Shawcross

Handpump Maintenance.

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HAND PUMP MAINTENANCE

Organizational Considerations for Water Supply Projects in Developing Countries

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Note: This is a draft report intended as a working document for further development. Numbers and costs quoted are based on available literature, some of which is several years old. Such data should be rechecked before general release of any document resulting from this draft.

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PREFACE

Wise pump design or selection may prevent many difficulties, but regular maintenance is the key to reliable pump performance.

The importance of maintenance as a means of avoiding hand pump breakdowns should be brought out more clearly. Lack of authoritive maintenance schemes, and shortage of mechanics all add to the poor performance record of numerous hand pumps. Many rural water supply programmes will need an improved system of maintaining the pumps, if their impact is to continue.

There are no fixed rules to determine which balance of government and village community (or other privately organized) involvement is right for each country. An effective hand pump system is not simply a technological object but a conglomerate of technology, institutions and people.

The selection of a hand pump maintenance strategy and the establishment of an effective set-up for hand pump maintenance require careful consideration of many factors. This study draws on information and experiences from hand pump tubewell programmes in a number of developing countries, and aims at providing guidelines for organizing effective hand pump maintenance.

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D R A F T

CHAPTER 1

DIMENSIONS OF THE PROBLEM

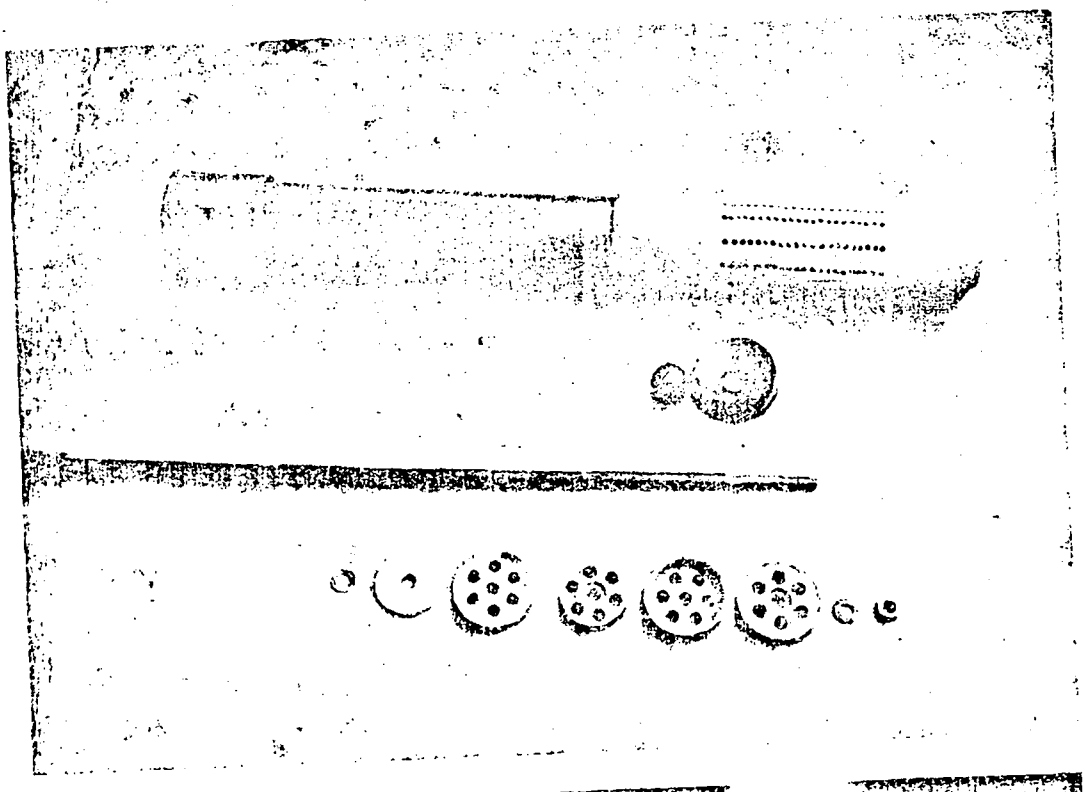
Introduction

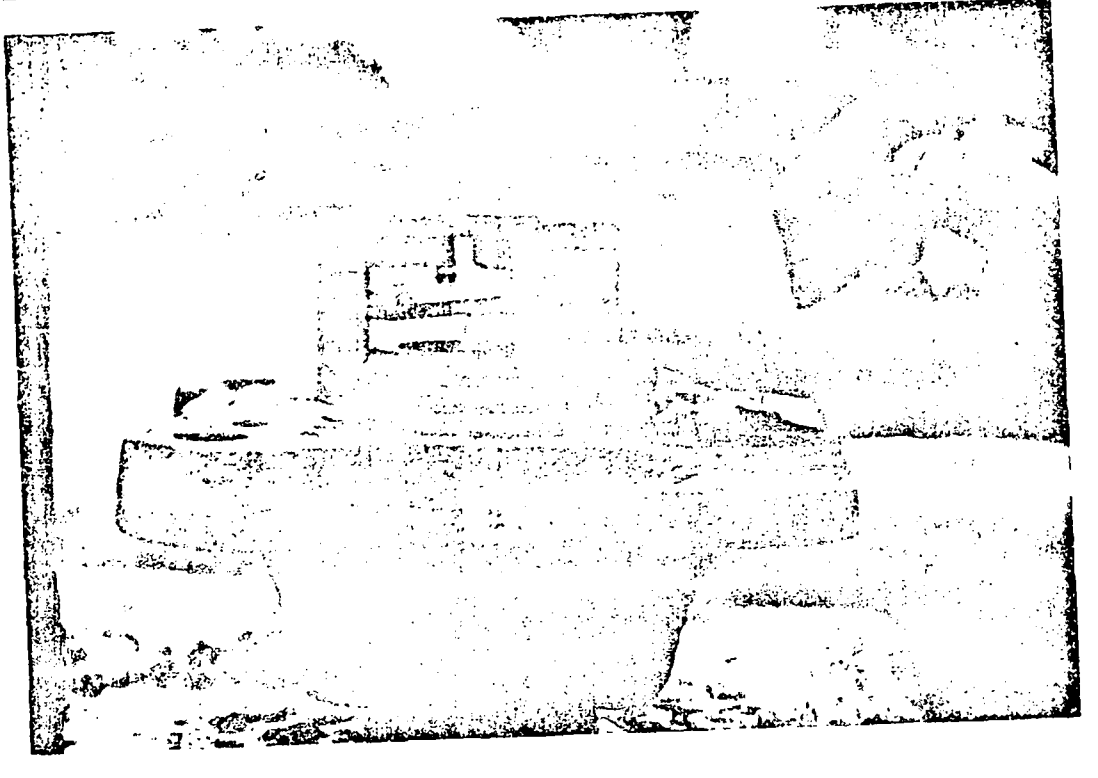
A hand pump is a simple device which can easily be kept in operating condition by periodic maintenance and the occasional replacement of parts. In contrast, it is extremely difficult to keep a large number of hand pumps continuously operating, particularly when these hand pumps are widely distributed in difficult terrain, in a country having a low technological base and relatively few people with managerial experience.

