THE
NITIES

Directorate-General
for Development

Directorate for General
Development Policy

Specialized Department for
Evaluation of Aid Operations

Brussels, August 1978

RB/mk/ldp

SECTORAL EVALUATION (EX-POST)
OF URBAN AND VILLAGE WATER SUPPLY PROJECTS

VOLUME II

Temporary Address: Rue de la Loi 200, B-1049 Brussels
Telephone : 735 00 40/735 80 40
Telegraph Address : "COMEUR Brussels"
Telex : "21877 COMEU B"

X 1261
Vol II

COMMISSION OF THE
EUROPEAN COMMUNITIES

Directorate-General
for Development

Directorate for General
Development Policy

Specialized Department for
Evaluation of Aid Operations

VIII/265(78) FR rev. 1

Brussels, August 1978

RB/mk/ldp

SECTORAL EVALUATION (EX-POST) OF URBAN AND VILLAGE WATER SUPPLY PROJECTS

VOLUME II

Temporary Address: Rue de la Loi 200, B-1049 Brussels
Telephone : 735 00 40/735 80 40
Telegraph Address : "COMEUR Brussels"
Telex : "21877 COMEU B"

CONTENTS

Page

PART ONE

LIST OF ABBREVIATIONS

AASM	Associated African States and Madagascar (Yaoundé Convention)
ACP	African, Caribbean and Pacific States (Lomé Convention)
DHER	Direction de l'Hydraulique et de l'Equipement Rural (Rural water engineering and supply directorate - a government department), Upper Volta
EDF	European Development Fund
NIGELEC	Société Nigerienne d'Electricité (Niger electricity company), Niger
OFEDES	Office des Eaux du Sous-sol (Bureau for groundwater), Niger
ONPR	Office National de Promotion Rurale (National rural development bureau), Ivory Coast
RNET	Régie National des Eaux du Togo (National water company, Togo)
SAH	Service Autonome de l'Hydraulique (Independent water authority), Ivory Coast
SETU	Société des Equipements et de Travaux Urbains (Urban services and works company), Ivory Coast
SERARHY	Service d'Entretien et de Renouvellement des Aménagements Ruraux Hydrauliques (Rural water supply services maintenance and renewal department - a government department), Chad
SNE	Société Nationale des Eaux (National water company), Upper Volta
SODECI	Société de Distribution d'Eau de la Côte d'Ivoire The water distribution company, Ivory Coast)
SOMH	Subdivision d'Outillage Méchanique Hydraulique du Sénégal (Department of water engineering supply, Senegal)
SONEES	Société Nationale d'Exploitation des Eaux du Sénégal (National water company, Senegal)
STEE	Société Tchadienne d'Energie Electrique (Chad electricity company)
WHO	World Health Organization

PREFACE AND INTRODUCTION

PREFACE

During 1976 and 1977 the Commission's departments made an ex-post evaluation of the projects financed by the Community through the resources of the European Development Fund (EDF). As the evaluation was concerned with examining the use made of completed projects, it was only able to include projects undertaken by the African states associated with the Community by the Yaoundé Convention (AASM).

This evaluation is a synthesis of the assessment of 29 completed urban and village water supply projects. The projects investigated were situated in the following six countries : the Ivory Coast, Upper Volta, Niger, Senegal, Chad, Togo.

The programme for this survey was drawn up in close co-operation with the operational and geographical departments responsible : The "Hydraulics" Division (C/6) of the Projects Directorate; the "West Africa" Division (B/1) of the Africa, Caribbean and Pacific Directorate.

INTRODUCTION

I Notes on methods

The object of this sectoral evaluation is to highlight certain aspects of the specific experience acquired. These, if taken into consideration, may contribute to an improvement of the effectiveness and the financial and technical viability of future projects of a similar type. The evaluation therefore endeavours to provide object lessons for the better dovetailing of new projects with the development strategies of the countries concerned.

The study in no way claims to provide a complete overview of all the political, socio-economic and technical problems which may arise in the design and investigation of a project, neither can it provide complete sectoral guidelines for community aid. Although the results and conclusions concentrate on the AASM, they may nevertheless be generalized and applied to all the African, Caribbean and Pacific (ACP) states which are signatories to the Lomé Convention.

As far as possible the report endeavours to take a practical and operational approach, and to present the lessons drawn from experience in terms of factors which can be used in the planning of new projects. Its objective implies the initiation of a dialogue with the recipients of aid concerning the concepts and practical solutions which experience has proved to be advantageous, functional and effective in their own countries.

The method of sectoral evaluation has been developed so as to :

- fit the projects into the scope of the objectives and resources of the water policies of the aided countries, and to check the factors determining "objective" needs and the actual demand for water on the basis of experience acquired,

- examine and evaluate the general and technical design of projects as a whole and in detail (guidelines for certain options; preliminary socio-economic, hydrogeological and technical studies; the selection of equipment; methods and techniques of construction, particularly in the case of village water supplies, etc),

- examine and evaluate the institutional and financial structure of the background to the projects (political responsibilities; responsibilities, nature and structure of the managing organizations; efficiency criteria for the managing organizations, etc),

- examine and evaluate tariff policy structures and principles,

- examine particular questions such as participation by the population in village projects, health education, etc,

- evaluate the direct and indirect effects of projects on health and social and economic conditions, particularly in the case of village water supply projects.

The evaluation is concerned with urban and village water supply projects, that is the work and institutional structures concerned with the collection, treatment, transport and distribution of potable water. Although water supply systems in urban areas must be designed as a part of an integrated water supply and drainage system, this study is not concerned with sanitation problems : the collection, treatment and disposal of liquid wastes.[1] Water supplies for stock (the watering of animals) are only marginally considered to the extent that they form an integral part of some of the projects evaluated.

1. It turned out that the few sanitation projects financed by the Community were not sufficiently representative for valid conclusions to be drawn.

There is no agreed definition of "urban" and "village" water supplies at international level. This evaluation follows the distinction generally applied by the EDF departments : urban water supplies comprise entire systems for the supply and distribution of water including collection, primary and secondary distribution networks, standposts and private connections, or the rudiments of such systems with only a primary distribution network and no private connections. In the countries visited such systems had only been installed in towns of more than about 3,000 inhabitants. Village water supplies include open wells and wells or boreholes provided with footpumps or handpumps located in villages of generally 300 to 1,000 inhabitants, but in no case exceeding 3,000 inhabitants.[1] Village water supplies from springs or reservoirs are not considered in this study through lack of representative projects.

The countries and projects figuring in this sectoral evaluation were selected bearing in mind three interdependent criteria :

- the projects should be completed or well advanced, and be capable of being regarded as representative of different types of community action,
- a large and/or significant amount of community aid should have been provided for the country's water supply,
- different types of national policy and system management should be represented.

On the basis of these criteria the evaluation extended to 29 water supply projects, including :

- 14 urban water supply projects (new facilities or extensions in 24 towns)
- 15 village water supply projects (including over 2,600 wells).

1. This definition does not correspond with the one used, for example, by the IRDB : in World Bank financing the term "rural" water supply applies up to 10,000 inhabitants.

All these projects are located in six AASM countries : the Ivory Coast, Upper Volta, Niger, Senegal, Chad, Togo. The full list of evaluated projects is in Appendix 1.

Together these evaluated projects (51 million EUA) represent 40% of the total commitment by the resources of the first three funds for water supply projects (128 million EUA).[1]

POTABLE WATER SUPPLY PROJECTS

	Total commitment by the first three funds	Projects evaluated		
	Million EUA	(Number)	Million EUA	%
Urban water supply projects	78	(14)	24	31
Village water supply projects	50	(15)	27	54
TOTAL	128	(29)	51	40

1. EUA = European unit of account. As an indication :
   1 EUA = 283 CFAF, 1 EUA = 1.22 $US (May 1978 value)

This report is based mainly on :

- evaluation visits made by Mr Rolf Brenner, a member of the Evaluation Department (A/2) to the Ivory Coast and Senegal (May 1976), Niger (November 1976, February and May 1977) and Togo (September 1977),

- evaluation visits made by consultant experts to Upper Volta (May 1977) and Chad (May 1977),

- a technical investigation carried out by a firm of engineering consultants.

The titles and references of these evaluation reports and technical studies are listed in Appendix 2.

The findings, the political and practical problems and the conclusions applicable to urban and village water supplies differ fundamentally from each other. Because of this the two contexts are dealt with separately :

- urban water supplies in the first part of the report (blue pages)

- village water supplies in the second part (yellow pages).

II. Satisfaction of the demand for potable water

1. Access to potable water

Human health and wellbeing are inexorably linked with the supply of potable water and the existence of at least rudimentary sanitary facilities. Thus water is of fundamental importance to economic and social development. All efforts made to improve health, to control endemic and epidemic diseases, to reduce infant mortality, to increase the productivity of labour and all other development efforts can only be successful if potable water of sufficient quality is available in adequate quantities.

These statements are further emphasized by the fact that the great majority of the populations of developing countries have no "reasonable access" to supplies of "clean" water and have no adequate facilities for the disposal of excrement.[1] In 1975 only 77% in urban populations, and 22% in rural populations (weighted average 38%) were satisfactorily served by water supply systems. These percentages vary greatly from one region of the world to another : in Africa the corresponding figures are 68% of the urban population and 21% of the rural population, with a weighted average of 29% (see table, Appendix 3).

In absolute figures the situation is even more disturbing. About 140 million people in urban areas and over 1,100 million in rural areas (about one third of the total world population) have no "reasonable access" to "clean" water. Even more people have no adequate facilities for the disposal of excrement.

---

1. The WHO definition of "reasonable access" in urban areas is : supply by private connection or from a standpost less than 200m from a house; the definition for rural areas is vague : the time expended in fetching water should not take up a disproportionate amount of the time available to a family. "Clean" water is non-contaminated water.

2. Objectives to be achieved at world level

In order to put this situation to rights the 25th World Health Assembly in 1972 set objectives for the world-wide improvement of water supplies in the Second Development Decade (1971-80);[1] in 1980, 92% in urban populations and 36% in rural populations should be served by a "clean" water supply.

The investment required between 1976 and 1980 in order to achieve these objectives was estimated at US $ 14,500 million for the supply of water in urban areas and US $ 6,500 million for the supply of rural areas (at 1975 prices). It is very unlikely that sums of this magnitude will be available for this purpose during the period in question. Other constraints also apply, in particular the lack of qualified management personnel, institutional weaknesses at all levels, poor knowledge of available water resources, and the low purchasing power of the consumers.

Generally speaking it can be assumed that countries can achieve the urban objectives more easily than the rural objectives; in the past investment has in fact been largely concentrated on urban facilities. This is revealed for example in the WHO figures for the six countries surveyed in this sectoral evaluation; the percentages for the urban populations served vary between 36% in Niger and 98% in the Ivory Coast, against percentages for the rural population served varying between 10% in Togo and 29% in the Ivory Coast (see table, Appendix 3).

However these examples raise serious doubts about the validity of the figures collected by the WHO and, therefore, about the true value of the objectives aimed at. Evaluation of the projects financed by the EDF has shown in particular that the existence of a "clean" water supply in no way guarantees that the population served consumes clean water. If it is assumed that almost all open cemented village wells without pumps are

---

1. In 1976 the 29th World Health Assembly examined a report on progress accomplished and the situation half way through the decade, and adopted new adjusted objectives for 1980. Only the revised objectives are quoted here.

exposed to pollution (see page 75), and if only such wells exist in the rural areas of a particular country, how is it that 26% (Niger) and 23% (Chad) of the rural population is served by a "clean" water supply? This discrepancy can only be explained by the fact that the WHO accepts the definition for urban and rural populations as it is given in each country. In urban areas the existence of standposts providing "reasonable access" [1] to "clean" water in no way prevents the population thus theoretically served from consuming contaminated water, originating either from standposts through the intermediary of water carriers (Chad) or from the traditional sources (wells, etc) used simultaneously in almost all large towns. Also it can happen that water distribution facilities recorded in the statistics remain unused, even if only partially, either through over-generous design or lack of maintenance and prolonged breakdowns.

For all these reasons it is very likely that in actual fact the situation regarding the supply of "clean" water is very much less favourable than it appears in the WHO reports, and that therefore the WHO objectives are too ambitious.

3. The contribution of community aid

During the last 15 years the Community has devoted more than a negligible part of its total finances to water supply and sanitation projects : 144 million EUA out of a total of 2,182 million EUA, or 6.6%.

1. In the strict sense of the WHO definition.

Financing decisions (commitments) (in million EUA) (*)

	EDF 1	EDF 2	EDF 3	Total
Total decisions (undertakings) of which:	570	734	878	2,182
urban water supplies	14	25	39	78
village water supplies	26	14	10	50
sanitation	9	3	4	16
Total water supply and sanitation	49	42	53	144
% of total	8.6	5.7	6.0	6.6

(*) Situation on 30.9.1977. 1 EUA = 1.22 US $ (May 1978 value)

While commitments for investment in villages fell from 26 million EUA (EDF 1) to 10 million EUA (EDF 3), commitment for urban facilities increased considerably - from 14 million EUA to 39 million EUA. This trend is indicative of the changes made in the objectives and priorities expressed by the Associated States. It can be explained mainly by the growth in the population of major towns since independence. But other factors have also contributed to the same trend, whether they relate to economic options (a given amount of investment will generally satisfy a larger number of inhabitants in an urban area), or financial constraints(income from the sale of water in large urban centres normally enables the system to be self financing), or merely political decisions.

The amount designated for water supply projects from the total for the outline programmes agreed with the ACP countries under the Lomé Convention is over 100 million EUA, including 45 million EUA for urban water supplies, 40 million EUA for village water supplies and 17 million EUA for sanitation.

III. The necessity for a national water policy

A consistent policy for water has not yet been formulated in many countries. Project evaluations have however shown how important this is : every government should take pains to lay down a policy for water which includes at least the overall aspects of potable water : urban water supplies, drainage of used water, sanitation, village water supplies. It would be better still if it also included all the other matters relating to water such as the watering of livestock (particularly in countries where areas of nomadic and sedentary lifestyles overlap), together with irrigation systems, river management, etc.

The national potable water policy must form an integral part of a country's general and social development policy. It must lay down principles and objectives for the use and management of water and provide a framework for investment plans and programmes and the activities connected with them. For their part these must be co-ordinated with other regional and sectoral development plans and programmes (agriculture, sanitation, etc.).

With regard to the supply of potable water itself the national water policy must answer fundamental questions of considerable social and economic moment such as : should priority be given to town or village water supplies? Should a privileged section of the population living in large towns be supplied while the population of urban centres of secondary importance is neglected? Should an urban minority which is able to pay the true cost of the water be supplied and the suburbs experiencing a rapid expansion in population be left without reasonable supplies?

PART ONE

THE DESIGN OF URBAN WATER SUPPLY PROJECTS

PART ONE

THE DESIGN OF URBAN WATER SUPPLY PROJECTS

A. THE DEMAND FOR WATER IN URBAN AREAS

Domestic consumption is generally only a part of total consumption in urban areas, but in developing countries it is usually the larger part. In addition to this, particularly in large towns, there is consumption for industrial and commercial purposes and consumption by public institutions (government, schools, hospitals, etc.). Because of the numerous factors governing water needs, estimation of the future development of demand requires a very complicated socio-economic approach. As a result ultimate reality can easily differ from predictions.

I. Some results of the project evaluations

The investigation of project utilization has shown that all projects have resulted in a considerable improvement in the supply of water to the target populations, both in the case of new facilities and the extension of existing water supply systems. However some facilities have proved to be too large or too small in relation to actual consumption. Incorrect forecasts arise from various debatable assumptions, of which the following may be mentioned :

1. Over-estimation of average consumption

The capacity of new facilities (boreholes, pump units, pipelines, service reservoirs) in some secondary centres was calculated on the assumption of an average consumption of 70 l/cap/d (Senegal) and 50 l/cap/d (Niger) whereas in fact average consumption only amounted to 20 l/cap/d in the secondary centres in Senegal and in Tahoua (Niger), and 10 l/cap/d in Filingué and Birni N'Konni (Niger).

Experience also shows that there is a general tendency to over-estimate average consumption : in the projects evaluated this amounted to between 40 and 80 l/cap/d in large towns of more than 100,000 inhabitants, and between 10 and 20 l/cap/d in secondary centres of 10,000 to 40,000 inhabitants. Furthermore these are averages which include all consumption by industry, commerce, government, etc. (Table, Appendix 4).

2. Over-estimation of consumption from standposts

In the project for the extension of Dakar's water supply (the Lake Guiers project, referred to hereafter as the Dakar project) the average consumption from standposts was estimated at 50 l/cap/d. In actual fact consumption is now some 20 l/cap/d (including wastage). This over-estimate contributed largely (12,000 m^3/d) to the incorrect total estimate (107,000 m^3/d in 1975) which is far in excess of present consumption (74,000 m^3/d).[1] Surveys in fact showed that average daily consumption from standposts rarely exceeds 25 l/cap/d, even in the largest towns and even at the end of the dry season.

3. Non-fulfilled expectations of urban population growth

In some cases estimates of population growth proved to be much higher than actual fact. This occurred mainly in secondary centres. In the design of the water supply to Filingué (Niger) for example, not enough attention was paid to the relatively unfavourable economic situation of the town and its prospects. Contrary to expectation the number of inhabitants has remained unchanged since the project was designed in 1969, which is why the facilities are excessively large; at the present time 2 hours pumping a day is sufficient to satisfy demand.

1. Actual output less 30% losses.

However the same thing also happened in some large towns. Thus in the Dakar project the assumption of a growth rate of 6% between 1965 and 1980 proved much too high. In the case of N'Djamena (Chad), actual population growth again did not match the forecasts made when the project was designed.

Under-estimation of the increase in demand was much more frequent in the case of major towns, and capital cities in particular, mainly because the assumptions used for population growth were too low. Thus for example in Lomé (Togo), Ouagadougou and Bobo-Dioulasso (Upper Volta) and Bouaké (Ivory Coast) all the estimates of population growth made at the time the projects were planned have been exceeded by a large margin. In the case of Ouagadougou a population of 130,000 inhabitants was forecast for 1982, whereas it already totalled 170,000 in 1975. In the case of Lomé a population of 200,000 was estimated for 1980, whereas this figure was reached by 1972. As a consequence the limits of installed capacity were reached far in advance of the dates estimated. It should however be recognised that initial projections of population growth in large African towns and capitals have been proved wrong by the exceptional circumstance of a continually increasing rural to urban drift which has become even greater in the recent years of drought.

However, even though investment in the towns mentioned was too small, designs have proved sufficiently flexible to allow for all the extensions ultimately necessary, without prejudicing the technical integrity of the whole system.

4. Incorrect assumptions concerning industrial demand

It is difficult to make projections of industrial consumption when a project is being designed; in point of fact large industrial consumers often use private boreholes, which they find cheaper to operate and/or more reliable. In Bouaké (Ivory Coast) for example, an industrial concern consumes 3,500 m^3

of water per day from a private installation, whereas the total consumption in the town is 8,000 m^3/day. Likewise in N'Djamena (Chad) large industrial consumers use private boreholes, thus considerably reducing the quantities sold through the town's water distribution system.

