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4 Domestic Water Supply in Rural Africa

Sandy Cairncross

1 Objectives

What is a water supply, and what is it for? The question is not as naive as it sounds — certainly not in the context of rural Africa. The World Health Organization estimates that four out of five rural Africans are without reasonable access to safe water. In compiling that estimate very different definitions of what is 'reasonable' and what is 'safe' were used in different countries. The variation in definition is not the result of bureaucratic whims, but reflects the fact that the standard of adequacy for a water supply depends on the purpose it is intended to serve. At one extreme, every human community has a water source of some kind, for without one it could not survive; but at the other, the standard of service found in most of Europe, with a twenty-four hour supply of limitless quantities of chlorinated water to multiple taps and fittings inside the home, is enjoyed by a negligible number of rural Africans — as is likely to be the case well beyond the end of this century.

The purpose that is most commonly ascribed to better water supply is that of improved health. The relationship of water supply to human health is complex and frequently misunderstood; but those who pay for, build and operate rural water supplies often do so for other reasons, whether or not these are openly expressed.

Although the importance of water supply for the promotion of health has been well-known for the last 150 years, and the colonial powers in Africa were generally keen to maintain high sanitary standards in the settler cities, they rarely thought of health as a motive for building rural water supplies. It is symptomatic that a recent book on health in colonial Africa (Sabben-Clare *et al.*, 1980) makes no mention at all of water supply as a health intervention. In those relatively infrequent cases where colonial administrations embarked on substantial rural water programmes, there was usually a link with settlement schemes. The aim was to make areas habitable and productive where previously human settlement, and particularly livestock farming, had been impractical, owing to the scarcity of water sources. This was the case, for example, with the wells built by the British administration in Anchau, Nigeria (Nash, 1948), and in the Chire valley, Malawi (Mitchell, 1956), by the French in the Baol-Saloum region of Senegal (Suret-Canale, 1976), and by the Portuguese in parts of Mozambique (Silva, 1956). The first and

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It was in the final years before independence, as internal self-government got under way, that water supply construction on any widespread scale began, as a response to political demand. Most of the rural water supplies built in colonial Tanganyika, for example, were built at the request of and with at least partial financing by the local Native Authorities (Tschannerl, 1979). In many countries, the local authorities were controlled by colonial administrators. This did not always make for equity. One observer (Brasseur, 1952, p. 44) noted that: 'Les dossiers abondent de requêtes émanant de personnages politiques ou religieux qu'on satisfait pour avoir la tranquillité; en même temps des besoins très urgents restent pendants.' In other cases, such as Basutoland, more enlightened colonial officials helped district councils to obtain funds for their rural water schemes in the belief that this would strengthen local democratic institutions.

However, it was only after independence that substantial expenditure on rural water began. In Kenya, the annual rate of investment in the sector increased from £48,000 to £654,000 between 1967 and 1971 (Carruthers, 1973, p. 9). The total sums involved were still small by comparison with other infrastructural investments, and too small to affect more than a minority of the population. In 1970, annual investment in rural water supply in Africa was little more than £8 million (Saunders & Warford, 1976, p. 10) At the costs prevailing at the time, this was enough to build water supplies for one million people a year, out of a rural population for the region of roughly 170 million. Over three times this sum was being spent on water supplies for the much smaller urban population.

Since then, the rate of investment in the sector has slowly increased, but still falls far short of what would be required to provide the same level of service to most of Africa's peasants. Moreover, awareness has gradually spread that simply to build water supplies is not enough, and that without adequate maintenance they break down (Cairncross & Feachem, 1977). In some countries they have been breaking down as fast as new ones are built.

The sector has come to depend increasingly on international aid and, as so often happens when aid donors are involved, it has suffered a fair amount of confusion of objectives. Aid agencies have often stressed the need for maintenance, but with few exceptions refused to contribute to the recurrent costs of the projects in which they have invested. A bilateral donor, while extolling the virtues of standardization and appropriate, locally-produced technology, will frequently press recipient governments to buy its own national brand of drilling rigs, handpumps or other equipment. The importance of institution-building is often emphasized, and yet there is an increasing tendency for a donor to bypass local institutions and set up its own parallel implementation system with a view to greater speed and efficiency.

