Chapter 13

ENVIRONMENTAL SURVEY

13. ENVIRONMENTAL SURVEY

13.1 Introduction

To identify and evaluate the potential environmental impact of the project, environmental laws and regulations of the nation are surveyed. And then, present situation of socio-economic and natural environments of the project site area and its vicinity are surveyed. Based on results of these surveys, potential environmental impacts are identified and related measures to prevent the impacts are suggested. Finally, overall evaluation is also provided.

13.2 Environmental Administration and Regulations of the Country

13.2.1 Environmental Laws and Regulations

The laws and regulations, which were existing at the time of independence of the country, have been kept effective if those will not violate or conflict with the nation's present constitution and laws.

(1) The Environmental Articles of the Presidential Law

The Presidential Law was enacted in 1980. Article No.59 of the Law refers to the right of water for drinking, its uses and distribution, and regulates waste water discharge. It also stipulates penealties on breaches of the article. On the other hand, Article No.44 of the Law stipulates that, when a facility will be newly constructed or repaired, the operator or owner of the facility shall report the details of the facility and the way of its water uses to the Ministry of Health and Public Hygiene.

(2) Environmental Basic Law (under preparation)

To stipulate the national environmental policy for achieveing sustainable development and to reflect the Rio Statement and the philosophy of Constitution of the nation, environmental basic law is being prepared and its draft will be completed soon now. The draft defines basic philosophy of natural environmental protections regarding water , air and soil quality, flora and fauna. It also pays attentions to environmental pollutions , discharges of chemical substances , radioactive materials, waste water and various solid wastes. To implement the the basic law , preparation of related regulations and guidelines will be needed.

The following articles of the basic law will be concerned with the mini-hydropower development project along Rio Manuel Jorge.

Article No.16: Rationale and sustainable use of natural resources, and diversifying production sources and their developments, and rationalization of consumptions are the basis of energy policy of the nation.

Article No.29: Surface water and groundwater shall be rationally used.

Article No.45: Implementation of Environmental Impact Assessment is a necessity for every construction project.

(3) Forest Law in draft form

The draft of Forest Law has already been approved by the Cabinet, pending to be past by the Parliament. The draft law will become the basis of the national policy on the ways of management of forest areas and their forestry, and defines forest areas into three forms, i.e. the long term protected, managed production and regular use forests. National park, protected natural and special areas will be established in the long term protected forest area.

The draft also refers to reorganization of the current Forest Agency, preparation of short term and long term forest policy, foundation of national forest fund, and establishment of forest protection guards.

(4) National parks

National parks have been defined both in Sao Tome and Principe islands, with total area of up to 30,000 hectares. 72% of them are located at Sao Tome island. The location of the mini-hydropower project is outside of the national park areas.

(5) Protected Fauna and Flora

Table 13.1 shows the list of endangered fauna of the nation, which was prepared based on the reference materials of ECOFAC (Conservation et Utilisation Rationnele des Ecosystemes Forestiers en Afrique Centrals) and IUCN (International Union for Conservation of Nature and Natural Resources). However, the biology and biological habitats have not yet been surveyed.

The list of protected flora has not yet been prepared due to lack of the related materials.

13.2.2 Environmental Administration

There is not a specialized environmental administrative organization in the nation. However, various environmental organizations have been existed , because there are many environmental scientists and engineers have already been educated and trained.

The environmental administrative functions have been distributed among various governmental and public organizations. Basically, MESA is responsible for implementation of national environmental policy. Under MESA, there is an agency called National Land Preparation and Environment which is responsible for environmental administration. However, the duty of the agency is not functioning. The key will be to centralize the environmental administrative functions now being distributed among various Ministries, such as those of Agriculture and Fishery, Public Health and Hygiene, MESA, Foreign Affairs, etc. It is noted that UNDP and UNEP have been assisting the nation in various aspects of environment.

13.3 Present Situation of Socio-econonic Environment of the Project Area and its Vicinity

13.3.1 Population, Land Utilization and Living Condition

The situation of land utilizations of the project area and its vicinity remaines similar characteristics to those of the colony era, at that time the wide land area of forest was developed into plantations. Cacao and coffee plantations are the typical style of them. At the central part of a plantation area, there are management and agricutural facilities, and living quarters for the laborers. Therefore, there are no independent villagers living alone outside of the plantation center. This means that the centers of plantations, forms villages of the area. There are four such villages distributed in the project area and its vicinity, which are called Milagrosa, Santa Clara, Quinta das Flores and Santa Luzia. All of them belong to the District of Me-Zochi, of which total population is 29,758 at the time of the survey. Fig.13.5 shows the locations of the four villages.

The following describe the present livelihood and their water uses of the four villages.

(1) Milagrosa

The village of Milagrosa has rather good social infrastructures established compared to the other villages. There are about 80 families with about 400 peaple living in Milagrosa, which are more than any others. Among the 400, about 200 peaple are young or adult, and 58

peaple of them obtained their own land in May 1995 under the national land distribution and privatization plan.

The peaple obtained the privatized land used to be the employees of Empresa Milagrosa. After obtaining the land, however, their livelihood have not been improved and agricultural loan can not be obtained. Their annual incomes are still very low.

Shortage of water with good quality and necessary electricity hinders development of the village. Public transportation is not available which also makes living condition difficult. Income from the agricurture is not enough and therefore many of the villagers have to work outside of their plantation in the form of temperary workers. Estimated average annual income per family is 1,920,000 Dbs (about 820 US$), which is quite high compared with other villages.

(2) Santa Clara

Santa Clara is located at downstrean side of the project site, with population of only about 60 peaple in 10 families. They are living at the plantation center with one assembled housing and two administrative facilities. All of them are the employees of the plantation, and have not obtained any privatized land. No schools or health center available in the village. Estimated average annual income per family of them is about 360,000 Dbs(about 153 US$).

(3) Quinta das Flores

The village is located at west side of Milagrosa and north of the project river, with the altitude higer than those of above two villages. There are 10 families of about 40 peaple living in five wooden houses of the plantation center. Nine families obtained privatized land. Estimated average annual income per family is about 1,550,000Dbs (about 660US$).

No public trasportation, schools or health center is available. Various difficulties are existing which hinder the development of the village.

(4) Santa Luzia

The village is most neaby the project site and is located at south side of the river. There are 9 families of about 35 peaple living at the village center. Similar to the case of Santa Clara, the villagers are emplyees of the Empresa Agricola. Estimated average annual income per

family is about 420,000 Dbs (about 180US$). No schools or health center are available in the village.

Main income sources and average annual income amount per family of the above four villages

Name of villages	Population	No. of family	Main income sources	Average annual income per family (Dobras)
Milagrosa	400	80	Agriculture, etc.	1,920,000
Santa Clara	60	10	Agriculture	360,000
Quinta das Flores	40	10	Agriculture	1,550,000
Santa Luzia	35	9	Agriculture	420,000
Total	535	109	Agriculture	1,062,500

(5) Water reduction area of the project

There will be about 1.5 km of water reduction section generated under the project. There are no any people living in the section area, and therefore no nagative impact will be incurred to the projrct area society.

(6) Water uses

Most of the villages rely on the river water of Rio Manuel Jorge, except that some of them obtain drinking water from other water sources. Water for irrigation and mini-power generators rely on the river. Water flow will be quite limited in dry season, and therefore water share between the project and existing needs of water in the concerned villages must be discussed and settled among concerned parties. The estimated amounts of water being used by the villages are shown in the following table.

Estimated amounts of water being used by the villages

Name of villages	Population	No. of family	Monthly amount of water being used per family (liters)	Annual amount of water being used (liters)
Milagrosa	400	80	9,000	8,640,000
Santa Clara	60	10	9,000	1,080,000
Quinta das Flores	40	10	9,000	1,080,000
Santa Luzia	35	9	9,000	972,000
Total	535	109	9,000	11,772,000

13.3.2 Agriculture and Industries

(1) Agriculture, forestry and stock breeding

Agricultural plants of the project area and its vicinity include cacao (Theobroma cacao) and banana (Musa sp.), which grow under the high trees of palm (Elaes quineensis), Antocarpus intergrifolia and Antocarpus communis. In Milagrosa, 205ha of total 260ha agricultural land is growing cacao which needs irrigation. 51ha of them is growing palm oil trees and other 2.5ha for pineapple. About 240ha has been allocated for privatization. After the privatization, all cattles have been shifted to other places outside of the plantation area.

