Basic Design Study Report
on
Integrated Water Use Project
in
The Republic of the Gambia

May 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

BASIC DESIGN STUDY REPORT

ON

INTEGRATED WATER USE PROJECT

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P R E F A C E

In response to a request from the Government of the Republic of the Gambia, the Government of Japan has decided to conduct a Basic Design Study on the Integrated Water Use Project and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the Gambia a study team headed by Mr. Nagatoshi Makita, Director, Kohnan Division, Waterworks Bureau, Yokohama Municipal Government from January 29 to March 4, 1990.

The team exchanged views with the officials concerned of the Government of the Gambia and conducted a field survey in North Bank, Lower River and MacCarthy Island Divisions. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Gambia for their close cooperation extended to the team.

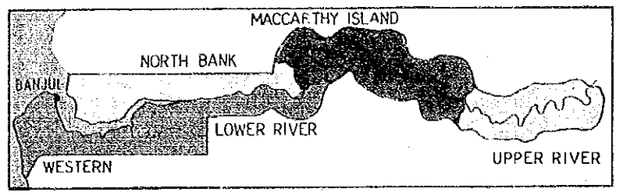
May, 1990

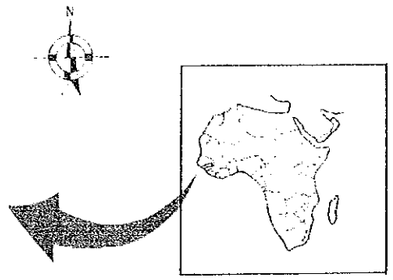
Kensuke Yanagiya

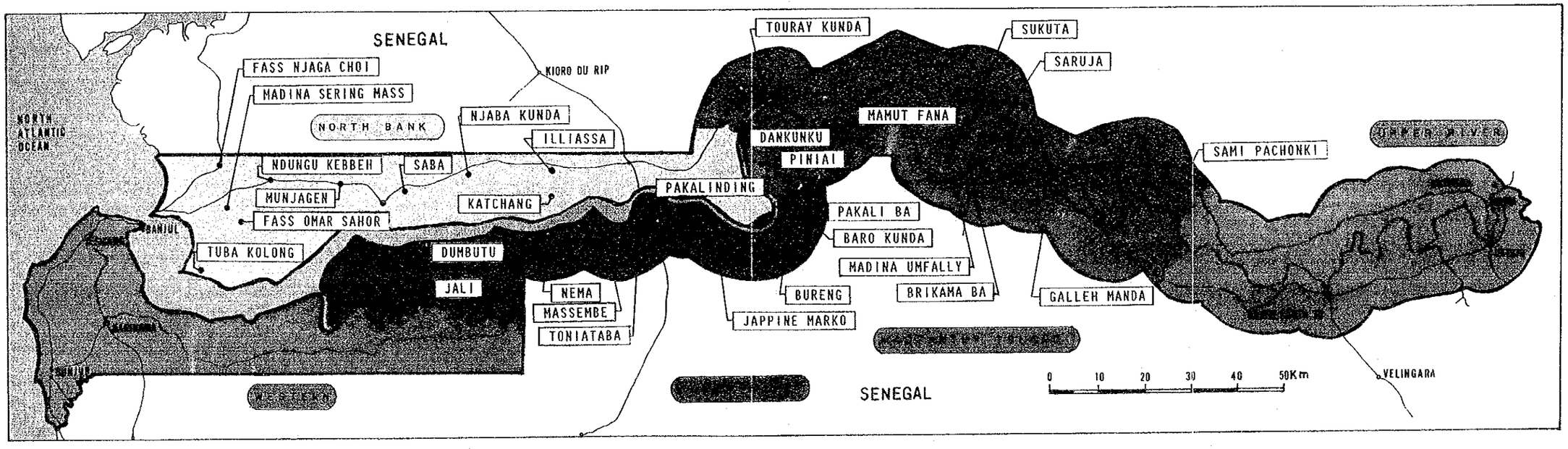
Kensuke Yanagiya
President
Japan International Cooperation Agency

PROJECT SITES

REPUBLIC OF THE GAMBIA







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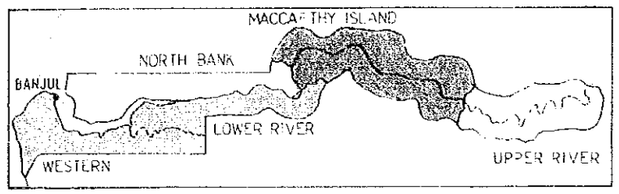

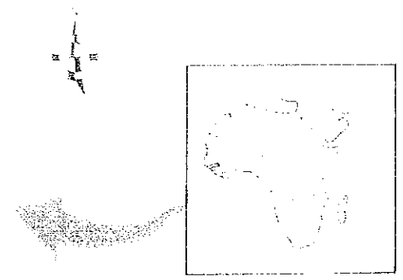

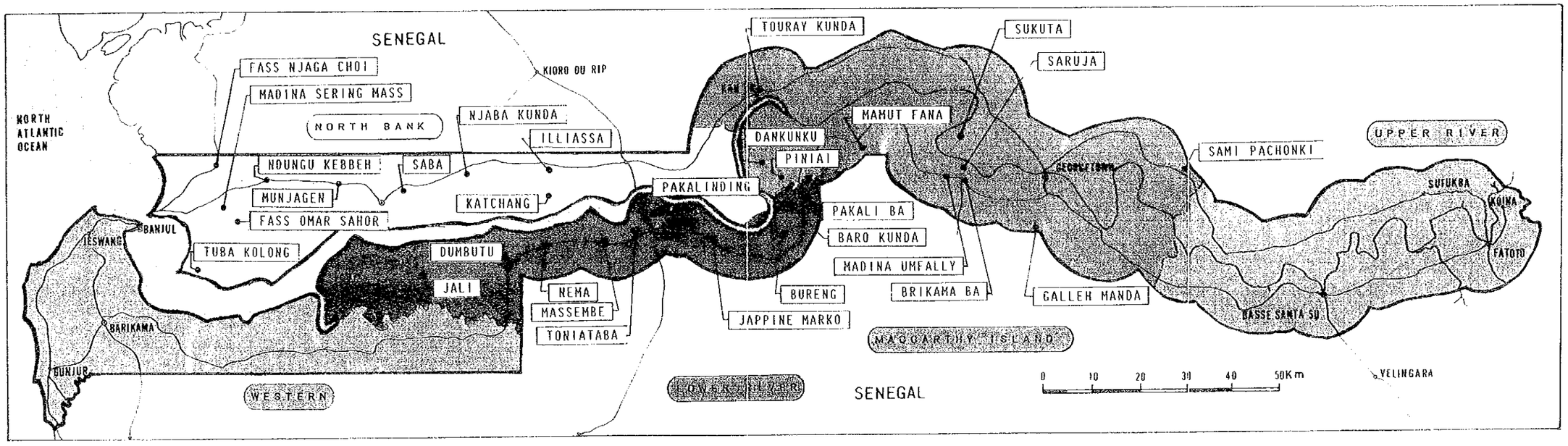

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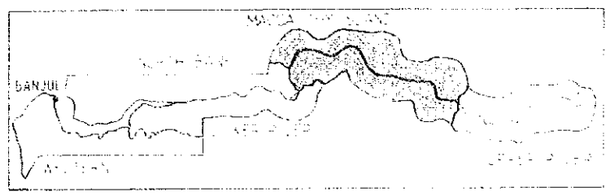

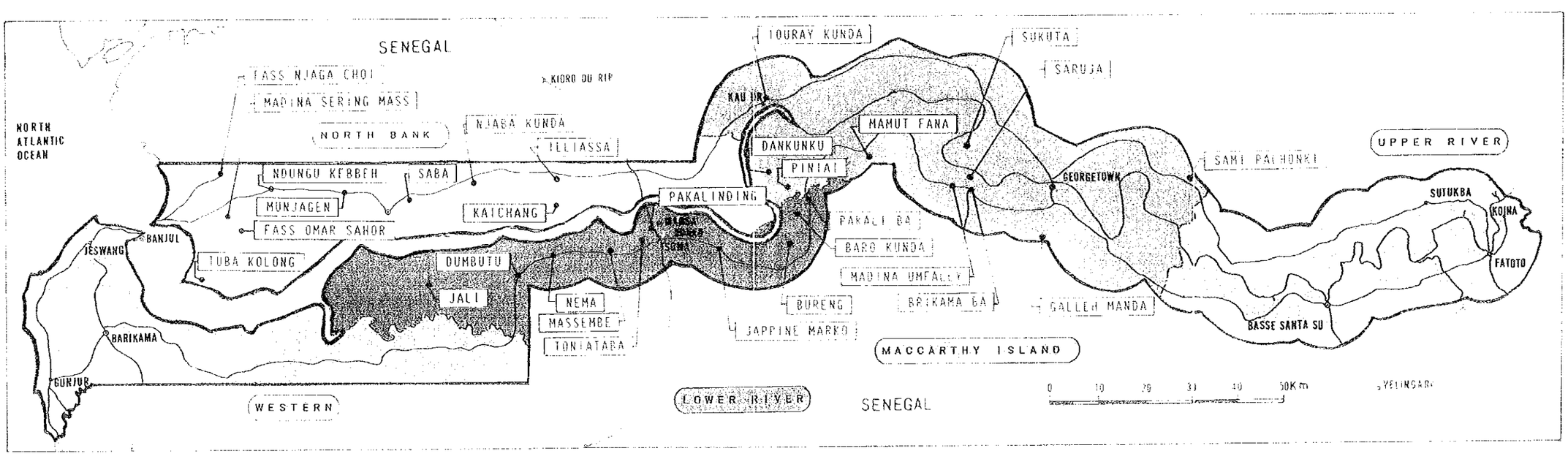

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LIST OF ABBREVIATIONS

Organizations

CEAO	Communauté Economique de l' Afrique de l'Ouest
CILSS	Comité Inter-Etats de Lutte Contre la Sécheresse dans le Sahel
DWR	Department of Water Resources
EEC	European Economic Community
GREC	Gambia Renewable Energy Center
GTZ	German Agency for Technical co-operation
GUC	Gambia Utilities Corporation
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
MEPID	Ministry of Economic Planning and Industrial Development
MWRFF	Ministry of Water Resources, Forestry and Fisheries
RWSD	Rural Water Supply Division
SSP	Saudi Sahelian Programme
UN	United Nations
UNCDF	United Nations Capital Development Fund

UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNSO	United Nations Sudano-Sahelian Office
UNV	United Nations Volunteers
WHO	World Health Organizations

SUMMARY

SUMMARY

The Republic of the Gambia is situated in the westernmost part of Sub-sahelian Africa, covers an area of about 11,295 km², and has a population of about 859 thousand (estimated in 1990). Most of the country consists of lowlands below 50 m above mean sea level and is located within the Sahel drought zone. The rural population of the Gambia (about 80% of the total) seriously suffers from the shortage of domestic water due to the arid climate. Until now, about 54% of the rural people have no water wells and are obliged to endure unsanitary drinking water. The Gambian people mainly depend on groundwater for their water needs, especially in the dry season. Even now, over 90% of the water wells are traditional wells; and only 7% are concrete lined wells and 2% are borehole type wells, where both types were drilled by the Rural Water Supply Division (RWSD) of the Department of Water Resources (DWR) under the Ministry of Water Resources, Forestry & Fisheries (MWRFF), and by international cooperations. Particularly, borehole type wells are so sanitary and stable quantitatively and qualitatively that more than 200 wells have been drilled and have become major water sources for the inhabitants. This type of well is being used for rural water supply (60%), for urban water supply (20%) and for irrigation and livestock (20%).

In 1981, the Republic of the Gambia established the RWSD of the DWR in the Ministry of Water Resources and Environment which was reorganized as MWRFF in 1988. This division commenced their activities for rural water supply schemes with the government budget and the cooperation provided by UNDP and other international agencies. Water supply facilities were planned to improve rapidly by the two Five Year Plans (1975-1981 and 1982-1986). The Economic Recovery Programme (ERP) (1986-1988) and the Third Five Year Plan (1987-1991) have given highest priorities to rural development in order to slow down the rural-to-urban migration by leveling the income and standard of living between rural and urban areas. However, wide gaps of income and standard of living still exist between the areas, and the population continue to flow into urban areas. In such conditions, a demand for further improvement of the water supply has arisen from rural inhabitants who suffer from the inability of securing minimal water supply. Thus, the Government of the Gambia decided to request major foreign countries including Japan to provide assistances for the improvement of rural water supplies in response to the demand, stressing the preference in introduction of the solar pumping method to cope with the energy problems of a non-oil producing country.

The Gambian government is hereby requesting the Government of Japan for economic cooperation and financial assistance in the form of a Grant Aid Project for the Integrated Water Use Project which will contribute to applied solutions to the problems arising from the drought situation, especially water supply shortage for human consumption as well as animal watering and agricultural purposes, and also to improve living conditions and public health conditions.

The project will be an integrated part of the Third Five Year Plan (1987-1991) and Economic Rolling Plan (1989-1991) and will also be fitted to the ERP (1986-1988).

The objective of this project is to establish the water supply systems which include construction of water supply facilities such as water wells, pumping units, storage tanks, pipelines and supply of equipment and materials concerning drilling works and operation and maintenance of the facilities.

In response to the request, the Japanese government decided to carry out a basic design study for the project and the Japan International Cooperation Agency (JICA) dispatched a team to the Gambia from January 29 to March 4, 1990 to carry out the basic design study which confirmed the details and background of the request, analyzed the scope, effects and feasibility of the cooperation and established basic concepts for designing an appropriate system together with necessary information.

The following is the summary of the recommendations and conclusious for the most appropriate rural water supply system for the Project. This is formulated through studying and analyzing the characteristics of groundwater resources and their underlying hydrological, meteorological and hydrogeological conditions, evaluating the reliability of the water resources, considering human-geographic environments such as surrounding conditions and areal characteristics, and discussions with the Government of the Gambia.

1) This project covers 30 sites as described below.

Division	District	Site
1) North Bank Division	6 Districts	10 Sites
2) Lower River Division	6 Districts	10 Sites
3) MacCarthy Island Division	8 Districts	10 Sites
3 Divisions	20 Districts	30 Sites

2) Design Conditions

Item	Design Conditions
Design Period	up to A.D. 2 0 0 0
Design Served Population	Population calculated on the basis of annual growth rate at 3.0%.
Unit Consumption	35 ℓ/capita/day, 35 ℓ/head of cattle/day
Daily Demand	(Daily Demand) = (Design Served Population) x (Unit Consumption) (Maximum Hourly Water Consumption) = (Hourly Demand) x (1.5)
Water Supply Facilities	The borehole type well is planned as the water source. Groundwater will be pumped and transported to an elevated water tank and distributed to the rural consumers. One public stand for people will be installated in each project site at the rate of 350 persons / unit and within a 15 minutes walking distance. A drinking trough for animals will be planned to be set at the order of 1,000 head of cattle/unit.

3) Scope of Project

The details of supply for this project was determined based on the basic concepts of the Gambian government and Rural Water Supply Projects assisted by WHO and UNDP, and on consideration of the urgency and self-contained nature of the project and the organizational capability of the RWSD which is deemed to execute the groundwater development projects after this project. This project will be initiated with the construction of water supply facilities for the existing borehole type wells of which hydrogeological characteristics as water sources are well defined in 5 sites, followed by the construction of water supply facilities for another 25 sites from the view point of the urgency and effective implementation of the project.

This project is summarized for the construction of water supply facilities and the supply of equipment and materials as below.

Construction of Water Supply Facilities (30 Project Sites)
1) Water Source: Borehole type wells 2) Intake Facilities: Submersible motor pumps, and diesel engine generators or solar systems 3) Water Tanks: Elevated water tanks 4) Distribution Lines: PVC/FRP and steel pipes 5) Service Facilities: Public stands for people, drinking troughs for animals

Supply of Equipment and Materials
1) Equipment and materials for borehole drilling and completion 2) Vehicles 3) Hydrogeological surveying equipment 4) Equipment for maintenance, spare parts

4) Implementation

This project is planned to be implemented in the following self-contained 4 phases in consideration of the work schedule, project scale, etc. Each phase is presumed to be completed within its implementation period of 12 months.

Phase	Project Description
1st Phase	1) Construction of water supply system for 4 sites using existing boreholes 2) Construction of borehole type wells for 2 sites 3) Supply of equipment and materials for boreholes drilling, construction and maintenance
2nd Phase	1) Construction of water supply system for 8 sites using existing boreholes 2) Construction of borehole type wells for 8 sites 3) Supply of equipment and materials for boreholes drilling, construction and maintenance
3rd Phase	1) Construction of water supply system for 9 sites using existing boreholes 2) Construction of borehole type wells for 8 sites 3) Supply of equipment and materials for operation and maintenance
4th Phase	1) Construction of water supply system for 9 sites using existing boreholes 2) Construction of borehole type wells for 7 sites 3) Supply of equipment and materials for boreholes drilling, construction and maintenance

5) Executing Agency

The executing agency for this project is the DWR under the MWRFF, whose RWSD is directly responsible for the project implementation.