This study concentrates on maintenance organizations in developing countries for water supplies based on small capacity wells fitted with manually operated pumps. It is assumed that some form of maintenance system is required, and can be successful, in all cases where reasonably adequate pumps are installed on competently engineered wells. In this study the technical problems of well construction are not discussed and hand pump selection is discussed only in a general way.

The terms maintenance and repair are often used loosely. The term preventive maintenance describes procedures used to avoid breakdown. These will normally be minor activities such as lubrication, cleaning, bolt tightening, and if necessary replacement of minor parts. Maintenance includes the above, but, also includes the repair of broken pumps. Repair, means bringing the hand pump back into operation after a breakdown.
In practice hand pump maintenance organizations often neglect preventive maintenance, and maintenance organizations became merely repair organizations sending out repair teams when breakdown of the pump occurs.

The necessity for an effective hand pump maintenance system is widely recognized. But despite much attention to the problem the proportion of inoperative hand pumps remains discouragingly high. Reasons for this lack of success are discussed in chapter 2. But, in general, the problem is complex and requires consideration of engineering, management, economics, sociology, administration, education and other diverse factors.





Importance of Hand Pump Maintenance

In developing countries it is important to maintain hand pumps:

- to preserve the health of people solely dependent on the well for safe drinking water
- to maintain in these people the habit of using well water
- to guard against possible deterioration and vandalism of the well itself
- to obtain the full return on the investment in the well construction and hand pump installation
- to encourage consumers to pay for use of the well and to provide an incentive for contributions for new well construction
- so that countries dependent on outside assistance for new well construction can convince donor agencies of the importance of financing further new construction

Economic Impact

The above factors are difficult to analyze from strictly an economic view point. However, economic impact may be assessed, for example, as follows: Bangladesh has approximately 400.000 government owned wells with about 75% in operation. Therefore, about 100.000 hand pumps are out of operation at any one time. If improved maintenance could halve the number of inoperative hand pumps there would be the equivalent of an extra 50.000 operating hand pump wells in the country, the equivalent of a capital investment of about US $ 10 million. Moreover, experience in Bangladesh has shown that hand pumps which remain out of order for more than a few days are likely to be vandalized, have parts stolen, the pump may be removed and the well damaged. In extreme cases, the well pipe material itself has been extracted for private use. There is, therefore, not only the loss of use of the well to consider, but, also the possible loss of the pump or of the well itself. Similar calculations could be made for other countries. In most the percentage of hand pumps out of order would be higher than 25% and the cost of each well would be more.

Health Impact

While the effects of inoperative hand pumps on health are difficult to quantify (Village Water Supply - A World Bank Paper - March 1976 - p. 57), nevertheless a UNICEF:WHO study (Skoda, Mendis, Chia/June 1977*), concluded that there was a correlation between use of well water and reducing diarrhoeal morbidity. The savings in labour time, where other water sources are more distant than the hand pump, which are lost when the hand pump is inoperative, is another adverse effect of inadequate maintenance.

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* Survey in Rural Bangladesh on Diarrhoeal Morbidity, Water Usage and Related [illegible] 1977 UNICEF:WHO Dacca

Social Impact

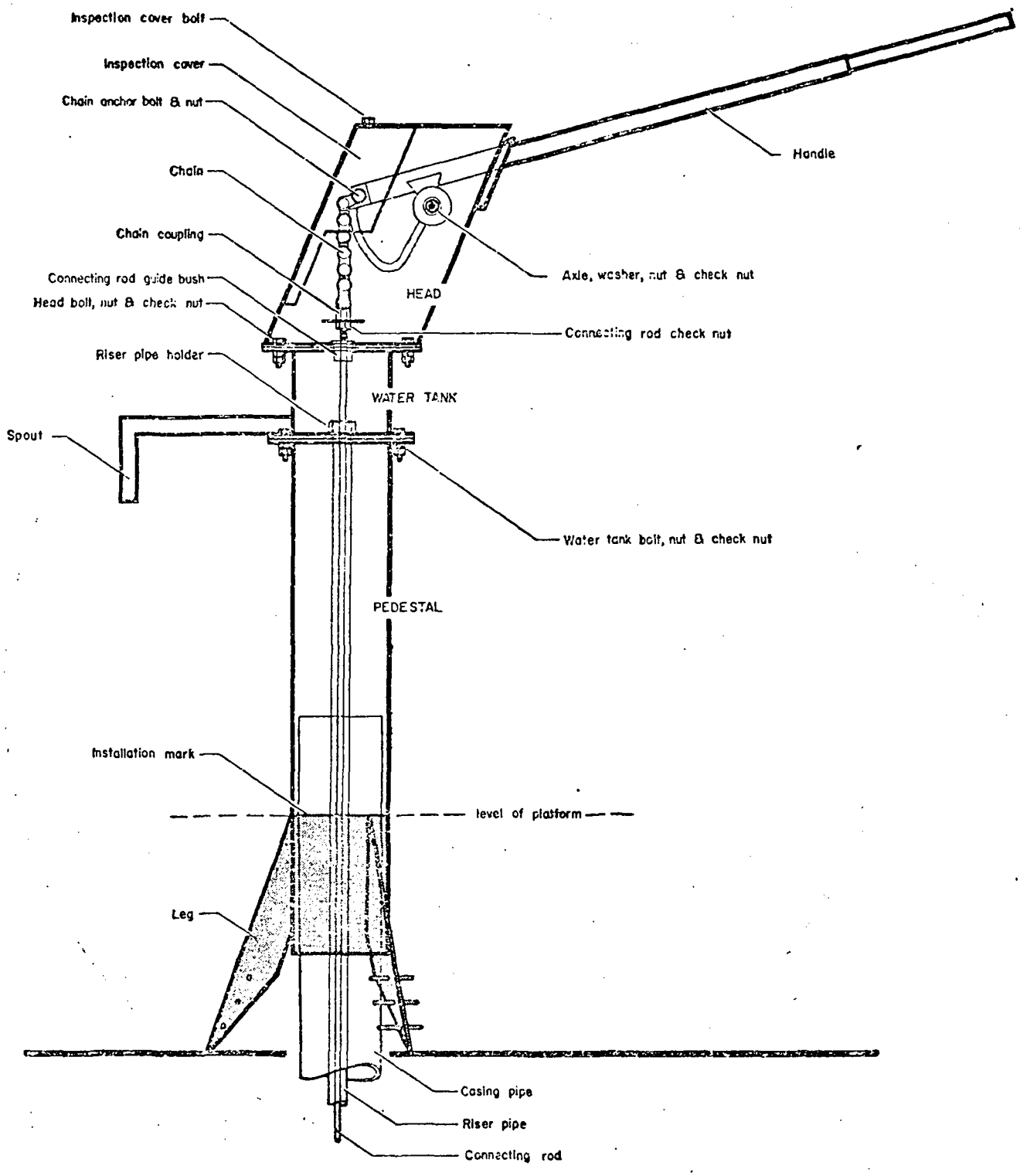
A third area of concern is the psychological impact of inoperative hand pumps. In the village areas where hand pumps can be most important, introduction of the well and pump can be a major event. To obtain maximum benefit, extension activities should accompany the event. This would include information on possible health benefits, correct use of well water for drinking, cooking and perhaps washing, and information on basic care of the hand pump. If the pump should become inoperative and not be repaired, the chance of changing the habits of a lifetime could be lost. Furthermore, if the well has been constructed with financial contributions by the villagers, they may view the loss of service as evidence their contribution was a poor investment and lose regard for the water agency and the government. Collection of periodic funds for maintenance would become even more difficult and news of the breakdown would spread to neighbouring communities and could make it more difficult to expand the hand pump well construction programme. This scenario is speculative and not applicable in every case, but it is clear that poor maintenance must have an adverse effect on the viability of any water system based on hand pump wells.

