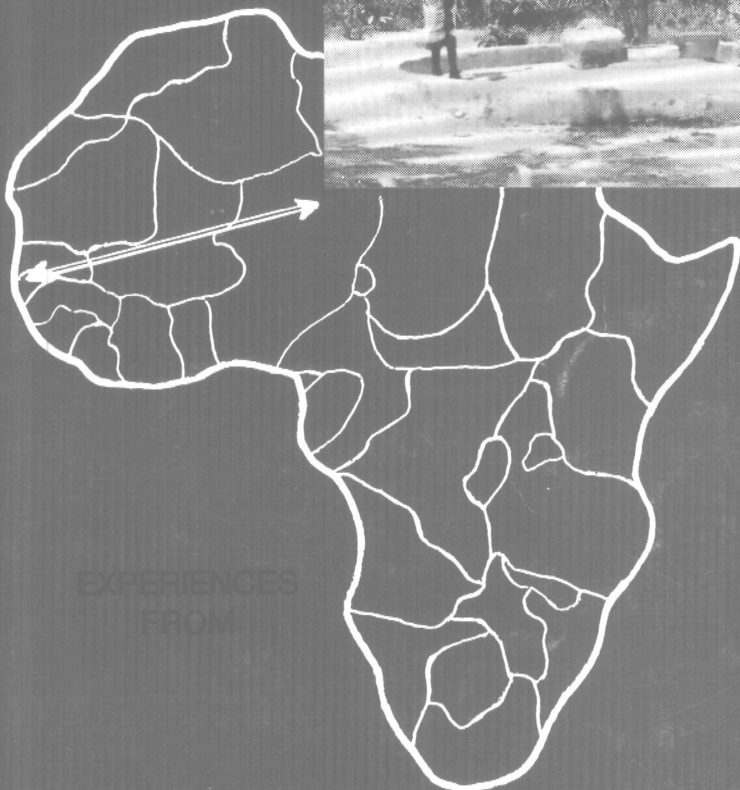
RURAL WATER SUPPLY DEVELOPMENT



EXPERIENCES
FROM

THE BUBA-TOMBALI WATER PROJECT
GUINEA-BISSAU
1978-1981

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REPÚBLICA DA GUINÉ-BISSAU

RURAL WATER SUPPLY DEVELOPMENT

THE BUBA-TOMBALI WATER PROJECT

PROJETO DE AGUA QUINARA-TOMBALI
RECURSOS NATURAIS
BUBA

1978-1981

SUPPORTED BY
THE DIRECTORATE GENERAL OF DEVELOPMENT COOPERATION
MINISTRY OF FOREIGN AFFAIRS
KINGDOM OF THE NETHERLANDS

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The present document has been prepared by Jan Teun Visscher and Ebbo Hofkes of the International Reference Centre for Community Water Supply and Sanitation.

The main resource was an extensive report prepared by the following members of the Buba-Tombali water supply project: Harry Derksen, Simon Dermijn, Michiel v.d. Drift, Liesbeth Kok, Yvonne Reinink, Janneke Smidt en Hans Schoolkate.

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FOREWORD

When one looks down at Guinea-Bissau from an airplane, green afforestation and numerous rivers give the impression of a country with a more than adequate natural water supply. However, especially concerning drinking water, the water situation is very pressing. The west faces heavy problems with salination. In the interior during the dry season, surface water recedes considerably and groundwater becomes very scarce. As a result, cattle from the northern and western parts have to be moved to the central valleys during these months.

In view of this water scarcity and its effects on the health of the people, the Government of Guinea-Bissau after independence has initiated a number of water supply projects as part of the general socio-economic development of the country. Cooperation with various friendly nations and international organizations made these projects possible.

The Dutch Buba-Tombali project is one of them. However, this project aimed not only at technical solutions. With great effort the project has succeeded in stimulating the people in this region to improve their living conditions by raising the quality of health services and welfare as well as productivity. Water was not only treated as a scarcity problem, but also as a hygiene and health issue.

Farmers usually are reluctant to accept change, especially when new initiatives go beyond their knowledge and capability. The Buba project managed to overcome these initial difficulties. An intelligent and patient approach by experts has taught the population that there is a link between technical and social aspects. In this way the objective of the project has been reached: the community is now sensitive to the advantages of using clean and safe water, and to the maintenance of wells and pumps. Moreover, the work in Buba-Tombali has attracted attention from other regions, where communities repeatedly request similar projects. A remarkable achievement of this Buba project has been the development of the Buba pump by the experts on the spot, despite various limitations and drawbacks. It shows their dedication and creativity and especially their courage to overcome the difficulties of a different environment and adapt themselves to the local circumstances.

Our compliments and gratitude go to all the experts who have contributed to this project at grass roots level. They have shown that real cooperation between a developed and a developing country is possible and beneficial. We are also thankful to the Dutch Government, which made this project possible through its financial and technical support. We are convinced that the project succeeded only because it concentrated on people: on the one hand people transferring knowledge and on the other hand people absorbing this knowledge and learning to use it to their advantage.

Samba Lamine Mané
Minister of Natural Resources
Guinea-Bissau.

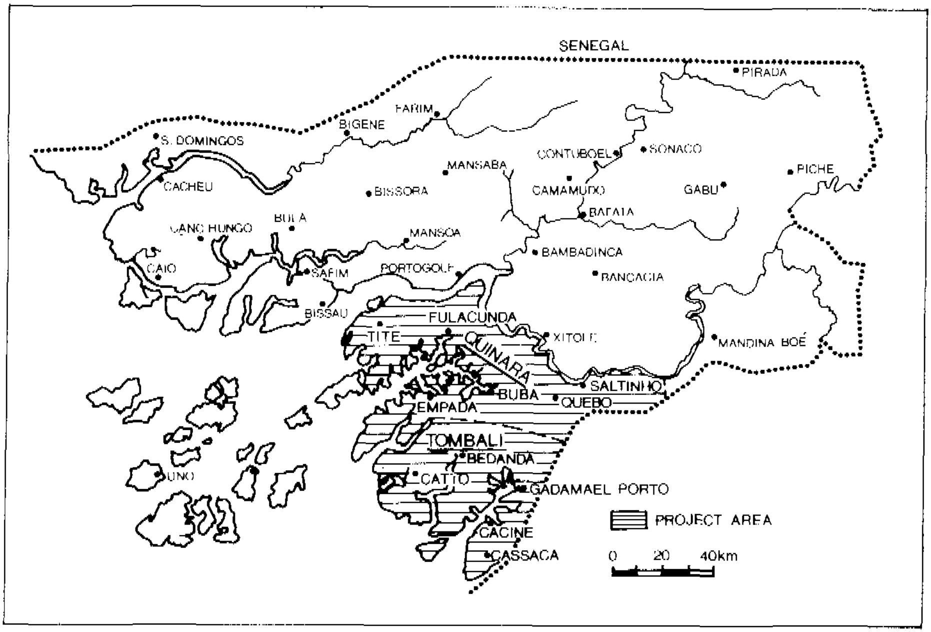


Figure 1.
The Republic of Guinea-Bissau.

Meandering river in the coastal plain

1. INTRODUCTION

1.1 History of the project

In 1977 as a result of consultations between the Government of Guinea-Bissau (Ministerio dos Recursos Naturais, further to be referred to as Ministry of Natural Resources), and the Government of The Netherlands (Directorate General for Development Cooperation), an identification mission was carried out by members of the Dutch "Working Group on Water Resources Development".

The mission proposed a project involving:
- rural water supply development in the regions of Quinara and Tombali;
- a geohydrological study of these regions;
- establishing a regional water supply centre to serve the southern regions of Guinea-Bissau;
- support to the central services of the Ministry in the capital city, Bissau.

Following the acceptance of the proposal by the Guinea-Bissau authorities, the Dutch Directorate General provided a team of experts and volunteers to further prepare the project. A group was formed in The Netherlands to support the project team.

The first members of the team arrived in Guinea-Bissau early 1978 and started the construction of housing and office facilities in Buba. A three-month pilot stage of the project involving the construction of 30 wells began in the last months of 1978, after which the execution of the actual project was initiated in March 1979. A Dutch consulting engineers'firm, experienced in shallow well projects, assisted in the preparation and execution of the pilot project.

This pilot project comprised mainly the following:
- a survey to obtain a general idea of the geohydrological situation in the area; (a number of hand-drilled test holes were made and electrical resistivity soundings were taken);
- an experiment on well construction techniques;

- a socio-economic survey of the area to define the task of the section which was going to promote the social activation part of the project.

One result of the pilot project was that, contrary to what was expected, it would be necessary to construct dug wells as it proved impossible to provide exclusively hand-drilled tubewells.

In May 1979, the well construction programme started. The Netherlands' financial contributions to the Buba-Tombali water project for the period 1978 - 1981 amounted to US $ 3.6 million. For the continuation of the project, in the period 1981-1984, a further US $ 2.5 million has been allocated. These financial contributions to the Buba-Tombali water project are part of The Netherlands'financial support to the Ministry of Natural Resources, which totals Hfl. 18.1 million (US $ 7.2 million) up to 1984.

This report describes the organization and results of the first phase of the well construction project for the period 1978-1981.

Not covered in this report are the construction of water distribution systems in three small villages for which preparations were made by the project team in Buba, and the support provided to the central services of the Ministry in Bissau.

1.2 Guinea-Bissau

Introduction to the country

The Republic of Guinea-Bissau is bordered by Senegal to the north, and Guinea-Conakry to the east and south. The country has an area of 36,125 square kilometres. Except for the vast foothills of the Fouta Djallon in the eastern region, Guinea-Bissau mostly consists of a coastal plain, deeply indented by estuaries. The main physical characteristics are meandering rivers and wide estuaria, with the tidal influence reaching as far as 120 kilometres inland. Some coastal islands and the offshore archipelago of the Bijagos Islands form part of Guinea-Bissau.

History

Guinea-Bissau had officially been a Portuguese colony for one century. In 1974, after twelve years of fighting, independence was granted by Portugal. The new government has established two basic principles to guide its efforts for improving the situation as left by the colonial regime and the liberation struggle:

- priority to the rural people;
- a structure of popular participation.

These two principles have been laid down by the leadership of the liberation movement Partido Africano da Independenicia da Guiné e do Cabo Verde (PAIGC), the single political party in the country. This policy has been reconfirmed in 1980 by the revolutionary council under the leadership of Jaõ Bernardo Vieira.

Economy

Agricultural production is the main economic activity in Guinea-Bissau but there has been a considerable setback during the liberation struggle. After the Portuguese left, only very few trained people were available to take up posts in management, planning and administration.

The new regime has been attempting to move the country away from a situation of dependency on any single product or source of external assistance. However, the economy of Guinea-Bissau is still in a persistent external trade deficit. The annual gross national product is about US $ 170 per capita.

Demography

The estimated population in 1980 was 780,000. The majority, around 80 %, lives in the rural areas.

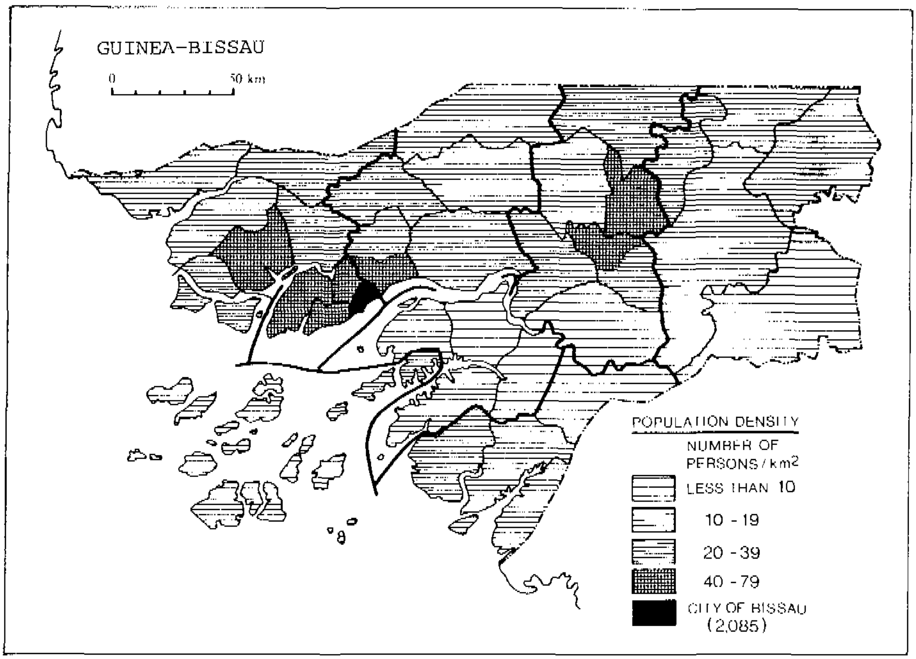


Figure 2. Population density.

Source: Guinea-Bissau Country Documentation No. 5, 1979 Royal Tropical Institute, Amsterdam

The ethnic distribution is as follows:

- Balanta	30%	Mandinga	13%
- Fula	20%	Papel	7%
- Manjaco	14%	Others	16%

The distribution by religion is: 60% of the people are animistic, 35% Muslim and 5% Roman Catholic.

Climate

The climate is tropical with a wet season (June-October) and a dry season (November-May). In fact it is possible to distinguish two climates: a maritime one on the coast, and one with Sahelian influences in the central and eastern regions.

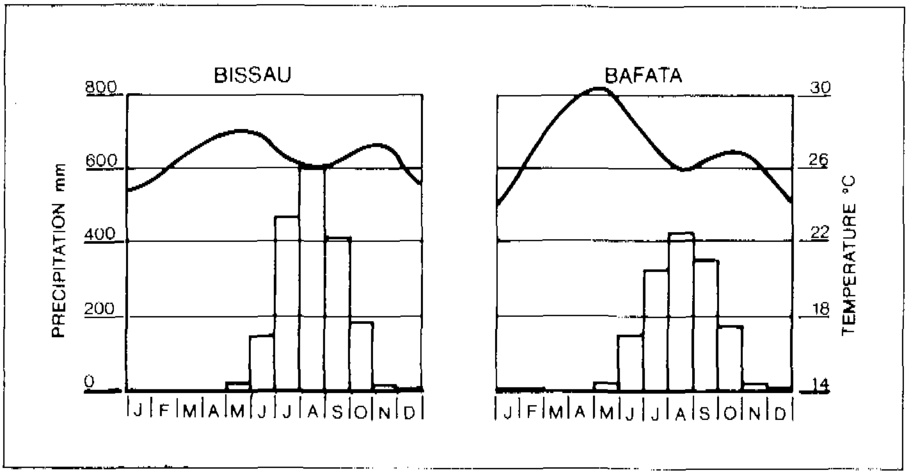
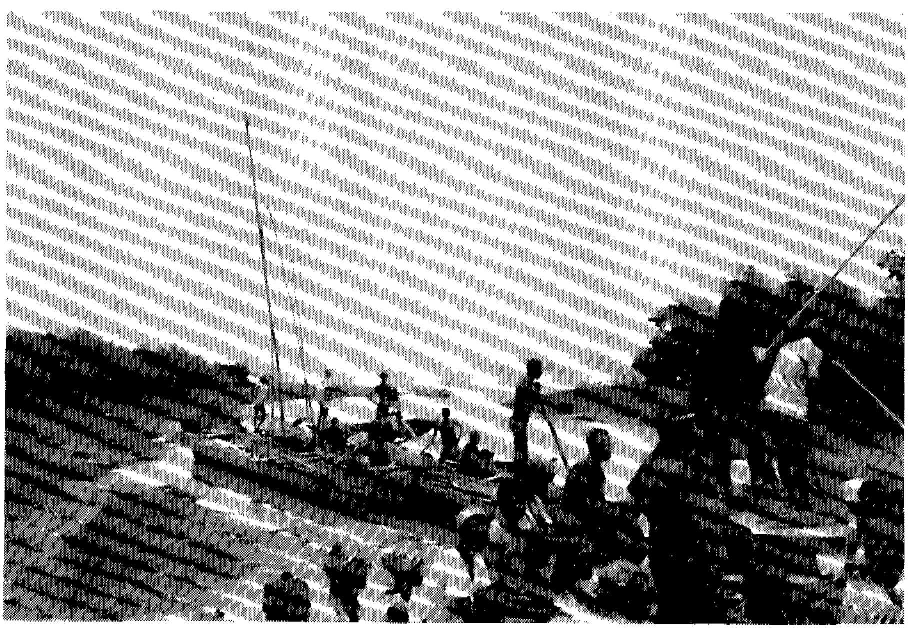


Figure 3.
Climate diagram.

Source: Guinea-Bissau Country Documentation No. 5, 1979
Royal Tropical Institute, Amsterdam



Transport by boat is common.

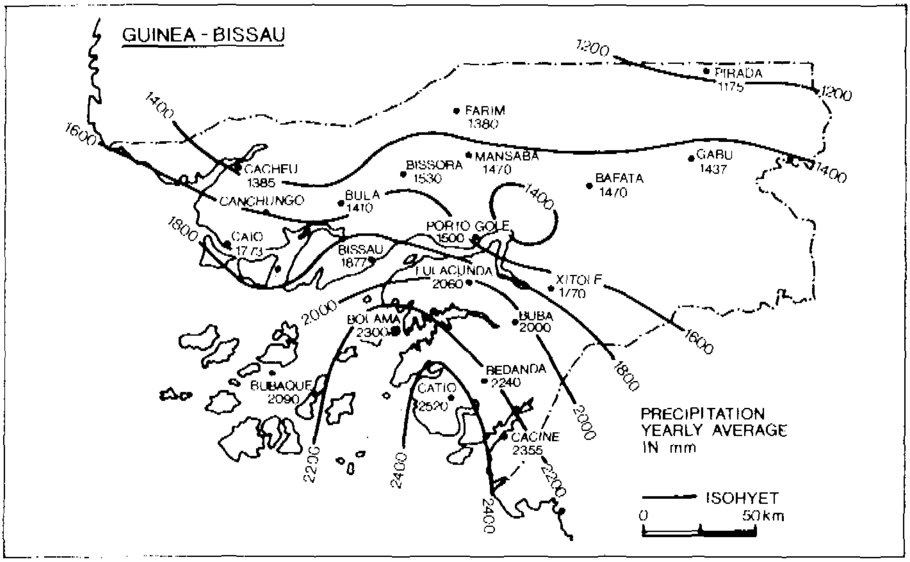


Figure 4.
Annual precipitation (1959).

Source: Guinea-Bissau Country Documentation No. 5, 1979
Royal Tropical Institute, Amsterdam

Rainfall is abundant in the coastal plains. A remarkable tendency towards lower annual rainfall rates has been observed during the seventies. This has resulted, among other things, in a considerable fall in agricultural output especially the production of rice.

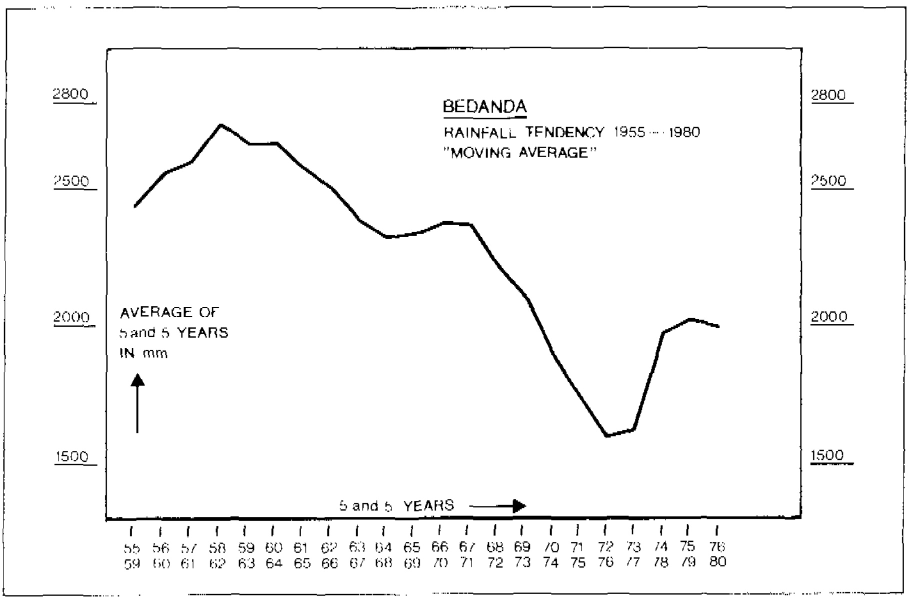


Figure 5.
Rainfall tendency.

1.3 The project area

Geography

The regions Quinara and Tombali, in which the well construction project was carried out, are very important rice production areas. The regions cover about 6,000 square kilometers bordered in the north by the Rio Geba and the Rio Corubal. Only one bridge, in the south-east near the village of Saltinho, connects Quinara and Tombali with the other parts of Guinea-Bissau. The area is largely situated in the coastal plain, deeply indented by estuaries and rivers.

Hydrogeological situation

The existing knowledge of the subsurface geological formations and the hydrogeological situation is extremely limited.

Schematic profiles as presented in Table 1 indicate the composition of the shallow geological formations. Profiles 1, 2 and 3 are found in the shallow ridges that are characteristic for the coastal plain. Profile 4 is found in the coastal islands.

Table 1.
Typical subsurface profiles for shallow geological formations in Guinea-Bissau.

Depth (m) \ Profile	1	2	3	4
2.0	laterite with sandy clay	laterite with sandy clay	laterite laterite, with streaks of clay	fine sand (aquifer)
4.0	dense laterite with streaks of clay		dense homogeneous clay	clayey fine sand
7.0	fine sand (aquifer)	laterite clayey sand (aquifer)		
12.0 to 16.0	dense clay	dense clay		

A schematic cross section of such a shallow ridge is shown in Figure 6.

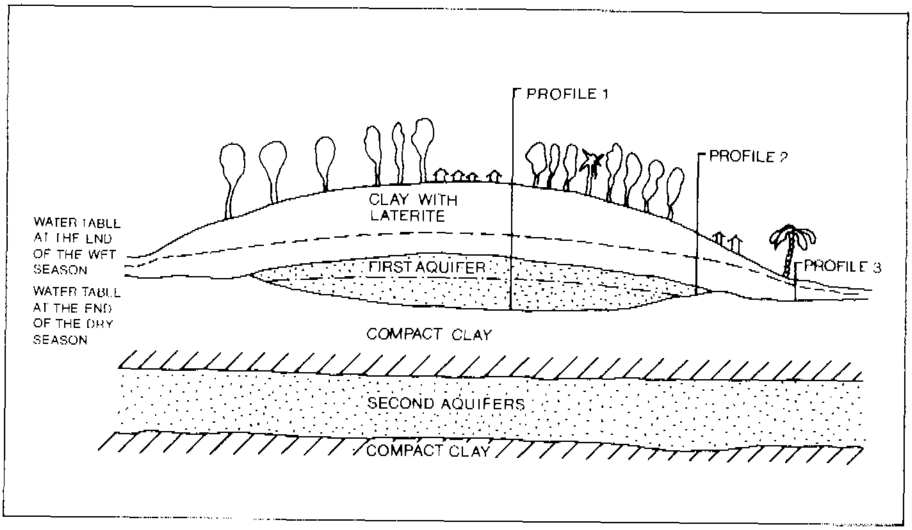


Figure 6.
Cross section of shallow ridge (schematic).

The profiles 1, 2 and 3 are also found in the south-east of Guinea-Bissau, but there are areas where hard rock has been encountered.

View on a shallow ridge; surface runoff eroding the topsoil.

For the deeper ground formations, very limited geological data are available. The profile presented in Table 2 is indicative only.

