

Figure 3.6 – 2 Location Map of Urban Water Reservoirs

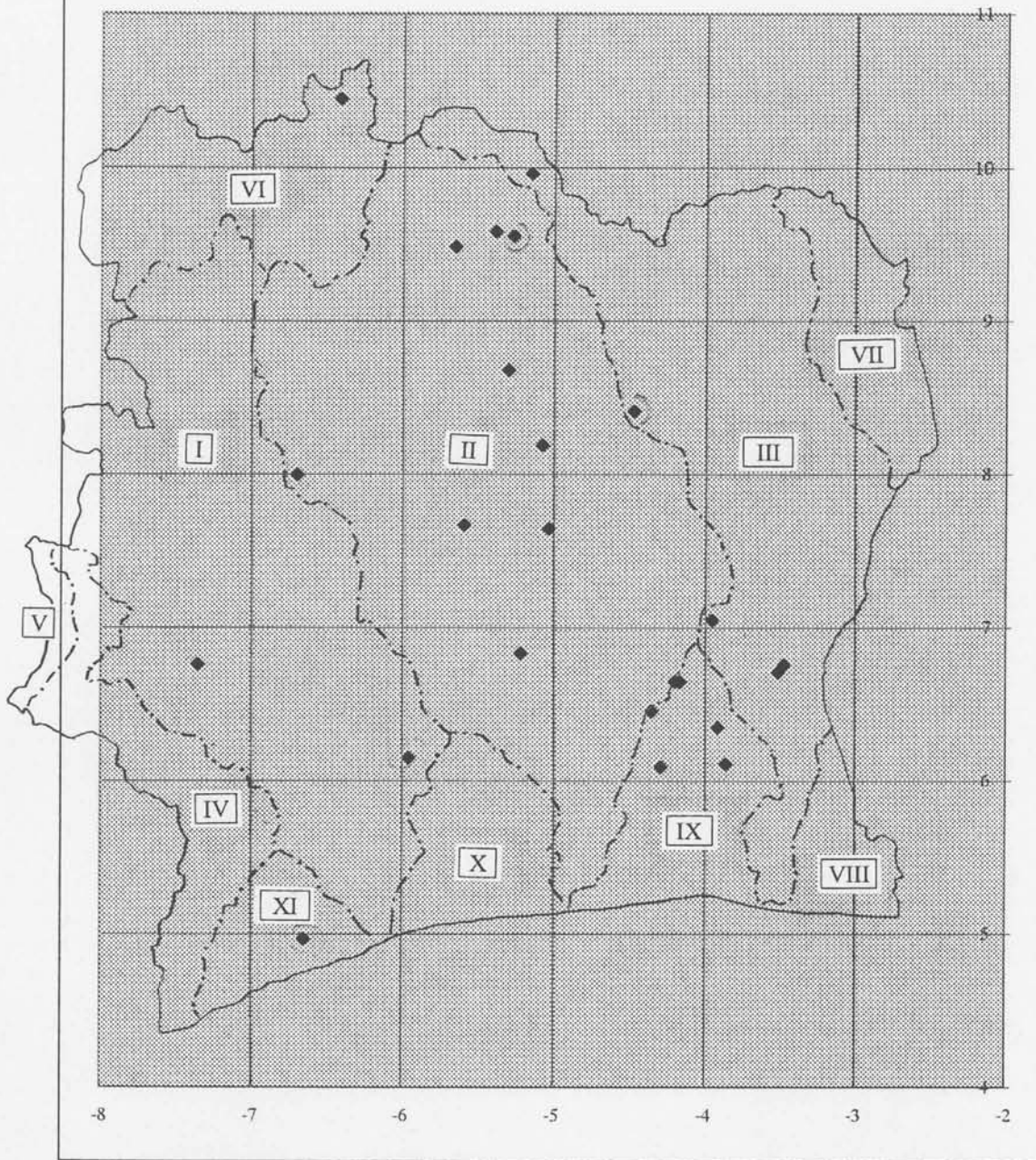


Figure 3.6 – 3 Location Map of Rice Irrigation Reservoirs

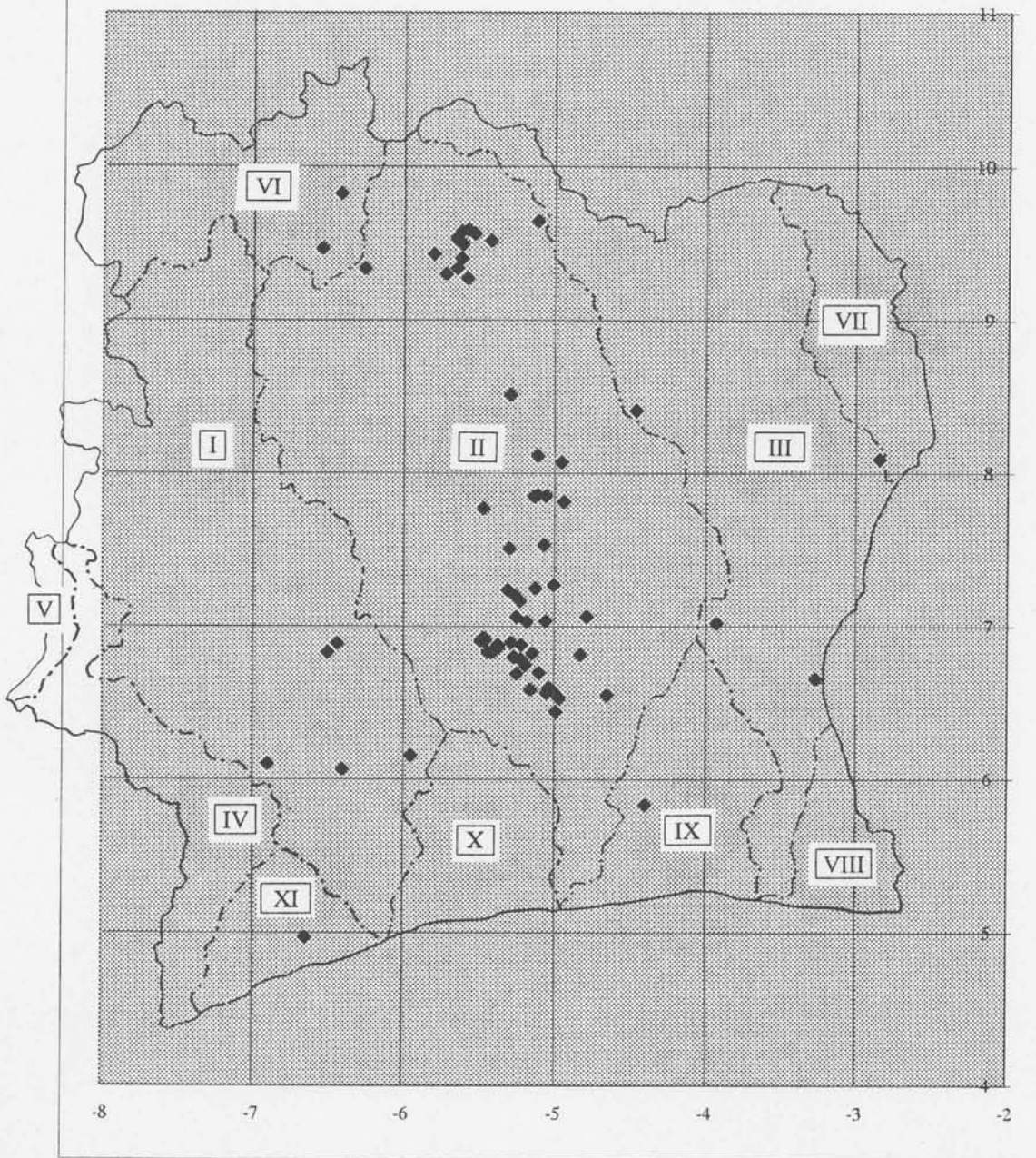


Figure 3.6 – 4 Location Map of Banana Irrigation Reservoirs

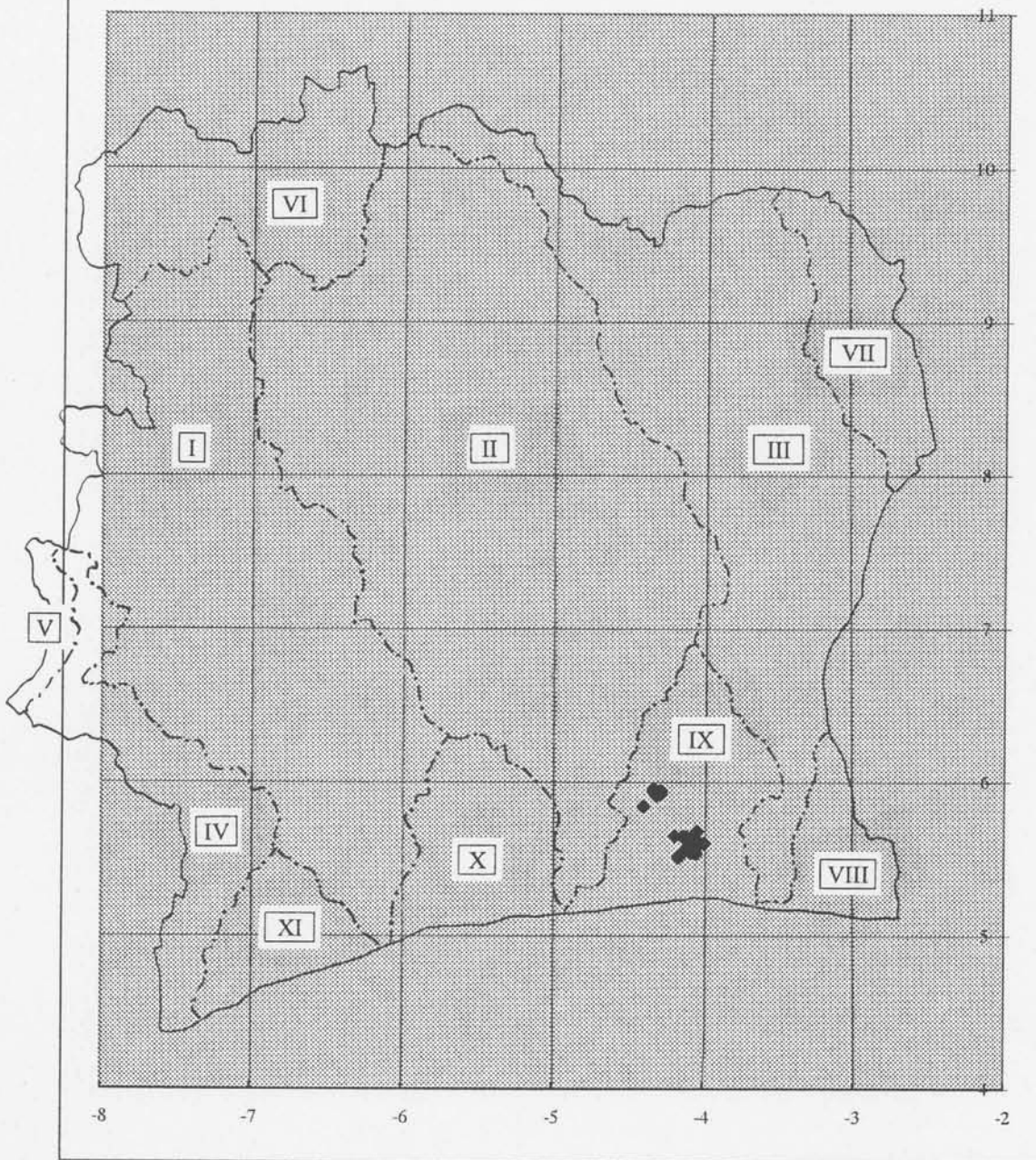
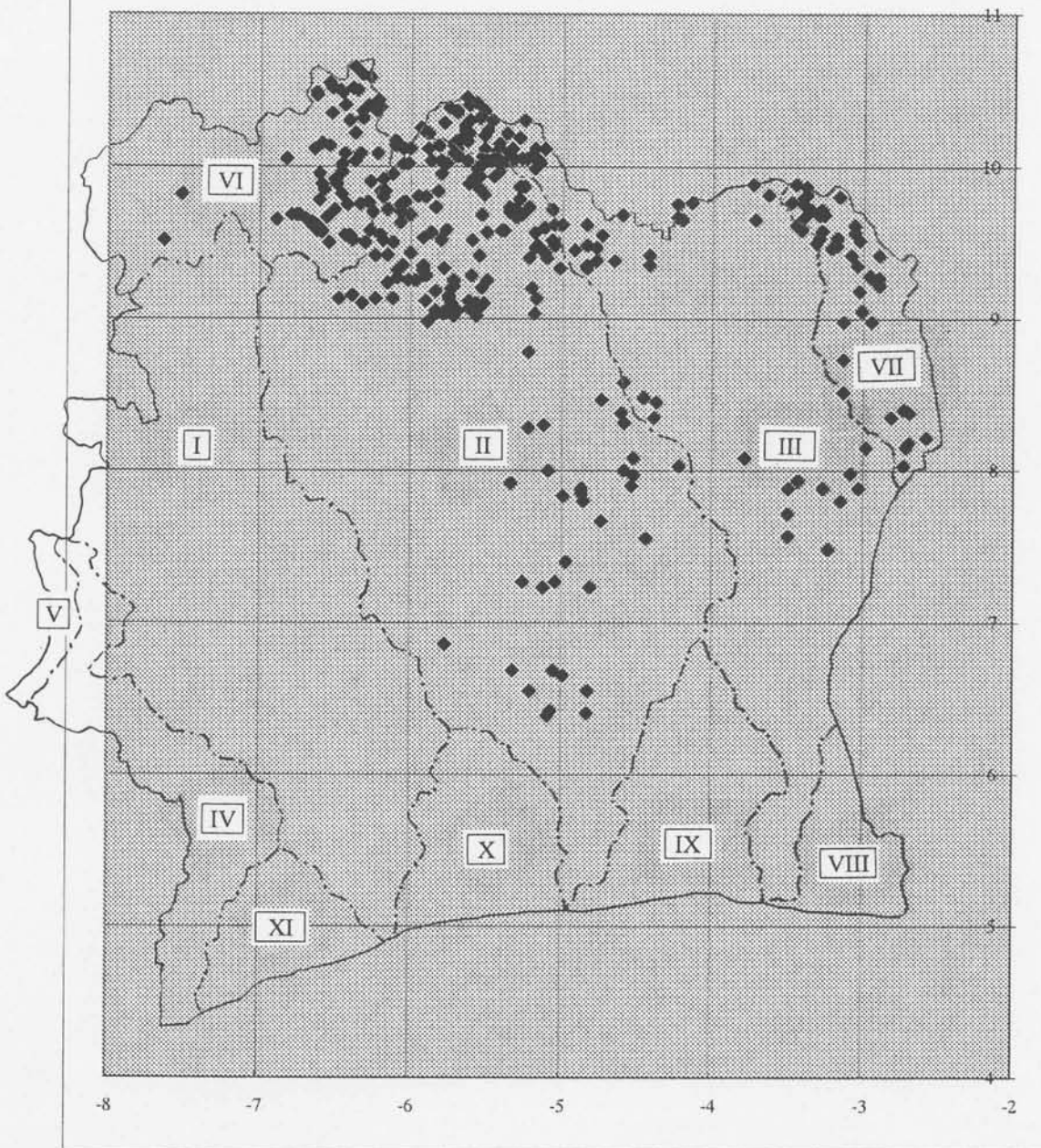


Figure 3.6 – 6 Location Map of Livestock Reservoirs



CHAPTER 7 FEATURES OF RELATED SECTORS FOR WATERSHED MANAGEMENT STUDY

7.1 Necessity to Understand the Present Features

It would be necessary to know the present features of the following sectors:

- (a) Rainfall and runoff
- (b) Population
- (c) Geology and groundwater
- (d) Water demand
- (e) Soil
- (f) Watershed erosion
- (g) Vegetation
- (h) Land use and land ownership
- (i) Forest
- (j) Forest management

These items are all related to the watershed management study. Without understanding the conditions of these items, it is difficult to study on the proposed measures for the watershed management.

The present conditions of the sectors related to the watershed management study are briefly explained in the following sub-sections.

7.2 Features of Rainfall and Runoff

The features of rainfall and runoff, related to the watershed management, are collected from some reference documents as well as the reports prepared by the JICA Team and summarized as follows:

- (a) The isohetal line of rainfall has been moving to south in most West African nations. In Cote d'Ivoire, the annual rainfall shows a slight decline in these 20 ~ 30 years in comparison with years before 1970. It is, however, difficult to say that the recent decreasing trend of rainfall is continued or not. A long-term such as 30 years and 50 years of circulation is not unusual in a region.
- (b) The annual runoff shows definite decline generally since 20 ~ 30 years ago. The rate and starting year of decline is different by location. And some areas do not show the decline especially in the western areas. (See: Table 3.7-1 and Figures 3.7-1 to 3.7- 7, for the reference)
- (c) The annual mean rainfall is 1,150-1,160 mm/year in the center and the north-east of

the country; 1,300 mm in the center-north, 1,480-1,490 mm in the center-south and in the north-west, 1,600 mm in the south-east, and 1,780 mm in the south-west.

- (d) The annual total runoff is estimated at 39 billions m³ in the whole territory of Côte d'Ivoire. This volume represents a run-off of 121 mm if it is assumed to be a uniform repartition over the whole country. The regional mean runoff is 35 to 45 mm for the North-East and South-East, 90 to 110 mm for the Center-South, the Center-North and the Center, 200 mm for the North-West, and 235 mm for the South-West.
- (e) A study of the runoff percentage of annual rainfall in West Africa (by Mr. F. LELONG in 1966) shows as follows:

Rainfall (mm)	800	900	1,000	1,100	1,200	1,300	1,400