New Construction and Maintenance

The relationship between new well construction and hand pump maintenance, frequently receives insufficient attention when new projects are planned. A hand pump well construction project requires a long-term commitment to maintaining hand pumps and providing spare parts. Whether the financing for new construction comes from internal or external sources, the relationship between construction and maintenance exists and should be considered from the start if the investment is not to be wasted.

There are many reasons that the relationship between construction and maintenance costs is not fully considered. Sometimes the organization responsible for well construction is different from the organization responsible for hand pump installation, which is again different from the organization responsible for hand pump maintenance. Sometimes, without any real justification, it is hoped that the local community will somehow maintain the well. International donor agencies frequently have funds available for new construction but are not prepared to finance hand pump maintenance, considering this to be a responsibility of the recipient country. For their part, the countries receiving assistance have a legimate need for additional wells, but also find it difficult to make adequate provision for

INDIA MARK-II HANDPUMP



the maintenance of existing hand pumps. It happens therefore, that new construction is sometimes used to replace existing wells and hand pumps which could have been repaired at much less cost.

This bias towards new construction at a high cost instead of hand pump maintenance at a lower cost is clearly unsatisfactory and as a result there is an increasing trend to link new construction with adequate provisions for hand pump maintenance. The objective of these provisions being to avoid the inadvertent generation of maintenance expenditures which cannot be raised within the country. Recent water supply projects in India (Tamil Nadu) and Bangladesh are examples of this trend. The paragraphs presented in Appendix B, extracted from the 1976 'Plan of Operations' between the Bangladesh government, WHO and UNICEF indicate this trend.

The relative proportion of expenditure on new well construction and maintenance would vary with the conditions existing in each country. But for each well constructed between 0.5 and 8 percent of that cost will be required annually for the maintenance of the hand pump. Provision for the eventual replacement of the well is not included in this estimate. The well must be replaced eventually and so the cost of well construction is not the end of the financial commitment. In the range of 3 to 10% of the replacement cost of each well should be committed annually. And therefore dependent on circumstances, in general between about 5 and 15 percent of the well cost is needed annually for maintenance and replacement costs of the well and hand pump. If no way can be found to adequately finance or otherwise arrange for the maintenance of new and existing wells it would be better to postpone major new well construction projects. Instead, attention should be focussed on the maintenance and repair of existing wells and on finding ways to shift the maintenance cost to groups able and prepared to pay. Once the hand pump maintenance problem is under control emphasis could again be moved to new construction.

CHAPTER 2

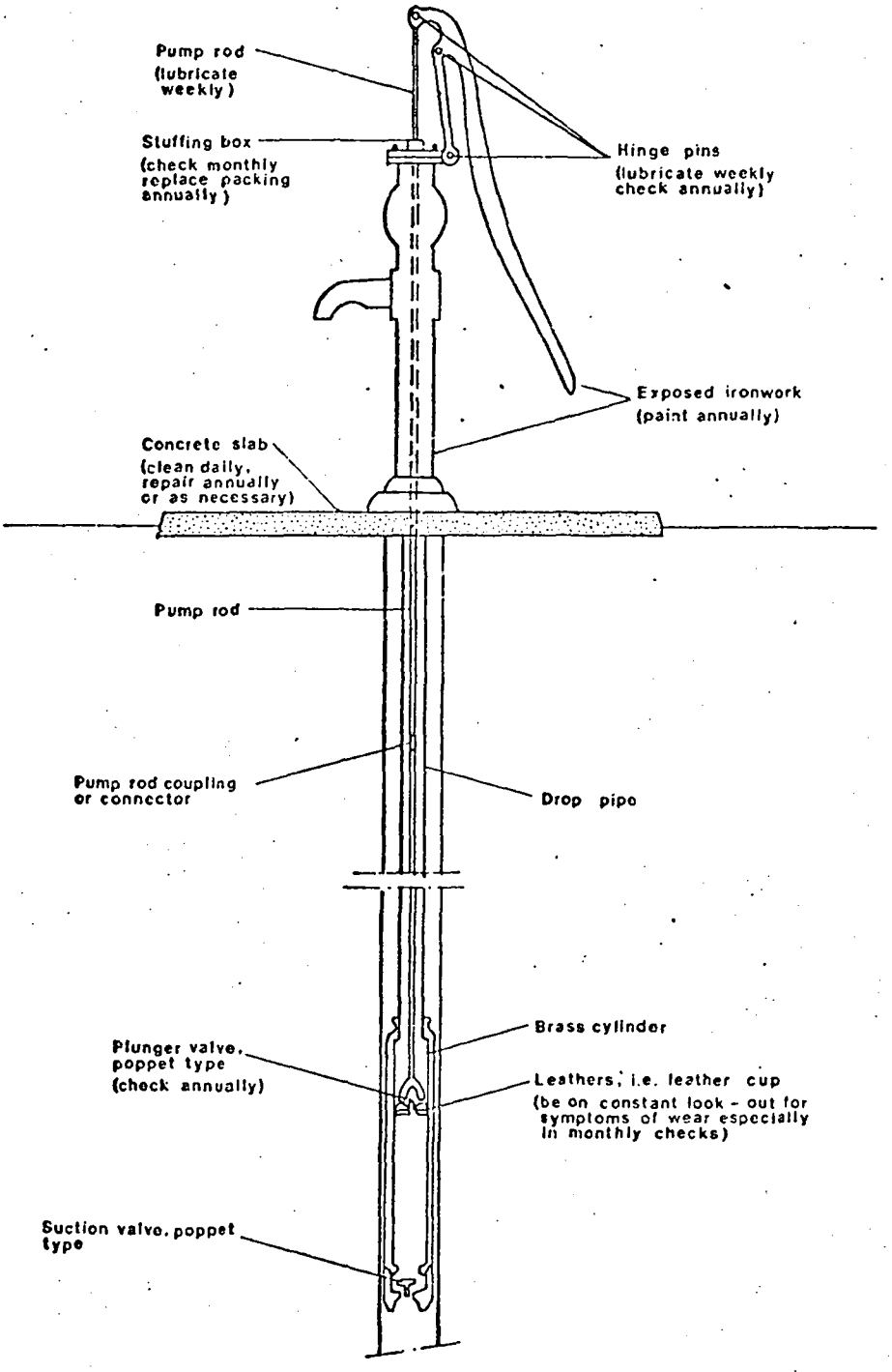
EXISTING SYSTEMS OF MAINTAINING HAND PUMPS

Introduction

Before the hand pump is installed and in operation a maintenance organization should be established to keep the pump in operation. In essence, the following are required:

