Strategies for Handpump Water Supply Programmes in Less-Developed Countries

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Abstract

Community water supply programmes in developing countries frequently utilize wells or boreholes equipped with handpumps as the technology of choice. Whilst simple targets concerning numbers of wells to be drilled or villages to be served are often prominent, the wider objectives of such programmes are rarely expressed in quantified terms and, as a consequence, programme impact is often disappointing as well as difficult to evaluate. Because objectives are not clear, programme strategy fails to include all the issues and activities which are necessary to achieve the maximum beneficial impact on participating communities. In the paper, target objectives, checklists of programme activities, and staffing requirements are proposed. The subject of programme impact is briefly discussed, and a realistic approach to programme evaluation is outlined. The paper is intended both as an aid to project planners and as a guide to managers and evaluators of existing well-handpump programmes.

Key words: **Boreholes; community water supply; developing countries; evaluation; handpumps; project planning; wells.**

Introduction

A common means of provision of rural domestic water in less-developed countries is the community well or borehole equipped with a handpump. Well-handpump water supply programmes are popular with governments, non-government organizations (NGOs), and donors, because they are perceived to consist of simple technology which is readily managed by rural communities.

Stated objectives of this type of water supply programme commonly include references to health improvement, and to time and energy saving. Such objectives are rarely explicit or expressed in quantified terms, and programme strategies consequently often fail to deliver the maximum potential benefits. The apparent simplicity of such programmes conceals a number of pitfalls. In order to achieve significant impact, these programmes must include several linked activities, failure or absence of any one of which can compromise the success of the programme.

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A consequence of inexplicit objectives is that expectations of impact on the community are often unrealistic and a lack of some of the necessary programme activities can mean that output and performance may be less than hoped for. Evaluation studies are often carried out over very short periods, during which it is difficult to assess impact, especially in the area of public health. The difficulties of evaluation are compounded by vague or unrealistic objectives.

This paper proposes a model for expression of programme objectives, and strategic planning of activities, and sets out a realistic statement concerning programme impact. It also provides some guidelines for rapid evaluation of such programmes.

Programme objectives

The usual statement of programme objectives puts priority on the improvement of public health. A second objective is to reduce the amount of time and energy expended by water carriers. More general objectives, making reference to improvement in the quality of life of rural communities, are often included – although such general improvements are indistinguishable from the first two. Whilst specific service levels (i.e. numbers of users per well and distances of carry) are rarely set out in programme objectives, there is often an emphasis on programme coverage, in the sense of population served. Once a programme has commenced, the reality is that simple targets such as the number of wells drilled or villages served take priority over wider and more complex objectives. Typical statements of objectives do not provide an adequate basis for development of programme strategy, and for subsequent meaningful evaluation. Objectives should be stated in such a way that the appropriate means and methods to be used become obvious.

The first stated objective of an East African programme recently evaluated by the first author is: 'to provide safe drinking water and to improve quantity and quality of water available within a reasonable distance of the users'. This objective begs the following questions:

(a) What precisely should be the water quality target?
(b) What measures will be taken to preserve water quality between the point of supply and the point of consumption?
(c) What should be the design *per capita* water quantity available?
(d) What measures will be taken to encourage increased actual usage of water up to the design figure?
(e) How close is 'a reason

(f) Will any measures be taken to alleviate the burden on human water carriers?

These are all issues of programme strategy, which a clearer statement of objectives would make explicit.

An ideal set of objectives in relation to the two main areas of expected impact – health and time/energy saving – would include quantified reference to the following aspects:

(i) Number of users per well;
(ii) Maximum distance from user to well;
(iii) Maximum time spent daily in water collection;
(iv) Target water consumption;
(v) Target water quality;
(vi) Maximum capital cost of supply, *per capita*;
(vii) Maximum recurrent cost of supply, *per capita*;
(viii) Target pump performance indicators (frequency of breakdown, response time, down-time); and
(ix) Targets regarding hygiene behaviour.