6) Project Evaluation

The implementation of the project is expected to have the following effects.

a. Domestic water is stably supplied, and water quality, living conditions and public health environment can be improved. The improvement of public health environment is expected to lead to the reduction of water borne diseases and digestive diseases and contribute much to the improvement of public health and living conditions.

b. Installation of water supply facilities in rural areas will shorten the distance between water sources and houses, and reduce the time consuming task of fetching water for rural inhabitants especially women and children. This will lead to the increased participation of these inhabitants in more productive sectors of the regional economy.

c. The beneficiaries of this project is expected to total 75,000 which corresponds to about 10% of the rural population of the Gambia together with approximately 37,000 heads of equivalent cattle.

d. This project is expected to contribute greatly to enforcing the capability of water resources development of DWR through transfer of techniques to counterparts.

Finally, this basic design study brings a conclusion that the project is feasible to be implemented by the grant aid cooperation of the Japanese government.

CHAPTER I INTRODUCTION

CHAPTER I
INTRODUCTION

The Gambia is the sixteenth member of the British Commonwealth and the 115th one of the United Nations, being headed by President Al-Hajji Sir Dawda Kairaba Jawara. After its independence from Great Britain on 18 February 1965, a referendum in 1970 resulted in the country becoming a republic.

About two-thirds of the population engage in rain-fed agriculture, mainly in subsistence farming, livestock raising, and the cultivation of groundnuts: the Gambia's principal cash crop. Although farming and fishery continue to be the backbone of the country's economy, tourism is increasing in importance. Manufacturing activity in the Gambia is still very limited; the main activities are fruit and groundnut processing, a brewery, a tannery, brick plants, soap making, and a plastics factory.

The Government of the Gambia has spent much efforts to improve agriculture and social infrastructures such as roads, electric power and water supply in order to accelerate the social and economic development. A majority of the population (about 80 %) resides in rural Gambia under an arid climate. Most of them are engaged in agriculture, and since they are widely spread over the country, they suffer from the inability of obtaining sufficient drinking and domestic water, and are forced to remain in unhealthy, unsanitary living circumstances. Therefore, it is urgently needed to improve the rural water supply.

In the Gambia, the Ministry of Works and Communications (MWC) is responsible for the urban water supply services, while the Department of Water Resources (DWR) in the Ministry of Water Resources, Forestry and Fisheries (MWRFF) takes care of rural water supply services. In 1981, the Gambian government established the RWSD in the DWR taking the opportunity offered by the "International Drinking Water Supply and Sanitation Decade" and commenced the Rural Water Supply Project which included studies and development programmes of groundwater resources with support from UNDP and other international aid sources. A high priority is given to the issue for water supply in the Third Five Year Plan (1987-1991).

Thus, the Government of the Republic of the Gambia requested the Government of Japan for a grant aid for the construction of water supply facilities using

groundwater under the name of "Integrated Water Use Project". In response to the request, the Japanese government decided to perform a basic design study and the Japan International Cooperation Agency (JICA) dispatched a basic design study team headed by Mr. Nagatoshi Makita, Director of Kohnan District, Yokohama Waterworks Bureau, Yokohama Municipal Government to the Republic of the Gambia from January 29 to March 4, 1990. The team carried out a feasibilty study for the evaluation of the project under the Japanese grant aid programme from view points of the background of request details and scope of cooperation, and effects of the Project.

This Basic Design Study Report was compiled through the domestic analysis work from the results of the site survey. The report contains the optimal facility design, material and equipment selection, an operation and maintenance plan and recommendations for the implementation of cooperation. The minutes of meeting, field survey itinerary, lists of study team members and visited persons are also included in Appendices.

CHAPTER Ⅱ
BACKGROUND OF THE PROJECT

CHAPTER II
BACKGROUND OF THE PROJECT

2-1 General Condition of the Gambia

The Republic of the Gambia is a West African independent nation facing the Atlantic Ocean and a member country of the British Commonwealth of Nations. The nation has boundaries with Senegal to the north, east and south, being a long and narrow country of 325 km east-west and 48 km north-south with 11,295km² of land area. The country, having the River Gambia in its center, is composed of flatlands and its highest point is 53.4 m above MSL on the boundary to the east. Climatically, the Gambia teeters on the edge of the arid Sahel zone receiving annual average rainfalls ranging from 600 to 850 mm.

The Gambian economy is predominantly agricultural with two-thirds of the population engaged in this sector, and groundnuts are the country's only significant export item and principal cash crop: the Gambia and Senegal being the world's largest commercial producers of groundnuts.

The population of the country estimated in 1990 is 858,000 persons and the population density is about 76 persons per km². According to the Ministry of Economic Planning and Industrial Development (MEPID), the Gross National Product (GNP) of the Gambia in 1989 was 1,552.6 million Dalasis, with an annual average growth rate of 17.2% in the previous year. The GNP per capita was D.1,919 or US$ 226 which indicated a 14.0% annual increase from the previous year. The trade balance in 1988/89 was D.311,724 million in exports and D.980,060 million in imports with a deficit of D.668,336 million. The trade balance with Japan in 1987/88 was D.30.4 million in exports compared to while D.223.0 million in imports.

2-2 National Development Plan

The Government of the Gambia promoted the First Five Year Plan (1976-1981) and the Second Five Year Plan (1982-1986) aiming at "a diversified, progressively self-reliant economy capable of sustained economic and social progress through development and efficient use of its own natural and human resources". The First Plan, ended in June 1981, targeted the rural development in order to reduce urban-rural disparities in incomes and levels of living and slow down

the rural-to-urban migration. The Second Plan (1981/82-1986/86) continued the intensive efforts to enhance agricultural production for achievement of rapid economic growth with a progressive improvement in the rural standards of living and welfare. However, the slugging agricultural production and the unfavorable price indices of agricultural products in the international market could not reverse the declining Gambian economy and led to the formulation of the Economic Recovery Programme (ERP) in 1985. The ERP established strategical comprehensive structural adjustments against the economic crisis by the stimulation of agricultural production, the expansion of promising sectors such as fisheries, industry and tourism and the reformation and reduction of the civil services. With these adjustments, the Gambian government could obtain the credit and monetary assistance from the World Bank and the IMF.

The rural living conditions are still far-behind that of urban areas; the power and water supplies remain almost unprepared, and the level of living is still quite low. In order to improve these delays, the Gambian government set a target for the preparation of better living conditions in rural areas and the betterment of the level of living in the Third Five Year Plan (1987-1991) and started to perform them as Action Plans.

But the low performance due to the rapidly changing international economic environment brought a formation of a more realistic "Rolling Plan (1989-91)" as revision of the Third Plan.

The Rolling Plan contains integrated groundwater development projects to exploit and supply groundwater of good quality along the River Gambia for human needs as well livestock consumption and horticultural use. Although some of these projects have already started under technical and economic assistance from foreign countries and international organizations, most of them tend to delay with various reasons. As for the rural drinking water supply plans, there are 1,848 villages to be applied in the country in accordance with the DWR. As of 1989, borehole type wells of more than 200 are completed and concrete-lined large diameter wells number about 1,200. And there are 250 villages with more than 500 population which are believed to urgently need water supply facilities provided with borehole type wells totalling more than 1,000.

2-3 Administration of Rural Water Supply

The Republic of the Gambia has a unified water administration under the National Water Resources Council (NWRC). The Council is organized by 6 Ministers of the MWRFF, the Ministry of Works and Communications (MWC), the Ministry of Agriculture, the Ministry of Health, the Environment and Social Welfare, the Ministry for Local Government and Lands and the Ministry of Tourism with technical advisers consisting of Directors from Departments of these Ministries. The Council is the national policy making body for water resources and water services. The water supply is being executed by two different types of agencies; the urban type water supply for populated areas and the rural type water supply for villages. The Gambia Utilities Corporation (GUC), administrated by the MWC, serves the metropolitan Banjul and other 13 major cities while the RWSD, the DWR under the direction of the MWRFF is in charge of the planning and execution of water supply to rural villages.

The GUC commenced the water service to Banjul in 1916 prior to its reorganization in 1972 for urban utility services such as water, power and sanitation. Its total manpower numbers 843 while the DWR has a 220 work force.

It is reported that water of 18,000 m^3 is being supplied daily to 170,000 population in the metropolitan Banjul, which is 110 ~140 ℓ per capita per day with a leakage rate of 31%.

On the other hand, the joint group of the RWSD and UNDP Rural Water Project Team in the DWR has carried out surveying of groundwater potential nation-wide and formulating action plans for rural water since 1981. The total number of personnel in the Department is 308 whilst the Division has 123 persons. According to the statistics by UN specialists, the total number of Gambian villages is estimated to be 1,848 with a 858,626 population in 1990. About 57% of these villages have some type of water supply facilities while the remaining 43% are not equipped with any wells and suffers from the difficulty of obtaining healthy and safe drinking water in the dry season.

Even in villages with water supply facilities, very few of them possess safe water supply system with pipe-lines, and the majority are drawing by hand pumps from concrete-lined shallow wells drawing by hand from dug wells. These are

not only unsanitary but also limited in drawing capacity. Thus, the water supply system with powered drawing and pipe lines is urgently needed.

The DWR is looking forward to the introduction of non-conventional type pumping systems as a non-oil-producing country for the qualitative and quantitative improvement in water supply for rural inhabitants. The solar-pump project was tested successfully for 5 years from 1984 to 1989 in Kaiaf, Lower River Division, for a 2,300 village population. The system draws and supplies groundwater with the solar-powered pump and pipe lines to the village under the technical assistance from UNDP and UNCDF. Also a solar-powered submersible pump was installed in a borehole type well in Jambanjali, Western Division, in 1982 and was supplying for 7 years water to its population of 3,000 and livestocks under the Saudi Sahelian Programme (SSP).

Although both of them unfortunately stopped operation due to a problem in the pump itself for the former and a distribution panel trouble for the latter, the DWR understands the general feasibility and applicability of the solar-pump system and intends to promote its application in requests for assistance to CILSS (Comité Inter-Etats pour de Lutte contre la Sécheresse dans le Sahel), EEC and the Government of Japan.

2-4 Current Situation of Non-conventional-energy-powered Pumping Systems

The Gambian government is posting a strategical policy, as a non-oil-producing country, which aims at the introduction of non-conventional-energy-powered pumping systems, and the government indicated it on requesting this Project. After testing such non-conventional energy as solar and wind as electrical source for pumping system in small villages, the solar pump system is gaining recognition that this type can be utilized in small villages which characterize this country, and that if the system is small in size, the system is very reliable and practical.

The CILSS which consists of eleven West African countries has already started the project for installation of a total of 1,040 units of solar-pump systems in the 11 countries under the cooperation with CEAO (Communauté Economique de l'Afrique de l'Ouest). In the Gambia, the project has an installation schedule of 63 units of solar-pump systems. Some of the solar systems are already being operated and maintained by hands of inhabitants with the assistance of UNDP.

The Gambia established the Gambia Renewal Energy Center (GREC) under the supervision of the Ministry of Economic Planning and Industrial Development (MEPID) for the technical appraisal and field testing of equipment for non-conventional energy service including solar and wind energies. As for Solar energy, photovoltaic (PV) systems have been installed, utilized and operated successfully in 25 health centers and in 11 telecommunication stations.

For water administration strategy, the Gambia has intended to develop non-conventional energy utilization as a departure from heavy dependence upon fuels. Many test sites were visited during the basic design study inclunding PV pump systems which have been utilized in Jambanjali and Kaiaf since 1982 and villages where wind powered pumps have been supplying water, and it is judged that the solar power utilization is proceeding rapidly in the Gambia. Seven units of wind-pumps have been installed along the coast line in relation with the DWR. Although the test results are rather satisfactory, the small capability of pumping by wind-power might limit the application to only coast areas.

The idea of utilizing solar energy for small scale water pumping in the Gambia seems to be effective, owing to the geographical position of the country, favorable irradiation and daily length of sunshine. In the first half of the dry season, November to January, the irradiation is at its lowest, whereas at the end of the dry season, March to May, it is highest. The sunshine time varies from 6 hours per day in rainy months, July and September, to 9 hours a day in March and April.

In addition to that, it is possible to pump up groundwater to water tanks for storage of potential energy by utilizing maximum solar energy in the day-time for the water supply facility. This, in turn, reduces the necessity of expensive batteries for the storage of electricity for night-time. Thus, the overall energy efficiency can be expected to be high. It is very important to design appropriately the capacity of water tanks taking consideration of the actual pattern of 24 hours' water demand.

2-5 Economic and Technical Cooperation

The rural water supply projects are directly managed and operated by the RWSD.

The assistance records for the Rural Water Supply Project which were granted from 1977 to 1989 are shown in Fig. 2-1. There has been no bilateral grant other than the W. Germany Project and the SSP (started in 1985) of Saudi Arabia. There are no new projects after the completion of some NGO projects, which were sponsored by Caritas Foundations and Rotary Clubs (England). Although the Division has spent much efforts aggressively to survey the national groundwater potential and carry out development of groundwater with technical assistance of the UNDP expert team since 1981, their activities is diminishing due to the economical situation inside and outside of the Gambia. Nonetheless, the Gambia intends to introduce non-conventional-energy-powered pumping systems as the surviving strategy of a non-oil producing country, and the nation has its own programme to install solar pump systems in the country as part of the CILSS programme.

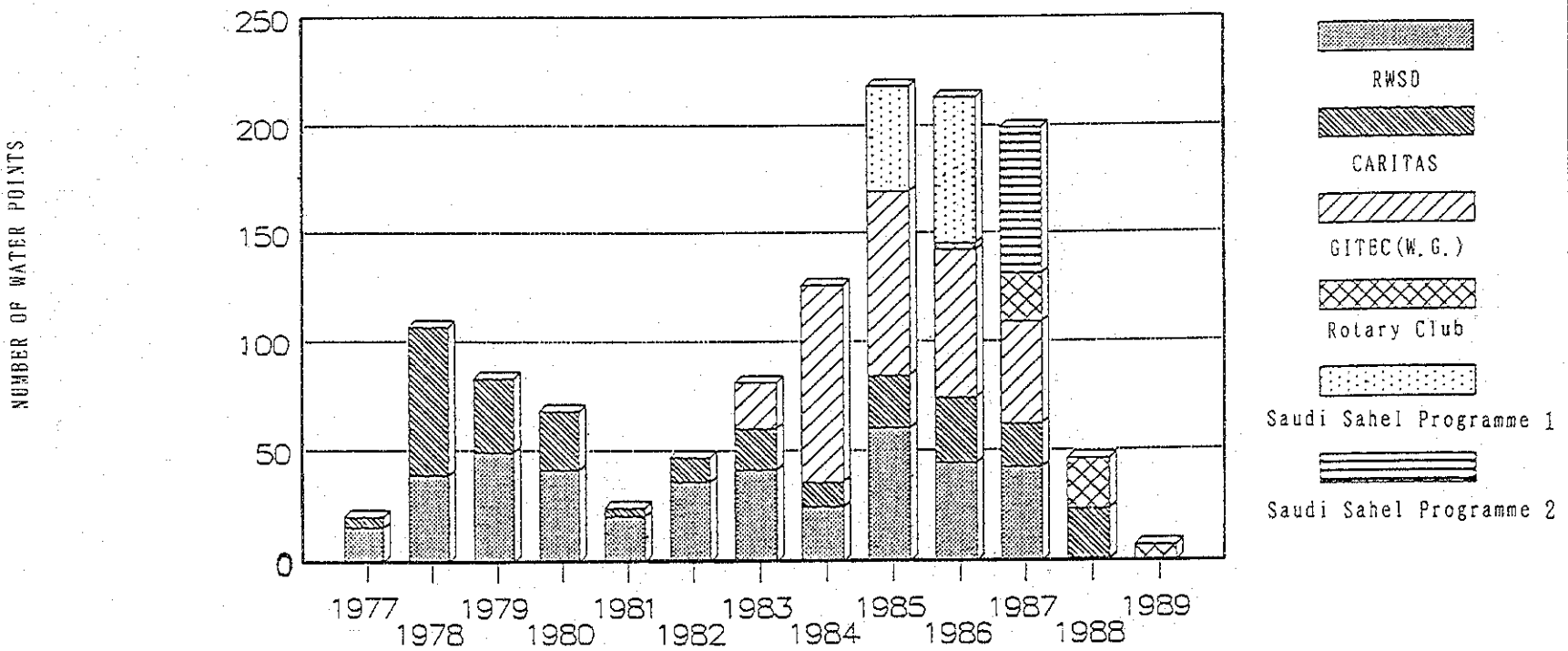
There are only two projects after 1990: one is an EEC project to rehabilitate 150 of the existing shallow wells, drill 13 borehole type deep wells and construct 20 pipeline water supply systems in relation to the CILSS programme for the utilization of solar-energy, and the other is under study for the supply of spare parts for maintenance material and equipment for the projects which were carried out by Saudi Arabia. Therefore, early implementation of the Japanese grant is eagerly desired.

Economic assistances have been granted by the Japanese government for such sectors as food, transportation, energy and fisheries, and technical assistances also have been given including training programmes and dispatching experts from Japan. Japan is in the sixth place for the amount of grant to the Gambia in 1987 with US$ 4,450 thousand (8.8% of total).

Particularly, the projects for power system of metropolitan Banjul and for Ferry Boats are evaluated to have a high impact on the Gambian economy among past grant aid projects. This is, however, the first project for rural water supply including groundwater development for Japan to the Gambia.

Fig. 2 — 1 Annual Water Point Production in the Gambia

1977–1989



2-6 Executing Agency

The executing agency of the Project shall be the DWR of the MWRFF, and the RWSD shall be in charge of actual activities. In 1988, the Ministry was reorganized from the Ministry of Water Resources and Environment which was established in 1981. The organization chart is shown in Fig. 2-2 for the MWRFF.