In Santa Clara, 70ha plantation is being operated. Besides the plantation, stock breeding of cattles, ships and pigs is also carried out.

Valuable trees of the area include mulberry (Chlrophora excisa), cedrela (Cedrela odoreta), marapiao (Phagara microphylla), gogo (Carapa procera), Artocarpus communis, Artocarpus integritolia and mango (Mangifera indica).

(2) Industies

There is no mining and manufacturing industries in the project area and its vicinity. There were fermentation and drying factory, and car repair and wood manufacturing facilities in Milagrosa in the past. These factory and facilities are now out of order and can not be used.

(3) Water Resource and its Uses

It is found that potential amount of water resources in the project area and its vicinity is enough for consumption by the concerned villages. In addition to Manuel Jorge river, there is a spring on Aqua Panada flowing through this area. All of them will guarantee the potable water supply and irrigation when needed in Santa Clara and Milagrosa. Besides, there are other three small springs in Milagrsa area.

Due to ups and downs of the land of the concerned area and existing of dry season, there are some places in Milagrosa and Santa Clara where irrigation cannot be carried out. Therefore, it is considered that a small scale water supply work be constructed. In case of Santa Clara, it is being considered to equipped with a certain hydropower water supply equipment.

13.3.3 Transportaion Network

There are roads running through Santa Clara and Milagrosa, which connect Trindade town and Sao Tome city. The roads are in good condition. In the past, the plantation of Milagrosa took care of the transpotation need around the nearby villages, but such service was terminated. There is no transportation road going through the project site. Access road has to be constructed for the project, if it will be implemented.

13.3.4 Public Facilities

Public service facilities are not sufficient in and around the project area and its vicinity. There is only one primary school (two class rooms), one health center and one emergency clinic in Milagrosa. There is one middle school in Trindade, but it is far away from the surrounding villages. Peaple with seriously injured or sick must receive treatment in Sao Tome city hospital.

13.3.5 Landscape

The project area and its vicinity are covered by secondary forest together with the plantation trees and the bush. Neaby the candidate site area, there are three waterfalls. Width of the river bed of the site area is about 10m to 20m. Fig. 15.6 shows the scenery of one of the waterfall and the river bed. Because of the small scale of the hydropower project, there will be no notable change to be caused to the existing landscape.

13.3.6 Cultural Assets and Others

Based on field survey of the project area and discussions made with the concerned personnel, it has been clarified that there is no any cultural asset or historical ruins in the project area and its vicinity.

13.4 Present Situation of Natural Environment of the Project Area and its Vicinity

13.4.1 Climate

Because of geographical and other conditions, climate of the area belongs to sub-humit to dry-humit region. Annual average temperature is about 25℃, and average annual rainfall is more than 2,500mm. However, humidity of the area is domerate.

13.4.2 Soil Condition

Based on the soil map of the country prepared in the year 1962, most of the soil in the areas of Milagrosa and Santa Clara are those generated from basalt with brown color. For details, refer to the chapter of geology of the project site. The pH value is in the range of 4.5 to 6.0. Most of the area is covered by the trees with wide diversity.

13.4.3 Flora

The project area and its vicinity cover the villages of Milagrosa, Santa Clara, Santa Luzia and Quinta das Flores, and has an area of 10.26ha with about 2,750m from north to south, and about 3,800m from west to east. Apart from the west side of the area, there is a forest area which is being considered as a natural conservation area, and is the source of several rivers.

Most of the area is covered by secondary forest mixed with the plantation trees of cacao, coffee and others. The secondary forest is composed of Pau Brancol (Tetrochidium didymostemon), Moindro (Aidia quintassi), Muandim (Penta clethra macrophylla) and Pau Sangue (Hurungana madagascariensis).

13.4.4 Fauna

As the terrestrial fauna, there are various birds habitat in the area. Monkeys also habitat here which cause damage to cacao and banana in the plantation. There are very few aquatic fauna in this area. Some kind of surface water shrips and fishes are existing, but their inventories are very little.

A kind of owl, which is an endemic bird of Sao Tome island, habitats in the west side of the project area. It is notable that bird watching tour of foreigners has become hamous in the recent years.

13.5 Identification of Potential Environmental Impacts

In case of the mini-hydropower plant project, intake-weir, headrace channel, headtank, penstock, power house and other auxiliary facilities will be constructed and operated. The following describe the potential environmental impacts which could be caused by the project.

13.5.1 Intake Weir

The weir height will be about 2 m, and therefore the water level to be kept by the weir is quite low and the land area to be submerged is very limited. No potential impact will be caused by the water level. Rather, the vallay of the project site is quite deep with its depth about 30m. In heavy raining saeson, a large amount of water flow will usually be generated, and therefore measures to protect against the flood shall be considered and taken into account in the project design.

To construct the weir, access road will be needed and constructed. This will cause some damage to the secodary forest. Such damage to the forest shall be limited as small as possible.

Water share between the hydropower plant and the villages for their living purpose must be considered. To avoid dispute between the project and the villagers, prior consultation must be carried out and agreement must be achieved. The water share issue is most critical for the dry season during which water flow will usually be quited limited.

In the water reduction area, some potential natural environmental impact could be induced during dry season. The potential impact could be quite limited. However, it is preferable that certain environmental monitoring will be carried out after the plant operation.

13.5.2 Headrace Channel

Distance of the water intake line will be about 1.5 km, which will go through more than ten private lands. There are cacao and other plantation trees being existed now. For the water intake line construction, some part of them will be damaged.

Compared with the case of Gue Gue hydropower plant, the water intake line will pass through much steeper slop areas. Therefore, more attention shall be paid to the issue of potential soil erosion throughout the line route. On the other hand, the project will be located at lower and more gentle location than the case of Condator plant. Water leakage from water intake line shall be avoid as to the extent possible. Such water leakage may cause erosion to the slop areas as those being happened to the existing living water intake line. As such, soil erosion will be a key issue which must be well considered and treated.

13.5.3 Headtank

To achieve a stable condition, headtank is built at a stable land location. On the other hand, design of the headtank shall be such that safety considerations to be given to the people who may come to the headtank for swimming and getting fun.

13.5.4 Penstock

Length of the penstock will be about 200m. Discussion shall be made on the slope stability after detailed design beocmes available.

13.5.5 Powerhouse

It is estimated that the area of powerhouse of the project will be about 250m². Therefore the space to be occupied is quite small and potential environmental impact will be very limited or even negligible. Potential issue will be the water quality of that discharged from the powerhouse.
Turbidity and mixed oil will be the points of the isuue. Mixed oil comes mainly from the leakage of lubricating oil of the water turbine and other equipment. To avoid the isuue, certain measure will be needed.

During raining season, a large amount of rviver water flow will be generated. Flood protection must be taken into account to the design of the powerhouse.

13.6 Summary of Potential Environmental Impacts

13.6.1 Potential Environmental Impacts during Construction

(1) Small change will be caused to landscape of the area.
(2) A certain damage will be caused to the cacao plantation along the route of water intake line and penstock.
(3) Water quality degradation will not be induced in the discharge from the powerhouse.
(4) Exhaust gas will be released, to some extent, to the environment fron construction vehicles and machines.
(5) Increase of transportation load along the road for material and equipment transportation.
(6) Increase of need of labour workwers (positive impact).
(7) Vibration and noise will be generated, to some extent, during construction work.

13.6.2 Potential Environmetal Impacts during Plant Operation

(1) A limited part of the land in upstream of the weir will be submerged. However, the area will be quite limited and therefore the impact will be almost negligible.

(2) Water flow of the fall located right after the weir will be reduced, which will not change the landcsape of the water fall, nevertheless.

(3) New transportation road will be added to the area, which is used for the site access purpose.

A limited noise will be generated from the powerhouse.