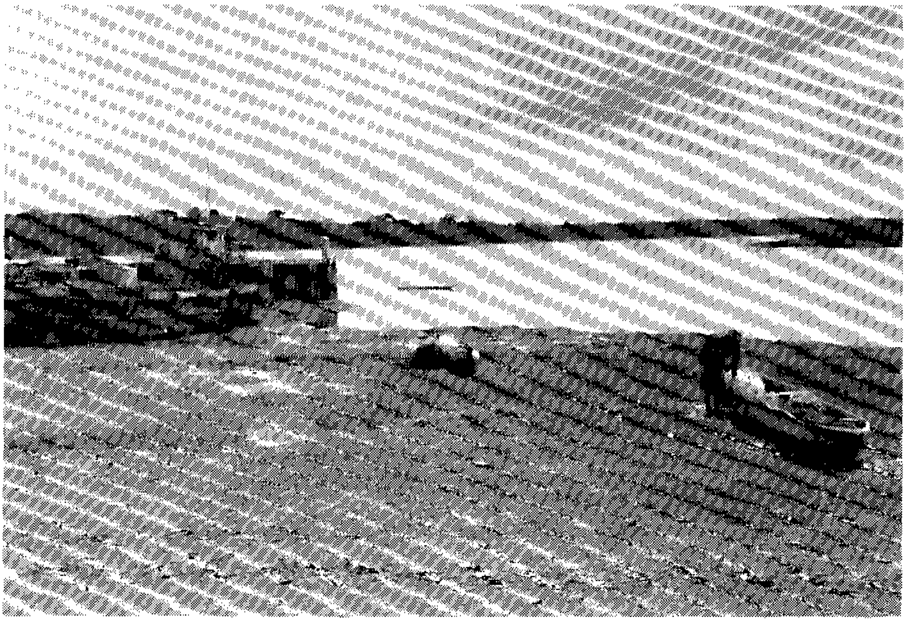
Table 2.
Indicative geological and hydrogeological data for ground profile near Bedanda (24).

DEPTH (meters)	LITHOLOGY	HYDROGEOLOGY
	lateritic sand and clay	first aquifer
7		
	clay	
22		
	limestone sand	second aquifer
25		
	clay	
32		
	sand clayish sand sandstone	third aquifer
68		
	clay	
75		
	schist	substratum

Transport and communications

Overland transport is difficult due to the topography of the country. In the south of Guinea-Bissau, there are only three all-weather roads with a total length of 60 kilometers. During the wet season several districts especially those near the coast are not accessible for trucks or Landrovers.

Transport by boat is common, although many villages can only be reached during high tide. In 1980, projects for improvement of the country's infrastructure started. A road construction programme financed by the World Bank has begun, and a national ferry service was introduced connecting the southern regions with the capital Bissau, on a six journeys per week schedule.



Various coastal villages are accessible by boat only during high-tide.

As Buba has no telephone connection with Bissau, the project used a radio transmittor for communication purposes.

Table 3.
Travel-time Buba-Bissau.

connection Buba - Bissau	travel time
by road	6 - 12 hours
by boat	36 - 48 hours
by road and ferry*	4 hours

* On a six journeys per week schedule.

Population

The official census held in 1979 produced the following data on the distribution of the population in the Quinara and Tombali regions of Guinea-Bissau.

Table 4.
Distribution of the population, by region.

Regions	district	villages	population
Quinara	Tite	50	11,000
	Fulacunda	50	5,000
	Buba	40	5,500
	Empada	60	7,500
Tombali	Catio	80	19,000
	Bedanda	55	12,000
	Cacine	50	7,000
	Quebo	35	5,000

The most important economic activity is traditional agriculture.

1.4 The Buba-Tombali water supply project

Objective of the project

The project's objective was to provide an adequate supply of safe water to the population in the two southern regions of Guinea-Bissau. Quantity as well as quality should be sufficient throughout the year, while walking distance should be limited.

To try to achieve this with fairly simple techniques and at moderate cost, the project was directed to the construction of shallow wells equipped with a pump or a bucket.

Experiences of similar projects in other developing countries have shown that constructing a well does not in itself guarantee that it will be actually used. For this reason, in the Buba-Tombali project a separate section was created with the special task of stimulating the proper use of the new wells. Co-operation between this "social activation" section and the project's technical sections was promoted vigorously, and proved to be one of the strong features of the project. Extensive liaison with the population enabled the project to be responsive to their needs.

The project was originally planned to produce, on average, 150 wells per year. The social activation section preferred a lower construction rate, because little experience existed initially to support their type of work. The construction section preferred a higher rate (200-250 wells per year).

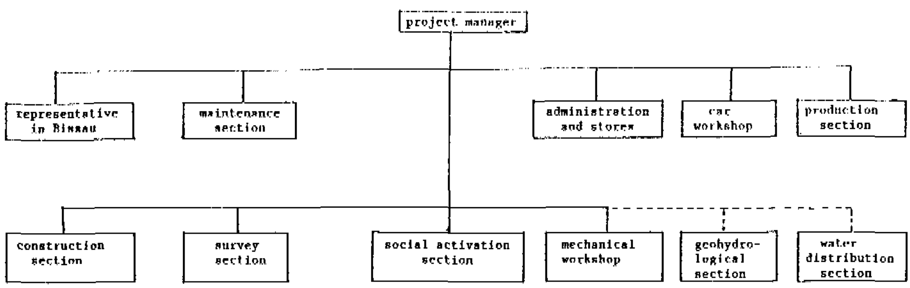
Project organization

The project was established as a fully separate entity within the Ministry of Natural Resources, as there was no existing organizational structure for the southern regions. Only in three small towns were skeletal services existent for maintenance of the water distribution systems. These originated from the Portuguese colonial regime, but they were barely functioning because of lack of tools, spares and organization.

The project functioned completely independently, and the payment of the local staff employed in the project was the responsibility of the project team itself. Although this was an important advantage, from the beginning ways and means were sought to transfer part of the costs of local staff to the budget of the Ministry, step by step.

The general organization of the project is shown in Diagram 1.

Diagram 1.
Organization Buba-Tombali water supply project.



The following provides a description of the project organization:

Social activation section

This section consisted of three closely related parts:
- the promotion unit: which consults with the community, provides guidance for the introduction of the new well, stimulates its proper use, and provides the necessary information for making adjustments to the well construction programme;
- the sociological investigation section which makes additional sociological investigations;
- the horticultural unit: which investigates the potential for the growing of vegetables using water from the new well.

Survey section

This section was responsible for making technical surveys, and selecting the design for each new well. The first site choice for a well was made by the community. For the investigation of the selected site, hand-drilling equipment was used. Only if the original site proved unsuitable, were alternative sites investigated.

Construction section

This section was charged with the actual construction of the wells, including the provision of a concrete cover and the installation of a pump or rope-and-bucket system.

The following well construction methods were used in the project:
- hand digging;
- hand drilling, using drilling equipment of Ø 30 cm diameter, and G.V.K. casing (reinforced plastic casing);
- motor drilling: a percussion rig was used in those villages where conditions did not allow drilling or digging by hand.

By June 1981, the following construction capacity was available:
- 2 teams with heavy hand-drill equipment;
- 9 teams for well digging;
- 1 team working with a percussion rig.

Production section

The production section was responsible for:
- supply of sand, gravel and filter sand;
- production of concrete rings and covers, for which a factory was established in Buba. The rings and covers were transported to each well site by truck. Sometimes, it was necessary to produce the rings and cover at the well site, for instance on the islands in the estuaries;
- manufacture of wooden furniture for offices and houses.

Mechanical workshop

The workshop assembled and repaired pumps, as well as rope-and-bucket systems.

Car workshop

A car workshop was set up for the repair and maintenance of the vehicles of the project. The building and all equipment for the car workshop were provided.

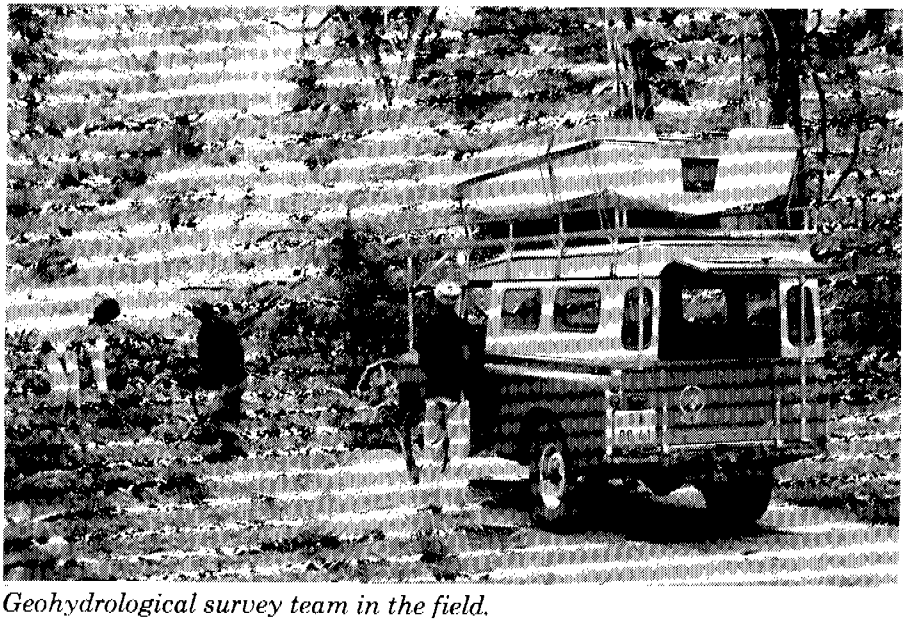
Maintenance section

Proper maintenance of all installed wells and pumps is extremely important. Efforts were made to establish a complete maintenance organization. Different maintenance systems were set up to select the most suitable one under the conditions prevailing in the project area, to arrange for the necessary budget covering the maintenance costs. It proved to be a serious problem. Towards the end of 1981, the Ministry of Natural Resources agreed to start financing the staff of the maintenance section and the fuel costs.

Geohydrological survey section

This section was charged with providing technical services such as:

- groundwater investigations;
- measurements of river water quality (e.g. total dissolved solids content);
- river discharge measurements;
- rainfall and evaporation data.



Geohydrological survey team in the field.

Representative in Bissau

The project centre in Buba is not easily accessible from Bissau, and Buba being a small town, very few facilities were available. For practical reasons, it was decided to post a permanent representative of the project in Bissau. The representative's major tasks were:

- communications, using the radio transmittors as there was no telephone connection;
- liaison with the Ministry in all matters pertaining to the project;
- financial matters and banking services, in particular with the national bank which is located in the capital Bissau;
- customs clearance of project materials at Bissau port, the port of entry for most of the materials and supplies imported for the project.

Personnel

The number of staff employed in the Buba-Tombali water project gradually grew as shown in Figure 7.

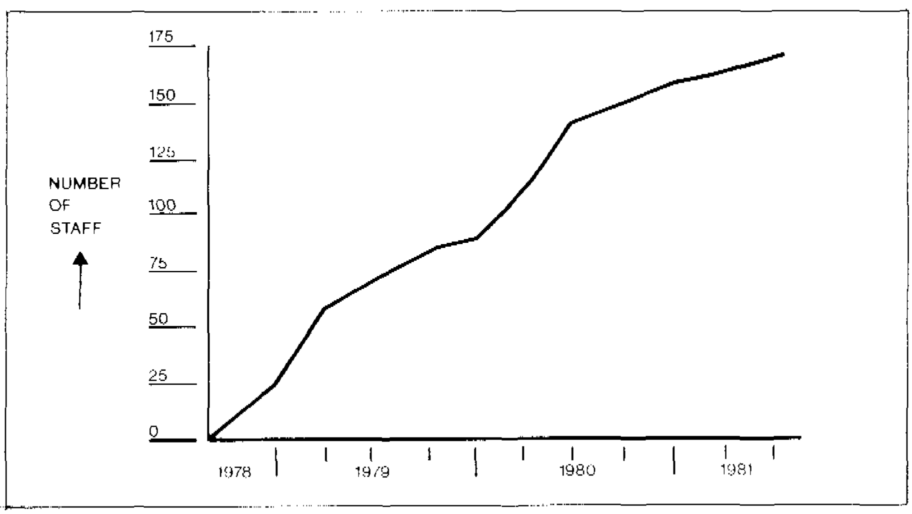
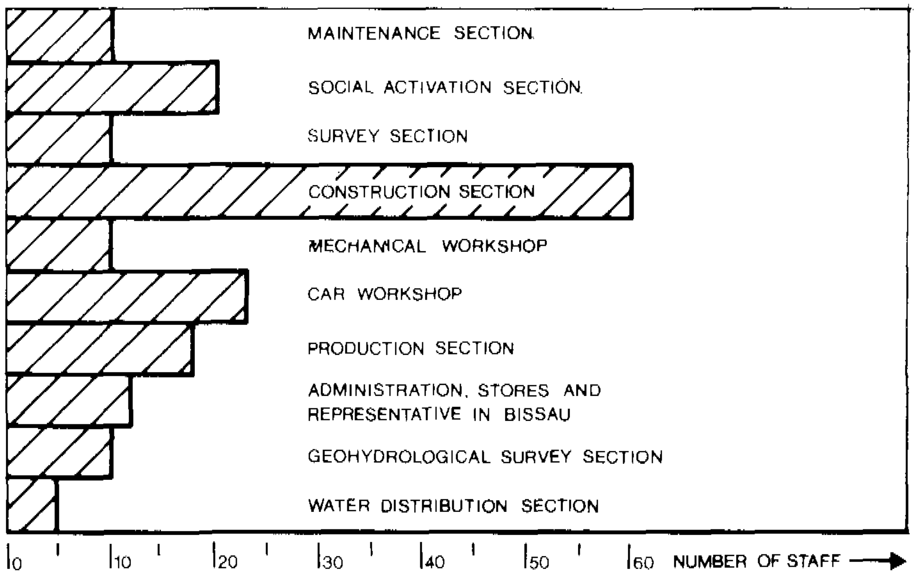


Figure 7.
Number of staff employed in the project.

By June 1981, the project employed 14 expatriate and 170 local staff. The distribution by section is presented in Table 5.

Table 5.
Distribution of project staff by section.



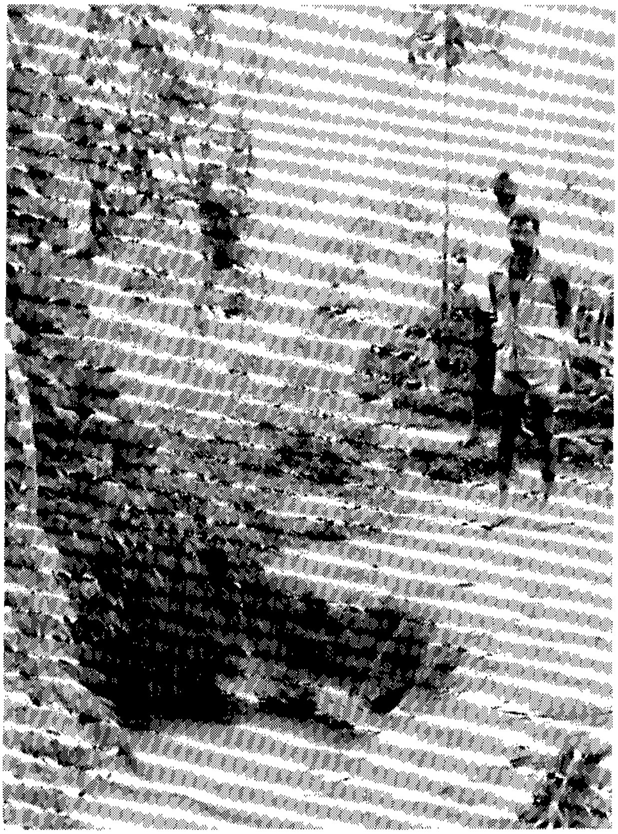
The recruitment of expatriate staff members was sometimes difficult, and time lags occurred in the replacement of project staff. Yet, it is very important to prevent these time lags, as they have a negative influence on the project results. New staff should get settled before the person who is to be replaced leaves the project team.
Such discontinuity in the project execution must be avoided. A good recruitment policy, therefore, requires close cooperation of the project team with the recruitment services both in The Netherlands and in Guinea-Bissau. The average time needed for the recruitment of expatriate staff members in the Buba-Tombali project was about nine months.

Training

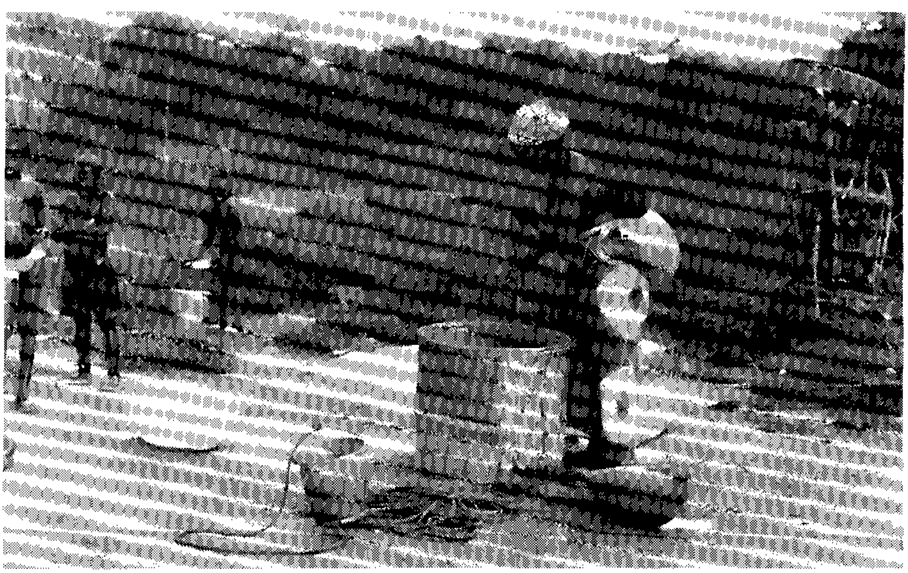
In the execution of the project much attention was paid to training, this being essential to promote the eventual successful transfer of the project to the Guinea-Bissau authorities.

Without transfer of knowledge and skills, little development will ultimately be achieved. Especially in the later phase of the project full attention was given to knowledge transfer, and the development of the necessary capabilities for maintenance and repair.

The existing water situation



A water hole.



A traditional well in a Fulani village.

Transport Means

As the road conditions in Guinea-Bissau are very rough, the project transport means had to be capable of meeting exacting requirements. To facilitate maintenance, only two types of vehicles were used: Landrovers and trucks.

A small ferry was bought to ensure a better transport connection with Bissau. Three small motorboats were used for transport to the islands.

Procurement of material

Much attention was needed for the ordering of equipment and supplies, as virtually all the materials for the project had to be imported from The Netherlands. The following figures may provide an indication of the quantities involved:

- petrol consumption: 150,000 litres/year
- cement usage: 350,000 kg/year.

A careful planning of the project supplies was very necessary. For instance, one missing spare part could result in a vehicle being out of service for 4 to 5 months or more.

1.5 Results

The principal result of the water well construction project up to June 1981 was that some 30,000 people were provided with a better supply of water on a year-round basis, and that the proper use of this water was promoted.

Survey

Up to June 1981, the project survey teams carried out 763 test drillings; 352 of them led to a suitable site selected for the construction of a well. Thus, on average, 2.3 test drillings were necessary to locate one suitable well site. The number of test drillings per well site ranged for the various areas from 1 to 10 test drillings per well.

Number of wells

The number of constructed wells is shown in Figure 8.

In June 1980, at the end of the dry season an investigation of the first 130 wells showed that 58% of the wells were successful, having no recharge problem.

Based on the experiences obtained, improved methods of site selection and well construction were introduced. As a result, by June 1981, out of all wells constructed after June 1980, 81% were without any recharge problems, which is the more remarkable as the wet season of 1980 had a very low rainfall.

Well equipment

By July 1981, 220 pumps and 113 rope-and-bucket systems had been installed.

Initially the wells were equipped with a foot-operated "Kangeroo" pump imported from The Netherlands. Later, as the people showed preference for a handpump, a special workshop for pumps and buckets was established. The "Buba" pump, developed by the project team, is now being provided. Except for the cylinders, this pump is completely manufactured in Guinea-Bissau, from imported material. The rope-and-bucket system was introduced to reduce the maintenance costs.

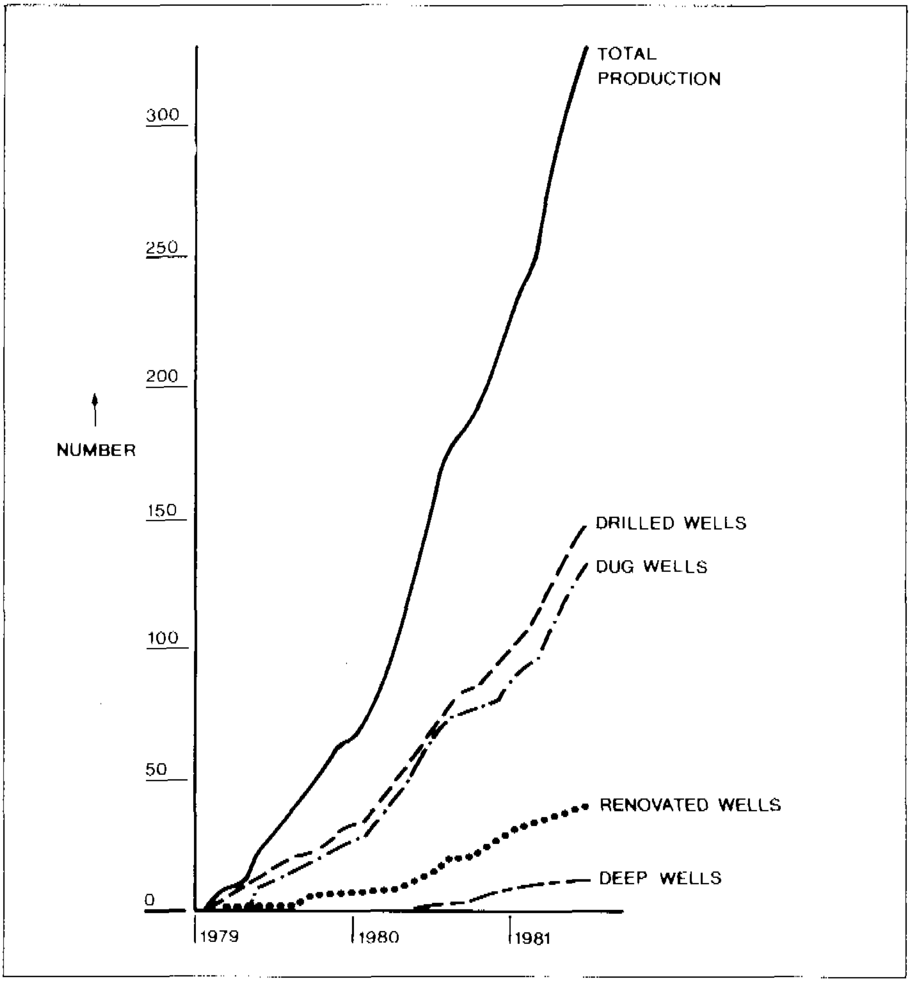


Figure 8.
Wells constructed in the Buba-Tombali water supply project.