In response to the "International Drinking Water Supply and Sanitation Decade" offered by UNDP, a hydrogeological team which consists of personnel from the DWR and specialists dispatched by UNDP has surveyed and exploited the groundwater in the Gambia under the support of UNDP. The UNDP Rural Water Supply Project, in particular, was completed successfully in February 1990 with such effects as technical transfer and management skills to the RWSD and equipment, materials and vehicles were transferred to the Division. Thus the Division is deemed to perform its own activities with technical assistance by volunteers sent by UNDP.

2-7 Outline of the Request

The Rural Water Supply Project by the Government of the Gambia has been revised several times since the first request in 1984, and the present request is based on the final revision of 1988. This project has not been requested to other countries during this period. The main objectives of the request are the supply of equipment and materials necessary for drilling borehole type wells as water sources; the construction of systematic facilities for clean and stable water supplies which include water sources matched to the scale of the village, pumping facilities, water tanks, distribution lines, public stands for people and drinking troughs for animals; the technical transfer regarding ground water development; and the supply of equipment and materials for maintenance of the above-mentioned facilities.
This is summarized as follows:

① Supply of equipment and materials necessary for water well drilling and for the operation and maintenance of supply facilities.
- Equipment and materials for drilling of borehole type wells.
- Equipment and materials for groundwater development.
- Vehicles, Equipment and materials for operation and maintenance.
- Spare Parts.

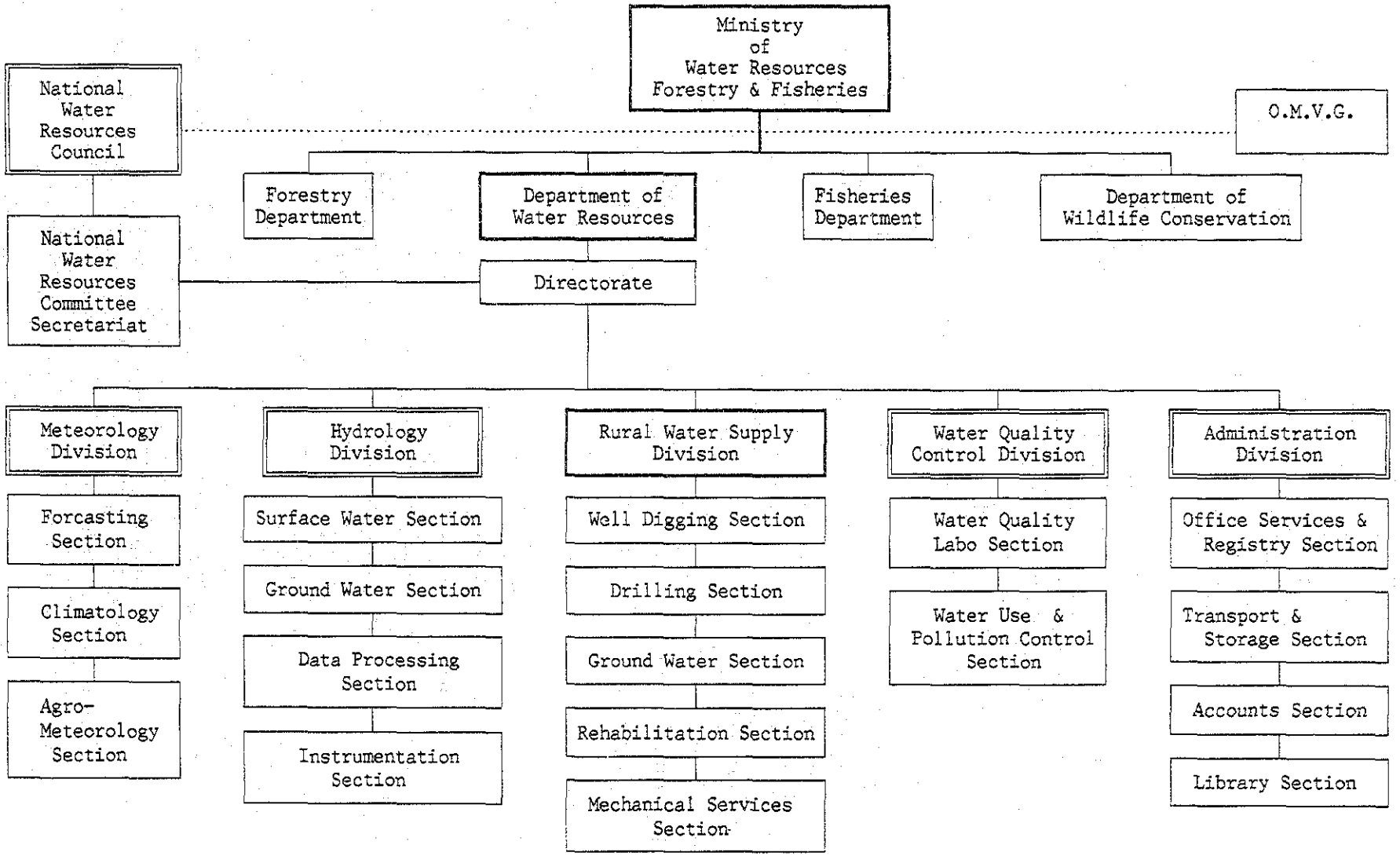


Fig. 2 — 2 Organization Chart of the Department of Water Resources

② Construction of piped water supply systems including borehole type wells for an objective 30 villages considering the solar-pump as a non-conventional-energy-powered pumping system.

③ Technical transfer related to the Project.

The DWR has spent its energy to promote the water supply services since early 1980's, but has still had rural water supply problem: the qualitative and quantative security of drinking water being the serious issue. The rural inhabitants of the Gambia (80% of the population) cannot receive sanitary and stable water supplies. In order to improve such living environments, the DWR requested to the Government of Japan to drill borehole type wells for non-polluted and stable water sources and to construct 30 sites of water supply facilities with distribution lines, supply equipment and materials related to the project, and introduce solar system which has been tested for operationability and maintenance since 1982 in the Gambia. As to the prioritiness of the project objective sites of 30 villages, initially 70 sites were selected among villages which had substantial population without sanitary water sources from a technical point of view with consideration of human-geographic environments, and were submitted to the NWRC which chose the 30 sites. The choice was agreed and desired at the Commissioner Meeting, assembled by Division Commissioners, to facilitate these water supply systems as soon as possible.

The Gambian government has posted the policies of rural development to stimulate agricultural production as an important issue, and the said Project is related to the Action Plan for improvement of the living environment and level of living in rural areas. Initially the rural water supply was defined by the Third Five Year Plan (1987-1991) but this was revised by the Rolling Plan (1989-1991) to cope with the rapidly changing national economy and is under action now.

This is the background for the Project which is formulated as an Action Plan. The actual effects from the Project are expected to be as follows:

① The security of stable and sanitary drinking water throughout the year and improvement of the level of living of these sites and public health environment through the water facilities of the project.

② The relief from heavy labour of women and children in carrying water by the shortened access to the water point through a public stand which will be set near the village. At the same time, they can contribute their relieved time and efforts to cultivate and produce vegetables in the "Women's Garden" by the increased available pumping rate.

③ Most of the villages where beneficiaries of the Project dwell are on traffically important and key points. Thus the increased benefits by the water supply will activate the local economy.

④ The future activities of the DWR will be strengthened to carry out groundwater development projects by themselves through the effect of the technical transfer and the materials and equipment for borehole drilling granted by the Project.

CHAPTER Ⅲ
OUTLINE OF THE PROJECT AREA

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OUTLINE OF THE PROJECT AREA

3-1 Project Area

The 30 sites requested by the Gambian government were surveyed (Fig. 3-1). The site study was carried out with an intimate cooperation of RWSD by questioning on the population, number of cattle, water use, water resources and water supply facilities, by hydrogeological survey, by geophysical survey, and by topographical survey of the village pattern.

From metropolitan Banjul, Medina Sering Mass is the nearest, 20 km away, and Sami Pachonki is the farthest, 300 km away, where both sites are located in the North Bank Division. The land is divided by the River Gambia and it is often needed to take a ferry boat for mobility. Careful scheduling is necessary to avoid waiting for hours and days to ride the ferry. Although Banjul/Bara and Elitenda/Bamba Tenda (which was granted from Japan in 1986) are quite punctual, ferries of Georgetown and Karawan have limited carrying capacity and are less punctual.

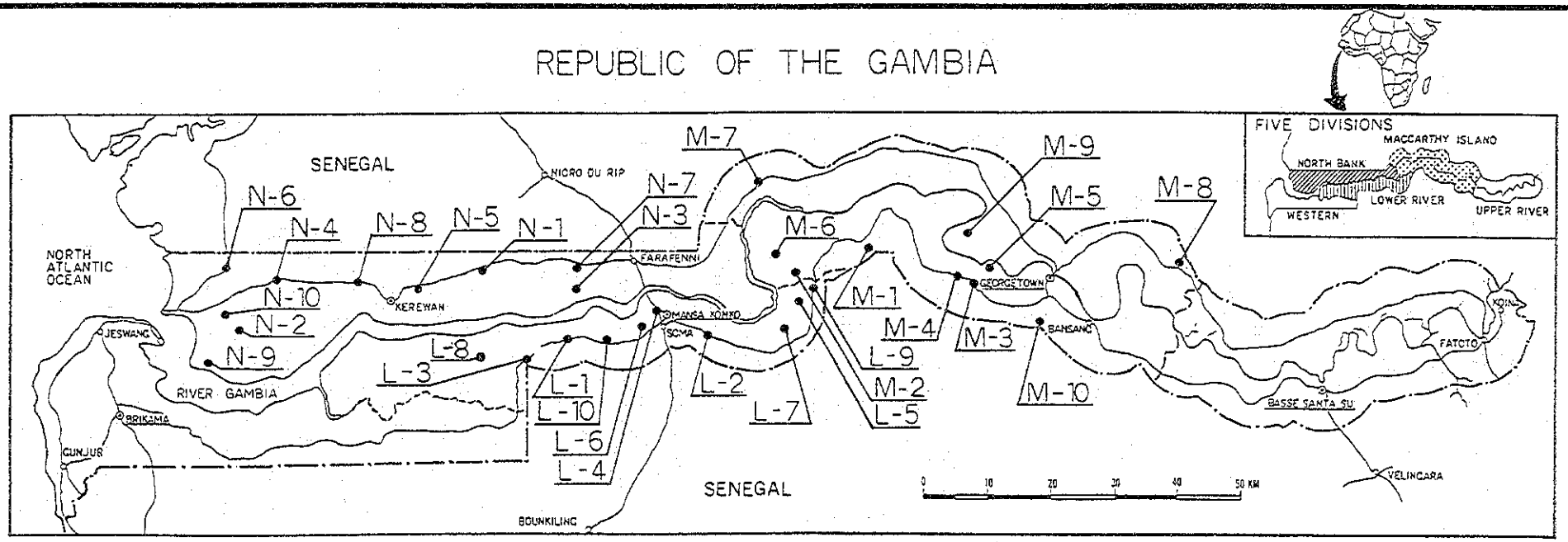
It is important to plan the construction period during the dry season because the unpaved roads are sometimes inaccessible during the rainy season, although the state roads are always poorly paved with numerous caved spots. Site access maps (a~g) are shown in Fig. 3-2.

3-2 Natural Conditions

3-2-1 Geography and Topography

The Republic of the Gambia is a long and narrow country with North-South distance of 48 km and East-West, 325 km along the River Gambia with a total area of 11,295 km^2. The country is bordered on three sides of North, East and South by the Republic of Senegal, and faces the Atlantic Ocean to the West. The Gambia lies between 13° 05′ and 13° 35′ north latitude and between 13° 50′ and 16° 47′ west longitude.

Fig. 3 — 1 Location of Project Sites



NORTH BANK			
No.	Code	Site Name	District
N— 1	4429	Njaba Kunda	Central Baddibu
N— 2	4114	Fass Omar Sahor	Upper Niumi
N— 3	4551	Katchang	Upper Baddibu
N— 4	4050	Ndungu Kebbeh	Lower Niumi
N— 5	4316	Saba	Lower Baddibu
N— 6	4014	Fass Njaga Choi	Lower Niumi
N— 7	4531	Illiassa	Upper Baddibu
N— 8	4233	Munjagen	Jokadu
N— 9	4156	Tuba Kolong	Upper Niumi
N—10	4044	Madina Sering Mass	Lower Niumi

LOWER RIVER			
No.	Code	Site Name	District
L— 1	3112	Nema	Kiang Central
L— 2	3412	Jappine Marko	Jarra Central
L— 3	3306	Dumbutu	Kiang West
L— 4	3313	Pakalinding	Jarra West
L— 5	3502	Baro Kunda	Jarra East
L— 6	3320	Toniataba	Jarra West
L— 7	3504	Bureng	Jarra East
L— 8	3007	Jali	Kiang West
L— 9	3521	Pakali Ba	Jarra East
L—10	3209	Massembe	Kiang East

MACCARTHY ISLAND			
No.	Code	Site Name	District
M— 1	6724	Mamut Pana	Niamina East
M— 2	6621	Piniai	Niamina West
M— 3	7413	Brikama Ba	Fuladu West
M— 4	7472	Madina Umfally	Fuladu West
M— 5	7543	Saruja	Fuladu West
M— 6	6506	Dankunku	Niamina Dankunku
M— 7	5064	Touray Kunda	Lower Saloum
M— 8	5454	Sami Pachonki	Sami
M— 9	5379	Sukuta	Niani
M—10	7437	Galleh Manda	Upper Niumi