Unquantified objectives should relate to reduction in water (and excreta-related) disease, and reduction of the effort, energy, and injury incurred in water collection. These areas of intended programme impact can be summarized as (a) consumption, (b) time, (c) effort, (d) quality, (e) cost, (f) health, and (g) reliability. Each of these is discussed in turn, before a set of targets is proposed.

Consumption

It is generally recognized that increasing the amount of water used for personal and household hygiene, regardless of quality, can bring health benefits. This is particularly so in relation to some skin and eye infections which are exacerbated by a lack of water for personal hygiene (the 'water-washed' infections), as well as those infections passed from excreta-contaminated hands to mouth (faecal-oral transmission). Increasing the amount of water actually used in the house should therefore be a major objective of water supply programmes.

In rural areas where the users live more than about 1 km from their water source, it is common for consumption to be around the bare minimum of 3–5 l *per capita*, or 20–40 l per household, per day. Twenty litres is about the maximum unit of water which can be carried by a woman, and therefore this consumption amounts to one or two journeys per day.

Taking a typical handpump production of 5500 l/d, then at a minimal consumption rate of 5 l/hd. d such handpumps could serve 1100 persons, or about 157 households each. At such service levels, benefits in terms of water quality, and perhaps proximity, may be experienced. The aim of increasing household consumption, however, cannot be realized. In order to increase *per capita* water consumption to the desirable level of 20–25 l/d, one well could only supply 250 persons (say 35 households). This is a fundamental point, which must affect programme strategy.

A high service level (i.e. small number of users per well) has other advantages. During drilling, mobilization costs are reduced, as rigs work one area until it is 'saturated'. In the post-construction stage, when one pump is out of order, others are available nearby. The potential disadvantages of high service level are twofold: first, the *per capita* cost of providing water is high. In a programme in southern Ethiopia, the cost of a successful well, with pump, is about £6250; at the service level presently adopted by this programme (about 1250 users per well), *per capita* cost of supply is £5. Service level could be improved three or four fold, approaching the level argued for above, with a rise in supply cost to £15–20 *per capita*. This cost is just at the guideline limit set by some funding agencies, and adopted below. The second problem with any attempt to deliver to a high service level is more political. In countries where the capacity of Government and NGOs to deliver water supply improvements is severely limited in comparison with the need, the pressure on implementing agencies, to 'spread the jam thinly' and bring some benefit to the maximum number of people, is immense. This pressure should be resisted.

Even if water is supplied to an appropriate design target, actual usage frequently falls below this level. A major objective of water supply programmes must be to bring about actual usage at a level sufficient to improve and maintain good health. Achieving stated targets of water consumption involves more than simply providing access to increased quantities of water at source. Community education in health and hygiene issues also has an important part to play.

Time

A common objective of well-handpump programmes is to reduce the amount of time women spend carrying water. In such cases this objective should be quantified. It is common, in Africa, for women to spend two or three, or even up to six, hours per day carrying water. The objective of saving time is offset to a certain extent by the objective of increasing household consumption. If the aim is to increase the quantity of water carried to the home by a certain factor, the reduction in distance to the (new) source must be by more than that factor, or no time saving will occur.

Two unproven assertions are proposed here. First, that a reduction in total time spent carrying water to a maximum of one woman-hour per day is an acceptable target; and second, that a target of 15 l/hd.d usage *in the home* (i.e. for personal and domestic hygiene) is also acceptable. (It is assumed here that an additional 5–10 l/hd.d is available at or near the well, for clothes washing.) Assuming, as before, an average household size of seven persons, the target then is that 105 l/d should be carried to the home. This quantity would require five journeys, each of which should take no more than 12 mins. At a reasonable walking speed (5 km/h), and allowing for time (5 mins, assuming little or no queuing) at the well, this means a maximum distance from user to well of about 300 m. Programme strategy must therefore be to provide access to a handpump within about 300 m of the home.