Estimates are that much more difficult to make because the decision of an industrial consumer to become connected to the public water supply depends on the technical and financial reliability of the facilities; however this can seldom be evaluated at the stage of project design because it is a matter of management (reliability of supply) and later political decisions (appropriate tariffs), etc.

5. Debatable basis of calculation

In the design of the Dakar project calculations were based on the 'potential output' of water in 1964 (68,000 m^3/d) which differed by 15% from the actual output (59,000 m^3/d) because of the inadequacy of certain production and distribution facilities. The supply of water was limited to 7 hours per day in the greater part of the conurbation. A more realistic initial (1964) output (the average of actual and potential output) would have led to more accurate forecasts.

6. Summary

In a very general way experience has shown that there is some risk, when designing a water supply, of :

a) over-estimating growth in demand, in particular in towns of secondary importance, which grow more slowly than major towns and are often cast in the role of administrative centres and centres for the collection of agricultural products, and therefore do not have the attraction for immigrants of the major towns,

b) under-estimating growth in demand, in particular in major towns and capital cities which often experience disproportionate and unforseeable population growth mainly due to the continuing rural to urban drift. Examples of over-estimates of growth in demand - Dakar (Senegal) and N'Djamena (Chad) - seem rather to be the exception.

II. Factors governing domestic demand

On the basis of the experience acquired a number of factors can be regarded as governing the domestic demand for water. "Objective" demand is regarded here as a factor in technical planning, as against actual demand which is governed by the behaviour of the consumers.

1. Present population

This figure is often of uncertain reliability in developing countries; the data submitted must be examined critically.

2. Population growth

The projection of population growth is very difficult. Trends sometimes change abruptly in an unexpected way. In any case it is worthwhile separating anticipated growth into natural increase and migration.

3. Estimated consumption

We have seen that average consumption from standposts rarely exceeds 20 to 25 l/cap/d. On the other hand average and overall consumption by private connections is more difficult to determine. It depends in particular on :

- the level of tariffs and their structure (because of the importance of this factor the problems relating to it are discussed on page 52 et seq.),
- the average number of persons per family,
- a family's standard of living (family income, purchasing power, level of health consciousness),
- household sanitary equipment (flush toilet, bath, washing machine, etc.).

4. Water quality

There are international and national standards for the quality of potable water which should normally be respected in the case of complex water supplies to major towns. However even the provision of a simpler small water distribution system which does not meet these standards may be of positive benefit in that an increase in quantity satisfies increasing demand, and in cases where such a system would decrease the incidence of certain diseases which result from the lack of a healthy supply.

5. Standards of service for water supplies

It is clear that the quantity and quality considerations will determine the standard of service : whether the treatment plant is complex or merely rudimentary; whether there is only a primary distribution system or a complex (primary, secondary and tertiary) system; whether there are only standposts or the system is a mixed one with private connections, or again whether there are only private connections (see section B, page 24 et seq.).

6. Other factors

Other factors such as climatic conditions, the habits and customs of the population, the existence of other sources of water and seasonal changes in consumption may have a strong influence on the demand for water which has to be satisfied. These are factors which govern actual demand rather than "objective" needs (see the following section).

III. "Objective" needs and actual demand

1. The use made of water supply systems

Surveys of the use made of various EDF projects show that the population does not make full use of the facilities for the distribution of water in hardly any of the secondary centres, or even in the major towns. Other existing sources of water such as concrete or traditional wells or other sources of surface water (rivers, lakes, etc.) also remain in use. This "competitive" situation applies mainly to the potential users of standposts. The reasons for this are chiefly :

- a very widespread lack of appreciation of the health qualities of water : very often ease of supply dictates that the nearest source of water is used regardless of the quality of the water. For example in Lomé (Togo) it is estimated that half the population obtains its supply, at least in part, from the numerous wells which tap the water table at a depth of 1.50 m. In Ouagadougou (Upper Volta) it is estimated that only 30% of the population without private connections uses standposts. However some traditional watering places which are fully used during the rainy season dry up in the dry season; as a result the demand for water from the public supply can vary by a factor of two between the rainy season and the dry season,

- taste may cause the water from a well to be preferred to that from the public supply. For example in Sokone (Senegal) thirty or so wells continue in use alongside the small water supply system installed in 1973, even though the water from this system is supplied free of charge. The water from deep wells or boreholes can have a different taste to that of surface water; it can contain more or less minerals than the population is used to,[1]

---

1. In the instance mentioned borehole water is used for washing clothes and cooking utensils (and of course for watering animals), but only well water is used for drinking.

- effective difficulties of access to standposts, either because they are too far away, or because of the monopolization of standposts in certain districts in large towns by the carriers and sellers of water (despite ostensibly free distribution), e.g. N'Djamena (Chad),

- the selling price of water, particularly at standposts : even a price equivalent to the 125 CFAF charged at Birni N'Konni (Niger) [1] may be prohibitive for a population which is not hygiene conscious where water is concerned.

2. Consequences

These factors must not be neglected in the design of an urban water supply project, particularly in the case of facilities for secondary centres situated in economically and socially backward rural areas. Actual demand may in fact be considerably less than "objective" needs (calculated as a technical planning factor).

Actual demand (and therefore the difference between "objective" needs and actual demand) depends on :

- tariff levels and structures (see page 52 et seq.)

- the purchasing power of the population,

- a town's level of economic and social development,

- the level of hygiene consciousness,

- the existence and yield of other sources of water,

- the effective accessibility of the public system.

---

1. The municipal authorities buy water from NIGELEC and sell it at a higher price through a private "agent" at each standpost. It is resold in drums of between 20 and 40 litres.

Two conclusions must be drawn if the creation of excess capacity is to be avoided :

a) the design of a water supply project must take into account not only "objective" needs, but also anticipated actual demand. This approach is particularly to be recommended for basic systems which include only standposts, and for the incorporation of standposts in mixed systems. Standposts are the most open to "competition" from "traditional" sources of water.

This approach is also recommended for projects whose intention is only to improve the quality of water (new systems; changeover from wells to standposts), because the lack of quality is not necessarily felt by the population, unless the project is accompanied by effective health education activities. On the other hand the difference between "objective" needs and actual demand will be less important if not insignificant in the case of projects which are intended to increase the quantity of available water (extension of a system to match increasing consumption).

b) the design of a water supply project should not be based on peak seasonal demand, but rather on average demand. If the facilities are designed for peak consumption there is a risk of providing capacity which is under-used for the greater part of the year.

IV. Factors governing industrial, commercial and public needs

The project evaluations have shown that consumption by industry, commerce and public institutions may form a significant proportion of total demand. For example; the proportion used by industry and commerce in Dakar (Senegal) is some 25%, and some 20% in Bouaké (Ivory Coast), without taking privately used boreholes into account. The proportion consumed by public institutions is even larger, particularly in secondary centres : 53% in Ouahigouya and Kaya (Upper Volta), 43% in Bouaké (Ivory Coast), 38% in Tahoua (Niger) (see table, Appendix 5).

Thus the various factors which may govern the amount of water required for these needs must be investigated closely in the planning of a project :

- existing and planned industries and public institutions must be investigated case by case,
- regional town planning and development plans must be consulted,
- the possibilities for the use of private boreholes by industry must be investigated, and the technical, financial and administrative conditions which must be fulfilled if industries are to be encouraged to become connected to the public water supply must be assessed.

B. GUIDELINES FOR INVESTMENTS IN URBAN CONTEXTS

I. Selection of the standard of service for a supply system

From the technical point of view an urban water supply may take various forms :

- a small basic water supply system with the rudiments of a primary distribution network and a few standposts. For example, the water supply to certain secondary centres in Senegal,[1]

- a more developed water supply system having a primary distribution network with the rudiments of a secondary network, with a larger number of standposts and a variable number of private connections between a few dozen (Birni N'Konni and Filingué in the Niger) and a few hundred (Toumodi in the Ivory Coast, Tahoua in the Niger),

- a complex water supply system and a full distribution network with a large number of private connections, to both private houses and commercial and industrial premises, and more standposts (Niamey in the Niger, N'Djamena in Chad, Dakar in Senegal, Bouaké in the Ivory Coast).

In theory it would be desirable to provide each conurbation with the most complete water supply system possible, if mainly financial constraints did not prevent it. On the other hand project evaluations have shown that the population does not in all cases even make full use of the water supply facilities available to it. Thus in order to avoid the risk of wasting scarce investment capital, the standard of service of each water supply system must be matched to the specific economic and social situation of the consumers.

---

1. EDF financed : Coki, N'Dindy, Diakhao, Sokone, Maleme-Hodar, Koungheul, Prokhane.

When the standard of service for an urban water supply is selected a number of factors must be taken into account, including in particular :

- "objective" needs and actual demand for water in terms of quantity and quality,
- the investment cost of the facilities required to satisfy these needs,
- available resources of investment capital and/or possibly the ability of users to contribute to the investment cost,
- operating costs,
- the ability of consumers to pay the true cost of water,
- financial resources which may be available to subsidize operating costs,
- adequate institutional structures for effective management of the facilities,
- the professional skills of technical, commercial and administrative personnel at all levels.

health objectives and means to realise them (eg. HC with standposts versus HC with [illegible])

It is clear from examination of these technical, economic and social factors that the decision on a standard of service for all the facilities which are necessary or desirable in a country can only be taken at a political level. Certain guiding principles must be laid down by the national water policy.

II. National water policy, plans and programmes

In the context of urban water supplies water policy must reconcile the satisfaction of quantitative and qualitative needs for water with opposing socio-economic and financial constraints. The principles and objectives for such a water policy will necessarily vary from one country to another in relation to each individual economic, social and political situation.

Such a water policy may be as ambitious as the one in the Ivory Coast : a national water supply programme for 1973/1985 specifies the provision of new water supplies in about one hundred secondary centres and necessary extensions to the existing systems in major towns and certain urban centres, but also the provision, on average, of one water point with a pump for every 600 inhabitants in every village of more than 100 inhabitants.[1] All these existing and future facilities are managed by a single management organization and their operation is ensured by a system of country-wide standardization of all water tariffs. In principle this system makes it possible for large sales of water in the capital to subsidize water supplies to secondary centres, and even to support the cost of the operation and maintenance of village wells and boreholes.

In contrast a water supply policy may be less ambitious so as to suit the constraints of a less favourable economic and social situation. The Niger's very realistic water policy explicitly rejects any schemes which do not match the financial resources available for investment and the operation of facilities, and existing management and operational capabilities.

Investment plans and programmes must reflect the objectives of a water policy. Thus planned investment must be assessed with regard, at regional and national level, to :

- the satisfactoriness of water supplies (reasonable access to "clean" water),
- the extent to which other basic needs are satisfied,
- the ratio between the population supplied with potable water and the population not adequately supplied,
- the value placed by the population on improvements in the quantity and/or quality of water,
- all the expected effects on health and the social and economic situation etc., of possible improvements in water supply,

---

1. i.e. the provision of 7,200 wells or boreholes between 1974 and 1980.

- the purchasing power of the consumers, and deriving from this, their ability to pay the true cost of the water or at least the operating cost of the facilities.

The example of the Ivory Coast shows pertinently that the existence of a general development plan for water and the existence of a detailed plan makes it possible to establish the volume and timing of investments in relation to identified bottlenecks and the priorities established, to plan active, effective and profitable strategies for the consumption and sale of water, and in the long term to ensure financial balance in the operation of all existing and future facilities.

Over and above these principles evaluation of the completed projects teaches the fundamental lesson that water supply investment plans and programmes should not be limited only to the provision of facilities; they should rather be implemented jointly with complementary programmes and activities essential to the satisfactory operation and maximum effectiveness of the facilities. To this end investment plans and programmes must be :

- planned within a wider context which also includes the setting up and strengthening of institutional and financial structures (management organizations, tariff policy, etc.),

- complemented by training and retraining schemes for technical, commercial and administrative staff at all levels,

- dovetailed with national and regional plans for general social and economic development,

- co-ordinated with other sectoral development plans and programmes, in particular urban, industrial and rural development, etc.

C. THE TECHNICAL DESIGN OF WATER SUPPLY SYSTEMS

The water supply systems financed in the past from the resources of the EDF and assessed in this evaluation study are neither sufficiently numerous nor varied to provide concrete examples of all the problems which can arise in the technical planning of a project. The guidance given below does not therefore intend to be exhaustive; its intention is merely to encourage thought. Thorough calculation of the economic viability of every alternative plan for a particular project is essential.

Water supply systems are designed in relation to a specified standard of service. Two sets of optimization problems (relating to investment costs and running costs) must be solved if the most beneficial alternative is to be selected :

- selection of the overall system for the supply of water, and
- selection of its various components : water collection facilities, pipelines, treatment, service reservoirs, distribution systems, private connections and standposts, etc.

One example will illustrate the problem : a water intake from a river may have the lowest investment and running costs of the various alternative forms of water collection. However as far as the whole water supply project is concerned this option may turn out to have the highest investment and running cost because it entails not only water treatment but also a supply pipeline.

I. The ultimate basis : selection of a source of water

The requirement that the water provided and distributed must be clean has a decisive effect on the technical design, the investment cost and the running costs of a water supply project.

In general groundwater requires no treatment in order that it should satisfy biological and chemical standards of cleanliness. Thus investment costs (boreholes alone) and operating costs remain relatively low. On the other hand surface water taken from a lake, a river or a dammed reservoir must be subjected to treatment, the cost of which varies in relation to the type of treatment required. Treatment requires fairly large investment (treatment plant), but above all running costs are very high (chemicals and fuel are consumed). In addition to this the risk of breakdown and the difficulties of technical management are greater (because of the complexity of the plant), and the regular supply of chemicals and spare parts can raise serious problems (foreign currency payments, transport difficulties, etc.).

The case studies have shown that a decision to use surface water should only be taken if all possibilities for the use of groundwater have been ruled out. In the case of the water supply to Dakar (water intake in Lake Guiers), the temporary expedient of using boreholes made available the time for a thorough study of the possible alternatives; there was also time to establish that groundwater reserves in Cape Verde are sufficient to satisfy Dakar's needs until at least 1990.

As this is a basic decision which often acts as a pointer for future policy on investments, and has considerable repercussions on the technical and financial viability of the system, it should in all cases :

- be based on thorough investigation of groundwater and surface water resources (usable quantities and the quality of the water) and the various means whereby these may be used. The example of the water supply to Lomé (Togo), which is based on boreholes, provides a good illustration of the utility and even the necessity of such studies, without which a decision to use surface water from the river Sio might have been taken as a long term solution,

- be justified by a firmly based economic analysis of the costs and advantages of the alternatives. The economic assessment is even more important when a government must reconcile the advantages of a reliable supply with the use of scarce available investment capital resources.

In conclusion preference should be given at the outset to groundwater in the planning of any water supply project. Generally speaking the use of groundwater is more reliable and flexible from a technical viewpoint, and both investment and running costs are much lower. The use of surface water should only be considered after all other possibilities have been ruled out. It is therefore essential that the fullest possible hydrogeological and economic studies be made in order to avoid incorrect decisions.

II. Water collection systems

If the selection of the source of water is of fundamental importance to the viability of a project, the choice of water collection facilities is no less important even though it is largely dependent on the first decision taken. The various technical possibilities are ranked as follows in order of the increasing investment costs of the water collection system : river or lake water, groundwater, water from a dammed reservoir.

- A river intake presumes a permanent flow which is adequate even in drought years. The technical design of the intake has to take flow conditions into account; it is therefore relatively difficult to design. Against this intakes cause few maintenance problems.

- Systems for the tapping of groundwater require boreholes, often of considerable depth (e.g. 700 m in Filingué, 600 m in Birni N'Konni in the Niger). The drilling of boreholes requires a high degree of technical skill and very specialised equipment. Pump units must generally be imported; these entail more than negligible energy costs (particularly in the case of diesel units) and require an efficient maintenance service (available spare parts, skilled personnel).

  Boreholes have one particular advantage; they can generally be located close to the distribution system, and therefore only need short pipelines. This applies to the water supply systems of N'Djamena (Chad), Lomé (Togo), and Tahoua, Filingué and Birni N'Konni (Niger). In contrast 65% of the total borehole output at Dakar is carried over a distance of between 30 and 40 km (Sebikotane and Pout boreholes).

- Water intakes from dammed reservoirs are generally the most expensive of the technical alternatives, mainly because of the cost of the dam. At Bouaké (Ivory Coast) for example, the dam accounted for 65% of the total cost of the water supply system.[1] What is more, dams are often a relatively long way from a distribution system, which affects the cost of the supply pipelines. In addition to this the design of a dam can raise major technical problems : permeability of the ground, silting, control of flow conditions, etc. For example at Koudougou (Upper Volta), conditions for filling the dam[2] were less favourable than anticipated, resulting in repeated water shortages despite the fact that the capacity of the reservoir was 100% larger than necessary.

---

1. Project initiated in 1963. The remaining 33% was divided between the treatment plant and pumping station, a pipeline and two storage tanks.

2. The Sambissogo dam, 8 km from the town, built three years previously and incorporated, after some modification work, into the water supply project.

III. Water pipelines

Apart from the length of a pipeline, two technical design factors must be taken into account : the way the pipeline is laid and its capacity.

1. Pipelaying

A surface pipeline may easily run into operating problems; there may be undesirable effects on the temperature of the water carried, and lastly there is a greater risk of corrosion.

These disadvantages can in theory be avoided by laying the pipeline underground. The example of the water supply to Dakar (Senegal) has shown that burial was no hindrance to the numerous depredations which the pipeline suffered between Lake Guiers and Dakar - the pipeline and associated structures, manholes in particular, were holed by nomadic herdsmen and even villagers attempting to provide water for themselves.

2. The capacity of a pipeline is generally related to estimated average daily demand, peaks in daily demand being met by service reservoirs in the distribution system. Capacity is governed by diameter and pressure; the latter may be produced by gravity or by pumping.

3. Optimization problems

The most beneficial balance between the cost of the pipeline and the cost of pumping must be found. The problems of optimization are as follows :

- Pipeline costs

The cost of the materials for a pipeline increases more than proportionately with diameter while the cost of pipelaying (trenching and the actual pipelaying) increases less than proportionately. In all the cost of a pipeline increases slightly more than proportionately with diameter.

- Pumping costs

For a given diameter the capacity of a pipeline increases with the square of the pressure; energy consumption increases in proportion to the pressure produced. It follows that the cost of pumping increases much more than proportionately with capacity.

- Cost optimization

The most beneficial balance is provided by the (simplified) relationships described above. Generally speaking a given capacity is best achieved by investing in a large diameter pipeline instead of producing the corresponding pressure by pumping.

The problem of cost optimization becomes more complicated when it is a question of finding the optimum size for a pipeline which is to satisfy an increasing demand. In general it is of greater advantage to put up with a single over-large pipeline from the start than to plan for two pipelines laid one after the other.

However two parallel pipelines may be necessary where mixing of the water from two separate sources might give rise to undesirable chemical reactions. In the example of the water supply to Dakar water from Lake Guiers and groundwater from Pout could hardly be mixed in the same pipeline.

