

## The Transfer of Technology Occasioned by the Senegal Village Water-Supply Project

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### ABSTRACT

This paper describes the technology transfer of a rural water-supply scheme in Senegal, West Africa, which was financed by a £6-million grant from the Overseas Development Administration and carried out by direct labour during 1983-88. The prime objectives of the transfer of technology through this project were (a) to achieve the project construction at a reasonable cost, and (b) to leave a skill pool in Senegal at Ministry, engineer and village level, so that the project works could be operated, maintained, extended and replicated in the years after completion. The scheme provided a safe supply of clean drinking water to 85 000 people based in 18 village centres.

*Key words:* Technology transfer; rural water supply; direct labour; boreholes; health education; diesel-driven pumps; sectional steel tanks.

### INTRODUCTION

Senegal is the most westerly country in West Africa (Fig. 1), 'sahalian' in climate in the north and sub-tropical in the south. Its people have suffered the deprivations of almost continuous drought through the 1970s and mid-1980s, and the semi-nomadic population and their animals have been severely affected by the lack of safe, permanent water supplies.

The project works were conceived to overcome the problems arising from the drought. Deep groundwater sources were to be exploited by means of diesel-driven pumps, and distributed to 85 000 people through systems of water towers and gravity-fed pipe networks at 18 rural centres throughout Senegal. These were scattered throughout the Louga Region in the north and along the Trans-Gambian highway in the Kolda Region in the south. The sites for construction were generally widely separated, remote, and posed many logistical problems.

The feasibility and design phases of the project were undertaken during 1983-84 by the authors' firm, who fielded a multi-disciplinary team consist-

ing of engineers, hydrogeologists, an economist and a social anthropologist. They recommended that the construction phases of the project should be carried out by direct labour. British drilling contractors were engaged for the specialized task of the construction of 13 deep boreholes, and purchasing and shipping were arranged through the Crown Agents.

### INTENTIONS

It was intended that the maximum transfer of knowledge should be effected by local participation at all levels. Technology was to be transferred directly from the supervisory group to the construction group at government, local authority and village levels, so that the existing Senegalese organizations should not only gain the ability to operate and maintain the facilities provided through the project, but be able to construct new facilities to serve other populations in the future as aid funds allowed.

The construction plant and equipment were to become the nucleus of the operation and maintenance facilities, and were to be available for further construction as required.

The most obvious technology to be transferred was that involved in the water-engineering works themselves, i.e. basic design and construction knowledge. Less obvious, but equally important, was the transfer of skills associated with other aspects of project life, such as management and accounting, language ability and the use of computers.

### INTENTIONS TRANSLATED INTO ACTIONS

During the outline design phase, the infrastructure, practices and preferences were investigated. The construction programme, using supervised direct labour, was planned to dovetail with existing organizational levels as far as was practical. Each member of the supervisory team (from resident engineer to mechanic) was matched by a local counterpart who would learn the functions of, and eventually replace, the supervisor. At the head of the team the projects

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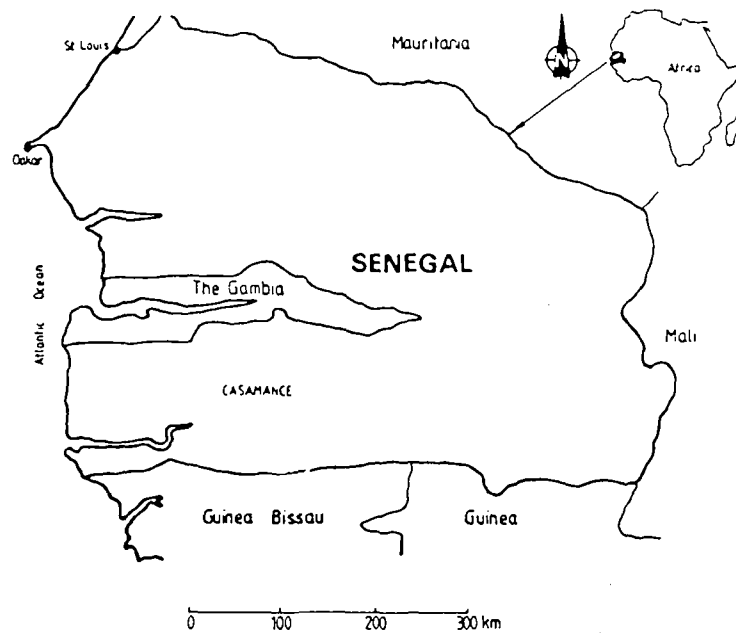