Surface runoff percentage	7	12	17	21	24	27	30

It is, however, noted that the percentage is much lower during the dry season. For example, with less than 800 mm of annual rainfall, the feeding (runoff to surface water) is quasi nil, and from 800 mm to 1,300 mm, the feeding is assured depending on the conditions of some factors, and over 1,300 mm, the feeding is assured.

- (g) Nearly 85 % of annual rainfall concentrates during the rainy season and only 15% during the dry season. The percentage may be different by region or by river basin, however, this characteristic is almost the same.
- (h) The runoff concentration to the rainy season is much more remarkable as shown as follows:

River Basin	Rainy season (%)	Dry season (%)
Sassandra	87 ~ 91 %	9 ~ 13 %
Bandama	96 ~ 99 %	1 ~ 4 %
Comoe	96 ~ 99 %	1 ~ 4 %

- (i) Nearly 74 % of rainfall is lost by evapo-transpiration and the runoff to the surface water is 8 or 9 % on an average in the whole country.

7.3 Features of Population

The Study Team estimated the population as follows:

Descriptions	2000	2015
Rural Population	8,224,828	11,740,575
Urban Population	8,307,548	15,287,258
Total	16,532,376	27,027,833
Population density	51.3 persons/km ²	83.8 persons/km ²

Note: Côte d'Ivoire has an area of 322,462 km²

The population of each zone is obtained from a document prepared by the government as follows:

Zones	Surface Km2	% of Surface	Population	% of Population	Density of population Person/km2
Savanna	135,189	42%	2,146,296	14%	16
Savanna-forest	44,905	14%	2,184,060	14%	49
Forest	142,271	44%	11,028,156	72%	78
Total	322,365	100%	15,358,512	100%	48

According to the census made in 1988, the population of Côte d'Ivoire is estimated at 10,810,201, consisted of:

- Rural population : 6,582,260 (60.9%)
- Urban population: 4,227,941 (39.1%).

In 1975, the rural population represented 65.2% of the total population, which was estimated at 6,702,866. The growth rate of urban population is much higher than that of rural population as summarized as follows:

Year	Urban population	Rural population
1975	35%	65%
1988	39%	61%
2000*	50%	50%
2015*	56%	44%

* : Estimated

The centralization and urbanization will be the definite trend even in the future. The growth rate estimated by a governmental agency is as follows:

	1990/1995	1995/2000	2000/2005	2005/2010
Urban population	5.3 %	4.9 %	4.4 %	4.0 %
Rural population	2.2 %	2.4 %	2.3 %	2.3 %
Total population	3.7 %	3.7 %	3.5 %	3.3 %

7.4 Features of Geology and Groundwater

Côte d'Ivoire belongs to the western part of Africa. The ground foundation of the country basically consists of metamorphic rocks and Precambrian gravel. The only sedimentary formation of the secondary and tertiary age is located in a narrow coastline, from the district of Sassandra on the west up to the border with Ghana on the east, covering only 3% of the country area.