Possibly the most muddled area is community participation, where the interests of both donors and recipients are served by keeping the concepts vague. This question has been trenchantly dissected by others (Feachem, 1980; White, 1983), and there is no need to add to a mountain of paper, beyond noting two often neglected points. First, setting up community institutions to participate in the construction and maintenance of rural water supplies is essentially the task of establishing local government. After all, local government in Europe began with institutions for the maintenance of community infrastructure, and that *is still* its main activity today. Conflict within the community, and also between it and the central government, can result, and political commitment at the highest level is therefore required. Second, community participation has a cost. Not only does it impose constraints on how the technical part of a water supply programme can be implemented — which will tend to make the programme more expensive — it also requires salaried community workers, vehicles and other inputs, the costs of which are rarely included when projects are appraised or evaluated.

Much confusion arises from reluctance to voice the real reasons for rural water programmes, which often underlie the vague statements of noble purpose. While local elites have long used village water supplies as instruments of patronage, the taboo on discussion of the political aspects is almost universal among the donors, and African governments are only too happy to help in the pretence that rural water supply is an untainted issue, like motherhood, which everyone must favour.

Whatever objective the aid agencies attribute to the rural water programmes they support, the political pressures at either end of the transaction generally arise from very different considerations. On the one hand, water supplies are attractive to the people who provide the aid agencies with funds, as they are more tangible and photogenic than many other forms of rural development activity and they can be completed within the span of a single aid agreement, providing the donor with visible evidence of his assistance in a short period of time. On the other hand, they are almost universally popular among their users, chiefly for their convenience and the saving in time that they can bring. They also involve minimal institutional conflict at village level and are much cheaper to maintain than schools or clinics. People with a water supply cannot be guaranteed to vote for the politician who facilitated it; but the *prospect* of water supply can be a strong inducement.

The political factor is not always electoral. For example, several African governments, such as those of Tanzania, Mozambique and the Congo, have tried to resettle their scattererd rural populations in villages. The rationale may be that concentration is necessary if infrastructural provision such as water supply is to be available in rural areas; but in practice officials see the formation of such villages as a means to better control of the peasantry, and water supply as a necessary precondition or incentive.

Each of the parties involved — politicians, aid agencies, government officials, users — has a different perception of the objectives of water supply, but two are particularly concerned about how in practice a water supply may improve the standard of living of users. The aid agencies are most usually concerned to bring about improvements in health, while the users are most aware of the saving in time spent collecting water. Setting these objectives explicitly has important consequences for rural water policy.

2 Health

Our understanding of the relationship between water supply and human health took a significant step forward with the publication in 1972 of Bradley's classification of water-related diseases (White, G.F. *et al.*, 1972 pp. 162-76). This classification was originally developed in the context of a study of water supply in Africa, but has found application in developing countries throughout the world. It is not based on the biological taxonomy of the pathogenic micro-organism which causes each disease, following the conventional practice in medicine. Instead, it considers the transmission route by which each kind of infection is passed from one person (or animal) to another.

Bradley defined four categories of transmission route:

(i) Water-borne transmission

This term has frequently been misused, to refer to disease transmission related to water in any way at all. Here it is used in the strict sense to mean transmission as a result of drinking water that contains the pathogens. With the exception of Guinea worm, all of the diseases that can be water-borne are faeco-oral, and they can also be transmitted in any other way by which faecal material can enter a person's mouth — for example, on contaminated fingers, food or utensils. This group of diseases includes not only notorious killers such as cholera and typhoid, but also a range of infections that are responsible for the endemic diarrhoeas of children in poor communities. These diarrhoeas cause some half a million infant deaths a year in Africa — more than were ever killed in a single cholera or typhoid epidemic. They also contribute in various ways to malnutrition and stunting.

(ii) Water-washed transmission

The non water-borne transmission routes of the faeco-oral diseases are facilitated by a shortage of water for personal and domestic hygiene. They are therefore susceptible to control by improving the quantity of water available for hygiene, irrespective of its quality, and such transmission can be called water-washed.

In addition to the faeco-oral diseases, which can be either water-borne or water-washed, there are various skin and eye infections that are water-washed but never water-borne. Trachoma, for example, is an eye infection causing blindness, and is especially prevalent in arid regions such as the Sahel belt. Improved water supply can be expected to control trachoma in several ways. First, greater access to water permits more frequent washing of the face; face-washing has been shown to be an effective preventive measure (Taylor *et al.*, 1985). Second, improved general domestic hygiene will help to reduce the number of flies, which can transmit the disease by settling on children's faces. Third, one of the attractions of children's faces to flies is the moisture that the flies can obtain there: improved water supply can divert flies by providing other sources of moisture in the environment such as a puddle of spilt water or a damp cloth.