13.7 Compensation

In case of implementing the project, it will requie the uses of the land of existing plantation for constructions of headtank, headrace and others. Therefore, it will require to cut down some parts of cacao, banana and other agricultural trees, for which compensations will be required. Use of lands will also need compensation. Actual total compensation amount can not be estimated at this stage due to lack of detailed design. Therefore, the unit prices of concerned agricultural products, land and others are provided here for reference.

(1) Unit price of agricultural products

Agricultural products	Yields (Kg/ha)	Unit price (Dbs/Kg)	Unit price (Dbs/Ha)
Cacao	200	1,800	360,000
Banana	5,000	200	1,000,000
Total			1,360,000

(2) Unit price of trees

Trees are evaluated as being the timbers. Unit price of timbers is estimated to be about US$70/m^3 in average.

(3) Unit price of land

Unit price of a land area defers between an agricultural and other lands. An agricultural land is estimated to be about US$583/ha. In case of others, it also defers depending on the type of investment. Based on the case of Aqua Grande District, it is estimated to be about US$129/ha.

13.8 Overall Evaluation

The agricultural activity going on now in the project area and its vicinity has come to a quite balanced condition due to its long term history accumulated to date. Sustainable development of the agriculture of this area is important to the soocio-economic environment. Fortunately, the mini-hydropower is a small project and therefore the potential environmental impacts are quite limited and even negligible.

A few attentions to be paid will be the issues of water share and land-compensation between the power project and the concerned villages, some damages to the plantation trees, and avoidance of potential soil erosions. Compensations to the villagers to be affected must be fairly considered when deemed necessary.

Tables 13.2 and 13.3 show the summary of socio-economic and natural environmental impact assessments of the project respectively, in which measures to mitigate potential impacts are also recommended.

Table 13.1 List of Species of Threatened Fauna in Sao Tome & Principe

Common Names	Species	Family	Notes
Musanho	*Crocidura poensis*	*Soricidade*	K
Morcego	*Tadarides thomersis*	*Molossidade*	I
Guembu	*Myonyceteris brancycephala*	*Pteropodida*	V
Morcego	*Pipistrellus sp.*	*Vespectition*	I
Tartaruga	*Chelonia nydas*	*Cheloniidade*	E
Tartaruga	*Eretmochelys imbricata*	*Cheloniidade*	E
Tartaruga	*Lepydochelys olivaceae*	*Cheloniidade*	E
Tartaruga	*Dermochelys coriacea*	*Dermochelyidae*	E
Patomarinho	*Sula leucogaster*	*Sulidae*	E
Papagaio	*Psittacus erithacus*	*Psittacidae*	V
Kitoli	*Otus hartlaubi*	*Strigidae*	R
Picanco	*Lanius newtoni*	*Laniidae*	I
Toldo	*Turdus olivaceofuscus*	*Muscicapidae*	EX(?)
Selele	*Dreptes thomensis*	*Nectariniidae*	R
Tchiliquito	*Speirops leucophoews*	*Zosteropidae*	R
Tchili-tchili	*Zosterops ficedulinus*	*Zosteropidae*	E
Pardal	*Neospiza concolor*	*Fringillidae*	I
Chotacafe	*Poliospiza rufobrunnea*	*Fringillidae*	E
Aqua doce	*Neritina manoeli*	*Neretidae*	E
Libelinhas	*Trithemis nigra*	*Libellulidae*	I
Escar aveihos	*Pachnoda canui*	*Libellulidae*	I
Borboletas	*Coeliades bocagii*	*Hesperiridae*	V
Borboletas	*Graphium thomasius*	*Papilionidae*	V
Borboletas	*Graphium santamarthae*	*Papilionidae*	E
Borboletas	*Epamera maris*	*Lycaenidae*	EX(?)
Borboletas	*Leptotes terrennus*	*Lycaenidae*	I
Borboletas	*Chilades sanctithomae*	*Lycaenidae*	I
Borboletas	*Charaxes defulvata*	*Nymphalida*	EX(?)
Borboletas	*Peseudacraea game*	*Nymphalida*	I
Borboletas	*Globanus integer*	*Nymphalida*	K
Borboletas	*Globanus marginescaber*	*Nymphalida*	K

(Notes) EX : Extinct; E : Endangered; V : Vulnerable; R : Rare
I : Not determined; K : Not well known

Table 13.2 Summary of Potential Socio-economic Environmental Impacts and Their Preventions and Mitigations

Socio-economic Environmental Factors	Potential Impacts	Remarks (Description of the potential impacts and measures to prevent/mitigate the impacts)
1. Resettlement of villagers		
(1) Reservoir area	△	No villagers are living in the reservoir area.
(2) Water reduction area	△	No villagers are living in the water reduction area.
2. Industries		
(1) Agriculture		
1) Project area	○	The routes and space for construction of headrace channel and headtank will need some land and to cut some plantation trees. Compensation will be needed.
2) Downstream area	△	No impacts will be incurred to the downstream area.
(2) Forestry	△	Only a few trees would be cut.
(3) Fishery	△	No fishes are existing in the river.
(4) Manufacturing / mining	△	No manufacturing or mining industry is existing.
(5) Tertiary industry (handcraft, tourism, etc.)	△	No such industry is existing.
3. Transportation	△	Impact of construction of an access road is moderate and will improve transportation network of this area.
4. Other infrastructure		
(1) Education	△	No school is existing in the project area.
(2) Public health	△	No water born disease could be induced due to very smal scale of the reservoir.
(3) Cultural assets	△	No cultural assets are existing in the project area.
5. Water utilization		
(1) Project area amd its vicinity	○	The villages such as Milagrosa and Santa Clara are using the river water for drinking and plantation. Prior agreement between EMAE and the villagers for reasonable sharing of the river water must be achieved.
(2) Downstream area	○	Water quality of the discharge water from powerhouse shall be kept acceptable by preventing leakage of oil and other substances.

(Legend) ● : Significant impact ○ : Moderate impact △ : Negligible or no impact

Table 13.3 Summary of Potential Natural Environmental Impacts and Their Preventions and Mitigations

Natural Environmental Factors	Potential Impacts	Remarks (Description of the potential impacts and measures to prevent/mitigate the impacts)
1. Topography		
(1) Sedimentation in reservoir	△	Upstream of the reservoir is rich in forest and therefore the soil condition is stable.
(2) Impact on downstream waterway	△	Scale of the project is very small and therefore the impact to downstream is negligible.
(3) Impact to coastal area	△	No direct impact due to existing of Gue Gue power station.
2. Soil condition		
(1) Slope collapse	○	Measures must be taken to prevent slope collapse along the routes of headrace and penstock.
(2) Soil erosion	△	Water leakage from headrace must be avoid to prevent soil erosion along its route.
3. River water		
(1) Change in water system	△	No change to water way.
(2) Impact to water quality	○	Impact can be avoided by good maintenance of the powerhouse.
4. Biosphere		
(1) Impact to flora	△	Impact is negligible due to small scale of the project.
(2) Impact to fauna	△	
(3) Impact to aquaic organisms	△	Impact is negligible due to small scale of the project.
(4) Impact to protected /valuable flora and fauna	△	No valuable aquatic organisms are existing in the project area. No such flora and fauna are existing.
5. Impact on national and natural parks	△	No such parks are existing.
6. Atmosphere		
(1) Air polution during construction	○	Measures must be taken to mitigate dust generation.
(2) Offensive odors	△	No offensive odors will be generated.
7. Noise and vibration	○	Measures must be taken to mitigate the noise and vibration to be occured during construction and plant operation.