There are two kinds of aquifer, according to the study by the hydro-geologist of the Study Team, as briefly explained follows:

(a) Discontinuous aquifer

Discontinuous aquifer is located in Precambrian formations, which are mostly impervious due to fresh and intact rock condition. The surface water infiltrates into the ground and is stored in shallower aquifer in superficial highly weathered zone of 20 ~ 25 m deep on an average. Then the water infiltrates into further deeper through faults and joints and is stored in deeper aquifer in discontinuous fissure of Precambrian rocks basement generally located 100m deep or less from the ground surface. The discontinuous aquifer can be classified into two major hydro-geological unit; granitic rocks and metamorphosed sedimentary rocks.

(b) General aquifer in the Continental terminal formation and Quaternary

General aquifer is sandy layers located in the Continental terminal and Quaternary. The aquifers of Continental terminal are lithologically divided into clayey sand, medium sand, coarse sand, and fine-medium sand in descending order. Total thickness of the aquifers is approximately 50m – 150 m in the plateau area and more than 200 m in the coastal area. The depth of major wells ranges from 80 to 120m.

The ratio of effective rainfall, which infiltrates into the ground, could be varied according to the geological conditions as well as the rainfall intensity. The capacity of renewable groundwater

resources is different by the locations due to changes of the rainfall and lithological and stratigraphical characteristic. The renewable volume is less than 50mm in a district and more than 400mm in an another district. The potential groundwater resources in the whole country are estimated at 123 billion m³, with the annual renewal volume of 33.8 billion m³, consisting of 31.0 billion m³ from discontinuous aquifer and 2.8 billion m³ from general aquifer.

On the other hand, the annual recharge/renewable volume of the ground water in Côte d'Ivoire was estimated at about 37,740 x 10⁶ m³ by the study of F. LELONG in 1982. The breakdown is as follows:

- Bedrock zone 35,000 x 10⁶ m³
- Tertiary table 2,100 x 10⁶ m³
- Quaternary table 640 x 10⁶ m³

The estimate of groundwater may be different by the method of analyses, the assumption of various factors, and the detailed level of survey.

7.5 Features of Water Demand

(1) Summary of Water Demand

There are the following major sectors of water use:

- (a) Agriculture,
- (b) Livestock
- (c) Fishery
- (d) Urban water supply
- (e) Rural water supply
- (f) Hydro-electric power generation
- (g) Others (Environmental conservation/improvement, Navigation, Recreation, etc.)

Among them, the sectors of agriculture & livestock and water supply (Urban and rural) are essential and actually consume the water. The mean annual water demand estimated by the Study Team is summarized as follows:

Sector	Surface Water		Ground Water		Total	
	1998	2015	1998	2015	1998	2015
Agriculture	706.76	4,803.34	94.93	338.06	801.69	5,141.4
Urban Water supply	24.50	324.34	102.06	384.14	126.56	708.48

Rural Water supply	---	---	19.12	35.70	19.12	35.70
Total	731.26	5,127.68	216.10	419.84	947.36	5,547.52

Unit: MCM

The annual demand estimated from another source is shown for reference as follows:

year	1995	2000	2025
Potable water supply	138	650	2,042
Agriculture	1,983	3,368	6,842
Livestock	250	250	500
Industry	25	25	14.5
Total (MCM)	2,396	4,293	13,692

(Source: Direction of Water)

Among them, the water demand of agricultural sector is significant.

(2) Water Use of Agricultural Sector

The irrigated areas represent just only 1% of the developed farm lands, i.e., 65,000 ha. The breakdown is as follows:

- 25,000 ha of paddy with 50% using river intakes and 50% stored-water from reservoirs.
- 19,000 ha of sugar cane distributed into 4 complexes: Ferké I (5,700 ha), Ferké II (6,000 ha), Zuenoula (4,200 ha) and Borotou (3,200 ha)
- 12,000 ha of old plantations of sugar cane transformed into seed producing plantation in Sérébou (5,750 ha) and into maize plantation in Katiola (6,000 ha). These two productions only use irrigation as addition means
- 5,000 ha of fruits plantations (essentially banana) and pineapples.
- 4,000 ha of vegetables on the area of a certain size up to 1,800 ha.

The water supplies of these zones are made through different ways:

- Water intake along the watercourse
- Water intake under dam
- Pumping from a reservoir.

An inventory implemented by the government in order to increase rice production brings out the following:

- 25,000 ha of developable lowland , already studied or identified
- 150,000 ha potentially developable, also in lowland
- 200,000 ha of potential land, wide plains (to be identified)
- 100,000 ha of potential land of coastal swamp

The Direction of Water (MIE) made an evaluation of the water demands at different levels, for the agricultural water demand with classification by irrigation of sugar cane and rice and the other crops. The results are shown as follows:

Year	1995	2000	2025
Rice	1,606	2,938	6,155
Sugar cane	221	241	340
Other crops	156	190	347
Total (1,000 m ³ /year)	1,983	3,368	6,842

(Source: Direction of Water)

On the other hand, that of livestock is summarized as follows:

Year	1995	2000	2025
Livestock (1,000 m ³ /year)	250	250	500

(Source: Direction of Water)

Some reference data of irrigation area, farm land and production are shown in Tables 4.7-2 to 4.

7.6 Features of Soils

Soils in Cote d'Ivoire are generally classified, mainly from agricultural viewpoints, into the following four categories:

(A) Ferruginous soils (predominant soil)

They cover practically all the country of Cote d'Ivoire. It could be further classified to three types of soils as follows:

- (a) A large halo of soils under high rainfall (more than 1,500mm) mould themselves on the ombrophile forest in the south and drawn up in the south between the Sassandra River and the frontier of Guinea
- (b) A second halo of soils under an attenuated rainfall (less than 1,500mm) constitutes a zone of transition. This Halo corresponds to the mesophile forest

in the south.

- (c) The rest of the country is occupied by fairly saturated soils. One can discern also many armored zones.

The characters of fertility of these soils are various. Soils, which are strongly de-saturated in the south, are widely adapted to cultures for palm or heave. Soils of transition are more favorable to cultures of coffee and cocoa. Soils, which are strongly de-saturated in the north, are favorable to cotton.

(B) Soils on basic rocks

The main elements are constituted of fragments of rock more or less adulterated and small black concretions. The characters of fertility depend essentially on the depth of the soil. It means the density of main elements. However, the valorization becomes difficult because only the bottoms of slope are generally susceptible to be used for cultures. These soils occupy mainly the ranges of hills of the volcano-sedimentary complex and they are often juxtaposed with armors.

(C) Ferruginous tropical soils

The soils characterize by a sandy and dense horizon, a friable beige horizon and a horizon rich on clay. These soils are not very fertile.

(D) Hydromorph soils

They are generally located in zones of flood plains. These soils have feeble fertility in low coast and are fertile especially for banana. However, it is also suitable for the mechanized culture of rice. In the north, these soils are favorable to all kinds of irrigated cultures.

It is noted that the soils may be classified by different ways depending on the purpose of use, scientific or general terms, etc.

7.7 Features of Watershed Erosion

It is generally said that the soil erosion has been accelerated year by year due to devastation of forest and increase of bare lands.

The soil distributed in the country is mostly laterite (in general term) made from weathered granite rock and including acid, aluminum and iron. The laterite soil is classifying into 3 groups depending on rainfall intensity as follows:

- Highly saturated soil under high rainfall more than 1,500 mm

- Saturated soil under rainfall less than 1,500 mm
- Unsaturated soil with gravel horizon.

The laterite soils do not have viscosity and are easily eroded by rainfall of high intensity. And it is also reported by another data source that the surface soils of Oxisol and Ultisol (another way of soil classification) are located widely in Cote d'Ivoire and these types of soil are very sensitive and easily weathered by changes of natural conditions by deforestation and farming.

Soil deterioration, mostly caused by soil erosion, has serious effect on the agricultural productivity. Although the effect is different by soil conditions and a kind of products, the remarkable reduction of products will appear when 5 ~ 10 cm of surface soil is eroded and such poor conditions will continue many years. It is difficult to estimate the soil production speed due to shortage of the research results. However, a research shows that the production is 0.7 t/ha/year on an average on the earth and 1 ~ 5 t/ha/year in the tropical regions. It is sure that forest can prevent the erosion of soil and instead produce soils. The soils in Cote d'Ivoire are moderately ~ intensively weathered and mostly caused by water erosion or wind erosion. But the original causes are human activities especially of the following:

- Excessive pasturage
- Inappropriate farming methods
- Forest logging
- Excessive use of charcoal

A report says that the sediment yield by erosion is estimated at 50 ~ 100 t/km²/year in Cote d'Ivoire and the neighboring countries. It is also reported that there are highly eroded areas, with the erosion rate of nearly 500 ton/ha/year, at bare land in hilly areas of the south region. Although, it seems there is no definite detailed survey data of erosion in Cote d'Ivoire.

Total transportation volume of sediments in rivers is considered to be close to the erosion volume. The general examples of the erosion rate, for a reference, are shown in the table below:

River name	Erosion rate (m ³ /km ² /Year)
Nile (Egypt)	13
Mississippi (USA)	59
Amazon (Brazil)	58
South-east Asian rivers	More than 100
Yellow river (China)	1,160
Rivers in Rocky mountain (USA)	Less than 200
Colorad river (mountain rivers in USA)	230
Alps rivers (mountain rivers in Europe)	100 ~ 800

Tone River (Largest river in Japan)	137
Kurobe River (mountain river in Japan)	6,872

As seen above, the erosion rate is remarkably different by natural conditions of soil, land form, climate, etc. However, there are general features as follows:

- The erosion is larger in areas with more rain.
- The erosion is remarkably larger in steep mountain areas.
- The erosion is larger in weathered fine soil areas.

In Cote d'Ivoire, the mountain areas are located in the western side. The other most of the territory of the country is generally flat with some isolated low mountains. In the mountain areas, the landform is generally steep and the stream flows rapidly. However, as far as seen during the field survey in the regions of Man, Danane and Odienne, remarkable slope erosion or riverbank scouring was not seen. And neither slope collapse nor land sliding was found there. In addition, it was also informed, the debris flow or mudflow does not happen in the streams. The land there is not devastated and generally covered with forest or vegetation. Accordingly, it seems to be not necessary to study on the slope protection works and sediment control works, such as check dams, drops, river training works, etc.

7.8 Features of Vegetation

The country is generally divided into three zonings based on vegetation type. They are explained from the south to the north as follows:

(A) Guinea domain (forest landscape)

So-called the "ombrophile" forest spreads in the south of the Isohyete of 1,600mm. It is characterized by the presence of giants trees (Lophira, Alata, Azobe) which reach 50 meters, foothills puck roots, stilt roots (*Upaca guineensis*), a richness of liana, and the rarity of grass in under-wood. This agglomeration creates a hot and wet climate.

