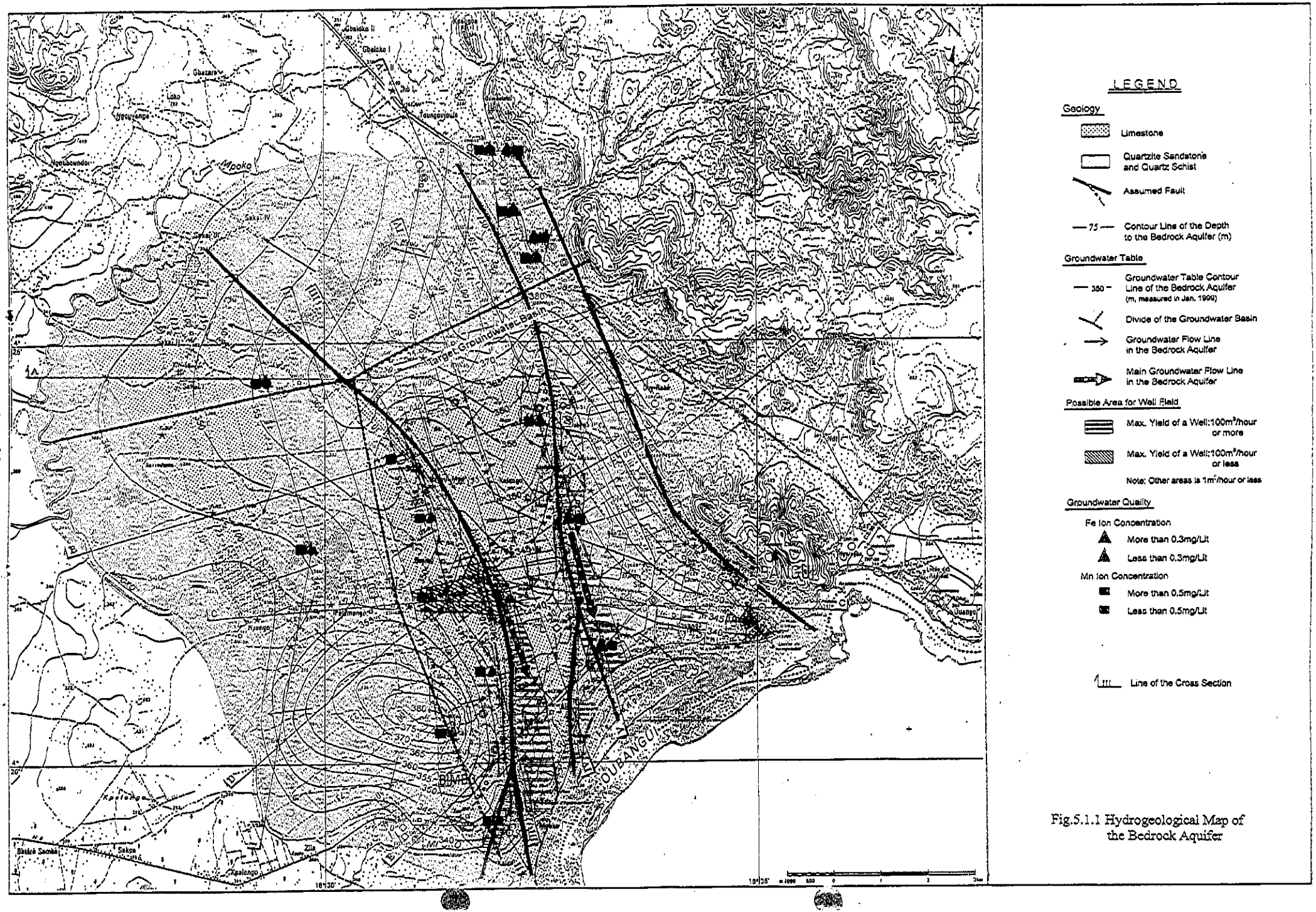


Fig.5.1.1 Hydrogeological Map of the Bedrock Aquifer

thick lateritic layers whose mother rock is Tertiary system.

The depth to the bedrock aquifer largely changes from place to place because of the depression. The depth to the bedrock aquifer deepens around the airport and gets shallower in the western area to the Bangui City.

(2) Piezometric Potential and Groundwater Basin

1) Piezometric Potential of the Laterite Aquifer

The Piezometric surface of the laterite aquifer has same configuration with topographic features, namely, piezometric potential is higher at plateau and lower at plain and valley. It is concluded that the laterite aquifer ca be classified typical unconfined aquifer which receives recharge mainly from the precipitation from the reasons mentioned above.

2) Piezometric Potential of the Bedrock Aquifer

Piezometric contour line of the bedrock aquifer measured in January 1999 is shown in the hydrogeological map (see Fig.5.1.1). Comparing the piezometric contour line of the bedrock aquifer with the contour line of the laterite aquifer, it is said that the piezometric contour line of the both aquifers are almost coincident except the zones along the assumed faults. Namely, the groundwater table of the bedrock aquifer gets lower than the laterite aquifer by about 10m along the faults because the piezometric valleys are formed along the faults. It is assumed that the groundwater is mainly flowing through the fractured zones of the faults.

5.3 Numerical Groundwater Simulation

Reproduction simulation of the present groundwater level is done in this chapter for the formulation of the hydrogeological model of the target groundwater basin. The simulation of future status of the groundwater level will be discussed for the estimation of the groundwater potential of the target groundwater basin.

The numerical groundwater simulation is conducted on the bedrock aquifer because the laterite aquifer is not adequate in terms of its low productivity and deteriorated water quality.

(1) Simulation Program

Modflow is employed for the numerical groundwater simulation. Modflow is constructed based on the differential element method and has been applied in various

field concerning the groundwater seepage and contamination.

(2) Basic Conditions for the Numerical Simulation

1) Grid Model and Boundary Condition

Grid model is formed at the spacing of 160m. Non-flow boundary condition is set along the boundary of the target groundwater basin and the head constant boundary is set along the Oubangui River.

2) Recharge Amount

The outflow amount from the bedrock aquifer is estimated 1.0MCM/year based on the result of the groundwater balance examination, the same value is given as the recharge amount to the bedrock aquifer.

3) Thickness of the Aquifer

Based on the results of the exploratory well drilling, 30m is given as the thickness of the bedrock aquifer.

4) Distribution of the Permeability

High permeability value is given along the groundwater paths (faults) and low permeability is given to another area according to the pumping test results.

(3) Trial of the Numerical Simulation

The groundwater numerical simulation was conducted through trial and error by changing the recharge amount and distribution of the permeability until the present groundwater level contour was reproduced in satisfactory accuracy.

(4) Reproduction Simulation of the Present Groundwater level

Comparing the reproduced contour by the simulation with the actual line shown in Fig.5.1.1, it is assumed that the reproduced contour line is almost coincident with the actual one.

(5) Numerical Simulation on the Future Status of the Groundwater Level

The numerical simulation on the future status of the groundwater level was conducted on condition that the groundwater of shallow wells scattered around the proposed production well fields would not be dried out by the new groundwater development even in dry season. Based on this simulation an exploitable groundwater volume in the study area was resulted at 800,000 m^3/year.

CHAPTER 6. SURFACE WATER POTENTIAL FOR THE WATER SUPPLY PLAN

The OUBANGUI river and the M'POKO river can be a water source of water supply system for the Project area. The study area is surrounded by the M'POKO river on the north, west and south parts. Of the M'POKO river system, the M'BALI river, one of major tributaries, joins the M'POKO near the west side of the study area. The M'BALI river is now free from contamination and there is no particular activity which causes to pollute the river water in future. Therefore, it is highly recommended that the M'BALI river shall be the source of water supply service for the study area in future. The location of the proposed intake facility was selected on the right bank of the MBALI river at about 1 Km upstream of the confluence of the both rivers.

1) OUBANGUI river

In 1964, the existing intake pump station was constructed on the right bank of the OUBANGI river, through which about 0.30 m^3/sec of water has been utilized for SODECA's water supply at present. At the time of the minimum discharge of the river in April 1990 (227 m^3/sec, 40-year probability), the intake was maintained well in use by drawing water through the floating pump. A total intake volume of 0.87 m^3/sec proposed in the master plan of this study is negligibly small to the drought discharge of 227 m^3/sec. The OUBANGUI river, having sufficient water quantity and water level as the water source, can supply domestic water demand in future.

2) M'POKO river

In the M'BALI river, the BOALI dam was constructed in November 1990 in order to ensure a stable water flow of 20 m^3/sec to the existing BOALI hydraulic power plants I and II with total capacity of 18.85 MW, which located at about 5 km downstream from the dam. These power plants were founded in 1953 and 1976 respectively and have been sending energy to BANGUI City. The dam has a storage capacity of 258 million m^3, by which excess rainwater is possible to be stored in the rainy. After certain trial operational period, the dam was started normal operation from August 1991 and then 20 m^3/sec of discharge enabled to be released to the plants constantly in the dry season.

Of the BOALI dam, water balance or discharge control/adjustment function was studied. As the result of the dam water balance simulation for 35 years from 1964 to 1998, no water shortage occurred in case of basic discharge of 20 m^3/s. In case of 25 m^3/sec basic discharge, the shortage happened in 2 years (106 days in 1988 and 37 days in 1990) and the recurrence interval was estimated 15-20 years.

The annual minimum discharge at BOALI of the M'BALI river was also studied.

Based on the dam inflow data (daily discharges at BOALI ICOT gauging station), the discharge calculation was carried out for a period from 1985 to 1998 in cases with dam and without dam. The annual minimum discharge and probability of non-exceedence were computed as below. In case without dam, probable minimum discharge of 5-year return period was 7.1 m^3/sec. In case with dam, the minimum value of 20-year probability was 20.4 m^3/sec.

From above, it was concluded that by the adjustment function of the BOALI dam the M'BALI river discharge should be stable. In case that the basic discharge of 20 m^3/sec be supplied from the dam to the power plants, water quantity problem shall not occur by taking water of 0.87 m^3/sec which estimated as the requirement of 2015 in the master plan of this study.

CHAPTER 7. ESTABLISHMENT OF MASTER PLAN

7.1 Policy of the Master Plan

As a basic policy of the Master Plan, the following condition shall be applied.

1) Target Year:

The final target year of Master Plan shall be 2015. A year of 2005 is the short ranged target which corresponds to the target of the Feasibility Study to be conducted in the next stage.

2) Source of water Supply

Water source is the groundwater and the surface water which have been analyzed and evaluated potential to be utilized in the First Stage of this Study. Quality of supply water shall satisfy with the international WHO guidelines.

3) Target Area

Main target area shall be peripheral zones of Bangui City where some are located outside of the existing water supply area and the others, even inside of the supply area, can not be supplied with adequate pressure and quantity. In case that the existing distribution pipeline can not cater to a future water demand, replacement of the existing pipeline nets shall be considered in the Master Plan.

4) Facilities to be Proposed

Water production facilities shall be applied to the type of the proposed water source. Each component of alternative plans shall be suitable to technical level of the local engineers and also be considered of from the easy and economical operation and maintenance point of view. Distribution facilities, house connections and public faucets, shall be designed in accordance with the criteria which are applied presently.