Fig. 3 – 2 a Site Access Map

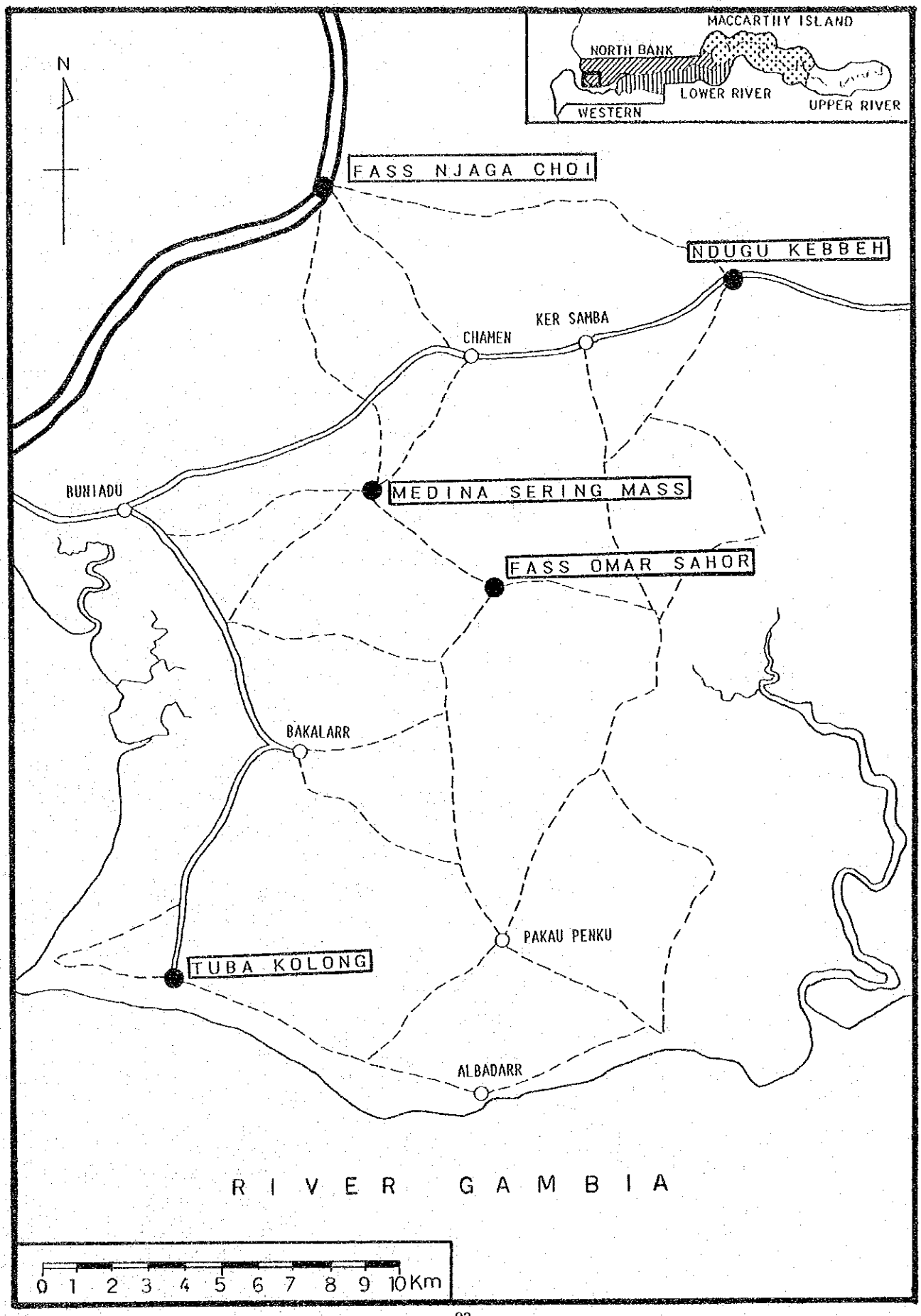


Fig. 3－2 b Site Access Map

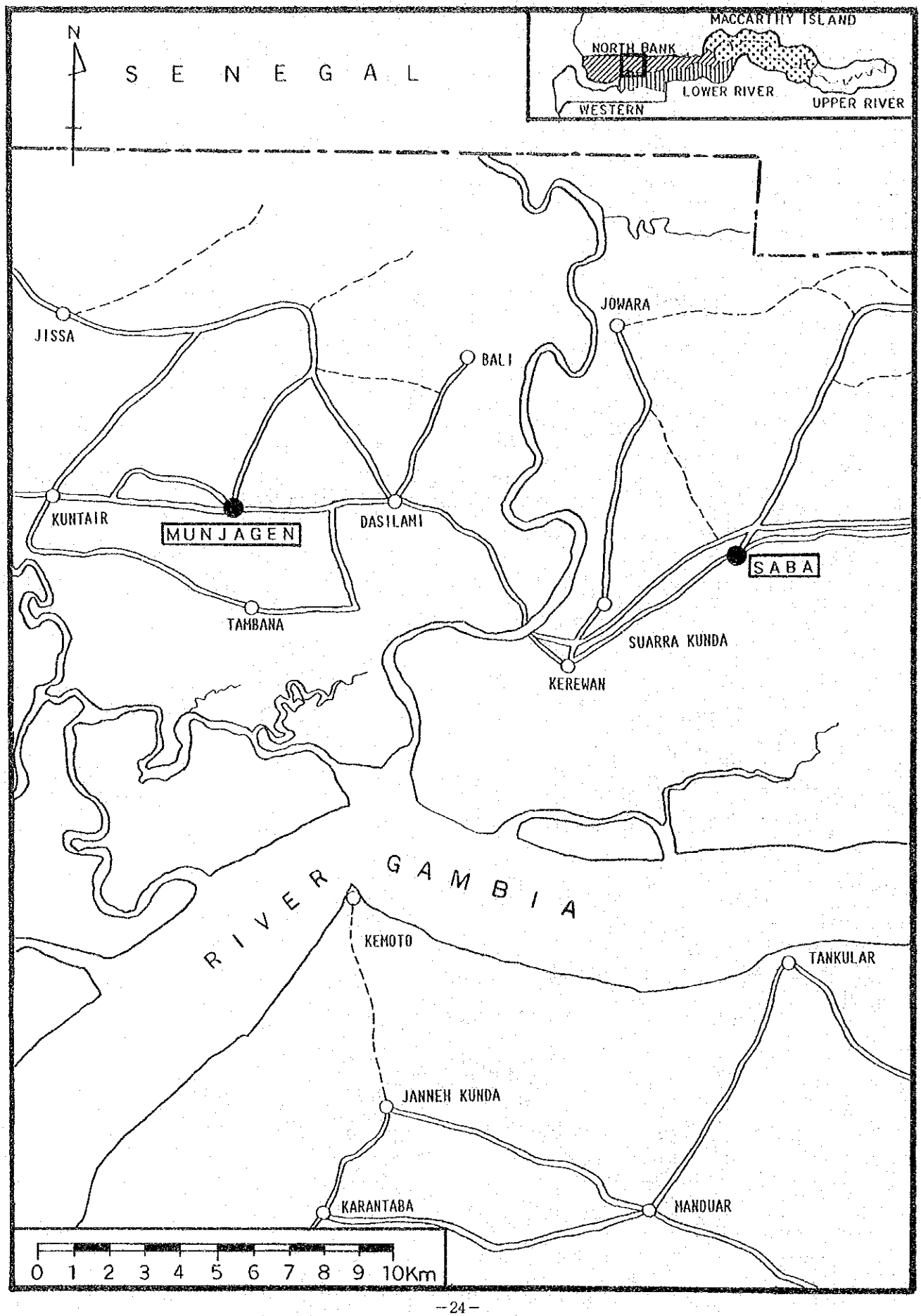


Fig. 3 — 2 c Site Access Map

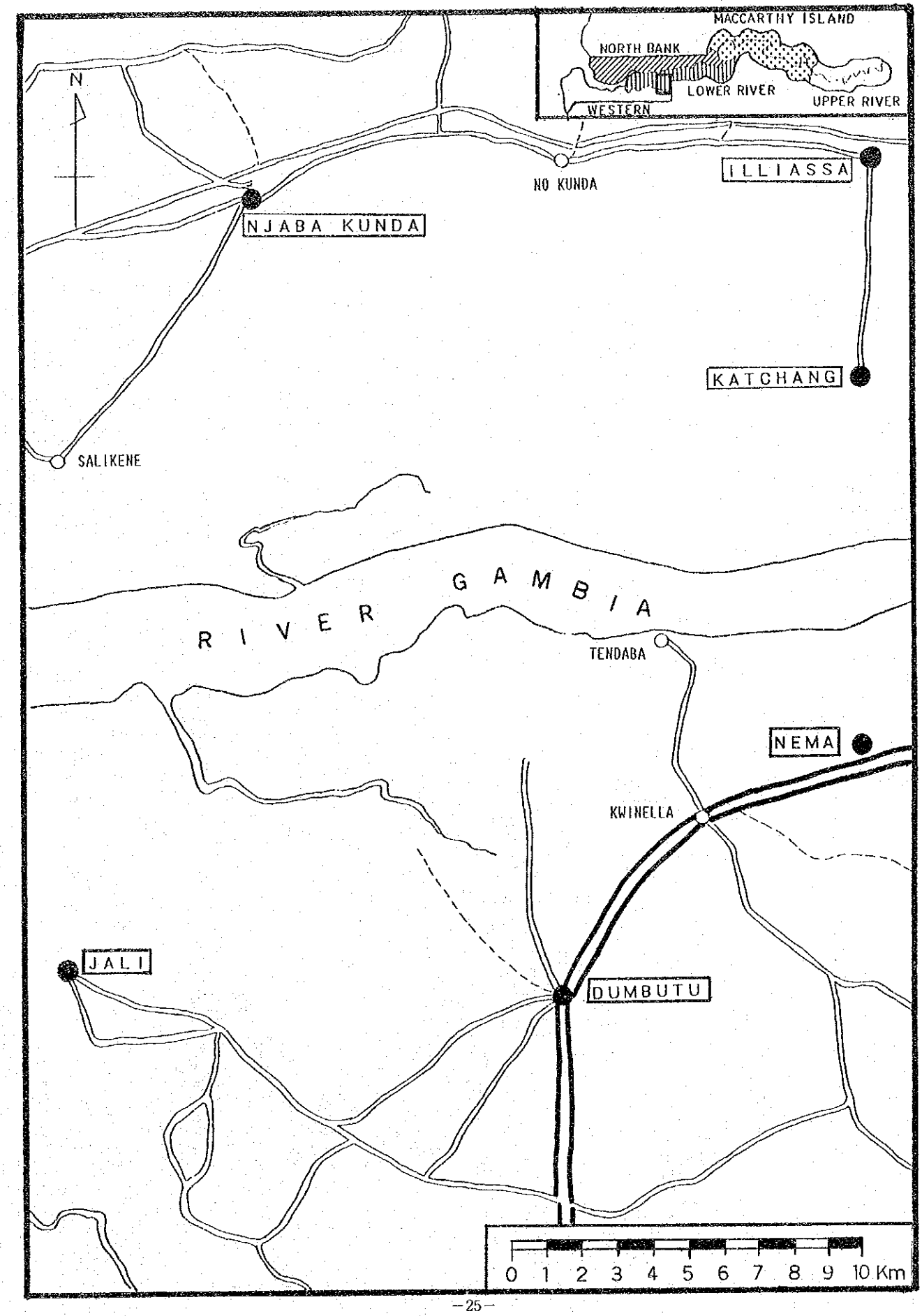


Fig. 3 – 2 d Site Access Map

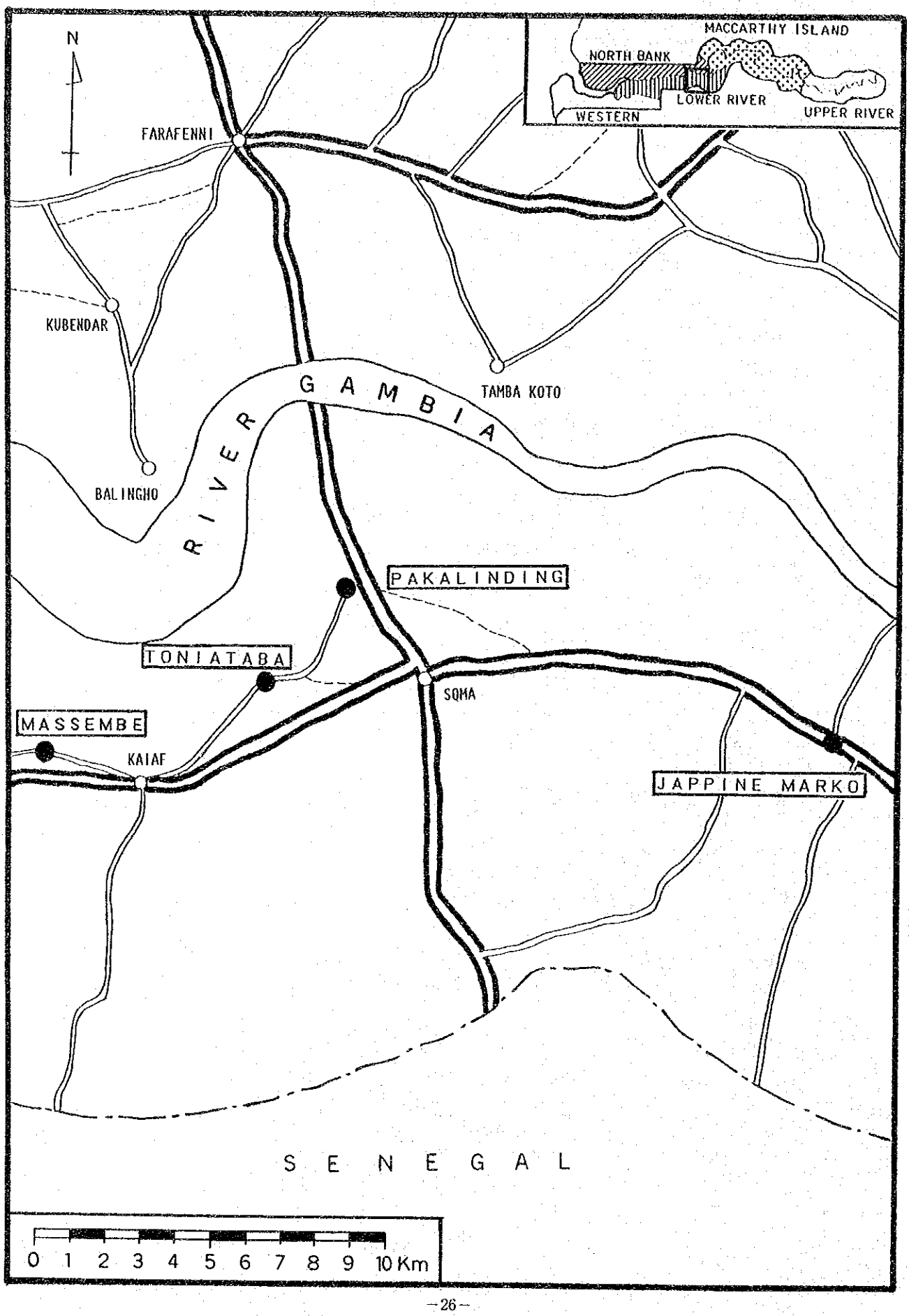


Fig. 3 — 2 e Site Access Map

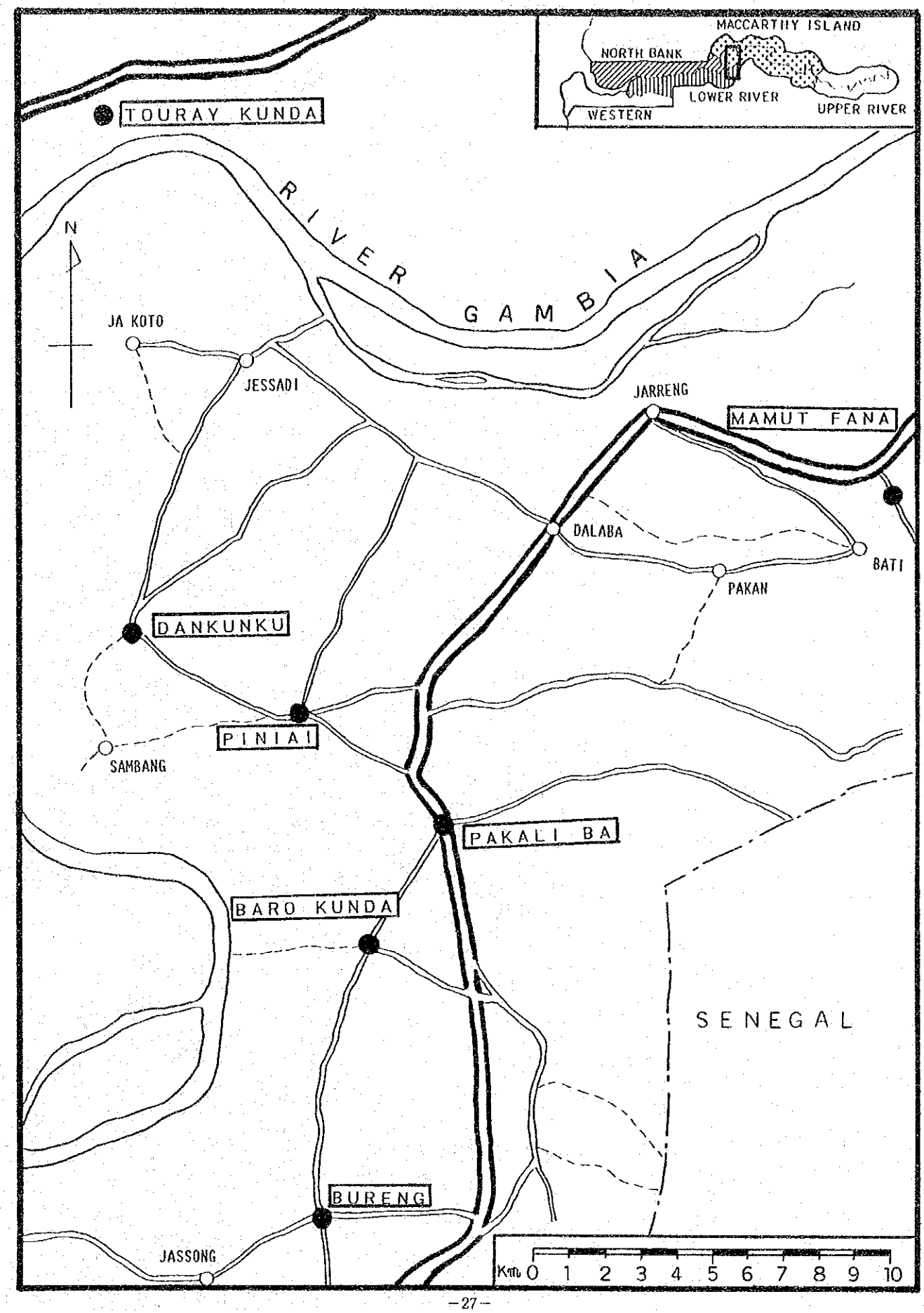


Fig. 3－2 f Site Access Map

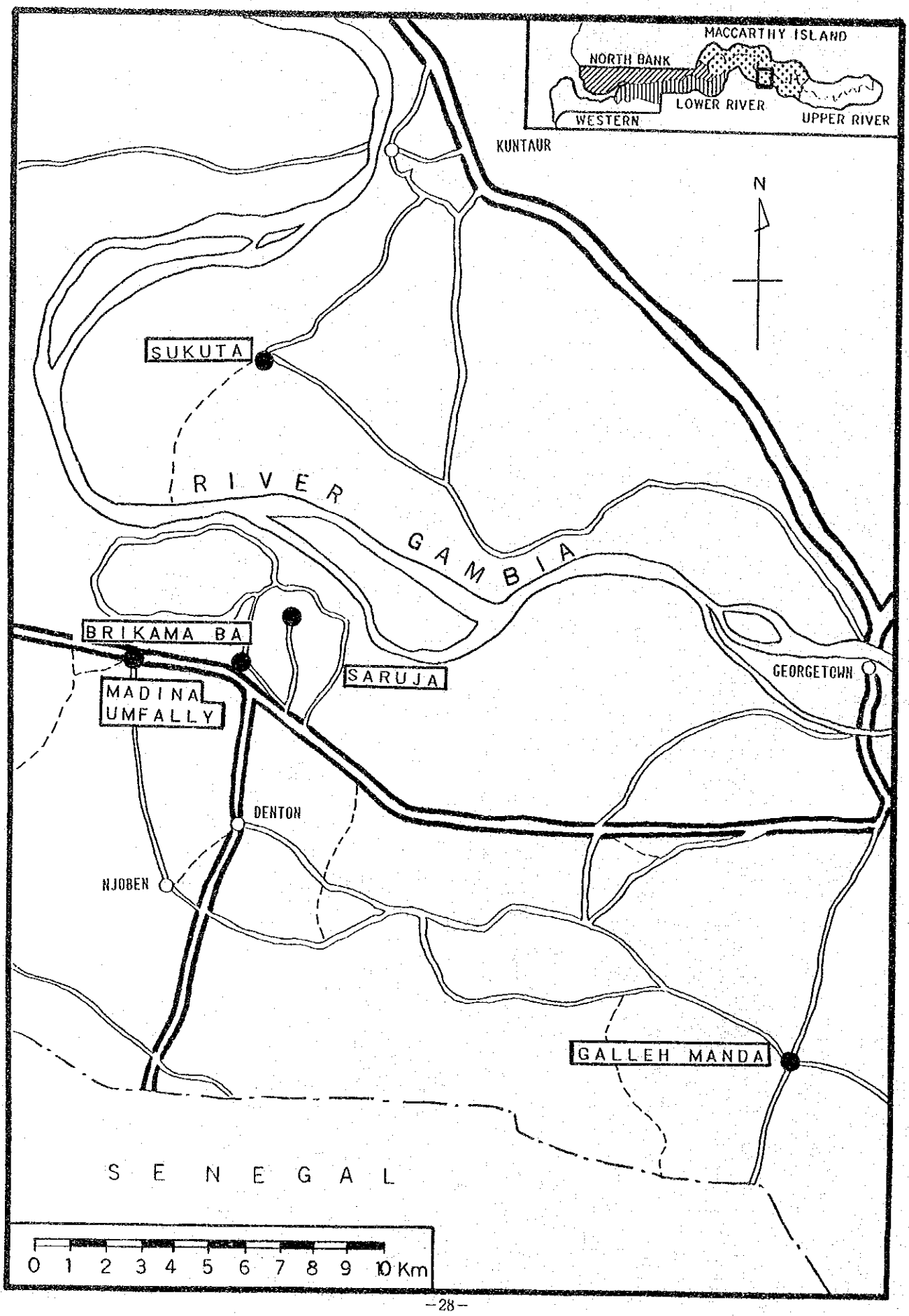
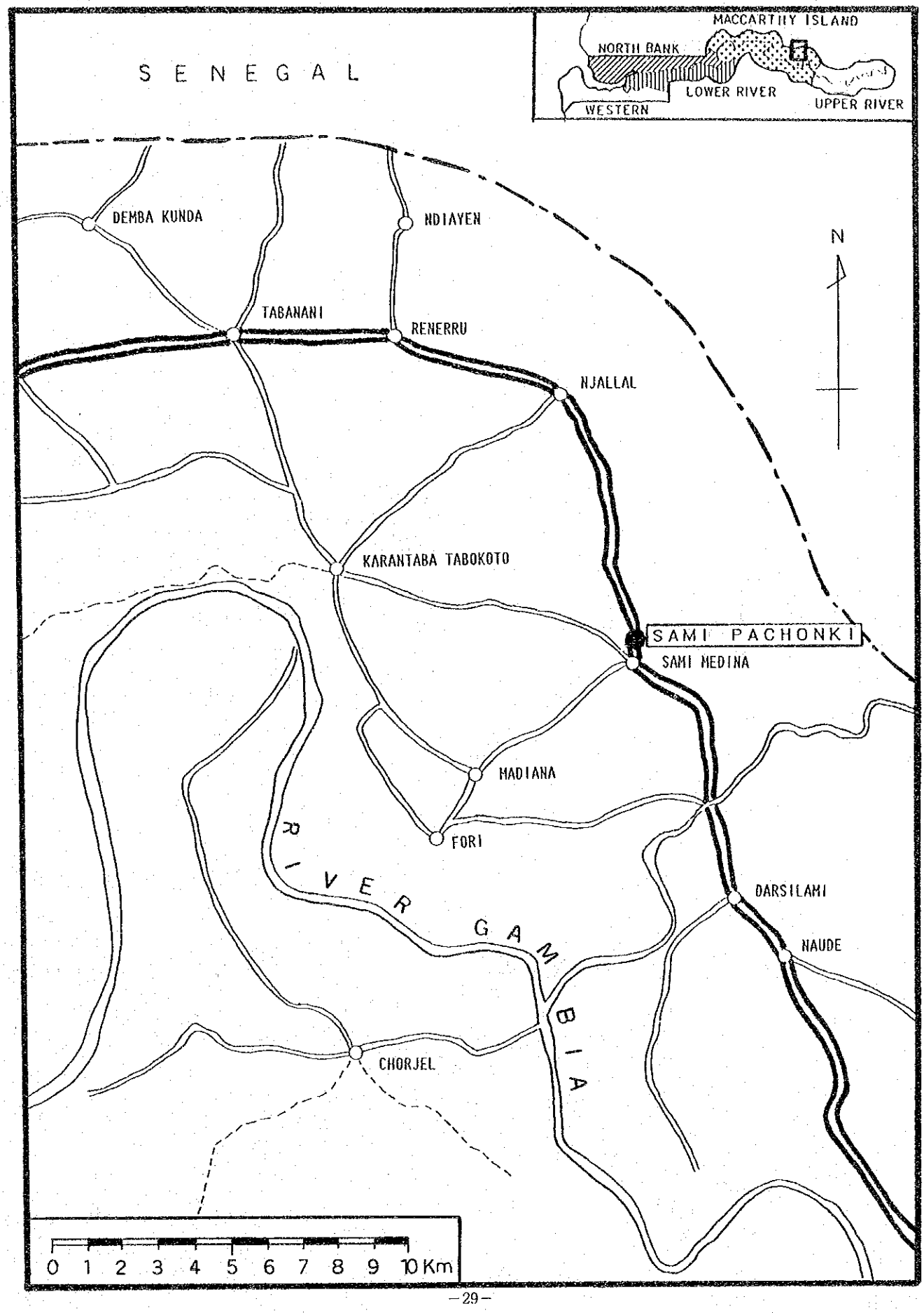


Fig. 3－2 g Site Access Map



Geographically, the Gambia is generally low and flat, with mangrove zones and swampy zones along the River Gambia and its tributaries and with hilly areas of outcrops of relatively dissected laterites. The hilly areas are dense woodlands, and villages and cultivated fields concentrate in low lands surrounded by hills with relative heights of 10 ~20 m. The highest point of this country is 53.4 m above MSL situated at the east end and slopes gently toward the west.

The River Gambia is a large river with a catchment area of about 77,850 km², originates from the north Fouta Djalon mountains and flows along the center of the Gambia from east to west. Its gradient is so gentle that saline water is said to go up 250 km in the dry season and 105 km in the rainy season from the estuary. Therefore, the river water is very salty so that this can not be used as either domestic water or cattle water.

3-2-2 Meteorology

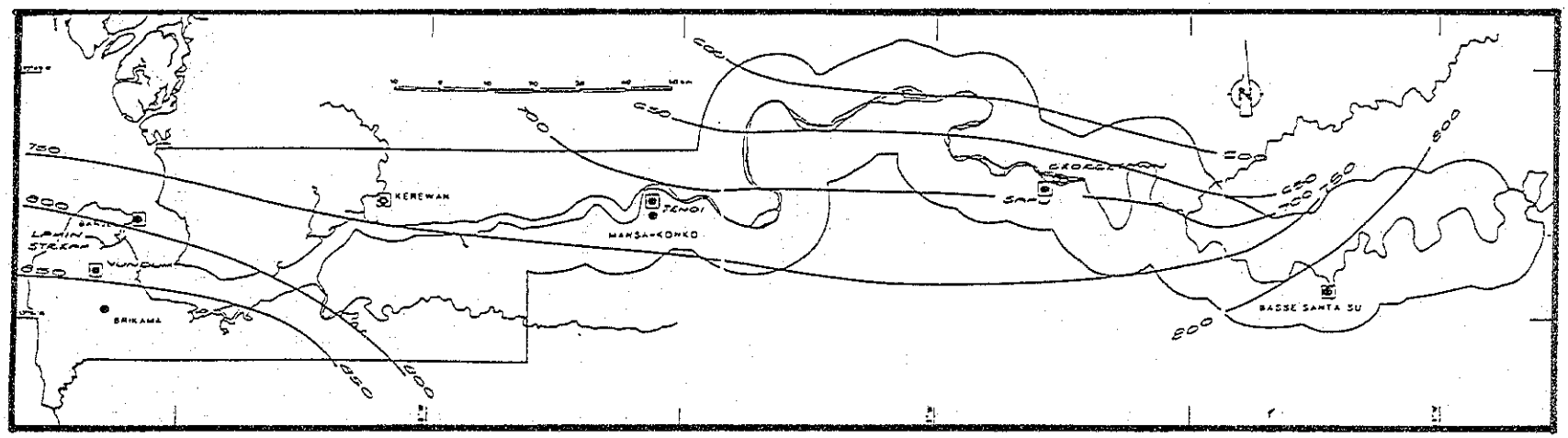
The Gambia has a semi-tropical savanna climate with rainy and dry seasons. Generally the dry season is November to May and the rainy season is June to October. The Harmattan, which is a seasonal wind containing dense fine sands, blows from the Sahara desert and brings lower humidity and relatively cool climate from December to February in the dry season.

Fig. 3-3 shows the average annual precipitation distribution from 1971 to 1985. The iso-precipitation lines are almost parallel east-west, increasing south ward: 600 mm in the north, 800~850 mm in the south. Although the annual precipitation ranges 600~850 mm, the annual evaporation is 1,600 ~2,220 mm which is more than double of the precipitation. (Table 3-1 and 2)

Table 3-3 shows the comparison ratio of the seasonal rainfalls in recent five years (1985-1989) to a normal year (country average 895.3 mm/year) for the Gambian major 8 cities in the rainy season (May-October). This table explains that the drought years have been recovering gradually because the ratio was 85% in 1985, 90% in 1986, 97% in 1987, 114% in 1988 and 99% in 1989 and recent years had more rainfalls than the normal year.

Fig. 3 — 3 Average Annual Rainfall in the Gambia

1971–1985



800 Isohyetals in mm

Meteorological Stations

Table 3 — 1 Mean Monthly Rainfalls at Meteorological Stations (1971～1985)

(Unit: mm)

Station / Month	Banjul	Yundum	Kerewan	Sapu	Georgetown	Jenoi	Basse
January	0.8	0.8	1.2	1.0	0.3	0.3	0.2
February	0.0	0.0	0.0	0.0	0.2	0.2	1.0
March	0.0	0.0	0.0	0.0	0.3	0.0	0.0
April	0.0	0.0	0.0	0.3	1.1	0.0	2.1
May	2.0	1.3	4.4	8.7	10.7	6.5	31.6
June	42.9	62.1	74.9	75.2	78.6	61.5	92.1
July	198.3	213.9	182.5	194.1	186.0	193.7	203.3
August	296.6	292.5	222.5	177.1	181.9	207.9	277.3
September	183.4	215.6	182.1	187.5	179.9	185.6	209.0
October	56.4	60.1	48.3	36.4	51.5	46.4	59.5
November	6.2	3.7	3.6	7.0	3.9	5.8	2.2
Decmber	1.0	1.5	2.2	1.7	1.1	1.5	0.5
Annual Total	787.6	851.5	721.7	689	695.5	709.4	828.8

Table 3 — 2 Mean Monthly Evapotranspiration at Meteorological Stations (1977～1986)