(Legend) ● : Significant impact ○ : Moderate impact △ : Negligible or no impact

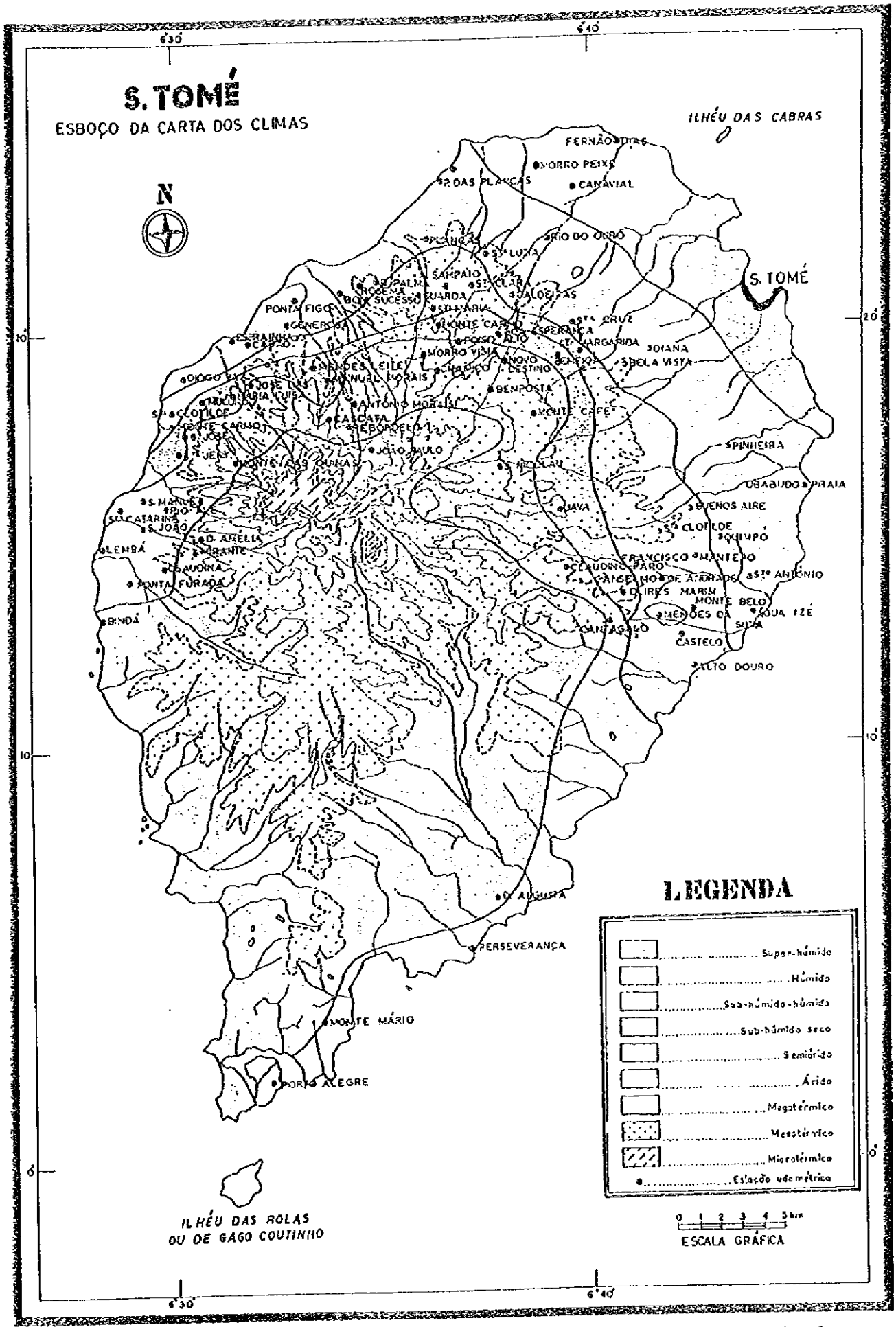
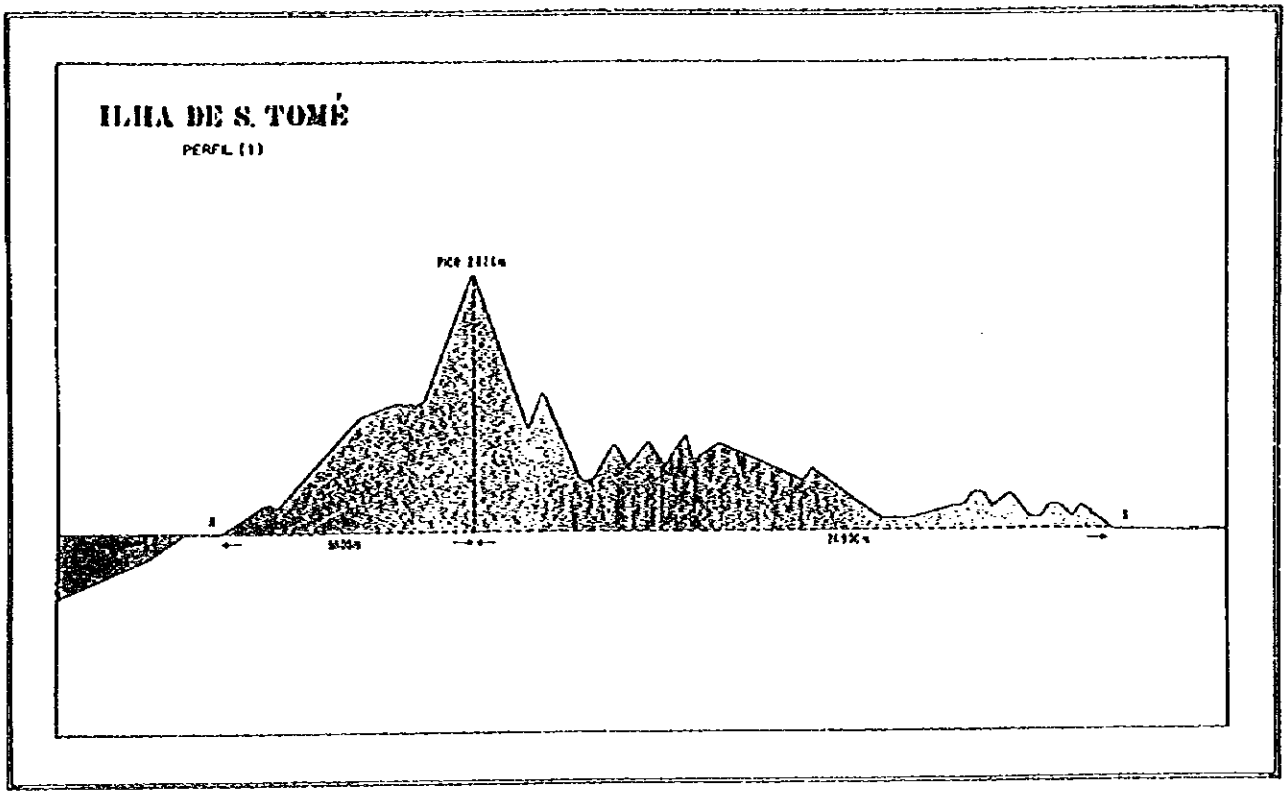