5) Materials for Construction

Materials to be utilized for construction of the project shall be selected among the locally produced ones as much as possible. In case imported materials are used, commonly distributed ones in the CAR shall be given priority.

7.2 Study of the Master Plan

7.2.1 Projection of Service Population

1) Present Population in the Study Area

In 1998 the third official census of the Central African Republic was conducted with a 10-year interval since 1988, the second. According to the census, annual population growth rate all over the country was estimated as 2.25%. The population inflow to Bimbo has become drastically incremental in recent years. The main reason of it is considered that residential areas in Bangui have become almost saturated and people migrating from countryside cannot afford costs for living in the city.

The population of the design area and the whole country were estimated as shown in Table 7.2.1.

Table 7.2.1 Present Population of Study Area Based on Census

Area	Population by Census in 1988			Estimated Population in 1998			Population Increase Ratio
	Total	Urban Area	Rural Area	Total	Urban Area	Rural Area	
1. Bangui City							
D-I	10,724	10,724	-	15,688	15,688	-	3.88%
D-II	55,801	55,801	-	81,631	81,631	-	3.88%
D-III	86,029	86,029	-	125,851	125,851	-	3.88%
D-IV	60,162	60,162	-	88,011	88,011	-	3.88%
D-V	105,732	105,732	-	154,676	154,676	-	3.88%
D-VI	53,507	53,507	-	78,275	78,275	-	3.88%
D-VII	34,428	34,428	-	50,365	50,365	-	3.88%
D-VIII	45,307	45,307	-	66,279	66,279	-	3.88%
Total	451,690	451,690	0	660,776	660,776	0	
2. Ombella & Mpoko Prefecture							
Bimbo District	69,176	10,751	58,425	158,350	23,022	135,328	7.91%
Ombella & Mpoko pref.	150,865	10,751	140,114	291,792	49,390	242,402	7.91%
3. Other Pref.	2,085,871	524,095	1,110,086	1,746,349	655,049	1,091,300	
4. Public of Central Africa	2,688,426	986,536	1,701,890	3,359,693	1,365,215	1,994,478	2.25%

(Source: Ministère Délégué à l'Economie, au Plan et à la Coopération Internationale)

2) Characteristic of the Study Area

The design water supply area consists of the Urbanized area of Bangui city, and the three sub-districts of Bimbo District located in the east of Mpoko river where are expected to be rapidly urbanized in near future. Bangui City is divided into eight administrative districts. And Bimbo in the study area was divided into ten zones, from B1 to B10, considering progress of urbanization of each zone.

The existing water supply area of the public water service (SODECA) covers almost Bangui city area except hilly area which stretches in the east side of the city from north-west to south-east and some parts of sub-district of Bimbo where urbanization is rapidly under way. The north half part of District VIII of Bangui is out of covering of the present water supply system. In the zone of B-1, B-2 and B-3 of Bimbo, the water service is partly provided through the distribution network. However, the people in these zones are served water with poor quantity and pressure and the service is suspended sometimes in the dry season.

The west half of the study area except B-1, B-2 and B-3 of Bimbo is out of the present water supply area. Depend on the locations of the existing main facilities such as a water treatment plant and reservoirs which are situated in the east part of Bangui city, expansion of the water supply area to west and north is facing to difficulties for lack of water volume and pressure. The above non water served areas of Bimbo in the study area are divided into the following three zones in terms of design level of development of water supply facilities.

a) B4, B5 and B6 of Bimbo (Semi-urban zone):
In these zones population is increasing almost as same as Bangui City, and people rely water on unsanitary traditional shallow wells. Therefore, an installation of sanitary water supply system is highly needed.

b) B7 of Bimbo (Pilot area of the urban developing plan)
In this zone a pilot project of urban developing plan is progressing. The objective of this urban developing plan is to absorb the rapid population increase that causes irregular settlement of people and expansion of a slum in the metropolitan of Bangui. There is a high need of water supply service.

c) B8, B9 and B10 (Zone of Urban Developing Plan for Future)
These zones, although the urban developing plan covers, are left undeveloped with a few populations. While a timetable of realization of the plan is not clear for these zones, need of water supply service remains in the next to the zone B7.

3) Estimation of the Population in Study Area

The population in these areas is projected by employing 3.88% as annual increase rates for Bangui and 7.91% for Bimbo, depend on the result of the two censuses in 1988 and 1998. Saturated densities of the study area are assumed as follows.

The whole Bangui city & B1, B2, B3	: 250 person/ha
In Bimbo: B4, B5 and B6	: 150 person/ha
In bimbo: B7, B8, B9 and B10	: 100 person/ha

The result of estimation of population is summarized in Fig. 7.2.1 and Table 7.2.2

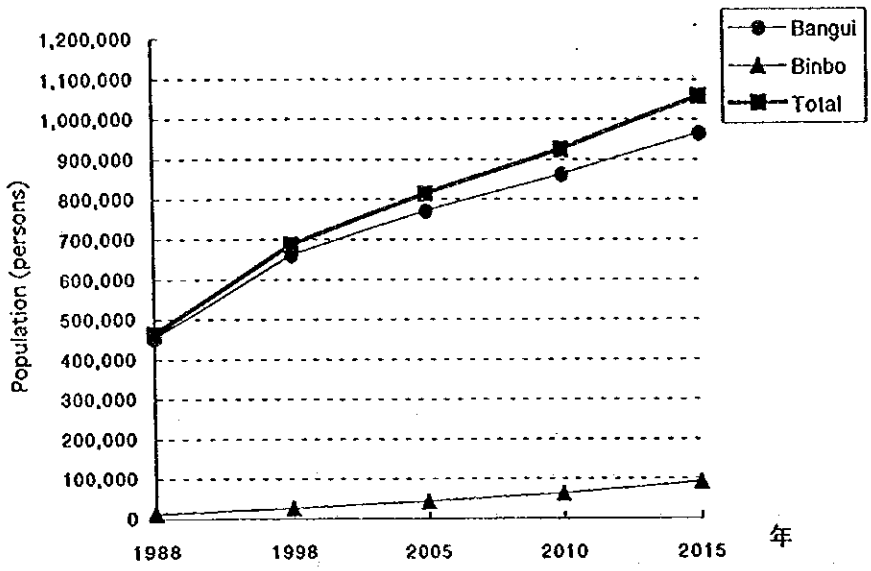


Figure 7.2.1 Estimation of Population

Table 7.2.2 Estimation of Population in Study Area

District	Year 1988	Year 1998	Year 2005	Year2010	Year 2015
Bangui City					
D- I	10,724	15,688	20,478	24,771	29,965
D- II	55,801	81,631	104,327	120,539	136,750
D- III	86,029	125,851	126,530	127,015	127,500
D- IV	60,162	88,011	108,492	123,121	137,750
D- V	105,732	154,676	156,868	158,434	160,000
D- VI	53,507	78,275	102,175	123,597	149,975
D- VII	34,428	50,365	65,743	79,527	96,499
D- VII(1)	22,307	32,624	42,586	51,514	62,508
D- VII(2)	23,000	33,655	43,931	53,141	64,483
Sub total	451,690	660,776	771,131	861,658	965,430
Binbo District					
B-1	-	6,000	10,223	14,959	21,888
B-2	-	4,000	6,815	9,972	14,592
B-3	-	3,500	5,963	8,726	12,768
B-4	-	3,000	5,112	7,479	10,944
B-5	-	1,500	2,556	3,740	5,472
B-6	-	2,500	4,260	6,233	9,120
B-7	-	1,000	1,704	2,493	3,648
B-8	-	500	852	1,247	1,824
B-9	-	1,500	2,556	3,740	5,472
B-10	-	1,500	2,556	3,740	5,472
Sub total	10,751	25,000	42,596	62,328	91,199
Grand total	462,441	685,776	813,727	923,986	1,056,629

7.2.2 Estimation of Water Demand

1) Condition for Water Demand Projection

a) Water Coverage Ratio

*The whole Bangui city and B1, B2 & B3:

According the present condition of SODECA's water supply service into account, the water coverage ratio shall be assumed at 30% from 1998 to 2000. In 2005 the ratio is assumed to improve up to 50% by implementation of a project for repairing of the existing distribution pipe network which is expected to commence from 1999 by a financial assistance of AFD. It is assumed that the water coverage ratio would reach to 60% in 2015.

*B4, B5, B6 & B7:

Providing that a short-term project will be completed in 2004, then water service can be started. It is assumed that the water coverage ratio would be 30% in 2004 and increase linearly to 60% in 2015.

*B8, B9 & B10:

It is Provided that these areas would be gradually developed after the completion of the short team project and installation of distribution pipe network would be expected to expedite after 2009 depending on a possible program of the project implementation. Accordingly the water coverage ratio in 2009 and 2015 in these area are assumed at 30% and 60% respectively.

The water coverage ratios for each zone are summarized in Fig 7.2.2

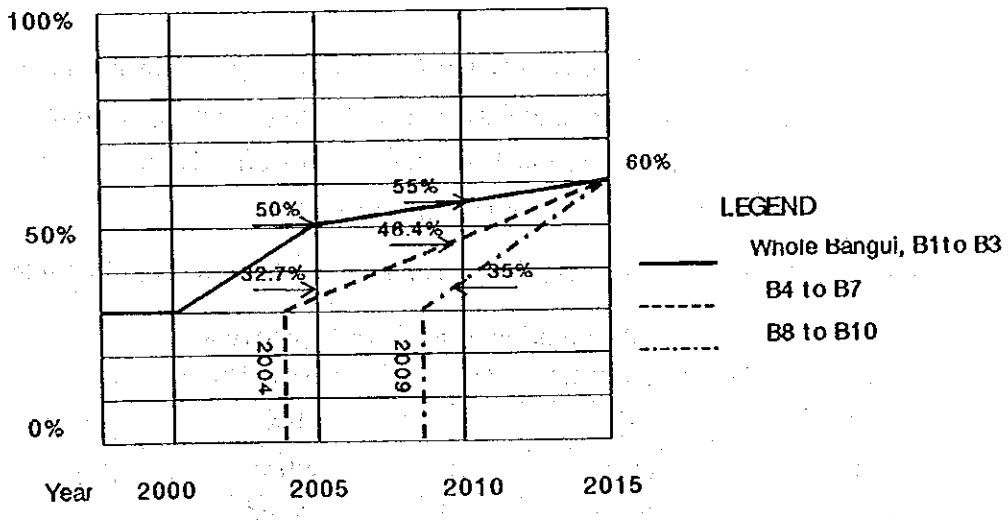


Fig. 7.2.2 Water Service Ratio for Each Zone

b) Proportion of Users of Public Faucet and Private Connection

Depending on the analysis for water service situation, the proportion of users of public faucet and private connection was summarized in Table 7.2.3.