Effort

The long distance haulage of water by women and children is one of the continuing scandals of rural poverty and under-development. In many African countries carrying water on the head results in compression of the vertebrae, and consequent neck injury. In

Ethiopia and Eritrea, water is carried on the back, resulting in back injuries, miscarriages, and hernias. Where donkeys are used for water hauling in Ethiopia, canvas or rubber panniers are often used, ironically giving the donkey rather more comfort than a woman carrier. Rural women routinely carry loads of 15–25 kg of water over many kilometres, and usually uphill.

There are several possible means of reducing the water-hauling burden on women such as (a) developing better techniques for human load-carrying; much work in this area has been carried out for military purposes and in the context of leisure trekking, but rarely has the knowledge been applied to the issue under consideration here[1], (b) assisting in the provision of beasts of burden and suitable panniers or carts, and (c) spreading the burden to the other half of the population – men – by the encouragement of water vending direct to the home (although the potential for this would appear greatest in urban and peri-urban settings)[2]. To reduce the physical burden on women, programme activities should also include attention to water-hauling practices.

Quality

If groundwater chemistry renders it unsuitable, or if proximity to pit latrines has already contaminated local groundwater, there is little that can be done in the context of well-handpump water supplies. However, in most cases where natural groundwater quality is acceptable, a well or borehole constructed with an adequate sanitary seal and an effective drainage apron can provide untreated water of potable quality. Unfortunately, because of groundwater contamination through imperfect sanitary seals in many wells, such water will not always meet World Health Organisation guideline values of nil faecal coliforms per 100 ml. The primary water quality criterion in this context should be an acceptable level of faecal coliforms. The level proposed here is 10 faecal coliforms per 100 ml – a reasonable value for an adequately protected untreated source[3].

Even if water is safe bacteriologically, numerous factors may render it unacceptable to the consumer. A water source may be rejected because of unpleasant, but not necessarily harmful, aesthetic water quality parameters, i.e. colour, taste, and odour. These can, in principle, be treated by aeration and filtration, but such an option may be unrealistic in practice. User rejection because of aesthetic factors is still commonly underestimated by water engineers, with serious consequences. Toxic species, such as fluoride and arsenic, may render a water unacceptable (and untreatable) from a health point of view. Nuisance species such as iron may be rendered less problematic by use of plastics for well and pump components, and by better quality control before and during installation.

Good quality at point of collection does not necessarily translate to good quality at point of use. If water is contaminated after collection – on the journey home, or in the home – then waterborne infections may still be transmitted. An objective of well-handpump water supply projects should be to maintain similar water quality at point of use to that achieved at the well itself, otherwise the efforts spent in wellhead protection will be in vain. This can only be achieved through public health and hygiene education.

Reliability

Handpumps, despite their beguiling simplicity, are notoriously unreliable. Many examples exist of handpump water supply programmes in which a large number – even the majority – of pumps are out of action at any one time, and in which repair times are unacceptably long. For this reason, some water supply projects forego the use of handpumps, preferring open wells and rope-and-bucket abstraction, despite the corresponding reductions in abstracted volumes and water quality.

Reynolds[4] points out the importance of minimizing down-time, even if repair frequency is high; a pump which breaks down frequently, but which is quickly and easily repaired, is better than one which breaks down infrequently, but then takes many months to repair. The emphasis on village level operation and management of maintenance technology acknowledges this fact.

The objective of high reliability implies correct technology choice, the establishment of a workable maintenance system, training, access to spare parts, and functioning recurrent cost recovery mechanisms[5].

Costs

Capital cost targets have already been mentioned, but all handpump programmes also involve recurrent (pump maintenance and repair) costs. These costs cover salaries for community level pump caretakers and maintenance technicians, spare parts, tools and transport, and, ideally, a pump replacement fund. Whatever revenue collection procedure is adopted, the authors would suggest that *per capita* annual costs of maintenance and repair should not exceed £1.

Programme activities to achieve proposed objectives

The foregoing discussion of objectives allows these to be summarized into a proposed model for well-handpump water supply projects. The clear statement of objectives set out here, as Table 1, then leads naturally into an analysis of required project activities.