- That the pump and the surrounding area be kept clean and that any necessary lubrication and bolt tightening be carried out at the proper time.
- That periodically some person with mechanical knowledge and appropriate tools inspect the hand pump to determine whether any parts require replacement.
- That there be a person or team with sufficient equipment to carry out major overhauls and repairs and that this team either periodically visit every hand pump or be informed which pump and well requires their attention and that the financial resources exist to pay for this major overhaul.
- That some organization exists to procure the necessary spare parts for the hand pump and to direct the flow of spare parts to areas of need and that the spare parts be held in stock in appropriate quantities. Some capital investment is required to establish this organization, build up the necessary stock, establish stores and employ staff. The organization must be reimbursed for the cost of the spare parts distributed to the system.
- The spare parts must be manufactured either close to the well, at some more distant location or imported from foreign countries, or parts may be produced from a combination of these sources.
- The raw materials and manufacturing ability must exist, together with the necessary capital investment and manufacturing plant to make the spare parts. This may be local, in country, or overseas. But it must be tied to the maintenance system to provide a flow of spare parts.
- That overall, the managerial ability and financial resources exist to establish and expand the system as necessary, and that the management of the system have sufficient flexibility to respond to changed circumstances and adapt the system and techniques accordingly.

The system or systems may be entirely in the government sector, entirely in the private sector or partly in each sector. They may be organized on a national, regional, or local scale. They may operate independently or jointly, and they may compete or they may cooperate.



MAINTENANCE NEEDS OF HAND PUMP COMPONENTS

(after Pacey, 1976)

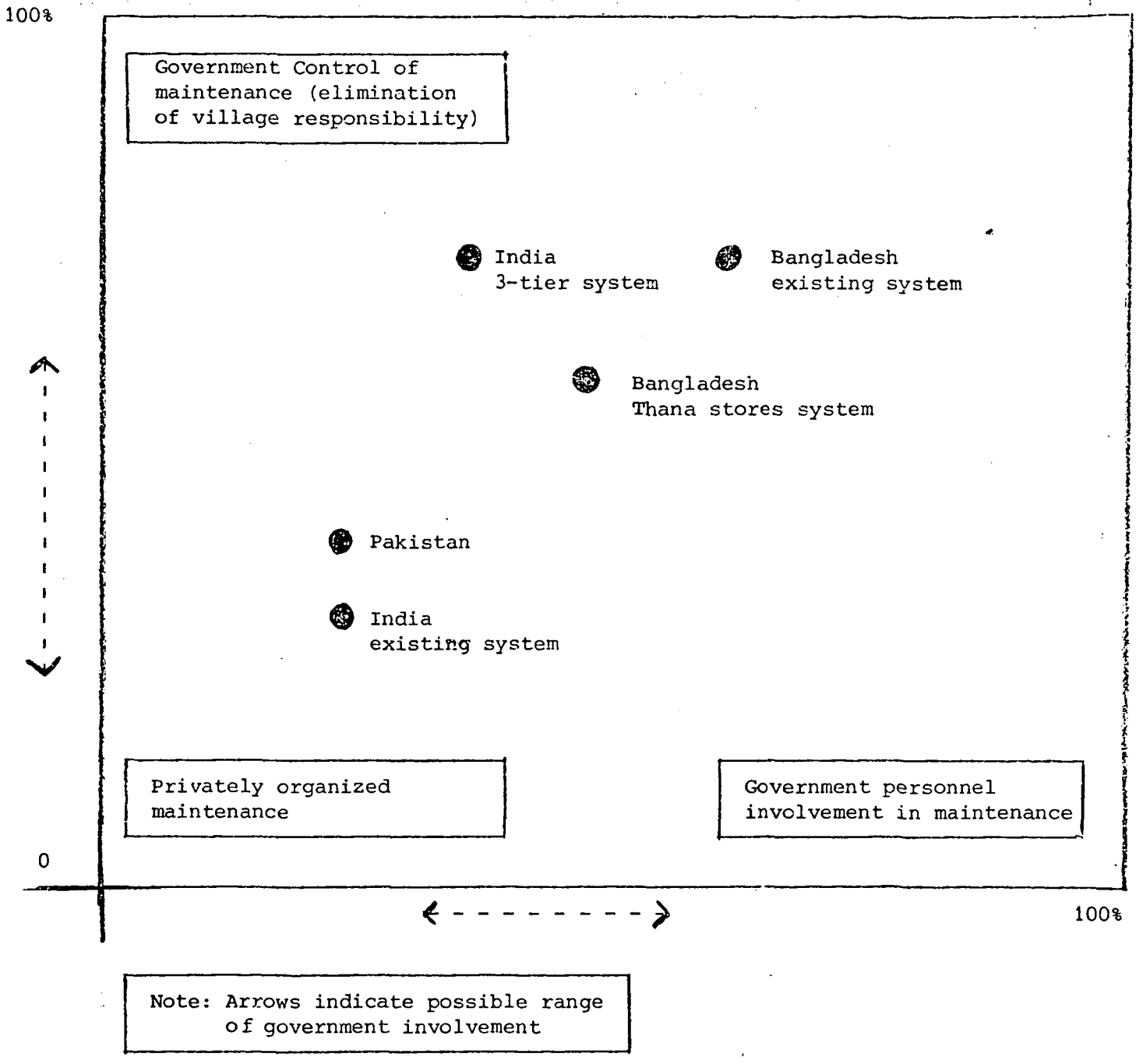


Fig. 2-1 Government involvement in maintenance of hand pumps

Through the history of hand pump use there have been many approaches to the problem of keeping large numbers of people supplied with water from hand pump wells. It is not possible to examine all the variations of the ways hand pump maintenance has been organized. Instead this chapter examines some of the ways used to maintain hand pumps, looks how the choice of pump, maintenance system, and source of funding are related, at how each approach keeps the hand pumps operating, how it succeeds or fails and how much the service costs. Figure 2-1 schematically illustrate the relative importance of government involvement in the maintenance systems discussed.

Privately organized maintenance

Quite frequently, there is no formal government organization for the maintenance of hand pump wells. Where the wells are financed exclusively from private sources this may be acceptable. The owners of the wells and hand pumps have sufficient resources to purchase spare parts, and the market is sufficiently well developed for spare parts to be on sale. In addition, where hand pumps are privately owned, use will be less intensive and the economic involvement of the owner will result in greater care in preventive maintenance than is normal for publicly owned systems.