Table 7.2.3 Proportion of Users of Public Faucet and Private Connection

year	Bangui city		B1 to B7 in Bimbo		B8 to B10 in Bimbo	
	Private connection	Public faucet	Private connection	Public faucet	Private connection	Public faucet
2005	30%	70%	15%	85%	0%	0%
2010	30%	70%	30%	70%	0%	100%
2015	30%	70%	30%	70%	10%	90%

c) Unit of water consumption

The units of water consumption are officially assumed as follows.

For private house connection user : 70 Lit./capita/day

For public faucet user : 25 Lit./capita/day

Taking these volumes into consideration, the units of water consumption for each area were summarized in Table 7.2.4.

Table 7.2.4 Assumption of Unit Water Consumption

year	Bangui city		B1 to B7 in Bimbo		B8 to B10 in Bimbo	
	Private connection	Public faucet	Private connection	Public faucet	Private connection	Public faucet
2005	70 lit./cpd	25 lit./cpd	70 lit./cpd	10 lit./cpd	Non supply	Non supply
2010	85 lit./cpd	25 lit./cpd	85 lit./cpd	17.5 lit./cpd	70 lit./cpd	10 lit./cpd
2015	100 lit./cpd	25 lit./cpd	100 lit./cpd	25 lit./cpd	85 lit./cpd	17.5 lit./cpd

d) Ratio of Effectiveness

The present ratio of effectiveness of SODECA's water supply was estimated 65%. The ratio of effectiveness in Bangui City and B1 to B3 can be expected to improve up to 75% in 2015. It was assumed that the ratio of effectiveness for B4 to B7 areas was 90% in 2005 and be reduced to 85% in 2015.

Accordingly the ratio of Effectiveness for each area are summarized in Table 7.2.5.

Table 7.2.5 Assumption of Ratio of Effectiveness

year	Bangui city & B1 to B3	B4 to B7 in Bimbo
1998	65%	0%
2005	69.1%	90%
2010	72.1%	87.5%
2015	75%	85%

e) Ratio of Load of Water Supply

In general ratio of load of water supply is adopted by concerning seasonal fluctuation of supply volume. According to the present water service of SODECA, the ratio of load of water supply can be assumed at 80%.

2) Water Demand Projection in Target year

Taking the above assumptions into consideration, the water demand in target years were estimated as mentioned in Table 7.2.6 and Fig. 7.2.3

In Table 7.2.6 the Area 1 corresponds the zones of B1 to B7 and D-VIII(1) in Bangui City where the public water supply does not cover presently, Area 2 also corresponds to B8 to B10 in Bimbo and Area 3 covers zone where people can receive the public water service sufficiently .

Table 7.2.6 Water Demand Projection (Unit: m^3/day)

Year	Area 1	Area 2	Area 3	Total
1998	950	0	22,550	23,500
2005	1,651	0	25,370	27,021
2010	3,222	44	33,218	36,483
2015	6,182	273	42,889	49,344

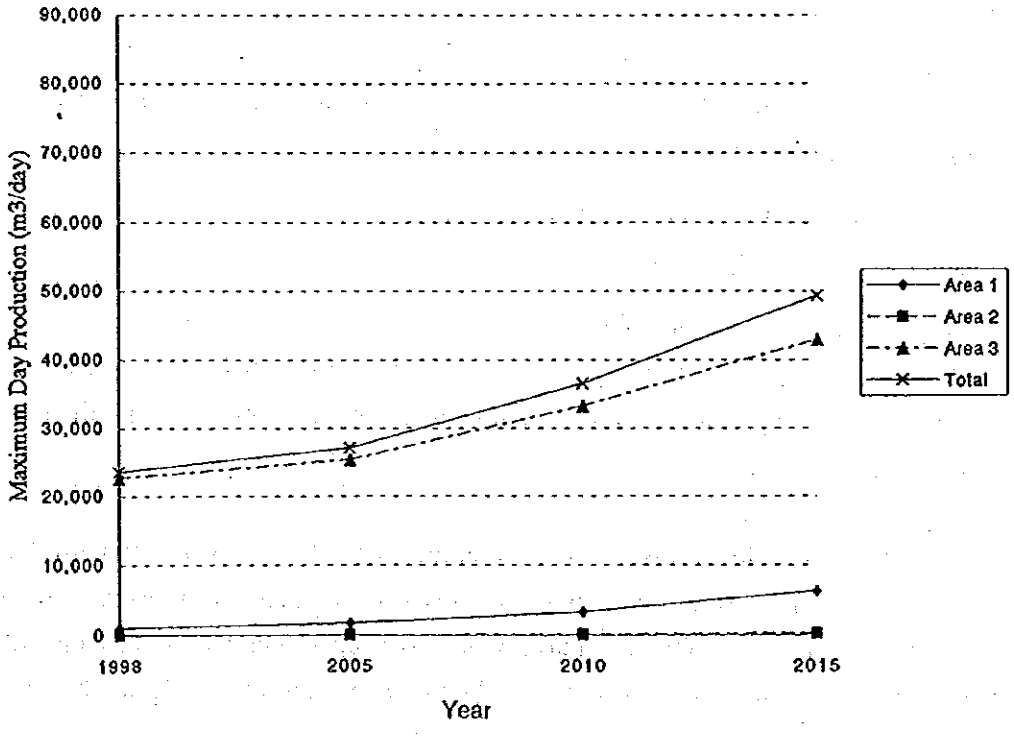


Figure 7.2.3 Water Demand Projection in Target Year

7.2.3 Concept of Proposed Master Plan

The alternative plans can be composed of the following sub-idea plans in order to cater the estimated future water demand. It is obvious that utilization of groundwater for the potable water source is more beneficial than surface water from less operational and maintenance cost point of view. For the short term target year 2005 a groundwater development project will be the most suitable for the peripheral areas of Bangui where population increase rate is rather high and public water service is not covered sufficiently. Then the water demand can be catered through the existing water treatment plant by the year 2008. Therefore after year 2009, the surface water shall be highly required in order to cover the future water demand because of limitation of the potential of usable groundwater. The alternative plans can be composed of the following sub-idea plans.

(1) Sub-project 1 : Groundwater development Project.

To use the design maximum water volume of groundwater: 2,200 m^3/day.

Proposed facilities are as follows,

Several Deep wells, a water reservoir in the hill of Bimbo, transmission main between wells and the reservoir, distribution pipeline network and other facilities.

(2) Sub-project 2 : Surface water utilizing Project

* Sub-project 2-1: Expansion of the exiting water treatment plant (capacity of 14,100 m^3/day)

Proposed facilities are as follows,

Installation of an intake pump, a new water treatment plant, a reservoir and distribution pipe network.

* Sub-project 2-2 : Construction of new water intake and treatment plant (capacity of 14,100 m^3/day)

Proposed facilities are as follows,

Water intake plant with pumping facilities on Mbali River, raw water transmission pipeline, a water treatment plant, a reservoir, and distribution pipeline network.

A deep well construction project will be completed in 2004. The water production capacity of this project is 2,200 m^3/day which will cover demand of Area 1 by 2007. After 2008 the water demand in Area 1 would exceed gradually the capacity of the groundwater system and the short water should be supplemented from the existing distribution system.

Area 3 is almost the same of the current water service area in Bangui City. Water demand of this area is expected to increase as a project for reinforcing and rehabilitating of the existing distribution pipeline would be implemented by the assistance of the AFD. The existing distribution system should also cater the surplus amount of water over the capacity of the proposed deep well project for Area 1 after 2008. That water demand is anticipated to reach the capacity of water production of the existing water treatment plant by 2009 and a new water supply system with a 14,100 m^3/day of water supply capacity should work then.

Accordingly, the total water supply capacity in the whole metropolitan area will be augmented by implementation of the above two sub-projects up to 35,200 m^3/day by 2004 and 49,300 m^3/day by 2009 which covers the total water demand in 2015.

The timing of implementation of these projects can be drawn in Fig. 7.2.4 with relation to the estimated water demand in the study area.

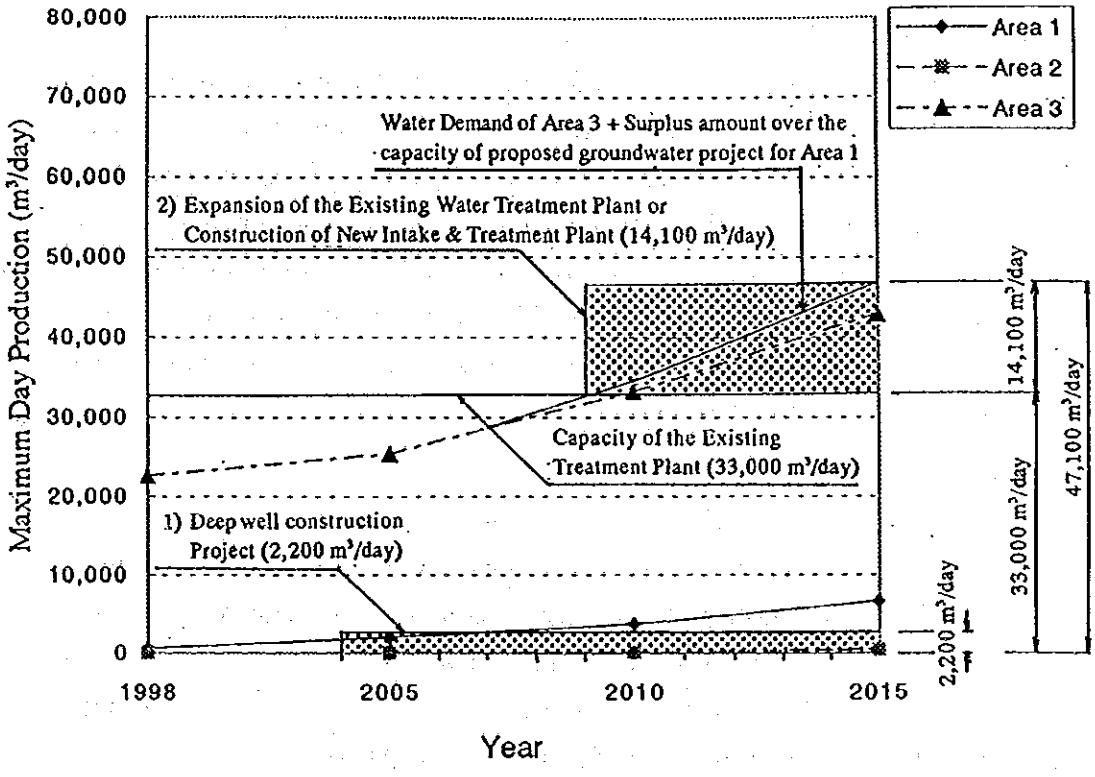


Fig. 7.2.4 Increase of Water Demand and Implementation of the Proposed Projects

7.2.4 Component of Alternative Plan

1) Sub-project 1

Considering requirement of water supply service, the highest priority shall be placed on the areas from B1 to B7 in Bimbo and Bangui VIII(1), because people's lives in these areas are exposed to unsanitary condition without safe and sufficient water. The Potential volume of groundwater can be suitable to cater these areas until around year 2005. Facilities concerned are proposed as follows,