It is clear from the statement of objectives in Table 1 that programme activities must encompass far more than simply drilling wells and equipping them with handpumps. To achieve the objectives listed, and to bring about sustainable development, a chain of activities is necessary, involving a wide range of professional skills.

Programme strategy

Table 2 sets out the programme-level strategic decisions, and community-level activities, needed to achieve well-handpump programme objectives. The aspects listed in section A of the table all need to be considered in the early stages of programme planning, since they determine how the programme will operate at community level. A well-conceived programme should (a) have clear documentation setting out its strategy on each of the items listed, (b) be flexible, and (c) be reviewed regularly in order to match the programme to its particular circumstances. All aspects should be developed in close consultation with the communities involved.

Table 1. Proposed objectives of well-handpump water supply programmes

Overall Aims

The aim of such projects and programmes is to bring about health improvements, and reductions in time and effort spent in water hauling. These benefits are to be achieved through increased consumption of water, of satisfactory quality, from sources close to the users' homes. These goals should be achieved at acceptable capital and recurrent costs.

Specifically, the objectives should be:

(i) to bring about per capita daily consumption of 15–25 litres, of which a minimum of 15 l/hd.d should be used in the home;
(ii) to provide one well and handpump for every 250 users;
(iii) to reduce time spent in water-hauling to a maximum of one woman-hour per day;
(iv) to bring about significant improvements in water-hauling technology;
(v) to achieve a water quality target of 10 faecal coliforms per 100 ml at the point of use;
(vi) to achieve pump downtimes of no more than 2% (7 days per year);
(vii) to supply these services at a per capita capital cost of no more than £15;
(viii) to supply these services at a per capita recurrent cost of no more than £1 per annum.

Table 2. Programme activities

A: Programme Strategy (programme level activities)

Programme should specify:
- (a) No of users per well.
- (b) Proximity of wells to users
- (c) Well design
- (d) Headworks design
- (e) Pump selection
- (f) Pump maintenance system
- (g) Cost recovery mechanism
- (h) Health/hygiene education procedures
- (i) Strategy to reduce water-hauling burden
- (j) Monitoring activities

B: On-site Activities

Health and hygiene education
- (a) community motivation
- (b) household practices
- (c) water hauling
- (d) safe excreta disposal

Establishment of cost recovery system
- (a) agreement with community
- (b) training of community

Establishment of maintenance system
- (a) pump attendants
- (b) pump committee
- (c) training of community

Site selection
- (a) community and Government consultation
- (b) hydrogeology
- (c) community mobilisation

Drilling and well completion
- (a) drilling, well construction, and development
- (b) pump installation
- (c) headworks construction

Monitoring
- (a) groundwater level
- (b) water usage
- (c) water quality
- (d) pump downtime
- (e) quality control
- (f) behavioural changes

Community-level activities

The following comments relate to part B of Table 2, and their purpose is to highlight key aspects of each of these broad activities.

Health and hygiene education

Three issues arise here. The first relates to the maximization of health impact through the achievement of increased water usage. Education is needed to motivate people to use quantities near to the target levels proposed in Table 1. In addition, education may be needed in hygiene practices, including safe excreta disposal, to help bring about the potential health benefits of having and using larger quantities of water[6,7]. The second issue is that of water quality protection between the point of collection and the point of use. Simple hygiene education can help to ensure that drinking water is not contaminated in the home. The third issue is that of women's physical health, in relation to the practices of water carrying. It is highly desirable that programme activities include measures for alleviating this burden.

Overall, the most important aspect of this subject is the fact that education is a much slower process than engineering. Until this reality is faced by rural water and sanitation programme planners and implementers, mistakes will continue to be made, and benefits lost. Programmes should be structured to take account of both the time-intensive needs of community education and the potentially conflicting financial imperative to obtain the maximum output from capital equipment.