Fig. 13-1 Climate map (Humidity Distribusion) Map of Sao Tome Island



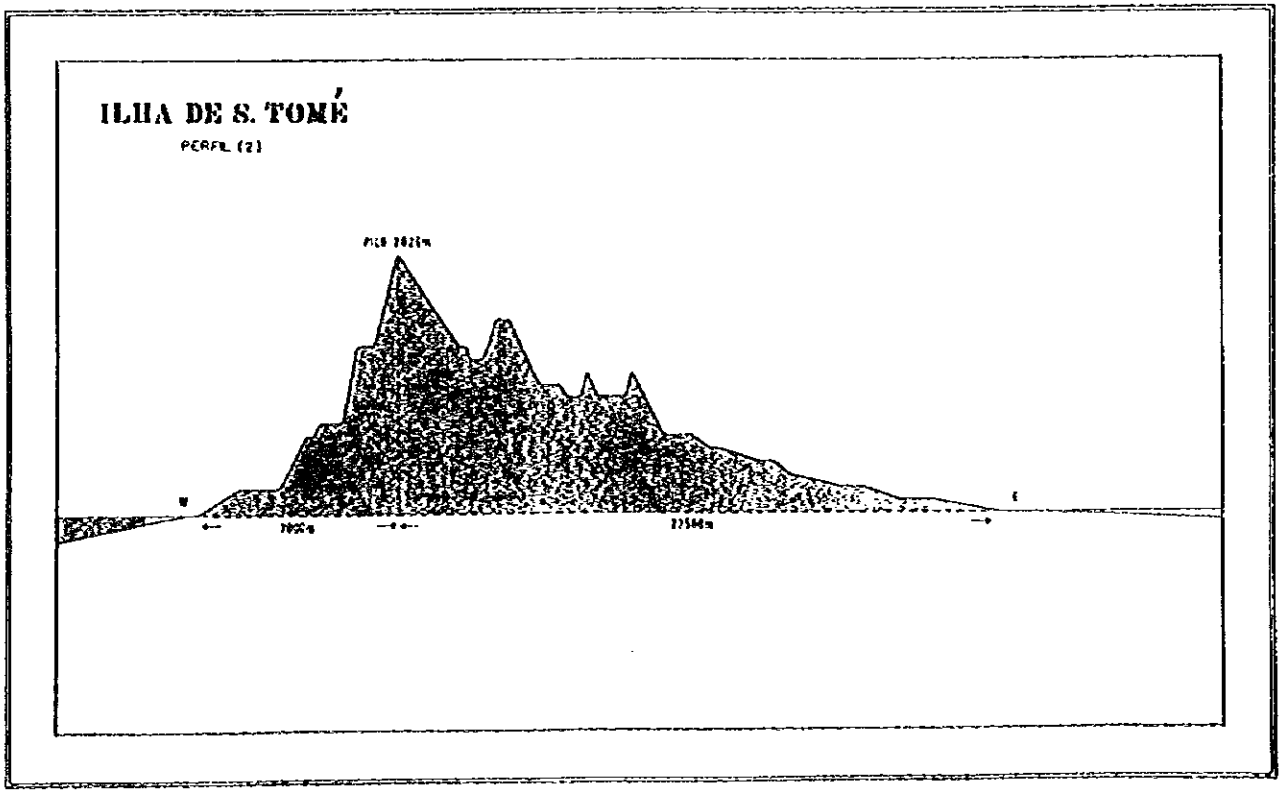


Fig. 13-2 Gepgraphical Sectional View maps of Sao Tome Island

Fig. 13-3 Agricultural Map of Sao Tome Island

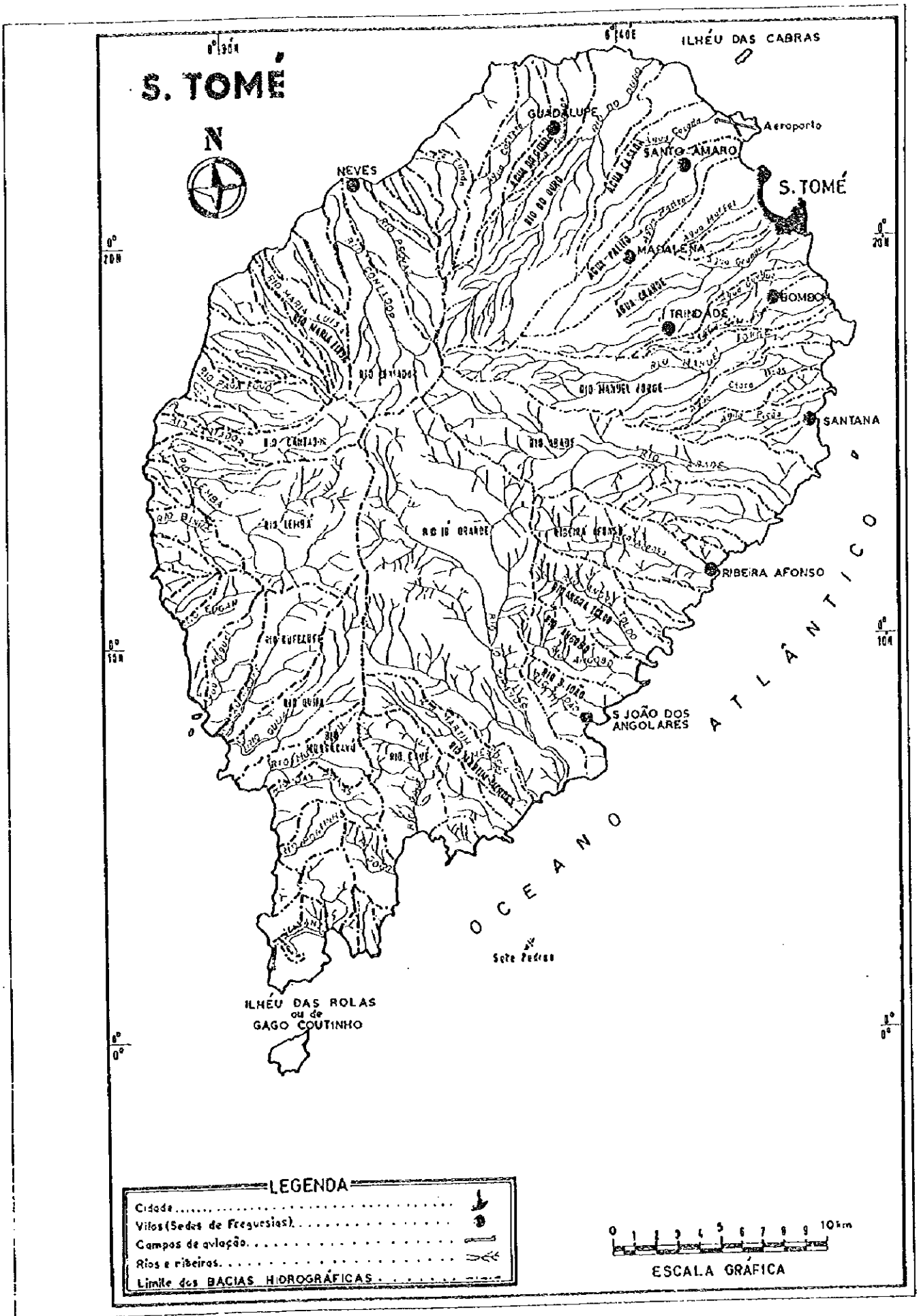


Fig. 13-4 Rivers and Their Basin Map of Sao Tome Island

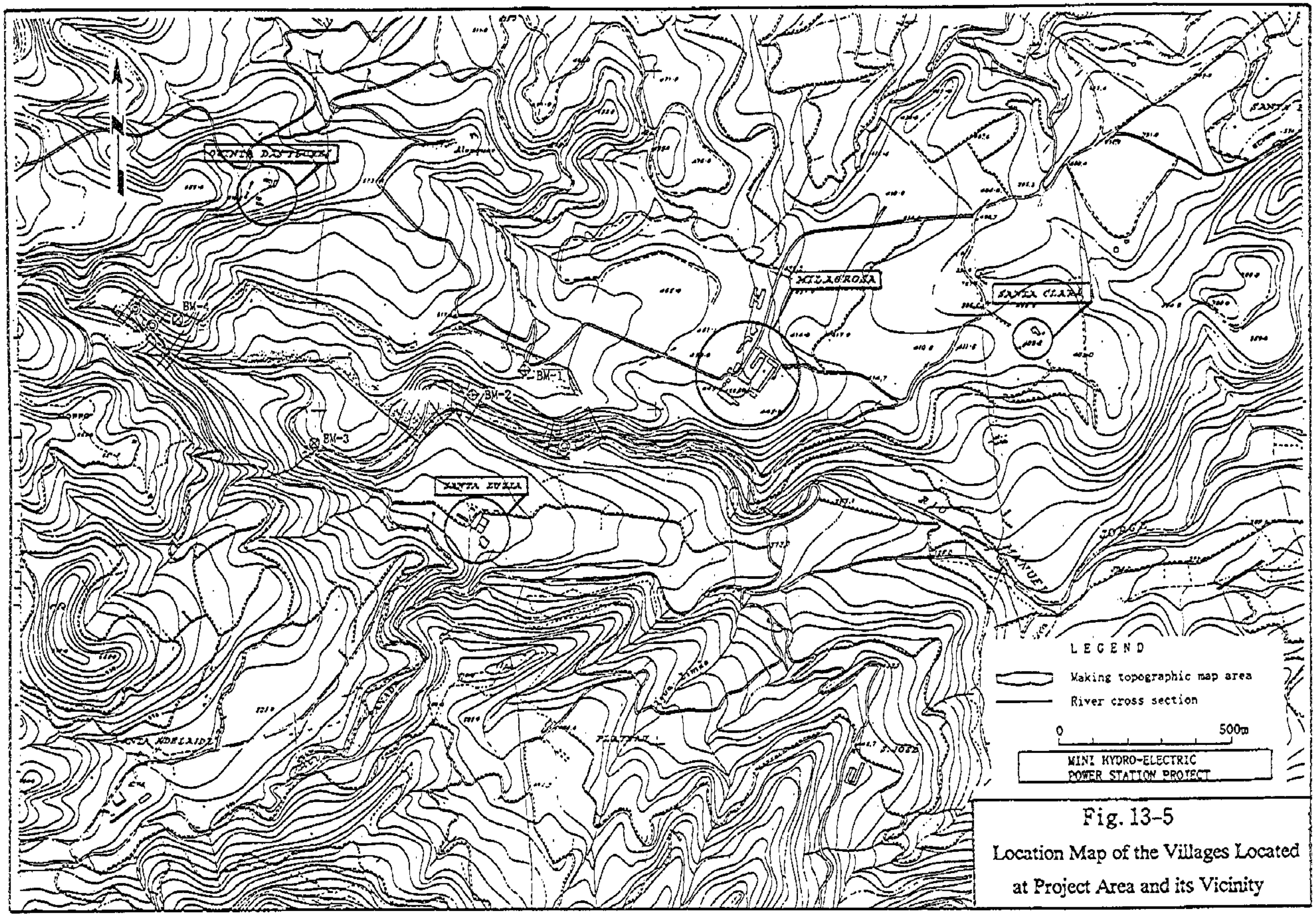


Fig. 13-5

Location Map of the Villages Located at Project Area and its Vicinity

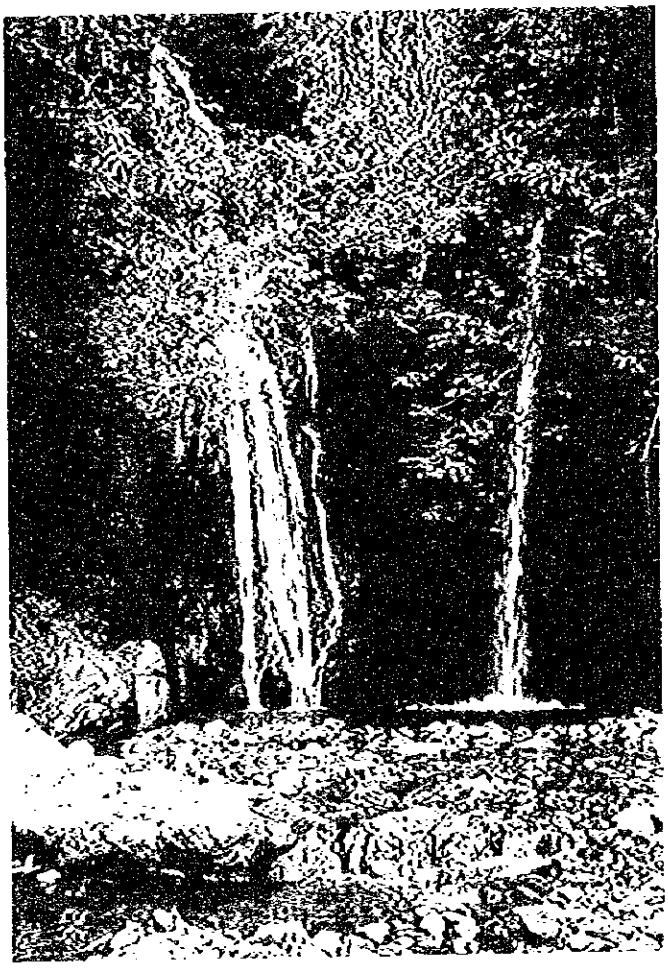


Fig. 13-6 The Scenery of a Waterfall and the River Bed of the Project Site Area

Chapter 14

ECONOMIC EVALUATION AND FINANCIAL ANALYSIS

14. ECONOMIC EVALUATION AND FINANCIAL ANALYSIS

14.1 Economic Evaluation

14.1.1 Methodology

For the methodology of economic evaluation of this project, the benefit-cost ratio method is used on the assumption that the present value of the total cost of an alternative power plant is the benefit and that the present value of the total cost of construction of this project is the cost. As for the alternative power generation, diesel-oil power generation plant that is installed in this country is used. Any adjustment for shadow price based on the exchange rate, unskilled workers and/or unemployment rate has not been conducted due to the following reasons:

(1) As for the exchange rate, it would be quite difficult to ascertain the appropriate level of the exchange rate, since import of this country amounts to five times as much as export, much of the difference thereof is financed by the grants from foreign sources, and foreign assistance including loans amounts to one and a half times as much as GDP.

(2) The portion of the investment cost that is paid in domestic currency and subject to adjustment of shadow price is calculated at a little bit more than US$51,000 and accounts for less than 1.2% of the total cost.

14.1.2 Cost

As shown in Table 14-1, the annual capital cost is US$388,553, which is 8.174% of the total investment cost and the annual operating and maintenance cost is US$47,535, making a total of US$436,088.

14.1.3 Benefit

Assuming that the alternative project is a diesel-oil power generation plant, the annual fixed cost would be US$5,174 and the variable cost would be US$73,856, making a total of US$79,030.

14.1.4 Economic Evaluation

Using the above calculation, the benefit/cost ratio is 79,030/436,088 = 0.181, which is well bellow the break-even point of one (1) for the economic evaluation. However, due to the following reasons, we consider taking up this project positively on the assumption that the project be financed on a grant basis:

(1) The Democratic Republic of Sao Tome and Principe is not in a position to adopt a thermal power plant due to its trade structure and external debt situation.

(2) In view of the topography and water-discharge, this project has an optimal condition for a hydro-power plant for this size in the present situation and its low investment efficiency can be justified.