(Unit: mm)

Station / Month	Banjul	Yundum	Kerewan	Sapu	Georgetown	Jenoi	Basse
January	125	157	180	157	132	163	139
February	132	158	190	166	138	169	150
March	160	193	244	203	171	211	192
April	150	187	242	209	176	219	207
May	134	178	232	217	181	215	224
June	114	154	193	189	156	180	179
July	137	145	168	163	140	161	151
August	130	135	150	148	133	150	141
September	129	120	141	137	128	140	133
October	142	139	159	146	138	151	143
November	136	131	158	133	127	143	130
Decmber	116	138	162	139	121	145	123
Annual Total	1606	1839	2221	2010	1741	2046	1912

Table 3 — 3 Comparison of Average Rainfall

Year / Station	Normal	1985		1986		1987		1988		1989	
	Seasonal Total (mm)	Seasonal Total (mm)	Percent Normal as 100%	Seasonal Total (mm)	Percent Normal as 100%	Seasonal Total (mm)	Percent Normal as 100%	Seasonal Total (mm)	Percent Normal as 100%	Seasonal Total (mm)	Percent Normal as 100%
Banjul	1017.9	929.2	91	696.8	69	903.1	89	1030.7	101	897.9	88
Serrekunda	796.5	913.1	115	694.6	97	843.5	106	1125.5	141	880.0	111
Yundom	1038.3	961.6	93	761.7	73	800.4	77	1228.8	118	1132.4	109
Kerewan	982.9	636.3	65	599.5	61	955.6	97	1337.0	136	717.4	73
Jendi	719.6	629.5	87	876.6	122	648.9	118	915.6	127	887.1	123
Sapu	792.8	556.6	70	819.0	103	862.8	109	819.77	94	860.6	109
Georgetown	873.3	625.1	72	1053.4	121	879.4	101	619.77	94	770.9	88
Fasse	940.9	824.4	89	951.4	101	824.1	86	943.1	100	944.9	100
Country Average	895.3	759.7	85	806.6	90	854.7	97	1022.2	114	886.4	99

3-2-3 Geology

The Republic of the Gambia is located at the east end of the central part of the Senegal sedimentary basin, and a majority of its land is of low hills and plateaus of below altitude 50 m and covered by thick laterite or dune system.

Its lithology corresponds well to that of neighbouring countries including Senegal (Fig. 3-4). The Senegal sedimentary basin has a basement of granite, gneiss and crystalline schist of Precambrian age or Paleozoic massif. A basin building occurred in late Paleozoic accompanied with step faults of S-N, West dip. Thick sediments of Mesozoic, lower Tertiary and upper Tertiary were formed and the sedimentation ended at a formation called Continental Terminal from Pliocene at the end of early Tertiary to Pleistocene of Quaternary.

The geophysical survey results for petroleum exploration at the estuary and in off shores revealed that the thickness of sediment is estimated to be about 10,000 m and a petroleum exploration well at Sere Kunda totaled the depth at 3,709 m in Aptian stage of Cretaceous formation.

3-2-4 Hydrogeology

The Republic of the Gambia has an affluent potential for groundwater all over the country. Fig. 3-5 represents the hydrogeological east-west cross section of the Gambia from the compilation of existing well data and groundwater exploration wells, and also indicates the piezometric level of confined aquifer in Maestrichtian.

From these facts, the aquifers can be expected as follows, and ③ Confined aquifer of Miocene is most prosperous, quantitatively and qualitatively.

① Un-confined aquifer in Holocene
② Semi-confined aquifer in Continental Terminal
③ Confined aquifer in Miocene
④ Confined aquifer in Maestrichtian

① Un-confined aquifer in Holocene spreads along the River Gambia and its tributaries. But saline water goes up the River Gambia to 250 km from Banjul in the dry season; thus, this water source is not considered to be appropriate for drinking due to the undesired water quality of high salinity and vegetable fibres in sediments.