Establishment of cost recovery system

The cost recovery system for pump repair and maintenance is the most critical, and potentially weakest, link in the whole system. It is widely recognized now that if the community does not cover the recurrent costs of its water supply, then no-one else will[8]. And yet the transition from using a traditional (free) source to a system in which water supply is an economic good, is a significant jump. It is easy to under-estimate the amount of work with the community, which is needed to make this transition successfully.

Moreover, public handpump water supplies present difficulties to the design of equitable and practicable cost recovery systems. Water is not metered, and it is debatable whether attempts should be made to establish flat-rate tariffs, or charges related to the amount of water used[9]. What is clear is that once communities accept the principle of payment, and the total sums needed, they should have the key role in determining the payment system to be adopted.

Establishment of maintenance system

At community level this involves the appointment of an attendant or caretaker for each pump, the establishment of a small committee centred on each pump, and training for caretaker and committee. Training of the pump caretaker should cover all aspects of his or her care

and maintenance tasks, as well as background information on health and hygiene, and pump operation. The main training need of pump committees is in the area of book-keeping and financial accountability, in order to ensure competent and transparent handling of user fees.

It is important that clear lines of reporting from the local community to the next tier of the pump maintenance system (either district level programme technicians or private sector mechanics, or programme level maintenance crew) are established.

Site selection

To achieve the necessary consensus on well location, it is important that programme management, community workers, and hydrogeologists all work together to agree well sites with community and local government. Because of the high unit cost of machine-drilled boreholes (especially in Africa), and to avoid disappointing community expectations, it is important to achieve as high as possible a success rate; dry or abandoned holes are both costly and discouraging. In this respect hydrogeological expertise, which may include the use of geophysical exploration techniques, is generally very cost effective.

Drilling and well completion

A key activity in the construction and completion of water wells is careful supervision. The importance of this aspect of quality control is particularly great when private sector contractors are responsible for implementation. High quality control in manufacture of materials, handling, drilling, well construction, well development, headworks construction, and pump installation, is vital to the sustainability of such programmes. Collection of well logs, yield data, and test pumping results, is also an important activity for the information needs of future programmes.

Monitoring

The issue of programme evaluation is discussed below; however, without routine monitoring any short duration evaluation is of limited value. In order to allow evaluation of the programme performance, routine monitoring should cover logging of programme activities and outputs as well as recording of selected indicators to allow (indirect) evaluation of programme impact. Detailed records of supervisory activities should also be kept to allow evaluation of construction and maintenance quality.

Staffing categories

The staff categories needed to carry out these community-level activities are set out in Table 3.

Table 3. Well-handpump programme staffing

Programme Management: coordination, strategic decision-making, logistics, staff training, procurement, financial accounting, well siting, supervision, overall monitoring and evaluation;
Hydrogeologist: well siting, drilling/well completion supervision, test pumping, logging, record-keeping;
Drilling Team: well drilling, well construction, well development;
Pump Installation Team: pump installation, headworks construction (with local community), record-keeping;
Community Work Team: community mobilisation, well siting, health and hygiene education, community institutional arrangements, cost recovery; community training, record-keeping;
Pump Maintenance Team: second or third tier maintenance, training and supervision of community pump attendants and second tier technicians, monitoring of pump/well performance.

Impact of programme

The beneficial impact of well-handpump water supply programmes has two aspects, (i) in relation to public health, and (ii) in relation to saving of time and effort. It is important to be realistic about the magnitude of the benefits which can result from this type of water supply improvement.

If well-handpump programmes succeed in bringing about the increases in consumption, mainly for home and personal hygiene (discussed earlier), and also achieve acceptable water quality targets at the point of use and behavioural changes associated with water use, a number of health improvements can be expected[7,10].

(a) Reduction in diarrhoea and water-borne intestinal infections;
(b) Reduction in certain skin and eye diseases caused by poor personal hygiene through lack of sufficient water;
(c) Reduction in water-based diseases such as schistosomiasis and guinea worm to which water users were (and presumably no longer are) exposed at traditional water sources; and
(d) Reduction in intestinal worm infections transmitted by a faecal-oral route.