Intake facility: Well with 6' dia., Submersible pump Q=510 lit./min	6 sets
Transmission Pipeline: Dia. 150 mm to 200 mm	7,400 m
Service Reservoir: V= 1,900 m3 at Bimbo hill	1 unit
Distribution pipe net: Dia. 50 mm to 300 mm	30,100 m

2) Sub-project 2-1

By completion of sub-project 1, the capacity of the water production facility will increase to 35,200 m^3/day, which corresponds to the estimated water demand of year 2008. Then it shall be required that the water supply volume should be augmented by construction of a new water intake and treatment plant etc. There is a space for installation of a new pump in the existing intake house and an enough land for construction of a system of water treatment with a 600m^3/h capacity in the concession of the existing water treatment plant. By this expansion the capacity of water production will cover the water demand of year 2015 by a 24 hours operation a day. Facilities concerned are proposed as follows,

Source of water: Oubangui River

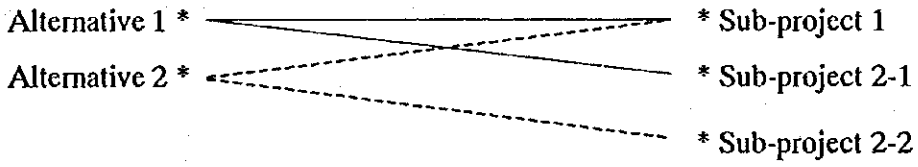
Intake facility: Installation of a new pump with a capacity of 11m^3/min. in the existing intake plant	1 unit
Treatment facilities: Construction of a new plant in the concession of the existing treatment plant. Capacity is 14,100 m^3/day (=600 m^3/hr)	1 unit
Transmission facilities: Installation of pump with a capacity of 59.8 lit./sec.	2 sets
Service reservoir: Construction a reservoir at Bimbo hill and a reservoir at the Bangui side	1 lot
Distribution pipe net: Dia. 50mm to 300mm	64,400m

3) Sub-project 2-2

As an alternative to the sub-project 2-1 above, a system with a capacity of 14,100 m^3/day which composes of a intake plant on Mbali River and a treatment plant at Bimbo hill shall be constructed. And the existing distribution pipe network shall be renovated to augment in order to convey water which corresponds to the estimated water demand year 2015. Facilities concerned are proposed as follow,

Water source: Mbali River	
Intake facility: Construction of a new intake plant at the south side of Mbali River, one of the tributaries of M'poko River	1 lot
pump with a capacity of 3.7 m^3/min.	4 sets
Raw water pipeline: Dia. 450mm	11,400m
Water treatment plant: Construction of a new at Bimbo Hill with a capacity of 14,100 m^3/day	1 unit
Service reservoir: Construction of a new reservoir in Bimbo Hill with a capacity of 7,400 m^3	1 lot
Distribution pipe net: Dia. 50mm to 300mm	64,400m

Accordingly, the alternative plans for the target year 2015 in the study area were formulated by combination with the above sub-projects as follows. A two step construction procedure, in which the sub-project 1 to be constructed by 2004 on the 1st stage and the sub-project 2 to be constructed by 2009 on the 2nd stage, should be adopted for the project implementation.



7.3 Cost Estimation of Alternative Project

Project Costs were estimated in Table 7.3.1.

Table 7.3.1 Cost Estimation of Alternative Project (1,000 FCFA)

Alternative project	Specification	Q'ty	Cost
I. Alternative 1			
1. Groundwater Development Project			
1) Intake well Facilities	Intake capacity 510 lit. /min. x6 unit	1lot	396,120
2) Raw water transmission pipeline	Dia.150mm to 200mm, steel pipe	7400m	403,350
3) Water reservoir	1,900m^3	1 unit	262,100
4) Distribution network	Dia. 50mm to 300mm, PVC	30,100m	1,452,190
Indirect cost		1 lot	1,005,500
Sub-total			3,519,260
2. Expansion of the Existing Water Treatment Plant			
1) Installation of intake pump	11 m^3/mini.	1 no.	64,760
2) Water treatment plant	15,500 m^3/day capacity	1 unit	3,630,000
3) Transmission Facilities	59.81 liters/sec., Head 143m, 140kW, 2nos	1 lot.	1,057,680
3) Water reservoir	5,500m^3+1,900 m^3	1 lot	999,000
4) Distribution network	Dia. 50mm to 300mm	64,400m	4,313,300
Indirect cost		1 lot	4,025,900
Sub-total			14,090,640
Grand Total of Alternative 1	**1+2**		**17,609,900**
II. Alternative 2			
1. Groundwater Development Project (same as Alternative 1)		1 lot	3,519,260
3. New Water Treatment plant in Bimbo Area			
1) Intake facilities on Mbali river	5.38 m^3/min. x 3 units	1 lot	636,900
2) Raw water transmission main	Dia. 400mm, DCIP	11,400 m	1,844,000
3) Treatment plant	15,500 m^3/day	1 unit	4,065,000
4) Reservoir	1,900 m^3	1 lot	256,500
5) Distribution network	Dia. 50 to 300mm	64,400 m	4,551,800
Indirect cost		1 lot	4,541,600
Sub-total			15,895,800
Ground total of Alternative 2	**1+3**		**19,415,000**

7. 4 Operation and Maintenance Plan

7.4.1 Organization of the Institute

Water supply service is one of the activities that are basically required for human lives especially in the urban. Therefore the service shall be managed in accordance with the national policy of social welfare and in general also be sustained by the principle that beneficiaries should pay for value of the service.

The organization in charge of water supply service has to cover the following activities. The experiences of SODECA can be said to be applicable for all the aspects needed for water supply activities in future.

1) Operation and maintenance of all the facilities on water intake, production, distribution, other related works
2) Study and planning for water supply project
3) Commercial and public relation which is composed of registration of subscribers, meter read and billing to the subscribers.
4) Administration of itself which composed of general affair of the organization, personnel administration, financial administration etc.

Those activities are basically as same as the one which SODECA has been managed. Concerning augmentation of water supply volume and service population, the institutional empowerment of the organization is indispensable. Especially the commercial and public relation field is so important to support the other activities, because this is only financial source for the organization.

7.4.2 Sanitation Improvement Plan

Parasite disease, malaria, and diarrheal disease are the most common diseases in CAR. Sanitation and hygiene improvement together with improvement of water quality make a great effect on diarrheal diseases, which are the most prevalent water and sanitation disease and the first mortal cause for children below five years of age. Improvement of water supply and related activities including sanitation/ Hygiene education can improve such condition notably.

The studies done by questioners and interview can indicate that water related disease awareness is generally high. However, the number of Community Health Workers is limited and its extension is strained. Relatively a larger number of people can get information, however it is not possible to select target group. Shortage of extension materials including, training kids, panels and hand-outs is problem.

There are few Sanitation/Hygiene projects run in Bangui by international organization and/or NGO. UNICEF is organizing a project through primary schools. International aid organizations and NGOs such as Afri-care and CALITUS are running also projects at minor level.

To improve sanitation/ hygiene condition, sanitation/ hygiene promotion activities are essential together with infrastructure input. Following is the suggestion to the program.

1) There are some resources to give such education in Bangui, however it is not sufficient. The first problem is that the information/ knowledge to be handed out to population is not well organized and sometimes in shortage. Usage of IEC must be more encouraged. Cheaply produced local material for course / training must be encouraged, which can be more audience friendly especially in the linguistic point of view.
2) The method to extend information must be reconsidered. Currently, sanitation/ hygiene education is done through Community Health Centers and Community Health workers' extension activities. It can be also efficient with other methods. For example, it can be briefer and more efficient to train some community representative (especially women) and to extend the information through them. This method can also create community development awareness.
3) The extension worker / trainer of these activities must be better trained. Well trained extension workers / trainers are essential to effective sanitation/ hygiene promotion activities.
4) The approach which UNICEF is going to practice is instructive. It is sanitation/ hygiene education through primary schools. Recently it is known as Child to Child approach. Through those activities, they can pass important message to each other.

7.4.3 Monitoring Plan

Since the groundwater recharge area is located in the urban area under the development, both of the quantity and quality of the groundwater is anticipated to change according to the urban development in future. Namely, the recharge amount to the groundwater will decrease because of the non-infiltration area such as roads and buildings will expand as a result of urban development. It is also supposed that the groundwater quality will deteriorate by the increase of the infiltration amount of the sewage drained from the household and factories whose number will be increasing every year.

As the groundwater development in the urban area has disadvantage in terms of the both of quantity and quality as stated above, the groundwater monitoring should be closely continued on the quantity (groundwater level) and quality of the groundwater.

The proposed monitoring frequency and monitoring items are as follows:

a. Subject wells for water quality monitoring : All of the production wells

b. Frequency of the water quality monitoring :

-During two months after the development	Once a week
-From two months to six months after the development	Twice a month
-From six months to the end of the project after the development	Once a month

c. Monitoring items : pH, Temperature, Electric conductivity, Hardness, NO_3 NH_4, SO_4, Mn, Fe, Cl, Ca, Mg, K, E. Coliform

7.5 Project Appraisal

Based upon the results of financial, economic and social analyses investigated hitherto, a comprehensive appraisal of the project can be summarized as follows:

1) In case of Alternative plans 1 and 2, FIRR shows less than zero (Alternative 1: -1.75% & Alternative 2: -2.13%). The result indicates these projects are generally negative, in other word these are not to be financed by loans but grants.

2) EIRR of these projects show at 5.90% and 5.08% respectively. Considering that some BHN projects have been recommended to be implemented even though EIRRs showed at 5% to 6%, the proposed Alternative plans can be justifible. The sensitivity analysis also requires to pay more attention to budget control / proper management of the project implementation, if proceeding with the project to the next steps, in order to secure effective use of limited financial resources.

3) In other respects, social analysis shows that the project, if once it is implemented, will be accompanied with some significant BHN impacts, especially in terms of relieving opportunity costs for children's and women's labor to attain time for education and other works, even though the effect is difficult to be quantitatively measured.

4) In conclusion, this project is not financially self-sufficient. It is feasible, on the other hand, if (a) BHN aspects are highly evaluated from political viewpoints, and (b) organizational arrangements to monitor proper management of various procedures and financial control of the project are successfully established.

The two alternatives are summarized in Table 7.5.1.

Table 7.5.1 Comprehensive Appraisal

Items	Alternative Plan 1	Alternative Plan 2
1. Financial Appraisal FIRR	-1.75%	-2.13%
2. Economical Appraisal EIRR Benefit / Cost Ratio	5.90% / 0.67	5.08% / 0.63
3. Level of Engineering Technology	Even	Even
4. Organization & Management of the proposed system	Better	Good
5. Environmental impact	Better	Good
6. Socio-economic impact	Even	Even
Comprehensive Appraisal	**Better**	**Good**

In accordance with the above table, it was decided that Alternative 1 is more beneficial and effective than Alternative 2 to implement for the study area in future.