1.6 Future planning

The project was originally planned for completion by July 1984, but in December 1981 a proposal was submitted to extend the project to 1986, for the following reasons:

- the transfer of the project to the Guinea-Bissau authorities proved more difficult than was originally envisaged, mainly because of the limited absorptive capacity of the economy of Guinea-Bissau;
- further studies showed it necessary to find a solution for the maintenance problems of the wells and pumps;
- the social activation section found that a more gradual transfer of their task to the Guinea-Bissau agencies would be essential;
- the adequate training of the Guinea-Bissau counterpart staff required more time; this was a crucial factor, as very few trained technicians were available in Guinea-Bissau; an extension of the project would allow more time for training efforts.

The proposal to extend the project was further supported by the findings of a mission of the project staff to several rural water supply projects in Tanzania.

Number of wells

The total number of wells to be constructed in the project was set at 850. This is about 400 more than was originally planned. Even so, it was necessary to relax the criteria of the project, as their full application would have required the construction of more than 1000 wells which appeared to be unrealistic under the given conditions.

Equipment

The distribution of the wells (both planned and constructed) by type, is as follows:

- 450 wells equipped with a pump;
- 400 wells with a bucket.

2. COMMUNITY PARTICIPATION IN THE BUBA-TOMBALI WATER PROJECT

2.1 The community participation concept

Community participation is an essential element of water supply and sanitation programmes in developing countries. However, considerable efforts are required for the concept of community participation to become truly operational. In a recent publication it is defined as:

> "the involvement of the local population actively in the decision-making concerning development projects or in their implementation" (White, 1981).

Thus, community participation should be much more than involving the population in the actual construction work of a project. In the following paragraphs, some of the major points are discussed.

The various forms of community participation

Many different types of activity are covered by the term "community participation". One recent classification lists ten forms (Diagram 2).

Diagram 2.
Forms of community participation.

1. Consultation
2. A financial contribution by the community
3. Self-help projects by groups of beneficiaries
4. Self-help projects involving the whole community
5. Community-based project assistants
6. Mass action
7. Collective commitment to behaviour change
8. Endogenous development
9. Autonomous community projects
10. Approaches to self-sufficiency

Source: White, 1981

It is interesting to note that only in the first five forms of community participation, is there a major role for the external agency.

Forms of community participation used in the project

The forms of community participation of relevance to the Buba-Tombali water project were: consultation, community-based project assistants, and to some degree self-help projects involving the whole community.

Consultation

The basic means for the community to participate in a water supply project, and for involving it in the decision-making process, is consultation. The objective is to ensure that the water wells and pumps introduced by the project would be suited to the needs of the communities, and would be supported by them. The necessary steps usually involved:

- consultations with community leaders (e.g. village chiefs); such consultation does not always represent true community participation, unless the community is one where the decisions formally made by such leaders are, in fact, the result of wider consultations and, in this way, based on consensus.
- consultations with all sections of the community; primarily a matter of ascertaining the views of those groups in the community which would normally be excluded from the decision-making process; this may apply to women, and any ethnic minorities or low-caste groups; the goal is to ensure that the project will also fully meet their needs, but this usually is not easy to achieve; there exist different views on the emphasis which can or need to be given to it.

Community-based project assistants

This consists of the appointment and training of one or a few community members to perform special tasks such as pump maintenance.

Self-help projects involving the whole community

These include projects in which the community is expected to make a contribution (usually in labour), which is matched to the input from the government, with foreign assistance.

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* For further reading, see IRC Technical Paper no. 17 Community Participation in Water and Sanitation, by Dr. A.T. White.

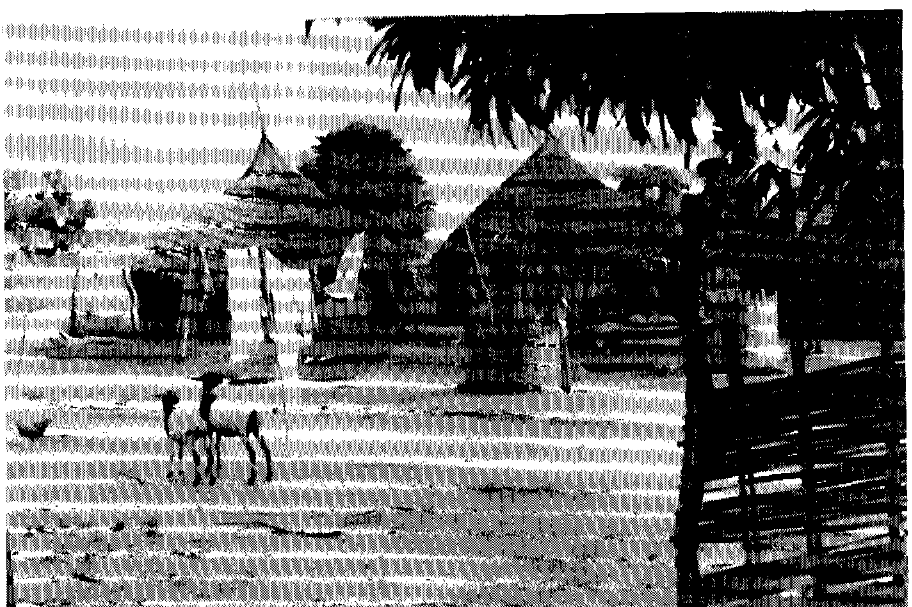
Potential benefits

Why should one consider the ways and means of promoting community participation? A summary of potential benefits is given in Diagram 3. Not all of these reasons are of equal value, in each case, but taken together they make a strong argument.

Diagram 3.
Ten potential benefits of community participation in water supply projects.

1. With participation, more will be accomplished.
2. With participation, services can be provided more cheaply.
3. Participation has an instrinsic value for participants.
4. Participation is a catalyst for further development.
5. Participation encourages a sense of responsibility.
6. Participation guarantees that a felt need is involved.
7. Participation ensures things are done the right way.
8. Participation uses valuable indigenous knowledge.
9. Participation frees people from dependence on others'skills.
10. Participation makes people more conscious of the causes of their poverty and what they can do about it.

source: White, 1981



A village in Guinea-Bissau.

2.2 Preliminary investigation

At the end of 1978, a sociologist, Drs. J.D. van der Ploeg was asked to prepare a preliminary social report in relation to the water supply problem in the regions Quinara and Tombali. It is useful to have a considerable amount of information on the communities and their social structure for effective planning of a programme of community participation. However, isolated information gathering activities should be limited as much as possible as the real objective is to have a full consultation with the communities.

The preliminary study

The preliminary study had the objective to establish a basis for the preparation of the workplan for the social activation part of the project. A separate section of the project organisation was established for promoting community partipation in the Buba-Tombali water supply project. The preliminary study was concerned with the existing water supply situation and the pattern of water consumption in selected villages, over a period of three months.

Survey

The survey of the existing water supply situation was carried out in 47 villages in the project area. As a first step, in each village the village committee was consulted. The purpose of the visit was explained and the committee's support was sought. Using the checklist shown in Diagram 4, information on the water supply situation was collected. The checklist also included questions relating to other uses of water such as for watering of vegetable gardens. Information on all of the community's water needs is likely to be the best basis for providing a supply.

In some selected villages, a detailed survey was made to investigate the water use specifically, using the following methods:
- observation of frequency of use of various water sources;
- registration of the time it takes the users to fetch water;
- each house was visited to ask women further information on their water use habits.

Diagram 4.
*Questionnaire for Survey on Water Situation**

1. Name of the village.
2. Name of the chairman of the village council.
3. Type of village, centralized or dispersed.
4. Number of inhabitants.
5. Ethnic group.
6. Which water sources available?
7. Which ones are used for drinking water; if not all, why not?
8. Which water is used for cooking?
9. Which for laundry purposes?
10. Which for washing and personal hygiene?
11. What kind of cattle is present in the village?
12. Where are the cattle watered?
13. Are clay blocks made for housing?
14. Are there gardens? If so, where does the water come for irrigating them?
15. Which vegetables are grown in the rainy and which in the dry season?
16. Are there any special problems not mentioned so far?

* Not exhaustive: the questionnaire is only meant to be a tool for systematised exchange of information beyond the posed questions.

Economic aspects

An important field not covered in the survey was the matter of possible water charges for an improved water supply. The Guinea-Bissau authorities regard village water supply as a basic need, which should be provided for by the government. Furthermore, it would have in any case been very difficult to charge for the water.

A special World Bank study has shown that people normally are unable and unwilling to spend more than 3-5% of their cash income on water. In a recent survey of two villages in Upper Volta, the feasibility of a financial contribution by the population in the costs of maintaining the improved water supply was investigated. Actual expenses for ropes and buckets used for lifting the water from the well were calculated and compared with the estimated income per person (Table 6).

Table 6.
Expenses for ropes and buckets in two villages in Upper-Volta

number of persons per family	village of BOARE population: 1130		village of ZIZIN population: 369	
	expenditure per person	% of estimated total expenses	expenditure per person	% of estimated total expenses
less than 6	342 CFA	9.5 %	162 CFA	2.9 %
between 6 and 10	185 CCFA	5.2 %	164 CFA	3.0 %
more than 10	140 CFA	3.9 %	145 CFA	2.6 %
average family	192 CFA	5.4 %	155 CFA	2.8 %

* the higher costs in Boare village are due to the greater depth of the well
** the village of Zizin is more wealthy
100 CFA = US$ 0.40

As the water supply situation in the village of Boare was very inadequate, the people were found willing to pay an extra charge of 60 CFA per person. Moreover, they would be prepared to provide assistance in the construction work needed to improve their water supply. Apparently, it can be possible to obtain some contributions from the users for meeting maintenance costs, provided the existing water supplies are replaced by a water supply system which is regarded by the users as much better (e.g. a good handpump instead of each individual family using its own bucket and rope).

Obviously, knowledge of the economic aspects is very important in all stages of a water supply project, as it may have a considerable influence on the design, the installation and the maintenance set up.

Institutional aspects

A further aspect covered by the preliminary survey --but not fully-- was the existing structure and capabilities of the government agencies involved. Important in this respect proves to be the existing health care structure. The introduction of a new water supply, and especially the promotion of its use, is usually regarded as the responsibility of the village health workers. However, formal arrangements for cooperation need to be made.

2.3 Field investigation data

The main results of the preliminary investigation are given below.

Existing drinking water supply situation

About 40% of the villages had no water well. The villagers were using water of small springs and pools, mostly highly polluted and situated at a considerable distance from their houses. Several of these pools and springs were dry in the last two months of the dry season. Of the villages with one or more wells, the majority had serious water problems in the dry season. Many of the drinking water facilities were also used for cattle, and for laundry.

Table 7.
Existing water facilities.

no. of wells per village	no. of villages	% of dry wells in dry season	population average	no. of persons per well
-	20	-	170	-
1	6	100	55	55
2	5	60	250	125
3	4	50	620	207
4-10	10	40	406	71
10-20	2	50	590	32

Water and hygiene

A difference could be noticed in the hygienic customs of the two main ethnic groups living in the project area. The Fulanis have a long-established concern for the cleanliness of water, and some of them use a water filter, although they do not fully understand the relationship between polluted water and disease. The traditional wells of the Fulanis have an upper part consisting of an old oil drum which is used as a cover against contamination.

In the Balanta villages the existing wells are usually less adequate. The construction of their wells is normally not such that surface runoff is prevented from entering. Pools of spilt water and wash water surround the wells, and the presence of frogs in the wells is by no means exceptional.

Number of wells

The number of existing wells and the average number of persons per well, were as given in Table 7. These data show a wide variation. In the villages of the Fulanis, where clean water is appreciated, the number of people using a well usually does not exceed 50 (Figure 9).

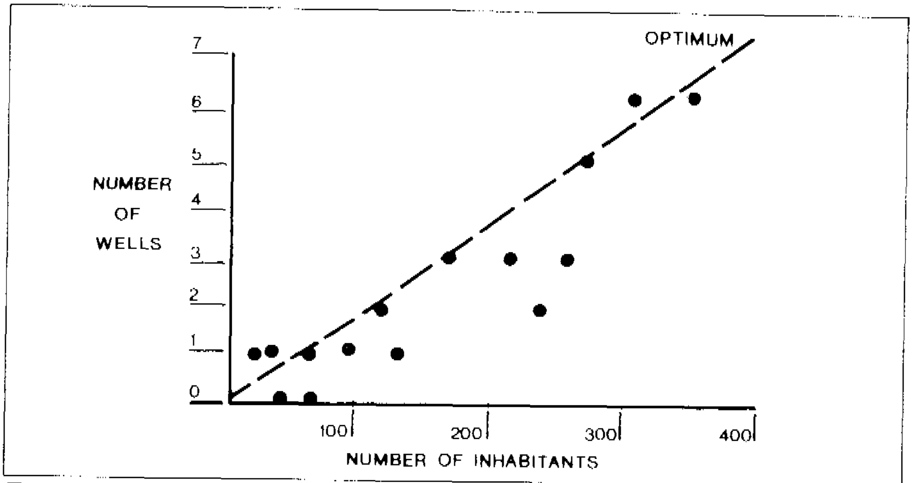
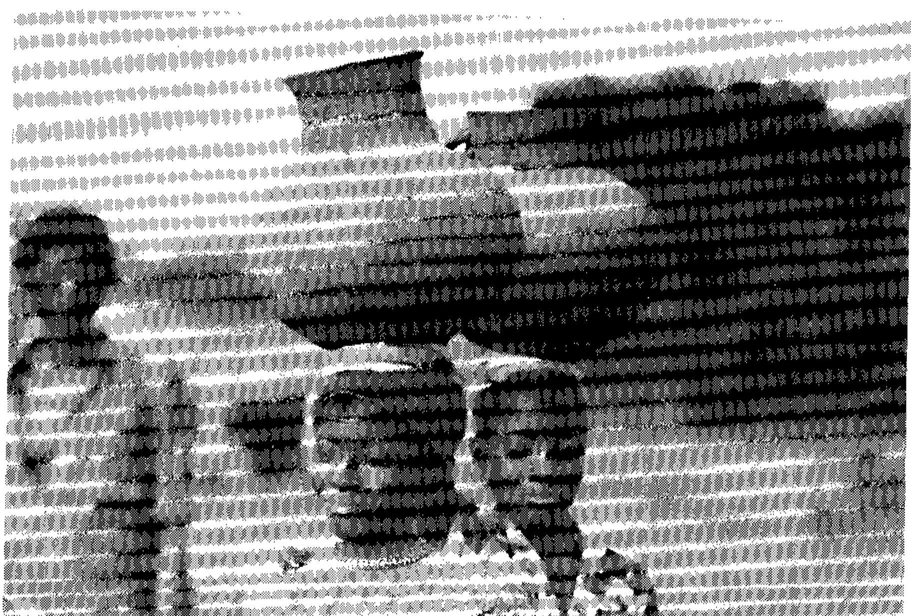


Figure 9.
Number of wells in Fulani villages.



Long walking distances are common.

Types of villages

Due to ethnic differences, geographical conditions and historical reasons, there are several different types of villages. These may be distinguished as follows:

1. Small settlements without a well, up to 100 persons;
2. Centralized villages, with one or more wells; these are mainly Fulani villages;
3. Centralized villages, where two different groups live; these groups live in separate parts of the village, so that such a village should in fact be regarded as two villages, side by side;
4. Villages with large family units; these are Balanta villages sometimes with units of more than 100 persons; many of these units have their own well which reflects the status and importance of the family head; however, outsiders are free to use the well.
5. 'Urban' villages; some are 'Spinola' villages, originally settlements which were established by the Portuguese during the liberation struggle, others were former army camps usually still having what had remained of the once-installed water distribution system.

The walking distance to the existing wells, generally, was less than 500 m. Springs and pools normally were at a greater distance, up to 1 or 2 km. In the dry season, walking distances up to 5 or even 10 km were no exception.

Taste and quality of the water

The most important factor which people consider in accepting water for drinking is its taste. Yes, the water should be without visible contamination, but to the users this seems not to be an essential point. Water which is somewhat high in mineral content, or water tasting of a high iron content, is often rejected as drinking water. Considerable walking distances are accepted to fetch other water with a "better" taste, even where a water well is situated close to the house.

Pattern of use of wells

The use of wells differs not only during the day, but also in the way it is used by various ethnic groups. This is shown in Figure 10. The pattern found in Gambile Balanta clearly indicates that the Balanta women take water only in the early morning and late in the afternoon, which has to do with the fact that they work all day in the fields.

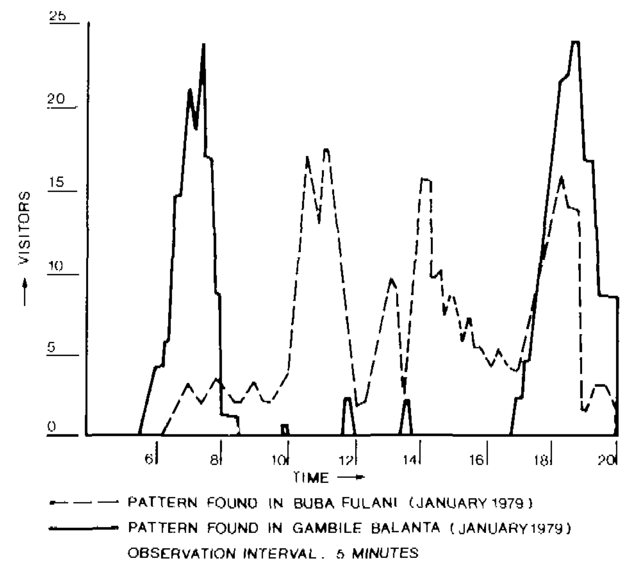


Figure 10.
Pattern of well use.

Types of water

The people distinguish water for different types of use (Table 8).

Table 8.
Types of water as distinguished by the population.

type of water	main characteristics
1. water for drinking	clean and tasty
2. water for cooking	close to the house
3. water for washing clothes	large quantity, not stagnant, place for social contacts
4. water for bathing	found on a sheltered spot

Installation of a pump not sufficient by itself

In one region of Guinea-Bissau, pumps were installed in a water supply project without community participatory efforts. A survey of twelve villages produced the following data:

- in two of the villages the population obtained their drinking water exclusively from the pump;
- in two other villages drinking water was taken from the pump, but also from existing wells;
- in four villages, the water from the new wells was rejected as drinking water because of taste;
- in three villages, the pump was out of operation;
- in one village, the pump was not used at all.

Although of a very limited scale, the survey indicated that the installation of a pump by itself would not necessarily stop people from using their old wells.

Influence of traditional belief

Traditional belief is still very strong, even in the Muslim section of the population. Nature is seen as a unity, influenced by good and evil divine spirits. The gods, therefore, should be consulted and their consent must be sought for every important step. For example, before cutting a tree or digging a hole, certain ceremonies must be fulfilled.

Women as the target group

In Guinea-Bissau a segregation exists between men and women. Although the official party tries to change this situation, women generally still are in a subordinate position.

But the women are responsible for most of the water supply tasks; in fact, for everything except watering the cattle and fetching water for preparing clay blocks. Thus, women as the main users of the well should be regarded as the main target group. In practice, they only could be approached with the consent of the men.

The women are the main target group.

The village structure

Typically, in a Guinean village a mixture of two structures exists:

- the traditional structure: in this structure the 'homens grandes' (old wise men) and 'mulheres grandes' (old wise women) were the community leaders;
- the new structure introduced by the official party in Guinea-Bissau; in this structure the 'comité de base', a committee of 5 persons (3 men and 2 women) from the village council are the leaders of the community.

Visitors are received by either the most important "homen grande", or the president of the village council.

Assessment of the felt need

The actual needs for an improved water supply are not the same in different villages. The main problems expressed by the people usually are:

- the great walking distance to the water source, particularly in the dry season;
- queuing for those wells that still yield water in the dry season;
- the water quality is not satisfactory;
- there are no suitable places for washing clothes and for personal hygiene;
- the existing wells are too few;
- there is no water for watering vegetable garden plots.

In a number of villages, the drinking water supply was not considered the priority need. They viewed the water problems of the rice fields as more important. It should be noted that these views were given by the village committee, and not by the women.

Rice-fields in Guinea-Bissau.

2.4 The projects social activation section

The section's objectives

Based on the results of the preliminary study, the social activation section in the Buba-Tombali water supply project aimed particularly at bringing the well construction activities fully in line with the views of the village community, and at promoting the proper use of the water from the wells.

Further aims were the introduction of health education, and the promotion of garden plot watering for the growing of vegetables. Consultation with villagers should be expected to lead to demands of this type, as in some villages the drinking water situation is not seen as the greatest problem.

Important in the project's approach was that the objectives were not fixed, but could be adapted on the basis of regular evaluation.

Specifications of the tasks

The social activation section was responsible for the following tasks:

a. Survey

An inventory of the existing water situation was made using the checklist presented in Diagram 4, with the following additional items:

- the preferred site of the new well; special attention was given to the views expressed by the women;
- a schematic plan of the village was drawn up, marking the houses, with the number of people and any existing sanitary facilities.

The information so obtained was summarized in a brief report in the local language and discussed in a public meeting with the villagers.

b. Informing the village communities about the project

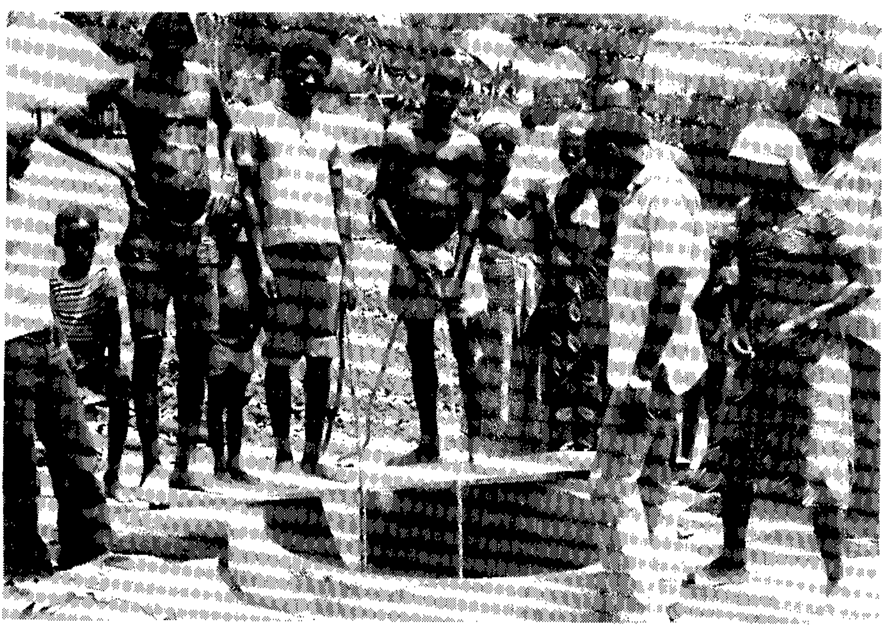
The village communities were informed:

- about the general objectives of the water supply project;
- that a test drilling and well construction team would come to the village for constructing the well;
- the different types of well construction;
- the number of wells which would be provided, using the guidelines shown in Table 9.

Table 9.
Guidelines on the number of wells.

Number of persons	number of wells	equipment
< 25	-	-
25 - 50	1	bucket
50 - 100	1	pump*
100 - 250	2	pump*
> 250	3 or more	pump*

* Sometimes a community preferred a bucket to a pump.