(3) At present a little bit more than ten thousand households are provided with the electricity. If this project is implemented and the electricity produced thereby were used only for the households, approximately 2,500 households additionally would receive electricity, making the ratio of diffusion more than about 60% from the current level of about 50%.

(4) Implementation of this project would save the foreign currency of US$74 thousand compared to the installation of a thermal power plant. This saving of the foreign currency would equal to 1.4% of the annual export (US$5.1 million) and 6.7% of the annual fuel import (US$1.1 million) that would make a valuable contribution to the external balance.

(5) The balance of external debt of the country exceeded three hundred million US dollars as of the end of 1995 and amounted to eight times as much as GDP with debt service ratio exceeding 100% (20% is the manageable level). In the last two years (1994/95) the debt relieves were made and the country is not in a position to increment its external debt any more.

(6) There is virtually no industry in the country and almost all industrial products including capital goods rely on import. The country has yet to get rid of mono-culture mainly based on cacao and relies on import for food. In consequences, import amounts to five times as much

as export and the food import exceeds the total export. The most important task for the country at the moment would be to achieve food self-sufficiency. The top priority for this target would be development of fishery, making a full use of its abundant natural environment and resources. However, due to the lack of freezing and refrigeration facilities for the stock of fish, these beautiful natural environment and resources have not been utilized. The greatest barrier for this lack of these facilities is insufficient supply of electricity and even for this reason the development of electric power is essential. The development of fishery is needed not only for achievement of food self-sufficiency but also for acquisition of foreign currency as one of the most promising measures.

(7) According to the National Energy Master Plan formulated under the support of France, construction of a total of approximately 15,000 kW new electric power plants is planned. If all of these plants are built in the form of thermal power plant, annual import of fuel of 6 - 7 million US Dollars would be needed. In view of the above-mentioned external position of the country, this is not possible and all new installation of power plants should be by means of the hydro-electric power. EMAE itself made it clear that all new installations except an emergency case would be hydro-electric power.

(8) In summary, with a view to achieving food self-sufficiency and producing a core export goods except cacao, thus making a step forward to an economic self-reliance, insufficiency in electric supply shall be solved and the implementation of this project will lead the country to this direction.