Fig. 1. Map of Senegal, West Africa

manager and his counterpart (the director of the *Direction de l'Hydraulique Rurale* (DHR)) worked together through frequent briefings, discussions and site visits. Counterpart engineers, allocated to work alongside the resident supervising engineers in all site works, were drawn from the DHR and a newly-formed operation and maintenance group called *Direction de l'Entretien et de la Maintenance* (DEM).

Two experienced mechanics supervised skilled teams responsible for the servicing of vehicles, plant and equipment, to ensure their efficient functioning during the period of the project.

In order to attain maximum flexibility, a skilled steelwork erector trained and supervised water-tower construction teams independently of the rest of the civil-works teams. Early in the project he trained an assistant to run a second group of teams. He was then able to work in one zone with the use of a mobile crane, whilst his assistant worked in the other zone to prepare for accelerated erection and to carry out completion work.

Teams of skilled construction workers were recruited through the client organizations, and after gaining practical site experience they rapidly increased in efficiency from commencement to completion of the project.

At village and site level, semi-skilled tradesmen were recruited for placing concrete, pipelaying, and surveying. Unskilled labourers carried out the excavation of water-tower foundations, pipeline trenches and backfilling. Each outlying village or hamlet was responsible for the excavation of pipe-

line trenches to enable the network to be brought to their homes. This was all unpaid and engendered a real sense of participation in the facilities provided. Works for the central facilities, i.e. the water-tower foundations, pumphouse and pumping main, were paid for to bring initial cash flow to the local population and to stimulate the local economy in order to encourage support for the initial operation and maintenance costs. These funds were administered by locally-formed 'management committees' which were involved, as far as possible, in the organization of the works. The management committees were also responsible for setting the level of, and collecting, contributions from users of the water supply, and for using this revenue for the operation and maintenance of the facilities. People who were destined to undertake the operation and maintenance of the finished facilities worked alongside the construction teams.

Operators of the central works, i.e. the borehole pumps and water reticulation system, were trained by the client organization DHR over a 6-month period in literacy (to enable accurate records to be kept) and in simple tasks such as checking and adjusting drive belts, bolts, oil levels, filters and the management of other mechanical consumables. In addition to this theoretical training, the operators were involved for as long as possible in the installation, commissioning and maintenance of their particular village works. Seminars by plant and equipment manufacturers, held in Dakar and Louga, added to the confidence of this group and of the client's own specialist fitters. These fitters,

already experienced in the installation of plant in general, are expected to be able to undertake all major repairs and replacements of pumps, motors and other major components on the project. They took part in the installation of project equipment when their other duties allowed, so that they too learned by practical experience.

In addition to the practical training at all levels, the counterpart engineers were given theoretical support. They were first schooled in English by the British Council teachers in Dakar and then sent to the UK for intensive English-language teaching until they were proficient enough for technical refresher courses. Training courses which these engineers attended in the UK were selected according to the individual's ability and the needs suggested by the client organizations in Senegal. Everyone benefited from intensive management training in the UK before returning to take up their duties in Senegal.

## RESULTS

### PROJECT WORKS

The planned project works were completed, commissioned and integrated into the Senegalese infrastructure. Final expenditure did not exceed the revised budgetary limits, as original limits were adjusted significantly early in the construction programme to take account of inflation, exchange rates, and other escalating costs which occurred between the feasibility studies and the actual construction work. Part of the proposed distribution scheme was curtailed in the same exercise to concentrate available resources on the provision of the central production and storage facilities in each centre.