Where the wells have been constructed and hand pumps provided by the government this method of financing maintenance can also be satisfactory. For success it requires the community to accept responsibility for maintenance and repair and for there to be the necessary resources locally to maintain and repair wells and hand pumps. However, the chances of this approach succeeding decrease in organizationally less advanced areas, in less settled areas and chances of success also decrease as the complexity of the pump increases.

One advantage of a conscious policy of encouraging the private maintenance of hand pumps is that it can bring out local intiative and provide the government with relief from the costs of maintenance. Government resources may then be directed to new well construction and hand pump installation. Success for this approach also depends on the peoples attitude towards the hand pump. Where the well and hand pump are seen as something the government has given without any local action or consultation, then the people will normally wait for the government to maintain the hand pump. However, if the people know the hand pump was achieved after considerable local political action, they feel it is theirs, and know that government policy will leave the maintenance to the local people, then under favourable circumstances they may satisfactorily carry out the maintenance.

A policy of the private maintenance of hand pumps delegates responsibility for hand pump maintenance from the government to the village. Where successful, it is an excellent strategy. But many developing countries do not have the necessary organizational, financial, or technological resources to expect villagers to maintain their own hand pump. In such condition, this system will result in an unacceptably large percentage of hand pumps out of operation, and a waste of the resources the government has invested in well construction and hand pump installation. Furthermore, in the early stages when people are not yet used to using well water, and may in fact prefer the taste of their old water source, leaving maintenance to local action provides a convenient excuse to return to the old ways at the first breakdown. The overall cost of private maintenance will be no less and possibly higher than other systems. However, the cost to the government is greatly reduced. Viewed on a national economic scale, a private maintenance system does require that private suppliers engage in spare part import, local manufacture, transportation, storage etc. And therefore it is quite possible that the foreign exchange costs of a private maintenance could be high. Where use of a very simple locally produced pump is possible, costs can be reduced from those which would result from the same pump and a centralized system. As noted, if the government installs the wells and hand pumps fall into disrepair through leaving maintenance to the users, the loss to the government is immense, both financially and psychologically.

Government controlled maintenance

At the opposite extreme to private maintenance (Fig. 2-1) is for the government to take all responsibility and assume all costs for the maintenance and repair of hand pumps. There are many ways the government structure can carry these duties. A specialist government agency may be established which would be responsible for the maintenance of all hand pumps constructed by the government. It would have offices in the capital city, in the region, in the subregion and at the lowest level in which the government can maintain offices. Alternately the government may establish an engineering organization which would be responsible for hand pumps, roads, electricity transmission and various other services which may conveniently be grouped together.

One advantage of the government taking all responsibility for maintenance is that there is no doubt where the responsibility rests. This is particularly true

This is particularly true, where one organization is responsible for both construction and maintenance. If the hand pumps are out of operation, then either the maintenance organization is at fault or insufficient resources have been reserved for maintenance of hand pumps. One central organization for well construction and hand pump maintenance also has the advantage of permitting the value of good quality construction to be recognized in terms of reduced maintenance costs. The costs of construction and maintenance can be internalized to minimize total cost.

Where the government assumes all responsibilities for maintenance it will arrange for the purchase of spare parts, manage preventive maintenance, provide staff and possibly provide for their accommodation, arrange transportation, carry out major hand pump repairs and, where feasible, renovate wells. Where the government has a very large hand pump programme and where spare parts are locally manufactured possibilities exist for standardisation, economies of scale and use of the governments mass purchasing powers to acquire raw materials and spare parts at low cost.

Where in the organization other functions not directly connected with hand pump maintenance are grouped under a government regional office, there is the disadvantage that the other demands may result in neglected hand pump maintenance. The road construction programme for example, may in a particularly active period take precedence over hand pump maintenance.
An advantage of the regional office approach is that economies are possible in the use of staff, transportation, and other facilities.

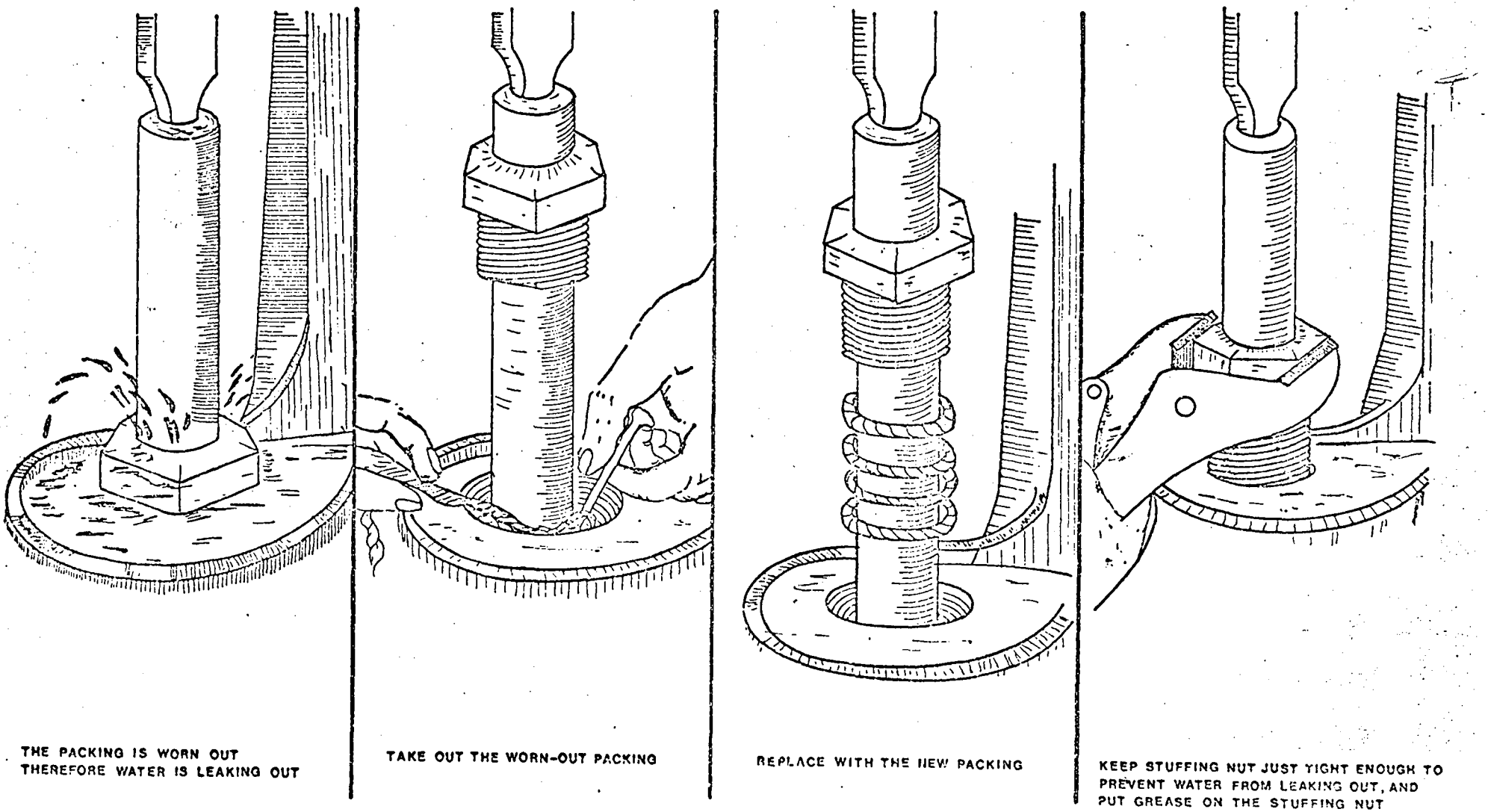
It should be noted that in some countries several government agencies are involved in hand pump construction and maintenance. This may be justified where the importence of hand pump water spplies is low and where the provision of hand pumps is a small part of much larger geographically well disposed schemes. But in general where there are sufficient hand pumps to justify it. The creation of a single agency responsible for hand pump supplies has advantages which increase as the importence of the hand pump water supplies increase in the national picture. Some possible disadvantages of full government control of the hand pump maintenance organization are that, the government loses financially in not obtaining the assistance of the people in maintaining the well, that, the community in failing to participate in the maintenance process will tend to misuse the hand pump, that possibilities of community action to further the advancements