14.2 Financial Analysis

14.2.1 Methodology

Assuming the optimal case (maximum power, annual power generation and construction cost) explained in Chapter 8, FIRR has been calculated. Then, based on the sensitivity analysis of FIRR and analyses of ROE and cash flow, the condition for this project to be viable has been sought. For financial analysis, the following assumptions have been set forth:

(1) Maximum power: 230 kW

(2) Annual power generation: 1,252,600 kWh/year

(3) Construction cost: US$4,754,000

(4) Currency: Only US Dollar is used (Only 1.2% of investment cost would be paid in local currency).

(5) Electricity rate: Based on the average prices of the last three years (1993-95) and international prices.

(6) O & M cost: Three levels of 0.5%, 1.0% and 2.0% of construction cost

(7) Depreciation: The method currently adopted by EMAE is used. Three levels of 20 years, 25 years for duration period with straight-line depreciation method are used.

(8) Interest rate: 8.0% p.a. as foreign currency interest rate

(9) Corporate income tax: 30% is applied with loss carry-overwithout any time-limitation

(10) Additional investment: An additional investment in the amount equal to the initial investment that has been fully depreciated is made on the year when the depreciation is finished.

(11) Borrowing: Construction cost x Ratio of EMAEs burden share

(12) Repayment: 7 years grace period and 20 years equal install payment thereafter.

(13) Construction cost for calculation of FIRR: Only EMAE's share is counted

(14) ROE, cash flow and cash balance: Those of the preceding year when the repayment of the borrowing starts are used.

14.2.2 Financial Cost and Benefit

Profit & Loss Statement and Cash Flow Statement & Financial Analysis for the base case, where EMAE's burden share is 100% and electricity tariff is 15 cent/kWh, are shown in Annex Table 14-1 and 14-2 respectively.

(1) Financial Cost

Financial cost of this project is the construction cost of hydro-electric power generation plant. At the first stage it is US$4,754,000 and, later on, the cost of each additional investment in the amount equal to each initial investment which has been fully depreciated is added as an additional financial cost when the depreciation thereof is finished.

(2) Financial benefit

Financial benefit of this project is the total of the benefit on the flow basis, i.e., electricity revenue minus O & M cost minus corporate tax (131,523 - 47,560 = 83,963 US$), and residue of the investment cost (construction cost minus accumulated depreciation).
As for electricity revenue, an electricity tariff of 15 cent/kWh and a ratio of 70% of the annual electricity sales to power generation are used. With regard to the electricity tariff, EMAE's actual tariff for the three years from 1993 to 1995 are calculated at 10.2 cent, 13.3 cent and 15.9 cent by dividing the total electric revenue by the electric sales volume (for 1995 the sales not yet billed are not counted, so the actual tariff must have exceeded 17 cent). The weighted average tariff for those three years is 13.0 cent/kWh. On the other hand, the ratios of annual electricity sales to annual power generation range from 66% to 72%.

As for O & M cost, generally accepted rates of 0.5%, 1.0% and 2.0% of the construction cost have been used. As for depreciation cost, in accordance with the method currently adopted by EMAE, the straight-line depreciation method with duration periods of 50 years, 25 years and 20 years has been used. The more details are shown below:

(a) O & M cost
- 0.5%: Preparation work, Civil work, Hydraulic equipment
- 1.0% Project controlling
- 2.0%: Electromechanical equipment

(b) Depreciation cost
- 50 year. Preparation work, Civil work, Hydraulic equipment
- 25 year. Transmission line
- 20 year. Turbine and generator

14.2.3 Financial Evaluation

The FIRR, as defined as a discount rate which makes the present value of the financial benefit equal to that of the financial cost, is calculated at -1.90% for the operation period of 35 years based on the

numbers shown in 14.2.2 above. However, as mentioned in "Economic evaluation", it is desirable to consider positively to take up this project for the following reasons:

(1) In order for the country to achieve an economic self-reliance, the solution to the shortage in the electric supply is essential.

(2) The development of electric power generation shall rely on hydro-electric power plants.

(3) Although the investment efficiency of this project is very low, it is considered as inevitable, because most of the mini-hydro projects are in the similar situation at this time.

In case a grant is given to this project, however the project will become viable. Assuming the tariff of 15 cent/kWh and the EMAE's share of 15% (the remaining 85% is covered by the grant), the project will earn an FIRR of 10.51% and become viable. However, if electricity tariff goes down to 10 cent/kWh - 15 cent/kWh is high for the international standard, it would be necessary to decrease the EMAE's share to 7 to 8% to make the project viable. On the other hand, the ROE, which is commonly used by the corporations for profitability analysis, will be -9.15 for the base case (EMAE's burden share is 100%) and 0.86% in case EMAE's burden share goes down to 15%. However, even in the latter case, if the electricity tariff goes down to 10 c/kWh, the ROE will be -5.29%.

14.3 Repayment Plan

Assuming the ceiling of the tariff of 15 cent/kWh and EMAE's share of 20%, the repayment would not be possible, as the cash balance at the beginning of the year when the repayment starts will be US$9,000, while the annual repayment amount to US$47,540. If the EMAE's share goes down to 15%, the repayment would become possible.

14.4 Financial Condition of EMAE

The balance sheets and profit and loss statements of EMAE for three years starting 1992 are shown in tables 16-2 and 16-3 respectively. (The financial statement for 1995 is not available due to a defect in the computer application program.)

16.4.1 Characteristics of Balance Sheets

Characteristics of the balance sheets are summarized as follows:

(1) 85% of the asset is represented by fixed assets such as building, other constructions and machinery and equipment.

(2) The source of the fund for the fixed asset consists of subsidy for equipment and capital account that includes reserve for revaluation. The portion of the subsidy is quite high and the ratio of the subsidy to the fixed asset increased from 34.7% as of the end of 1993 to 49.1% as of the end of 1994 on the stock basis. On the flow basis 96.3% of the newly-installed fixed asset was funded by subsidy in 1993, while 27.3% was funded by subsidy in 1994. In recent years almost all fixed assets were funded by subsidy (Please refer to Table 16l-4)

16.4.2 Characteristics of Profit and Loss Statements

Characteristics of the profit and loss statements are as follows:

(1) The final profit and loss account showed red figures for the two years in a row for 1992 and 1993. However, the year 1994 turned into the black. Thanks to the increase in the tariff from 10.2 cent/kWh in 1993 to 13.3 cent/kWh in 1994, loss in the operating profit decreased remarkably. In addition, a substantial amount of subsidies were given by France and the STP government. Were it not for these substantial amount of subsidies the final profit and loss account for 1994 would have been in a red figure as well. The subsidies counted in this profit and loss account pertain only to technical assistance and supply of spare parts and did not include the subsidies provided for the purchase of the fixed assets. (The latter was appropriated on the liability side as a contra account, so, did not constitute a profit.)

(2) Transfers to and from reserve for revaluation account amounted to huge amounts compared to amounts derived from the operation. (EMAE books the fixed assets in French Franc, the currency of the major donor country, and revalues them at the end of each financial year.)

To summarize from both the balance sheets and the profit and loss statements, the financial structure of EMAE is vulnerable, as the operating profit and loss account remained in red (Revenue from sales of electricity and water doesn't cover running cost). In addition, depreciation cost as well as the cost of new investment is covered by the subsidy from France and the other donors.

14.5 Sensitivity Analysis

The sensitivity analysis of FIRR with variables of the ratio of EMAE's burden share and the electricity tariff is shown in Table 16-5. In order to achieve an FIRR of 10%, which is generally considered in the country to cover the capital cost, with the electricity tariff of 15 cent/kWh, the ratio of EMAE's burden share shall go down to 15%. However, if the electricity tariff goes down to 10 cent/kWh, which would come closer to the international standard, it is necessary to decrease the ratio of EMAE's burden share to 7%.

14.6 Summary

Although the investment efficiency of this project is quite low from both economic and financial point of views, it would be considered inevitable due to the topographical conditions that this country occupies a very small island and that most of the mini-hydro projects are in the similar situation at this time. On the other hand, the solution to the electricity shortage is essential to the economic self-reliance and there would be no other way than mini hydro-electric power plants to develop electric power from the external point of view. Therefore, with a high hope that this project will be implemented, we hereby recommend that necessary preparatory works such as detailed designing be processed in continuation to the present study.