(iii) Water-based transmission

This is the route followed by various parasitic worms which require a period of development in an aquatic host such as a snail before they can re-infect people. The main example in Africa is schistosomiasis, which infects people when the worm penetrates the skin. But the supply of water at a public well or tap is unlikely to prevent people, especially children, from swimming in infected water on a hot afternoon, and so catching the disease. The other important water-based infection in Africa is Guinea worm, about which more later.

(iv) Water-related insect vector transmission

This category includes West African sleeping sickness, transmitted by riverine tsetse flies which bite near water. Water supply may reduce the need for women to visit river banks, and hence their exposure to this disease. Other diseases are transmitted by mosquitoes, which breed in water. The way in which mosquitoes may be affected by water supply depends on the species involved and on its breeding habits. For example, several haemorrhage-causing viruses, such as dengue and yellow fever, can be transmitted by the *Aedes aegypti* mosquitoes which breed in domestic water-storage pots.

Expectations of health benefits from water supply usually focus on the faeco-oral group of diseases. Although Bradley left the question open as to whether their transmission was mainly water-borne or water-washed, the planners have tended to assume the former. Nevertheless, an increasing weight of evidence, much of it from rural Africa, has accumulated

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(Feachem *et al.*, 1978, pp. 139–79; Young and Briscoe, 1986, Annex B) that the endemic paediatric diarrhoeas of poor communities are largely water-washed, as they are not substantially affected by water quality improvements when hygiene and access to water are unchanged. Moreover, one significant study in Nigeria (Tomkins et *al.*, 1978) showed that better access to water was associated with a benefit to children even more significant than freedom of diarrhoea, although possibly a result of it — namely, better nutritional status.

It should be stressed that measuring the health benefits of water supplies is extremely difficult. The incidence of a disease may easily be found to be lower in one community than another. But such a difference cannot easily be ascribed to the presence of a water supply, as can be seen from the data in Tables 4.1 and 4.2. If the figures in brackets were ignored, piped water would seem to give excellent protection against diarrhoea and typhoid; only the unusual circumstances of the two villages, by which not everyone drinks piped water in either, make it possible to see that there must be other factors at work.

Table 4.1 Children under 5 years having diarrhoea during previous week in two villages in Tanzania

Village	Piped water	Dug hole
Namabengo	15/216 = 7%	(5/70 = 7%)
Mkongo	(37/100 =37%)	39/134 = 29%)
Total	52/316 = 16%	44/204 = 22%

Table 4.2 Children under 5 years with antibodies to typhoid fever in the same villages

Village	Piped water	Dug hole
Namabengo	4/216 = 1.9%	(1/70 = 1.4)
Mkongo	(7/100 = 7.0%)	12/133 = 9.0%
Total	11/316 = 3.5%	13/203 = 22%

Source: Prag JB, Balslev, K. Boesen, J,. Kapinga B.S., (1983) 'Water Master Plan for Iringa, Ruvuma and Mbeya Regions', *Tanzania*, Vol. 13, Ch. 11. Centre for Development Research, Copenhagen.

However, quite a few amateur epidemiologists have been undeterred by such difficulties (e.g. Gaddal *et al.*, 1986). Science is not well served when they publish their results and ascribe a spurious certainty to dubious data, especially when the authors have a personal interest in the project whose impact they claim to have measured.

One way around the problem of attributing a difference in disease incidence to the effect of water supplies is to consider many more than two villages; it can then be hoped that extraneous factors will cancel out. This becomes feasible with the case-control method (Briscoe *et al.*, 1985). Whereas conventional studies usually compare the incidence of diarrhoea in two communities (one with water supply and one without it), the case-control method compares the incidence of water supply between two groups of people; those with diarrhoea and those without it.

The method, which is still in an experimental stage of development, had its first trial in Malawi (Young & Briscoe, 1986). Africa is full of cases where laying on water supplies greatly improves access to water, and so probably the quantities used. Unfortunately, the study area in Malawi happened to be one where the taps of the water supply were no closer to users than the traditional water sources had been. In the circumstances it was to be expected that no significant difference in incidence would be found. The result only added more evidence to support the hypothesis that the endemic diarrhoeas of rural Africa are mainly water-washed.