CHAPTER 8. SELECTION OF PROJECT FOR FEASIBILITY STUDY

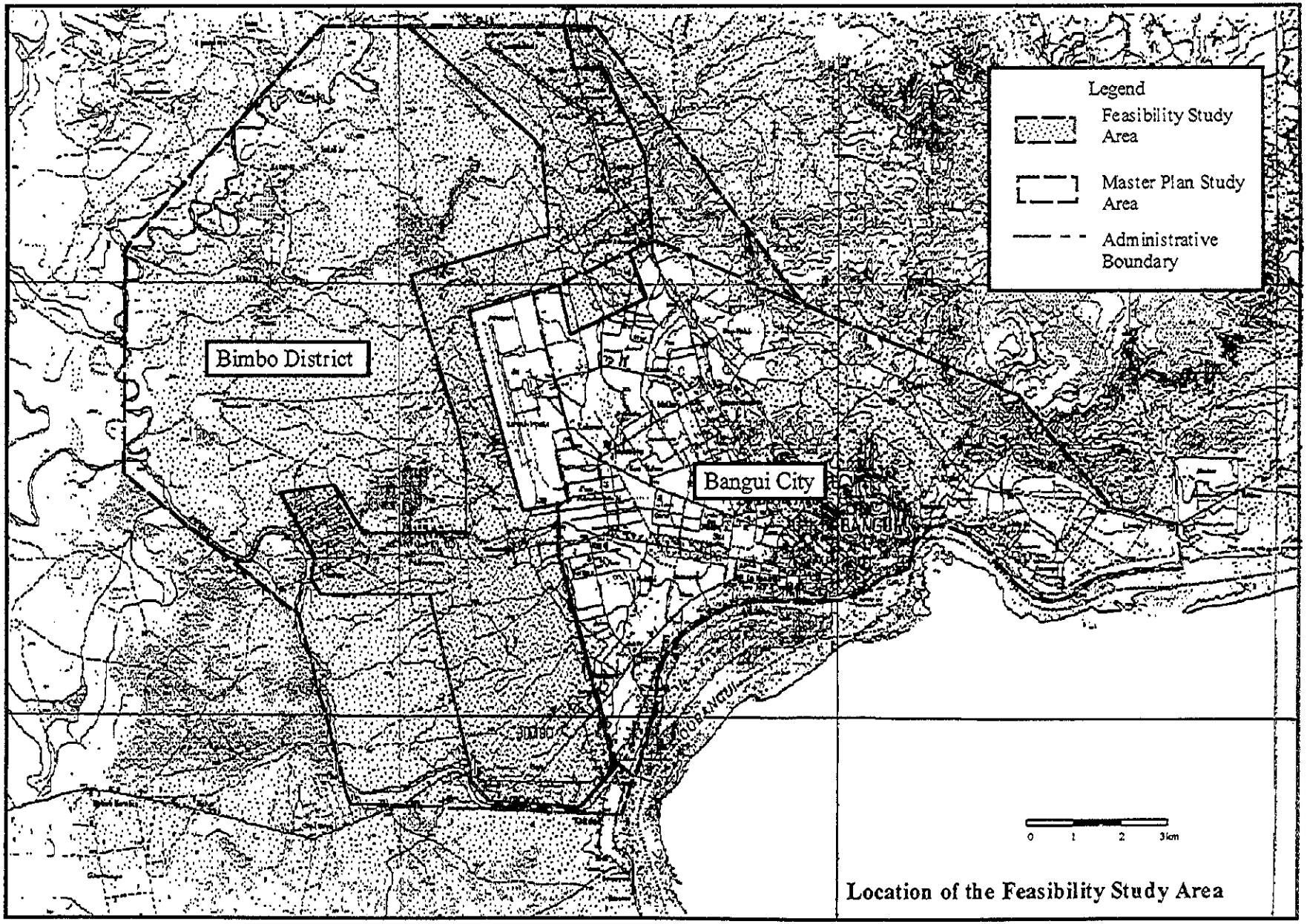
In accordance with the result obtained in Chapter 7, Clause 7.5, the alternative plans for the target year 2015 are appraised as negative to be implemented as the loan basis project. However, considering a steep increase of population and water demand in the Metropolitan area, a feasibility study for short ranged period should be indispensable especially for the suburban area of Bangui City.

The groundwater development project formulated as the sub-project covers the area where population is highly growing under the circumstance without sufficient and sanitary water. Moreover, the people in this area are generally categorized into the lowest income group in the Metropolitan and they are also exposed to a high risk of sweep of water born diseases.

The groundwater development project has an advantage of utilizing raw water which costs cheaper to produce than the surface water which shall be treated with chemicals and energy and more manpower for purifying the raw water. An initial cost of this project is also lower than the other sub-projects whose source is the surface water.

From the BHN point of view the groundwater development project can be consequently identified as the most suitable one for feasibility study to be done the next stage.

FEASIBILITY STUDY



Location of the Feasibility Study Area

FEASIBILITY STUDY

CHAPTER1. INTRODUCTION

1.1 Background

In the Master Plan study two alternative plans were formulated to cater the water demand until 2015 in the metropolitan area of Bangui. A groundwater development project was adopted as a sub-project in the both alternative plans due to its financial and technical advantages such as a less cost for construction and operation, an easy maintenance skills etc.

The both alternative plans as a whole were not given a sufficient point to exploit by the financial and economic appraisals. However, the proposed groundwater development project, which constituted an element of the alternative plans, were concluded that it would give a high benefit to the population who unavoidably faced to a hard sanitary condition. Therefore the project was highly recommended to implement from the BHN's point of view.

1.2 Study Area

The study area for the feasibility study is the west or north peripherals of present water supply service. The study area has generally been urbanized by sprawl phenomenon. Therefore physical and social infrastructures in the area can not be properly introduced as the population increase. Sanitary potable water service, drainage system, sewerage system, medical service, education for children etc. are lacking in the area. A steep increase of population drives up the requirement of these services.

1.3 Basic Policy and Strategy for Feasibility Study

Basic policy and strategy used in compiling the feasibility study are as follows:

1) The objective of the Feasibility Study is to provide for the projected 2005 water demands of the areas where are eminently urgent need for improvement of sanitary conditions.
2) Based on the result of the Master Plan and site survey, the production well sites shall be proposed. The necessary measures against deterioration of the water quality shall also be recommended.
3) Facilities to be designed should be suitable to technical level of the local engineer. Equipment and materials for the proposed facilities should be also procured among ones generally distributed in the CAR as much as possible.

CHAPTER 2. PRESENT CONDITIONS OF FEASIBILITY STUDY AREA

2.1 Water Use & Sanitary Condition

2.1.1 Water Use Condition

The areas for the feasibility study in general have been sprawling without proper regulation or restriction. The majority of the populations in the study area are migrants from the provinces in seeking jobs or expecting better lives in the capital. Depending on a high potential of shallow groundwater in these areas, people can access easily groundwater from shallow wells dug inside their owned land or centers of small communities. The water of these shallow wells are contaminated by coliform and bacteria that implies intrusion of excreta to the groundwater from latrines which are dug in a corner of the concessions without a sufficient distance form the wells.

2.1.2 Sanitary Condition

Sprawl and population increase affects also sanitary condition in the study areas. There is no proper drainage system and sewage system. Many people flash wastewater away on the ground and let it dry out. Drain canals excavated in front of some houses are not maintained well.

Education or workshops concerning sanitation or hygiene are often held at a community level by health workers of the local government or NGO, but still insufficient. UNICEF has been continuing to promote people's awareness on sanitation and hygiene on a project basis.

2.2 Socioeconomic Condition

2.2.1 Population

The population in the study area of feasibility study was estimated at about 54,000 as of 1998 in the Master Plan study. The population increase rate in Bimbo district was also estimated at 7.91% per year which marked more than twice larger than the one of Bangui City, 3.88% per year.

2.2.2 Land Use and Economic Activities

The study area is categorized semi urban area where urbanization was started earlier than another study areas.

In general, the majority of families in these areas, who earn their lives by involving works or jobs in Bangui City, are categorized into a low income level.

CHAPTER 3. WATER RESOURCES DEVELOPMENT PLAN

3.1 Proposed Well Field

The well field should be located in the area that meets the following conditions:

- High yield area of the groundwater (area of high permeability)
- Downstream area of the groundwater flow path
- Converging area of the groundwater in the groundwater basin
- Area where the groundwater quality is better

The suitable well fields which meet the above conditions are situated in the limited areas in the Study Area as shown in the hydrogeological map in Master Plan Report. Namely, there are two proposed well fields in the target groundwater basin. One of them is located in the Bakonngo area and another is Mbossoro area.

3.2 Groundwater Potential

The groundwater potential is examined in the case that the groundwater development is done in the bedrock aquifer at the two well fields mentioned above with six production wells. The numerical simulation on the future status of the groundwater level was conducted for the examination of the groundwater potential based on the hydrogeological model described in Master Plan Report.

The simulation was conducted in the six cases of the development. The maximum regional draw-down of the groundwater level caused by the development is summarized in Table 3.2.1.

Table 3.2.1 Assumed Maximum Regional Draw-down Caused by the Development

Development Case	Development amount (MCM/year)	Maximum Regional Draw-down (m)
Case-1	0.6	1.0
Case-2	0.7	1.2
Case-3	0.8	1.4
Case-4	0.9	1.6
Case-5	1.0	1.8
Case-6	1.1	2.0

It is anticipated that the regional draw-down area of the groundwater level will widely spread in the hinterland of the well fields according to the simulation results.

It is also supposed that the drawing of the river water will start from the Oubangui river to the well fields incase that the development amount exceeds the recharge amount

(1.0MCM/year) and make the draw-down smaller. The draw-down itself caused by the development is supposed small in every development cases and it may range from 1.2m to 2.0m.

The bedrock aquifer is hydraulically connected with the shallow laterite aquifer and the groundwater level of the shallow laterite aquifer will decrease in accordance with the groundwater level draw-down of the bedrock aquifer. There are many existing wells excavated in the shallow laterite aquifer and many people is dependant on the shallow wells. Even after the completion of the urban water supply system, the shallow wells will be still indispensable for the life of the people.

As the reason mentioned above, the regional draw-down to be caused by the groundwater development should be kept within 1.5m. Accordingly, the groundwater potential of the bedrock aquifer is 0.8MCM/year whose regional draw-down is assumed 1.4m.

3.3 Groundwater Quality

3.3.1 Present Groundwater Quality in the Target Groundwater Basin

The groundwater quality is out of WHO standard for potable water in following items in the deep bedrock aquifer in the target groundwater located in the Bangui city area.

-Coliform, -Mn, -Fe, -NO3

The proposed well construction sites, however, were decided in the areas where groundwater quality cleared the WHO standard and contamination would not expect to affect so much in future.

3.3.2 Examination on the Groundwater Quality Change

Since the groundwater recharge area is located in the urban area under the development, the quality of the groundwater is anticipated to change according to the urban development in future.

1) Coliform and nitrate ion (NO_3)

Present NO_3 concentration in the groundwater is around 10mg/lit to 20mg/lit and it can be concluded that the NO_3 concentration still remains low level so far comparing with WHO standard (50mg/lit).

As the contaminant source of NO_3 is human activities such as feces and sewage, it is

assumed that the NO_3 contamination of the groundwater will advance in accordance with the increase of the population.