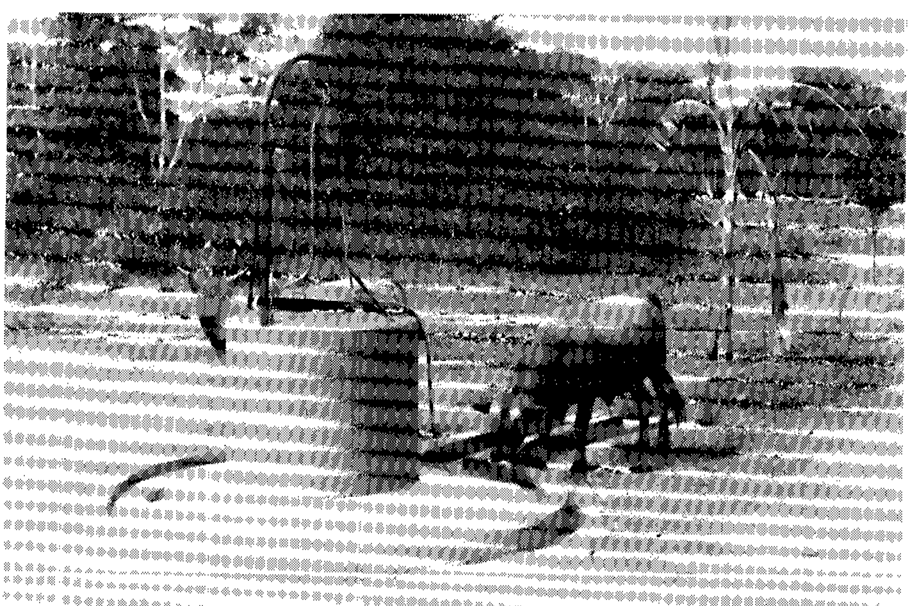
Volunteers helping in the construction of the well.

c. Decisions to be made and contributions expected from the villagers

The villagers were informed which decisions they would have to make, and which contributions were expected from them. This is summarized in Diagram 5.

Diagram 5.
Decisions to be made by the villagers concerning their contributions to well construction and pump maintenance.

Aspects	Contribution by the village
construction of the well	- access road suitable for truck must exist or be prepared - provision of free labour (2 labourers/day) - provision of sleeping accomodation and food for the construction team
selection of the well site and the type of equipment	- decision to be made in a community meeting
pump maintenance	- selection of one man responsible for the lubrication of the pump and one woman for cleaning the surroundings
construction of watering place for cattle and/or concrete floor for the laundry	- payment of 25% of the material costs - provision of free labour for the construction



Cattle investigating the new well; soon after completion, the well must be fenced.

d. Maintenance of the well and its surroundings

To promote proper maintenance of the pump, and care for the well and its surroundings, the following tasks were introduced by the promotional team:

- lubricate, once a week, the pump; this task to be carried out by the pump caretaker; he also should report any break down of the pump to the regional maintenance centre;
- cleaning, every day, of the well and its surroundings; this task to be assigned to a woman;
- regular inspection to ensure that certain hazardous activities are excluded from the vicinity of the well; these are listed in Diagram 6.

Diagram 6.
Checklist of activities to be prohibited in the vicinity of a well.

Activity	Within a distance of (meters)
clay digging for construction purposes	100
preparation of latrines	100
washing of clothes	25
planting a garden	25
watering cattle *	25

*) If cattle are present the well should be fenced.

e. Improvement of water use habits

To promote a better use of the water, the following matters were discussed with the villagers:

- water should be generously used for washing clothes, cleaning of the kitchen, utensils and washing for personal hygiene; the traditional low water-use habits often have developed in the existing situation of water scarcity;
- the growing of vegetables, possible by an adequate supply of water available on a year-round basis;
- health education, emphasizing ways and means to avoid disease, and the need for using sanitary facilities.

Promotional team

The promotional teams which were responsible for making the first contact with the village consisted of a man and a woman recruited by the project team. Where possible, these promotors were recruited from the areas in which they would operate. Because of the social structure prevailing in Guinea-Bissau, they have to be well-respected members of the community. A female promotor, for this reason, should be either a woman with children, or a 'mulher grande', an old wise woman. The project team preferred the mothers of children for the promotional team, as the 'mulher grande' might be too much bound by the traditional social pattern. Especially for contacting the women in the villages, the female promotor is very important as the women have a social framework quite separate from the men.

A female promotor visiting a village.

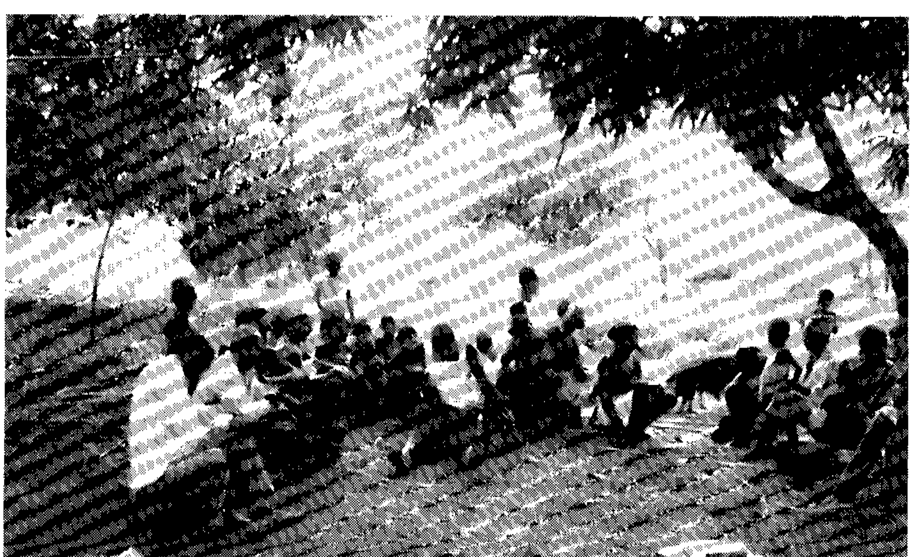
The choice of young female promotors with children posed some practical problems which were solved by:

- the provision of a baby sitter to take care of the children, to allow the mothers to take part in meetings with the promotional team;
- for every three teams one extra female promotor was appointed as a stand-in (e.g. for when a promotor could not attend to her work because of illness of one of her children);
- pregnant promotors were given two-month's leave; after this, one month's work in the project centre followed, and then normal field work would be resumed.

In Guinea-Bissau, children are generally breast fed up to the age of two. During field trips the female promotors, therefore, usually take their babies with them.

2.5 Field procedures

When the water supply projects entered a new area, a regional meeting was called to which representatives of all village committees were invited. These meetings took place about six months before the start of the actual well construction. In the following three months, a team consisting of a male and a female promotor would visit each community in the project area.



A village assembly.

Plan of action

The plan of action generally was as shown in Diagram 7, with each visit focused on one subject. Audiovisual materials, photographs and drawings were used to support verbal communication.

Although the promotors carried out their tasks with commendable enthusiasm, the first results did not fully meet expectations.

Evaluation of the first results

From the very beginning when the social activation section began its activities, it was decided to regularly evaluate the effects. As there was very little known about the methods used and experiences obtained in other water supply projects, the project's approach for involving the communities was initially of a tentative nature. In December 1980, an evaluation was done by a French sociologist, Mrs. A. Hochet, jointly with the project staff.

The main findings were:

- A positive relationship was found between the visits of the promotional team and the actual use of the new well for drinking water supply. In villages where there had been no follow-up visits after the construction of the well, a much smaller part of the population was using water from the well for drinking and domestic purposes, than was the case in the villages that had been regularly visited. In one village the new well which had been constructed outside the village was initially not used at all. But after several visits of the promotional team, almost all women began taking water exclusively from this well.
- Due to their high work load, women in the villages could only be be contacted at their places of work;
- The women regarded looking at pictures and talking in meetings as a waste of precious time, because their work was waiting;
- The women were not interested in health education and information on the need for sanitation, as their relationship to disease was not clear to them;
- The women were made responsible for keeping the surroundings of the well clean, but they were not taught how to organize for this work;

- The promotional team was found arrogant by the villagers; the reasons for this might be:
  . the manner in which meetings were conducted, with the promotors acting as teachers or instructors;
  . the promotors sometimes did not fully understand the information they were presenting; this led them to avoid difficult questions by taking an imposing style of discussion which left little opportunity for the people to put their problems forward.

The women need to be contacted at their working place as they have little time available, due to their high work load.

Based on the result of the evaluation, the sociologist recommended that:

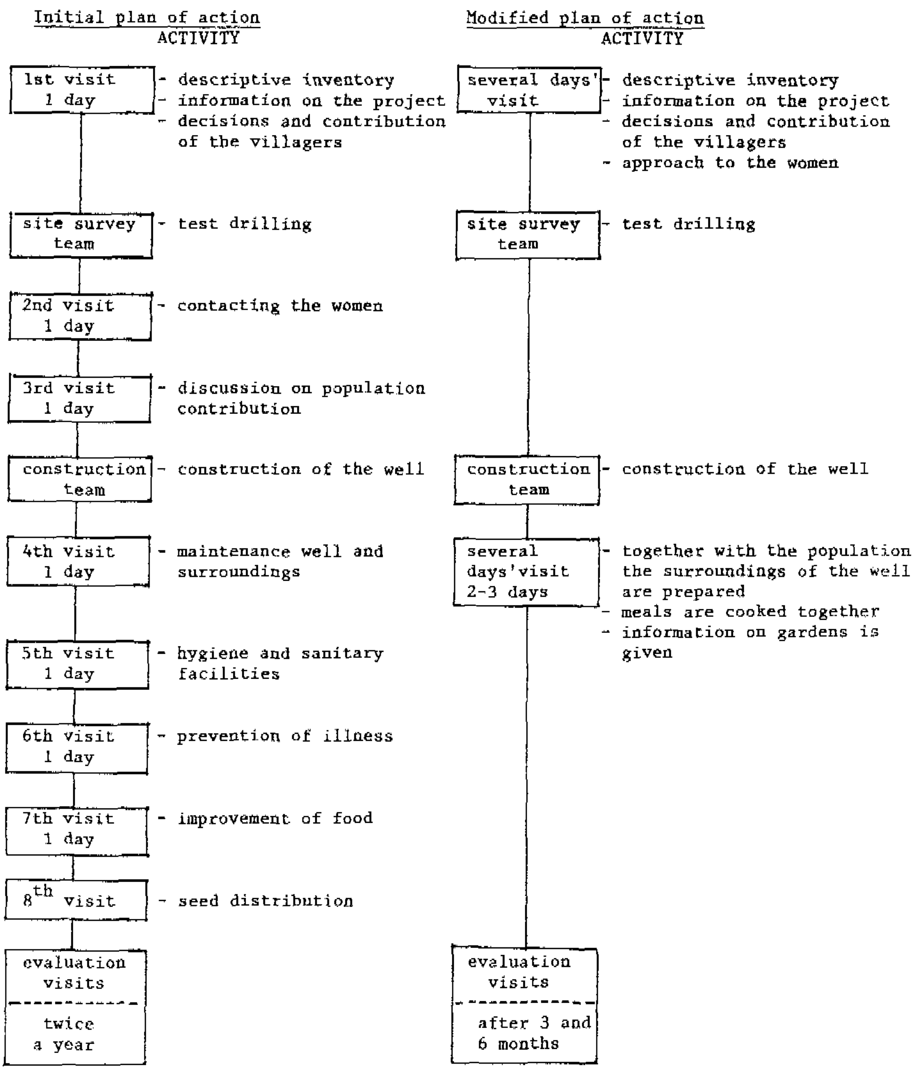
a. the approach should be more practical; rather than giving instruction it would be more effective to work with the women showing them how tasks should be done in a practical way;

b. the work load of the women should be reduced; improving the water situation represents a good start, but to change deeply ingrained behaviour would require a considerable further reduction of the work load. This would require things such as the provision of small oil presses, rice-husking machines and fishing nets.

The modified plan of action

On the basis of the evaluation results, the plan for the social activation section was modified. The modified plan is shown in Diagram 7. The original plan of action is also included in the diagram for comparison.

Diagram 7.
The initial and the modified plan of action.



The modified plan of action comprised the following steps:

The first visit

The team introduced itself to the village committee and a programme for the visit was decided upon jointly. The programme was flexible, and could be adapted to the situation of the village concerned.

Usually the first activity was to contact the women. They were visited at their working places or houses to discuss various points listed in a questionnaire, concerning the water supply situation. The information was then summarized in the local language, in a brief report that was discussed in a general village assembly at the end of the visit. This meeting was, in particular, used to check whether all villagers were in agreement with the selected well site(s), and fully aware of the contributions they would be required to make,

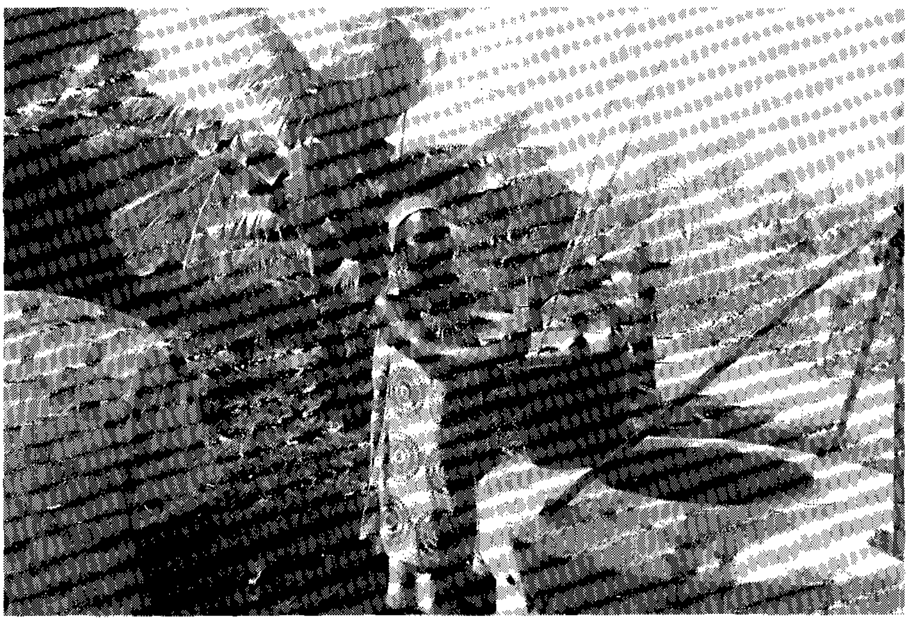
A woman is responsible for cleaning the well surroundings.

Visit of the technical team

The promotors, who as a result of their visit(s) should have had a clear idea of the existing situation, discussed any alternatives for the water supply system with the technical team. The necessary hydrological and hydrogeological data should have been collected in time to provide a basis for this consultation. Considerations included the possible upgrading of the existing water wells, if any, the selection of the site where the well was to be made, the drilling or digging of new wells and the type of water-lifting device to be used. The construction team usually would inform the community about the final decision. Only if the selected site was very different from what the community indicated as its preference, would the promotional team return to the village for a further discussion of the matter.

The second visit

After the well was constructed, a second visit of two to three days would be made. A meeting with all the women of the village was held in which the team informed them of the planned activities. A programme for these activities is shown in Diagram 8.



The seed of domestic vegetables was offered for sale as a supporting activity for the water project. Because of the great shortage of soap, the promotional team also started the sale of soap rather than pressing on with advice on the need for sanitation. However, as various studies have clearly established the importance of

Diagram 8.
Activities executed by the promotional team in co-operation with the women.

- clean the surroundings of the well
- select and prepare a place for laundry purposes
- construct a fence (if necessary)
- indicate and prepare a plot for a garden
- prepare meals for the children

sanitation programmes, to leave out health education would mean that a better understanding of the causes of disease would not be provided. This remains important if an improvement of the overall health situation is to be obtained, and further investigations are needed to find ways and means of making health education more acceptable to the population.

The new, modified working method really proved to be a considerable improvement, and the well construction programme gained much more support from the population.

Evaluation visits

Evaluation visits once every half year were conducted to check the results of the project and to identify any changes needed. They also served to stimulate the community to continue their support to the project. The main purposes of the visits were:
- to find out whether the new well was actually used;
- to check whether the attitude of the community was supportive to a proper use of the new well;
- to see whether any modifications had been made by the villagers for making the well more suitable to their needs.

After the evaluation of the first sociological study, so far no further study has been made. A sociologist joined the project team in July 1981.


In one village, the area around the well was covered with shells.

The contribution of the villages

Another important point covered in the evaluation study was the possible contribution to be made by the villagers. This involved the following points:

a. work done to improve the access road to the village;

b. supply of food for the construction workers;

c. whether the necessary tasks had been carried out by volunteers.

Access road

Out of 200 villages, nine had not provided an access road. This was remarkable because five of these had a serious water problem in the dry season. One reason might be that the villages concerned were usually situated at a considerable distance, some 5-10 km from existing roads. Another important reason why no work had been done on the access road seemed to be that it would require the men to do the work whereas the fetching of water is a woman's task. The following story is illustrative:

"Two promotors crossing a rice field encountered several women from a village they had visited half a year ago. The women were fetching water at half-an-hour's walking distance from their village. The promotors were asked to come again to the village because after the initial visit, the men had decided not to open up the access road and, on account of this, no well had been constructed. This time it would be different. The women told the promotors they would feed the men only dry rice and refuse to sleep with them until they opened up the access road."

Table 10. Contribution of the population.

team	supply of food			availability of volunteers		
	always	sometimes	never	always	sometimes	never
drilling survey	78	17	5	59	17	21
well digging	84	11	5	68	27	5
well drilling	79	14	7	72	14	14

Food for the workers

As can be seen in Table 10, a number of villages did not supply food for the construction team. In some cases this was because the villagers did not have enough food to feed outsiders. In other villagers the new organizational pattern which was needed for this type of arrangement did not yet exist. Earlier it was the head of a single family who decided that a well should be constructed, and he paid the labourers either in cash or by supplying liquor and food. In the new situation, the village as a whole had to decide to build the well, but the social structure for organizing the contribution was lacking. It appears that it is necessary to deal with the matter of food supply to the construction teams before the actual well construction starts. An investigation should show whether the social structure of the village concerned can cope with this requirement.

Voluntary labour

In some villages, it was difficult finding volunteers to assist in the construction work. In five villages, for this reason, a smaller number of wells were constructed than these villagers were entitled to. The following factors were relevant:

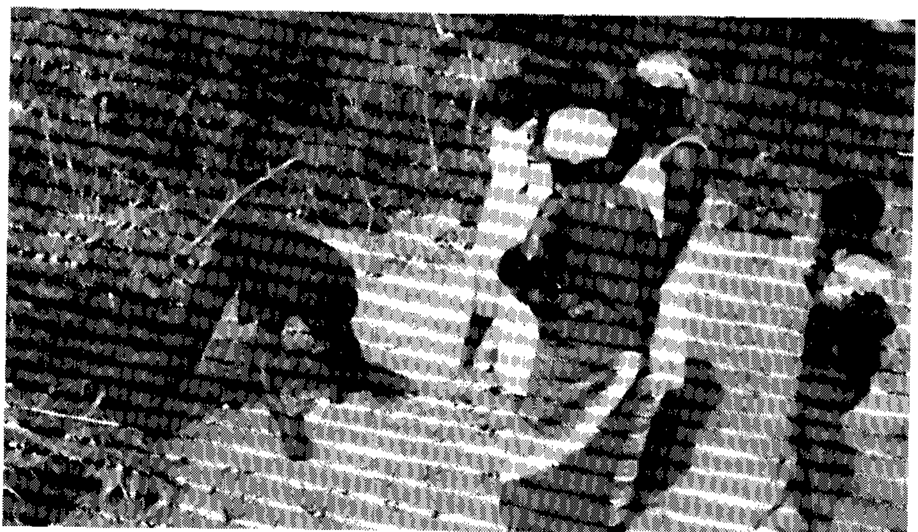
- whilst the custom is that young men are paid for a job, in these cases payment was not forthcoming; the reason being that the job was done for the whole village, and for nobody in particular.
- the villagers did not feel the need to contribute as they were already paying taxes to the government;
- the volunteers were mostly men, who are not the first to benefit from the new well.

Additional provisions

Next to the construction of the well, the following additional provisions were optional:

- facilities for watering cattle;
- a wash basin for doing the laundry.

The community would have to pay 25% of the costs of these provisions. Although many villagers were interested to have these, very few were actually constructed.



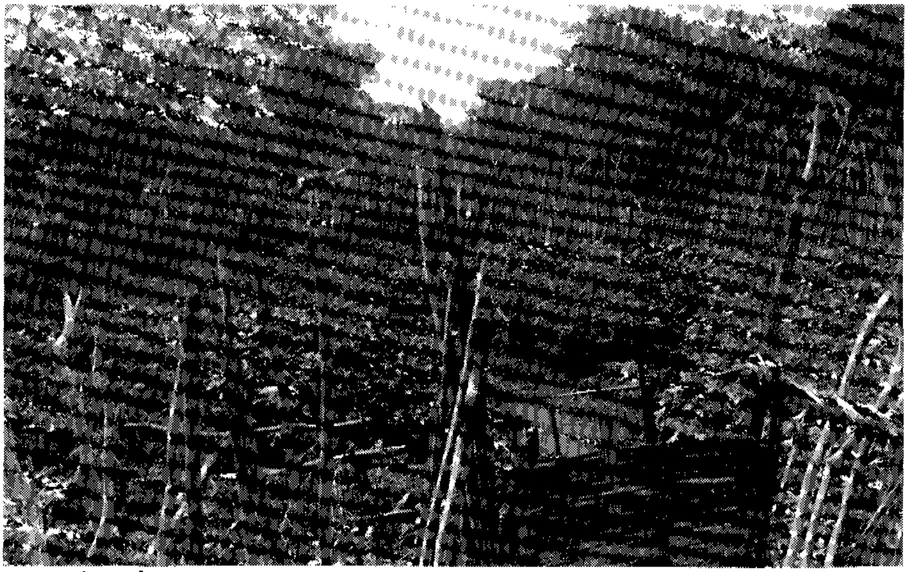
A promotor assists in crop planting.

Vegetable plot irrigation

Vegetable plot gardening becomes feasible when using water from the improved supply. An individual section of the project organization was established for promoting plot irrigation. This group cooperated closely with the promotional teams.

After several experiments, the following approach was chosen:

- in Buba a garden was made for production of seeds, and also to improve existing cultivation techniques;
- the growing of vegetables was studied and promoted in six selected villages of different ethnic groups;
- the promotors of the social activation section were trained to lay out the garden plots and to give basic instruction in crop planting.


A garden plot.

Conclusion

A number of positive effects of the efforts to promote community participation in the Buba-Tombali water supply project may be mentioned:

a. It appears that the work of promotional teams is accepted by the villagers. This can be important for similar development projects in other fields such as agriculture, road building and sanitation improvement.

b. The involvement of a pump caretaker and a woman to clean the pump's surroundings provides a basis for ensuring that part of the necessary maintenance tasks are carried out at village level. The lubrication of the pumps is an example; it is frequently done quite satisfactorily.

c. Proper involvement of the population allows them to have a considerable influence in the siting of the well, which should be regarded as a positive point. In this way, it is avoided that wells are constructed at sites that are not convenient for the population. The importance of this is illustrated by the following event, which occurred in a project in which there had been no special participatory programme:

> "A well was to be constructed in a village. For practical reasons a site was chosen at the edge of the village near a road. The drilling machine was put in its place and everything was set to start the drilling; but the village committee approached the workers and explained that even if the well which was to be constructed would give water, they could not use it because an 'irao' (a spirit) was living there. Had there been consultation with the community in an earlier part of the project, this situation could have been avoided".

d. The selling of seeds in the villages, to meet the need as identified by the promotional teams, was appreciated by the population. It might help the women improve their income.

e. A side effect of the community participation efforts in the Buba-Tombali water project proved to be the closer co-operation between the various government departments involved. The tasks of the social activation section being in the area of responsibility of more than one ministry, and as the consultations of the communities also identified problems in other fields, co-operation between the ministries proved both necessary and fruitful.