Although the beneficial effects of water supply on the purely water-washed diseases such as trachoma have long been well-known, studies have only recently been published which measure them directly. Two of these studies were conducted in rural Africa (Keyran-Larijani *et al.*, in press; Cairncross & Cliff, 1987) and they have confirmed that the effects can be substantial.

Most health benefits, then, are likely to stem from use of increased quantities of water. How is this to be achieved? Health educators may rarely be deterred by failure, but they are unlikely to have much success in prompting by exhortation an increase in water use. Their efforts are likely to be dwarfed by the increases that occur spontaneously when access to water is significantly improved.

Table 4.3 compares the quantities used for various purposes in two comparable villages in Mozambique, one before and one after construction of a water supply. The journey to collect a bucket of water took over five hours for the unsupplied village, so the example is an extreme one; but it illustrates two points that may have general relevance.

First, a substantial proportion of the increased amount used in the supplied village was for personal hygiene. The bathing of adults and children and the washing of clothes represent 70 per cent of the total. In the other village, these items constitute less than half of a much smaller total. The most obvious aspect of this difference is the frequency with which children were bathed: every day in one village, but hardly ever in the other.

Table 4.3 Volumes of water used for different purposes, in litres per capita per day (l.c.d.), in two villages in Mozambique; one before and one after installing a water supply

	Before (90 person-days) Village A		After (95 person-days) Village B	
	lcd	%	lcd	%
Drinking	0.21	6	0.36	3
Cooking	0.67	21	1.93	16
Washing dishes and food	0.50	15	1.36	11
Bathing	0.80	25	4.75	39
Bathing children	0.04	1	1.23	10
Washing clothes	0.54	17	2.64	21
Other (animals, etc.)	0.48	15	0.03	0.3
Totals	3.24	100	12.30	100

Source: Cairncross and Cliff, 'Water use and health'in Mueda, Mozambique, *Trans. Roy. Soc. Med. and Hygiene*, **81**: 51–4.

Also remarkable is the difference in the quantity used for cooking. Villagers sometimes claimed that they had cooked little food, and only once in the day, because of lack of water for cooking. Healthy adults may make up the difference with raw cassava, but small children and the elderly cannot. Water supply, it seems, can also affect people's health through their diet.

As the example shows, improved access to water can lead to greatly increased consumption. However, it does not always do so. Current knowledge of how domestic water consumption is related to access is based on few studies (White, G.F. *et al.*, 1972; Feachem et al., 1978; Cairncross & Cliff, 1987; Ministry of Health, Mozambique, 1981, Vol. 2, Tomo 2, p. 30; Warner, 1973, pp. 119–29), but all of them were conducted in rural Africa. The consensus from them gives a surprising relationship (Figure 4.1). As the time required to collect a bucket of water is reduced, water use increases progressively until it reaches a plateau at about thirty minutes, equivalent to a walking distance of 1 km each way, to and from the water source. Within this range, bringing the water source closer to the home does not lead to increased consumption.

Collection of water at a public standpipe, well or pump is therefore likely to cause increased water consumption only if the previous source of water was over a kilometre away. If health benefits are to be maximized, those whose source of water is further away than this should have priority in the allocation of water supplies. If, on the other hand, no-one lives so far away from a source of water, water supplies with house connections would be needed to increase consumption further.