IV. Water treatment

Water may be treated chemically and/or mechanically. In some cases simple disinfection with hypochlorite may be enough. The cost of a hypochlorite unit and the hypochlorite is relatively low, and the treatment is relatively simple and easy to apply. In contrast the investment and operating costs of chemical and mechanical treatment by filtration, settling, flocculation and disinfection are much higher.

A major decision which must be made is whether to site the treatment plant at the beginning or end of the pipeline. Siting the treatment plant close to the intake has the advantage that deposits and the deterioration of equipment which could shorten the life of the pipeline and/or prejudice fault-free technical operation are avoided. The treatment plant for the Dakar water supply (Senegal) was sited at Lake Guiers for these reasons.

On the other hand if the treatment plant is sited at the beginning of the pipeline, far away from the distribution system, it may be more difficult to operate - problems with supplies of chemicals and perhaps their transport during the rainy season, greater difficulties with logistic back-up for maintenance. For example the Lake Guiers treatment plant, which can only be reached by a bush track, is cut off from all supplies for several weeks in the rainy season.

Chemicals used in treatment must generally be imported; the planning of a project should not ignore this continual commitment for foreign exchange.

V. Service reservoirs

Service reservoirs may be designed as water towers or as reservoirs at ground level, depending upon topography and their intended function. Their purpose is to :

- provide the pressure necessary for distribution,

- provide a reserve in order to smooth out changes in consumption during the day.

Generally speaking the capacity of a reservoir should not be less than 50% of peak daily consumption.

As in the case of pipeline design there is the problem of optimizing costs - what is the optimum capacity of a reservoir? Is it better to plan for a larger capacity reservoir at the outset or to make provision for spacing out the provision of capacity as it subsequently becomes necessary? Because of the high construction cost of reservoirs, which are usually built of concrete, over-large capacities should generally be avoided.

Project evaluation has shown that some water towers built in secondary centres are too large. For example reservoir capacity is equivalent to 6 times average daily consumption in Filingué (Niger), 5 times in Birni N'Konni (Niger) and 3 times in Tahoua (Niger). These capacities will be more than sufficient even for the anticipated ceiling of fully utilized facilities, and also from the point of view of maximum peak daily consumption in these Sahel areas.

In contrast storage capacity in large towns, where the trend in consumption tends to be under-estimated, is often a major bottleneck (at least in the short term). This may be due to insufficient total storage capacity, as for example in Lomé (Togo), where capacity in 1977 (7,900 m^3/d) did not even amount to 50% of average consumption (17,500 m^3/d). It may however also be due to poor distribution of the capacities of the various water towers : for example in Dakar (Senegal), in the early sixties, certain reservoirs had too little capacity although the total capacity of all the water towers was adequate.

VI. The distribution network

The overall distribution network must be related to total present and future needs which can be divided simultaneously by districts (population density, standard of living, etc.) and consumer groups (private individuals, industry, commerce, public institutions, etc.).

A new network must be designed to both satisfy peaks in consumption during the day and allow necessary future extensions. The laying of distribution mains in congested urban areas is usually expensive and therefore it is better to provide sufficient capacity from the start. Designs should be based on existing town plans and should at least take into account the urban growth anticipated in the long term.

The design of an extension to an already existing network is more complicated. It presupposes that present and future consumption, by different consumer groups and by districts, is known, failing which any investment may produce a permanent or temporary imbalance. The water supply to Lomé (Togo) is an example which should not be repeated. Continual repairs and/or patching up without reference to a detailed master plan has led to a situation of permanent imbalance.

As far as the investment cost of a distribution network is concerned, its share of the total cost of a water supply system generally increases in relation to the number of inhabitants supplied and the standard of the supply service. It is obvious that a network of private connections is more expensive than a system of public standposts.

VII. Private connections and public standposts

As we have already seen (section B, page 24 et seq.), it is up to the national political authorities to make a policy decision on the standards of service for water supplies. Thus the emphasis of a project may be mainly on standposts, or on private connections. However the relative composition of a mixed system is also related to the ability of the consumers to pay for the true cost of the provision (or hire) of private connections and the water consumed.

In the initial stages, intended to satisfy the primary needs of a population lacking a permanent water supply, the provision of a network of standposts, supplemented perhaps by a small number of private connections, seems to be the most appropriate arrangement, if not the only possible arrangement. In the second stage the provision of an increasing number of private connections in parallel with the changing economic and social level of the population of an urban centre becomes essential. The problem of the relative composition of a mixed system then becomes more and more complicated, particularly in large towns. The better the provision of private connections in various districts, the smaller is the need for standposts. New districts on the other hand may require private connections, standposts or a mixture of the two.

Thus the major problem in the technical planning of a mixed system in a large town is mainly the provision of a network of standposts in relation to remaining and/or new demand. Project evaluation has shown that the majority of standposts are located in planned areas, where many inhabitants can obtain water from a neighbour's private connection, either free or for payment.[1] In contrast few or no standposts at all are located in the unplanned suburban

---

1. It seems that people are thus attempting to recreate in an urban environment the traditional situation in which the collection and distribution of water is based on social and family relationships. This may explain the slight stigma which seems to be attached to those people without social ties who must use the standposts.

areas experiencing rapid population growth, where the need for water is felt most intensely. Urban services, and thus the provision of standpost networks (not to mention private connections), generally lag behind the rapid increase in demand in the disorderly cluster of dwellings in these surrounding suburbs.

In conclusion, the design of a mixed network must therefore attach particular importance to satisfying the needs of the more disadvantaged strata of the urban population.

The network of standposts must :

- satisfy remaining demand in planned areas, i.e. those needs which are not satisfied by private connections. Technically standposts can easily be connected (at a negligible cost) to the existing distribution network,

- satisfy essential needs in unplanned areas. Where there is no existing network this may be achieved technically by the provision of relatively inexpensive simple networks of standposts which can be demolished and replaced when the infrastructure for services is later provided. Alternatively, or in parallel, small independent boreholes with handpumps could be provided if hydrogeological conditions permit.

As far as the provision of standposts is concerned, one standpost should not as a rule supply more than between 500 and 1,500 inhabitants, and standposts should not be further than at most 250 to 300 m away from the consumers. If this is the case an average capacity of 25 m^3/d should generally be sufficient.

VIII. Water troughs within urban water supply systems

In the Sahel it might seem attractive in theory to make use of a water supply in order to provide facilities for the watering of livestock. The example of the Niger however shows that none of the water troughs forming part of the water supply system in a secondary centre (Tahoua, Birni N'Konni, Filingué) are used. The reason is quite simple. The water supply system is managed by the operating company NIGELEC, which sells the water; neither the nomadic herdsmen nor the owners of animals in the town are prepared to pay for water if they can get it for nothing elsewhere - either from rural wells or from boreholes in grazing areas (which in the case of the Niger are operated by OFEDES). On the other hand the municipal and district authorities have neither the financial resources nor the inclination to take over the sale of water for watering livestock from NIGELEC.

In conclusion , a system for watering livestock should only be included in an urban water supply system if the two groups of consumers can be treated equally - either by free distribution or by the sale of all the water supplied.

IX. Water losses and investment in extensions

The project evaluations have revealed that water losses in a supply system are sometimes considerable. It is possible to distinguish :

- true water losses due to leaks in the system, caused by shortcomings in technical design, the materials used, maintenance, etc. This amount of water is therefore denied to the consumers,

- spurious water "losses" caused by technical management or administrative failures : defective or inaccurate meters, inadequate meter reading, failure to invoice certain users, illegal connections, etc. These quantities are actually consumed, but they are "lost" as far as water output and the income of the management organization are concerned.

Whereas real losses of about 10% must be regarded as normal, total water losses (true and spurious losses) sometimes amount to extremes of 30% and even 50%.

In some cases investment in the extension of all or parts of a water supply system only appears to be necessary because of considerable losses of water, thus in fact because of the under-utilization of existing capacity.

Before any investment in extensions is planned or put into effect it is therefore essential that all the possibilities for improvement in the efficiency of existing facilities should be examined carefully. This involves

- investigation of the causes of water loss, and

- finding appropriate remedies, either through the repair of defective equipment or by the improvement of technical and/or administrative procedures (see also page 51).

X. Essential detailed studies

The paragraphs above make it clear that the technical design of a water supply system must be based on prior hydrogeological, technical and socio-economic studies which are as complete as possible :

- studies of groundwater and surface water resources, and the possibilities of using these,

- thorough studies of the technical design of the entire existing and future system and its components,

- technical and financial viability studies to determine the investment cost and the maintenance and running costs of the various possible technical alternatives.

If a project has to be completed urgently it must be designed so that it can be incorporated into the overall plan in the long term. If the long term plan has not yet been finalized the project should satisfy the requirements for flexibility and possible extensions as fully as possible.

D. INSTITUTIONAL AND FINANCIAL STRUCTURES

I. Political responsibility

In the majority of the countries visited political responsibility for all matters relating to potable water (urban and village water supplies, waste water drainage) is shared between several ministries and national and/or local authorities and/or specialist organizations, etc. This gives rise to a number of difficulties, particularly in

- the planning of a balanced and concerted water supply policy,
- the co-ordination of programmes and the utilization of all investment in this field,
- ensuring the consistent management of all the facilities.

Thus political responsibility for all matters relating to potable water must as far as possible be vested in a single authority at national level. This authority should be responsible for :

- establishing principles and objectives for a policy on potable water,
- long term planning of development in this sector,
- supervising the implementation of programmes,
- supervising the technical and financial management of facilities, including all matters relating to tariff policy (structure, charges, adjustments, etc.),
- co-ordinating with other organizations whose activities have repercussions on the water sector.

The Ivory Coast has such a single authority; the Service Autonome de l' Hydraulique (SAH), formed in 1973, has replaced various previously existing administrative structures.

Where there is no concentration of political responsibility, rigorous co-ordination between the various organizations responsible is essential. Co-ordination between ministries occurs in several countries, with a greater or lesser degree of success. Examples of this are : the Water Co-ordination Committee in Chad, the National Water Commission in the Niger, the Interministerial Water Committee in Upper Volta.[1]

II. Water management

Water management organizations can only achieve the objectives of a water policy if

- appropriate management structures are available,
- their responsibilities in relation to the government are clearly defined, and their financial viability is guaranteed.

1. Management structures

In most of the countries visited a single management organization is responsible for the operation of all urban water supplies : SODECI in the Ivory Coast, SONEES in Senegal, etc. On the other hand, in the Niger for example, responsibility is shared between NIGELEC (the operation of commercial water supply systems in large towns and some secondary centres) and OFEDES (the management of non-commercial water supplies in small secondary centres).[2]

In one case the company responsible for urban water supplies is also responsible for the management of village water supply facilities (SODECI in the Ivory Coast).

In some cases the water supply company is also responsible for sanitation (SONEES in Senegal), and in others water supply and the draining of waste water is shared between two operators (SODECI and SETU in the Ivory Coast).

1. In the course of being set up.
2. NIGELEC is first and foremost an electricity company for which water is but a by-product from the use of facilities installed for the generation of electricity. It therefore only assumes responsibility for small water supplies once electricity has been provided.

In theory the most rational arrangement would seem to be to entrust urban and village water supplies and the drainage of waste water to a single management organization at national level; the planning, installation and operation of these facilities in fact require the same type of technical specialization. In addition to this the existence of a single management organization assists the consistent implementation of water policy. If the regrouping of all these services into a single structure is not possible, then at least the operation of all urban water supplies should be the responsibility of a single management organization.

2. Responsibilities of the management organization

The project evaluations have emphasized the difficulties for the management organization in reconciling.

- the social objectives of water policy - the supply of the largest number of consumers at the lowest possible price, with

- the demands of sound and balanced financial management.

Generally speaking, it can be said that sound management based on commercial principles can only be achieved through the maximum possible financial independence and freedom of action. From this point of view the ideal situation would be for the management organization to establish its own tariffs, within the limits specified by directives and controls, to decide upon its own investments and to manage its financial activities independently.

In practice it is obvious that an organization which is required to provide social services cannot be given this much independence. However, if a government places social matters first, and if it reserves the right to decide upon tariff levels and new investment exclusively to itself, then it must also take the necessary steps to ensure the financial viability of the management organization.

It follows that the (management, concession or leasing) contract between the licensing authority and the management organization is of fundamental importance. It must state their respective responsibilities clearly and unambiguously, particularly in relation to

- the water supply services to be provided by the management organization,
- the power of decision over investments,
- financial management (the conditions governing the fixing and adjustment of tariffs, possible government subsidies, capital repayments, etc.),
- technical management (maintenance, repairs, replacements, etc.).

3. Efficiency of the management organization

Given that respective responsibilities are well defined, the efficiency of the management organization depends not only on the existence of a single structure at national level, but also on other conditions, namely :

- a form of control which lends itself to dynamic management,
- an appropriate organizational structure with a reasonable distribution of functions between the central, regional and local levels,
- the professional skill of technical and administrative staff at all levels, and its development through effective training and retraining schemes,
- a strict system of technical and administrative management.

III. Forms of management

Water management may be entrusted to a government department or to a specialist company. As governments generally are unable to call upon the necessary specialist staff the management of urban water supplies is usually entrusted to one or more management companies through the expedient of public control or management, leasing or concession agreements.

There is no ideal form of management for the operation of water supply systems applicable to all countries or regions. It is more a cost of taking the individual features of each situation into account. As the project evaluations only extended to the French speaking countries of Africa the various forms of management encountered and described here are largely cast in the mould of the concepts of French administrative law relating to public services (see table, page 47).

1. Public control

Publicly controlled companies are made responsible by the licensing authority for the operation and maintenance of public facilities, e.g. the RNET in Togo. In principle a publicly controlled company is reimbursed purely and simply for the costs of operation, maintenance, repairs and minor extension works, and is paid a fee for services rendered.

Instead of merely providing for the reimbursement of the cost of repairs and extensions the contract may authorize a publicly controlled company to enter a particular rate of depreciation on all the assets managed as an expense; the sums provided by this means can be used not only to finance minor repairs and extension work but also, if necessary, to ensure liquidity.

2. Management agreements

Managers are responsible for operating and maintaining the facilities financed and provided by the licensing authority, often with participation by the managers, for and on behalf of the said authority. Examples are NIGELEC (Niger), STEE (Chad), SNE (Upper Volta). In principle managers obtain a contractual payment which is fixed or proportional to the amount of water provided or sold. This payment covers operating costs. The amount by which the fixed sum exceeds operating costs is retained by the managers as payment for their services.

Managers may be responsible for repairs and minor extension works. For this purpose the managers may enter depreciation on all the facilities operated by them as a cost regardless of the conditions applicable to the finance for these facilities or its origin (government, foreign aid, managers, loan, subsidy). Obviously the sums allowed against depreciation can also be used as liquidity reserves.

3. Leasing

The licensing authority grants a lessee the exclusive right to operate existing or future facilities, which remain the property of the licensing authority. The lessee is responsible at his own expense for the operation, maintenance and renewal of the facilities. Income is paid to the lessee. Payment for the lessee's services is provided by the net operating profit. E.g. SODECI in the Ivory Coast.

Although in principle replacements are charged to the lessee, in the Ivory Coast for example the construction of works with a long lifetime (boreholes, major civil engineering works, dams, etc.) is undertaken by the licensing authority.

4. Concession agreements

The licensing authority grants a licensee the exclusive right to operate existing and future facilities. The licensing authority remains the owner of existing facilities, but the licensee becomes the owner of new facilities provided by himself. The licensee is responsible, at his own expense and risk, for operation and maintenance, and for the execution of new works. Income is paid to the licensee. The licensee's remuneration is provided by the net operating profit. One example of a modified concession agreement is SONEES in Senegal.

VARIOUS FORMS OF WATER SUPPLY SYSTEM MANAGEMENT

	Public control	Management agreement	Leasing	Concession agreement
Ownership of - existing facilities - new facilities	 licensing authority licensing authority	 licensing authority licensing authority	 licensing authority licensing authority	 licensing authority licensee
Terms of the contract between the licensing authority and the management organization	the publicly controlled company is responsible for operating and maintaining public facilities	managers are responsible for operating and maintaining public facilities for and on behalf of the licensing authority	exclusive right to operate facilities at the lessee's expense; the lessee is responsible for operation, maintenance, and renewal	exclusive right to operate facilities at the licensee's expense and risk; the licensee is responsible for operation, maintenance and the provision of new facilities
Payment of operating and maintenance costs	repayment of the cost of - operation - maintenance - repairs	contractual payment for - operation - maintenance	income from the sale of water	income from the sale of water
Payment for services rendered ("profit")	payment of a fixed fee	balance of the contractual payment less operating costs	net operating profit	net operating profit
Provision for repairs and minor extension work - in principle - in some cases	 licensing authority publicly controlled company	 licensing authority manager	 lessee licensing authority in the case of major investments	 licensee licensing authority in the case of major investments
Provision for replacements	licensing authority	licensing authority	lessee	licensee
Debt servicing (repayments and interest)	licensing authority	licensing authority	licensing authority	licensee; in some cases the licensing authority
Examples	RNET (Togo)	NIGELEC (Niger) STEE (Chad) SNE (Upper Volta)	SODECI (Ivory Coast)	SONEES (Senegal)

5. Overall view

Which form of management is most appropriate? In order to answer this question the various forms of management will be compared on the basis of the following three criteria : power of decision on investments, financial viability, good commercial practice.

a) Power of decision on investments

In principle the licensing authority decides on the amounts and types of investment necessary in the case of public control, management agreements and also leasing (at least in the case of major works). The advantage of this is that the government can make decisions in the light of social needs and policy aims. There is a danger however that insufficient attention will be paid to the technical and financial constraints on operation and that excessively large facilities which are expensive to operate and/or difficult to maintain will be selected.

On the other hand licensees themselves decide on investments, but they may be inclined to restrict new investment in order not to erode profit margins. From the social point of view, and therefore particularly in developing countries, concession agreements are of debatable benefit.

b) Financial viability

Financial viability depends primarily on tariffs, which are fixed without regard to the form of management. However other factors which are influenced by the form of management also have an effect on financial viability :

- financial charges are generally borne by the owner of the facilities. Debt servicing (repayments and interest on loans) is the responsibility of the licensing authority in the case of public control, management agreements and leasing, but (in principle) that of the licensee in the case of concession agreements.

- the cost of providing for replacements, repairs and minor extension work is in principle borne by the licensing authority in the case of public control and management agreements, but by the operator in the case of leasing and concession agreements,

- technical depreciation is in general claimed by the operator. This is quite normal in the case of leasing and concession agreements where the operator is responsible for replacements. On the other hand in the case of public control and management agreements where the licensing authority is responsible for such replacements the contracts nevertheless allow the operator to enter provision for depreciation as an expense so as to allow for the self financing of necessary minor repair and replacement work, and also to cover the need for liquidity.

It is clear that this opportunity for the operator to treat the depreciation on assets of which he is not the owner as an expense encourages a certain amount of slackness in commercial management. The liquidity reserve provided by this depreciation is likely to free the operator to some extent from the need to enforce a strict system for the payment of invoices and the collection of arrears.

c) <u>Good commercial practice</u>

It is not possible to select the most appropriate form of management on the basis of the factors mentioned above. Good commercial practice therefore becomes the decisive factor. It is very important that the operator can act as a private company. In order to ensure the most efficient management the operator must be motivated by the possibility of making reasonable profits.