Based on this idea, it is anticipated that the NO_3 concentration will reach the WHO standard in case that the population will increase by 2.5 times of the present population.

2) Mn and Fe ions

It is inferred the Mn and Fe concentration may not greatly change in the proposed well fields because the groundwater inflow amount from the high concentration area will be small as shown in the map of groundwater flow vector after the groundwater development.

CHAPTER 4. WATER SUPPLY PLAN

4.1 Water Supply Area and Population

The study area was selected by the following viewpoints.

a) Non-water supply area

b) Area whose water service condition remains poor in pressure and quantity

c) Area where a rate of population increase is so high

d) Area where the population are exposed to a high risk of sweep of water born diseases.

Considering the above conditions as a whole, the west or north peripherals of the present water service area are corresponded.

The toatl population of study area in future are summarized as in Fig. 4.1.1.

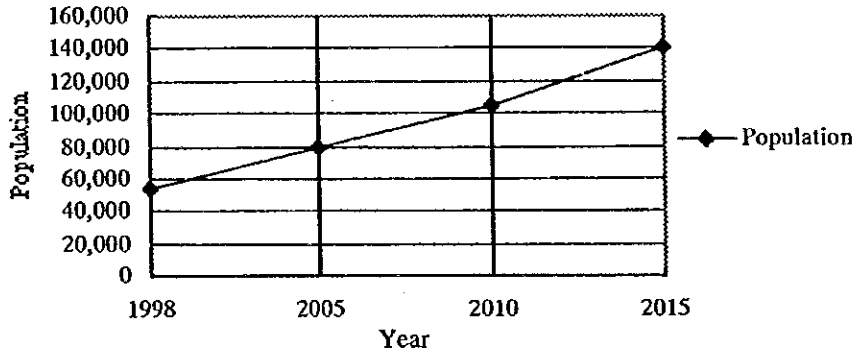


Fig. 4.1.1 Total Population Projection

4.2 Water Demand Projection

Projection of water service population and water demand are shown in the following figures.

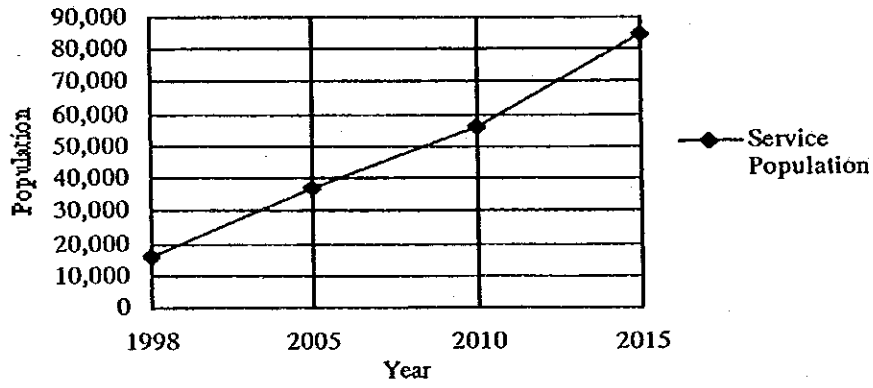


Fig. 4.2.1 Service Population

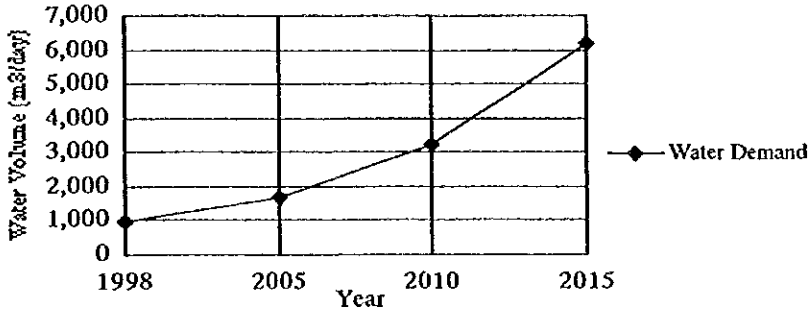


Fig. 4.2.2 Water Demand Projection

4.3 Facilities Arrangement

Basic policies of facility arrangement are as follows.

1) In accordance with the water demand projection, in the target year 2005 the water demand was estimated at 1,650 m^3/day. After then, the water demand was presumed to increase at steeper rate than before and reach the amount of exploitable groundwater, which was estimated at 2,200 m^3/day, by 2007. Since facilities proposed in this study are expected to complete in around year 2004, it would be reasonable to allow several years as the capacity of the system. Therefore 2,200 m^3/day, that corresponds to the exploitable groundwater volume, should be the design maximum day demand.

2) The proposed water supply system consists of intake wells, a transmission main, a reservoir and distribution facilities. Considering the following cases, the main pipes should be connected between the new system and the existing one.

   Case 1: At the primary stage of operation of the new system the water demand in the target area would be smaller than the capacity of the system. From an efficient utility of the water point of view, the surplus amount of water can be conveyed to the existing water service area through connecting points.

   Case 2: When water service is suspended in an emergency, the service could be continued by supplying water through connecting points.

   Case 3: According to the water demand projection, water demand in the target area would increase the proposed production water volume in around 2007. After then water should be drawn from the existing distribution network through connecting pipes.

3) From the basic policy of BHN point of view, the facilities of public faucet should be included in the scope of the project.

CHAPTER 5. DESIGN OF WATER SUPPLY FACILITIES AND EQUIPMENT

5.1 Design Criteria

5.1.1 Water Demand

The maximum day demand have worked out at 2,200 m^3.

5.1.2 Intake Facilities

Intake facilities is composed of six deepwells and conveyance pipeline. Of these six wells, four deepwells are normally operated for 18 hours, and the remaining two deepwells are stand-bys.

5.1.3 Transmission Facilities

Three units of transmission pumps have been proposed in this facilities, two transmission pumps are normally operated for 18 hours, and the remaining one pump is stand-by.

5.1.4 Service Reservoir

The required storage volumes of service reservoir will be basically provided for 12 hours of maximum day demand, and the storage volume will be taken the efficiency for future arrangement of extra reservoir into account.

5.1.5 Public Fountain

A public fountain is located within a radius of 500 meters (medium distance) and the typical design of the fountain in CAR is adopted in this project

5.1.6 Dosage of Chlorine

A dosage of 2 mg/lit. is required for disinfection alone, and residual chlorine in water shall be 0.1 to 0.2 mg/lit. at the last tap in the distribution pipeline.

5.2 Proposed Facilities

The specification of the proposed facilities are summarized in Table 5.2.1 below.

Table 5.2.1 Proposed Facilities

Facility	component	Specification	No.
Well Facility	Deep Well	Dia. 12"1/4, Depth 50m to 150m, FRP Casing Dia. 6", INOX type screen Dia. 6"	6
	Submersible Pump	Q=0.51 m^3/min., 2.4 kw to 5.43 kw	6
	Raw water main	Dia. 100 mm to 200mm, DCIP	3,120 m
	Aqueduct	Dia. 150 mm, L=29m	1
Transmission Facility	Receiving tank	RC structure, V=122 m^3	1
	Transmission main	Dia. 200 mm, DCIP	4,780m
	Transmission pump	1.07 m^3/day, 31.66 kw	3
	Disinfection device	Hypochlorite dosing system	1
Distribution Facilitiy	Pipeline	Dia, 50 mm to 300 mm, DCIP / PVC	71,840
	Distribution Reservoir	RC structure, V=1700 m^3	1
	Public fountain		40

5.3 Equipment for Operation and Maintenance

The following equipment shall be required for the DGH in order to operate and manage the project's implementation. Procurement of these equipment shall be included in the scope of the project.

(1) Vehicles: 4WD Pick-up type -3 No.
(2) Radio communication set: HF 125 W -1 set. (Station 1 No. + Transceiver 10 No.)
(3) Computer, Printer and Software: Personal desk-top type 1 set
(4) Water Analysis Equipment and reagents

CHAPTER 6. OPERATION AND MAINTENANCE PLAN

6.1 Organizational Arrangement for Study and Construction Stage

Assuming that the construction of new drinking water supply facilities is carried out, the Government of the CAR need to bear the following:

- Site preparation for the facilities to be constructed, e.g. securing the land, obtaining public consensus regarding the use of land for facilities construction, etc.,
- Providing necessary utility services connection to the site, including electricity, telecommunication, and so forth,
- Securing the smooth custom clearance and land transportation of the machinery and materials for the construction, including exemption of import duties and relevant taxation,
- Exemption of taxes and other relevant charges for the enterprises and entities to be involved in the project execution under the contract with the CAR Government,
- Assignment of counterpart expert personnel for the transfer of operation and maintenance technologies and practices as well as for on-site confirmation of the construction works,
- Catering salaries of counterpart staff assigned for project implementation and expenses necessary for their activities,
- proper and sustainable operation and maintenance of the constructed facilities, and
- other necessary undertakings.

The organization responsible for executing the undertakings of CAR during the construction period is to be built in the Project Division in the organization of the DGH. The proposed organizational diagram is given in Figure 6.1.1.

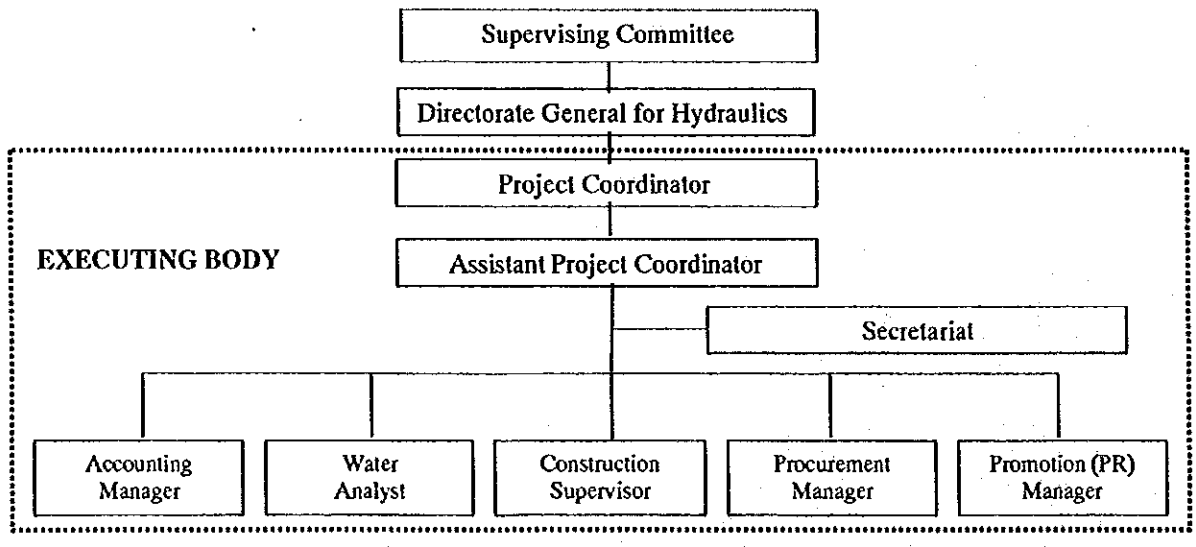


Fig. 6.1.1 Proposed Organization during the Construction Period of DGH

6.2 Organizational Arrangement for Operation and Maintenance Stage

(1) Organization for Conducting the Supervision Role of the Government of the CAR

The principal role of DGH for the project is to supervise operation and maintenance of the groundwater supply facilities while actual facility operation and maintenance are commissioned by contract to the private sector.