Fig. 3 — 4 Geological Map of the Gambia and Neighbouring Countries

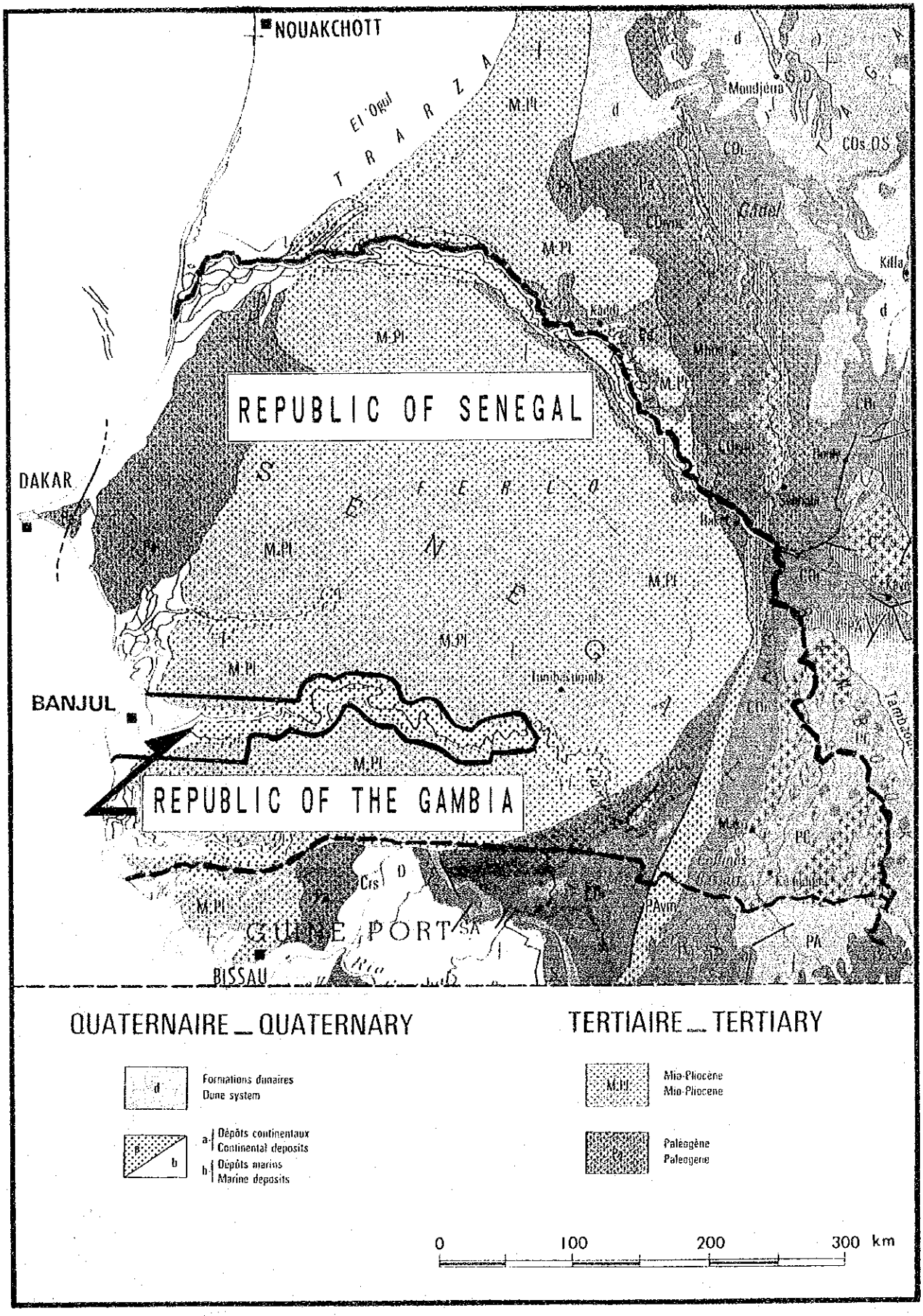


Fig. 3 — 4 Geological Map of the Gambia and Neighbouring Countries

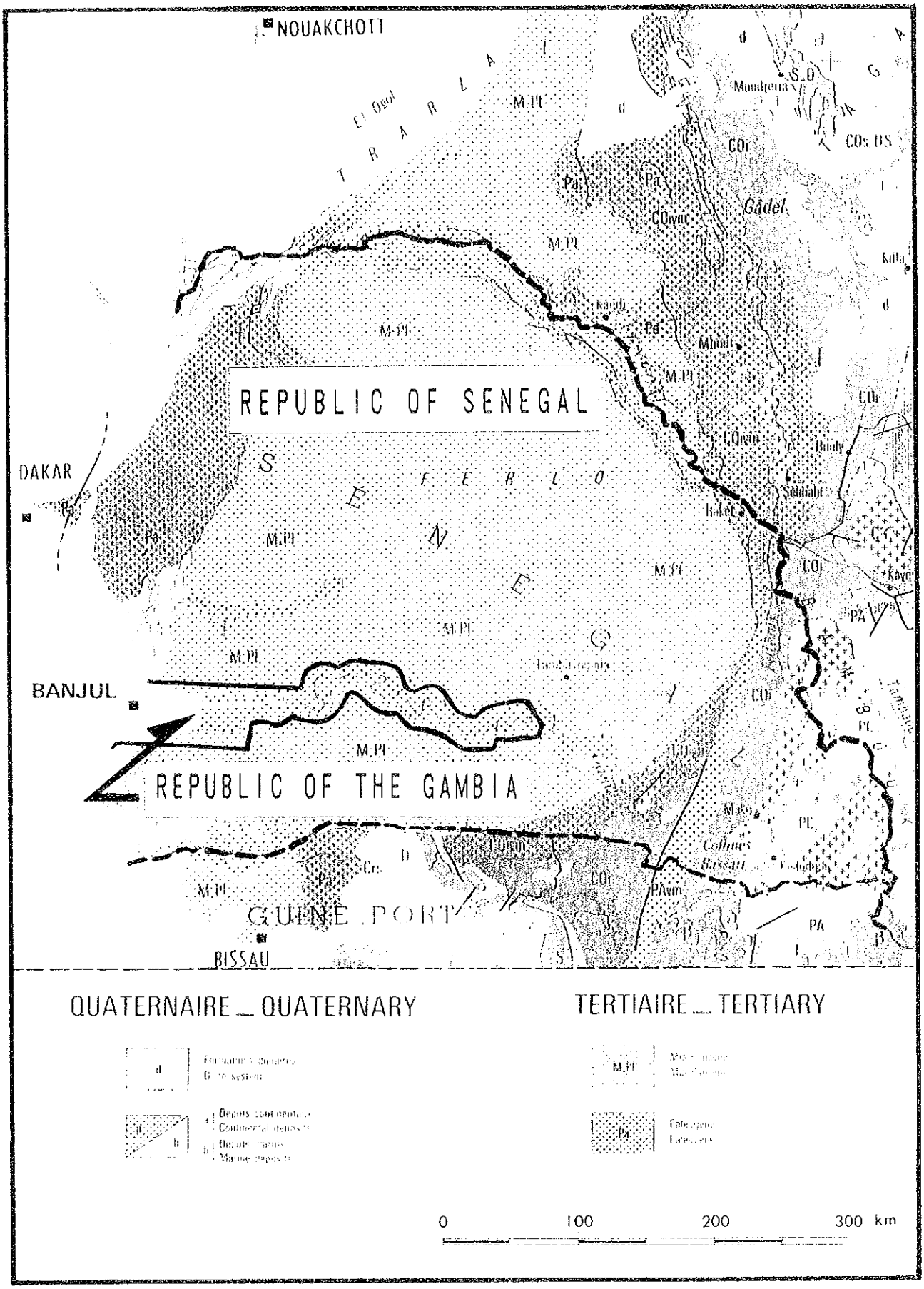


Fig. 3 — 5 Hydrogeological Section of the Gambia

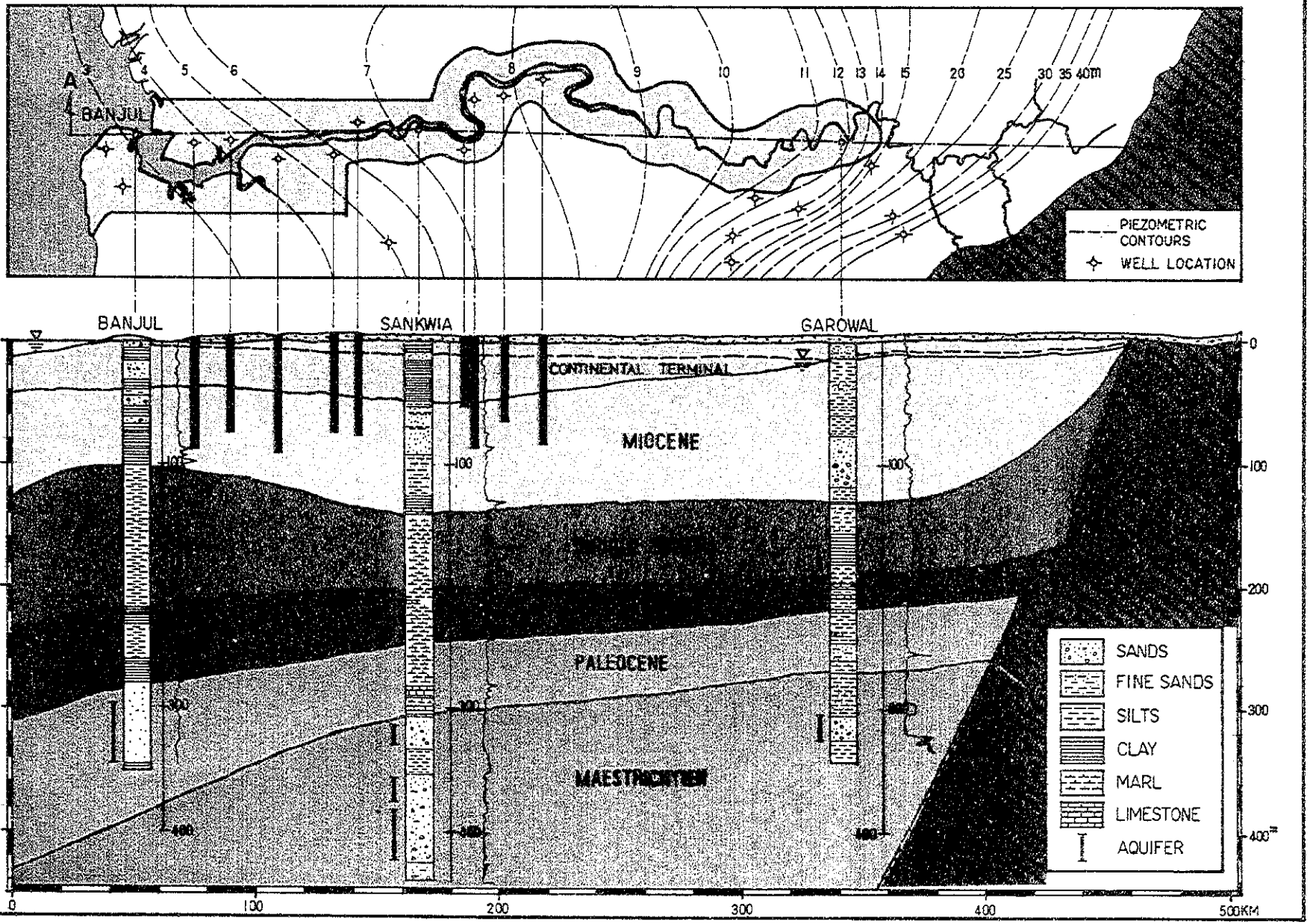
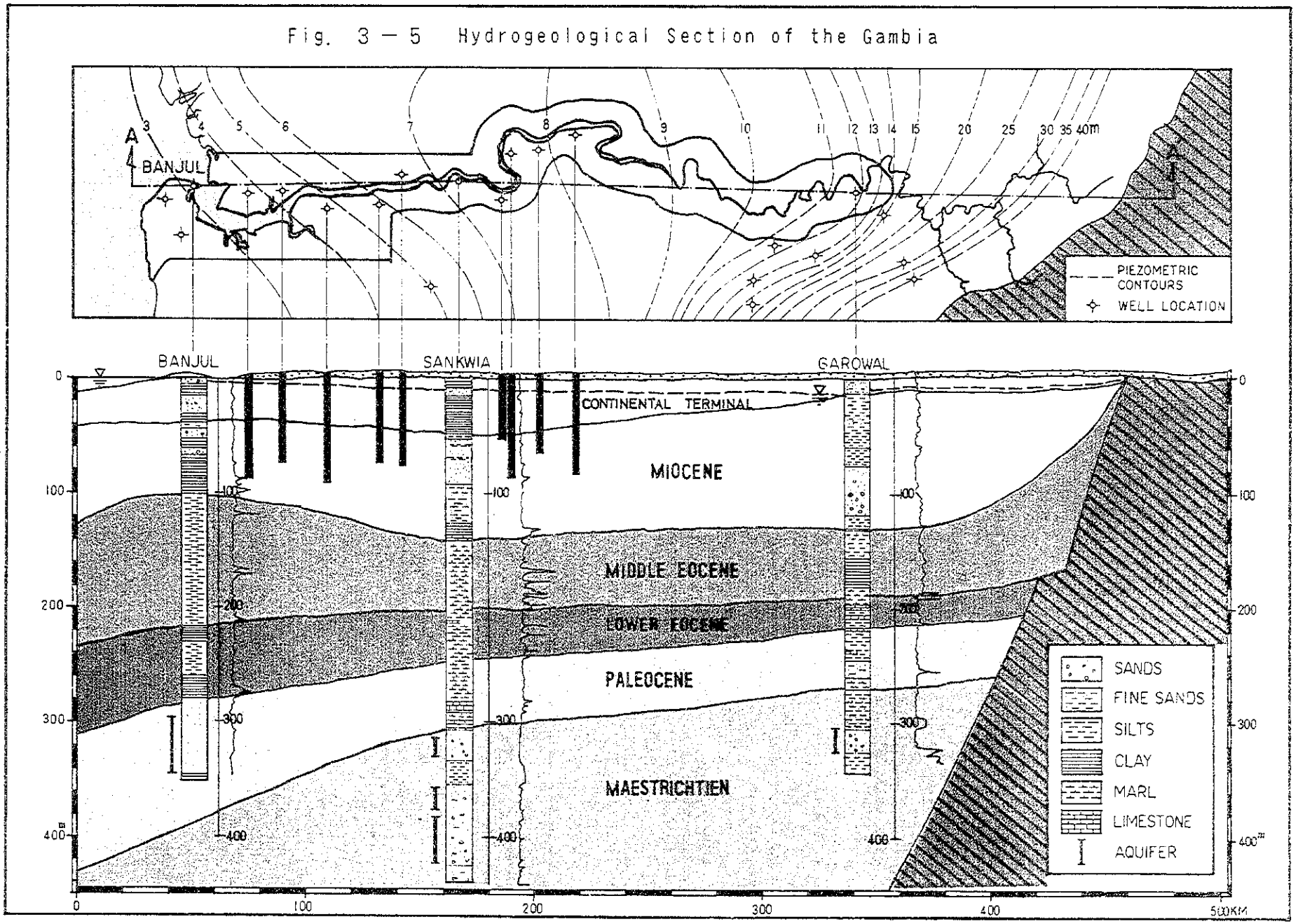


Fig. 3 — 5 Hydrogeological Section of the Gambia



② The semi-confined aquifer in Continental Terminal is a major source of traditional shallow wells of 20～30 m depths all over the country. However, the static water level is becoming lower, year by year, due to recent droughts, and it exceeds 30 m in some areas. Although there is no water quality problem, some contamination problems have recently occurred from the surface by human pollution. This is one of the proper water sources at the moment, but the productivity as aquifer is lower than confined aquifer.

③ The confined aquifer of Miocene has recently started to be developed with boreholes. The depths of aquifer is 80 ～120 m, and the potential for groundwater is quite high, and therefore this is the target formation for this project. There is no quality problem.

④ Although the confined aquifer of Maestrichtian is a major target to develop in Senegal, this aquifer has not been exploited yet in the Gambia, and the CILSS confirmed recently the existence of groundwater by drilling down to 350～ 400 m. The project, however, disregards this as a water source although this zone will be bright in the future for groundwater development.

3-3 Socio-economic Conditions

3-3-1 Population and Administrative Divisions

The latest population census was performed on 15 April 1983 in the Republic of the Gambia. It was published recently as the "Population and Housing Census 1983 (Vol.1 & 2)" by the Ministry of Economic Planning and Industrial Development (MEPID). This project employs, however, the analysis report which was made by the DWR and UNDP Rural Water Project Team surveying the villages and population for the rural water supply in addition to the above census report.

The Gambia is administratively divided into 5 Divisions, having a total population of 858 thousand people, and the population of metropolitan Banjul is believed to be 75 thousand.

The number of villages, estimated population and population break down (%) are

shown below for each Division. The Divisions related to this project are North Bank, Lower River and MacCarthy Island Divisions.

The overall area is 11,295㎢ and its population density is 76 persons / ㎢. The annual growth rate of the population ranges 2.8% ～3.4% depending on the references, but this project employs 3.0% from the UNDP Rural Water Project.

Average life expectancy is 41.3 years for men and 44.2 years for women according to the Ministry of Health, the Environment, Labour and Social Welfare. Urban population and rural population are 20% and 80%, respectively.

Population Distribution by Division (1990)

No.	Administrative Divisions	Number of Villages	Estimated Population	Break Down (%)
1	Western Division	361	315,150	40.9
2	North Bank Division	342	141,958	16.5
3	Lower River Division	144	67,803	7.9
4	MacCarthy Island Division	639	158,575	18.5
5	Upper River Division	362	139,140	16.2
計		1,848	858,626	100.0

3-3-2 Ethnic Groups, Language and Religion

The ethnical break down is shown below.

Ethnic Group	Break down (%)
Mandingo	42.3
Fula	18.2
Wollof	15.7
Jola	9.5
Sarahuli	8.7
Serere	2.1
Manjago	1.3
Aku	1.0
Bambara	0.4
Other Gambians	0.8

The official language is English. Local ones such as Mandingo, Wollof are popular languages.
Religion: Islamic 95%, Christian, Traditional and others 5%

3-3-3 Economic Situation

The Gross National Product (GNP) of the Republic of the Gambia was Dalasi 1,552.6 million in 1989, the Gross Domestic Product (GDP) was D 1,489.6 million and the growth rates to the previous year are 17.2% and 15.9%, respectively, according to the MEPID.

The GNP per capita was calculated as D 1,919 and this was equivalent to US$ 226 at the exchange rate of that time (US$ 1=8.5 Dalasi). This was classified as LLDC. But recent GDP values have shown quite high growth rates except in 1988: 1987, 17.3%; 1988, 4.1%; 1989, 15.9%; and it is expected to be 12.8% in 1990.

It is remarkable that the recent structural change of industrial break down is being promoted by the decrease of population in agriculture, forest and fisheries and the expansion of groundnuts trading and tourism in the service sector.

The export in 1988/89 was D 311,724 thousand and import was D 980,060 thousand with import deficit of D 668,336 thousand.

The number-one export item is groundnuts at D 51,269 thousand (16.4% of total), and fishes, cotton and leather are other major items. Importation items are food and livestock at 29.7%, machine and vehicles, chemical products, commodities, meats and vegetables, drinks and tobacco, fuels and other industrial products. Export to Japan was D 30,390 thousand and import from Japan was D 223,000 thousand in favour of Japanese exportation.

Its currrency is Dalasi, and exchange rates were 1 US$ = D 7.82, 1 Japanese Yen = D 0.053, 1 Deutch Mark = D 4.66, 1 French Franc = D 1.38 as of 26 February, 1990.

The reserved foreign currency was US$ 1,730 thousand (1985, IMF), and foreign debt was US$ 228 million (1986, the World Bank).

3-4 Current Situation of Surveyed Sites

3-4-1 Human-Geographic Environments

The survey was carried out for each site regarding such human-geographic environments as the population of settlements, number of cattles, existing water resources, water facilities, mosques, churches, health centers, maternity clinics, cooperatives, markets, and social infrastractures like agricultural development centers and agricultural products. Results of the survey are summarized in Table 3-4 for the population in Project sites, and in Table 3-5 for the list of public facilities.