3. *TECHNICAL ASPECTS*

3.1 Groundwater exploration (introduction)

Successful groundwater exploration requires a basic knowledge of the manner in which water exists in the aquifers (water-bearing ground formations). Without this knowledge, constructing wells becomes something like a game of roulette.

The aim of the groundwater exploration must be clearly defined. Is it for providing a small local supply or is it to obtain an overview of groundwater occurrence in an entire region or country?

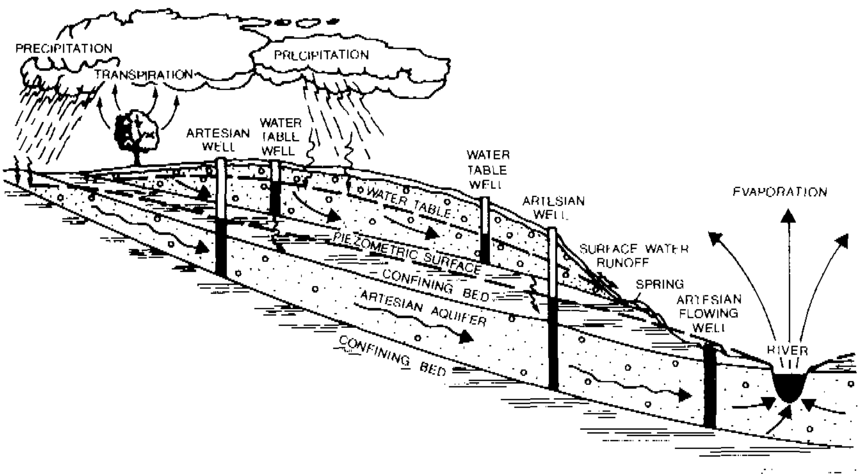


Figure 11.
Groundwater movement (schematic).

Important is the determination of the area of study. A frequent reason for failure of groundwater exploration is that too small a study area is chosen.

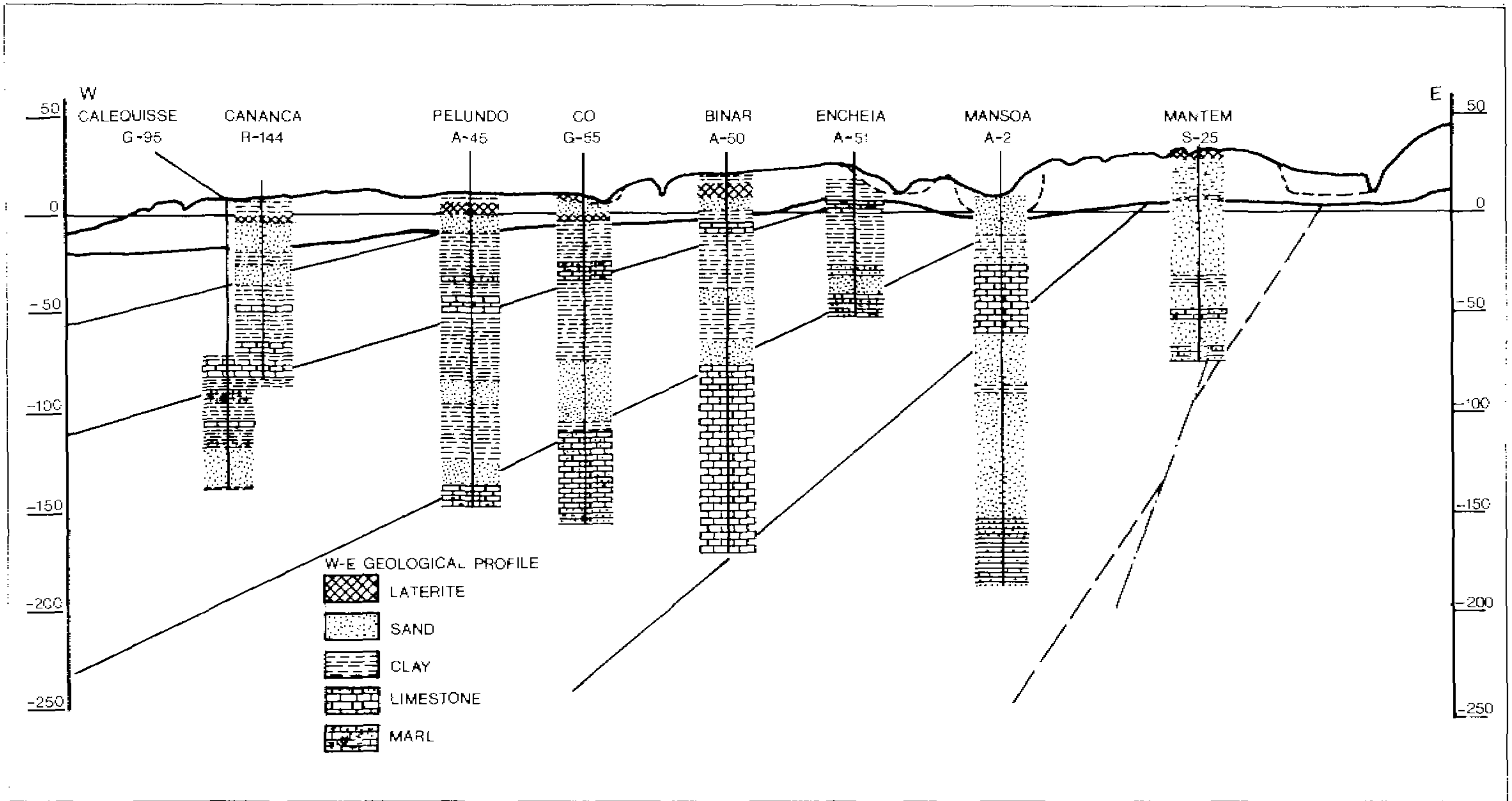


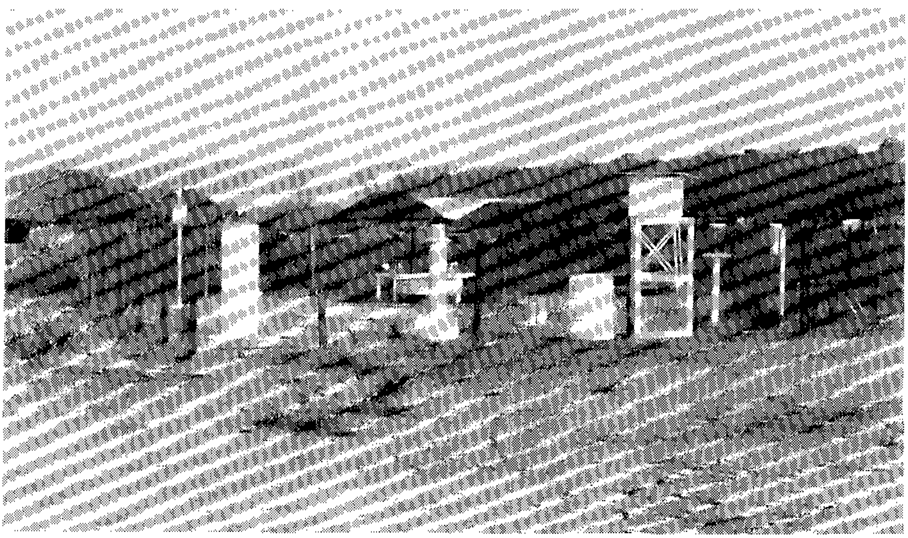
Figure 12.
Geological cross section of Guinea-Bissau (schematic).

Source: Rural water supply project GBS 77/002
UNDP/UNICEF, prepared in 1981

Collection of existing data

The collection of information for the study area may involve:

- geological maps, even if they are inaccurate, incomplete or not readily available (as is frequently the case in developing countries);
- topographical maps (e.g. 1 : 25,000 scale);
- information on existing wells;
- meteorological records;
- hydrological data.



Meteorological station in Buba

As part of the information collection effort, a survey of the area should be made, preferably towards the end of the dry season when groundwater levels will probably be at their lowest. If information on existing wells is available, one of the lowest-cost techniques for locating suitable aquifers is to develop schematical geological cross sections of the area. This is done by analysing well logs and any available pump tests of the wells.

The aim of the survey should be to produce sufficient data for the drawing up of a hydrogeological map, showing the (tentative) distribution of aquifers; any springs present; depth of the groundwater table; yield of existing groundwater sources, and the quality of the water from them.

The role of traditional hydrogeological investigations for effective groundwater exploration should not be overlooked. Traditional groundwater prospecting should be supplemented, not replaced, by modern geophysical exploration techniques such as electrical resistivity, seismic refraction or well logging. These geophysical exploration methods are most important for obtaining supplementary, and more accurate information about the subsurface conditions and aquifer characteristics. They may be used to complement the groundwater data obtained by traditional investigations (Figure 13).

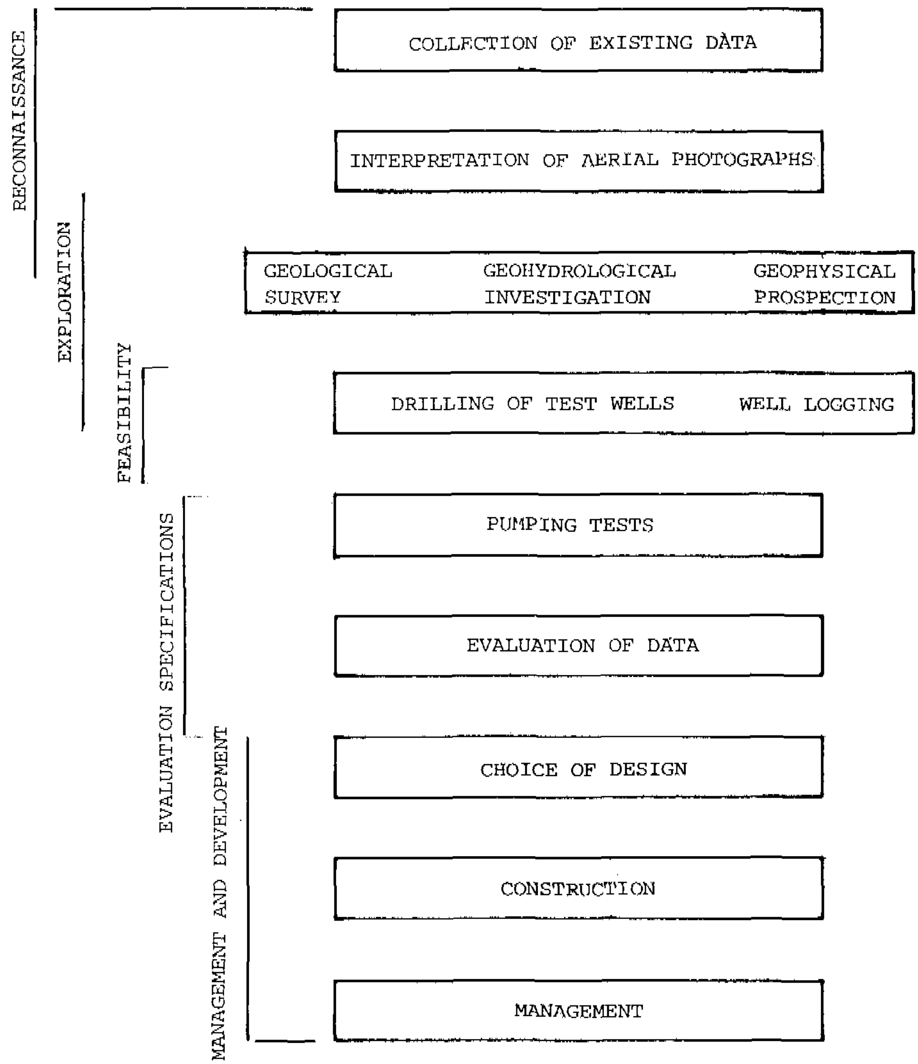


Figure 13.
Stages of groundwater exploration and development.

Surface exploration

Several surface exploration techniques may be used to acqui information on the groundwater resources in an area without the use of costly borings. These are:

- stream monitoring; by monitoring stream flow, areas can be identified where the stream receives an inflow of groundwater that might be intercepted by wells;

- photogrammetry and remote sensing; identification of groundwater resources through aerial photographs (e.g. 1 : 50,000 scale) or satellite imagery; these methods are generally useful for obtaining an overview for large areas, i.e. for an entire country or region;

- surface geophysical prospection methods; geophysical methods provide information of subsurface formations and, through interpretation, allow the identification of formations having water-bearing capacity; the electrical resistivity, and the seismic refraction methods are the most important in surface exploration of shallow groundwater strata; sometimes, a gravity survey can form a useful addition to these methods, and may help to save on the overall costs of the groundwater exploration.

Test drilling

The best but most expensive way to check subsurface geological formations on groundwater occurrence and aquifer potential is test drilling. Various methods for test drilling exist; the choice of method depends on factors such as the type of ground structure, the depth of the groundwater table, and the degree of accessibility of the sites.

3.2 Groundwater exploration in the Buba-Tombali project

In the Buba-Tombali water supply project, shallow wells were chosen as the most appropriate technology for the Tombali and Quinara regions. Most of the existing deep bore holes had not been accepted by the population because of the salinity or the iron content of the water. Moreover, the investigation of deep groundwater is quite expensive.

In the Buba-Tombali project the following groundwater exploration methods were selectively used.

Aerial photography

In January 1978, aerial photographs were taken of the regions Tombali and Quinara to obtain basic information on the topography of the area and the distribution of the settlements. This survey technique was not employed to obtain information on the water resources.

Electrical resistivity measurements

During 1979, the suitability of electrical resistivity measurements was checked for determining the presence of deep aquifers. At the same time the suitability of this groundwater survey method for locating shallow wells was assessed.

Aquifers at great depth

In a pilot survey area covering part of the Quinara region, the usefulness of the electrical resistivity survey method was tested. The method was found suitable for deep groundwater investigations in the project area although the interpretation of results required considerable expertise. A tentative conclusion based on the data obtained was that fresh groundwater aquifers at greater depth are only existent in very few parts of the southern regions of Guinea-Bissau.

The location of shallow wells

An electrical resistivity survey was carried out in a small area near the village of Cobumba. The investigation showed this survey method to be of limited use in locating shallow wells in the regions concerned as:

- the method is very time consuming as the laterite is very compact and difficult to penetrate;
- the electrical resistance of dry laterite is very high.

The drilling of a test-hole.

Test drilling

For the conditions pertaining in the project area, test drilling was selected as the most suitable groundwater exploration method.

The drilling of test holes was combined with the making of production wells. Although the emphasis on immediate results in an early stage of the project can be justified by many valid "political" reasons, a more complete groundwater survey, by the construction of a limited number of wells in the first year of the project, would probably have been better. Experience in the Buba-Tombali project as well as in other similar projects shows that of the wells constructed in the first stage of the project a considerable percentage dried out at the end of the dry season.

All wells were checked in June 1980, and the well logs were compared. The results showed that 58% of the wells had no recharge problems. On the basis of this investigation the site selection criteria were modified. Standard profiles for drilled and dug wells were established based on the profiles of the wells that showed no recharge problems (Table 11). The test-drilling results had to come close to these profiles and the yield had to be acceptable before the decision to construct a well was taken. A survey in June 1981, of the wells constructed according to the modified selection criteria, showed the number of wells without recharge problems rising to 81%.

Test-drilling results

On average, 2.3 test drillings were needed to locate a suitable well site. In some areas, it was necessary to take a large number of test drillings. In one village no suitable well site could be found, 15 drillings being unsuccessful. To avoid such a situation, it would be very useful to investigate whether an additional groundwater exploration method could be used to reduce the number of test holes required.

Collection of ground samples.

Yield test

In order to get some insight in the yield of the test hole a drawdown test of 30 minutes was carried out, with a simple hand-operated pump down in the bore hole. Before starting the pumping, the water level was measured. During pumping the water level and the yield were recorded every five minutes. The rise of the water level in the hole after pumping was stopped and recorded every minute.

Observation wells

To get some insight in the fluctuations of the groundwater level, observation wells were made at a number of sites. These wells were equipped with Ø 30 mm PVC tubing and well screens, and with a 2" galvanised tube placed at ground level.

The water level was checked daily by local observers. This was decided for practical reasons, as a daily check is more easy to arrange than a weekly one.

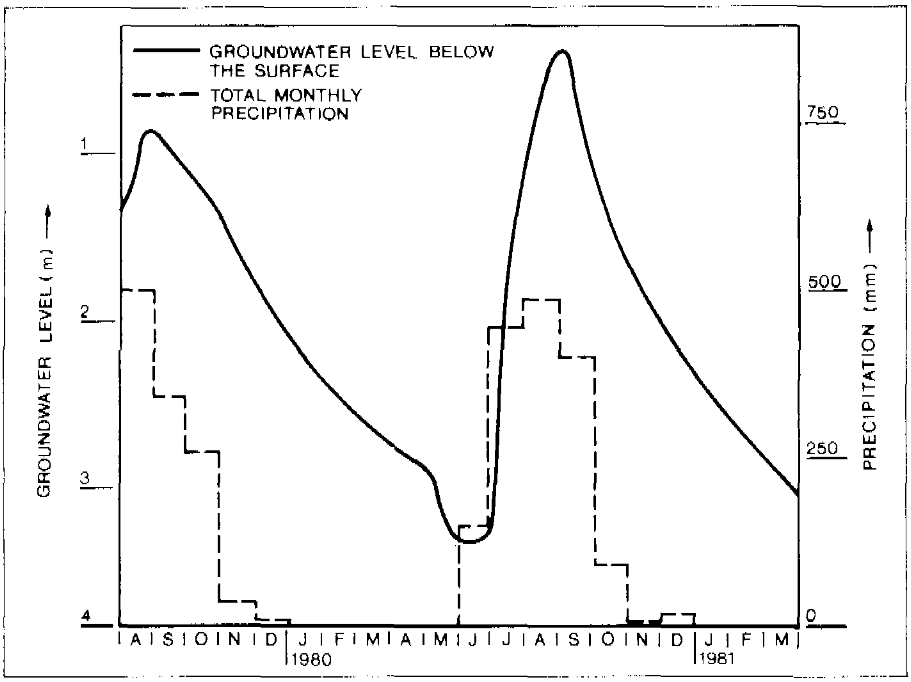
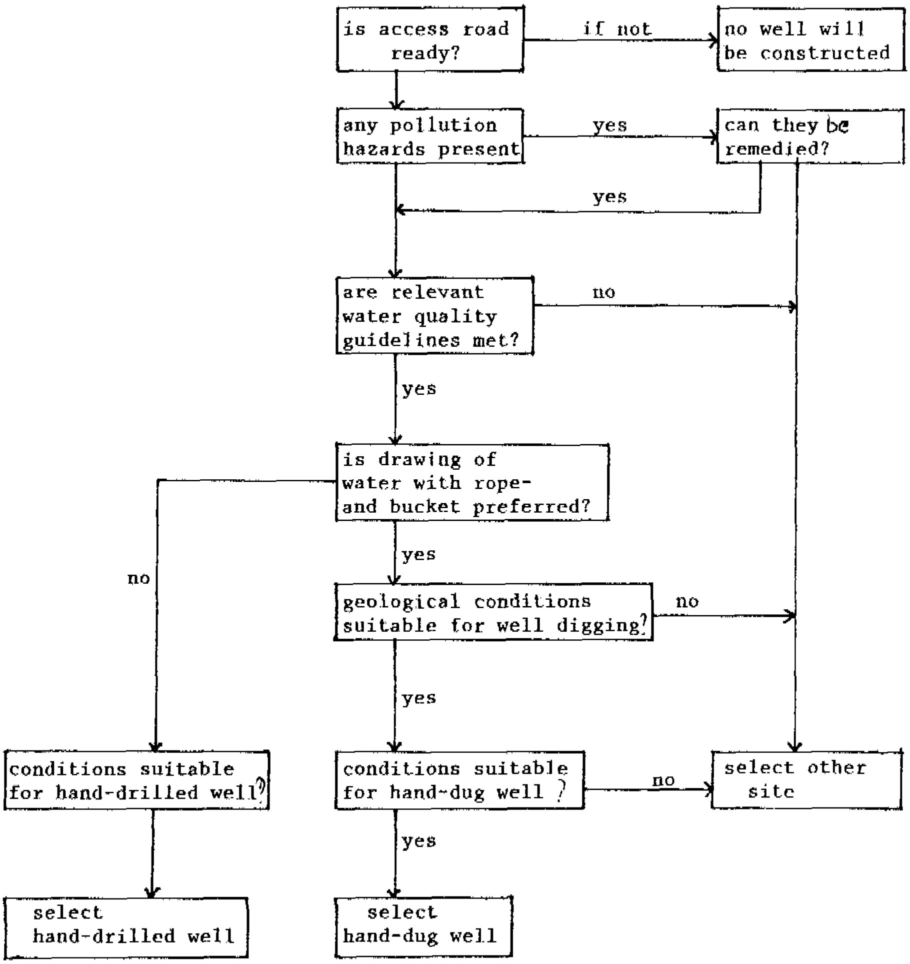


Figure 14.
A water level record of the groundwater table in the upper aquifer.

Selection of well sites

The selection of well sites was based on consultations with the community, and on the test-drilling results. Diagram 9 shows the various steps in the well-site selection process.

Diagram 9.
Steps in the well-site selection process.



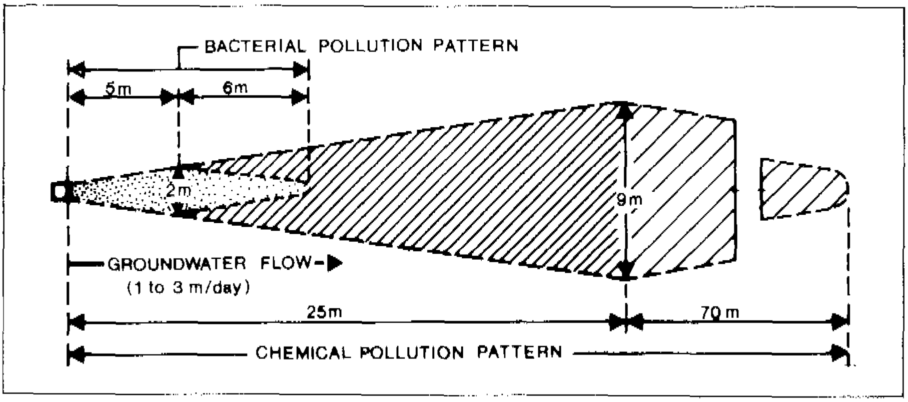
Some details of the criteria mentioned in Diagram 9 are given below.

Access road to the village

Where there was no access road, and where the villagers were not prepared to build one, no survey was made and no well was constructed.

Pollution hazards

If there were cattle pools or latrines nearby, a well would be liable to become polluted. The manner in which bacterial and chemical pollution is transmitted with groundwater flow, is shown in Figure 15.



Source: WHO Monograph series No. 39 (lit. 37).

Figure 15.
Bacterial and chemical pollution pattern.

While the community was making the decision on where to locate the well, they would be informed by the social activation promotors about pollution hazards. An adequate distance between the well and any sources of pollution is always necessary.

Water quality guidelines

The water from a well must be acceptable to the community. The main quality factor used in the Buba-Tombali water project was the taste of the water. If no water could be found that would be acceptable to the community as drinking water (i.e. where the water has high iron content), then the well might still be constructed to provide water for other purposes than for drinking.

Preference for a dug well

Where the village community in question preferred to draw water with a bucket instead of a pump, the geological conditions were investigated to check whether it would be possible to dig the well. If this proved feasible, then the community's preference was followed.

Selection of well type

The test-drilling results were compared with standard sample profiles for dug and drilled wells (Table 11).