A type called "hupper-ombrophile" (or "*Diospyros* spp; *Tarrieta utilis* (niangon)" and "*Mapania* spp"), which required soils with good capacities to retain water, is located in the southeast and the southwest on green rocks and in the more favorable climatic regions (1,800mm of annual rain but with dry season).

(B) Pre-forester Guinea District

It constitutes a special zone between two domains, that is, Guinea and Soudanian. Parts of mesophile forest and some large parts of savanna characterize this zone. At the end of the rainy season, the most land becomes like a thick continuous sheet of grass of about 1.50m

high. In the grassy lands, some parts are covered with bushes (*Annona senegalensis*, *cochlospermum planchonii*) or forest trees (*Borassus aethiopicum*, *Lophira lanceolata*, *piliostigma*, *thonningii*, *Cussonia barteri*).

(C) Soudanian and Sub-Soudanian Domains.

This zone, located on the north, has juxtaposition of forest and savannas and the localization mainly depends on the climatic factors.

(a) Clear forest

It is a formation of two kinds of forest, that is, shrubby forest and grassy forest. The latter is composed of trees with bunches (*Andropogon tectorum*, *Hyparyenna chrysargyrea*). The prevalent trees are *Isobertia doka*, *Daniellia oliveri*, *Pterocarpus erinaceus*, *Azelia africana*, and *Khaya senegalensis*.

(b) Savannas

It develops in all the part of the northern area, which includes Touba, Seguela, Brobo, Nassian, and Bondoukou. A zone corresponds to the extension surface of the Sudanese climate. The density of the vegetation is tied directly to the long time and the harsh of the dry season. Savannas are often presented as discontinuous places of vegetation/trees. It is sometimes further classified to arborescent savanna, shrubby savanna and woody savanna. Representative trees are *Loudetia superba*, *Ctenium elegans*, *Andropogon* and *Ivorenensis*.

It is noted that the western mountain areas are sometimes classified separately.

7.9 Features of Land Use and Land Ownership

(1) Land Use

The specific data concerning the land use of the country was not obtained. However, a source from the governmental office shows the proposed land use as follows:

Description	Area (ha)	Area (%)
Cultivation land	3,645,823	11%
Protected area/Forest	6,574,400	20%
Cities/Towns	149,852	1%
Lake	297,143	1%
Others	21,620,581	67%
Total	32,287,799	100%

Note : Definition of each category is not sure.

The total area of water body at present is approximately 4,700,000 ha, in which 25 % is lagoons, 51% reservoirs/lakes, and 24% rivers (another data source).

As seen above, the area of other uses occupies two third of the country. The most of these lands may be difficult to be classified. But, they are mostly not used at present.

Changes of land use in Cote d'Ivoire and the neighboring countries are obtained from a reference book as shown in Table 4.7-5. The land classifications and its percentages may become different by the survey sources. Some information and comments on major land use items are presented as follows:

(A) Forest area

It seems to be difficult to define the forest area mainly due to variable density of trees and percentage of actual forest area. Some documents inform that the forest area was once (before early 20th century) 160,000 to 180,000 km², that is nearly 50 % of the country area, but decreases extensively to 25,000 to 30,000 km² at present. The major causes area due to the large expansion of plantation area, logging industry development, and slash and burn cultivation. Accordingly, the government already recognized since nearly 20 years ago that the reforestation is the most important program to maintain the watershed of the river basin and as well as for the environmental conservation of the whole country.

(B) Cultivation area

The existing cultivation/farmland area is estimated at 58,000 km², occupying 18 % of the country area (the figures are different by the data source). Out of 58,000 km², 60 % is perennial crop area and 40 % food crop area. The plantations of cocoa, coffee, and palm respectively occupy a large portion of 10 %, 15 % and 15 % of the total farm area. Those crops are mainly planted at hilly area in the southern region with rich rainfall. On the other hand, the food crops are paddy, yam, cassava, taro, etc, which are mainly cultivated at the northern and mid-western area of the country.

(C) Not-used area

The not-used area may have two categories as follows:

- Water body
- Land (mostly grass lands with bushes in some areas)

In the land area, a source evaluated that the total area of 24 million ha can potentially be used for agriculture, that is 75%, of the country. However, such large potential areas are abandoned to use at present due to various reasons such as follows:

- Shortage of water (rainfall)
- Difficulty of land reclamation due to land forms
- Difficulty of land reclamation due to shortage of budget

- Others (No idea to use, land ownership issues, etc.)

It seems that major causes of large not-used land are related to the following:

- No (detailed) inventory survey of land use
- No reliable analyses and planning for appropriate land use
- No intensive management on land use

(2) Land Ownership

It was informed that the whole the country areas officially belong to the state government. However, a person or a company actually is possible to purchase/obtain lands except certain restricted areas including protected areas. In these days, it is a tendency that the official documents as an owner are required even in rural area.

In rural area, however, it is a common sense in every village, that all the surrounding lands are owned by the village and the chief of village has a right to decide the uses. Any people may get permission to use from the village-chief with payment of a certain amount.

7.10 Features of Forest

(1) Reduction of Forest Area

The forest area was remarkably reduced in a period of 1960 – 1980, due to excessive logging for economic development. The forest area was 15 million ha in 1960 and reduced to 3 million ha in 1980. Since then, the reduction rate become lower. But, nearly 3,000 ha has been lost every year on an average as seen below:

Early 20 th century	: more than 15 million ha
1956	: 12 million ha
1965/66	: 9 million ha (Reduction: 300 thousands ha / year from 1956)
1975	: 6 million
1988	: 3.5 million
1991	: 2.5 million ha (Reduction: 250 thousands ha / year from 1965)

Note: Existing forest area is counted sometimes at 300 million ha or more. There are no definite methods to classify the forest area.

It is often said that between 1955 and 1990, the rural population of the forest zones has been multiplied by 4 and the forest surface has been divided by 4.

(2) Classification of Existing Forest

The existing forest is classified as follows:

- (a) National park (protected) : 1.856 million ha (8 parks at present)
- (b) Natural reserve (protected) : 0.442 million ha
 - Natural full reserve (1 location) : 0.005 million ha
 - Partial Natural reserve (4 Animal reserves) : 0.239 million ha
 - Partial Natural reserve (16 Botanical reserve) : 0.198 million ha
- (c) Botanical garden
- (d) Classified forest : 3.633 million ha
- (e) Others

Note: Azani national park, located at the river mouth of the Bandama River is only a proposed area to be ratified as a protected area under Ramsar Treaty.

In the protected areas, the regulation restricts hunting, logging and settlement.

The general locations of national parks and classified forest are shown in Figure 3.7-8.

(3) Plants replaced in the forest

The forest areas have been replaced by non-domestication plants, which have widely invaded into the forest areas. The major plants are such as follows

- (a) Living Plants : Cassava, Maize, Groundnut, Poteto, Pimento, Tomato, Avocado
- (b) Mercantile Plants : Cocoa, Sisal, Nanas, Tabaco,
- (c) Fruits : Papaya, Jayvee, Carrousel
- (d) Plants for decoration : Bougainvillea, Frangipane, Plumeria
- (e) Plants of reforestation/logging : "Anacardier" , Plumeria Rubra

(4) Factors of Deforestation

The major factors of deforestation are considered to be as follows:

- Development of industrial cultures (or cash crops) such as cotton, cocoa, rice, rubber, coffee, palms, etc
- Bush fires
- Pasture for breeding animals
- Opening of track in forest
- Increase of wood need (energy, manufacturing, housing etc.)
- Lack of harnessing in the natural forest (no respect of delimitation)
- Demographic pressure including strong immigration to the South

7.11 Features of Forest Management

(1) Forest Management Office

The Ministry of Construction and Environment, reorganized in 2000, has three departments and

one public corporation related to the forest management as listed as follows:

- (a) Natural Protection Department (DPN)
Management of national parks and reserves (protection of forest, promotion of ecological-tourism, control of hunting, etc.)
- (b) Forest Industry and Afforestation Department (DPIFR)
Management of forest excluding National parks, Natural reserves and Classified forest (Logging management, wood industry and export management, afforestation, etc.)
- (c) Forest Inspection and Control Department (DPFC)
Control of activities in all the forest areas
- (d) SODEFOR (Public Corporation)
Management of Classified forest

Various international organizations and countries have provided the assistance for forest protection, especially for the protection of national parks and the forest development plans. They are World Bank, GEF, EDF, EU, CCE, CFC, GTZ, kfw, IUCN, WWF and others.

(2) SODEFOR

SODEFOR was established in 1966 as a kind of research center. The responsibility and duty of SODEFOR became stronger in 1992 and became a public corporation in 1993. And SODEFOR became a sole agency in charge of planning, restoration, and management of all the areas of “Classified forest” (3.6 million ha in total). SODEFOR with 7 departments/divisions in the head office manages all the “Classified forest” by dividing into 7 blocks and with more than 1,200 staff. Many of them are capable and experienced engineers and experts in various fields for preparation of effective planning and management of forest

There are 218 areas of classified forest at present. Among them, nearly 82 forests have already the forest management and development plan. Each development plan is scheduled to complete in 10 years (previously 20 years) at present. Because of the importance of SODEFOR, some reference information and data are presented as follows:

- (a) In natural forest, trees are generally classified into three sizes and the following number of trees should be necessary to exist for deciding logging.
 - Small tree (5 ~ 20 cm in diameter*) : more than 150 ~ 250 nos./ha
 - Middle tree (20 ~ 50 cm in diameter*) : more than 40 ~ 60 nos./ha
- * : Actual size is different by the zones established by SODEFOR.

Then only large trees (larger than 60 ~ 80 cm in diameter) are allowed to cut, but there is a minimum number of large trees to be left after logging (4 ~ 8 nos./ha).