of health educational concepts are lost, and that the system is expensive because the government must employ specialist staff and have heavy transportation costs. There can be no question that any failure to develop community participation and to involve the public in health educational activities is disadvantageous. But the system is uneconomic only when used in relatively sparsely populated areas. As the population density increases a specialist hand pump maintenance organization becomes more cost-efficient and costs of transportation becomes relatively less important.

The internal structure of the organization becomes important when the government exercises responsibility for the maintenance of hand pumps through a single organization. In chapter 3, the organizational structural types known as "flat structure" and "tall structure" are discussed. With an exclusively tall structure, i.e. with many levels of authority between the village and the top of the organization, the flow of information and instructions can be very slow. The system may be satisfactory when responsibility is delegated. But where responsibility is centrally concentrated a tall structure can become ineffective and unable to respond to the needs of the people. The problem increases with the number of, and the geographical spread of, the organization. In one country, a government minister must authorize each well and signs the site drawing. Repair also requires a high level authorisation. While such situations may be feasible when a few dozen wells are installed each year they are plainly impractical for a large construction and maintenance programme. The internal structure of the government organization and ability to delegate authority is therefore important in determining overall success. That power should be delegated to the operational levels is generally true. But in many cases such delegation has been found to result in the misuse of power and of funds. Each case must therefore be judged on its merits.

An example of a government controlled system is given by Bangladesh. The existing Bangladesh system operates as follows. The government purchases spare parts on a bulk scale and collects them into central stores. Spares are distributed according to need and allocation where demand exceeds supply to district and subdivisional level stores. At the next lower level, the thana, maintenance men, normally four in number, each have responsibility for maintaining about 200 hand pumps. They collect spare parts from the subdivisional level stores and bicycle out to the villages to maintain or repair hand pumps. In this system there is no payment by the people for the spare parts.

HOW TO REPLACE WORN-OUT PACKING



PAGE FROM LAOTIAN HAND PUMP MAINTENANCE MANUAL FOR FIELD USE
(original in Laotian and English)

The maintenance mechanics are, in theory, responsible for routine preventive maintenance. However, their role frequently reverts to that of repair man, traveling to the broken hand pump when informed by the local people. The system is one in which the hand pump requires frequent maintenance, funding is by the government, and the whole country falls under one great maintenance organization. Involvement of the people is minimal, exept in the initial selection of well sites and the appointment of a caretaker who is nominally responsible for the well.

A government controlled maintenance system can be economical in a high hand pump density, low labour cost, simple hand pump situation. Total maintenance costs of US $ 5 per pump per year or US $ 0.05 per person per year or less are possible under such circumstances. However, where wells are separated by considerable distances, roads are rough or non-existent, pumps are complex and labour costs high, the costs of maintenance can be very much more. Annual maintenance costs of as much as US $ 125 (Tanzanian shillings 1000) per hand pump (based on two well checks per year) are reported for central Tanzania.

Government construction and repair

In some countries the government constructs wells, installs hand pumps and arranges for any major hand pump repairs or well reconstruction after failure. Preventive maintenance and the periodic replacement of minor parts is the duty of the local authority. An advantage of this approach is that the government can standardize equipment and ensure the satisfactory construction of the wells and the installation of suitable hand pumps. The government may standardize components and the types of hand pumps installed. The disadvantages of this method are similar to those of the private maintenance approach, and also because the government does not develop an organization to carry out the detailed routine maintenance it does not have the capacity to promote health education activities through the maintenance network. However, such activities may be conducted through alternative channels. One danger of the government agreeing to carry out major repairs is that people in the village, knowing that the government will repair the pump will not spend money for preventive maintenance which could avoid a major breakdown.

This type of system has been used in India with generally poor results. (A more comprehensive maintenance system is under development in India, and is described later in this Chapter).

The costs of this approach to hand pump maintenance must be considered in a similar way to the private maintenance costs. However, if mobile teams are held ready for major repair works, dependent on the level of service and location, costs could increase to levels approaching those of government controlled maintenance.