### EXTENSIONS AND ADDITIONS

Even before the project was completed, the villagers in two localities had organized extensions and additions to the networks provided through the project. In one case, at Djida Maouda, a major pipeline extension to bring water to a new expanding community about 2 km from the rest of the scheme was undertaken by the DHR, who used project-trained labour, skilled tradesmen, counterpart supervisors, project plant and equipment. In the other case, at Boudouk, the locals themselves planned, funded and constructed two additional cattle-watering points. The schemes were carried out by local tradesmen who had participated in the village works and had copied the designs and construction methods. The finished local products were as satisfactory as the project plants themselves.

### OPERATION AND MAINTENANCE

Plant, equipment and vehicle fleet used in the project construction were handed over to the DHR

and DEM on completion of the supervisory works. They were intended to form the nucleus of the facility for operation and maintenance support, not only to all the project works but for all water-supply works in the southern part of Senegal, and to reinforce existing facilities in the north.

The management of the important southern maintenance depot was handed over to one of the counterpart engineers from the DEM on his return to Senegal from training in the UK. This depot is to be extended and subsequently re-equipped under a further aid programme.

However, the plant, equipment and vehicles remaining from the project are vital components in the operation and maintenance efforts in the south.

A technical cooperation officer has been appointed by the Overseas Development Administration to support the client organizations and to liaise with them in the post-project phase. His efforts are also largely directed towards sustaining the operation and maintenance of the project works. In addition, the project component concerned with health and hygiene considerations has been funded by the Overseas Development Administration through *Oxfam*, to reinforce the local understanding of fundamental health issues associated with the provision of a new reliable water supply to these villages.

## CONCLUSIONS

1. The transfer of technology was maximized by carrying out the project using indigenous labour and reinforcing the available local-management skills, rather than involving foreign contractors.
2. The future of the technology to be transferred has to be relevant to the immediate needs of the participants, and must be presented in a manner which can be absorbed rapidly so that the benefits are immediately recognized and appreciated.
3. The ability and attitude of the participants are vital. Likewise, the motivation and continuity afforded in the project are also directly relevant.
4. Transmission language does not need to be spoken or written: although fluent French was required of the participants, transmission often took place despite the language rather than because of it.

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of the supervisory works, form the nucleus of the maintenance support, not only for all water-supply works but for all water-supply part of Senegal, and to be based in the north.

The important southern depot is handed over to one of the staff members on the DEM on his return to the UK. This depot is to be used to be eventually re-equipped under a

project which includes equipment and vehicles. These are vital components in the maintenance efforts in the south. The training officer has been replaced by a Overseas Development Administration officer who has been in the post-project phase. His work has been directed towards sustaining the maintenance of the project works. A major component concerned with the maintenance of the project has been funded by the Overseas Development Administration to force the local understanding of the issues associated with the maintenance of a reliable water supply to these

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Technology was maximized by the project using indigenous labour and available local-management involving foreign contractors. The technology to be transferred to the immediate needs of the project must be presented in a manner which is absorbed rapidly so that the project is immediately recognized and appreciated.

The attitude of the participants are important. The motivation and continuity of the project are also directly relevant. The language does not need to be perfect. Although fluent French was spoken by the participants, transmission often occurred in the language rather than

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dor and the staff of the British Embassy in Dakar, and numerous other organizations and individuals, both in the UK and in Senegal.

## DISCUSSION

(Abridged)

**Mr S. J. Hugman** (CASA, Denmark), opening the discussion, felt that the paper had as much relevance for technology transfer in the UK as in Africa.

He said that the authors referred to transfer from the donor to the recipient, which was a one-way process. However, at the end of the paper they had concluded that the process of transfer was two-way. He said that this was well-recognized in marketing, where customer response was continuously assessed and reassessed. Similarly, good trainers were often recognized as those who were continuously looking for feedback from the trainee. A two-way process may be especially important where the trainer was unfamiliar with local practice and conditions, or where the technology itself was undergoing rapid development. He asked if, in future projects, the authors would consider building into the programme ways of encouraging such feedback.