Because the population of each site at request was given as of the 1983 census, the current population was estimated as 52,000 persons through hearing on the number of housings and the analysis data of the UNDP Rural Water Project Team. The smallest settlement is Piniai with 630 persons while the largest village is Touray Kunda with 4,560 persons. And most of the sites have population ranging 1,000~2,500 persons.

Each site has a mosque but no church. And most of the sites provide also such public facilities as schools, health centers and maternity clinics. In particular, a "Cooperative", which is an autonomic organization within a settlement, is very active and is told to be in charge of operation and maintenance of the completed water facility. People have strong interests in water problems and at present the preference of non-conventional-energy-powered pumping (solar) system. Although the DWR is carrying out extension diggings for the existing wells which cannot provide water because of lowered water level, some "Cooperatives" have performed such work with their own funds and self-help spirit.

3-4-2 Water Supply Conditions

The present conditions of water supply in the sites are hand drawing or pumping by hand-pump from such water sources as traditional dug wells, concrete-lined shallow wells and borehole type wells.

Table 3 — 4 Current Population in Project Sites

DIVISION	No.	Site Name	Population (1990)
NORTH BANK	N— 1	Njaba Kunda	2,650
	2	Fass Omar Sahor	1,650
	3	Katchang	2,700
	4	Ndungu Kebbeh	2,340
	5	Saba	2,270
	6	Fass Njaga Choi	2,260
	7	Illiassa	1,690
	8	Munjagen	1,340
	9	Tuba Kolong	1,190
	10	Madina Sering Mass	1,000
	Sub Total		19,090
LOWER RIVER	L— 1	Nema	1,390
	2	Jappine Marko	1,380
	3	Dumbutu	710
	4	Pakalinding	2,520
	5	Baro Kunda	2,280
	6	Toniataba	2,040
	7	Bureng	1,860
	8	Jali	1,050
	9	Pakali Ba	1,580
	10	Massembe	1,280
	Sub Total		16,090
MACCARTHY ISLAND	M— 1	Mamut Fana	1,600
	2	Piniai	630
	3	Brikama Ba	2,610
	4	Madina Umfally	2,070
	5	Saruja	2,000
	6	Dankunku	1,940
	7	Touray Kunda	4,560
	8	Sami Pachonki	1,580
	9	Sukuta	1,350
	10	Galleh Manda	1,160
	Sub Total		19,500
	Total		54,680

Table 3 – 5 Public Facilities in Project Sites

DIVISION	No.	Site Name	Mosque	School		Hospital	Drug Store	Health Center	Maternity	Market	Cooperative	A.D.C.
				Arab	Public							
NORTH BANK	N – 1	Njaba Kunda	●	●	●	●	●	●	●	●	●	
	2	Fass Omar Sahor	●	●				●		●	●	
	3	Katchang	●		●			●		●	●	
	4	Ndungu Kebbeh	●	●	●			●	●	●	●	
	5	Saba	●	●	●			●	●		●	
	6	Fass Njaga Choi	●	●	●			●	●	●	●	
	7	Illiassa	●	●	●			●	●	●	●	
	8	Munjagen	●	●	●			●			●	
	9	Tuba Kolong	●	●	●			●			●	
	10	Madina Sering Mass	●	●	●			●			●	
LOWER RIVER	L – 1	Nema	●	●	●		●	●			●	
	2	Jappine Marko	●	●	●			●	●	●	●	
	3	Dumbutu	●	●	●			●	●		●	
	4	Pakalinding	●	●	●			●		●	●	
	5	Baro Kunda	●	●	●			●			●	
	6	Toniataba	●	●				●			●	
	7	Bureng	●	●	●			●	●		●	
	8	Jali	●	●	●		●				●	
	9	Pakali Ba	●		●			●			●	
	10	Massembe	●	●				●			●	
MACCARTHY ISLAND	M – 1	Mamut Fana	●	●	●			●			●	
	2	Piniai	●		●			●			●	
	3	Brikama Ba	●	●	●		●	●		●	●	
	4	Madina Umfally	●	●				●			●	
	5	Saruja	●	●				●			●	
	6	Dankunku	●		●		●	●	●	●	●	●
	7	Touray Kunda	●		●	●				●	●	
	8	Sami Pachonki	●	●	●			●			●	
	9	Sukuta	●	●				●			●	
	10	Galleh Manda	●	●	●		●	●			●	

* A.D.C ・・・・ Agricaltural Development Center

There is no site with powered pumping equipment yet. The three sites in MacCarthy Island, Mamut Fana, Piniai and Galleh Manda, are drawing without hand-pumps. There are only five sites where drinking troughs are provided for animals.

A day's water use pattern shows that somebody is getting water at the water facilities all day long from early in the morning to late in the evening. Also there are herds of cattle, donkies and horses around the facilities. Thus the urgent necessity of powered pumping is recognized because manual drawing has already reached the limit. Furthermore, since carrying water is women's duty, women are very busy with tasks including preparation of meals in the morning and evening, and washing cloths at the water point in the daytime in addition to carrying water 1 ~ 2 km distance with a bucket of 10~ 20 ℓ. Therefore, water supply systems with distribution lines and public water stands are judged to be needed in the sites.

The aim of the integrated water use includes water for drinking, for domestic use, and for livestock if possible. Also, a farm called "women's garden" is located close to a settlement in the site, which is mainly managed by women. Women carry water there to cultivate various merchandise crops such as cabbages, tomatoes, green peppers, egg plants and onions. This has been promoted by the Ministry of Agriculture for several years. Seeds of these vegetables are supplied to the inhabitants and schools, but in turn, water demands expand further. This activity is praised to be the application of the concept of Women in Development (WID).

The existing water supply facility is summarized in Table 3-6, and the water analysis results are shown in Table 3-7. The majority of water sources are traditional dug wells and others are concrete lined shallow wells and borehole type wells. Groundwater is drawn with hand pumps and supplied for safe drinking in 27 sites except those sites in MacCarthy Island Division. However, the bacteria tests revealed contamination from bacteria in many sites; contamination by both coliform organisms and general bacteria was indicated in 8 sites, and either contamination in another 8 sites.

Table 3 — 6 Existing Water Supply Facilities

DIVISION	No.	Site Name	Shallow Well	Concrete Lined Shallow Well	Borehole Well	Others				Existing Facilities				
						River	Swamp	Spring	Rain Fall	Hand Pump	Motor Pump	Tank	Public Stand	Drinking Trough
NORTH BANK	N - 1	Njaba Kunda	3	2	0	—	—	—	●	4	0	0	0	0
	2	Fass Omar Sahor	2	2	1	—	—	—	●	2	0	0	0	0
	3	Katchang	15	3	0	●	—	—	●	2	0	0	0	1
	4	Ndungu Kebbeh	8	2	0	—	—	—	●	2	0	0	0	0
	5	Saba	13	1	0	—	—	—	●	2	0	0	0	0
	6	Fass Njaga Choi	20	1	0	—	—	—	●	2	0	0	0	1
	7	Illiassa	20	2	0	—	—	—	●	3	0	0	0	0
	8	Munjagen	0	6	1	—	—	—	●	2	0	0	0	0
	9	Tuba Kolong	10	1	0	●	—	—	●	2	0	0	0	0
	10	Madina Sering Mass	4	2	0	—	—	—	●	2	0	0	0	0
LOWER RIVER	L - 1	Nema	0	2	0	—	—	—	●	2	0	0	0	0
	2	Jappine Marko	8	4	1	—	●	—	●	3	0	0	0	1
	3	Dumbutu	6	1	1	●	—	—	●	2	0	0	0	1
	4	Pakalinding	14	4	0	—	—	—	●	3	0	0	0	0
	5	Baro Kunda	25	5	0	—	—	—	●	2	0	0	0	0
	6	Toniataba	12	3	0	—	—	—	●	2	0	0	0	0
	7	Bureng	6	5	1	—	—	—	—	2	0	0	0	0
	8	Jali	4	2	1	●	—	—	●	2	0	0	0	0
	9	Pakali Ba	7	2	0	●	—	—	●	3	0	0	0	0
	10	Massembe	3	2	0	—	—	—	●	2	0	0	0	0
MACCARTHY ISLAND	M - 1	Mamut Fana	8	2	1	—	—	—	●	0	0	0	0	0
	2	Piniai	6	2	1	—	—	—	●	0	0	0	0	0
	3	Brikama Ba	6	2	0	—	—	—	●	4	0	0	0	0
	4	Madina Umfally	5	1	0	●	—	—	●	2	0	0	0	0
	5	Saruja	12	1	0	—	—	—	●	2	0	0	0	0
	6	Dankunku	4	5	0	—	—	—	●	5	0	0	0	0
	7	Touray Kunda	33	1	1	—	—	—	●	2	0	0	1	0
	8	Sami Pachonki	1	8	0	—	—	—	●	2	0	0	0	0
	9	Sukuta	6	3	0	—	—	—	●	2	0	0	0	0
	10	Galleh Manda	3	3	0	—	—	—	●	0	0	0	0	0

Table 3 — 7 Water Quality in Project Sites

DIVISION	No.	SITE NAME		pH	Cl^- (mg/ℓ)	T-Fe (mg/ℓ)	F^- (mg/ℓ)	Total Hard. (mg/ℓ)	Mn (mg/ℓ)	Zn (mg/ℓ)	NH_4-N (mg/ℓ)	NO_2-N (mg/ℓ)	NO_3-N (mg/ℓ)	Coliform Count (N/mℓ)	General Bacteria (N/mℓ)	Electric. Conduct. (μs/cm)
NORTH BANK	N— 1	Njaba Kunda		5.30	110	< 0.1	0	85	0	0	0	0	1.8	2	3	420
	2	Fass Omar Sahor		5.12	15	0.1	0	20	0	0	0	0	1.2	0	0	85
	3	Katchang		6.10	400	0.1	0.1	300	0	0	0	0	6.5	2	7	1,200
	4	Ndungu Kebbeh		4.67	45	0.1	0.3	75	0	0	0	0	3.2	1	0	155
	5	Saba		5.31	13	0.1	0	23	0	0	0	0	1.0	2	0	90
	6	Fass Njaga Choi		4.73	25	0.1	0	31	0	0	0	0	5.5	0	0	220
	7	Illiassa		5.31	25	0.1	0	27	0	0	0	0	1.2	1	5	240
	8	Munjagen		5.07	55	0.1	0	60	0	0	0	0.01	6.5	5	2	400
	9	Tuba Kolong		5.35	13	0.1	0.5<	15	0	0	0	0	1.0	3	1	32
	10	Madina Sering Mass		5.03	10	0.1	0	20	0	0	0	0	1.9	2	0	73
LOWER RIVER	L— 1	Nema		5.44	25	0.1	0.3	23	0	0	0.8	0.02	1.9	3	50	72
	2	Jappine Marko		5.58	15	< 0.1	0.5	53	0	0	0	0	0	0	0	95
	3	Jali		5.76	18	1.0	0.2	65	0	0	0	0	0	1	0	100
	4	Pakalinding		6.12	105	< 0.1	0	85	0	0	0	0	1.3	5	16	190
	5	Baro Kunda		5.56	170	0.5	1.0	120	0	0	0.4	0.12	6.5	8	18	410
	6	Toniataba		5.73	25	< 0.1	0	25	0	0	0	0	1.9	0	12	95
	7	Bureng		5.14	17	0.1	0	45	0	0	0	0	0	0	0	35
	8	Dumbutu		6.03	15	3.0<	1.0	93	0.3	0	0	0	0	0	0	100
	9	Pakali Ba		6.33	165	< 0.1	0	325	0	0	0	0	6.5	8	43	800
	10	Massembe		5.13	180	0.1	0	155	0	0	0	0	6.5	5	3	350
MACCARTHY ISLAND	M— 1	Mamut Fana		5.75	45	0.1	0	60	0	0	0	0	1.8	3	0	144
	2	Piniai		5.45	20	0.1	0	25	0	0	0	0	1.0	2	0	120
	3	Brikama Ba		4.93	25	0.1	0	22	0	0	0	0	1.2	0	0	70
	4	Madina Umfally		5.02	55	0.1	0	77	0	0	0	0	1.9	0	0	180
	5	Saruja		5.09	20	0.1	0	17	0	0	0	0	1.3	0	0	60
	6	Dankunku		4.26	230	0.1	0.2	10	0.7	0	0.3	0	5.0	0	0	870
	7	Touray Kunda	A	5.64	25	0.1	0	38	0	0.3	0	0.02	2.5	0	0	100
			B	6.46	430	0.1	0	175	0	0	0	0	1.2	0	0	650
	8	Sami Packonki		5.47	17	< 0.1	0	17	0	0	0	0	1.9	9	4	40
	9	Sukuta		4.73	83	< 0.1	0	220	0	0	0	0	4.6	5	6	385
	10	Galleh Manda		5.78	13	< 0.1	0	7	0	0	0	0	0	0	3	23
DRINKING WATER QUALITY STANDARDS	WHO			7.0 ～ 8.5	200 ～ 400	0.3	1.0 ～ 1.5	100 ～ 500	0.1	5	0.5	—	40 ～ 80	MPN 10	—	2,000
	FRANCE			—	250	0.1	1.0	—	0.05	5	—	—	10	—	0	—
	JAPAN			5.8～8.6	200	0.3	0.8	300	0.3	1	Not detected at same time		10	—	100	—

These water supply facilities were concrete lined, but these must be reconsidered from a water supply facility point of view due to human surface contamination and the fact that livestock gather very close to houses.

There are 7 sites where inhabitants use water from streams and lakes rather than groundwater for domestic water use. But they use rain for drinking and domestic water in the rainy season because of the shortage of water in all of the 30 sites.

In addition, the harshness of the lowered water level was often observed when the extensive digging works of private wells were encountered during the field survey here and there.

During the field survey, the hydrogeological potential of each site could be defined clearly through hydrogeological and geophysical surveys. The Gambian geological formation and groundwater potential is presented in Table 3-8 related to the analysis. Currently the most exploited aquifer is the semi-confined aquifer in the Continental Terminal with depths of 20 ~50 m. Nonetheless, borehole type wells are being selected even for hand pumps due to the declining water volume, water quality and contamination from the surface. Thus, the target aquifer is being converted to the confined aquifer in lower Miocene as justified by abundant water quantity and safe and sanitary quality. Therefore, the target aquifer is concluded to be the confined aquifer in Miocene even though total depths will be relatively deeper in North Bank, Lower River and MacCarthy Island Divisions where the project areas are covered.

The 5 existing borehole type wells at 5 sites were determined to be usable through the water production rate examination and water quality analysis.

Table 3 — 8 Geological Formation and Groundwater Potential

Period		Epoch	Stage		Formation	Thickness	Groundwater Potential
Quaternary		Holocene	Holocene		Laterite, Sands, Clays	3 ～ 10m	○
		Pleistocene	Continental Terminal		Sandy clays, Sands	10 ～ 70m	○
Tertiary	Neogene	Pliocene					
		Miocene	Miocene Series		Sands, Clays	70 ～ 130m	◎
	Palaeogene	Oligocene	Oligocene Series		Limestones	130 ～ 160m	×
		Eocene	Eocene Series		Limestones, Marls	160 ～ 240m	×
		Palaeocene	Palaeocene Series		Limestones with marls	240 ～ 270m	×
Upper Cretaceous			Maestrichtian Series		Sands, Sandstones	270 ～ 400m	◎
			Campanian Series		Clay with silt and sandstone	400m +	×

* ◎ ---Favorable
○ ---Moderate
× ---Unfavorable

CHAPTER Ⅳ
DESCRIPTION OF THE PROJECT

CHAPTER IV
DESCRIPTION OF THE PROJECT

4-1 Objective

The objective of this project is to install water supply systems which will enable a supply of stably sanitary water to the inhabitants of the 30 project sites of the Integrated Water Use Project requested by the Gambian government. After its completion, the living environment is expected to improve widely in the project areas.

4-2 Outline of the Request

4-2-1 Project Sites

The objective sites of the Project total 30 sites: 10 sites each in 3 Divisions out of 5 Divisions in the Republic of the Gambia. Two sites of Keneba and Kwinella Sansakono in the Lower River Division were replaced with Dumbutu and Jali, prior to the survey, by the proposal of the Gambian government because the former 2 sites had been chosen for construction of water supply facilities as medical key stations. Table 4-1 shows administrative divisions.

Prior to the investigation for the proposed 30 sites, a field survey was carried out to study the situation of piped water supply systems which the Government of the Gambia is promoting with high priority to populated villages in 5 Divisions. This survey revealed that the Western Division, including Banjul with high urbanization and high concentration of population (having 40% of the national population) had the high coverage. On the contrary, the Upper River Division (U.R.D.), situated in the eastern most area, had 0% coverage, that is, no piped water supply. The remaining three project Divisions of North Bank, Lower River and MacCarthy Island had low coverage as well.

The Gambian Government has, for the early resolution of these 4 undeveloped Divisions, requested cooperation to EEC for the construction of piped water supply systems for 20 sites in the U.R.D. and the project will probably start this April.