Package systems

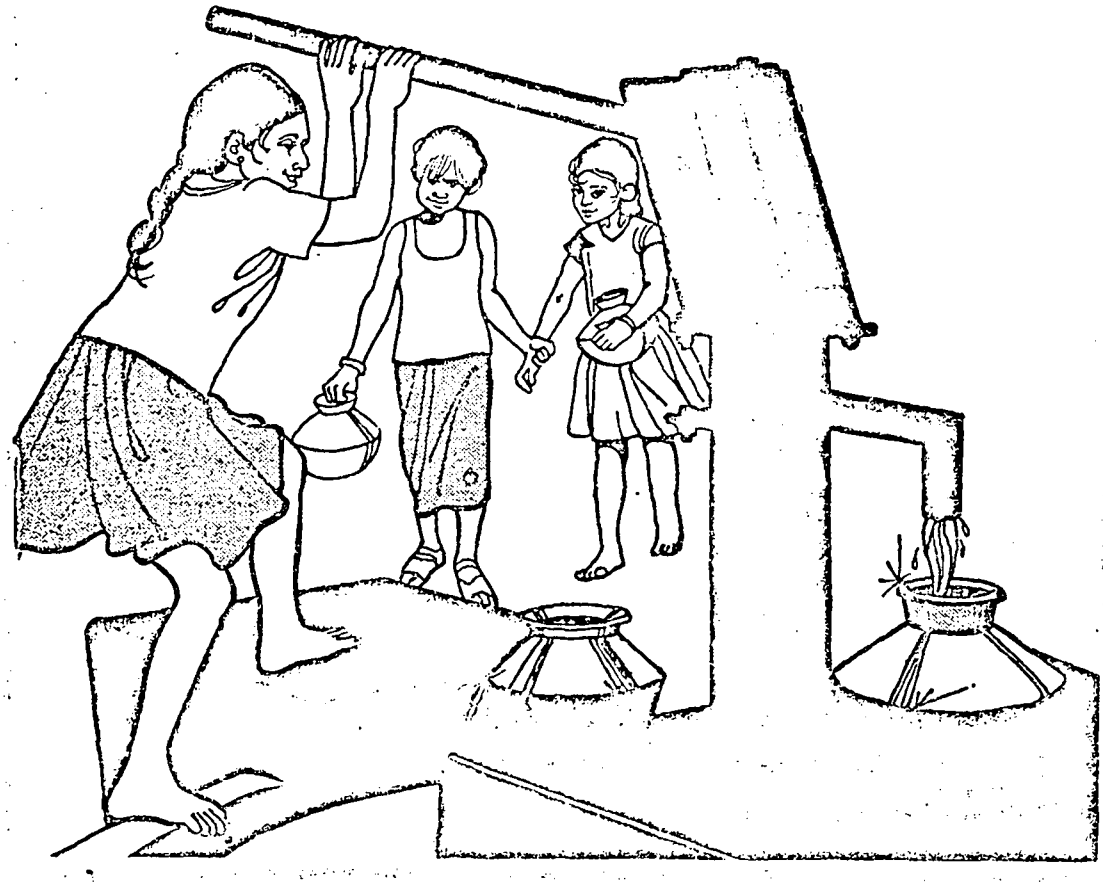
The preceeding three maintenance concepts, no-action, government control, and partial government involvement, describe three frequently used maintenance organizational types. In a very useful booklet, Hand Pump Maintenance, (1977), Pacey suggests three 'packages' to be applied under various situations. In place of privately organised maintenance, 'total village self-reliance' is suggested, based on a very simple locally manufactured hand pump, installed and operated by local village people. Such pumps have been developed. Bamboo pipes have been used to pierce confined aquifers and develop flowing wells in various places and bamboo, wood and even welded sheet steel pumps have been developed at various times and places.

In place of government controlled maintenance, Pacey speaks of the elimination of village level responsibility by the installation of an extremely robust pump which requires maintenance only very infrequently and which could therefore be maintained by government employees making infrequent visits to the well. This concept is most applicable in areas requiring deep well pumps and with a sparse population spread over difficult terrain. However, this is not the only way the government can effectively take control of maintenance.

The third package is for partial self-reliance using factory made pumps. This could be similar to the type of government construction and repair organization recently prevalent in India but with greater emphasis on community participation to carry out hand pump maintenance. However, the partial self-reliance package does not describe how spare parts would be distributed or financed.

In addition to the useful detail in the pamphlet, Pacey's major contribution to understanding hand pump maintenance problem is in emphasizing the relationship between the pump selected and the circumstances of its use. In chapter 3 this concept is expanded to more fully consider the relationship between the pre-existing situational factors and the choice of pump, organization and maintenance funding.

GUIDE TO SELECTION AND TRAINING OF VILLAGE HANDPUMP CARETAKERS



Evolving large scale maintenance systems

The following sections describe recent developments in India and Bangladesh where maintenance systems considering the needs and inter-relationship of pumps, people and organizations have been developed to overcome local maintenance problems. These approaches are also of significance in other countries.

India Three-Tier Maintenance System

Until recently in India the government, through the State governments, constructed wells and installed pumps, but left pump maintenance to the local communities. In a few years many as 80 per cent of the completed hand pumps were inoperative. Efforts were made to find a better hand pump and discover what could be done to improve hand pump maintenance. The new system, referred to as the three-tier maintenance system, was first used in the State of Tamil Nadu. This system has been successful in reducing the number of inoperative hand pumps. The maintenance system is described in a UNICEF publication entitled 'Guide to Selection and Training of Village Hand Pump Caretakers', a short booklet which illustrates how the community may be involved in maintenance and how attention to the health aspects of pure water use may be increased. The follcwing description of the system is abstracted from the booklet.

> The three-tier maintenance system provides for staff at village, block and district level to look after all hand pumps.
>
> At village level: In the villages there is a hand pump caretaker appointed by the community. He ensures that the hand pump is working properly, that there is proper drainage of exess water, that there is some sort of control over the use of the hand pump to ensure that it is not abused, and that the villagers are aware of the importance, for health reasons, of taking drinking water from a protected source. If a hand pump breaks down it is his duty to report it to the district maintenance team.
>
> At block level: There is one inspector-mechanic whose duty it is to regularly visit and check approximately 100 hand pumps. He reports breakdowns that he cannot repair to the district maintenance team. He is equipped to repair minor faults in the pump head mechanisms.
>
> At district level: Each district has one or more mobile maintenance teams which can quickly reach and repair any hand pump that breaks down. These teams consist of three men under an assistant engineer, equipped with a vehicle.
>
> Mobile maintenance teams carry the tools and spare parts needed to do any type of hand pump repair job. They also install new conversion heads on old hand pump installations.

Hand pump caretaker: The first tier of the new maintenance system - the village caretaker - is crucial to the success of the system. Unless the Tamid Nadu Water Supply and Drainage Board staff is informed promptly when a hand pump breaks down repars and delayed and the whole maintenance system breaks down.

The pump selected for use with the three-tier maintenance system is the Indian Mark II deep well hand pump. This was carefully tested and may be categorized as a robust unit requiring only infrequent major servicing. The village level caretaker is a volunteer and receives no payment from the government although his position may provide some non-monetary rewards and he may receive some allowance from the local community. Maintenance is shared between the caretaker in the village, the inspector-mechanic at block level, and major repairs are handled at district level by the mobile maintenance team. The cost of maintenance is principally the governments but by providing a caretaker on a voluntary basis the community is involved in the care of its pump. During training the hand pump caretaker is informed of the importance of good health habits and of using a pure water supply. It is intended that he will become a health education advocate in his village.

The mobile team will use a service exchange system. This means that rather than carry out repairs at the well site an exchange new or reconditioned unit would be fitted and the used unit returted to the workshop for service. This process speeds up the work of the mobile team, ensures that they leave the hand pump in good condition and allows repair work to be conducted under controlled conditions.

The costs of three-tier maintenance system have been estimated for service to 500 wells and hand pumps as follows:

	Annual cost, US$
Vehicle depreciation	1.052
Mobile team salaries	1.176
Fuel etc.	1.200
Local staff (excl. caretakers)	1.400
Spares and contingencies	5.172
	US$ 10.000

Based on 500 wells annual maintenance cost is US$ 20 per well. This does not include any allowance for the caretakers expenses which in other areas might have to be paid locally. However, the contingencies included are sufficiently large to include this item.

It is too early to judge whether the three-tier system will have the enduring beneficial effects desired. But the system appears to have a good chance of success. UNICEF project staff have concluded as follows, "until the local bodies at block level are upgraded to cope with maintenance, or we can design a deep well pump that they can maintain.... then there's no doubt in our minds that only a governmental structure at this point in time can successfully effect viable maintenance".