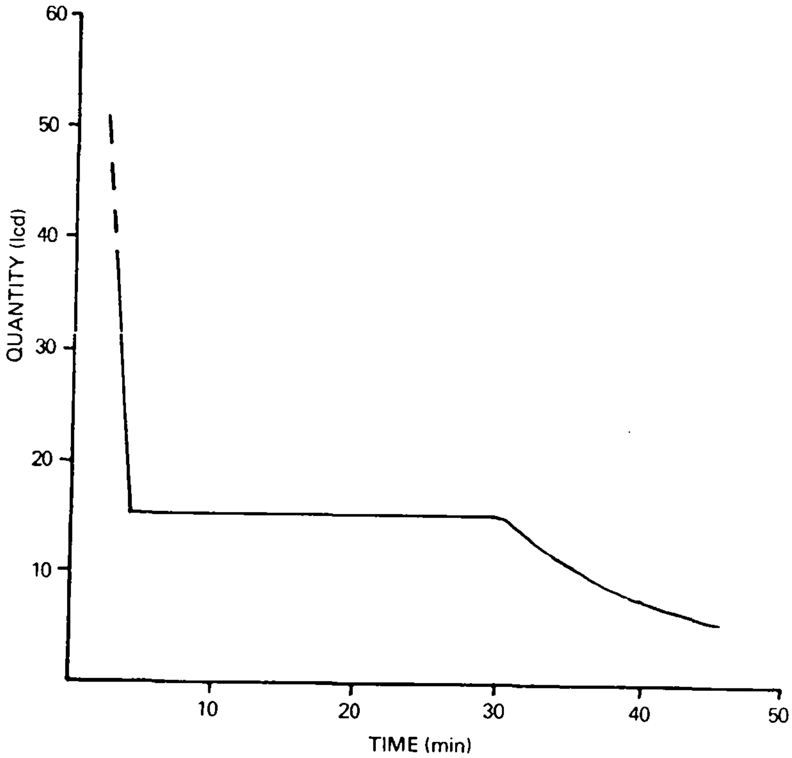

Figure 4.1 *Schematic representation of the relationship between time taken to collect a bucket of water and the quantity used, in litres per capita per day (l.c.d.)*

3 Time saving

The scant attention given this benefit by many writers on rural water supply in Africa (see, e.g., Roundy, 1985) may reflect a difference in perception between them and the users. Saunders & Warford, in their book (1976, pp. 72–3) which became a benchmark for World Bank policy on rural water supply over the subsequent decade, gave it only two pages. Significantly, the examples of water collection time which they mention are all from rural Africa.

Again, it was Bradley and his colleagues (White, G.F. *et al.*93–8) who pioneered the serious study of this aspect of water supply.

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They measured the length of the water collection journey in various environments, and attempted to put a value on it by estimating the calories of energy consumed on the way, and the cost of enough food to provide those calories.

Others (e.g. Dalton & Parker, 1973), seeking a simpler solution, have asked women how they would spend the time saved if they had an improved water supply, and valued the time savings on the basis of the percentage that would be spent on productive work. There are two serious flaws in this approach.

First, very little confidence can be placed in the response to such hypothetical questions. Could the reader say what he or she would have done with the time that could have been saved by not reading this book? Observation is needed of what women actually do with their time if reliable conclusions are to be drawn.

Time-budget observation data of this kind were collected in connection with a evaluation of Lesotho's rural water programme in 1976 (Feachem et *al.*, 1976, pp. 187–92). The saving in time and the number of woman-days in the data collected were too small to estimate directly how time saved from water collection was reallocated. Instead, a comparison was made of the time-budgets of women among households having various numbers of other able women. In a household with two or more able women, the household tasks can be shared and the workload of each woman is reduced. Comparison of the different households shows how women use the time saved, not only from water collection, but from household chores as a whole.

The results are shown in Table 4.4. In the extreme case, a woman who is one of six in a household would be saved 250 minutes per day (more than four hours) of household duties, by comparison with a woman on her own. The figures in the table show that this time was very largely spent on social and leisure activities, not on agricultural work. Reading down the columns, it is clear that as women spent less time on household work they spent correspondingly more on social and leisure activities rather than on agriculture.

Table 4.4 Variation in Lesotho women's time-budgets with the number of able women in their household (minutes per day)

No. of women	Water collection	Other household work	Agricultural work	Rest, social, meals, etc.	Total	No. of women-days observed
1	33	537	34	238	842	5
2	10	478	70	291	849	14
3	15	375	44	376	810	18
6	·7	287	94	524	912	12

Source: Feachem et *al.*, (1978) *Water, Health and Development: an Interdisciplinary Evaluation*, Tri-Med Books.

In another study, in northern Mozambique (Cairncross & Cliff, 1987), I was able to make a direct comparison between the time-budgets of women using a traditional water source and those with access to a standpipe in their village. The saving in time was over five hours per water collection journey, and nearly two hours per woman per day (Table 4.5). Here again the time saved was not primarily re-allocated to agriculture, but to rest, social activity and other household work.

Table 4.5 Average time budgets of adult women (minutes per day) in two Mozambican villages, one before and one after installing a water supply

Activity	Before (110 women-days)	After (118 woman-days)	*Difference*
Fetching water	131	25	−106
Housework	126	161	+35
Grinding	84	98	+14
Agriculture	154	160	+6
Rest	385	433	+48
Totals	880	877	−3

Note: The standard deviation from each of the means given here was about 150 minutes. The standard error of each mean, therefore, is about ± 15 *minutes*.