Table 4 — 1 Administrative Divisions in Project Sites

No.	Code	Division	District	Site Name
N- 1	4429	North Bank	Central Baddibu	Njaba Kunda
2	4114	North Bank	Upper Niumi	Fass Omar Sahor
3	4551	North Bank	Upper Baddibu	Katchang
4	4050	North Bank	Lower Niumi	Ndungu Kebbeh
5	4316	North Bank	Lower Baddibu	Saba
6	4014	North Bank	Lower Niumi	Fass Njaga Choi
7	4531	North Bank	Upper Baddibu	Illiassa
8	4233	North Bank	Jokadu	Munjagen
9	4156	North Bank	Upper Niumi	Tuba Kolong
10	4044	North Bank	Lower Niumi	Madina Sering Mass
L- 1	3112	Lower River	Kiang Central	Nema
2	3412	Lower River	Jarra Central	Jappine Marko
3	3306	Lower River	Kiang West	Dumbutu
4	3313	Lower River	Jarra West	Pakalinding
5	3502	Lower River	Jarra East	Baro Kunda
6	3320	Lower River	Jarra West	Toniataba
7	3504	Lower River	Jarra East	Bureng
8	3007	Lower River	Kiang West	Jali
9	3521	Lower River	Jarra East	Pakali Ba
10	3209	Lower River	Kiang East	Massembe
M- 1	6724	MacCarthy Island	Niamina East	Mamut Fana
2	6621	MacCarthy Island	Niamina West	Piniai
3	7413	MacCarthy Island	Fuladu West	Brikama Ba
4	7472	MacCarthy Island	Fuladu West	Madina Umfally
5	7543	MacCarthy Island	Fuladu West	Saruja
6	6506	MacCarthy Island	Niamina Dankunku	Dankunku
7	5064	MacCarthy Island	Lower Saloum	Touray Kunda
8	5454	MacCarthy Island	Sami	Sami Pachonki
9	5379	MacCarthy Island	Niani	Sukuta
10	7437	MacCarthy Island	Upper Niumi	Galleh Manda

In addition, the Gambian Government requested this project of 30 sites to the Government of Japan for the undeveloped three Divisions.

The targeted number of villages to be equipped with piped water supply facilities are 65 for U.R.D. and 200 for all of N.B.D., L.R.D. and M.I.D. When the EEC project is completed, 30% of the target will be covered. And after completion of the Japanese project, 15% of the target for the three Divisions will be covered, and therefore 25% of the total target will be completed. This can be evaluated significantly for the Gambia.

A detailed investigation was carried out for each of the 30 proposed project sites regarding human-geographic background, hydrogeologocal characteristics of water resources, various design conditions for facilities, and accessibility during the construction period, based upon the results of site survey. And the investigation found that the village sizes of the 30 sites are proper for the objectives of the piped water supply plan; groundwater from borehole type wells yields, as water resources, sufficient hydrogeological parameters of pumping rates and water quality for the water supply plan; and the site conditions are confirmed together with the sites for drilling and the accessibility of machines and equipment for construction.

The 30 sites are considered capable to operate and maintain the completed water supply facilities through the cooperatives as decided with self-reliance concept.

The above-mentioned 30 project sites were examined to study the human-geographic background for each village, possible hydrogeological problems of water sources which is the key element for a successful water supply system, conditions for the facility planning and accessibility to the project sites during the implementation of the project based on results of the field survey. Thus, it is concluded that the villages have appropriate size and extension for the piped water supply plan, and the water sources are judged to meet the requirements of the water supply plan clearing such hydrogeological conditions as drilling locations, groundwater potential and water quality for the groundwater use with borehole type wells.

The completed facilities will be autonomously managed and maintained by the "Cooperative" of each site. Therefore, the 30 project sites are evaluated to

be appropriate for the project from a management and maintenance point of view.

The following 5 sites were selected for the first water supply facility construction where existing boreholes are available.

① N-2 Fass Omar Sahor
② L-2 Jappine Marko
③ L-7 Bureng
④ L-8 Jali
⑤ M-2 Piniai

In addition, the other 25 sites will be presumed to drill new wells. After the field survey, all of the 30 sites were justified for the objective areas of the water supply and the project was feasibly confirmed.

The equal allocation of sites to three Divisions can be judged as appropriate from the water supply administration point of view. The project size of 30 sites is evaluated as reasonable in consideration of the village size, details of facilities including utilization of existing wells, local conditions during the implementation period for the grant aid system by the Japanese Government.

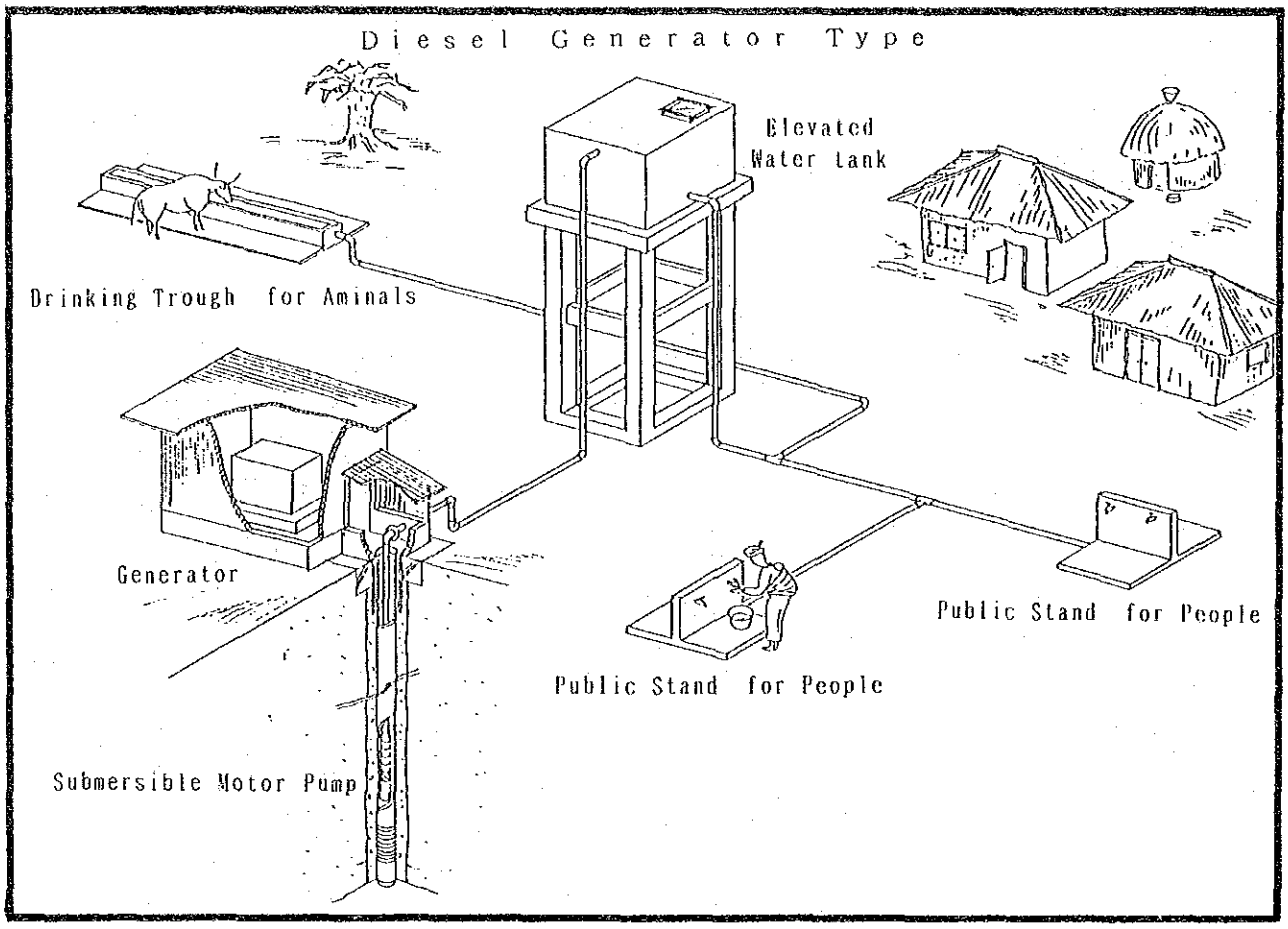
4-2-2 Examination of the Request

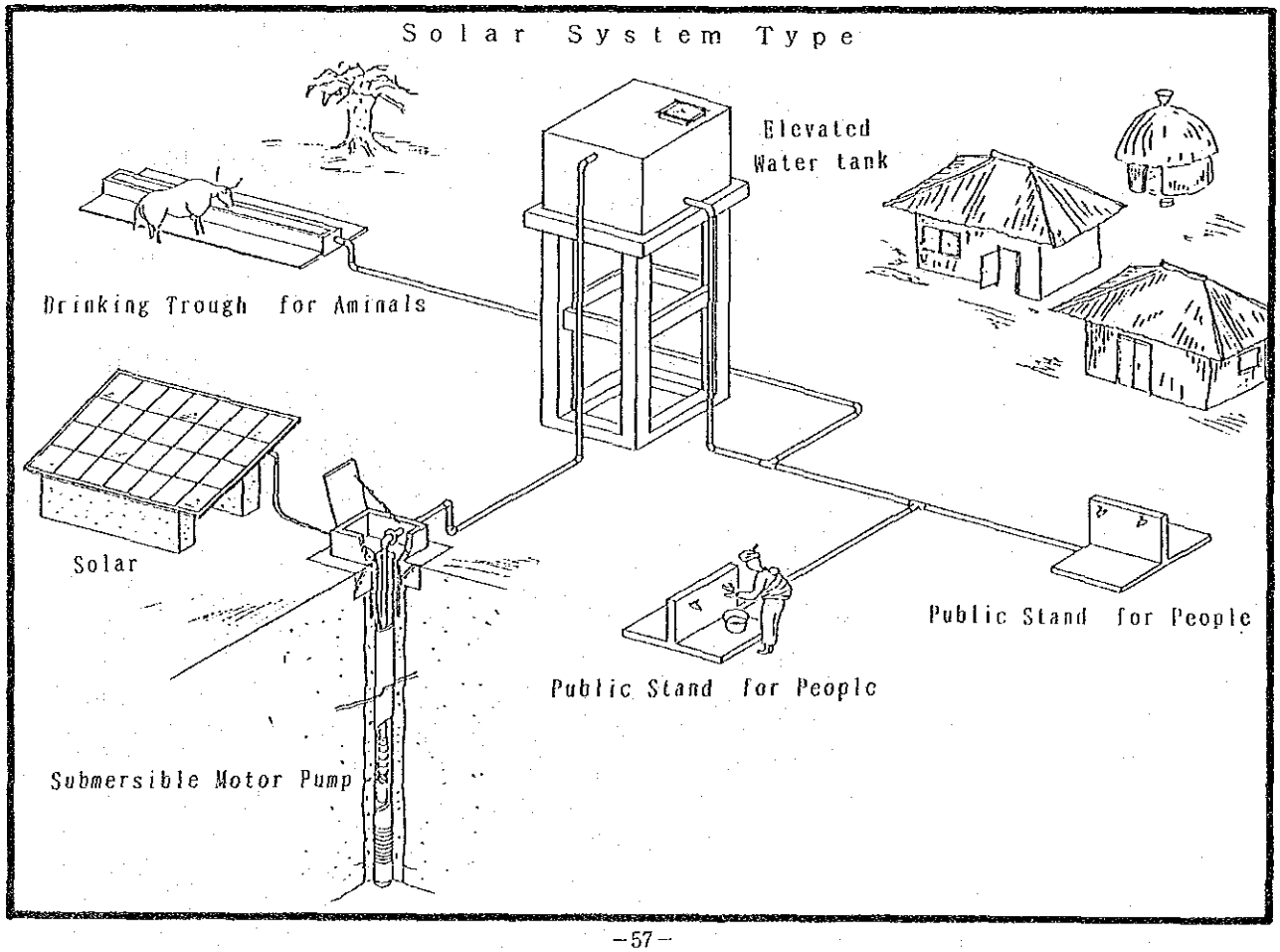
The following outline of the request by the Gambian government was examined and confirmed unchanged during discussions with the executing agency (the RWSD, Department of Water Resources). Water supply systems are conceptually shown for Diesel Generator and Solar System Types in Fig. 4-1.

(1) Supply of materials and equipment necessary for the construction and drilling of the borehole type wells and operation and maintenance.

- Equipment and materials for the drilling of borehole type wells.
- Equipment for geophysical survey and analysis for groundwater development and equipment for communication
- Vehicles
- Spare parts for the above

Fig. 4 — 1 Conceptional Water Supply System





(2) Construction at 30 sites with Piped Water Supply Systems

(3) Technical Transfer during the implementation of the project

4-3 Outline of Project Facilities

The proposed facilities for each site is outlined in Table 4-2 based on the request and the field survey. The solar pumping system as a non-conventional method, which was requested by the Gambian government, was compared with the conventional diesel generator system for each site and the feasibility of either system was evaluated.

4-3-1 Water Source Evaluation

The concrete-lined shallow wells or borehole type wells have been constructed since 1981 as sanitary water sources, instead of the conventional shallow dug wells, with assistance from international organizations and foreign countries such as the UNDP, the Saudi Sahelian Programme (SSP), and West Germany (GTZ). However, the use of shallow dug wells have decreased in the dry season due to lowered water levels. Even the depths of boreholes have been deepened recently to 40～ 80 m and sometimes more than 100 m because the pumping rates of boreholes have declined due to the lowered water levels. The potential of groundwater development was evaluated for each site based on the results of the hydrogeological survey, geophysical survey and existing well data, and this is summarized for each Division in the following table. A conclusion is given that the potentiality of groundwater is very promising as a whole and that it is possible to pump enough water required for each project site, including the existing wells at 5 sites.

Divisions	Aquifer	Well Depth (m)	Static Water Level (m)	Specific Capacity ($m^3/d/m$)
North Bank	Miocene Sands	80 - 100	22 - 28	30 - 80
Lower River	Miocene Sands	80 - 120	21 - 25	60 - 140
MacCarthy Island	Miocene Sands	80 - 100	17 - 19	40 - 80

Table 4 — 2 Description of Facility Plan

DIVISION	No.	Site Name	Population	Cattle	Daily Demand (m³/day)	Water Source	Pumping Equipment	Pipe Length (m)	Water Tank Capacity (m³×No.)	Public Stand	Drinking Trough
NORTH BANK	N— 1	Njaba Kunda	3,560	220	132.3	New	Conventional	2,450	80× 1	11	1
	2	Fass Omar Sahor	2,220	990	112.4	Exising	Conventional	1,076	50 〃	7	1
	3	Katchang	3,630	910	158.9	New	Conventional	2,483	80 〃	11	1
	4	Ndungu Kebbeh	3,140	1,370	157.9	New	Conventional	2,198	80 〃	10	2
	5	Saba	3,050	1,130	146.3	New	Conventional	1,953	80 〃	9	1
	6	Fass Njaga Choi	3,040	2,150	181.7	New	Conventional	1,933	80 〃	9	2
	7	Illiassa	2,270	620	101.2	New	Conventional	1,312	50 〃	7	1
	8	Munjagen	1,800	3,860	198.1	New	Conventional	1,284	80 〃	6	4
	9	Tuba Kolong	1,600	200	63.0	New	Solar	708	30 〃	5	1
	10	Madina Sering Mass	2,800	1,300	143.5	New	Conventional	1,632	80 〃	9	2
		Sub Total	27,110	12,750	1,395.3	10	10	17,030	10	84	16
LOWER RIVER	L— 1	Nema	1,870	360	78.0	New	Solar	896	50× 1	6	1
	2	Jappine Marko	1,850	800	92.8	Exising	Solar	1,453	50 〃	6	1
	3	Dumbutu	950	820	62.0	New	Solar	989	30 〃	3	1
	4	Pakalinding	3,390	960	152.3	New	Conventional	2,278	80 〃	10	1
	5	Baro Kunda	3,060	540	126.0	New	Conventional	1,473	80 〃	9	1
	6	Toniataba	2,740	2,710	190.8	New	Conventional	1,715	80 〃	8	2
	7	Bureng	2,500	2,570	177.5	Exising	Conventional	1,346	80 〃	8	2
	8	Jali	1,680	1,950	127.1	Exising	Conventional	1,033	50 〃	5	2
	9	Pakali Ba	2,120	780	101.5	New	Conventional	1,272	50 〃	7	1
	10	Massembe	1,720	870	90.7	New	Conventional	850	50 〃	5	1
		Sub Total	21,880	12,360	1,198.7	10	10	13,304	10	67	15
MACCARTHY ISLAND	M— 1	Mamut Fana	2,150	2,900	176.8	New	Conventional	1,038	80× 1	7	2
	2	Piniai	850	220	37.5	Exising	Solar	415	30 〃	3	1
	3	Brikama Ba	3,510	510	140.7	New	Conventional	1,874	80 〃	11	1
	4	Madina Umfally	2,780	590	118.0	New	Conventional	1,151	65 〃	9	1
	5	Saruja	2,690	960	127.8	New	Conventional	1,061	65 〃	8	1
	6	Dankunku	2,610	1,490	143.5	New	Conventional	1,665	65 〃	8	2
	7	Touray Kunda	2,140	260	224.0	New	Conventional	6,263	100 〃	18	1
	8	Sami Pachonki	2,120	1,890	140.4	New	Conventional	1,227	65 〃	7	2
	9	Sukuta	1,810	2,240	141.8	New	Conventional	855	65 〃	6	2
	10	Galleh Manda	1,560	500	72.1	New	Solar	914	30 〃	5	1
		Sub Total	26,220	11,560	1,322.6	10	10	16,462	10	82	15
		Total	75,210	36,670	3,916.6	30	30	46,796	30	233	46