The Figure 6.2.1 proposes the reformed organizational structure of DGH that reinforces the function of contractor management and supervision.

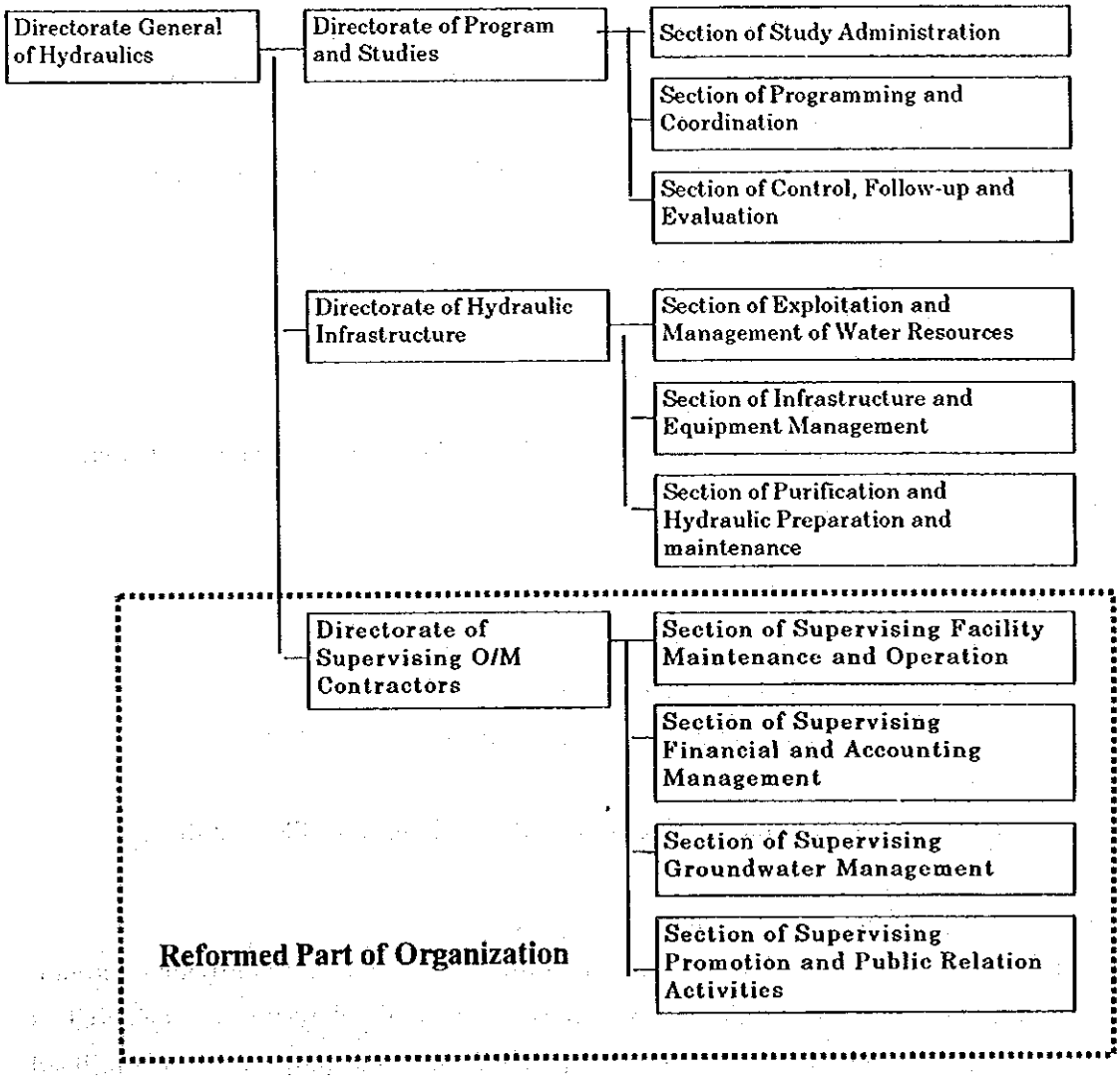


Fig. 6.2.1 Proposed Organizational Reform of DGH

(2) Commissioned O/M Works

In principle, all operation and maintenance works of facilities are commissioned to the selected private contractor. The contractor will conduct all the operation and maintenance works including metering and bill collection. The collected bills are the income of the contractor, some of which will be paid to DGH probably as facility leasing charges. Major Commissioned O/M works to the private contractor are:

a) Facilities Maintenance and Repair Works (groundwater pumping facilities, distribution pipes, electromechanic device, etc.)
b) Operation of Facilities (Operation, operation data processing and management of facilities)
c) Groundwater level and quality management (monitoring and analysis)
d) Metering, billing, and bill collection
e) Accounting and Financial Management (Expenditure control, bookkeeping, preparation of the company's financial reports –B/S, P/L, etc.)
f) Customer management (customer information processing and management, customer's complaint procedure, etc.)
g) Marketing and promotion activities (Water demand analysis, PR activities)
h) Other related activities

(3) Supervising Roles of the Government

The following operation and maintenance works of the contractor may be subject to supervision and examination by DGH.

- facility maintenance and repair works records
- facilities operation records
- groundwater level and quality monitoring records
- metering, billing, and bill collection records
- the contractor's financial and accounting reports (B/S, P/L, etc.)
- customer management records
- marketing and promotion activities (water demand analysis, PR activities)

(4) DGH's Supervising Capacity and Training Needs

The education and training for capacity building of DGH can be provided through various training programs of bilateral as well as multilateral aid agencies. The NGO's experience and capacity of community development and education can be also utilized in promoting and disseminating the use of safe groundwater, as well as in involving community for the management and operation of public faucets (kiosks).

6.3 Recommendation for Community-based KIOSK Operation and Management

(1) Background

While, the current registration system of individual concession holders of Kiosks will be mainly succeeded with some improvement on qualification and supervision mechanisms, the Study Team also recommends below the community-based management of kiosks, as an option of kiosks operation and management. The possibility of community-based management of kiosks can be examined by conducting some pilot studies.

Followings are particular advantages for Community Based Management of the kiosks in this project:

- SNE and DGH have relevant experience in this field.
- In the study of kiosk, management problems are shown clearly. Community Based Management is one of the possible solutions to this problem.
- Involving communities will create a positive attitude of the population towards the project.
- Generally, the willingness to pay will increase once Community Based Management is introduced.
- Transparency of financial management is also a very important aspect. If Community Based Management is properly done, financial management will be transparent to the community. It makes the population feel more secure and responsible to buy water because they will see the benefit goes to them.
- If Community Based Management is introduced, the benefits will return to the community.

(2) Establishment of the Animation Team

To realize the strategy Community Based Management, the project must establish a well trained animation team.

Followings are the topics that the animation team should cover;

*For training of population

- Basic knowledge of sanitation and hygiene to encourage people to use potable water and proper storage of water
- Participatory planning technique, including conflict management technique.
- General idea of sustainable water resource management
- Basic technical knowledge

*For training of committee

- Leadership training

- Management Knowledge
- Bookkeeping
- Hygienic Management of Kiosks

6.4 Analysis of Water Tariff Structure

The groundwater development project shall be profitable. In case that the groundwater development system be integrated to the existing one, it is confirmed that the impact of this profit would not largely affect to the present financial situation. Because the production water volume from the new system would share only less than 10 % of the total supply water volume of the existing system. It means the impact of groundwater development project to the financial situation would be too small to consider reduction of the present water tariff within first several years. The present water tariff structure was resulted to be appropriate. Although the profit to be gained by the new project is small, it could assist to improve the present financial situation.

CHAPTER 7. PROJECT COST & PROJECT IMPLEMENTATION PLAN

7.1 Project Cost

(1) Currency Exchange Rate

The exchange rate of foreign currencies were surveyed at the Banquè Internationale Pour Le Centrafrique (BICA) on June 2, 1999. The exchange rates for the cost estimate are adjusted as follows:

FRF1 = 100.00FCFA
US$1 = 627.23FCFA
J.Yen1 = 5.18FCFA

(2) Construction Cost

Construction cost is estimated in Table 7.1.1

Table 7.1.1 Construction Cost

Description	Foreign Currency (FRF)	Local Currency (FCFA)
1.Direct Cost	22,935,000	1,518,439,000
(1) Drilling Works	2,924,000	0
(2) Civil Works	20,011,000	1,488,566,000
(3) Electrical Works	0	29,873,000
2. Indirect Cost	6,881,000	455,532,000
(1) Temporary work cost 20% x (1)	4,587,000	303,688,000
(2) Field office cost 10%x (1)	2,294,000	151,844,000
3.Land Acquisition/Compensation	0	2,488,000
4. Engineering Fee 10% x (1+2)	2,982,000	197,398,000
5. Physical Contingency 10% x (1+2+3+4)	3,280,000	217,386,000
6. Price Escalation 5% for foreign and 2% local x (1+2+3+4+5)	1,804,000	47,825,000
Total	37,882,000	2,439,068,000

7.2 Recurrent Cost

Annual Operation & Maintenance Costs (O&M Costs) were estimated at about 39.1 million FCFA including electricity, salary and chemicals. Other operating cost were estimated in accordance with the actual balance sheet of SODECA in 1998.

7.3 Project Implementation Plan

(1) Basic Considerations

1) Weather Conditions

During rainy season from May to October, it rains heavily and occasionally. Existing drainage system is very poor in project area, especially in Bimbo District. Due to such heavy rains, drainage system usually does not function, and the land becomes too sluggish for construction. For this reason, the construction works should be desirably avoided during the rainy season.

2) Construction Period

In order to meet water demand at the target year of F/S project, the construction works including the commissioning should be preferably completed by the end of year 2003.

(2) Implementation Schedule

The implementation schedule of the Project is formulated as shown in Figure.7.1.1.