- (b) Accordingly, actual number of logging is not much. Large trees exist generally approximately 20 nos./ha (40 nos./ha in best areas). Approximately only 30 species are selected for logging tree.
- (c) In addition, the volume of log production is generally only 1 ~ 3m³ /tree (8 ~ 10 m³/tree is exceptionally large case). That is, in natural forest, the total production is limited. However, the production volume per ha of planted trees is remarkably larger (150 ~ 200 m³ /ha) due to many logging trees per ha.
- (d) Classified forest (in case of natural forest) is considered to have 20 ~ 25 years cycle. That is, logging activities may be carried out again every 20 ~ 25 years. In this case, some middle size trees may be grown up to large size trees after 20 ~ 25 years.
- (e) The size of tree is generally decide by the diameter at 1.3m in height from the ground or at a certain height above the slope of bottom portion, for tropical type trees with large expanded bottom.
- (f) According to the survey of tree covering area (canopy covering area) for 130 classified forest located below 8 degree in the north Latitude, the results are obtained as follows:

Type	Covering ratio of canopy	Survey results
I	More than 90%	50 forests
II	90 ~ 60%	70 forests
III	Less than 60%	80 forests
Total	-----	130 forests

- (g) For the forest development plan, the area is generally classified as follows:
- Production area (logging)
 - Reforestation(afforestation) area
 - Improvement area (removing invaluable trees)
 - Conservation area (due to fauna protection)
 - Conservation area (due to flora protection)
 - Pasture (no tree plantation)
- (h) Among 82 forests with the development plan, only 10 ~ 15 plans have been approved by the government. That is, many plans are just waiting for the approval of execution. While, some additional plans are on the way of preparation.
- (i) Planted (afforestation) trees from the nursery are expected to be grown up after the following years.
- Fast growing trees : 10 ~ 20 years

- Medium growing trees : 25 ~ 30 years
 - Slow growing trees : Longer than 30 years
- (j) In the Classified forest, a large area (approximately 1/4 ~ 1/3) may be covered by the plantation trees such as cacao and coffee.
- (k) SODEFOR organized Forest Peasant Committee (FPC) with members of related organizations. FPC has main objectives as follows:
- Exclusion of agricultural activities from the forest area
 - Assisting in agricultural development in the surrounding areas of forest
 - Participation of village people for forest planning and management
 - Consistence of forest restoration with crop production
 - Management and planning of trees in harmony with eco-system and restore the property of forest industry
- (l) SODEFOR takes care of enhancement of employment for forest activities and utilization of forest for the benefit of local people.
- (m) Basic steps of management of Classified Forest by SODEFOR are generally as follows:
- Data collection
 - Map preparation
 - Inventory survey for forest ledger
 - Socio-economic survey
 - Preparation of management plan
 - Soil survey
 - Selection of planting tree
 - Study on periodical inspection and planting cycle
- (n) General procedure of logging by SODEFOR is as follows:
- SODEFOR prepares the definite logging plan.
 - SODEFOR makes marking on trees for logging in a unit block (generally 500 ~ 1,000ha).
 - Tender of logging for a block by local contractors
 - Contractor of the lowest price gets a license of logging (SODEFOR decides the minimum price beforehand, from the estimated logging volume and appropriate unit prices, generally 9,000 ~ 10,000CFA/m³)
 - Every log has to be identified by numbers indicated by SODEFOR.

(3) DPIFR

DPIFR is in charge of forest management of non-protected areas but excluding the classified forest, which is managed by SODEFOR. Some reference information and data concerning DPIFR activities are presented as follows:

- (a) At present, the objective areas of DPIFR management are all the areas located below the north Latitude line of 8 degree, but excluding the following areas:
 - National parks
 - Natural reserve
 - Classified forest
 - Buffer zone of the above forests
 - Special areas (Two areas with scarce trees and one politically decided area)
- (b) The objective areas are divided into blocks. Each block has the license number, block number and ID number of the contractor, which is selected for each block.
- (c) DPIFR can decide a contractor (there are nearly 150 timber companies) of logging, but the official license of logging is signed by the minister.). That is, DPIF controls the activities of timber companies. Contractor gets the license of logging for 10 years and pays 122 CFA/ha/year to the government.
- (d) Every contractor has duty of afforestation (reforestation) in the respective block. The government office makes a program (area in ha) of afforestation in every block and indicate to contractors every year. The actual locations are decided by discussion among the DPIFR regional office, the contractor and the villages. It is informed that, they can substitute the necessary area (ha) in a classified forest, if they can not find appropriate sites for planting.
- (e) The area of afforestation is generally based on the logging quantities as follows:
 - Tropical/ general area: 1 ha for 250 m³ of logging production
 - Savanna area: 1 ha for 150 m³ of logging production
- (f) DPIFR takes care of promotion of afforestation in the northern zone as well. However, no definite budget is prepared for this purpose. Sometimes, the donations from some contractors can be used for the activities.

(4) Inspection

Inspection of activities in forest is carried out by patrol. But the system seems to be not functioning effectively. There are no technical difficulties according to SODEFOR. Social issues are more serious such as follows:

- Resettlement of villages to outside locations is not easy.
- Farmers easily enter to forest for cutting trees or other activities.

- Existing laws and regulations are not practically effective (No strict punishment or sometimes political support to farmers)
- Facilities for inspection are not well maintained due to budget shortage.
- Forest is too wide for human inspection.

(5) Ownership of Trees

Trees are property of the government. Only licensed contractors can log and sell trees. The contractors have to pay tax for logging and the afforestation in the logged areas is their duty.

If a village has the utilization right of land in a forest, the village can cut or burn the trees for their land use, although they can not sell logs.

(6) Wood Industry

The wood industry has been developed due to the following:

- High demand of industrialized/developed countries
- Increasing needs of the national market
- Opening of two major ports, Abidjan and San Pedro
- Development of roads system

There are more than 700 different species of trees in the forests, but almost thirty species are exploited for domestic uses as well as for export. The main species are: “acajou”, bété, “samba”, “teck”, “avoidiré”, “makoré”, “Iroko”.

Wood industry gives many job opportunities for logging, construction of forest roads, manufacturing, and port activities. It was one of major industries in Cote d’Ivoire and contributes to earning by export.

It is said that wood exploitation in Cote d’Ivoire has been continued since 1880. Until 1951, however, the exploitation of wood was limited and only some species were cut down. From 1951, the exploitation has been increased steadily for nearly 30 years. But, in these 20 years, the exploitation is not active in comparison with that in 1970s possibly due to the following reasons:

- Forest areas are remarkably reduced. And the government control and management started. Many dense forests became protected areas.
- Forest areas especially located comparatively close to Abidjan and San Pedro ports are reduced. The location of forest for logging generally moved from the south to the middle.
- Species with higher demand and benefit became rare.

- Economic activities of the country slowed down.

The production volume of wood industry was 650,000m³ in 1958, 4,275,000 m³ in 1969 and 5,194,000 m³ in 1973. After a small reduction in 1974 and in 1975, because of the world economic crisis, the production increases and becomes 5,120,000 m³ in 1976 and it stays at the same level until 1980. Then it is reduced to 4,000,000 m³ in 1981. It was one of the first industrial sectors of the country.

Production of wood industries in 1976 and 1981 is shown for reference in the table below:

	Total in m3		Value in billion of FCFA		Consumed in Ivory Coast(m3)		Exported(m3)	
	1976	1981	1976	1981	1976	1981	1976	1981
Industries								
Sawmills	577,000	603,000	15,187	29,388	249,000	340,000	328,000	263,000
Enrollment	31,000	102,00	1,114	1,944	?	66,000	31,000	36,000
Cutting	3,300	8713	400	1,603	500	1,732	2,800	6,981
Plywood	45,400	42,200	3,065	7,018	28,100	23,100	17,300	19,100

Although the annual data of wood industry since 1981 are not obtained, it is informed from SODEROR as follows:

- Annual production from natural forest : approximately 600 thousands m³
(Not increased in these years)
- Annual production from planted forest : approximately 100 thousands m³
(Increasing trends, planting for logging tree started in 1928)

Then DPIFR showed the data of wood industry in 1999 of the whole Cote d'Ivoire as summarized as follows:

Descriptions	Volume (1999)
Volume of Logging Production (Transported to factories)	2,176,632 m ³
Volume of Manufactured Production	1,872,710 m ³

In comparison with the total logging production in 1970s and 1980, the production is nearly a half or less at present. But, it seems to be necessary to review the more detailed and reliable data of long-term for the evaluation of logging production.

(7) Forest Management Plan

A source estimates that the rural population may increase from 7.5 million at present to 12 or 13 million by 2015, although the urban population will increase much more, especially in Abidjan. If no effective countermeasures are taken, many of these increased people have to find their living space in a forest.

The population increase in urban areas also requires more lands for sources of their consumption of foods. If the population becomes double, the food requirement becomes 2 times in minimum but probably 2.5 ~ 3 times actually in consideration of improvement of living standards. It would be difficult to find the way to import the sufficient quantity of foods from the viewpoints of unstable availability and similar issues of the neighboring countries.

At present, forest management is carried out on a basis of "Forest Plan 1988 – 2015", which was officially approved in 1988 and has main objective to increase the forest area at about 20% of the country. The plan contains the following:

- Implementation of a plan with the aim to re-establish an exploitable potential which would at least be similar to the one at the beginning of the century, about 4 million m³ of coarse wood per year
- Start of new actions which will allow to develop at a large scale the classified forests, while continuing the efforts of industrial afforestation
- Implementation of an afforestation extension program in the rural forest domain
- Rationalization of forest exploitation, respecting the possibility of a strong production of the forest.

The Action Plan 1988-1995 was established for rehabilitation of the forest sector so as to avoid the disappearance of the dense forest by 1995, the decline of the wood industry and the irreparable deterioration of the farming environment. The decentralization of the forest management is a valuable tool for the implementation of the following actions:

- Predevelopment plan (2.43 million ha)
- Acknowledgement of the limits of the classified forests and their materialization on the land with appropriate means
- Implementation of a surveillance plan of the forest
- Balancing of the classified forest by relocating illicit inhabitants to other areas
- Development operations for development-exploitation conventions with the companies, including the possibilities of the forest that can be exploited.
- Forest plantation for wood industry (55,000 ha)

- Afforestation by the local people (95,000 ha)

This program (1988-1995 plan) consists in encouraging the local people, the local collectives and the villagers to create their own tree nurseries and to plant species for multiple use from which they will get the direct benefit (firewood, service-wood, fruit etc.), which will motivate them to look after the plantations. The significance of the following items are proposed as well:

- Development of national parks and reserves
- Wood industry management
- Revision of forest work tax system
- Elimination of temporary exploitation permit
- Granting of concessions for bigger surfaces and for a long term
- Development of a processing technology
- Encouragement of professional training, etc.