Neither public control nor management contracts allow anyone to benefit from good management. In contrast leasing and concession agreements are more favourable to efficient management. Operating profits can benefit those providing capital (both at home and abroad), or the managers of the operating company can be paid in part through a form of profit sharing, etc. In addition to this private operating companies or those of a mixed economy type (SODECI in the Ivory Coast) have all the advantages of administrative flexibility and flexibility in the recruitment and management of skilled technical and administrative staff.

d) Summary

The comparison of the various forms of management has shown that within the limits of the social obligations specified in the (public control, management or concessionary) contract a public water supply service may be merely "administered" without any incentive for deriving benefit from good management, or it can be "run" like a private company with the possibility of making reasonable profits. In view of these considerations leasing and concessionary arrangements seem to be more likely to foster management on commercial principles than public control or management contracts.

IV. Organizational structures

The operating company may allow its departments considerable independence at local level. However because of the general shortage of financial resources among municipal authorities and of skilled personnel in many countries, the establishment of excessively small structures (for each locality) or too thinly spread and/or too specialized structures is to be avoided.

A central organization at national level with some decentralization of various services seems to be the most appropriate form. SODECI (Ivory Coast) is a model example; its organizational structure

- ensures an appropriate distribution of functions between the centre (management, administration, personnel departments, accounts, etc.) and regional and local levels (basic administrative functions, new customers, meter reading, invoicing, disconnections, etc.),

- provides a limited but permanent local representation for ongoing technical functions (operation and maintenance),

- makes provision for the execution of other technical work on site (major repairs, inspection of facilities) by mobile teams controlled by regional managements.

V. Staff

The efficiency of the management organization depends to a large extent on the professional skill of technical and administrative staff at all levels.

Because of both the general lack of skilled personnel and the changing nature of the water industry,training, refresher courses and retraining in all specializations are a very important basic task in most countries :

- management : engineers, technologists, chemists, bacteriologists, administrative personnel, accountants, etc.,

- supervisory staff : drillers, mechanics, etc.,

- local staff : mechanics, operators, plumbers, masons, etc.

Training, refresher courses and retraining can be provided in service, either as part of day to day operations or as part of the provision of new facilities. Training may also be provided through specific technical aid programmes or specialist training courses in the countries themselves, or in Europe. The latter alternative should be restricted to the most highly qualified students appointed to management posts. The operating companies should be encouraged to provide institutions for the professional training of their own staff.

The efficiency of the management organization also depends on the status of its staff. Generally speaking a private contract of employment is always preferable to the status of an established post. There is more flexibility and the administrative procedures involved in recruitment, secondment, severance, etc., are less burdensome. As far as pay is concerned, it should be compatible with competing jobs in order to avoid the loss of skilled personnel.

IV. Strict technical and administrative management systems

Whatever its form of management and whatever the resulting opportunities for management on commercial principles, the efficiency of an organization responsible for the operation of a water supply system also depends on a tight and efficient system of technical and administrative control.

The pre-requisites for a system of tight technical control are particularly :

- in the planning and outlay of investment : detailed definition of the technical specifications for equipment, control of the quality of the materials used, close supervision of the work done,

- in operation : the regular and efficient maintenance and supervision of all facilities, i.e. a close check on technical efficiency; this however requires skilled technical personnel at all levels, appropriate organizational structures, adequate stocks of spare parts, etc.

Efficient administrative management requires a very strict system of meter reading and invoicing, prompt severance in cases of non-payment, etc. With regard to the latter the management organization must have the power to constrain customers, particularly public institutions, a power which in actual fact is often lacking.

E. TARIFF SYSTEM STRUCTURES AND PRINCIPLES

The financial viability of a management organization depends primarily on tariffs. Tariff levels and structures are therefore of fundamental importance.

Project evaluation has revealed a great variety of tariff systems in use (table, Appendix 6). The various tariff systems possible can be identified from some of their common characteristics.

I. Current consumer tariffs[1]

The consumer tariffs currently applied in the countries visited vary between 45 CFAF/m^3 (Togo), 119 CFAF/m^3 (Ivory Coast) and 120 CFAF/m^3 (Chad). Various forms of tariff system are in use. Proportional tariffs (related to quantities) and basic and contractual tariffs will be mentioned in particular.

1. Proportional tariffs

These tariffs generally apply to the amounts of water consumed.

Different types of tariff are possible :

- a single tariff for all urban water supplies in one country. Eg. 45 CFAF/m^3 in Togo, 70 CFAF/m^3 in Upper Volta,

- regionally differentiated tariffs, which vary for example between 55 and 95 CFAF/m^3 for different towns in the Niger, or between 52 and 120 CFAF/m^3 [2] in urban centres in Chad,

- graded tariffs,
  either graded in relation to consumer groups (private individuals, government establishments, standposts, transport, industry, commerce, etc.), varying for example between 33 and 105 CFAF/m^3 in Senegal,

---

1. Tariffs applicable in 1976 or 1977.

2. Less tax.

or graded in relation to quantities consumed, varying between 119 and 45 CFAF/m^3 in the Ivory Coast for example. The grading may be either progressive or degressive.

2. Basic and contractual tariffs

Tariffs based on quantities are generally the most important but not the only factors governing income from the sale of water. Generally some basic tariff is collected, e.g. in the form of a standing charge or a meter rent.

In most of the countries visited the total cost of a private connection is charged entirely to the consumer. Because the sum can easily amount to say 30,000 CFAF in Niger and Upper Volta or 65,000 CFAF in Chad, for a small diameter meter, this charge is an important factor is discouraging consumption.

To overcome this problem various countries have taken steps to encourage sales of water :

- the sale of "party connections" at 15% of the cost, this contribution being regarded as an advance payment against consumption (Ivory Coast, 1976),

- the hire of connections : installation is free or charged according to a preferential scale (Niger).

The difference between the price charged and the true cost is met from a fund maintained either by a surcharge on consumption (Ivory Coast), or from the provisions for depreciation made by the operating company (Niger).

II. The principles of tariff policy

The consumer tariff is not necessarily the amount received by the operating company. It may instead be subject to a number of specific deductions made for various purposes. The question therefore is : what is the purpose of tariffs and what are the principles on which the most appropriate tariff system must be based?

1. The principle of covering costs

In many countries the public and the government tend to regard access to potable water as a human right. Thus the supply of water is often regarded as a social service which should be obtained for nothing or for only a minimum charge. However it is increasingly being recognised that this attitude must change - that potable water is not a free asset, that the state is not obliged to provide this service without charge, that the true cost of water must be paid for.

To this end the tariff system must be capable of financing the operation (in the broadest sense of the word) of the facilities for the collection and distribution of water. The coverage of costs can be regarded from two points of view :

- from the point of view of the management organisation the tariff must be sufficient only to cover the operation, maintenance and repair of facilities, and minor extensions. In some cases this "management" quota is the same as the final consumer tariff (Niger, Togo); in other cases this "management" quota is only a fraction of the final tariff (56.8 CFAF out of 119 CFAF in the Ivory Coast, 62.5 CFAF out of 105 CFAF in Senegal),

- from the government's point of view the tariff must not only be sufficient to cover operating costs, but it must also provide for debt servicing (interest and repayments on negotiated loans) and depreciation on invested capital (provision for the renewal of facilities).

With this object the tariff may include surcharges for the maintenance of

- a fund for the financing of renewal or extension work, e.g. 8.0 CFAF/m^3 in Dakar (Senegal);

- a fund to cover financial charges (interest and repayments on negotiated loans) for all investments made, e.g. 30 CFAF/m^3 in Dakar (Senegal).

In the countries visited tariffs cover operating costs and debt servicing only in the Ivory Coast and Senegal.

Tariffs may also be used to collect funds which can be used for activities connected with the supply of water, for example by :

- a sanitation surcharge, intended to cover the operating costs and financial charges relating to facilities for the drainage of waste water, e.g. 14.9 CFAF/m^3 in the Ivory Coast,

- a health education surcharge, intended to finance programmes of activities in this field, e.g. 1.0 CFAF/m^3 in the Ivory Coast, of which 0.7 CFAF/m^3 is paid to the National Bureau for Rural Development which is responsible for an enormous programme to educate the rural population in public health, and 0.3 CFAF/m^3 is made available to the Ministry of Health for permanent checking of water quality,

- a municipal surcharge, which enables the municipal authorities to do certain work connected with the distribution of water, e.g. between 2.4 and 9.0 CFAF/m^3 in the Ivory Coast.

2. Social and economic constraints

The principle of covering costs could lead to tariffs being fixed separately for every water supply on the basis of its individual production and distribution costs. In some countries this is the rule which applies, at least partially. In the Niger the tariff in the capital (Niamey) is 55 CFAF/m^3; in Zinder and many secondary centres it is 95 CFAF/m^3. In Chad the cost of water is 52 CFAF/m^3 in the capital(N'Djamena) and 120 CFAF/m^3 in some secondary centres.

It is clear that these tariff structures are likely to conflict with the social and economic objectives of water supply. Although they reflect actual operating costs they do not take into account differences in the consumers' ability to pay, and they favour large towns to the disadvantage of secondary centres. The population finds difficulty in paying relatively high charges, so the latter are not only likely to stifle the economic and social development of secondary centres, they will also hinder the desired changeover from traditional sources of water to potable water supplies.

Charges should not differ too much from the standard of living of the population in question. From this viewpoint it is more logical to apply higher tariffs in the major towns than in the secondary centres.

An adjustment of this kind to some existing tariff structures is unlikely to have undesirable effects on demand. Conversely all the trials made show that increased charges produce virtually no fall in sales. In other words the elasticity of demand for water in relation to increased charges is very low. On the other hand charges should be sufficiently reasonable to encourage consumption as much as possible. Experience shows that demand is likely to increase when charges are reduced; the elasticity of the demand for water in relation to reduced charges is very high. It is even higher for private connections than it is for standposts.[1]

3. Possible alternatives : standardized and differentiated tariffs

Two alternative tariff systems which take social and economic constraints into account and encourage consumption as much as possible are available :

---

1. The problem of the elasticity of the demand for water in relation to price, and also in relation to incomes, deserves a thorough investigation which is beyond the scope of this sectoral evaluation.

a) Standardization at national level

The charges applicable to all supplies of water may be evened out by country-wide standardization. For this purpose a single tariff or tariff structure is fixed so as to cover the average of all costs. Thus the profits obtained for example from the sale of water in the capital or in the major towns can be used to subsidize inland centres where operating conditions are less favourable. Such a tariff favours the populations of secondary centres in rural areas and is more appropriate to the more favourable economic circumstances of consumers in the major towns.

In the case of the Niger for example tariffs could be standardized to a single tariff lying between the two existing extremes (55 and 95 CFAF/m^3), or the present tariff structure could be reversed (95 CFAF/m^3 in Niamey and 55 CFAF/m^3 in the secondary centres). In addition to this, standardization could in this case be extended to small water systems operated by OFEDES which are not economically viable at the present time and are still dependent on government subsidies.

Clearly standardization may be applied

- either at the level of the management organization, covering the average of all operating costs,

- or at government level, covering the average of all operating costs and all financial charges. This is the formula applied in the Ivory Coast where standardization even includes the operation of village water supply facilities.

b) Differentiated tariffs

Tariffs may be made more flexible and varied by suitably differentiating them in relation to different consumer groups and in relation to quantities consumed, the two criteria overlapping somewhat.

- Differentiation in relation to consumer groups

Some of the tariffs applicable to large towns, for example those based on a nationwide standard, may be too high for some of the poorer strata of the urban population. These social factors can be taken into account by differentiating the tariffs according to a social scale for small consumers. In the Ivory Coast for example the "social tariff" is fixed at 80 CFAF/m^3 (instead of 119 CFAF/m^3) for consumption of between 0 and 60 m^3 per annum, i.e. a maximum of 17 l/d per capita.[1] It is obvious that a "social" tariff of this kind which does not cover collection and distribution costs must be compensated for by relatively higher tariffs for other consumer groups.

It may be to the advantage of large industrial consumers for them to install their own sources of water. Tariff systems must take this into account

. either through a system of preferential tariffs for large industrial consumers; in the Ivory Coast for example these are graded on three degressive scales from 101.5 to 45.0 CFAF/m^3,

. or through "prohibitive" tariffs levied on private abstractions of groundwater; in the Ivory Coast for example these range from 20.6 to 43.3 CFAF/m^3 (Abidjan only).

In most of the countries visited water from standposts is distributed free of charge. Consumption is nevertheless invoiced to the town authorities,

. either at the normal rate (Niger, Togo, Chad),

. or at a preferential rate (63 instead of 119 CFAF/m^3 in the Ivory Coast, 72 instead of 105 CFAF/m^3 in Dakar, 47 instead of 93 CFAF/m^3 in secondary centres in Senegal).

---

1. On the assumption that 10 people are supplied from each connection.

- Differentiation in relation to quantities consumed

  Some tariffs are differentiated in relation to quantities consumed.

  Degressive differentiation is for example applied in the Ivory Coast; there are three degressive scales (between 101.5 and 45 CFAF/m^3) related to increasing industrial consumption.

  A form of progressive differentiation is applied in Upper Volta. The progression is limited to the dry season between March and May for consumption in excess of 50 m^3 per month, in order to encourage a reduction in peak consumption.

4. The principle of direct financial contribution by all consumers

In principle every consumer should contribute directly to covering at least an appropriate proportion of the cost of water corresponding to the purchasing power of his social group. This principle is the logical corollary of the principle of covering costs (to ensure the financial viability of the management organization) and the principle of standardized and differentiated tariffs (to take into account social and economic constraints). Potable water should not be provided free of charge.

This principle is not applied in most of the countries visited, where part of the water supplied, the water consumed at standposts, is still distributed free of charge. In other countries it is sold. Practical experience shows however that it is quite appropriate to sell water from standposts, for two main reasons :

- the municipal authorities, which are charged for the water, are often not in a position to make proper payment for consumption. This presents the management organizations with problems of liquidity and makes it more difficult for them to be financially viable.

- the activities of the carriers and sellers of water prove that the population's ability to pay is generally greater than is believed. In some countries and/or some towns where water from standposts is free, water carriers resell water at relatively high prices (equivalent to between 400 and 700 CFAF/m^3 in N'Djamena, Chad, for example).

but see p. 21!

In some countries water from standposts is not sold for the sole reason that the management organization is unwilling to face the problems and drawbacks resulting from the management of standposts : problems of supervision, the permanent risk of material damage, the problems of "managing" every standpost. Experience shows however that these problems are not so difficult that they cannot be resolved, e.g. by the expedient of a standpost "manager" who may be either an employee of the organization (e.g. Upper Volta), or be authorized by the latter to sell water at his own risk, but at a maximum fixed price (e.g. Niger).[1] Despite the prices being slightly higher than the selling price at private connections[2], this arrangement is in any event more equitable than indulging the activities of "independent" water sellers whose activities in "monopolizing" standposts are often tacitly tolerated.

5. Summary

To summarize, appropriate tariffs which are to meet the requirements for sound and balanced financial management and at the same time fulfil the social objectives of water policy should pay attention to the following principles :

- income from the sale of water must cover at least operating costs, and also debt servicing and the repayment of invested capital insofar as is possible,

---

1. In Upper Volta for example water is resold at 1 CFAF per 10 l bucket, i.e. 100 CFAF/m^3.

2. A price equivalent to 100 CFAF/m^3 in comparison with 70 CFAF/m^3 in Upper Volta.

- a tariff system must not only take into account the principle of covering costs, but also the ability of the consumers to pay; from this point of view it should take all existing social and economic constraints into account. To this end, and to encourage consumption as much as possible, it should make provision for standardization of the various charges and tariffs at national level and differentiation in relation to consumer groups and quantities consumed,

- finally, every consumer must contribute directly to the cost of water services; from this point of view the sale of water from standposts seems wholly appropriate.

PART TWO

THE PLANNING OF VILLAGE WATER SUPPLY PROJECTS

PART TWO

THE PLANNING OF VILLAGE WATER SUPPLY PROJECTS

A. BACKGROUND AND OBJECTIVES OF VILLAGE WATER SUPPLY PROJECTS

I. Plans and programmes

In the countries of the Sahel, more than anywhere else, water is an essential prime necessity for life and governs all social and economic progress in rural and village environments. In several of the countries visited - in the Niger, Senegal, Chad and in the northern parts of Upper Volta - the water situation is characterized by a very long dry season so that most of the population is affected by the partial or complete drying up of traditional watering places over a period of several months, and by the fact that they are often located a long way away from the villages.

In other countries such as the Ivory Coast and Togo where rainfall is abundant it is nevertheless difficult for the population to obtain groundwater by digging wells; because of the low permeability of most soils accessible groundwater is meagre and difficult to obtain from wells.

At the time of independence the countries generally had but very vague and fragmentary plans and programmes for village water supplies. The first EDF projects were therefore more or less isolated ventures (wells in Senegal and Chad). Some later projects on the other hand formed a logical part of plans and programmes, which defined an order of priorities for the villages needing facilities and made it possible for a reasonable and balanced decision on the provision of wells to be made at national level.

The best examples of well integrated programmes are :

- the "national programme for water supplies" in the Ivory Coast (1974-1985), which specifies the amounts and timing of all investment in urban and village water supplies and lays down the financial principles and measures necessary for the operation of all the facilities within this sector (standardization of charges and tariffs at national level),

- the "programmes for water supplies" in the Niger and the "ten year plans" (1965-74 and 1973-82) which are the outcome of a very realistic water policy. By rejecting plans which do not match the financial resources available for both investment and operations, this policy has ensured a properly balanced development of facilities for the supply of water and the best use of investments.

II. Project objectives

The objectives of the 15 projects for the construction of wells, boreholes and dams considered in this evaluation reflect various efforts by governments to improve the supply of water to villages.

The common objectives were :

- to ensure the year-round availability of water of suitable quality in sufficient quantities to the entire population in the close vicinity of all villages of, for example, more than 500 inhabitants (Niger),

- to improve living conditions by making access to water easier, and thus improving the health of the population,

- in some cases also to assist the watering of livestock in settled areas (Upper Volta, Niger, Ivory Coast),

- in certain specific cases to give rise to new permanent villages in agriculturally productive areas (Niger).

B. PROJECT UTILIZATION

I. Definitions : concrete wells and traditional watering places

About 200 wells were visited in the course of the various evaluation missions, some 8% of the wells built as part of the projects covered by this evaluation study. In rural areas recently built "modern" concrete wells with linings and means for lifting the water are generally in a situation where they "compete" with pre-existing "traditional" watering places, which include :

- uncemented traditional wells with or without complete or partial wooden casing dug by the villagers or by local craftsmen,

- water holes, very simple annual sources of water dug by the villagers with a depth of generally no more than 3 metres,

- flashes or ponds, hollows in the ground in which surface water collects and stands.

To simplify matters a distinction will be made below between the two groups of "concrete wells" and "traditional watering places".