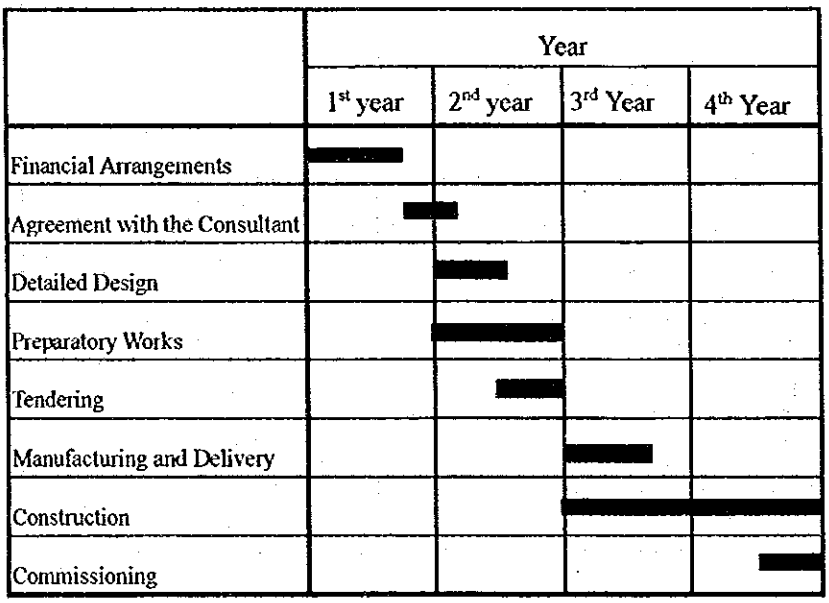


Figure 7.1.1 Implementation Schedule of the Project

CHAPTER 8. EMVIRONMENT IMPACT ASSESMENT (EIA)

8.1 Natural Aspects

(1) Land Erosion

It is anticipated that the land erosion will not take place by the groundwater development because any excavation and embankment work will not be done for the groundwater development.

(2) Groundwater

It is anticipated that the regional serious groundwater level draw-down which will cause the drying up of the existing wells will not arise because the groundwater development amount was determined so as to prevent such negative.

However, the monitoring on the groundwater level should be continued after the groundwater development because the prediction will not always right.

(3) River

Although the discharge amount of the sewage will increase in accordance with the increase of the water supply amount, the contaminant amount itself discharged to the river will not change because the contaminant discharging rate per Capita will not get larger even if the water consumption rate per Capita will increase. Therefore this project will not cause directly increase discharge of contaminant to the river.

(4) Land subsidence

It is anticipated that the land subsidence will not arise because the laterite layers are hard enough and the regional draw-down of the groundwater level to be caused by the groundwater development is kept as small as less than 1.4m.

8.2 Social Aspect

It is anticipated that the damage of economic activities in the manioc fields on the proposed route of access road will not arise because the disturbance is minor. Lands for the route and the water reservoir belong to the Government and the proposed well sites belong to private owners. Lands necessary for the well sites should be acquired by the Government. Therefore a large scaled of compensation for land acquisition will not be required. The cultivators agreed with project to use the land.

CHAPTER 9. PROJECT APPRAISAL

9.1 Introduction

Feasibility of the project is appreciated from financial, economic, social, and environmental viewpoints. The project-life period is assumed as 33 years starting from 2001 up to 2033 (30 years after facilities operation). Benefits (both financial and economic) of the project and operational & maintenance (O&M) costs are annually appropriated on the basis of income and expenditure calculation by the cost planning staff of JICA Study Team.

9.2 Synthetic Project Appraisal

Based on the results of financial and economic appraisal of the project hitherto with its social and environmental analyses to be discussed hereunder, comprehensive appraisal of the project is made as follows:

(1) FIRR of the project is negative (-1.95%). The result indicates that the project is not to be financed by loans but grants.

(2) EIRR of the project is 3.71%. It implies that the project could not be implemented for economic development. It also tells that it is still difficult to justify the project for responding the Basic Human Needs.

(3) If the project is implemented on the grant aid basis instead of the loan basis, it is most important that the operating revenues of the project would cover not only the annual expenditures but also replacement costs for all the proposed facilities in accordance with their life spans. The life spans of the facilities are as follows.

Pumps and electrical apparatus:	16 years
Pipes and well facilities:	40 years
Reservoir and other RC structures:	60 years

An annual cash flow for managing the project was analyzed during the operation period of 60 years after the commencement of operation, while all the proposed facilities would be replaced at least once. The analysis implied that the project would be self-sustained to cover the replacement cost of the facilities, which might be a huge burden against the financial management, without any external financing.

(4) In terms of social benefit, the project is expected to produce some important BHN impacts as follows:

- Releasing the women and children from hard work load and time for drinking water collection, then increasing the opportunity and potential of the people to be engaged in more productive activities,
- Improving the present hygiene and sanitation conditions, then releasing the people from the present serious risk of water-borne diseases and also reducing their burden for medical expenditure,
- correcting a locational inequality for access to the public water service,
- production of job opportunity and labor demand

(5) In terms of the environment, no serious negative impact was identified in the Environmental Impact Assessment by the JICA Study Team.

From the result of comprehensive appraisal of the project above, the project still have some important social benefit not to be ignored in terms of Basic Human Needs although it is very difficult to justify in financial and economic terms.

CHAPTER 10. CONCLUSION AND RECOMMENDATION

10.1 Conclusions

The project of groundwater development project was established as follows.

(1) Water Resource

In accordance with Hydrogeological survey, 2 sites were selected at Bakongo and Mbossor in Bangui City as the optimum well field. The exploitable groundwater volume was decided at 800,000 m^3/year from the view point that water level of the existing shallow wells around the proposed deep well would not get down more than 1.5 m from the present level even in the dry season. Groundwater produced from the proposed deep wells can be distributed to the consumers through only a chlorination system.

(2) Population Projection

The population estimated to be supplied by 2005, the target year of Feasibility Study is 37,300. In year 2007, when the proposed system would be operated fully, the service population is estimated at about 45,000.

(3) Water Demand Projection

In accordance with the water demand of the project area, maximum daily supply volume was estimated at 1,650 m^3/day by 2005, 3,220 m^3/day by 2010 and 6,180 m^3/day by 1015. The proposed production volume of the wells, 2,200 m^3/day, corresponds to the maximum daily supply volume in 2007.

(4) Proposed Facilities

The proposed facilities were designed correspondently with the proposed production volume 2,200 m^3/day. The proposed facilities consist of Well Facility, Transmission Facility and Distribution facility.

(5) Project Cost

- The cost for design and construction stage was estimated at 37,882,000F-Franc as a foreign currency portion and 2,439,068,000 FCFA as a local currency portion.
- Main recurrent costs, which shall be annually invested for electricity, salary, Chemicals, and others for operation and maintenance of the new system, are calculated. These have been assumed to come out of the Project's operational budget, and therefore

funded from Project's revenue.

- The cost per capita over the total investment for the scope of the feasibility study comes to F-Franc 1,380 (equivalent to US$ 220) considering a estimated water service population in 2007 when the full capacity of the new system would meet the estimated demand.

(6) Conclusion

The project was evaluated not so positive to implement on loan basis. It is anticipated, however, that the project could be managed with profitable balance at the operation and maintenance stage. The operation of the new facilities can be covered by the present capacity of the local engineers. The Government of CAR can entrust operation and maintenance work of the new system to the private firm under its supervision, that is the same manner as the Government does now. From the BHN point of view, it was justified that implementation of this project can highly contribute to improve the present circumstance in the target area.

10.2 Recommendations

In order to guarantee more sustainability of the project's implementation, the following issues are recommended to the Government of CAR.

(1) Establishment of Monitoring System on Groundwater Level and Water Quality

The water source of the project is groundwater to be developed in the urbanized area. The proposed production volume of the groundwater was decided in order that the shallow groundwater would not dry up due to operation of the proposed wells even in the dry season. Quality of the groundwater to be developed by the project was anticipated to clear the WHO's guideline even in future. However, considering difficulty to foresee precisely changes of water level and quality, that might occur due to influence of continual pumping and various activities in the recharging area of groundwater, it is recommended to establish a monitoring system on groundwater level and water quality in the DGH body. Data accumulated by this system will enable the DGH to make a necessary study and take proper measures about revise of pumping rate of groundwater, installation of removing device of Fe or Mn or others in due time.

(2) Formulation of counter measure for groundwater preservation

At present there are several large factories and offices which might cause groundwater pollution, in the groundwater recharging area. The result of field survey conducted by the study team showed that these would not contaminate the groundwater. There is neither regulation nor law that shall prohibit to erect chemical related factories or dye works in Bangui City and Bimbo District. Therefore, in order to protect of groundwater quality, it is recommended that the Government of the CAR should establish underground water preservation law over the recharge area and regulate to discharge of pollutants or to erect a chemical industry without proper treatment facilities. Although the NO_3 concentration in the groundwater still presently remains in low level and it may take long time to exceed the WHO standard in future, it is recommended that furnishing septic tanks in the private houses shall be also conducted. On the other hand a project for arrangement of sewage system should be commenced in near future in Bangui City.

(3) Reinforcement of the DGH

The DGH, the implementing organization of the project of the CAR side, has been involved in development of water supply service in rural area for more than 10 years under the Ministry of Mines and Energy. Under the organizational reform policy of the Government, the DGH was appointed to implement and promote water supply activities in the whole country last year. Therefore the DGH is preparing a proposal for new organizational structure. In accordance with its experience of various project's implementation, the DGH can manage study and construction for the proposed project. At the operation and maintenance stage of the project, however, the DGH has not enough experienced staff and know-how on entrustment of operation and maintenance of the proposed facilities to the private firm, supervision and evaluation of the performance of the private firm, billing and financial management, public relation activities, etc. Therefore, the DGH has to reinforce its capacity by employment of proper capable persons and training of their staff by participation to certain training programs presented by NGO or international aid organizations. It is highly recommended that the Government of the CAR should support the DGH's activities by all means in points of finance and personnel.

(4) Formulation and implementation of measures for increasing the water service ratio

The CAR Government has been making effort to increase the water service ratio in Bangui City by introducing financial and technical assistance from mainly French

Government for years. Recently a review of the study on 4th project for rehabilitation and reinforcement of the existing distribution pipe network was completed by the assistance of the AFD. The study aims at augmentation water service population and strengthening of management of the sector. The Government of CAR has requested the Government of France to implement this project through the AFD. Increase of water service ratio would bring the project better effects such as increase of the workability of the system and efficient use of water resource and consequently profitable management. Therefore the Government of the CAR is recommended to promote formulating and implementing proper measures for increase of the water service ratio by its own responsibility.

(5) Pilot management of public faucet by community oriented water committee

This project aims to serve safe potable water stable to the people who are categorized into low income class and live under the worse sanitary situation. It is expected that most of them would become public faucet (kiosk) users after completion of the facilities. If profit on selling water at kiosk can be returned to the users, the project would be more accepted by the people. Therefore it was proposed to introduce a system of community based kiosk operation in the project as a pilot system. There may be various obstacles to introduce the new system, however, the DGH is recommended to play a significant role to organize, educate and train the community in order for the system to take loot in the target area.

(6) Thorough education for inhabitants about the utilization of water supply

The purpose of the public water supply is to provide safe water in stable to the peoples in order to support their healthy and cultural life. And the water supply service is sustained by collecting of water charges properly from the water users. People in the project area are mostly migrants, who aim to obtain better jobs in the urban area, from the rural area. They are still continued same life as they did in their home regions. Therefore they generally do not know a proper manner for use of the public faucet (kiosk) and its advantages. And also, in many cases, they are lack of adequate understanding on paying water. Therefore, in order to diffuse the proper water supply service, edification movement on the utilization of water supply should be conducted to such inhabitants.

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