Table 11.
Standard sample profiles for dug and drilled wells.

A. Typical profile for drilled well

depth (m)	type of, geological	color	additional notes	dry	humid	water bearing
3.5	clayish sand	red	small streaks of laterite	x		
5.0	sandy clay	grey	" " " "		x	
8.0	clay	red/ grey	laterite	x		
11.0	clayish sand	yellow	fine sand		x	
13.0	fine sand	grey/ yellow	clay			x
14.0	middle coarse	white/ yellow	fine sand			x
15.0	compact clay	grey/ yellow	--	x		

B. Typical profile for dug well

depth	type of geological formation	color	additional notes	dry	humid	water bearing
5.0	clay	red/grey	laterite	x		
9.0	clay	grey/red	small streaks of laterite		x	
12.0	sandy clay	grey	" " " "			x
13.0	dense clay	grey/ yellow	--			

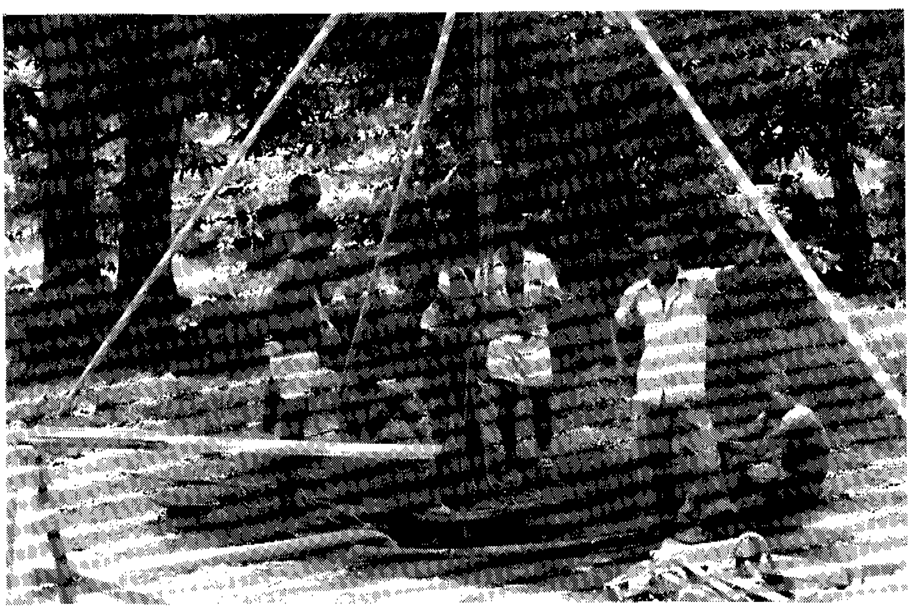
Obviously, the water layer in the aquifer had to be of sufficient depth to allow the ready inflow of groundwater into the well. (Table 12)

Table 12.
Minimal thickness of aquifer

Month	Minimal depth of groundwater (m)	Month	Minimal depth of groundwater (m)
October	3.2	March	1.7
November	2.9	April	1.4
December	2.6	May	1.1
January	2.3	June	0.8
February	2.0	July	0.5

Wet season well

Where it was impossible to find a suitable site for a well with a year-round supply, a so-called "wet-season well" might be constructed. Such a well would dry out in the course of the dry season. Yet, during about nine months of each year, the villagers would have an adequate supply of water close to their dwellings, which represents a considerable improvement over the existing situation. In the dry period of about three months, the villagers would have to resort to permanent water sources at a greater distance.



In a number of villages dug wells were preferred.

3.3 Well construction

There are many different well construction techniques. The most widely used techniques are:

- hand digging;
- mechanical digging;
- drilling with hand auger;
- percussion drilling;
- rotary drilling.

An overview of well construction techniques and their characteristics is given in Table 13.

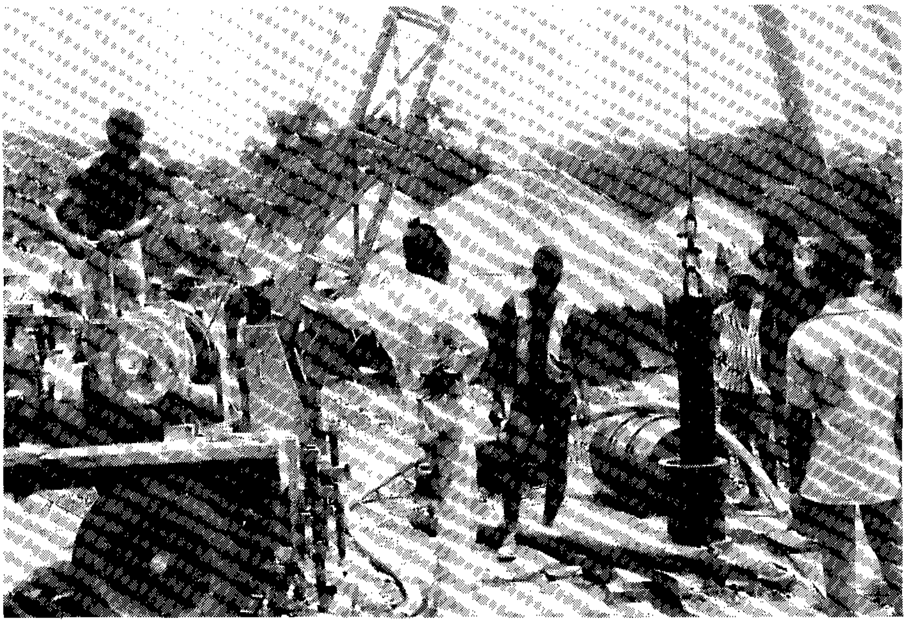
Table 13.
Well construction techniques and their characteristics.

characteristics / well construction techniques	type of geological formation	construction: max.depth (m)	construction: diameter (m)	technical equipment weight	degree of technical complexity	operation & maintenance aspect
hand-digging	unconsolidated	80	1.0m	low/medium	low	low/medium
mechanical digging	unconsolidated & consolidated	80	1.5m	medium	medium	medium
hand-drilling	unconsolidated	20	0,1-0,15m	low	low	low
cable-tool percussion	consolidated & unconsolidated	200	0,1-0,6m	fairly high	medium	medium
rotary drilling	unconsolidated excepting hard gravel	300	0,15m	high	high	high

Choice of construction method

For shallow wells, drilling with a hand auger, and hand digging can be suitable construction methods.
In the Buba-Tombali water supply project, at first preference was given to hand drilling, as it requires little in the way of equipment and investment, and has the advantage that the hole does not need to be pumped dry during construction. At a later stage, when in several places low recharge rates were observed, hand-dug wells were chosen; small-diameter tubewells are unsuitable for that condition.

To provide for those areas where neither hand drilling nor the digging of wells could be tried, a percussion rig was used in order to drill for deep groundwater.



Percussion rig.

Percussion drilling was preferred to rotary drilling, in view of the following conditions pertaining to Guinea-Bissau:

- the capacity to repair complex machinery is very limited; for instance, a rotary drill used in another water supply project was already out of service for more than a year!;
- thin aquifers might be sealed off by the drilling fluid;
- no deep wells were envisaged; the deepest well constructed in the project was 80 m.

The use of a well digging machine was not seriously considered by the project team. Experiences in another water project with such machinery were rather unfavourable due to frequent mechanical failure, lack of fuel, and other problems.

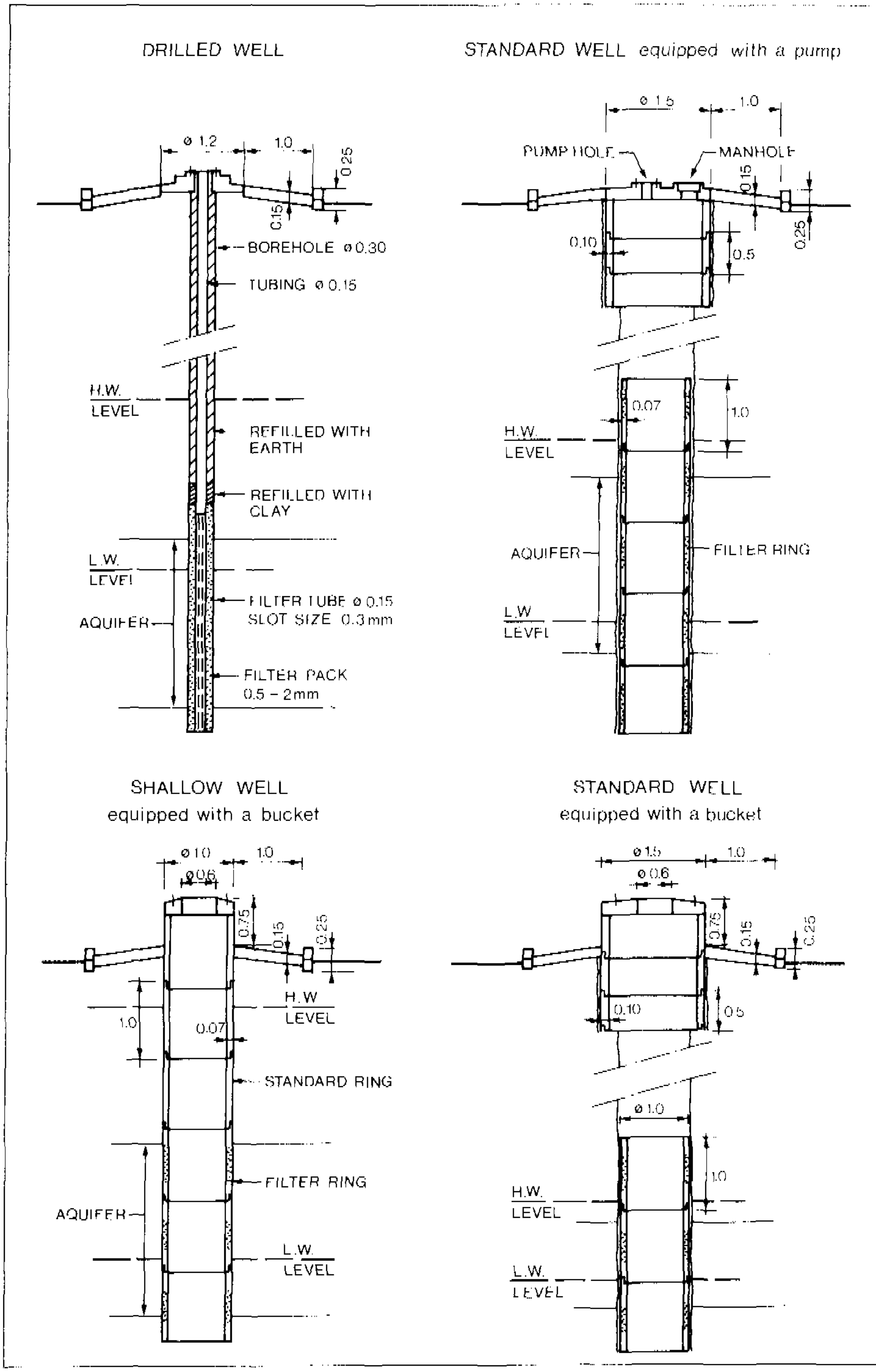


Figure 16.
Type of wells constructed in the project.

Types of wells

The following types of wells were constructed in the Buba-Tombali water supply project:

- dug well with telescopic construction;
- dug well with constant diameter over full depth;
- drilled well;
- renovated traditional well.

In Table 14 the main characteristics of dug wells and hand-drilled wells, as constructed in the Buba-Tombali project, are compared.

Table 14.
The main characteristics of dug wells and hand-drilled wells.

	HAND-DUG WELLS	HAND DRILLED WELLS
Geological aspects	Site survey required not feasible in sand layers over 3 m possible to penetrate hard rock	site survey required not suitable in low-recharge layers hard rock may present problems
Technical aspects	established construction method heavy vehicle with hoisting gear needed lining necessary 4 weeks construction time, 2 workers	relatively new technology light vehicle sufficient plastic tubing adequate 1 week construction time, 6 workers
Materials and equipment	sand, gravel; should be locally available high-capacity pump needed during construction low-maintenance equipment	filterpack requiring sand, gravel should be locally available low maintenance equipment
Community aspects	community may choose pump or rope-and-bucket if pump breaks down, well can continue to be used	only pump option if pump breaks down, well becomes useless

Dug wells

Dug wells should in almost all cases be lined their full depth. Various materials can be used for the lining of dug wells:

- prefabricated concrete rings;
- brickwork;
- concrete lining cast on site.

Lowering a filter ring into the hole.

In the Buba-Tombali water supply project, prefabricated concrete rings were chosen for lining the wells, because brickwork lining would have required more labour and thus taken much longer to build. Concrete lining, cast on site, required a large number of moulds and technical supervision during construction. For the production of the needed concrete rings, a factory was built in Buba.

Production of concrete rings in Buba.

The construction of the well started by staking out a circle with a diameter of 1.5 m. A small roof was made to provide the workers with shelter against sun and rain. A hole of 1-1.5 m deep was excavated in which the upper part of the lining was placed. Digging then proceeded in a smaller diameter. In most cases the laterite layers were so hard that they had to be broken with pick-axes. The loosened rock then was removed with a bucket. When the groundwater level was reached, filter rings with a diameter of 1 m were placed in the hole using a tripod 4 m high. Digging then continued until the hard clay layer was reached. In some cases, digging would continue at least a further 0.5 m into the hard clay so as to provide a greater storage capacity in the well.

During the work, water was pumped from the hole with an electrical pump powered by a generator.

The filter rings of one meter height were placed in the hole below the level of the highest expected groundwater table.

A typical dug well, on average, was 11 m deep; the upper part consisting of 4 rings 0.5 m high, and 1.5 m in diameter; the lower part 5 rings 1.0 m in diameter and 1.0 m high. The middle section usually did not need a concrete lining (Figure 16).

The ring of 1 m diameter provides 0.8 m internal space. It is the minimum size in which a man has sufficient space to do the digging. This ring size, the smallest possible, was choosen because there were no trucks available in the initial stage of the project, so weight had to be reduced as much as possible.

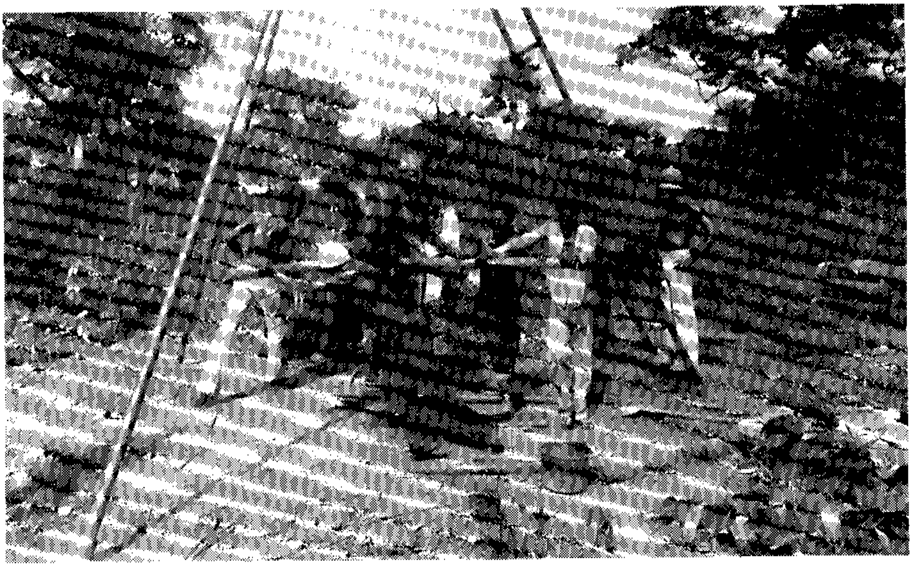
Rehabilitation of existing wells

In some villages, existing wells were rehabilitated instead of new well construction . The rehabilitation work involved a deepening of the hole and lining the well with concrete rings. Unfortunately, rehabilitation of existing wells proved not very successful, as the recharge problems continued. Furthermore the number of wells remaining the same, the availability of water was not much improved by rehabilitating an existing well. In some cases the water quality deteriorated after the further excavation of the well. Rehabilitation of existing wells is no longer promoted in the project.

Drilled wells

The hand-drilling equipment used in the Buba-Tombali water supply project enabled the drilling of tube wells of 25-30 cm diameter to a depth of 15-20 m.

A heavy tripod equipped with a winch was placed over the well site, and the 30 cm auger centered. A heavy cross-piece with handles was mounted on the drill. Eight persons rotated the auger, until it was completely filled with earth. The drill was then lifted by means of the winch and the drillings were removed from the auger.



Hand-drilling.

The auger.

For penetrating hard layers, up to 8 persons could load the cross section to pressure the auger.

Penetration of hard layers.

When sand was struck below the groundwater table, a casing had to be inserted. Drilling then proceeded using a bailer. The casing was sunk by rotating it under loading.

When penetrating hard layers, the bailer was exchanged for an auger with a smaller diameter, and drilling was continued within the casing until the desired depth was reached.

Opposite the aquifer a 6" PVC filter screen was installed with a 0.3 mm slot size. This filter required a filter pack of fine gravel (0.5-2 mm size). As the gravel was poured in the hole, the casing was slowly pulled up. Finally, the space around the 6" PVC tubing was sealed with clay, at the top part.

Finishing the cemented apron of a borehole.

Filter pack

For an optimal recharge of the well, the filter pack and the slot size generally should be selected with care. For handpumps, however, the withdrawal rate is much less than the actual recharge from the aquifer, and the filter-pack design is not so critical. Thus, a standardization of the filter pack was possible in the Buba-Tombali project.

During the execution of the project, the required core sand for use in the filter packs was found in the region of Bafata. When this gravel was used, the problem of sand entering the bore holes no longer occurred.

3.4 Handpumps and rope - and - bucket systems

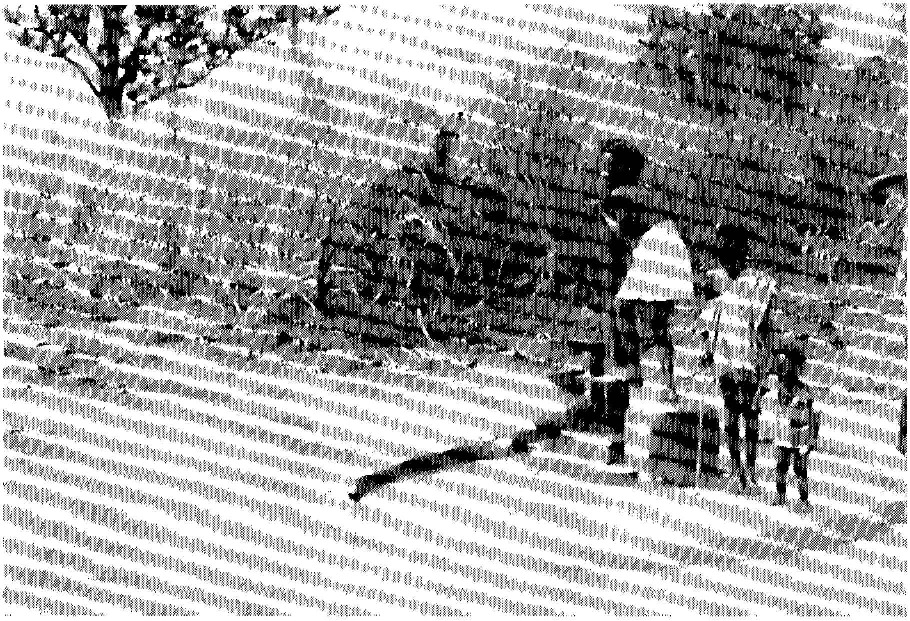
The search for handpumps with limited maintenance requirements is on-going. At first the tendency was to construct very sturdy handpumps, requiring as little maintenance as possible. This approach was not very successful. Present pump models frequently involve very high actual costs of repair and maintenance. Moreover, an unacceptable high percentage of these pumps are not operative.

A new approach has been developed in the UNDP/World Bank Project for Testing and Technological Development of Handpumps. *No longer is the* reduction of breakdowns the first priority, but the suitability for local maintenance and repair. Especially the use of easily repairable below-ground components is seen as an essential step. This will help avoid the need of lifting the pump cylinder from the well for repair. The use of plastics in below-ground parts has considerable potential. Another promising development is represented by cylinders which can be lowered inside the rising main. In case of a repair they can be lifted manually, while the rising main itself remains in the bore hole.

The main objective is to simplify maintenance and repair, and to have a stock of spares readily available at the village level. This will enable the local population after a period of training, to carry out *routine maintenance. The new approach ties in with the concept of* community participation in water supply projects. Unfortunately, the development of these new pumps and pump maintenance systems is still in an experimental stage. The experience so far obtained in the Buba-Tombali project, especially with the rope-and-bucket system, points to potentially very limited maintenance costs and a promising degree of participation at village level.

The pumps used in the Buba-Tombali water supply project

Suction pumps were not suitable for use in the Buba-Tombali project because the groundwater level generally is deeper than 7 m. Initially, foot-operated deep-well pumps (the"Kangeroo" pump) were installed.



The 'Kangeroo' footpump.

Although the current model of this pump seems to give acceptable performance results, some major drawbacks remain. The project team decided to introduce another pump (the "Buba"pump) which would be more in accordance with the preference of the people and the findings of the social activation units. (See Table 15).

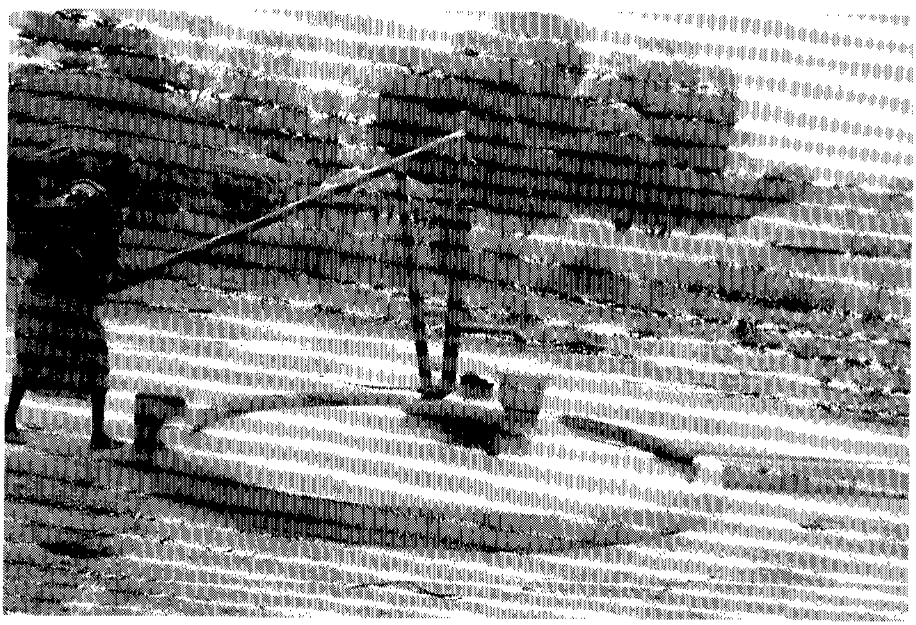
Production of the "Buba" handpump

Only the pump head was manufactured in Buba, the other parts were imported. The pump has a cylinder of 2-inches (approx. 51 mm) or 3-inches (approx. 76 mm) in diameter, depending on the depth of the groundwater table and the yield of the well. The rising main is 1½-inches (approx. 38 mm) galvanized pipe assembled from standard lengths of 3-2-1-0.5 meter. The complete pump cylinder is imported.