One reason for this result would seem to be that there are often other constraints on an African peasant woman's production, such as her access to arable land, to traction for ploughing or to cash for inputs such as seeds or fertilizer. In the Lesotho case, women having a greater number of fields did spend more time tending them. When the Mozambican data were analysed in terms of the number of women in the households, it appeared that in households with many women, each woman spent more time in the fields, probably because polygamous men had more land as well as more female labour power at their disposal.

There is a second flaw in the method of valuing women's time on the basis of the amount they spend in farming. In addition to their agricultural production, peasant women provide a variety of unpaid services to their families, many of which are of undeniable value. Many household chores involve cleaning, sweeping, scrubbing and washing, and bring added health benefits in so far as they promote hygiene.

A meticulous study in Asia (Popkin & Solon, 1976) has shown how mothers with more free time raise children who are better nourished, because they can give more attention to food preparation and to feeding their children. This is certainly one possible explanation for the findings of the Nigeria study mentioned above (Tomkins *et al.*, 1978), and it may well be the most accurate one.

Moreover, an increase in women's free time constitutes a benefit in itself, however it is spent. It is a significant improvement in the quality

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of their lives, and a step towards their emancipation. That this benefit is perceived to be worth money is evident from the fact that households that are better-off financially often pay someone to collect water for them (Zaroff & Okun, 1984).

A striking feature of the time-budgets in Table 4.5 is the amount of time spent by the average woman in grinding, i.e. in pounding cereals with a large pestle. A similar result was found in another time-budget study (McSweeney, 1979) in a village in Burkina Faso, where the average woman spent 108 minutes a day pounding grain, compared with thirty-eight minutes collecting water. If the objective of water supplies is to free women's time from an onerous chore, the same objective might often be met more cheaply by providing a grain mill.

Nevertheless, the cost per minute of time saved by a water supply can be very low indeed (Cairncross *et al.*, 1980, p. 168). A typical water supply in rural Africa, costing £10 per head per year (including depreciation of capital and operation and maintenance costs) may save each adult woman an hour a day. This is equivalent to 146 hours per year per head, if women constitute 40 per cent of the total population. This puts the cost at 7p per hour saved. If the time saved were more than an hour a day, or if part of the cost were justified by health benefits, the cost per hour of the time-saving benefit would be cheaper still.

The cost per hour saved is typically less than the prevailing unskilled wage rate, which is quite a reasonable estimate of the value of that time to the beneficiaries. Observation of the behaviour of Americans paying to avoid a queue (Deacon & Sonstelie, 1985) has shown that their implicit estimates of the value of their time are quite similar to their after-tax wage rates. Rural Africans are probably just as rational.

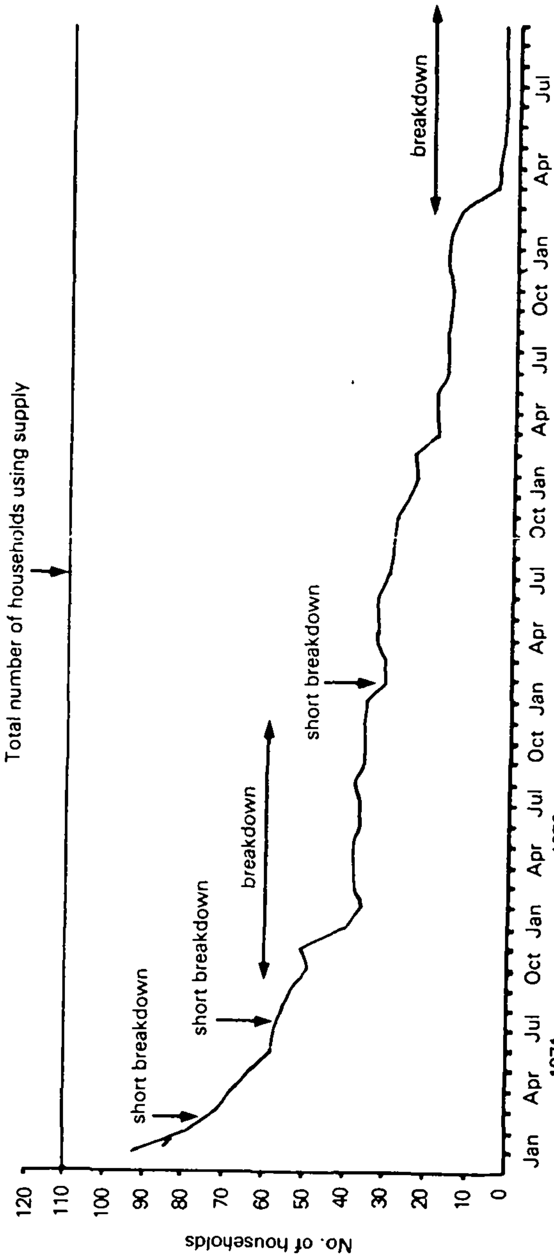
The implications for rural water policy of setting time-saving as an objective are similar to those of using a health objective. Both objectives can be met most effectively by giving priority to those who live furthest from their present source of water, and to improving their access to water in quantity and convenience.