In the context of the implementation of this medium term action program, which enforces the long term plan (1988-2015), several projects are financed and carried out such as listed below:

- Sectorial forest project
- Project for Afforestation and Forest Development in the Savannah and Relation of Forest-Savannah
- Rehabilitation of East forests
- Creation of the South-east Management center
- Development Project of the Duekoue forest

Table 3.7-1 Annual Rainfall at Major Locations

Year	ABENGOUROU 4	BOUAKE 55	BOUNA 61	GRAND LAHO 109	GUIGLO 112	KORHOGO 121	ODIENNE 160
1907						1,428	
1908						1,274	
1909						1,911	
1910		1,450				1,578	
1911		1,166				1,785	
1912		1,153				1,365	
1913		741				872	
1914		1,465				1,102	
1915		1,120				1,249	
1916		1,090				1,220	
1917		1,400				1,489	
1918		1,540				1,337	
1919		1,450				1,262	
1920	1,015	950	875			1,066	
1921	1,561	942	940	1,006		1,451	
1922	1,252	1248	885	1,125		1,350	1,848
1923	1,336	1,196	1,065	2,460		1,146	1,190
1924	1,203	1,308	1,345	1,733		1,507	2,188
1925	1,389	1,313	1,384	1,613	1,728	1,672	1,666
1926	1,383	1,338	1,209	2,004	1,608	1,184	1,815
1927	1,482	1,389	1,306	1,348	1,561		1,588
1928	1,356	1,386	1,327	1,401	1,973		1,736
1929	1,620	1,568	1,336	2,349	1,566		2,195
1930	1,134	1,456	925	1,520	1,793		1,185
1931	1,811	1,166	1,282	1,595	2,175		1,604
1932	1,107	1,128	1,034	1,514	1,511		1,967
1933	1,595	1,197	1,369	1,963	1,585		1,442
1934	1,496	955	1,176	1,320	1,283		1,490
1935	1,188	1,505	1,164	2,072	1,594		1,376
1936	1,242	1,031	892	1,396	2,069		1,649
1937	1,358	1,342	1,007	1,337	1,957		1,576
1938	1,492	1,043	1,053	1,763	1,573		1,591
1939	1,123	1,185	1,126	1,414	1,539		1,691
1940	1,320	982	1,124	1,629	1,561		1,239
1941	1,361	1,006	837	1,692	1,840		1,567
1942	1,159	909	821	1,378	1,448		1,410
1943	1,524	1,324	983	1,851	2,133		1,640
1944	1,176	1,225	962	2,021	1,460	1,380	1,269
1945	1,087	1,226	1,068	1,335	1,446	1,418	2,127
1946	852	995	726	1,002	1,637	889	1,921
1947	1,577	1,265	1,177	2,240	2,056	1,347	1,498
1948	1,187	1,163	914	1,395	1,371	1,274	1,605
1949	1,502	1,754	1,163	1,996	1,475	1,598	1,783
1950	1,101	901	1,025	1,606	1,288	1,258	1,203
1951	1,447	1,671	1,327	1,700	1,797	1,572	1,763
1952	1,970	1,126	1,358	1,948	1,704	1,434	1,648
1953	1,202	1,265	1,001	1,752	1,616	1,404	1,958

1954	1,578	1,103	1,047	3,051	1,677	1,307	2,188
1955	1,545	1,227	1,152	2,419	2,161	1,629	1,565
1956	1,114	789	949	2,082	1,116	1,216	1,416
1957	1,373	1,618	1,447	2,277	2,086	2,045	1,863
1958	1,159	914	1,013	1,246	1,326	925	1,496
1959	1,534	1,280	1,519	2,328	1,846	1,187	1,576
1960	1,547	1,259	1,154	1,192	1,826	1,705	1,421
1961	1,379	840	667	1,515	1,484	811	1,570
1962	1,397	1,092	1,389	2,581	1,774	1,410	1,626
1963	1,994	1,364	1,501	1415	2,446	1,565	1,769
1964	1,376	1,151	891	1,723	1,714	1,572	1,744
1965	1,207	999	1,018	1,617	1,687	1,415	1,529
1966	1,314	1,343	882	1,293	1,863	1,560	1,571
1967	1,151	939	994	1,843	1,145	1,255	1,626
1968	1,972	1,308	1,850	1,734	1,865	1,269	1,559
1969	1,275	990	1,325	2,555	1,544	1,559	1,562
1970	1,145	986	833	1,305	1,477	1,410	1,504
1971	909	1,266	1,078	2,329	1,755	1,152	1,750
1972	1,441	1,008	934	949	1,830	1,362	1,709
1973	1,480	931	1,099	1,203	1,383	1,183	1,357
1974	1,169	1,174	1,106	1,520	1,768	1,393	1,258
1975	1,322	918	1,103	1,762	1,585	1,326	1,451
1976	1,324	859	856	1,865	1,519	1,241	1,797
1977	1,358	1,248	1,111	1,735	1,682	1,350	1,624
1978	1,358	1,248	1,111	1,735	1,682	1,350	1,624
1979	1,358	1,248	1,111	1,735	1,682	1,350	1,624
1980	1,167	1,422	852	1,131	1,868	1,346	1,410
1981	1,447	1,150	802	1,205	1,618	1,198	1,457
1982	1,224	998	955	1,642	1,702	1,171	1,611
1983	1,095	727	722	983	1,305	836	1,038
1984	1,212	1,096	1,134	1,259	1,385	1,410	1,241
1985	1,502	1,423	1,073	1,320	1,617	1,425	1,099
1986	1,048	1,020	912	1,173	1,452	1,278	1,010
1987	1,491	1,222	1,153	1,328	1,501	1,176	992
1988	1,231	1,171	878	1,085	1,391	1,275	1,252
1989	1,974	1,149	1,315	1,849	1,760	1,242	1,355
1990	1,252	887	1,204	1,033	1,425	959	1,169
1991	893	1,058	997	1,373	1,860	1,212	1,305
1992	1,209	900	934	1,283	1,463	1,394	1,042
1993			1,118	1,867	1,853	1,099	1,197
1994		954	769	2,157	1,730	1,053	1,485
1995	1,537		1,118			1,356	1,533
1996	1,458	1,117	919	1,500	1,947	1,174	1,329
1997							
1998							
1999							
2000							
Average							
1921	1,358	1,248	1,111	1,735	1,682	1,350	1,624
1974							

Table 3.7-2 Periodical Changes of Irrigation Area and Farm Lands

Year	Irrigation area 1,000ha	Irrigation/Farm land %	Farm Land Million ha
1970	20	0.7	2.86
1975	38	1.1	3.45
1980	58	1.5	3.87
1985	64	1.6	4.00
1995	?	?	?

Table 3.7-3 Paddy Area and Production (1984)

Total Paddy area ha	Irrigated Paddy area ha	Percentage %	Production t	Production t/ha
400000	30,000	8	490,000	1.225

Table 3.7-4 Irrigation Area (1989)

Sugarcane	33,000ha
Paddy	20,000ha
Orchard	5,000ha
Vegetable	4,000ha
Total	62,000ha
Irrigation are	1.00%

Table 3.7-5 Land Use Change in Cote d'Ivoire and Neighboring Countries
(Unit: 10,000 ha)

Country	1974					1989					Total Area	Population Density (person /km ²)
	Farm land	Orchard/ Plantation	Grass land	Forest	Others	Farm land	Orchard/ Plantation	Grass land	Forest	Others		
Cote d'Ivoire	178	110	1,300	1,138	455	320	1	4,500	1,281	6,491	3,225	4.8
%	6	3	40	35	14	10	0	140	40	201	100	
Burkina Faso	244	1	1,000	756	737	355	1	1,000	666	716	2,742	35.7
%	9	0	36	28	27	13	0	36	24	26	100	
Ghana	105	189	500	919	587	114	158	500	814	717	2,385	72.3
%	4	8	21	39	25	5	7	21	34	30	100	
Guinea	58	11	615	1,554	221	61	12	615	1,464	307	2,459	25.6
%	2	0	25	63	9	2	0	25	60	12	100	
Liberia	13	24	570	216	141	13	25	570	176	180	1,114	29.4
%	1	2	51	19	13	1	2	51	16	16	100	
Mali	180	0	3,000	743	8,279	209	0	3,000	698	8,295	12,401	8.3
%	1	0	24	6	67	2	0	24	6	67	100	
West Africa	5,033	652	21,558	10,712	35,167	5,589	646	21,467	9,219	36,220	74,181	37.7
%	7	1	29	14	47	8	1	29	12	49	100	
Africa	15,687	1,707	89,580	72,266	117,178	16,816	1,883	89,084	68,357	120,273	303,068	23.7
%	5	1	30	24	39	6	1	29	23	40	100	

Others: Urban area, roads, desert, etc.