Mr Hugman said that the authors had described a study phase which had involved investigation, presumably by the consultant's team. He asked how Ministry staff had been involved in the drawing up of the project objectives, and whether the study team had used this opportunity to motivate and develop the analytical skills of personnel within the Ministry.

He said that they had also described how counterparts with little previous experience worked alongside the team members, but did not have full responsibility – in particular for management of the project funds. At the end of the project these same counterparts would have to take full responsibility for control of the project. He asked the authors to explain how the hand-over was carried out, especially with respect to the provision of follow-up support to the recently-trained engineers. He wondered if earlier control of funds by the counterparts would have facilitated this process.

With reference to extension of the project he said that, although successful extension of two of the systems had been carried out by the consumers themselves, the authors had referred to a lack of consumer cooperation on a third system. He asked if they were able to comment on the reasons for this, especially in relation to the need for community development work to be carried out as an integral part of such projects.

Mr Hugman said that restrictions on the use of aid donations limited purchase of equipment to the donor country. Imports during the described project were mainly of UK origin. However, the scheme was being complemented by two further projects: one funded by Italy and another by Germany. He asked how the authors viewed the long-term viability of the transfer of hardware specific skills when equipment purchases, in the future, were likely to be from different manufacturers.

**Dr D. H. Rees** (East Worcester Water Co.) said that the main source of supply for the scheme seemed to have been the groundwater aquifer, and asked the authors to comment upon the type of basic resource assessment that was carried out. His concern, based on a number of instances in various parts of the world, was that very often

with groundwater schemes construction was the priority. On occasions there was inadequate assessment of the resources, and this had a crucial effect on the sustainability of a project in the long term.

**Mr P. Styles** (Severn Trent WA) said that, from recent experiences in India, he had found that with such projects the tendency to fail was after the technology transfer had taken place and had been highly successful. He asked if the technology transfer had included future administration to ensure that the system would be maintained and would continue to operate.

**Mr R. G. Amster** (Binnie & Partners) said that he was interested in the length of the project (5 to 6 years), because normally the Overseas Development Administration would not commit funds so far ahead. He wondered if the authors could indicate if, originally, it had been a two-year project which had been extended.

With regard to the identification of training needs, he suspected that aspects were identified as the scheme progressed, concentrating on 'on the job' training; however, the underpinning of management was also an area which might have been considered at the outset.

**Mr J. Carter** (South Staffordshire Water Co.) said that the transfer was a two-way subject and his Company had found tremendous benefit in taking part in such exercises. It was an excellent staff development exercise, and it was also important to see that the client obtained quantifiable benefit from the project.

He considered that it was good to train people and to see results, but, whilst the World Bank embraced the concept of partnership, he felt that the Overseas Development Administration still seemed somewhat reserved. Many projects with a small infusion of money or continuity would pay off in benefits, and it was the personal touch as well as the technical touch that made these things worthwhile.

**Mr H. C. Balfour** (Mott McDonald) said he wished to second previous comments on the importance of long-term need and personal involvement. In his view the word 'aid' meant benefit to both sides and on a long-term basis.

He referred to a study which had involved both a lady social anthropologist and a lady economist. He felt that their interest in village life had much to do with the understanding of some of the problems of the people.

He asked if the authors would make any changes, either to the work or to the organization of the project, with the benefit of hindsight. He also wondered how many of the 18 villages were now obtaining sufficient funds to operate their jobs and extend the installed system.

**Ms A. Morton** (Strathclyde Regional Council) said that she was a member of Soroptimist International which had also sponsored a water project in Senegal. She said that her main query was about the selection of sites and how various donor organizations were involved in discussions.

She asked whether there was any follow-up to ensure that the facilities were adequately maintained, and whether there was any testing with regard to water quality.