4 Future perspectives

If rural water supplies in Africa are to provide health improvements and time-savings, could these benefits be increased? Mention has already been made that water supplies are only being built for a tiny percentage of Africa's rural population each year, and that inadequate maintenance is an increasing problem.

The problem of maintenance is not essentially one of ignorance. In an African village of today one is quite likely to find at least a couple of inhabitants who know how to repair a motor vehicle or even a radio, and for them a broken pipe or handpump holds few mysteries.

Rather, the problem is one of institutional weakness and lack of material resources such as tools and spare parts. The weakness of



Source: Feachem *et al.* (1978), *Water, Health and Development: an Interdisciplinary Evaluation*, Tri-Mex Books.

Figure 4.2 Number of households paying a nominal monthly subscription towards a diesel-pumped water supply in Lesotho. January 1971–July 1975. (Breakdowns of the supply are also shown.)

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Figure 4.2 Number of households paying a nominal monthly subscription towards a diesel-pumped water supply in Lesotho, January 1971–July 1975. (Breakdowns of the supply are also shown.)

Source: Feachem *et al.* (1978), *Water, Health and Development: an Interdisciplinary Evaluation*, Tri-Mex Books.

village institutions contributes to the shortage of resources. In most countries in Africa a village is not a constituted body with legal powers to raise funds from its inhabitants. Without such powers and some form of sanction behind them, it is not possible to raise funds on a regular basis for the maintenance of water supplies or any other village infrastructure. Voluntary contributions in cash or labour may be easy enough to mobilize for a specific occasion such as the building of a new supply. But to maintain it on a voluntary basis does not work in the long term.

This failing is illustrated by the graph in Figure 4.2, showing the number of families in a village in Lesotho who contributed each month towards the diesel to operate their water pump. The steady decline in contributions was not a result of the occasional breakdowns in the supply; rather, families continued to contribute then, towards its repair. The defaulters simply noticed that their neighbours had already stopped contributing and that the village water committee was powerless to make them pay up.

Alastair White (1983) has argued cogently that the way to obtain wider coverage and more reliable functioning of rural water supplies is to choose cheaper interventions, in which the subsidy to the users is greatly reduced. The same budget could then serve more people, bringing most of the rural population to some minimal level of improvement in a few years, rather than leaving out most of them indefinitely, as at present.

A reduction in the subsidy would mean that the beneficiaries' contribution would be a more significant part of the total cost, and so give them more control over the process. It would also tend toward simpler technology, such as the windlass and the bucket rather than the pump, which would be easier for villagers to maintain (Wright, 1985; on the ingenious bucket pump, see Morgan & McPherson, 1985).

There is one health benefit which such minimal improvements can be more than adequate to achieve. Guinea worm is an excruciatingly painful parasitic disease found throughout much of the Sahel belt (World Health Organization, 1982). The victim is infected by drinking contaminated water, and the female worm emerges at the body surface under the skin one year later, causing an inflamed blister. The sufferer a feels strong desire to relieve the burning sensation by pouring water on the blister; this causes it to burst, releasing thousands of microscopic larvae of the worm. The process is repeated over several weeks, and if the larvae can reach a source of drinking water, the cycle can begin again.