Annual Rainfall, Abengourou

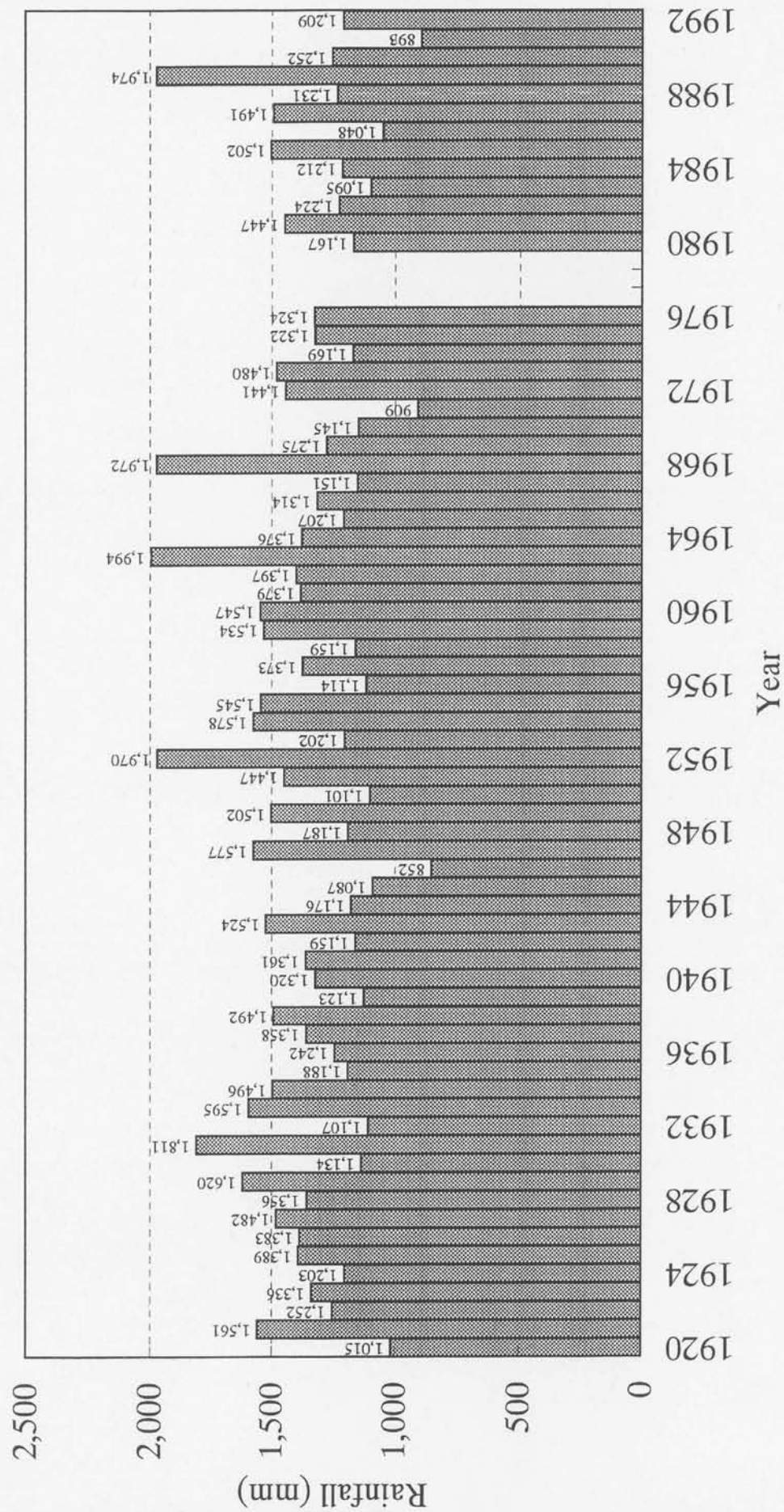


Figure 3.7 - 1 Annual Rainfall, Abengourou

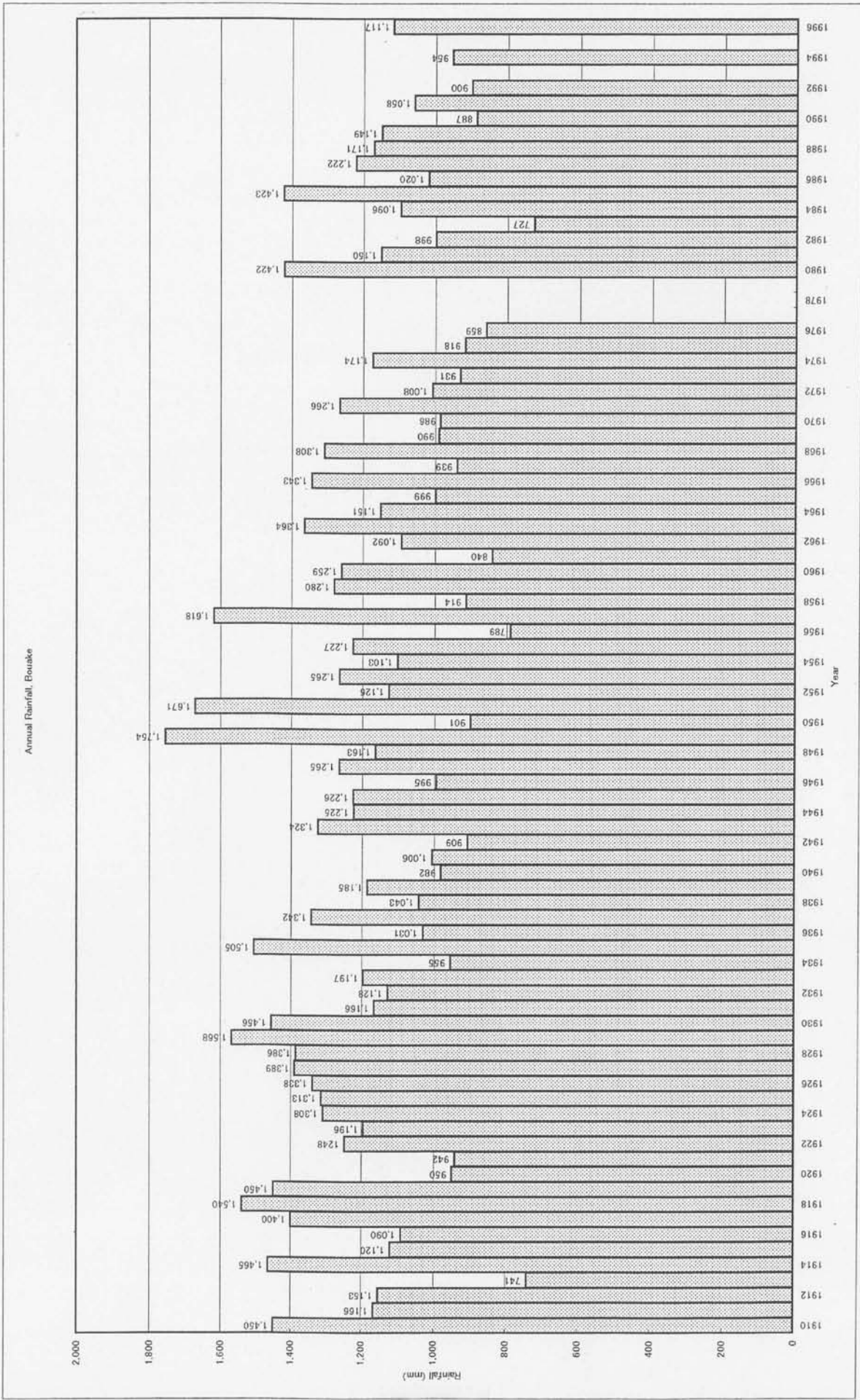


Figure 3.7 – 2 Annual Rainfall, Bouake

Annual Rainfall, Bouna

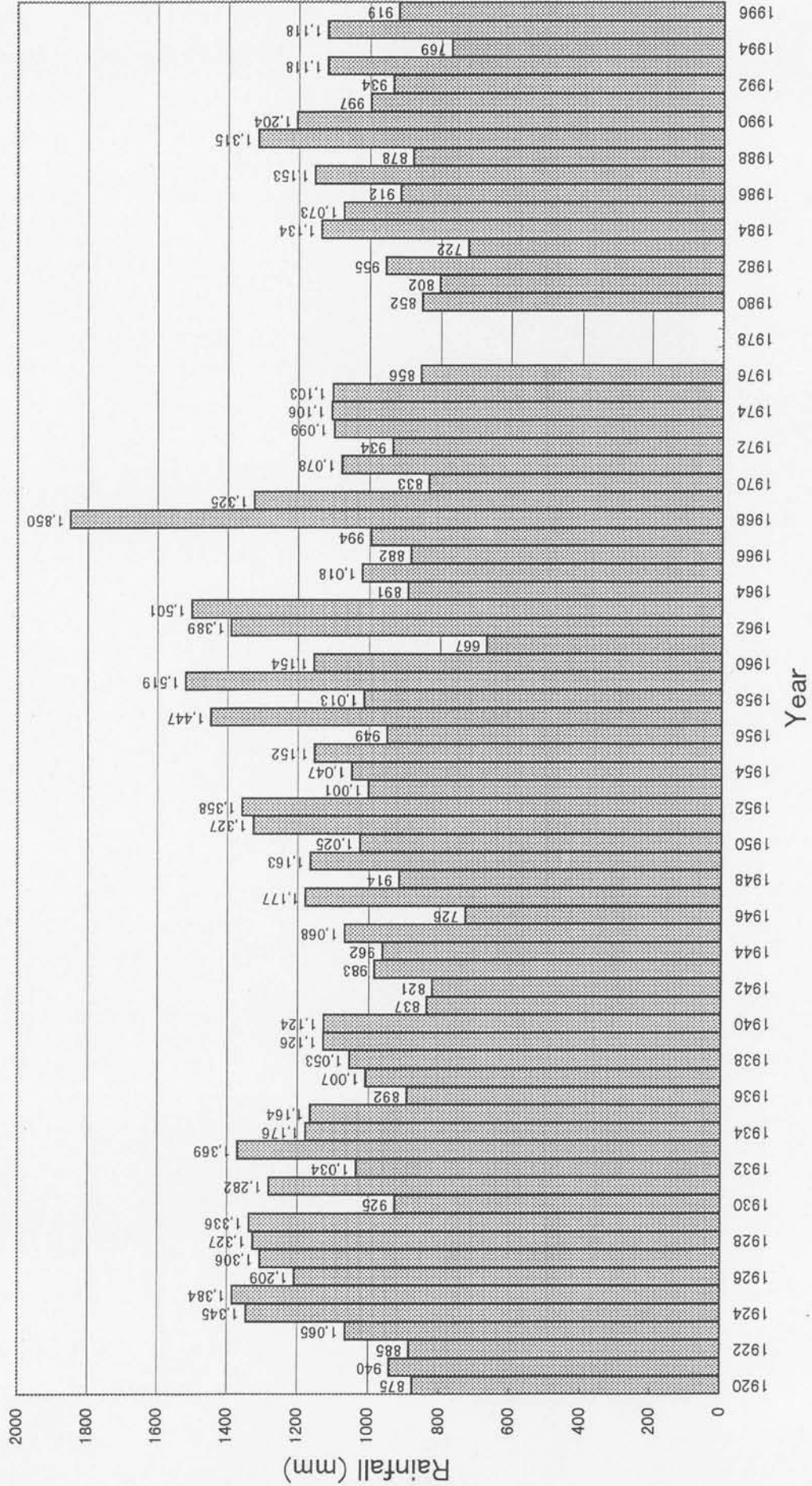


Figure 3.7 - 3 Annual Rainfall, Bouna