**Mr R. Brown** (Institute of Hydrology) said that the authors had referred to facilities for the drainage and safe disposal of spillage at the stand taps. There were many examples where it had been shown to be more harmful to provide a water supply without providing adequate disposal of water, for public health reasons, than to provide no supply at all. For example, in Burkina Faso, the irrigation of 1200 ha of rice fields in the plain of Loumana created conditions which induced an outbreak of onchocerciasis, resulting in the desertion of the settlement and the

dilapidation of the system five years later (1957-1962) after 15% of women and 20% of men became blind [HERVOUËT, J. P. Aménagement hydro-agricole et onchocercose: Loumana (Haute-Volta): in: *De l'Epidémiologie à la Géographie Humaine, Travaux et Documents de Géographie Tropicale no. 48*, éditions ACCT/CNRS, Paris, 1983, 271-276]. He wondered whether there was any public-health involvement at the planning stage and what waste-disposal options were considered. Was 'supply and disposal' of water seen as a unified concept at the outset of the project?

Mr W. Ray (Consultant) said that the taps at the water points appeared to be of the ordinary household pattern. In other countries in Africa, it had been considered preferable to use self-closing taps in order to conserve water and avoid waste, and he asked if these had been considered for Senegal.

With regard to the use of Braithwaite pattern sectional-steel tanks, whilst these could be erected by unskilled labour, it might be thought that they were not of an attractive appearance. With hindsight, would the authors consider any other type of tank or configuration of prefabricated tank?

Mr Ray wondered if the authors could give more information on the pipes that had been used. If the distribution mains were constructed from asbestos cement, had any problems been experienced with breakages during shipment, and were any difficulties experienced in achieving satisfactory pressure tests?

#### Authors' Reply

Replying to Mr Hugman, Dr Wenn agreed that the transfer of technology was a two-way process, and emphasized that it was more personal when carried out on a one-to-one basis. The people to whom technology was quickly transferred became one's friends, and personal contacts developed quickly - which benefited both parties.

He said that in this particular case he thought that timescale was the limiting factor and that the bulk of flow was in one direction simply because time was short. The information which was transferred in the opposite direction came rather informally, and was felt as much as it was spoken. He agreed that feedback was important, and certainly the Overseas Development Administration had begun to gather information through the placement of a technical assistant in Senegal on a long-term basis.

With reference to the motivation and involvement of the Ministry staff, Dr Wenn said that they had been fortunate in finding Martin Coly and his colleagues, who were well motivated and participated from the beginning. They had helped in the preparatory work so that, at an early stage, a closely-knit team had been formed that checked every stage of the project. The initial motivation was bolstered by the enthusiasm which the team generated when it could see the huge potential the project offered.

He said that the counterparts had a good theoretical training prior to involvement with the project, but had limited practical experience because the funding of the majority of their works was from aid which, in its traditional form, almost excluded them from participation. The donor nation's contractor would arrive, do his work and withdraw.

In reply to Mr Rees, he explained that in Senegal the supply water was drawn from deep aquifers which were part of a large structure underlying the major part of Senegal and adjacent countries. They apparently received

a substantial input of water from various surface sources, but it had been beyond the scope of the reported project. However, the French technical cooperation with Senegal had undertaken a long-term study, and its results had been utilized. After construction, standard pumping tests had been carried out to establish the performance of each particular well.

Replying to Mr Styles, Dr Wenn said that at the feasibility stage of the project a significant amount of money had been included to provide for spares at project completion. In fact not all of the money had been used for spares; some had been used to finance an operation and maintenance facility in the southern area. He understood that adequate spares had been provided for five years' operation.

With regard to the administrative structure for maintenance, he said that in Senegal there was a well-established structural network to support the maintenance requirements. At village level a management committee had responsibility delegated from the Ministry for operating each well. As soon as a facility had been completed and put into use, the local management committee took over responsibility for its operation.