Table14-1 Economical Evaluation

Item	Unit	Optimal Case	Remarks
Maximum Output	kW	230	
Firm Peak Output	kW	76.5	12hrs peak generation
Firm Output	kW	36.4	97%(355days) Firm Output
Annual Energy Production	MWh	1,253	
Construction Cost (A)	US$	4,753,517	excl. Interest during Construction
2. Economical Index			
a) Construction Cost per kW	US$/kW	20,667	
b) construction Cost per kWh	US$/kWh	3.79	
c) Benefit			
Loss Factor of Effective Output	%	2.9	
Loss Factor of Effective Energy	%	4.9	
Effective Output	kW	35.3	
Effective Energy	Mwh	1,191.2	
kW Value	US$/kW	146.4	
kWh Value	US$/kWh	0.062	
Benefirt of kW	US$	5,174	
Benefit of kWh	US$	73,856	
Total Annual Benefit (B)	US$	79,030	
d) Cost			CRF=0.08(1+0.08)^50/
Capita Recovery Factor : CRF	%	8.174	{(1-0.08)^50-1}=0.08174
O & M Cost	%	1.000	
Total Annual Cost (C-1)	US$	436,088	incl. Capital recovery cost
Total Annual Cost (C-2)	US$	47,535	excl. Capital recovery cost
c) Benefit Cost Ratio : (B) / (C-1)		0.181	
Benefit Coct Ratio : (B) / (C-2)		1.663	
d) Benefit - Cost : (B)-(C-1)	US$	-357,057	
Benefit - Cost : (B)-(C-2)	US$	31,495	
e) Justifiable Investment Cost	US$	861,459	(B)/(0.0874)-0.01)
f) Necessary Aid Fund	US$	3,892,058	(A)-{(B)/(0.08174-0.01)}

Table14-2 Balance Sheet of EMAE

(Unit : Million Dobra)

	1992	1993	1994
Assets			
Cash & Deposit	130	97	275
Account Receivable	221	435	819
Other Liquid Asset		11	930
Adjustmen account	69	116	426
Exploitation Fund	44	88	527
Fixed Asset	2,887	3,725	10,684
Building	883	1,192	4,699
Other Construct.	644	916	2,171
Transportation Equipment	44	70	136
Machenery/Equip.	1,307	1,547	3,422
(Asset Total)	3,342	4,471	12,957
Liabilities			
Account Payable	281	337	522
Domestic	25	106	39
Foreign	256	231	483
Adjustment Account	14	22	95
Clients Deposit	19	25	40
Provision for Risk/Charge	0	0	222
(Liability Total)	314	376	880
Subsidy for Equipkment	508	1,317	5,473
Capital Account			
Total	2,519	2,770	6,604
Paid-in Capital	364	179	368
Reserve for Revaluation	2,244	2,705	6,096
Reserve accumulated	0	-90	-114
Net Income for year	-90	-24	254
(Liability/Capital Total)	3,342	4,471	12,957

Table14-3 Profit & Loss Statement of EMAE
(Unit : Million Dobra)

	1992	1993	1994
Revenue	465	693	1,681
Energy	421	635	1,579
Water	28	28	46
Others	17	30	57
Expenditure	861	1,076	1,758
Oil	363	335	685
Spare Parts	125	203	213
Transportation	30	24	41
Technical Services	0	54	136
Management Services	330	458	676
Operating Profit	-396	-383	-76
Non-Operating Revenue	281	751	1,256
Cumplementary Tariff	0	299	0
Subsidy from Government	278	352	1,016
Subsidy from France	6	20	17
Others	6	20	17
Non-Operating Expenditure	97	139	246
Personnel Expense	90	138	217
Others			
Curent Profit	-209	229	933
Financial/Subventionary Track	-37	-296	-750
Exchange Grain	11	50	95
Subsidy for Amortization	183	0	0
Recover/Amortization Sub	41	74	317
Exchange Loss	-11	-37	-65
Amortization	-225	-321	-865
Provision for Exch. Loss	0	0	-222
Credit Loss Provision	-37	-62	-11
Other Revenue	3,524	1,899	9,694
Recovery of Reval. Reserve	3,236	1,679	9,378
Other Expenditure	3,368	1,856	9,622
Extraordinary Amortization	3,236	1,670	9,379
Net Income	-90	-24	254

Table14-4 Trend of subsidies provided for Fixed Assets

		Currency Subsidy	Unit	Total	Building	Other Constr.	Transp. Equipment	Machinery Equipment
1993	Balance Year-end	Dbr	Million	3,725	1,192	916	70	1,547
		FFR	Thousand	41,467	13,270	10,195	776	17,225
		Subsideze	Million Dbr	1,294	50	481	58	706
		% subsid.	% subsid.	34.7%	4.2%	52.5%	83.3%	45.6%
	Installed in the year	Dbr	Million	703	59	116	28	500
		Subsideze	Million Dbr	677	50	116	23	487
		% subsid.	% subsid.	96.3%	85.2%	100.0%	85.1%	97.4%
1994	Balance Year-end	Dbr	Million	10,684	4,812	2,171	278	3,422
		FFR	Thousand	47,347	21,324	9,623	1,230	15,166
		Subsideze	Million Dbr	5,251	2,073	1,176	228	1,774
		% subsid.	% subsid.	49.1%	43.1%	54.2%	82.0%	51.8%
	Installed in the year	Dbr	Million	2,341	2,014	0	146	181
		Subsideze	Million Dbr	2,278	1,965	0	109	177
		% subsid.	% subsid.	97.3%	97.6%	—	75.0%	97.6%

Table14-5 Sensitivity Analysis --- FIRR for 35 years

(Unit : %)

EMAE's Burden Share	Electric Charge (c/kWh)								
	15 c/kWh	14 c/kWh	13 c/kWh	12 c/kWh	11 c/kWh	10 c/kWh	9 c/kWh	8 c/kWh	7 c/kWh
5 %	28.10	25.45	22.79	20.09	17.36	14.57	11.67	8.39	4.13
6 %	23.87	21.64	19.38	17.10	14.77	12.37	9.82	6.74	2.83
7 %	20.81	18.87	16.91	14.91	12.87	10.75	8.31	5.38	1.86
8 %	18.49	16.76	15302	13.24	11.40	9.41	7.09	4.30	1.10
9 %	16.65	15.10	13.52	11.90	10.21	8.27	6.05	3.42	0.49
10%	15.17	13.75	12.30	10.81	9.16	7.30	5.14	2.70	-0.02
15%	10.51	9.41	8.21	6.92	5.46	3.89	2.21	0.39	-1.61
20%	7.71	6.73	5.63	4.46	3.24	1-95	0.59	-0.87	-2.45
50%	0.95	0.38	-0.19	-0.79	-1.40	-2.04	-2.70	-3.37	-4-08
100%	-1.90	-2.23	-2.55	-2.89	-3.23	-3.57	-3.93	-4.29	-4.65

Financial Summary

(Unit : US$)

EMAE's Burden Share Electric Charge	100% 15 c/kWh	50% 15 c/kWh	20% 15 c/kWh	15% 15 c/kWh	15% 10 c/kWh	7 % 10 c/kWh	5 % 10 c/kWh
FIRR	-1.90%	0.95%	7.71%	10.51%	3.89%	10.75%	14.75%
Borrowing	4,754,000	2,377,000	950,800	713,100	713,100	332,780	237,700
Profit before Tax	-435,057	-175,547,	-19,841	6,110	-37,731	3,791	14,170
Profit after Tax	-435,057	-175,547	-19,841	4,277	-37,731	2,653	9,920
ROE before Tax	-9-15%	-7.39%	-20.9%	0.86%	-2.29%	1.14%	5.96%
ROE after Tax	-9.15%	-7.39%	-2.09%	0.60%	-5.29%	0.80%	4.17%
Cash Balance	-296,357	-106,197	7,899	25,082	-16,926	12,362	16,855
Accumulated Cash Balance	-1968,302	-732,262	9,362	130,525	-130,080	64,857	94,473
Repayment / Year	237,700	118,850	47,540	35,655	35,655	16,639	11,885