For some medical centres in the southern regions of Guinea-Bissau, the "Buba" handpump was modified in such a way that it could pump water into a small elevated water tank, placed on a supporting frame 4 m high.

Table 15
Comparison of pumps and rope- and -bucket systems in Guinea-Bissau.

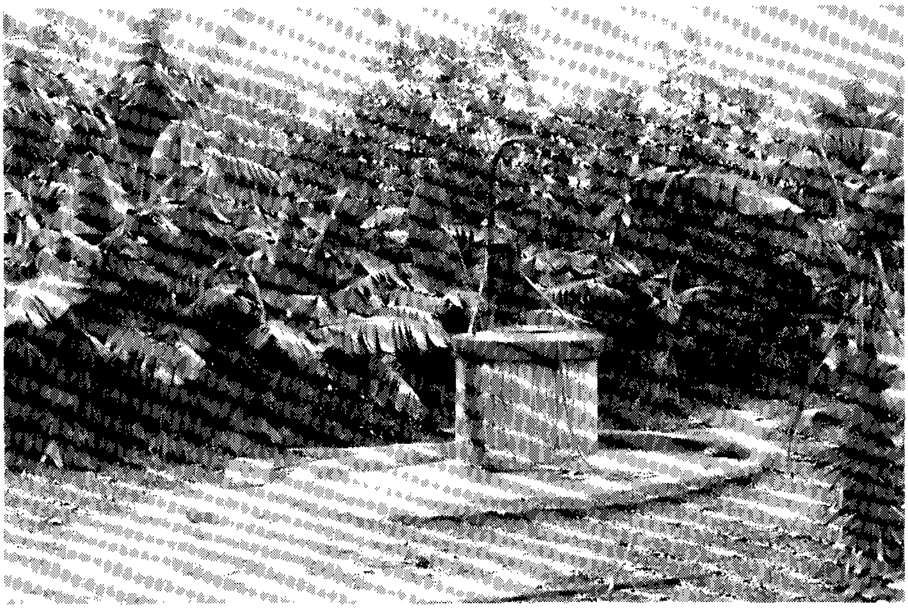
	FOOT PUMP	FOOT PUMP	ROPE-AND-BUCKET
Maintenance	pump must be lubricated monthly local palm oil available spring must be replaced after 2-3 years, leather cups every year	pump must be lubricated monthly grease (imported) bearings to be replaced after 2 years, leather cups every year	pulley must be lubricated weekly grease (imported) rope replacement every 2 years, bucket every year
Acceptance	low acceptance as elderly people and children have difficulty operating pump *pump operation unfamiliar and unpopular*	easy to operate by users *operational mode familiar*	preferred where pump repair on breakdown a problem
Local Production	local manufacture feasible pump imported	local manufacture feasible, but complicated pump imported	local manufacture possible most materials available
Pollution	*well sealed from pollution*	*well sealed from pollution*	well *open; possible pollution*



The Buba pump.

The rope-and-bucket system

Because of the necessity to reduce maintenance costs as much as possible, *the rope-and-bucket system was accepted in the project,* in spite of its drawbacks (i.e. pollution hazards, heavy work for drawing water).



Well equipped with a rope- and -bucket system.

In practice, the rope-and-bucket system proved not as simple as it looked. The following problems were encountered:

- the rope; normal 18 mm twined sisal rope lasted for two months only, after which the rope opened up; twined nylon rope did no better; later a woven nylon rope proved successful; a generous length of rope must be provided as it shrinks 5-10%;
- the pulley; several types of pulleys were tested;
- the bucket; a 7-liter bucket was used, with a flat bottom; a 12-liter bucket was found too heavy; in a test, a bucket with a round bottom was provided, which could not be placed on the ground, and so would be less polluted; however, the people may have assumed that the round bottom was a manufacturing fault, and they flattened it by using big stones for a hammer.

Sisal rope proved unsuitable.

The use of the rope-and-bucket system was also tried out on a few tube wells using a bailer instead of a bucket. This was not successful because:

- it took very long before clean water could be drawn, due to the surging effect of the bailer;
- the people did not like it because when the rope breaks, they are *unable to fish the bailer out of the well; the tube well is then* blocked and no water at all can be drawn; for a tube well, the population strongly preferred a pump.

To find out whether a dug well with a rope and bucket is hygienically acceptable, a small bacteriological survey was carried out. The results are given in Table 16.

Table 16. Results of a bacteriological survey.

Type of well	E.coli/100 ml	Coliforms/100 ml
traditional, n=5	450	1300
dug well; bucket, n=9	14	40
dug well; pump, n=10	0.4	5
drilled well; pump, n=5	0	0
Guideline value WHO	absent	10

Further, a bacteriological survey was made to check the quality of water stored in the houses. Even water that was definitely not

polluted at the moment it was drawn from the well, in several instances was found to be seriously polluted when stored in the house. This is not unusual, and is confirmed by others (lit.10).
Although the results of the survey were indicative only, the difference found between traditional wells and the new wells was very significant. Further investigations are necessary, but it is clear that as long as adequate maintenance of handpumps cannot be guaranteed the rope-and-bucket system must be accepted as an intermediate solution. It should be seen as a minimal provision, and should be improved as soon as conditions permit.

3.5 Maintenance

Although appreciable progress is being made in many developing countries with regard to well construction and handpump installation for rural water supplies, the same is unfortunately not true of the maintenance of the pumps once they are installed.

Wells and pumps are intended to provide safe drinking water to the users, but too often they become inoperative, and remain unrepaired for long periods of time. Adequate maintenance is lacking, and concentrated efforts are necessary to improve this situation.

Repair of a Buba pump.

Maintenance is one of the most neglected aspects of water supply projects, and the number of inoperative pumps remains discouragingly high. Ideally a handpump and well, once installed, should continue to provide water for a lifetime without any repair or inspection needed. However, a certain amount of regular maintenance will always be required to ensure the proper functioning of pumps and wells.

Reasons for the poor maintenance record

The most important reasons for the poor maintenance record are:

Financial constraints

International and bilateral agencies frequently offer funds for new construction but are not so prepared to finance maintenance, considering this to be a responsibility of the recipient country. But many, if not most government water supply agencies in developing countries have only a very limited, or a non-existent budget for meeting the maintenance costs associated with handpump installation programmes. It is a fact that many developing countries can scarcely afford the costs of maintenance, whereas investment costs are often born by donor agencies. It happens, therefore, that new handpump installations are sometimes used to replace existing pumps which could have been rehabilitated at much less cost.

The maintenance costs expressed as a proportion of the investment cost of new handpump installations will vary considerably depending on the type of maintenance system used, density of the handpump installations, the country's infrastructure, prices of fuel and spare parts, wage level and a host of other factors, such as the quality and durability of the pump.

A national handpump programme requires a long term commitment to maintaining the pumps and providing the spare parts needed. Whether the funds for new constuction come from national or external sources, the relationship between construction and maintenance exists, and should be considered from the start. Otherwise the investment is likely to be completely wasted.

Organisational constraints

In many countries there are considerable problems stemming from the lack of manpower, and inadequate procedures for reporting and repairing pumps that have broken down. Non-operative pumps deteriorate very quickly as people tend to damage them when they do not deliver the desired water. The training of manpower and the set up of a maintenance organization must be considered from the start of a water supply project.

Lack of standardization

It is not uncommon that new projects adopt new handpump designs and use equipment that is new to the country concerned. As a result, countries receiving assistance would have to provide for the maintenance of a large number of completely different handpumps and equipment. This is a serious problem hampering the provision of adequate maintenance, as it requires excessively large stocks of different spare parts.

Consequences of insufficient maintenance

The most important consequences of inadequate maintenance are:

Negative psychological impact

In areas where handpump water supplies are vital, the introduction of the wells and pumps frequently is a major event. To obtain the maximum benefit, health educational activities are increasingly promoted and organized to accompany the event. This involves information on health benefits, and explaining the hygienic reasons for using safe water for drinking, cooking and personal hygiene. If the pump becomes inoperative and is not repaired, the chance of improving water use and hygiene is lost, perhaps for many years.

Furthermore, if the village wells were constructed with contributions from the communities, they may view the pump's breakdown as evidence that their support was wasted. They may lose regard for the water supply agency and the government, and they will not look forward to co-operating in other governmental projects. This may lead to a complete stop of the entire process of rural development, as an improvement of the village water supplies often forms an early part of the development efforts in the rural areas.

Serious Economic Loss

When pump maintenance is not provided for adequately, the economic loss that is suffered by handpumps breaking down and remaining out of service will be considerable.

Approach to a better maintenance concept

It would appear there are basically two convergent lines of approach which should be followed when searching for a solution to the serious maintenance problems experienced in the upkeep of handpump rural water supplies:

A. Adopt handpump designs that enable part of the maintenance tasks to be carried out at village level; in this way, regular maintenance could be better secured, and costs reduced.
B. Organise for providing back-up maintenance services, and the supply of spare parts to support the pump caretaker(s) at the village level; these services should assist in carrying out the maintenance tasks that are outside the scope of village-level capabilities.

Maintenance set-up selected in the Buba-Tombali project

Provisions for pump maintenance were incorporated in an early stage of the project. In every village in which a pump was installed, a male caretaker was appointed to take care of the greasing of the pump and to report any failure of the pump to the project centre. A woman was made responsible for cleaning the surroundings of the pump. However, only in 1980, when the first pump failures were taking place, did the organization of this system for maintenance and repair of pumps become gradually appreciated.

The matter of handpump maintenance was taken up with the Ministry of Natural Resources. It had become clear that it would be very difficult for the Ministry to finance the maintenance of the pumps especially in the initial stage. So far, the maintenance costs had to be charged to the project budget. Ways and means must still be found for financing the maintenance costs in the long run. One result of the discussions has been a proposal prepared jointly with staff members of other water projects, which calls for a degree of standardization of equipment. A start was made to promote actively the standardization of handpumps used in Guinea-Bissau.

Regional maintenance centres

In both the Tombali and Quinara regions, a small maintenance centre was built by the project. For each centre, a team was trained to carry out the maintenance of the pumps and wells in the region concerned.

The teams consisted of:
- 1 regional maintenance officer;
- 1 mechanic;
- 1 driver.

Each team was provided with a Landrover.

Experience shows that each team was capable of maintaining about 200 wells, although at the price of fairly long breakdown periods. At the end of the project, 850 wells will have been constructed. This implies that more maintenance teams will have to be formed. Thus, the total maintenance costs would likely rise unless other ways can be found for assuring the upkeep of the pumps and wells.

It appears that an extension of the existing maintenance set up would increase the costs of maintenance to a very high level and in any case would remain vulnerable because of the many transport facilities needed. Therefore, it was decided to study and test the following maintenance concepts:

Maintenance at sector level

In this set up, one mechanic would be stationed in every sector of a region. As each region has four sectors, four mechanics need to be added to the existing regional teams. All of them would get a motorbike.

These sector mechanics would be responsible for the maintenance of pumps in their sector. Major repairs, such as the complete overhaul of a pump, should be made with the assistance of the regional team. The regional team would renovate worn out pumps and cylinders. This system is to be tested in two sectors.

Maintenance at block level

The villages would be grouped in blocks. For every block a volunteer is selected and trained to maintain pumps and bucket systems in the villages forming part of the block. The volunteer mechanic is provided with spare parts and tools by the regional centre, which would also assist him in major repairs. This type of maintenance system is already functioning satisfactorily on the island of Caiar, and will be tested in five more areas.

Maintenance at village level

In this approach, the male caretaker for the pump in the village would be trained to carry out regular maintenance tasks. He would be provided with tools and spare parts by the regional centre which will support him in any major repairs. Ten villages will be selected to take part in testing this approach. The main advantage here is that the breakdown time of the pump would be limited. It may also generate a cash contribution from the community as the volunteer would gain status and might receive small payments from the community.

It should be clear that the handpump maintenance problem in the Buba-Tombali project is not yet solved. But a good start has been made with effective arrangements for regular maintenance at the village level, including the involvement of a local caretaker for the pump.
A decision on the most suitable maintenance system would probably have to be made by 1984.

If the tests prove that major maintenance tasks and repair are feasible at village level, the way to a full solution will be open. It is likely that, for several years, external funds and assistance will be needed in view of the scarce national resources available in Guinea-Bissau.

4. ORGANIZATION, TRAINING AND LOGISTICS

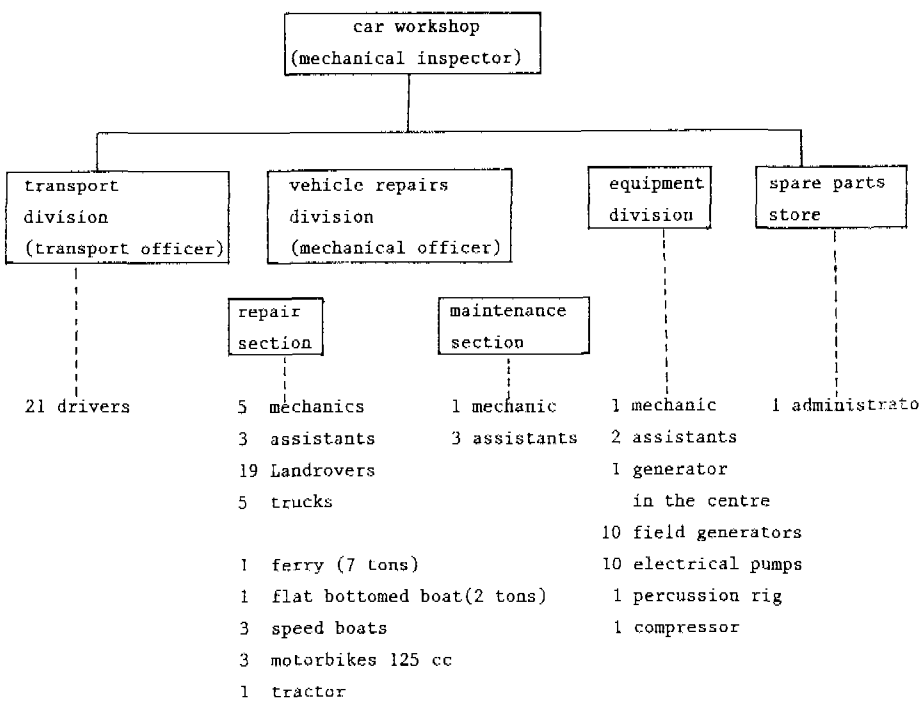
4.1 Organization

Expanding on the general outline given in Chapter 1, the organization, training structure and logistics of the project are described here in more detail.

Car workshop

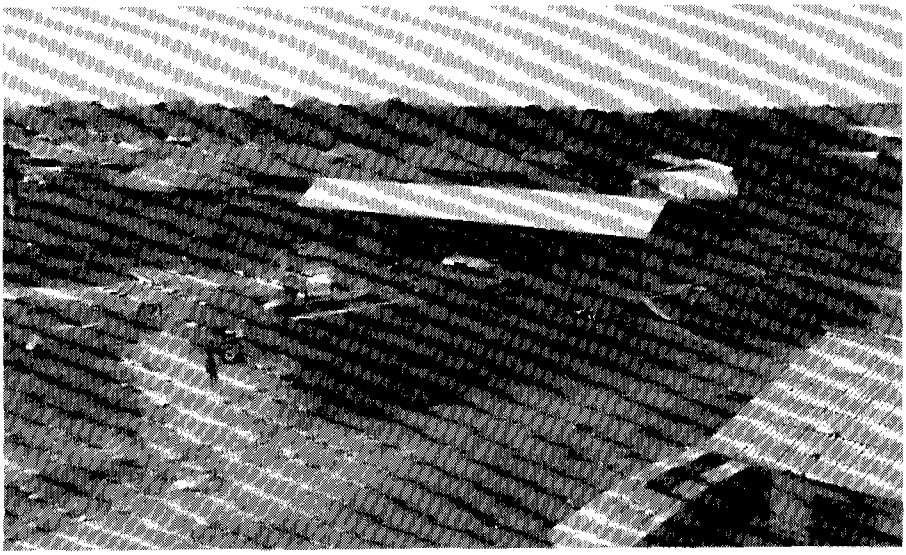
The structure of the workshop is shown in Diagram 10.

Diagram 10.
Organization chart of the car workshop.



The workshop was designed for repairing four vehicles at the same time. This relatively large capacity was decided on because:

- the rough road conditions in Guinea-Bissau make frequent maintenance of the vehicles necessary;
- this workshop being the only one with adequate facilities and trained mechanics in the whole southern region of Guinea-Bissau, local authorities and those in other projects frequently requested repairs to be made on their vehicles. Space and time permitting, these repairs were made at cost.



The car workshop under construction.

Maintenance of Project Vehicles

The first requirement to keep the vehicles operating is to ensure that each driver feels responsible for the necessary day-to-day checking and maintenance of his vehicle. The driver should check the following items every day:

- oil level;
- water level;
- battery fluid;
- tire pressure.

The driver should report any problem he detects at once to the workshop. Unfortunately, the benefits of preventative maintenance are not yet commonly understood by most of the Guinean drivers and mechanics.

Usually they would repair the cars only after breakdown. A proposal for encouraging the drivers to pay attention to the condition of their cars is now being considered by the Ministry of Natural Resources. Instead of charging the drivers for part of the repair costs, as caused by a lack of care on their part, they would get a bonus for every three months of driving without a breakdown.

Every three months a complete maintenance of each vehicle is carried out.

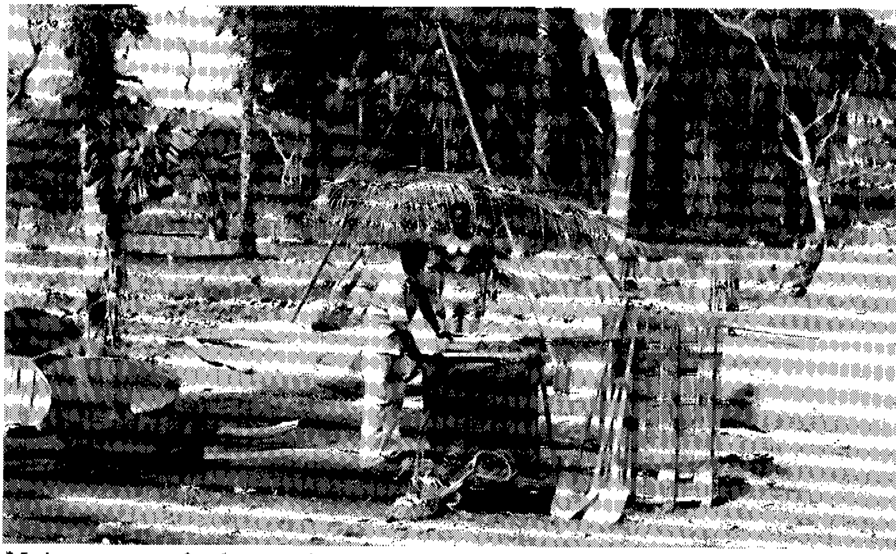
Repairs

Most of the mechanics employed by the project had little experience, and only very limited time was available for training purposes. For this reason, each mechanic was trained for a specific task (e.g. repair of the gearbox, repair of the electrical system etc.). To reduce the time required for an overhaul, complete components such as gearboxes and electrical generators were replaced from a stock of overhauled ones. The removed components then were overhauled, after the vehicle had left the workshop. Frequent problems occurred with the suspension springs, the gearboxes and the frames. In itself, this is testimony of the rough road conditions.

Assembling of pumps.

Maintenance and repair of other equipment

Except for complicated repairs, maintenance and repair of other equipment were carried out on the spot.



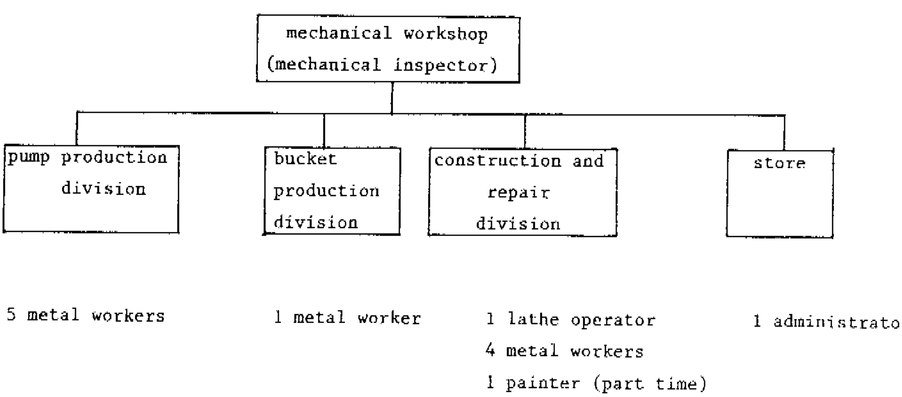
Maintenance of other equipment was carried out on the spot.

Mechanical workshop

The mechanical workshop was set up for:

- production of pumps and rope-and-bucket systems
- repairing tools and equipment

Diagram 11.
Organization chart of the mechanical workshop.

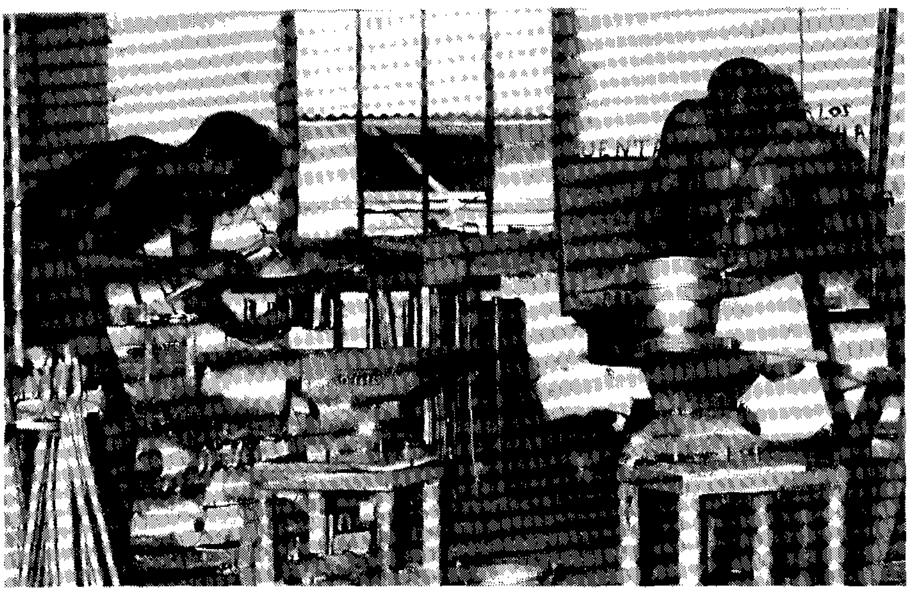


Each mechanic received a set of tools for which he was required to assume responsibility. Special tools had to be obtained separately from the store, with the name of the user registered by the storekeeper. The equipment used in the workshop is shown in Table 17.

Table 17.
Mechanical workshop equipment.