Apart from the suffering it causes, the disease severely damages the rural economy, since the infection usually matures around the planting season, and pain in the affected limb greatly reduces the sufferer's ability to work (Belcher *et al.*, 1975). More than half the population may be affected, and many of them incapacitated for three months or longer. Schools sometimes have to close during the Guinea worm season (Nwosu *et al.*, 1982). There is evidence that increasing migration and dam construction are introducing the disease to new areas (Watts, 1984; Adekolu-John, 1983).

In many areas, unprotected springs and unlined wells are the principal or even the only focus of transmission. A simple spring box, or a parapet around a well to deflect spilt water away from the wellhead, can be enough to eradicate the disease in a year. Guinea worm is the only disease that can be completely eliminated by improved water supplies (US National Academy of Sciences, 1983). It has been suggested that its world eradication should be a goal of the World Water Decade. The Government of India, one of the few non-African countries affected, has taken up this challenge, and it is unfortunate that African governments seem not to share this enthusiasm.

Another simple improvement is the 'wet-season well' — a well which, though it may fail to provide water in the dry season, will at least provide it relatively close to home during the rains. It has been pointed out (Chambers *et al.*, 1979) that the wet season is the worst time of the year for many rural Africans; it is typically marked by a concurrence of food shortages, high demands for agricultural work, high exposure to infection — especially diarrhoea, malaria and skin diseases — loss of body weight, low birth weights, high neonatal mortality, poor child care, malnutrition, sickness and indebtedness. Women are among the most vulnerable at this time, and any lessening of their work burden by improved access to water is particularly valuable. Wet-season wells can often be built where perennial wells are not feasible. For example, they are used in parts of Shinyanga Region, Tanzania (DHV Consulting Engineers, 1978).

An alternative to the 'minimal improvement' policy, which has not received much attention in Africa, is to aim for a *higher* level of service, promoting as many private connections as possible. This is the policy followed in many Latin American countries, not all of which are much more developed than parts of tropical Africa. It has three important advantages.

First, the time-saving benefit is greater. A pioneering study by Tony Churchill of the World Bank (unfortunately still unpublished) has shown how, at typical costs and a value for time of US 10 cents per hour, the extra expense of a pumped water supply with private connections over a more rudimentary borehole and handpump system is justified by the value of the time saved from water carrying.

Second, it is through private connections that the greatest increase in water consumption occurs, and that health benefit is most likely. In the best-known documented cases of significant health benefits from rural water supplies, such as those quoted in the World Health Organization's manual on the subject (Wagner & Lanoix, 1959), this was the level of service provided. The greater the health benefit, the greater

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the externalities, and hence the stronger the case for meeting part of the cost of water supply from government subsidies.

Third, the institutional problem of collecting payment for the water supply is vastly simplified, as defaulters who have private connections can be disconnected. This simple sanction is enough to ensure an ample income for hundreds of rural water supplies in Latin America. USAID discovered its efficacy after the failure of two rural water supply projects in Thailand (Dworkin & Pillsbury, 1980), where people failed to make their contributions to the upkeep of the water supplies — hand pumps in the first project, and standpipes in the second. In the third project, house connections were allowed and the connecting households were required to pay the full operation and maintenance cost of the systems. A high proportion of families made the regular payments for this level of service, and the project was successful.

To entrust cost recovery to the private sector, as has been suggested by some writers (Lewis & Miller, 1987), neglects the arguments for at least a partial subsidy, and is likely to create more problems than it solves (Cairncross, 1987). House connections could increase the benefits of rural water supply, and might, by facilitating some recovery of cost, enable governments to widen coverage of this service.

There are few examples of this level of service in rural Africa. However, in our research in Lesotho (Feachem *et al.*, 1978) we were struck by the fact that the only village in the country with house connections was one of the tiny minority of villages with a surplus of funds for operation and maintenance — a very different story from that shown by Figure 4.2.

The extra cost of this higher service level need not be very great. Where gravity-piped systems are the type installed, as in much of Lesotho, Rwanda, Cameroon and Malawi, house connections could even be added to existing supplies. Pumped systems might be designed to run for only a few hours a day, as London's water supply did until the 1890s (Hardy, 1984), so avoiding the need for expensive storage.

My fellow engineers are notoriously conservative, and often unused to considering the broader issues related to their work. It will not be easy to persuade them to countenance the sweeping reappraisal of rural water technology and policy which these suggestions imply, and which modern rural Africa needs. Social scientists are well placed to try, if they are prepared to open the dialogue.

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