Furthermore, if water supply programmes significantly ameliorate the load-carrying duties of women and children, some improvement should be expected in their physical health too. However, in none of the disease categories should one expect to see complete elimination of disease or injury, since disease transmission is brought about by numerous routes which may be untouched by water supply improvements.

Esrey *et al*'s synthesis of studies of the health impact of water and sanitation programmes[10] showed that diarrhoea morbidity could be reduced by about 26%, and mortality by perhaps 65%, while reductions in a few particularly responsive infections, such as guinea worm, of up to 78% could be achieved. The most effective programmes are generally those which include water supply, sanitation, and health education components[6].

In relation to time saving, the point has already been made that an increase in the amount of water consumed in the home requires a more than proportional reduction in distance from source to user; if this is not achieved, either consumption will increase at the cost of greater time expenditure, or, more likely, consumption will not increase. The literature contains methodologies[8] for quantifying and valuing time-saving benefits, although the difficulty of adequately valuing women's time will remain an inherent problem in such approaches. In the authors' view, the use of such approaches to carry out

benefit-cost analyses is both invidious and unnecessary. The use of a target maximum time-spent, as proposed earlier, is much simpler and less problematic.

Evaluation

Evaluations of well-handpump water supply programmes are frequently undertaken. Explicitly or implicitly some measure of programme impact (as well as of programme activities) is required. Team, or single-consultant, evaluation visits are often very short, and baseline, or pre-programme, data are usually missing. Against such a background, the authors would question whether it is possible to carry out a meaningful and constructive evaluation.

Evaluation is (in some respects) an unfortunate word, since its main connotation is that of examining and scoring and those being evaluated inevitably feel that a finger of blame may be pointed at them for any shortcomings in the programme. The word 'evaluation' tends to create a defensive attitude on the part of the evaluated, and an assertive approach on the part of the evaluator. A notion of evaluation as a joint, constructive, mutual learning process is more helpful. Indeed, for a short external evaluation to achieve worthwhile results, it should build on on-going internal monitoring and analysis related to objectives such as those in Table 1. Issues which need to be addressed are (i) 'to what extent, and to what standards, is the programme delivering outputs?' and (ii) 'to what extent are the intended benefits reaching the end-user?' These relate respectively to programme activities and user behaviour. Ideally one would measure the impact on the users in terms of health improvements and time savings, but the difficulties inherent, especially in the first of these, mean that one can practically only measure impact indirectly through observing water use behaviour[7,11,12]. Indicators such as amount of water used, hand-washing after defecation and before eating, care of drinking water in the home, and safe disposal of excreta (especially of infants), can be used as surrogates for more direct, but far less accessible measures of health impact.

This approach reflects that of WHO's Minimum Evaluation Procedure[13]. Water supply, sanitation, and hygiene education are each evaluated in terms of functioning and utilization. The first is a measure of the objectives and activities of the project or programme, and the second a measure, via surrogates of the kind just discussed, of impact.

Conclusions

1. The objectives of well-handpump community water supply programmes in developing countries should be stated in terms of quantitative targets relating to intended consumption, time and effort spent in water collection, quality at point of use, source reliability, and cost.
2. In order to achieve such objectives, water supply programmes should include the following activities: (a) well site selection, (b) drilling and well completion, (c) establishment of maintenance and cost recovery systems, (d) health and hygiene education, and (e) monitoring. It should be realized that health and hygiene education and other community work aspects have to operate on a significantly longer time scale than the engineering aspects of such programmes.
3. These activities require appropriate management and technical staff, and community workers.
4. Beneficial impacts of well-handpump programmes in public health and time saving can be expected, but the level of expectations should be realistic. Family, and especially child, health should improve, and the burden on women should be reduced; nevertheless, water and excreta-related disease will still be prevalent, and women will continue to use significant amounts of time and energy on water collection.
5. Rapid evaluations of well-handpump water supply programmes should (a) measure the extent to which the quantified targets set out in this paper have been achieved, and (b) observe, and attempt to quantify, behavioural changes in water use brought about by the provision of improved water supply.

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