Annual Rainfall, Grand Lahou

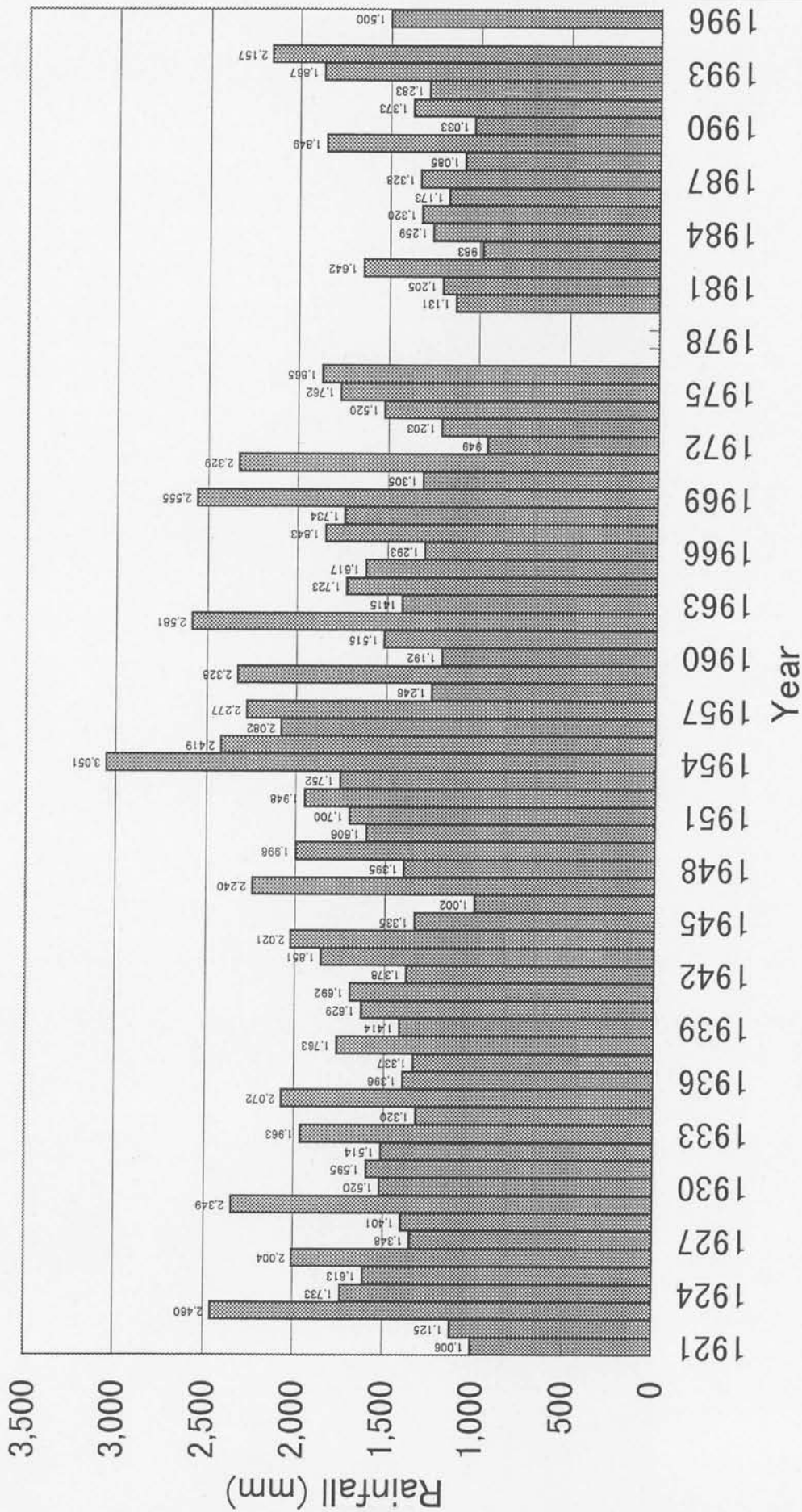


Figure 3.7 - 4 Annual Rainfall, Grand Lahou

Annual Rainfall, Guiglo

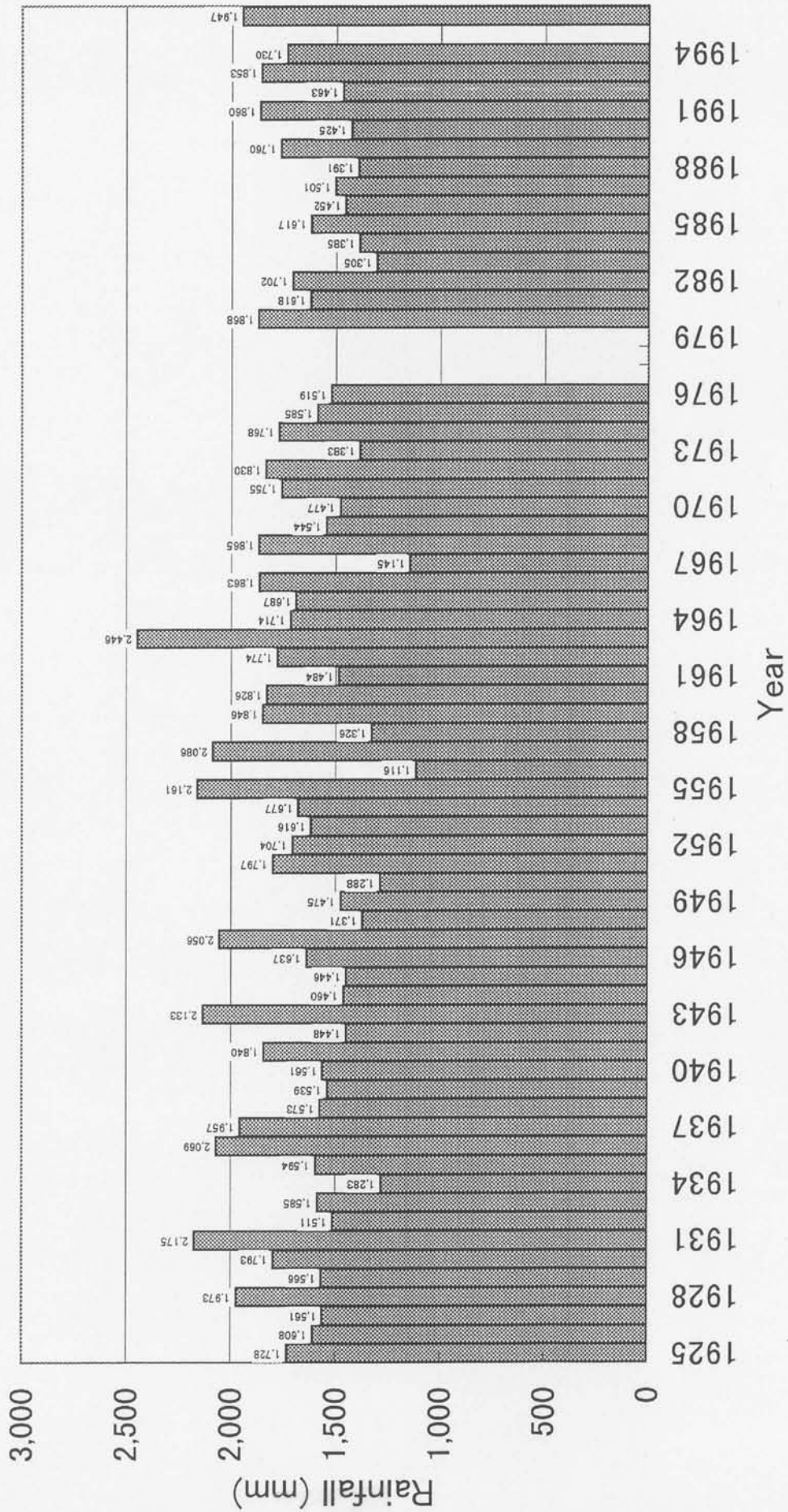


Figure 3.7 - 5 Annual Rainfall, Guiglo

Annual Rainfall, Korhogo

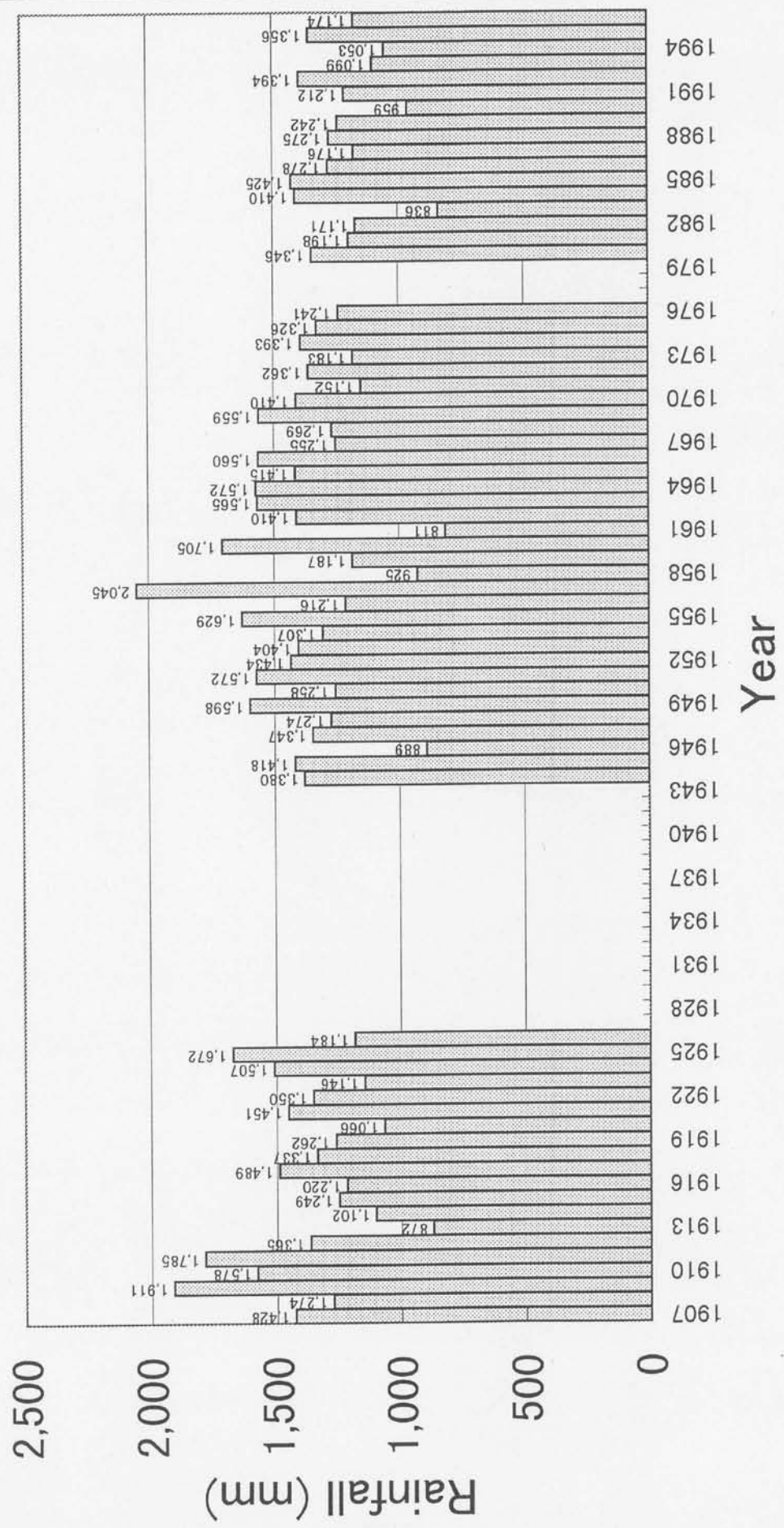


Figure 3.7 - 6 Annual Rainfall, Korhogo