II. The use made of wells

Examination of the use made of wells has revealed that almost all village wells are used throughout the year. However the extent to which they are used varies considerably in relation to the existence and yield of alternative watering places. In almost all cases the population continues to use traditional sources of water alongside and in spite of the concrete wells provided. Use of the concrete wells generally only increases if traditional watering places dry up, in particular in the dry season.

Why is only such limited use made of the new concrete wells? Two classes of factor governing the extent to which a well is used can be identified : socio-economic factors and hydrogeological factors.

1. Socio-economic factors

- Lack of hygiene consciousness

The population of rural areas is almost completely unaware of the health properties of water. Consequently no distinction is perceived between the health properties of water from concrete wells and traditional watering places. None of the villagers questioned during the evaluation visits believed that there was a relationship between water and health, or even between the consumption of water and a particular disease, with one single exception : some had realized that the incidence of Guinea worm had dropped following the construction of a concrete well. Contrary to what one might assume, the presence of a school or dispensary in a village seems to have very little effect on this opinion.

On the other hand in the villages lying within the area of influence of the major towns (e.g. within about 25 km of Bouaké, 170,000 inhabitants, Ivory Coast) a higher standard of living and perhaps also the effects of a certain amount of health information lead to at least the recognition that the water from a concrete well is of better quality, but this does not prevent the population from continuing to use traditional watering places.

The only advantage of a concrete well as far as the villagers are concerned is its greater yield, particularly in the dry season, and its long life in relation to traditional wells which are continually threatened with collapse.

- Ease of access

Ease of access, i.e. distance travelled, is the dominant factor in the use made of a well, provided that the quality of the water is immaterial. The closest traditional watering place is almost always preferred to a more distant concrete well. The users only return to the concrete well when the traditional watering places dry up. This means that the villagers will only put up with a longer distance if the need for water becomes essential, but they will not shift to obtain better quality water. Proximity again favours traditional watering places in an area where there is abundant rainfall, permanent watercourses and an abundance of groundwater within only a few metres of the surface, where anyone can easily dig a well for himself (for example in Basse Casamance in Senegal).

- <u>Ease of drawing water</u>

  Through lack of a sufficiently large sample, it is impossible to say from the project evaluations how the presence of a pump affects the use made of a well or borehole. There are indications however that a hand-pump does not necessarily have an overwhelming advantage over a traditional watering place, mainly because it too requires effort and because its limited output often means time spent waiting at the well.

- <u>The taste of water</u>

  The taste of water from a traditional watering place is often held to be better; the taste of a more distant traditional watering place may even be preferred to that of a concrete well nearer to hand. In this case water from the concrete well is only used for washing clothes and watering livestock, etc., whereas water from the traditional watering place is used for drinking purposes.

- <u>Social constraints</u>

  With the object of increasing their prestige or "traditional" power, some individuals wish to have their own well on their own land. This leads the notables and the rich to have a "private" well dug which will then be used by related or socially dependent families.

Lastly traditional watering places may be preferred to new concrete wells because the latter have been placed for example in sacred ground or an old cemetery.

2. Hydrogeological factors

The utilization of a new well may be impeded by hydrogeological and technical factors :

- Excessively low yield

  Excessively low yield may be the result of a fault in technical design (the well fails to collect water), or unsuitable location, or the lack of adequate preliminary investigation.

- Depth

  Generally speaking the depth of a well, and consequently the effort required in drawing water, seems to have a direct effect on its use. Under some conditions the depth of a well may be prohibitive beyond certain limits (about 100 m in nomadic areas). In the Niger for example, a concrete well 120 m deep on the edge of a village (Tanout region) is not used at all; the villagers prefer several traditional waterholes 2 to 3 m deep even though they are 2km away from the village. In contrast other wells of between 80 and 100 m in the same area are fully utilized, in particular by nomadic herdsmen who use animal powered pulley tackles and supply the villagers at the same time.

- Lack of maintenance

  The consequences of a lack of regular maintenance (choking with sand, reduced yield) may have a considerable adverse effect on the use made of a concrete well and encourage the population to go back to traditional watering places.

III. Average consumption and consumer habits

1. Average consumption

Average consumption per inhabitant per day varies considerably from one region to another, even between different villages in the same region, and in relation to prevailing climatic conditions and rainfall.

Surveys conducted among peasant families in Upper Volta, the Niger and Chad during the dry season provided the following results :

In the Niger[1], the amount of water drawn and carried home by the women[2] lies between 100 and 200 litres per day per family. After subtraction of the amount of water consumed by the smaller livestock (between 20 and 50% of the water carried home, mainly for goats and sheep) average consumption amounts to between 50 and 160 litres per day per family, i.e. depending upon the number of persons in one family, between 10 and 20 litres per inhabitant per day (l/cap/d). In Chad[3] average consumption was found to be 21 l/cap/d for wells of more than 32 m depth, and 27 l/cap/d for wells of less than 32 m depth. In Upper Volta[4] average consumption was found to lie between 11 and 14 l/cap/d.

Unfortunately there is insufficient data on consumption in the rainy season. However there is nothing to indicate that it will be very much higher unless in a particular situation consumption in the dry season is limited by inadequate resources. Consumption is found to vary widely between 5 and 50 l/cap/d, which agrees broadly speaking with the information given in the literature. The figure in rural areas is taken to be between 4 and 40 l/cap/day when wells are the source of supply.

2. Consumer habits

The surveys made have provided an estimate of how consumption generally responds to the following two factors :

- improvements in accessibility (shorter distances),

- improvements in the quality of a supply (concrete wells, boreholes provided with pumps, etc.).

---

1. Surveys carried out in all regions; all wells lie at a distance of between 100 and 1000 m from a village.

2. Water is generally carried in jars of 10 to 20 l on the head.

3. Surveys carried out in the cotton belt.

4. Surveys carried out in the Yatenga and Bobo Dioulasso/Banfora regions.

Some basic conclusions can be drawn from this. Other things being equal,

- a considerable reduction in distance (of the order of 1 to 2 km) will generally lead to an increase in average consumption per inhabitant per day. An excessively large distance limits the volume of water carried home (limits of physical strength and available time),

- an insignificant reduction in distance (less than 1 km) will not necessarily affect the amounts consumed; there is scarcely any increase in average consumption per inhabitant per day,

- an improvement in the quality of a supply (a concrete well with a collection and filtration system in contrast to a traditional watering place, a borehole or well provided with a pump) is not generally reflected by an increase in average consumption per inhabitant per day (because of a lack of awareness of the health properties of the water).

What therefore are the factors which lead to an increase in consumption? Many indicators suggest that an increase in average consumption per inhabitant per day is more a function of increased material prosperity - the level of development achieved by the population and certain social pressures (imitation effects).

IV. The utilization of dams

In the Ivory Coast a dozen small dams were built instead of wells[1] in a hydrogeologically difficult area where it was believed that groundwater would be virtually impossible to find.[2] Each of the dams was supposed to provide water for several villages. The project evaluation showed that none of the dams were used owing to hydrological reasons (poor filling characteristics, water losses due to seepage) and socio-economic reasons (the population preferred traditional watering places closer to hand).

---

1. Designed and built in the early sixties.

2. Cocoa belt; Birrimi shales.

From this hardly encouraging experience it can be concluded that small dams as an alternative supply of potable water are questionable, mainly for health reasons (standing water, serious pollution unless the water is treated) but also for hydrogeological reasons. In the case in point, present survey methods and techniques would have discovered the relatively deep aquifers which were not detected earlier, and the alternative of boreholes could have been adopted from the outset. In any event the example emphasizes the importance of preliminary studies.

C. EFFECTS OF THE PROJECTS

I. The availability of water

Generally speaking the provision of village wells has had a favourable effect on the water supply situation for the populations served. The majority of wells have ensured or increased the year-round availability of adequate quantities of water close to the villages, particularly in the dry season. In some villages the new concrete well is the only supply of water which does not dry up at the end of the dry season. Thus in the Niger for example, several village wells have made a significant contribution to an improvement in the standards of village life and have proved their usefulness, particularly in the situation of exceptional hardship due to the latest major drought.

However the availability of water is lessened if the yield of a well is inadequate or if a well dries up temporarily. Adequate technical design, i.e. sufficient penetration of the aquifer by the collection shaft, is a prerequisite for a permanent yield. The availability of water is limited, for example, in the majority of wells built in Upper Volta, particularly those built using self-help (designed without a collection shaft), and some wells sunk into the crystalline basement in Chad.

The provision of wells in order to improve the availability of water is of questionable usefulness if the population continues to use traditional watering places alongside them. In fact in the case where rainfall is as favourable, for example, as it is in Basse Casamance (Senegal), investment in wells is likely to provide only a very marginal contribution to needs which are already largely satisfied, and they are unlikely to be as fully utilized or as effective as may be expected.

In such cases the new well is merely an adjunct to existing supplies, and because its advantages in relation to water quality are not recognized it is unable to offset the population's preference for traditional watering places. The well is likely to be an investment which is solely of benefit to the small proportion of the village population living within a short distance of the new water point. In the case of Basse Camance, for example, it would have been of more use to site the sixty-odd wells in more disadvantaged regions, e.g. east Senegal.

A new well in a scattered village may be of questionable usefulness if it is located close to the part of the village which is grouped together, where there is generally no lack of water. The more disadvantaged inhabitants who are in greatest need of the well are generally immigrants who form small scattered groups or whose dwellings are spread more thinly (e.g. the dwellings of the Mossi in Upper Volta). Consequently the siting of a well in a scattered village should not be based on the administrative definition of the village but rather should take into account real groupings.

To summarize, a new well is clearly useful if it provides a considerable improvement in supply in terms of availability (adequate quantities within close reach of the consumers) and permanency (year-round availability, particularly in the dry season). In other words :

- a new village well is useful if it satisfies an essential quantifiable need (availability and permanency) - if without the new well the population would be deprived of any source of water or would only have the use of watering places which were very far off or dried up in the dry season,

- a new village well is less useful if the population already has other inexhaustible sources of water, even if these are traditional watering places, because in this case the essential quantifiable demand is satisfied; the usefulness of the well then resides fully in improvement of the quality of supply.

II. Effects on health

1. Some actual results

In addition to the objective of greater availability of water, village wells are generally justified on the basis of their beneficial effects on the population's state of health. However, contrary to what is generally assumed, some indicators suggest that these effects are, at least to some extent, in doubt.

It would be useful to find out whether an improvement in water supplies in rural areas, for example as a result of the transition from traditional watering places to concrete wells, is actually reflected in an improvement in the health of the users. However, research of this kind would be far beyond the scope and possibilities of this evaluation. Consequently the statements which follow are based on a thorough investigation of this topic which was carried out recently in Lesotho.[1] Our own surveys and inquiries make it reasonable to assume that certain principles and fundamental relationships discovered in Lesotho also apply in other comparable African countries. Nevertheless this comparison requires a few qualifications :

- There are no open, traditional or "modern" wells in Lesotho; as a rule the traditional watering places are natural springs. The new facilities are either covered springs with a small distribution network and a few standposts, or boreholes provided with pumps. If the pessimistic findings of the investigation in Lesotho are valid for the transition to these "improved" facilities, they should be even more valid for the small improvement provided by the open concrete wells of the projects which we have evaluated.

- In Lesotho, as in all southern Africa, the problems of disease differ from those in West Africa. In particular the Guinea worm, which is not found in southern Africa, is a very important parasite in West Africa,

1. Nine specialists from the University of Birmingham carried out a thorough evaluation study of human water supply projects in Lesotho over 18 months in 1975/76. Source : The Evaluation of Village Water Supplies in Lesotho; Some Preliminary Findings, by Dr. R. Feachem, Dr. S. Cairncross, A. Cronin, P. Cross, D. Curtis, D. Lamb.

where it has become very much less prevalent following the construction of wells with lips.

By analogy with the study in Lesotho it is possible to state that :

- Almost all wells, whether traditional or concrete, are exposed to faecal pollution, mainly of animal origin; the muddy areas which form around the well are polluted by the faeces of livestock. Polluted water percolates into the ground and reaches the water table, particularly where this is shallow; in addition to this it enters the well from returned water, and the ropes and vessels used in drawing water.

- "Improved" facilities (wells or boreholes provided with pumps, small supply lines, etc.) are much less exposed to pollution.

- All wells are slightly more polluted during the rainy season than they are during the dry season.

- Faecal contamination occurs not only at the well, but also between collection of the water and consumption at home, so that even good quality water obtained from "improved" facilities is generally exposed to contamination right up to the time it is consumed; this faecal pollution is mainly of human origin and increases with the time between collection and consumption.

- The incidence and the seasonality of water-borne infections are virtually the same for villages with or without "improved" facilities.

On the basis of these findings the Lesotho study concludes that "improved" water supplies in rural areas have scarcely any quantifiable effect on health; the open concrete wells provided through the projects financed by the EDF are likely to have even less. The reasons for this are probably as follows :

- Improvementsin the supply of water have no effect on water-washed diseases such as "surface" infections of the skin and eyes[1], because :

  . neither a reduction in the distance to the water point nor a qualitative improvement in supply are generally reflected in an increase in consumption[2],

  . hygienic practices are no different in villages with or without "improved" facilities.

- The fact that certain water-borne diseases such as diarrhoea and typhoid[3] are more frequent in the rainy season may suggest that the infection is due to sudden faecal pollution of the well. However the peaks also occur in villages without "improved" facilities. Consequently it must be assumed that these peaks of water-borne infection are due to other causes, namely :

  . conditions for the survival of pathogens are much better in the hot, damp rainy season,

  . the healthiness of the environment is appreciably worse during the rainy season. By using all flashes, water holes and ponds for example, the population is exposed to a much higher risk of infection.

2. Disappointing conclusions

To summarize, the following conclusions, which have yet to be proved however, apply to village water supply projects, particularly concrete wells but also "improved" facilities such as wells or boreholes provided with pumps :

- Where the basic need for water is already satisfied neither an increase

---

1. Particularly scabies and trachoma. These water-washed diseases may be reduced by improved personal and domestic hygiene, and by improvements in the quantity and accessibility of water.

2. See pages 69/70.

3. These water-borne diseases may be reduced by improvements in the quality of water.

in the quantity of water available (from concrete wells or small "improved" facilities), nor an improvement in water supply facilities (shorter distances, standposts) will produce an increase in consumption per inhabitant.

- It is doubtful whether improvements in water supplies, as generally practiced in villages by the projects financed by the EDF, i.e. the construction of concrete wells or small "improved" facilities, have any significant effects on the overall health of the population, At the most they have a partially beneficial effect, as in the reduction in Guinea worm in West Africa.

- It seems that many water-borne diseases are caused instead by a lack of appreciation of the health qualities of water, and consequently by the neglect of environmental hygiene and existing unhygienic practices.

- The conclusion is that investment in village water supplies can only lead to an overall improvement in health if it is accompanied by an improvement in general hygiene.

Thus water supplies are necessary but far from sufficient for an improvement in the health of the population. Parallel developments in other fields such as the removal of excreta, housing, health education, medicine, nutrition, etc., are also needed.

III. Direct effects on development

The surveys which we made in the villages have shown that other direct effects on development resulting from a village well are more or less insignificant :

a) In no case was it found that the provision of a new well had led to new spontaneous agricultural or gainful activity (e.g. market gardening, or even the carrying of water).

b) None of the new villages which were supposed to follow upon the construction of 17 wells in the Niger ever materialized. The wells are nevertheless used as water supplies for grazing stock. It would appear that the construction of a well alone, without appropriate accompanying measures, is not enough to initiate the founding of a new village or even to bring about a regrouping in the population.

c) Generally speaking no local immigration has been observed following the provision of a new village well. Local immigration which does occur is always caused by other factors, such as the availability of arable land.

d) In no case has a concrete well been able to cut down rural to urban drift. The villagers emigrate for reasons other than an inadequate water supply : some of these reasons are for example the economic and social attractions of the conurbations, family quarrels, difficulties in the acquisition of land by young people, etc.

e) The time saved as a result of the shorter distance to a new well in comparison with the old watering place is very rarely used for additional gainful economic activity, according to our survey. However there is more leisure time available to the women and they can engage in minor domestic tasks of more than negligible benefit : the more careful and more regular preparation of meals, the collection of wood, traditional basketwork, etc. The saving in time thus gives rise to an improved quality of life and offers an opportunity for raising the general social and cultural level.

f) In some regions the watering of livestock is undoubtedly made very much easier (Upper Volta, Niger). In Chad wells have become essential for the service of villages where tilling with draught animals has become widespread with the modernization of agricultural methods. In the majority of cases the yield from traditional wells is not enough to provide water for all the draught animals, which are unable to follow the herds to pasture at the beginning of the rainy season.

g) In some regions the provision of a concrete well has enabled other development activities to expand, like the formation of small dairy herds in settled areas (Niger).

In conclusion, water is an essential prerequisite for any economic activity, but the provision of a village well as an isolated act is extremely unlikely to bring about any direct development effects. The construction of village wells should rather be regarded and planned as a complement to other development projects or incentives, unless it is simply a question of satisfying an essential need for a water supply.

D. POLICIES AND STRATEGIES FOR VILLAGE WATER SUPPLIES

I. Basic policy options

A more or less detailed village water supply policy is in existence in all the countries visited. We found the whole range from a very rudimentary policy without precise sectoral development plans (Chad), to a full and complicated policy expressed in a programme of action over several years which also specifies that the operation of facilities will be financed by a standardized system of charges and tariffs (Ivory Coast), that one water point with a hand pump for an average 600 inhabitants will be provided in all villages of more than 100 inhabitants and that village water supplies will be subsidized by the sale of water in the major towns.

Such an ambitious policy is possible in the Ivory Coast because several particularly favourable conditions allow it to be implemented; purchasing power is high enough to allow a system of profitable tariffs, the selling price of water in the capital is relatively low, water is sold in sufficient quantity, etc.

However this system is not capable of being transferred as it stands to other underdeveloped countries which have to apply limitations to suit their financial abilities. In this more limited scope we feel that the Niger's practical and very realistic policy is exemplary. The objective of progressively covering the whole country with village water points is linked with a policy decision to build open wells without pumps. Absolute priority is given to relief of the water shortage before methods for lifting the water, which require high investment and maintenance costs, are improved.

The Niger's policy decision in favour of open wells without pumps deserves to be emphasized. More help is given to the population by satisfying its essential need for a regular water supply than by making the water easier to lift.

but protection?

It would not however be possible to transfer this policy of the Niger as it stands to other countries either, mainly because of traditional and hydrogeological reasons. The arrangement adopted in the Niger is based on an ancient tradition of the construction and use of wells in a predominantly pastoral economy in a country where there are very regular large aquifers.

Summarizing, the basic policy options for the satisfaction of quantitative needs (number of water points) and qualitative needs (water drawn by hand or hand pumps) in village environments must take into account the socio-economic situation and also the hydrogeological situation individual to each country.

II. Criteria and strategies for the satisfaction of demand

Within the scope of basic policy options, what criteria can be used to determine priorities and strategies for the satisfaction of demand?

In theory there is a relatively simple reply to this question. First of all the real needs of the various villages and regions must be identified, and then the resulting priorities must be reconciled with possible strategies and the resources available.