In answer to Ms Morton, he said that women were influential in these management committees since they were major users. In some cases the management committee was totally composed of women.

Replying to Mr Amster, he said that a rapid feasibility study had been undertaken which had been followed by about 18 months' delay whilst financing was fixed. The construction phase had lasted about two years, and he felt that there was still a tendency for the ODA to consider two-year projects.

Dr Wenn said that the training needs had been identified as the project progressed, but in the feasibility study a training programme had been laid out for (a) the operatives who would have daily charge for the wells, (b) those who would operate and maintain them monthly, and (c) the newly-established organization which would take over the operation and maintenance of all the facilities in the country.

In answer to Mr Carter, he presumed that the Overseas Development Administration were going to measure the benefits from the project, and he hoped that this would be carried out.

He felt that with hindsight there were some changes that could be made, and perhaps the most relevant were twofold. Firstly, the widespread geographical location of the sites across Senegal had caused serious logistical problems, and a closer grouping of the sites would have made the project more cost effective; however, it may not necessarily have helped as many people or dealt with as many urgent cases. Secondly, he would have preferred a longer time-scale on which to achieve the final phases of the project - the liaison after construction and initial operation really needed to be at least twelve months.

Replying to Ms Morton, he explained that site-selection had been agreed between the UK Government, through the Overseas Development Administration and the Senegalese Government. He said that the study team had received a list of 24 potential sites. These had been studied and then ranked essentially in terms of need. Eighteen had then been chosen for financing, which was the limiting condition.

Following construction, water quality had been tested at each well and village centre. He understood that it was

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water quality had been tested at tre. He understood that it was

tested annually, and the waters required minimal treat- ment to bring them within potable limits. The water was abstracted from deep underground sources and arrived at the surface at 25°C (in some cases), and obviously had a high total dissolved-salt content. There was almost nothing that could be done about it within the financial envelope and in the available time-scale. However, aeration devices had been fitted to some of the supplies to reduce the iron content, which was high, but this was the limit of treatment that was undertaken.

Dr Wenn explained that health-education aspects were separately organized as a sub-part of the project through Oxfam, and he understood that this was still ongoing. An educational programme to help people to both use and dispose of water had been planned. During the preparation of the feasibility study there had been much discussion about the structures, and a lively discussion had taken place with the design team as they visited each location as to how to site most of the facilities and to cater for other needs such as washing and safe disposal. Many regional variations had been found that were of interest.

In response to Mr Ray, he said that their local counterpart organization was strongly against the use of self-closing taps in the particular environment, technical problems having been experienced in their operation and maintenance. In the project one particular member of the local populace had been given responsibility for each standpipe. This person oversaw operation on a daily basis and maintenance on a regular basis, so that ordinary taps, which could be easily obtained and locally replaced, seemed to be the better option.

He said that the aesthetics of the tanks had received

serious consideration. However, cost and reliability of many other materials had been considered. Concrete had been rejected because the quality of the materials and the workmanship which they could bring were likely to be low, and it was therefore considered to be safer to construct in metal. Other modern equivalents of the Braithwaite tank had been considered, but were found to be economically less attractive.

He said that more than 100 km of UPVC pipes had been laid for delivery of supplies to the local network, and ductile-iron pumping mains had been installed from the pumphouses to the water towers. The pipework had presented very few difficulties.

With regard to materials, Mr Coly who had worked on the project, said that their mechanics were familiar with a variety of equipment and materials. Monopumps had not been introduced to Senegal prior to the project, but adequate training had been given to the Senegal mechanics.

In response to Ms Morton, he said that about ten years ago Senegal had been implementing a policy which aimed to restructure the countryside. Now the countryside was structured in rural communities where women were fully involved, especially in the selection of sites for building standpipes or boreholes, because they were in charge of providing water for the home.

With respect to water quality, Mr Coly said that the cleanest water was rainwater – and secondly groundwater. After reaching the aquifer, water from a borehole was analysed and found to be of good enough quality not to require treatment prior to being put into supply.