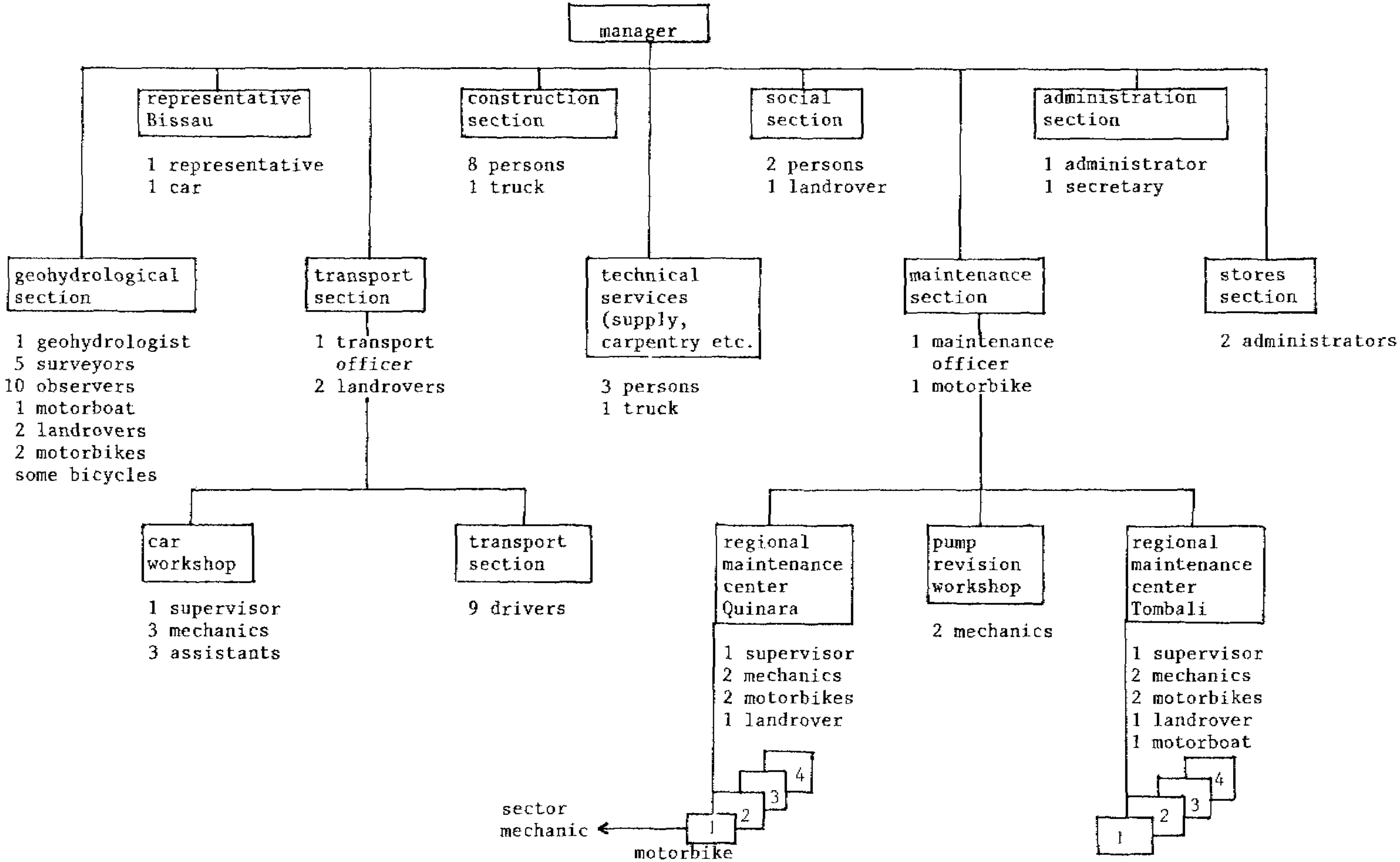
1	lathe (1200 mm)	1	compressor
3	electric welding machines	1	hydraulic press (12 tons)
1	welding generator	1	shearing machine
2	welder's torches	1	profile rolling machine
1	sawing machine	1	sheet rolling machine
1	drill press	1	slotting machine
1	grinding machine	1	smith's hearth

The mechanics were allowed to use the equipment in the workshop for personal purposes after working hours.



Production of buckets.

Diagram 12.
The proposed organogram for the Buba water centre for the regions Quimara and Tombali in 1986.



Regional water supply centre at Buba

In the plans of the Ministry of Natural Resources, the project centre at Buba will become a regional water centre, after the completion of the project.

Three of such centres are planned by the Ministry. Each of them will be responsible for two regions.

In a proposal prepared by the project team, in cooperation with the Ministry of Natural Resources, the centre in Buba would be assigned the following tasks:

- the collection and processing of geohydrological data; these data provide a basis for assessment of water resources, for water supply as well as for irrigation purposes;
- the maintenance and repair of the existing facilities; the estimated production capacity is about 25 wells per year; some of these wells will be new ones; a team of promotors of the social activation section will continue to be required;
- the repair of handpumps; repairs of pumps in the two regions will be locally carried out by repair crews, the pumps and cylinders will be overhauled in Buba;
- the repair of the vehicles and other equipment of the centre.

The proposed organization of the centre and the required number of staff is given in Diagram 12.

This diagram shows the most comprehensive and, thus, the most expensive organization that should be considered. As testing of different maintenance systems is still underway, modifications of the proposed maintenance organization may have to be considered.

4.2 Communications

Radio transmittors were ordered for communication between Buba and Bissau. It took more than a year to obtain a license to use them. Once installed, they proved very useful. Daily contact between Buba and Bissau helped improve the project operations considerably. Emergency calls could be made, and no longer would a project vehicle travel in vain to meet the ferryboat, as now the project centre could be informed whether it would come or not. Two portable radio transmittors were bought to facilitate the field communications. One was installed on a truck, and the other on the ferryboat.

Liaison with other organizations

Much attention was paid to the development of liaison and cooperation with government departments and other organizations. A well construction project of a duration of five years will have a limited impact on the water supply situation and especially health conditions if existing behaviour runs counter to the proper use of the water from the wells. Changing the traditional customs will require a considerably longer period of time. To expand the impact of the project, initiatives taken by the project team should be taken up as much as possible by other organizations. Thus, in an early stage of the project, contact was made and consultations were started with many of these organizations.

The social activation section organized a seminar, which was held in September 1979, in Bissau. Officials and project managers of the Ministries of Agriculture, Education and Public Health were invited. The purpose of the seminar was an exchange of information, especially on the subject of promotors working at the village level, and to discuss the possibilities of future collaboration. Many useful contacts were established during this seminar.

Special attention was paid to cooperation with the Women's Union. The members of this organization were willing to collaborate in mobilising the women but, due to lack of staff, funds and transport, only a little assistance was actually forthcoming. Some of the Union members in the southern regions gave firm and useful support. It was found that direct contacts at the village and regional level generally were more useful. As a result of meetings with the promotors of the social activation section, some village health workers and school teachers started instruction and education on the prevention of disease, and on the hygienic use of water and food preparation. Another favourable development was that the Ministry of Agriculture in 1981, for the first time, supplied the project with seeds for vegetables.

4.3 Training

Scarcity of skilled staff has been clearly identified as the most common and important obstacle to a more rapid improvement of rural water supplies. The reasons for manpower problems are:

- the training capacity is small and lags behind the fast growing needs;
- the required numbers of staff are increasing because the emphasis has shifted to labour-intensive schemes;
- the shortage of technical staff is critical;
- there is a shortage of managers due to the rapid expansion of government and industrial services;
- jobs in the private sector are generally more attractive than those offered in the government service;

"On the job" training is probably the most useful and flexible way of training technicians and skilled workers, such as supervisors, foremen and workshop mechanics. For professional staff, such as managers and engineers, "on the job" training opportunities obviously are limited, and extensive education has to be provided in another way. Thus, financial provisions should be made for such advanced education and especially the provision of scholarships can be important.

Training in the Buba-Tombali water supply project

The transfer of the project to the authorities of Guinea-Bissau will only be successful if sufficient manpower would become available. Training constituted an essential part of the project. So far, training has only been "on the job" backed up with some teaching of theoretical aspects. These lessons were mostly given during the wet season as work then slowed down or came to a complete stop.

The following matters were important:

Linguistic problems

The expatriates did not have a sufficient command of Portuguese nor of Creolo, the language which is widely spoken in Guinea-Bissau. This made it extremely difficult for them to give theoretical lessons;

practical lessons, however, were less of a problem as much could be demonstrated. The lack of theoretical understanding remained a constraint. To try to overcome this, contact was made with Guinean teachers. For lessons in mathematics this was successful, but for the transfer of more specific knowledge on a higher level no practical solution has yet been found.

Another linguistic problem was encountered in the ordering of materials and equipment. Most of the materials were ordered in The Netherlands, and all catalogues were in the Dutch or English languages. For training staff in the ordering of materials and equipment, the catalogues needed to be translated. Some Dutch companies were contacted to see if in the nearby future ordering in Portugese or French could be a possibility.

Level of schooling

The level of schooling of the staff varied widely from the elementary stage of reading and writing, up to high school. To accomodate these differences in the Buba-Tombali project, the groups were divided according to level of education. The group with the highest level received training from the expatriates. In turn, this better educated group acted as the teachers of the next group.

A village school.

Living conditions in Buba not attractive

Graduates of the high school in Bissau did not see Buba as an attractive place of work, as it has no cinema, no restaurant and only one shop. Moreover, most of the graduates did not have family in or around Buba. These circumstances made it very difficult to recruit counterpart staff for the project.

Training materials not available

The material for use in training work had to be prepared by the expatriate project staff. However, preparation of such material is very time-consuming and difficult. At a later stage, contact was established with relevant institutions in Brazil. The materials so obtained were useful but needed adaptation to the local conditions.

Qualifications for training

In general, the expatriate members of the project team had been selected for their professional training and experience, as relevant to the well construction project. They did not necessarily possess capabilities for training of staff. This was an important factor because in view of the specific situation in Guinea-Bissau and the relatively low starting level of education of counterparts, a careful and intensive training programme proved to be an essential element of the project.

In the mechanical workshop, this problem was solved by asking a trained teacher of the technical school in Bissau to give special courses covering the theoretical aspects for the mechanics. The "on the job" training was provided by expatriates.

Production the first requirement

As soon as practical problems arose in the field, the tendency was to immediately shift attention from training to problem solving. Although there was not a specific target for the number of wells to be constructed, the project team saw production as its first task. Because it is often easier and quicker to do a job yourself then to train somebody else to do it, the importance of training was easily overshadowed by the day-to-day operational requirements.

Long-term versus short-term considerations

In the selection of training objectives, often a choice must be made between a long-term and a short-term approach. This might be illustrated by the training in the vehicle workshop. It was in the interest of the project that the work should be executed with speed, for which good maintenance was essential.
To obtain some capable mechanics after a very short training period, each of them was trained for a narrow task. One mechanic concentrated on gearboxes, another repaired only the breaks of motor cars. In this way, a team of mechanics very soon became capable of repairing a car. But no one was able to do all of the repairs. At a later stage, this type of training was modified to a more comprehensive one, as it was important for the country to obtain manpower with a more complete training.

Looking after the baby while the mother is attending a project group meeting.

Training of the promotors

The training procedures followed in the social activation section should be given further attention. In this training not only theoretical and practical information was passed on, but also social skills.

The main training tool used was role playing. The staff members were enthusiastic and role playing proved much more successful than transfer of theoretical knowledge through lectures. This was so because the nationals had a limited theoretical background, and were not used to classroom-style abstractions. A further problem in the lessons was the lack of concentration, often associated when the learning process is not learner-oriented.

After the training by role playing, the student promotors paid a field visit to several villages, together with a senior promotor and an expatriate. After a few visits, the new promotors were sufficiently trained to start work on their own. Later, the theoretical lessons on sanitation were stopped because of their limited effect. Emphasis was shifted to a more practical approach.

A special problem was the training of the male and female promotors jointly. The men were accustomed to take the leading role and responsibility. In Guinea-Bissau it is not common that a woman is in charge, and most village committees directed themselves exclusively to the male promotor, and not to the woman in the promotional team.
As a result the male promotors were taking up their tasks more easily and the female promotors made little progress. Once the female promotors, after many discussions, became more secure in taking up their tasks, the male and female promotors became equally effective.

4.4 Logistics

The operation of a well construction project largely depends on a regular supply of materials and equipment. In the Buba-Tombali water supply project this was extremely important, as almost all materials were imported from abroad. The procurement and storage of materials and equipment had to be carefully planned.

Procurement of material

Most of the material and equipment were ordered in The Netherlands. A careful planning of the orders was necessary as it took over six months before the ordered items would be delivered, and substantial savings in costs could be obtained by reducing the number of shipments to a minimum. The procurement schedule is shown in Figure 17.

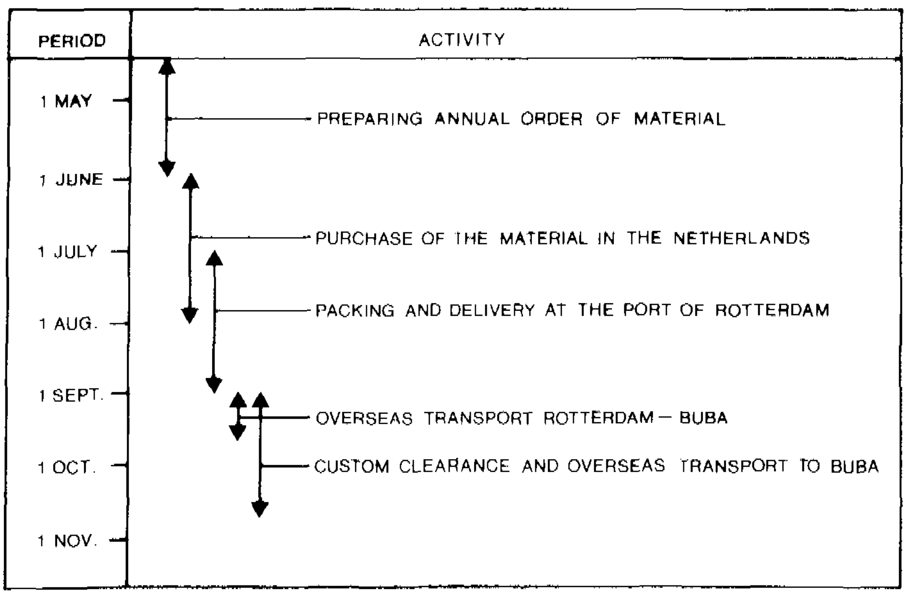
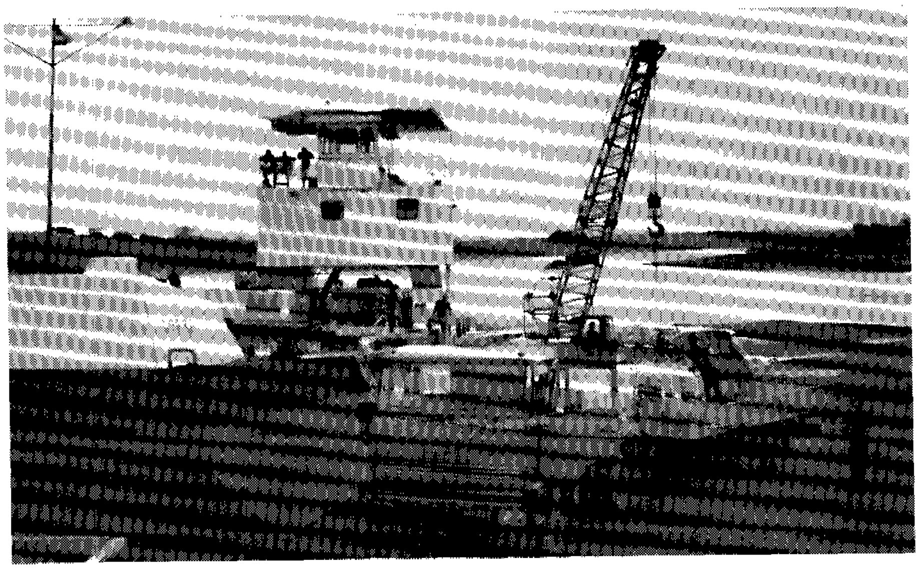


Figure 17.
Procurement and delivery schedule of materials for the project.

The lists of material and equipment to be ordered were prepared by the project team and sent to the procurement office of the Directorate General for Development Cooperation, in The Hague. This office then placed the orders and made arrangements for their shipment. The procurement officer of the project regularly visited the office in The Hague, to assist in the ordering of the required materials and the shipping arrangements.

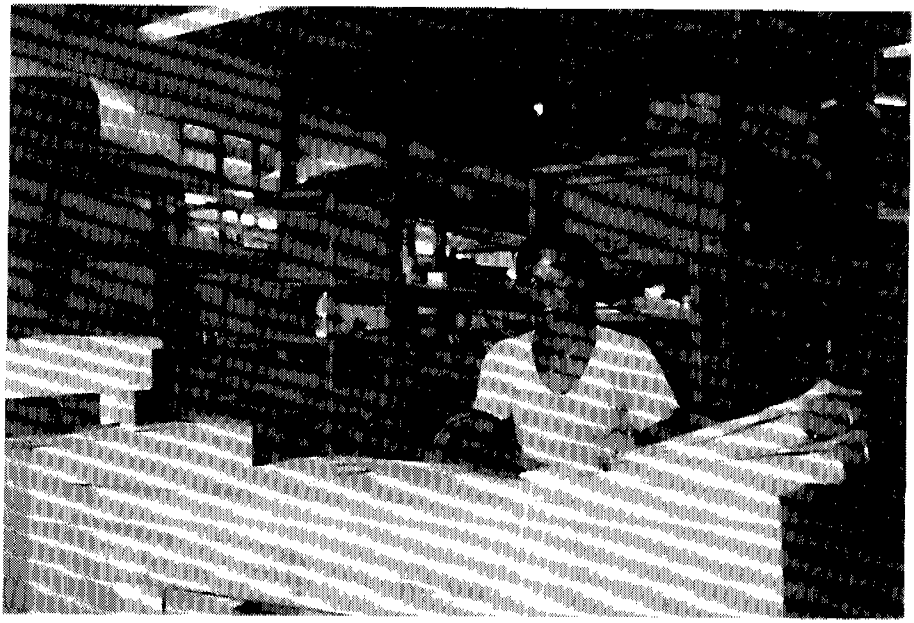


Arrival of project material in Buba.

Stores

A good storage system is very important for any project, so as to avoid that progress is hampered by a shortage of materials or equipment.

The time and effort that were spent in arranging the storage system and the stock administration definitely paid off. Important factors for determining the size of the required stock were rate of turn-over, delivery schedule and the costs of storage. An aspect not to be overlooked is the reliability of supplies, especially of local products. For example the acetylene used in the project was initially obtained in Bissau, but when local production was stopped for more than a year, the acetylene had to be obtained from Senegal.



Administrator in the store.

5. COST DATA

In this chapter some cost data on the Buba-Tombali water supply project are presented for September 1977 - December 1981.

5.1 Investment costs

The total capital investment in the project during this period amounted to US $ 3.65 million, as specified in Table 18.

Table 18.
Capital investment Buba-Tombali water supply project.

Feasibility studies	US $	185,000.	5%
Workshop, offices, housing		425,000.	11%
Vehicles		685,000.	18%
Equipment		425,000.	11%
Material		800,000.	22%
Salary		1,100,000.	30%
Fuel		100,000.	3%
TOTAL	US $	3,650,000.	100%

As can be seen in the table, the construction costs of the workshop, offices and housing for project staff absorbed a considerable portion of the total investment. This might be more than in comparable well projects, because very few facilities were available in Buba at the start of the project.

Capital investment per well

The capital investment per well, specified for the various project inputs, is shown in Table 19. The capital investment in 1980 was divided over 150 wells, the total number of wells constructed in that year.

Table 19.
Investment cost per completed well (in US dollars).

Section	Imported material	Local expenditures	Salaries expatriates	Total per section	
Social activation	25.	130.	815.	970.	17%
Survey	15.	105.	160.	275.	5%
Construction	660.	435.	160.	1255.	22%
Vehicle workshop	560.	55.	130.	745.	13%
Mechanical workshop	255.	50.	255.	560.	10%
Production	230.	185.		410.	7%
Overhead *	45.	665.	670.	1375.	25%
Total	1790.	1625.	2190.	5590.	100%

* Calculated for 1980; 150 completed wells.

As shown in the table, the social activation work took a substantial portion of the overall investment, which was partly due to the relatively high costs of expatriate staff. It should however be realized that very little experience was available for the social activation work, so that the extensive expatriate input was needed to develop this activity.

The experience gained in the project should be very useful to similar water supply projects both in Guinea-Bissau and in other countries. Substantial cost savings may be had in such social activation activities using the lessons learned in the Buba-Tombali project.

Cost data of well construction

The actual construction costs for dug wells and hand-drilled wells produced by the project were as shown in Table 20.

Table 20.
Construction costs of wells.

Dug well, 12 m depth		Hand-drilled well, 15 m depth	
4 rings Ø 1.50 m	US $ 145.	5 metres filter tubing	100.
5 rings Ø 1.00 m	180.	10 metres tubing Ø 15 cm.	140.
1 well cover	35.	gravel for filter pack	35.
cement	65.	well cover	35.
generator (30 hours)	40.	cement	65.
transport	350.	transport	300.
salaries (2 persons)	225.	salaries	180.
TOTAL	US $ 1,040.	TOTAL US $	855.

The table shows that hand drilling from the view point of costs was advantageous over well digging. Hand drilling also required less in the way of transport of equipment, which in the conditions of Guinea-Bissau was an important advantage. The equipment and transport requirements for well digging and well drilling are shown in Table 21.

Table 21.
Equipment and transport requirements for well digging and well drilling.

A. Equipment and transport requirements for five teams of two persons; each team producing one dug well/month

1	truck (for 5 teams)	US $	48,000.
1	Landrover		14,000.
4	generators + pump		32,000.
	equipment*		7,000.
	Total investment	US $	101,000.

B. Equipment and transport requirements for one team of six persons producing 4 drilled wells/month

1	drilling set	US $	14,000.
1	Landrover + trailer		16,000.
	Total investment	US $	30,000.

* The steel moulds for the concrete ring production were made in the workshop of the project.

Transport costs

The costs of the Landrovers and trucks used in the project were substantial. Unit costs, expressed per kilometer, are presented in Table 22.

Table 22.
Costs of a Landrover and a truck, per kilometer.

	Landrover	Truck
Spare parts	US $ 0.36	0.80
Maintenance and repair	0.07	0.07
Insurance	0.01	0.02
Fuel	0.07	0.17
Driver	0.10	0.10
TOTAL	US $ 0.61	1.16

Based on 12,500 km per year for the Landrover;
20,000 km per year for the truck.

Pump production costs

The production costs of the "Buba" pump, and those of the rope-and-bucket system are shown in Table 23. The cost data were computed for a production rate of 150 pumps and 50 rope-and-bucket systems per year.

Tabel 23. Production costs of 'Buba' pump and rope- and -bucket system.

	"Buba" pump, installation depth of cylinder 12 m	Rope-and-bucket system
Material	US $ 56.	US $ 66.
Salaries *	40.	20.
Rising main	100.	
Cylinder	120.	
Overhead	100.	60.
Depreciation	32.	18.
TOTAL	US $ 448.	US $ 164.

* Payment of the workers was in local currency;
The figures are computed for an annual production rate of 150 pumps and 50 rope-and-bucket systems

When, in the future, the mechanical workshop will be run by local staff without expatriate assistance, overhead and supervision costs will be less. The total production costs of one pump are estimated at US $ 450 and those of the rope-and-bucket system, at US $ 120, for the estimated production rate of 150 pumps and 50 rope-and-bucket systems per year.

5.2 Recurrent costs

For a full cost analysis all the relevant costs should be taken into account. In addition to the investment costs, the recurrent costs of the water supply agency of maintenance replacement of parts and transport should be considered. The investment costs of a pump, for instance, may be not more than 15 - 25% of its total "life-time" costs.

As there are very few cost data on maintenance and replacement of the Buba pump and of the rope-and-bucket system available, a full cost analysis is not yet possible. However, it is clear that the production costs as well as recurrent costs of a rope-and-bucket system are considerably lower than those of the pump.

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