1. Socio-economic criteria for the establishment of priorities

Priority needs can be established on the basis of the following socio-economic criteria :

- the existing village water supply : existing sources of water (number, condition, maintenance authority, etc.), their distance from the village and their permanency (situation in the rainy season and in the dry season), depth, water quality (health properties), utilization,

- the number of actual and potential consumers; livestock owned and transient livestock,

- the degree of water shortage : quantity and quality,

- the demographic and socio-economic development potential of the village : existing agricultural and human resources; agricultural practices; existence of a market, school or dispensary; craft activities; urban drift; etc.

- the benefit to the village and the inclination of the inhabitants to participate physically and financially in construction and maintenance.

The relative priority of the needs of every village can thus be determined with some precision (e.g. Niger). However in actual fact village water supply programmes are often based on improvised and fairly arbitrary criteria, for example the distance between the village and its traditional watering place. The criterion of the number of inhabitants (Ivory Coast) seems more valid in view of the fact that the overall programme makes provision for the equipment of all villages within a given period.

2. <u>Strategies for the satisfaction of demand</u>

In theory demand may be satisfied in the established order of priorities. This kind of strategy is however likely to run up against financial constraints (inadequate resources), economic constraints (difficulties in the organization of the work, resulting in a high unit cost) and management constraints (difficulty of organizing maintenance of scattered facilities, particularly pumps). Other strategies are possible, for example :

- concentrating all effort in one or more regions which are receiving other development aid at the same time,

- serving the largest number of inhabitants from the financial resources available,

- selecting villages on the basis of anticipated participation by the population in order to guarantee the technical and financial viability of the facilities.

In practice a pragmatic combination of the various possible strategies is selected in order as far as possible to reconcile :

- the target socio-economic objectives, i.e. satisfaction of the needs of all, and the most pressing first,

- the requirement that the action should be effective, which assumes that it is integrated with other regional and/or sectoral activities for economic and social development, and the requirement that it should be efficient, matching financial, economic and technical constraints.

3. Alterations in policies and strategies

The project evaluations showed that in practice any investment programme based on well defined policies and strategies is liable to be altered

- either by local political influences (village chiefs, notables, priests, political representatives, etc.)

- or by technological concerns connected with the organization of the work.

These constraints may come to light either when the programme is being prepared or when it is being implemented. They may give rise to changes in location (choice of village, choice of site in relation to a village), changes in the quality of equipment, etc.

In this connection project evaluation has shown that almost all the institutions involved in the preparation and implementation of village water supply programmes.

- are liable to be easily blinded by the objective of providing the largest possible number of units, putting real needs into the background, and

- tend to attach too much importance to the question of the average cost of the units provided and attempt to avoid exceeding certain threshold maxima. Because of this the selection of sites is liable to be distorted in favour of the accepted criterion for success, whether it is the number of units completed or the number of failures avoided. Cost effectiveness thus prevails unduly over effectiveness. In actual fact it may be more useful to complete a single well at a cost of 6 million CFAF in a very difficult hydrogeological situation where there is a serious shortage, than to complete three wells at a cost of 2 million CFAF each in sites which are easier from the point of view of geology, accessibility, etc., but of lower priority.

This applies to aid organizations, governments, national operating organizations (controlled companies) and private companies (in so far as contractual conditions allow them leeway in the number of units to be completed).

In conclusion it is very important that all the special and contractual conditions applicable to the preparation and implementation of a programme (priorities, selected villages, local siting of water points, equipment quality, etc.) be defined as narrowly and in as much detail as possible in order to avoid the policies and strategies established in order to satisfy priority needs being altered during the preparation or implementation of the programme by "outside" influences (which are sometimes based on apparently rational technological and accounting reasons).

E. THE TECHNICAL DESIGN OF VILLAGE WATER SUPPLY PROJECTS

I. Local siting of wells and/or boreholes

As the survey of well utilization has shown, the construction of village wells and/or boreholes, and more specifically their location, must reconcile the needs of the socio-economic context (ease of access, consumer habits, social relationships, etc.) with the constraints of the hydrogeological situation.

1. Socio-economic factors

The local siting of a source of water has to take easy accessibility and in particular certain social and cultural factors into account in order to ensure that it is used to the fullest extent.

- Accessibility. The well should be sited within or as close as possible to a village, preferably on its very edge, except in the case of a well which is primarily intended for livestock in nomadic areas where it should preferably be sited a little further from the village. At all events the new supply should not be further away than the traditional watering place(s) previously in use.

- Social and cultural factors. The well should not be sunk in ground which is regarded as sacred or in the immediate neighbourhood of graves, old cemeteries, etc. In the case of a scattered settlement the well should be located either at the geographical centre of the various hamlets, or, better still, at the most appropriate point in relation to the inhabitants traditional relationships (which do not necessarily coincide with administrative boundaries).

As all these factors have a critical influence on the use made of a new source of water, the entire village population, particularly the women and not just the chief and notables, should be consulted about the best site. In the past such consultation did not occur, or did so only very superficially.

2. Hydrogeological parameters

In practice the best site for a water point based on socio-economic considerations may not be feasible because of hydrogeological constraints. In most of the projects included in the evaluation the local hydrogeological situation had not been investigated in advance, e.g. wells in the Ivory Coast, Upper Volta and the Niger. This being the case the choice of site for several of the wells visited in the evaluation missions seems often to have been dictated simply by the greatest probability of finding water, i.e. sites were close to traditional watering places, or in hollows (Niger, Chad). Sites chosen in this way have often proved inadequate and unsuited to the needs of the users.[1]

The most important hydrogeological factors are the depth of the water table, the mechanical properties of the rock, the permeability of the rock and the continuity or discontinuity of the aquifer.

a) The depth of the water table in relation to the surface is basic and directly dictates

- the depth of the work, and thus the investment cost,
- the possibility of drawing water by hand,
- (occasionally) the choice of facility : well or borehole.

b) The mechanical properties of the rock may be represented by two extremes :

- very hard rock requiring powerful techniques for penetration (explosives) or drilling (percussion), which in return provides a well which holds up perfectly and is certain to have a long life,

---

1. In this connection it would be worthwhile investigating traditional survey methods, which some non-governmental organizations seem to depend on to a great extent.

- soft ground (fine sands, sandy clays, etc.) which causes difficulties during sinking and with hold-up, and the risk of subsequent clogging of the collection shaft.

c) The permeability of the rock is relatively of secondary importance, in view of the low flow rates demanded of village wells. However low permeability requires a well with a deep collection shaft and causes the level of the productive water table to be drawn down a long way. In addition to this rock of low permeability is subject to large seasonal and year-to-year pressure variations. In contrast large sedimentary aquifers are much less dependent on changes in supply, except for local abnormalities, and pressure variations are normally small.

d) Continuity or discontinuity of the aquifer is also of relatively secondary importance in relation to the above criteria, except where preliminary studies are concerned.

All these characteristics apply to exposed aquifers. It goes without saying that for village water supplies the water table, that is to say the aquifer nearest to the surface, is the most useful 9 times out of 10. To summarize it can be said that the ideal aquifer for a village water supply is an aquifer which is

- shallow,

- comprised of rock of good mechanical strength, good permeability and good homogeneity (few discontinuities),

- without pressure variations.[1]

It is clear that these ideal conditions are seldom fulfilled. Consequently a village water supply programme requires a whole series of activities to find

---

1. A good example is provided by certain soft sandstones which are fairly widespread in West Africa in the Continental Terminal or Continental Intercalary formations, in areas where water is close to the surface.

the best location in relation to hydrogeological conditions, and to determine the most appropriate methods and/or techniques for surveys and for constructing the wells and/or boreholes.

II. Preliminary studies and surveys

The aim of preliminary studies is to reduce the overall cost of the work by optimizing the total cost of the studies plus the construction work.

The objectives of the preliminary studies are to

- identify usable aquifers and their characteristics; their geological type, extent and limits, geomorphological characteristics, continuity or discontinuity, the depth of the water in relation to the surface, the mechanical strength of the rock, the quality of the water,

- to establish the nature of the work required and the means whereby it should be carried out; total depth, diameter, collection shaft length, sinking or drilling methods, etc.,

- to foresee the likelihood of failure and to reduce this to a minimum.

1. Hydrogeological survey procedures and techniques

a) Survey procedures

Very different hydrogeological survey procedures apply to continuous and discontinuous aquifers :

- In continuous aquifers the characteristics of each water point can be deduced, except in cases of local irregularities, from a sufficiently detailed large scale survey. A large scale regional survey should in any case precede any construction work, and be supplemented locally if it should prove necessary.

- In discontinuous aquifers, a regional survey is but a first step and will only provide probability data. Subsequent detailed studies of each location are essential, each water point being treated individually.

b) Survey techniques

Generally speaking it is possible to make a distinction between a regional survey and local investigations.

A regional survey is intended to identify aquifers and their limits, to discover their structure and general characteristics. For a start, whatever the nature of the ground, suitably accurate geological maps and surveys are needed (or must be completed beforehand). These documents are in existence for most developing countries. Then a list of existing watering places must be drawn up in order to determine the depth of the water table, the mechanical and hydraulic properties of the rock, etc.

- Local investigations have the objective of either investigating and testing continuous aquifers and sedimentary basins at key points or of identifying favourable sites in discontinuous aquifers in which only weathered and fractured zones contain water.

The following methods may be used:

The study of aerial photograph coverage is one basis for the location of water points in ancient rocks or in the basement. It can be used to identify

- local geomorphological structures which control weathering or the formation of belts of laterite in certain climatic zones,

- jointing and tectonic shatter zones, which are the only or the most favourable productive zones depending upon the type of rock.

Geophysical procedures, including the electrical resistivity methods which are essential to geophysical prospecting applied to the search for groundwater, reveal the limits of the geological strata and favourable discontinuities.

Survey work provides the irreplaceable factor of direct knowledge of the rock and its properties; cross sections of the rock and measurements of all kinds.

Test borings can be used mainly for flow tests in order to test the aquifer or to estimate the likely yield at a particular point and therefore discover whether the planned unit will or will not fulfil its objectives. Accurate flow tests are essential. This is an important point to remember as flow tests are expensive and are too often neglected for this reason.

2. Preliminary studies of continuous aquifers

In recent sedimentary basins, which generally contain aquifers, a study can be made of the whole aquifer system once and for all. Basic data is collected at all watering places wherever possible, and not necessarily in direct relation to future well sites. The data can be used for a compilation from which local characteristics can be deduced by interpolation.

Nevertheless general studies of sedimentary basins usually gloss over a few local uncertainties : the limits of dry zones resulting from changes in sedimentation, dry or briny pinch-outs, etc. Electrical and seismic prospecting techniques will generally resolve these problems.

3. Preliminary studies in discontinuous aquifers

In ancient formations, which generally contain discontinuous aquifers, the main purpose of the study is to decide upon locations. The study should be made site by site because preliminary regional surveys only provide probability data.

a) In the preliminary stage, the objective of the general and regional large scale studies is to divide up a territory into a series of areas of probably similar hydrogeological characteristics.[1]

In each area

- the type of water point required, the most suitable equipment and the corresponding method of construction is decided upon,

- the number of likely failures is calculated for water points located at random; this basic figure can only be obtained from accummulated experience of the hydrogeological characteristics of comparable areas,[2]

- the programme and cost of the site studies and surveys is determined,

- the cost of construction is estimated.

b) In the second stage, the site by site studies include

- Study of sites on the basis of air photographs and government data; the most favourable site(s) and the nature of the facility required can be determined from inquiries among the villagers and study of the terrain and existing watering places. The location is marked on the ground; the proposed site(s) for survey or construction is/are marked by means of marked trees, stakes or cement markers.

---

1. In a territory as small as Togo (56,000 km^2) it is possible to identify at least 10 areas of different ancient formations, some of which must be subdivided into smaller areas of differing characteristics.

2. For example experience in Ghana and the Ivory Coast is very important to other countries in the region as some areas are comparable from one country to another. However these results are still not used extensively enough.

- Electrical prospecting

  Where necessary, in unfavourable formations, a stage of electrical prospecting then follows for the purpose of accurate site identification.

- The final stage is a direct field survey.

  . Pilot holes driven as far as the water may be sufficient in the case of hand dug wells. These provide information on the rock immediately above the producing section, thus eliminating most unknowns, and they may also be used to test yield.

  . In the case of small diameter boreholes the drilling work itself constitutes a survey, the borehole being fitted out if it is productive or abandoned if not.

c) Site survey strategy

In every programme for the systematic provision of facilities in ancient formations (discontinuous aquifers) the problem of the desirability, the nature and the sequencing of surveys needs to be examined. A strategy which will enable the entire programme to be completed at a minimum cost should be found in every case.

The strategy will depend on a combination of three factors : rock type, minimum yield sought and the type of construction required. Generally speaking the following steps will be necessary :

- where there is a very small chance of success : a systematic preliminary survey,

- where there is some chance of success : a preliminary survey restricted to the sites regarded as being particularly chancy; as a rule the number of these sites should be equal to the number of failures expected if no survey were made,

- where there is very little chance of failure : no preliminary survey, or a subsequent survey on sites which have proved failures so as to avoid repetitions.

4. Summary

Summarizing, general and regional surveys should be conducted as a first step in the case of continuous aquifers in recent sedimentary basins; the site of an individual water point can be determined by interpolation based on summaries.

The situation with discontinuous aquifers (ancient formations) is completely different. As output from a unit is dependent on the local nature of the rock (weathering, fractures), a regional approach and a study of existing watering places will only provide probability data on hydrogeological characteristics. Thus the essential factor is a detailed survey of each site and if necessary an electrical geophysical survey or a test boring at a selected point. The problem lies in knowing whether, in any given region, it is better to conduct systematic site surveys or to rely on the statistical probability of success. A minimum number of site surveys is in fact always necessary, but the nature, magnitude and extent of the surveys should be determined in relation to the risks of failure.[1]

III. Types of excavation

There seems no doubt that as far as village water supplies are concerned the future lies in drilling. However large diameter open wells from which water can be drawn by hand or by animal power are still of major importance, because

- the problems of pump maintenance have not yet been solved,

- wells, because of a long tradition, are the most suitable type of watering place for the pastoral economy of nomad areas with widespread stock raising,

- recurrent costs for wells are very low.

---

1. In order to evaluate the failure rate in the absence of surveys and the the success rate of a particular survey operation it will be necessary to increase the number of "ex post" analyses of the hydrogeological results of village water supply programmes. The BURGEAP study (Appendix 2) provides examples of the mathematical approach to the problem.

Three major classes of excavation may be distinguished : they differ greatly in their manner of use and investment and operating costs.

1. Open wells

Open wells of average diameter between 1.40 and 1.80 m from which water is drawn by hand down to 80 m [1] are particularly suitable for soft sandstones and shales, or firm sands, when the water table is close to the surface. The length of the collection shaft, which depends on the permeability of the rock and variations in level, should generally be between 3 and 15 m, and at least 10 m in the basement.[2]

The abstraction capacity of the traditional techniques used by herdsmen in the Sahel is in practice 20 to 50 m^3/day.[3] Yields of this order of magnitude are currently provided only by wells in continuous aquifers (sedimentary formations).

Investment costs vary greatly from country to country depending on wages, the cost of materials (cement, reinforcing rods, etc.) and distance or isolation, etc. The cost per linear metre in the Niger and Upper Volta (government controlled contractor) is 50,000 to 70,000 CFAF, and in Chad and Mali over 100,000 CFAF/linear metre (see table, Appendix 7).

The maintenance cost of a well is between 25,000 and 30,000 CFAF/year; this is the actual cost of the regular maintenance which in principle is carried out every three years by OFEDES in the Niger.

2. Boreholes with handpumps[4]

In the basement and in ancient formations (granite, gneiss, schists or compact sandstones), where the rock is generally of low permeability and groundwater is at the surface, the most suitable village water point from the hydrogeological point of view is a borehole of diameter 6" and a depth

---

1. The limit is a practical one; there are however wells of more than 100 m financed by the EDF in the Zinder/Tanout region (Niger).

2. In the basement yield is subject to fluctuations in the water table.

3. Up to 4-5 m^3/hr can be drawn from a well of average depth (≈ 30 m) by animal power.

4. To simplify matters hand pumps are also taken to mean foot pumps.

of 30 to 70 m fitted with a handpump, the depth of the borehole being limited by the capacity of the handpump and the depth of the productive water level (the depth depending on drawdown, i.e. the difference between the equilibrium level and the level during abstraction).

Investment costs are of the order of 45,000 CFAF/linear metre. The abstraction capacity is in practice 5 to 10 m^3/day. The bulk of the maintenance cost of a borehole is due to the pump, some 50,000 CFAF/year.

3. Boreholes with motor driven pumps

When water has to be pumped from a borehole more than 50 m deep it is virtually essential that an immersed motor driven pump be installed. This is often the case in rocks of very high permeability (limestone and dolomite, basalt sands and soft sandstones). The depth of such boreholes may be as much as 250 m.

The investment costs and above all the running costs of this type of equipment rapidly become prohibitive in small isolated villages, so that a water point of this kind can often only be viable when larger groups (1,000 to 3,000 inhabitants) or livestock are supplied. When this is the case storage facilities (service reservoir) and possibly a distribution system (small network, standposts, watering troughs) must be added.

4. Summary and conclusion

Without taking investment and running costs into account it is possible to state that :

- wells are best suited to stock-raising areas in recent sedimentary basins. With an animal powered abstraction rate of several m^3/hr the only alternative is a borehole with a motor driven pump,

- boreholes with handpumps are the best suited technically to the ancient formations of the basement where the water table is shallow,

- boreholes with motor driven pumps are necessary where the water is too deep to be raised or pumped by hand. They can only be made economically viable by suitably extensive distribution.

The most difficult problems therefore arise in the supply of small groups of people scattered in areas where the water table is at a great depth.

From what has been said above it can be concluded that boreholes are more productive and more reliable than wells (no risk of drying up) in the basement and in discontinuous aquifers in general. However wells continue to be built in many countries to avoid the problem of pump maintenance, which governs the use made of boreholes.

5. Structures surrounding open wells

The designs of the more than 2,600 wells dealt with in this evaluation include a whole range of different structures, for example :

- a simple lip with a flagging surround (some wells in Upper Volta and the Niger, wells in Togo),

- simple structures provided with equipment for drawing water by hand; gallows and possibly pulleys (wells in Senegal and Chad, some wells in the Niger),

- octagonal platforms about 2m wide, incorporating water troughs and access ladders (wells in the Niger),

- structures with integral watering troughs (wells in Upper Volta, the Niger, and Chad) or separate watering troughs (wells in the Niger).

The investigation into the use made of village wells showed that most types of structure were not very satisfactory for the purpose for which they were originally intended, namely improving the cleanliness of the water and helping to raise it :

- structures are incapable of preventing contamination of the water because mud forms just as frequently on top of the surrounds and around the lip. This also applies to the more developed octagonal structures in the Niger which are not used as was intended, even though they are of a suitable design. Only choking of the well by sand is considerably reduced by these structures, at least in settled areas. On the other hand nothing can prevent sanding due to the animals used to draw the water in nomad areas.

- Gallows are almost always deprived of their original equipment (pulleys, rollers) and are therefore almost never used for shallow wells. They are however useful for deep wells in nomad areas, where they really do help in the drawing of water by animal power using the herdsmen's home-made pulleys.

- Integral watering troughs, which are often blocked, are an additional cause of external soiling and contamination of the well. On the other hand separate watering troughs are generally relatively clean; their distance reduces the risk of contamination of the well.

To conclude, in view of their cost[1] and the problems they create, complicated and heavy superstructures, however attractive they may appear, can be considered superfluous. A simple lip with a small flagging surround and in some well defined circumstances simple and strong metal structures and simple separate watering troughs are quite sufficient.

IV. Drilling methods and equipment

There are 4 methods of drilling and types of drilling equipment which can be used for almost all small diameter work.

1. Cable tool drilling

This, the oldest method, is the only universal method. The equipment is simple, robust, reliable and cheap (35 to 50 million CFAF for a complete unit with spares). This method is the best for firm, even hard ground. However efficiency falls off very quickly with increasing hardness, and costs become prohibitive in very hard rock.

---

1. The present cost of the octagonal structures in the Niger for example is about 500,000 CFAF.

Its disadvantage is its slowness, 0.1 to 1 m/hr. Running costs amount to 40,000 to 45,000 CFAF per metre of hole, everything included,[1] in firm ground for holes of the order of 50 m.

2. Rotary mudflush

This method can be used in practice to make deep holes in various sedimentary rocks. Efficiency falls off rapidly with increasing hardness; its drilling rate, normally 2 to 5 m/hr, falls below 1 m/hr. Equipment costs are higher than for cable tools (80 to 100 million CFAF). Running costs are of the order of 100,000 CFAF per metre of hole, everything included, although they vary considerably depending upon field conditions. Rotary drilling requires very experienced personnel and a close watch on progress, both of the job and of the drilling technique itself.

3. Down hole percussion drilling

This method is the best suited to drilling to a depth of 30 to 80 m in the basement or hard ancient formations. The technique is simple and manageable, with the exception of the compressor, and cheap (70 to 80 million CFAF), but it can only be used in firm ground.[2] Drilling is very fast (2 to 10 m/hr). The cost of the hole is about 40,000 CFAF/m, when drilled in quantity.

4. Rotary air drilling

This is an extremely fast method for soft but firm ground (up to 25 m/hr). With the addition of a down hole percussion bit this provides an almost universal rig for ancient rocks. The cost of the relatively complicated equipment is 80 to 120 million CFAF, the running cost is about 30,000 to 50,000 CFAF per metre of hole.

---

1. Running costs are calculated for a properly managed public drilling corporation and for a relatively large number of holes.

2. Unless a special sinking tube is used, but this will not go beyond 40 m.

5. Conclusion

Because of the relatively limited range in which these methods are efficient, the only one to compete effectively with the others is cable tool drilling. This method is of great value because of its universality and its simplicity.

Comparisons should therefore be made

- between air and cable tool drilling in ancient rocks (basement),

- between rotary and cable tool drilling in sedimentary formations.

V. Selection of drilling equipment

The particularly uncertain nature of drilling work can be seen clearly from companies' tenders; the considerable price differences arise essentially from different estimates of difficulties with the rock, supplies or transferring from one site to another. Specifying drilling efficiency and cost is therefore pointless except in relation to prevalent conditions.

The selection of drilling equipment must therefore be preceded by a thorough analysis of :

- the content and the nature of programmes in the medium term,

- the characteristics of geological formations (thickness, mechanical properties, depth of weathering, etc.),

- available infrastructure and resources in terms of personnel and equipment if a public drilling corporation is to be formed.

In ancient rocks (basement, hard rocks) cable tool drilling is to be preferred for scattered sites and small batches, or where maintenance is difficult. On the other hand modern compressed air equipment (down hole percussion and rotary air drilling) has more advantages where a large number of holes must be drilled, but it needs a very good maintenance organization and mechanical back-up close at hand.

In the soft and loose ground and, more generally, in sedimentary formations the alternative in the great majority of cases is between cable tool drilling and rotary mudflush, the former being preferable for holes of less than 50 m and the latter being more suitable for deeper holes (up to 200 m and over).

In conclusion, cable tool drilling is ideal for scattered and remote sites and small programmes. Most public drilling services and organizations in Africa began with this method, which is well suited to the training of personnel. On the other hand modern methods seem better able to fulfil the needs of large scale programmes which have to be completed in a short time.

Because it is simple and robust a cable tool rig can operate with a certain amount of independence; all other types of drilling rig require effective logistic and highly specialized support because of their complexity and performance.

VI. Selection of means : wells or boreholes

1. Permeability of the rock

The permeability of the rock dictates the depth required for the collection of water; low permeability demands a deep collection shaft and causes considerable drawdown in producing levels. In addition to this rocks of low permeability are subject to large seasonal and year-to-year pressure variations. This is the reason why several wells in ancient formations (basement) dried up during the latest major drought years even though they were well designed (but in relation to normal conditions). Boreholes on the other hand, which penetrate more deeply into the aquifer, were hardly affected.

Conversely, aquifers in sedimentary rocks of good permeability are much less subject to variations in supply and pressure variations are generally small. Thus wells in sedimentary basins have been affected much less by the drought, or not at all.

2. Wells or boreholes in ancient formations

For reasons to do with the rock (low permeability, water level generally close to the surface, seasonal and annual fluctuations, discontinuity of the water bearing fissures) and hydraulic reasons (ratio of the diameters of wells and boreholes), wells making use of "pockets of weathering" in the basement should have ten or so metres of water at equilibrium whereas a borehole should penetrate 20 or 30 m into the aquifer.

Generally speaking therefore, a well 20 metres deep for example can be compared with a borehole 30 to 40 metres deep. Despite its lower cost per linear metre (~45,000 CFAF), the total cost of a borehole is therefore of the same order as that of a well (~ 70,000 CFAF/linear metre).

This relationship tends to change with increasing depth (deeper water); in hard rock the cost per metre of well becomes higher with increasing depth and hardness, while the cost of extending a borehole becomes marginal. Thus boreholes become more advantageous at greater depths.

3. Wells or boreholes in soft formations

Permeability is higher in shallow aquifers in soft formations (sands, soft sandstones, etc.).

Thus wells and boreholes can be of more or less tha same depth. For this reason the high fixed costs of drilling a borehole virtually rule it out in favour of a well, where shallow depths are concerned. In contrast the costs seem to be comparable at greater depths.

4. Other factors

Other factors can have a considerable influence on the choice between village wells and boreholes,

- disadvantages of boreholes : the problems due to pump maintenance, the practical limit on the output of handpumps (0.5 to 1.0 m^3/hr), the technical specialization of the personnel necessary,

- disadvantages of wells : the slow progress of the work (generally several months), the organizational constraints on several sites working simultaneously, the lower reliability of wells, at least those in the basement.

5. Conclusions

- In sedimentary areas with a pastoral tradition an open well is of much greater advantage than a borehole. However this type of structure will not necessarily suit other conditions.

- In the hard rocks which are predominant in ancient formations and in the crystalline basement a borehole about 50 m deep is of more advantage than a well. However a borehole needs a pump if it is to be used. If regular and proper maintenance of the mechanical pump cannot be guaranteed then it may be more effective and of greater benefit, even in the basement, to provide a well at a higher investment cost than to drill a borehole.

- When water is obtained from a borehole more than 50 m deep, a motor driven pump is essential. The cost (investment and running costs) rapidly becomes "prohibitive". Thus it is necessary to examine the possibility of serving the largest possible number of people in order to make the water point as viable as possible. This being the case it is essential to ensure first of all that there is no possibility of using other less deep aquifers, even though they are less productive.

F. INSTITUTIONAL STRUCTURES

I. Political responsibilities

As already described in the case of urban water supplies[1], political responsibility for all matters relating to potable water, and even the construction and maintenance of village water supplies alone (wells, boreholes), is often divided between several ministries, national and/or regional authorities and/or organizations, etc. Various difficulties arise, in particular :

- the difficulty of formulating a consistent water policy covering all aspects of potable water supply,
- the difficulty of co-ordinating the planning and outlay of investments in this field,
- the difficulty of consistently supervising the operation and maintenance of the facilities.

Thus political responsibility for all matters relating to potable water, and at least all those relating to village water supplies, should be vested in a single authority at national level.

II. Organization of the maintenance of wells and boreholes

1. Well maintenance

Wells sunk in firm rock without casing have an unlimited life and only require cleaning out from time to time. In contrast wells sunk in soft formations are vulnerable if the mechanical strength of the rock is poor. However even in very unstable formations a well constructed and regularly maintained well may have a lifetime of a few decades. Nevertheless changes occur in these formations (slumping, sanding, deformation) and periodical checks are therefore necessary.

1. See page 41.

The most frequent maintenance and repair operations are as follows :

- cleaning out : removal of debris which has fallen down the well or sand which has either fallen from the surface or been washed out of the formation,

- backfilling or clearance around the well-head,

- mechanical or chemical workover, reconditioning of the well after bailing or relining,

- addition of gravel filters around the base of the shaft,

- repairs to concrete work : grouting, lip, paving, watering troughs.

Project evaluation has shown that insufficient maintenance work is actually done on wells, either because of a failure to provide the government department responsible with funds (the rural engineering department in Senegal, DHER in Upper Volta, SERARHY in Chad), or because of a lack of maintenance equipment, or because the existing maintenance equipment is being used for the construction of new wells (Water engineering sub-division, Togo), or again because of the lack of appropriate logistical support.

In contrast, OFEDES in the Niger is an interesting example of the organization of regular maintenance : in principle each of the 4,200 concrete wells now in use in the Niger is inspected every three years. OFEDES maintains 26 maintenance teams for this purpose[1], based in 7 regional divisions. In principle each team can maintain an average of 50 wells per year. In order to keep its regular maintenance programme going without hindrance OFEDES attempts to reduce emergency work to a strict minimum. The annual maintenance cost of a well is between 25,000 and 30,000 CFAF, and in principle this is covered by a contribution from the district authorities and a subsidy from the national budget.

---

1. Each team is provided with a drilling rig, and includes the driller, his assistant, a winch-man and three drilling hands.

Given that OFEDES' maintenance service works well, and in view of the relatively unfavourable natural conditions in the Niger (a vast country, scattered wells, mainly sandy formations), the financial basis described above could be regarded as an order of magnitude applicable to all countries, provided of course that the operation is well managed.

2. Maintenance and use of boreholes

Generally speaking village boreholes, provided they are properly made, should have a long life without the need for continuous maintenance or major repairs. Borehole maintenance is therefore mainly a matter of the equipment : hand pumps, motor driven pumps, associated structures (service reservoirs, watering troughs, etc.).

a) Hand pump maintenance

Virtually no pump will operate for a long period without maintenance. All experience shows that the problem of maintenance has not been solved really satisfactorily anywhere. Regular pump maintenance requires a suitable efficient organization and adequate available financial resources.

The two projects involving wells fitted with pumps which were put in hand in the Ivory Coast between 1961 and 1965 and were financed by the EDF have demonstrated the full range of problems and difficulties which can result from the use and maintenance of hand pumps. Despite the existence of a maintenance service no pumps were working in some regions over a period of several years; in others many pumps were always breaking down. As wells were involved in most of the cases the population was able to revert to the traditional drawing of water by hand, but in the case of a borehole a pump breakdown immediately renders the water point unusable. The situation with the continuous maintenance of pumps has improved considerably in recent years mainly as a result of persistent pressure by the Commission's Delegation in Abidjan, and the search for a formula has made progress.

According to the terms of its lease, SODECI, the operator of urban water supplies, has also been made responsible for the operation and maintenance of village water supplies since 1974. SODECI has begun to set up a supplementary administrative and technical structure which includes :

- agents paid by the villages, responsible for pump lubrication and the detection of breakdowns,
- inspection teams responsible for regular technical inspection and simple repairs,
- breakdown teams responsible for major repairs.

The assumption of responsibility for the maintenance of wells and pumps by SODECI is an effective and interesting solution to this major problem; the first positive results were already visible at the time of our evaluation mission in 1976. The village well and pump maintenance budget in 1976 was 80 million CFAF, or 35,000 CFAF per well and pump, financed out of the nationally standardized SODECI tariffs; the additional charge of 2.3 CFAF/m^3 [1] levied on paying consumers in the major towns is reasonable and not burdensome.

Although an optimum arrangement like this one cannot be transferred as it stands to another country, some organization for pump maintenance should be set up whatever the circumstances,

- adequate and regular budgetary provision must be made available,[2]
- the organization should respond closely to local requirements for flexibility, mobility and practicability; relatively simple logistics, short distances, light transport equipment, etc.

---

1. 80 million CFAF spread over the 34.8 million m^3 of water sold by SODECI in major towns. For the method of standardization see page 57.

2. The possibilities for financial participation by the population are dealt with on pages 116/117.

b) Maintenance and use of motor driven pumps

As maintenance is an inseparable concomitant of pump operation it should be organized so that pump operation can be checked regularly and action can be taken "immediately" (within not more than 48 hours) when breakdowns occur. In general only boreholes are provided with motor driven pumps, mainly in grazing areas. In the Niger maintenance is the responsibility of OFEDES, in Senegal SOMH. In both cases the water is distributed free of charge and the cost is covered by government subsidy. The annual operating cost of a borehole in a grazing area lies between 1.6 million CFAF (Senegal, 1975) and 2 million CFAF (Niger, 1976), without financial charges.

3. Methods of organizing maintenance

Project evaluation has revealed a very wide variety of ways in which well and borehole maintenance can be organized. Generally speaking the following systems can be distinguished :

a) Government department

Examples : Upper Volta, Senegal, Togo. This is generally a relatively rigid arrangement : ponderous administrative procedures, civil servant status of the personnel, problems with the regular provision of funds, difficulty in adapting to specific technical changes, etc.

b) Independent public authority or organization

For example : OFEDES in the Niger. A certain amount of financial independence and less ponderous administrative procedures provide for more flexible operation than a government department.

c) Private or mixed economy company

For example : SODECI in the Ivory Coast. This arrangement benefits from maximum financial and administrative flexibility. It is even more effective if the terms of the concession or leasing contract make allowance for the social nature of the services provided, specify methods of maintenance and provide for penalties in the event of non-fulfilment.[1]

4. The importance of maintenance

It is obvious that regular maintenance is necessary if the full utilization of open wells is to be guaranteed. However wells can be used more or less normally, at least temporarily, even if maintenance is inadequate.

In contrast the maintenance of the hand pumps and foot pumps with which wells or boreholes are provided is vital to the population; continuous proper functioning of the pump is essential if a borehole is to be used. A breakdown can rapidly assume catastrophic proportions for the population if regular operation cannot be guaranteed and if the borehole is the only source of water in a radius of several kilometers. For this reason many countries continue to build open wells even though their average cost is higher than that of boreholes. Even if the provision of pumps is a policy decision there may be advantages in mounting the pump on an open well; unlike a borehole, the well can still be used if the pump should break down.

III. Organization of the making of wells and boreholes

Project evaluation has shown that in most countries it is much easier to provide new facilities than to solve the problems of maintenance satisfactorily; maintenance needs are less obvious and new facilities are much more spectacular. As a result maintenance problems have been largely neglected in the past. Although in principle maintenance should be exclusively an internal matter, aid and the services of foreign companies can always be obtained for the provision of new facilities. Thus many countries tend to think in terms of setting up an organization for the latter purpose.

---

1. In the Ivory Coast SODECI is penalized at the rate of 3,000 CFAF per day for village pump breakdowns in excess of 72 hours.

However a suitable maintenance organization is an absolute priority. A country should not become involved in setting up structures for the construction of wells and later also possibly boreholes until all problems with the maintenance of existing facilities have been solved.

However a national organization for construction may be necessary in some special cases :

- as a replacement for private companies which may not be interested in working in particularly unfavourable conditions (countries that are islands or enclaves, a small number of units, difficult access to villages etc.), or which ask exorbitant prices for doing so,

- in order to ensure the necessary technical back-up for active participation by the population.

1. Organization of well construction

Techniques of making wells are slow and are essentially based on manual labour (labour cost approximately 30%, see Appendix 7); relatively simple equipment is used.

The construction of fairly deep wells in all kinds of ground requires a large amount of equipment : derrick-shearlegs, bailer, compressor, compressed air pump, pneumatic drill, casing formers, etc. As regards staff, continuous on-the-job training of the men is essential to ensure the best performance from construction teams.

The greatest difficulty in constructing wells is co-ordinating sites and providing supplies in good time. This is mainly a question of specifying accurately the date and period for which the bottoming-out team will be required, and of carefulling organizing the movement of men and materials. The manufacture of casing should be investigated in relation to site distribution[1]; manufacture can take place either on site or at a central point with the casing being transported to each site.

In the Niger for example, the activities of OFEDES, which was originally set up for the maintenance of rural water facilities, have been widened over the years to include the construction of new wells and boreholes. A connection of this kind between the maintenance and construction services within one organization is common : The Water Engineering Department in Togo, SERARHY in Chad, DHER in Upper Volta.

The advantages are that

- the organization will pay particular attention to the technical design and quality of construction in order to assist later maintenance as much as possible,

- maintenance services are able to accumulate a valuable body of experience, as well as information on hydrogeological, socio-economic and sociological conditions which may be used to advantage in the design of new units.

The disadvantages of such a link are that the organization is always liable to extend its construction activities to the detriment of continuing maintenance. The constraints inherent in a programme for the construction of new wells, in particular political pressures and contractual deadlines, may induce the organization to transfer resources in men and equipment from the maintenance departments to the construction departments.

2. Organization borehole construction

Drilling techniques are fast and are essentially based on specialized equipment. The weak points of an organization involved in this work are generally :

1. A 140 cm intake tube weighs 1,200 kg.

- the high level of skill of the drillers and mechanics, which often necessitates foreign technical assistance,

- the organization and operation of the logistic infrastructure, particularly the organization of stores, the prompt provision of required spare parts, the repair of complex equipment, etc.

The approximate annual budget necessary is of the order of 500 million CFAF for an administrative organization dependent on the technical support of foreign contractors[1]. This demonstrates the financial and economic constraints resulting from such a commitment. For the implementation of drilling programmes the employment of private companies seems to be the arrangement most in keeping with the level of economic development of most countries. However this arrangement requires efficient control on the part of the government, and it is therefore desirable that the control departments be strengthened.

---

1. A company with 4 modern rigs would be able to make about 300 boreholes 50 m deep in one year, if properly organized.

G. PARTICIPATION BY THE POPULATION

The population may take part in the construction and/or maintenance of village water supply facilities.

I. Active participation by the population in construction : self-help wells

The planning of wells built with "self-help" is one of many efforts by some countries and private organizations to involve the population actively in development. The consumers can become to some extent aware of the problems of water and in particular of their own water supplies[1]. With this in mind, participation by the population is generally "voluntary".[2]

1. The design of self-help wells

In some countries the design of self-help wells has been based on the idea that it is possible to produce a well which is intermediate between traditional wells, which are always threatened by slumping, and concrete wells with collection shafts. In the early days (Upper Volta) simple wells without collection shafts were built entirely by the population. However it was found that without help from a technically specialized organization these wells were unable to penetrate deeply into the aquifer where the geological formations tapped required a long collection column. Consequently many of these wells were not permanent. Subsequently the construction of wells was entrusted to a specialized technical organization and self-help was fully integrated with the work carried on by this organization.

This arrangement has ensured the success of self-help as practised for example in the Niger during the last ten years or so :

---

1. The micro-projects mentioned by the Lomé Convention are a similar kind of idea.

2. In particular circumstances "payment" is made in the form of food provided by foreign aid.

OFEDES built the wells and made as much use of the villagers as technical requirements allowed.

The villagers undertook to provide unskilled labour for certain simple and well-defined jobs : sinking the well, removal of spoil, concrete mixing, help in grouting. As far as possible they undertook to collect and sieve local materials (gravel, sand), and to provide any water necessary, as well as huts for the accommodation of specialist staff (the well foreman, the bottoming-out team).

OFEDES provided specialist staff (a well foreman and his assistant), the technical equipment required (vehicles, winches, derricks) and materials (cement, reinforcing rods, tools). OFEDES was responsible for supplying the site, ensuring that the equipment was in working order, and supervising the work of the villagers, and itself carried out work in the aquifer.

It seems that the government of the Niger has recently decided to abandon this self-help arrangement in view of the increasing reticence of the populations involved, which has to do with the fact that :

- programmes with and without participation by the population may exist side by side in the same area,
- some wells are used in addition by herdsmen, who, by not taking part in their construction, are considered by the settled population to be taking unfair advantage.

2. Conditions for participation by the population

Despite this recent trend in the Niger, project evaluation has shown that generally speaking participation by the population can be achieved :

- if information and motivation is got over effectively beforehand, for example by meetings to inform and arouse interest.

however the work must be put in hand promptly after this approach, otherwise the villagers will be disappointed in their expectations, and their willingness may falter,

- if the villagers have a really urgent need for water, or the need is expressed in terms of the quantity of available water rather than quality; if there is only one very distant source of water or if the traditional wells dry up quickly; if the villagers normally obtain water from a water hole, and if the object of the well is only to improve water quality, then the village will hardly feel any need,

- if the village is compact. In contrast participation may be very difficult to obtain if the village is scattered.

- if the population is actually available during the construction period[1]; this availability may be restricted under certain circumstances : herdsmen in nomad areas are busy almost throughout the year (it is virtually impossible to build wells with self-help in nomad areas); the existence of irrigation systems (in settled areas) enables crops to be grown out of season; the seasonal emigration of the young to other countries; a fall in the villagers' enthusiasm; custom and some peculiarities of the social system[2],

- if there is no work being carried out concurrently in the region by government agencies or by firms without participation by the population,

- if the depth of the well does not exceed certain limits (say 60m); it has been found that the population is reluctant to work at more than this depth, but also the work would be too dangerous for unskilled labour.

---

1. On average a self-help construction team manages about 10 linear metres per month: a team from a government agency should be able to make between 10 and 15 linear metres per month.

2. Some ceremonies may halt all activity in a village for a particular period; differences in social rank within a village may make some work unacceptable to certain people.

Finally it is self evident that participation by villagers in the sinking of wells is limited by certain hydrogeological circumstances : very hard rock (mechanical tools or explosives) and unstable ground (caisson work).

3. Advantages and disadvantages of self-help

Two main advantages favour the construction of wells with self-help, in comparison with construction by governments or private companies :

- cost : the difference is not as great as might be supposed, because the cost saved is that of unskilled labour, which is not very high in any case.

  All other costs (supervision, materials, operations, equipment) are virtually identical (table, Appendix 7).

- the psychological factor : the villagers are motivated to take their destiny in their own hands and contribute to the development of the country. It is questionable however whether this motivation will be long lived, and whether it will survive the completion of the well.

  The main disadvantages are lower efficiency and a longer time to completion. These can however be reduced by rational organization of the work.

II. Active participation by the population in maintenance

The evaluations made show that villagers who have actively taken part in the construction of a well with their own hands consider it to be their own work. They are blind to the fact or refuse to accept, or are even unaware that a specialist organization has provided them with know-how, specialist equipment, etc. However, and contrary to what might be expected, the population rapidly takes the attitude that it is the government's job to maintain the well. But, it is also necessary to be realistic :

although the villagers can, if need be, carry out cleaning and sand bailing, maintenance as such and repairs require specialized equipment. It is therefore essential that a competent and well equipped maintenance service should exist. Its main task should be the periodical inspection of wells. It goes without saying that these maintenance and repair visits by a "government" organization will confirm the population in their negative attitudes to the responsibility for this maintenance work.

In conclusion, if the active participation of the villagers in maintenance is to be ensured, it is essential that

- some well-chosen villagers should be trained so that they can be capable of doing a minimum amount of maintenance,

- they should be motivated so that they continue to be aware of their responsibility for their well and/or pumps,
  clear arrangements on mutual responsibilities at initiation of work

- logistic back-up and an efficient maintenance service is provided for the training of the villagers and for more complicated tasks.

It should however be added that the maintenance of a concrete well by the population also raises sociological problems; according to tradition the man responsible for maintenance is also the one who controls the well; however few villagers generally have the opportunity or the power to take control of water points as large as concrete wells.

III. Financial participation by the population in construction and maintenance

The provision of facilities by a religious organization in Togo shows that in certain circumstances the population is quite prepared to take part not only physically, but also financially, in the construction of wells and/or boreholes and their maintenance, and in the purchase and maintenance of handpumps. In contrast, in the Ivory Coast, attempts to obtain the financial participation of the population in pump maintenance in the sixties failed because of the high cost of repairs and the excessively long time between the collection of funds and the completion of the work.

Generally speaking from some of the experience acquired it can be said that financial participation by the population may be expected if :

- maintenance is in the essential interests of the population, i.e. if there are no alternative sources of water,

- appreciation of the health properties of the water from modern wells prevails over the ease of obtaining supplies from traditional watering places,

- the villagers' interest in the well (satisfaction of a need) or pump (ease of drawing water, improvements in quality) is encouraged in a very lively way,

- sustained follow-up maintains interest in the correct use of the well and/or pump, and in the collection of money for every repair,

- the funds collected are in reasonable proportion with the average income of the villagers, which generally means that part must be paid by the state,

- where funds are being collected for a foreign construction and/or maintenance organization, that this is organized in such a way that the necessary work and/or repairs are completed without delay and there is thus a clear connection between the collection of funds and construction and/or repairs.

IV. Summary

Active and/or financial participation by the population in the construction and/or maintenance of village water supply facilities is important if their chances of success are to be increased. It is essential that when the project is planned :

- the interest of the villagers in the work and the likelyhood of their taking part be assessed or encouraged,

- the material and financial ability of the villagers to take part be assessed,

- the necessary conditions and actions required to ensure this participation be established,

- the construction, supportive and organizational tasks which must be undertaken by the government or a specialist organization be established,

- the method by which the construction and/or maintenance work is organized be established.

H. HEALTH EDUCATION

As we have already seen, the persistence of habits and also an almost total lack of appreciation of the health qualities of water, particularly in rural areas, makes it likely that the users will consider a new well as just another source of water which is no different from any other traditional watering place. Thus investment in the provision of village water supplies will not be wholly beneficial unless the population is made aware of the health properties of the water.

It follows that programmes for the construction of wells should in principle be accompanied by appropriate health education activities so that the population can understand and appreciate the health advantages of unpolluted potable water, so that they feel improvements in health are their own responsibility.

This health education could be provided by the public health services, either by personnel specializing in health education or by the medical and paramedical personnel in contact with the population. It could perhaps be provided in association with other services such as general education, rural development or agricultural advisory services. Appropriate support from all possible audio-visual media may be useful provided that there is close co-ordination between the various activities.

Specific health education programmes are generally very costly if they are to have a suitable impact. However their impact generally seems to be relatively weak, and even visible temporary effects seem to disappear rapidly once the activities end. This may be one reason why in most countries social health education is relegated to the background, and handicapped even more by the poor financial resources allocated for this purpose.

The arrangement adopted in the Ivory Coast seems to be promising; all education activities linked with the "national programme" for village water supplies are concentrated in a special bureau (ONPR) financed by a small surcharge on the sale of water in major towns.[1] In principle mobile two man teams train peasant propagandists with the help of teaching material (slides, picture books, audio-visual materials). The effectiveness of such an organization depends on rational and effective use of the funds made available to it and on the extent of practical work in the bush. At any rate the ever present tendency to start with the formation of a bureaucracy in the capital to the detriment of centres of activity in the countryside must be avoided at the outset.

To sum up, health education alone provided in an isolated way is very unlikely to have a useful impact. It should be linked with other educational, motivational or mere development activities in other sectors.

APPENDICES

APPENDIX 1

LIST OF PROJECTS EXAMINED IN THE SECTORAL EVALUATION

Situation as of 30.9.1977

Country	Account No	Project title	Project cost(*) in '000s EUA
IVORY COAST	11.21.508	Water supply to Bouaké	1,136
	12.21.504	Three water supply systems (Divo, Agnibilekrou, Toumodi)	-
	11.21.501 } 12.21.504 }	Construction of 10 dams in the cocoa belt	5,060
	11.21.501 } 12.21.504 }	Water supplies for the public and for grazing (354 wells)	
	12.21.504	Public water supplies (148 wells; site surveys for 300 wells in grazing areas)	-
	215.106.25	Public water supplies (200 wells in the north)	1,116 (**)
UPPER VOLTA	12.21.702	Water supplies for the public and for grazing (21 wells)	158
	211.009.14	Public water supplies (76 wells made with self-help)	117
	11.21.705	Three water supply systems (Kaya, Koudougou, Ouahigouya)	470
	11.21.707	Water supply and drainage in Ouagadougou	903 (1)
	11.21.710	Extension to the water supply system in Ouagadougou	729

UPPER VOLTA (continued)	211.009.24	Improving the water supply to Ouagadougou	2,576
	215.009.19	Provision of water and electricity for the textile plant and the town of Koudougou	572 (1)
	3100.472.09.03	Extension of the water supply system in Bobo-Diolasso	2,360 (**)
NIGER	12.21.801	Construction of 395 wells	4,902
	211.013.04	Construction of 150 wells	1,292
	211.013.19	Construction of 514 wells	5,939
	211.013.27	Three water supply systems (Filingué, Birni N'Konni, Tahoua)	1,477
	3100.071.13.19	Public water supplies (300 wells with self-help)	1,732 (**)
SENEGAL	11.21.112	Wells (133 wells)	1,150
	11.21.112	Boreholes (24 boreholes)	1,061
	11.21.116	Water supply systems to 8 secondary centres	410
	211.015.16	Watter supply system to Dakar (Thies-Dakar pipeline)	4,787
CHAD	12.23.401	Water supplies to villages and in grazing areas (185 wells)	2,939
	3100.172.17.18	Water supply system for N'Djamena (emergency quota)	2,240 (**)
	3100.672.17.26	Water supply system for N'Djamena (final works)	5,677 (**)

TOGO	11.22.111	Water supply system for Lomé	535
	3100.671.18.07	Village water supply systems (~135 wells)	1,797 (**)
	3100.071.18.12	Village water supplies - maintenance equipment	221 (**)

(*) Total cost (expenditure)

(**) Total sum of contracts

(1) Proportion for water supplies only

APPENDIX 2

BASIC DOCUMENTS FOR THE SECTORAL EVALUATION

EEC : Rolf BRENNER Ex-post evaluation of public water supply projects, Ivory Coast	VIII/A/2/708(76)FR 19 January 1977
EEC : Rolf BRENNER Ex-post evaluation of public water supply projects, Senegal	VIII/767(76)FR 25 March 1977
INTERNATIONAL RESEARCH AND TRAINING INSTITUTE, PARIS (IRFED) Ex-post public water supply projects, Chad	May 1977
INTERNATIONAL RURAL DEVELOPMENT ASSOCIATION (AIDR) Brussels Evaluation of public water supply projects in Upper Volta	September 1977
EEC : Rolf BRENNER Ex-post evaluation of public water supply project, Niger	VIII/556(77)FR 12 October 1977
EEC : Rolf BRENNER Ex-post evaluation of public water supply project, Togo	VIII/1086(77)FR October 1977
BURGEAP, Paris The provision of wells and boreholes for villages in relation to hydrogeological conditions in the ACP states of Africa (types of facilities and equipment, prior investigations and surveys)	1978
EEC Report of the Commission to the Council of the Communities concerning the utilization of aid by Associated States and recipient countries and territories in 1972 (Part 2, section II).	SEC(73)3040 final 13 September 1973
EEC Report of the Commission to the Council of the Communities concerning the utilization of aid by Associated States and recipient countries and territories in 1971 (Part 2, B).	SEC(72)2666 final 26 July 1972

APPENDIX 3

PUBLIC WATER SUPPLIES (1)

Region/ Country	Urban population served			Rural population served	Total (weighted average)
	Private connections	Stand-posts	Total urban		
WORLD TOTAL					
Today (1975)	57%	20%	77%	22%	38%
1980 Objectives	68%	24%	92%	36%	
AFRICA					
Today (1975)	37%	31%	68%	21%	29%
1980 Objectives	45%	35%	80%	35%	
1975 SITUATION (2)					
Chad	7%	36%	43%	23%	26%
Ivory Coast (3)	-	-	98%	29%	44%
Niger	28%	8%	36%	26%	27%
Senegal	28%	28%	56%	-	-
Togo	-	-	49%	10%	16%
Upper Volta	19%	31%	50%	23%	25%

(1) Source : WHO - World sanitation statistics report, Vo. 29, No. 10/1976. Special number : Public water supplies and the evacuation of excreta in developing countries. Report on progress achieved.

(2) For the countries dealt with in the sectoral evaluation.

(3) 1970 figures.

APPENDIX 4

URBAN WATER SUPPLIES
AVERAGE CONSUMPTION
1975

Town	Country	Inhabitants	l/cap/d
Lomé	Togo	240,000	75
Ouagadougou	Upper Volta	170,000	57
N'Djamena	Chad	224,000	54
Bouaké	Ivory Coast	170,000	47
Bobo Dioulasso	Upper Volta	115,000	37
Tahoua	Niger	36,000	19
Birni N'Konni	Niger	12,000	10
Filingué	Niger	10,000	10
Toumodi	Ivory Coast	13,000	13
Ouahigouya	Upper Volta	25,000	10

APPENDIX 5

URBAN WATER SUPPLIES

MAIN CONSUMER GROUPS

Town (Country)	Year	No of inhabitants	Total consumption m³	Government consumption m³	%	Private consumption m³	%	Consumption from standposts m³	%	No of private connections	No of standposts
Dakar (Senegal)	1974		23,490,000	2,720,000	11			2,890,000	12		
Ouagadougou (Upper Volta)	1975	170,000			24		53		9		62
Bobo Dioulasso (Upper Volta)	1975	115,000			16		51		9		
N'Djamena (Chad)	1976	230,000								3,500	50 (1)
Lomé (Togo)	1976	230,000								5,340	196
Niamey (Niger)	1975		4,382,000	1,384,000	32	2,799,000	64	89,000	2		
Zinder (Niger)	1975		580,000	165,000	28	267,000	46	139,000	24		
Maradi (Niger)	1975		525,000	106,000	20	242,000	46	166,000	32		
Bouaké (Ivory Coast)	1974	170,000	2,300,000	991,000	43	907,000	39	-	-	3,600	-
Koudougou (Upper Volta)	1975	36,000			20		35		1		
Ouahigouya (Upper Volta)	1975	25,000			53		41		6		
Kaya (Upper Volta)	1975	18,000			53		38		9		
Tahoua (Niger)	1975	35,000	235,000	89,000	38	66,000	28	73,000	31	323	30 (1)
Birni N'Konni (Niger)	1975	11,500	44,000	3,000	7	10,000	23	31,000	70	134	16 (1)
Filingué (Niger)	1975	10,000	34,000	4,000	12	30,000	88		-	167	15 (1)
Toumodi (Ivory Coast)	1975	13,000	60,000							201	4

(1) Some of the standposts are out of use.

APPENDIX 6

TARIFF STRUCTURES
in CFAF/m^3

	Chad	Ivory Coast	Niger	Senegal	Togo	Upper Volta
Tariff in force : Year	(1977)	(1976)	(1976)	(1974)	(1977)	(1977)
Full consumer tariff	52 - 120 (10)	119	55 - 95	105 (8)	45	70
including:						
- operating company's income(1)	52 - 120	56.8	55 - 95	65 (9)	45	70
- "renewal fund" surcharge(2)	-	-	-	8	-	
- "sinking fund" surcharge(3)	-	37.3(7)	-	30	-	
- sanitation surcharge(4)	-	14.9	-	-	-	
- health education surcharge(5)	-	1.0	-	-	-	
- municipal surcharge(6)	-	9.0(7)	-	2	-	
Type of tariff						
- single tariff for all water	-	119		-	45	70
- regional tariffs						
. capital	52	119	55	105	45	70
. secondary centres	65 - 120	119	55 - 95	93 - 96	45	70
Differentiated tariffs						
- by consumer groups	-	-	-		-	
. private individuals	105					
. government	100					
. industry	33 - 46				30	
. standposts	72	63				
- in relation to consumption	-	119 - 45	45 - 85	-	-	70 - 153 (March to May only)
Tariffs for private abstraction of groundwater	-	43.3 - 20.6	-	-	-	-

(1) Including provision for depreciation of assets not owned by the operator.
(2) To finance extension work and/or replacements.
(3) To cover financial charges (interest and repayments on negotiated loans).
(4) To cover operating costs and financial charges on waste water drainage facilities.
(5) To finance health education activity programmes.
(6) To finance municipal work related to water distribution.
(7) Abidjan. (8) Dakar and Cape Verde tariff. (9) Including 2.5% sales tax. (10) All tariffs subject to a 9.93% tax surcharge.

APPENDIX 7

INVESTMENT COST OF VILLAGE WELLS

	NIGER (3) (1976)		NIGER (3) (1976)		CHAD (6) (1975/76)	
	Government controlled (1) organization		Self-help		Government controlled (2) organization	
Cost	CFAF/l.m.	%	CFAF/l.m.	%	CFAF/l.m.	%
Labour						
Workmen	10,440 (4)	21	3,440 (4)	8	17,470	18
Supervisors	3,060 (4)	6	3,060 (4)	7	11,730	12
Total labour	13,500	27	6,500	15	29,200	30
Materials	15,950	31	15,950	36	27,300	27
Operating costs	7,800	15	7,800	18	16,370	16
Equipment	13,750	27	13,750	31	21,200	21
Miscellaneous	- (5)	-	- (5)	-	5,930	6
Total cost	51,000	100	44,000	100	100,000	100

(1) Construction by OFEDES
(2) Construction by SERARHY
(3) Basis of calculation : estimated work by one OFEDES well construction unit (consisting of one bottoming-out team, one casing team, nine excavating teams) required to build 25 wells per year totalling 900 linear metres, for an average depth of 36 m per well. Price including all taxes.
(4) Estimate
(5) Miscellaneous costs are included under individual items; motivation costs not included
(6) Basis of calculation : 14 wells 50 m deep built in Batha in 1975.