Bangladesh Thana Stores Maintenance System

Bangladesh has a better record for hand pump maintenance than many other countries. However, twenty-five per cent of wells out of order at any one time is considered too high a proportion and the existing system requires the government to entirely pay for the cost of hand pump maintenance.

With 400,000 hand pumps in operation and an annual maintenance cost per hand pump of US$ 3 in spare parts, and US$ 2 in establishment costs, the total annual expenditure on hand pump maintenance is 2 million dollars. For only 2 million dollars hand pumps serving almost 40 million people may be maintained in operating condition. But in a country with a gross national product of only $? it is difficult to make US$ 2 million available and the maintenance sum increases as more pumps are added to the system. It is therefore desirable to transfer the cost of maintenance from the central government to the people.

The existing system in Bangladesh was described earlier. The following modifications were proposed to make it possible to charge the people for the cost of hand pump maintenance. The central government would continue to purchase locally and, where necessary import, all spare parts. These would be stored by the water authority. From these central stores, spares would be distributed to government stores at the subdivisional level. The government would establish small new stores at the thana level, an additional 350 stores, throughout the country. At the thana level would be a government sub-assistant engineer supervising a group of government maintenance men. At the next lower level, the union level, each union would appoint a union maintenance man who would be paid a small salary by the union and would have the duty of maintaining all hand pumps in the union. The cost of the spare parts required in the union, would be borne by the union budget. The necessary funds for spares could be raised by local taxation or by directly charging for spare parts. The system would operate as follows. The government would obtain additional spare parts and send them to the thana stores. The union maintenance man would service hand pumps in the union, installing any necessary spare parts.

He would purchase spare parts from the thana stores. Each hand pump would continue under the direct charge of a caretaker. The caretaker is generally a responsible person living close to the well who would receive some training from the government with regard to proper care of the hand pump and some health education training. Part of his duties would be to keep the area around the hand pump clean and carry out the most routine maintenance. He would also be expected to keep a record of the visits of the union maintenance man, and in the event of pump break down, he would inform the union mechanic. The government employed maintenance man at thana level would be expected to carry out the more major repairs. For example, in the event that the well itself became clogged with sand they would be expected to cleanse out the well and so prolong the life of the entire installation. This new system has been tested on a pilot scale and may be generally introduced with some modifications for the entire country during the next few years. The system is not perfect and adds to the cost of hand pump maintenance. But, it does offer the first possibility in Bangladesh of transferring the cost of maintenance from the government to the people and increasing local involvement in hand pump maintenance.

The thana stores system does not raise capital for the eventual replacement of the well. It is not known at this time what the life of the new wells based on PVC pipes and PVC well screens will be, but it would seem that a life of between 10 and 30 years may be expected. It is therefore necessary to reserve in the order of US$ 10 per year to provide for the eventual replacement of the well and hand pump. By pricing the cost of spares supplied by the thana maintenance system above cost price, it would be possible to raise money towards the eventual replacement of well and hand pump. However, there is an upper limit to how much can be charged for hand pump spare parts which is imposed by the cost of spare parts on the private market. Some other mechanism will therefore be necessary for finance the full cost of the replacement well and hand pump.

Assessing Existing Maintenance Systems

It is not always possible to clearly separate the efficiency of a maintenance system from the abilities of the people staffing the system. A system may not be working well but better results could be obtained with different staff. For example, a group of agricultural extension workers discovered that some 80 per cent of the hand pumps in an area they were working in were out of order. They proposed to take responsibility for maintenance in this area and, as an experiment, the government agreed. The system used had been for the government employed maintenance

RIVERS STATE
RURAL WATER SUPPLY SCHEME

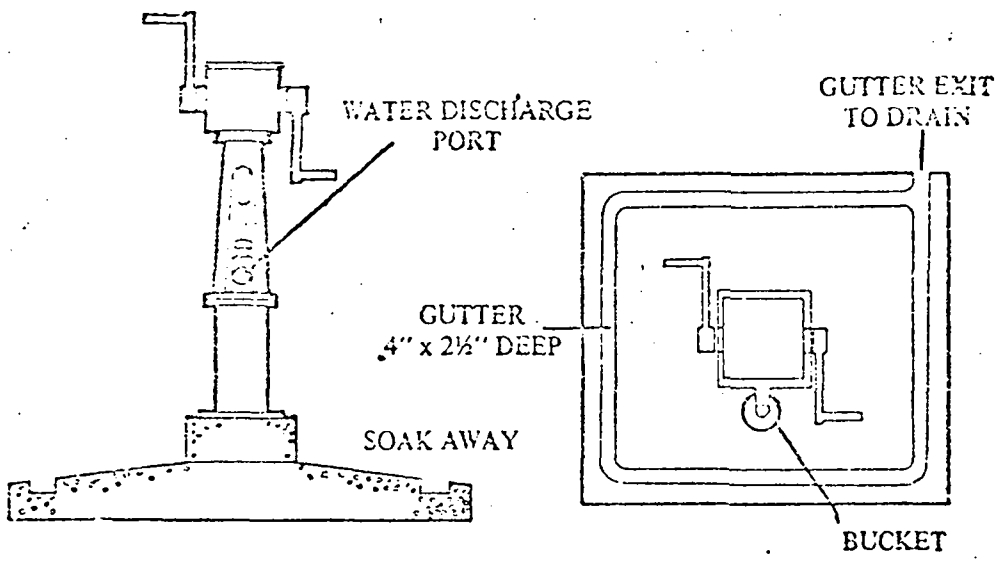


Figure 2: Mono-lift pump in Nigeria – detail of top end, (by permission of MONO PUMPS ENG. LTD).

Below: Instructions aimed at users

IMPORTANT

1. IT IS THE DUTY OF THE VILLAGE/TOWN PLANNING COMMITTEE TO ENSURE THAT ALL PEOPLE KNOW HOW TO USE THE PUMP CORRECTLY
2. DO NOT TRY TO FORCE OR JERK THE HANDLES ROUND OR APPLY ANY MECHANICAL MEANS IF STIFFNESS IS ENCOUNTERED REMEMBER THIS IS A HAND OPERATED PUMP.
3. A SLOW EASY ROTARY MOVEMENT IS REQUIRED TO OPERATE THE PUMP – CONSTANT USE WILL RELIEVE ANY STIFFNESS.
4. DO NOT LET CHILDREN PLAY WITH THE PUMP – IT IS NOT A TOY.
5. REMEMBER THIS PUMP IS YOUR GATEWAY TO A BETTER HEALTHIER LIFE: IT'S WORKING LIFE WILL BE DETERMINED BY THE WAY YOU LOOK AFTER IT.

man to obtain spare parts from a government store and bicycle to a group of hand pumps each day for maintenance and necessary repairs. The maintenance men complained they were issued with insufficient spare parts to do their duties. But there is a possibility that they sold part of their stock to private hand pump owners. New maintenance men were recruited by the extension workers and received training from the government. The overseer established a card for each hand pump. On this card was space to fill out lines of information for each visit to the hand pump. Data included on the card (see figure 2-1) would be location of the hand pump, date of the visit, any spare parts fitted, and the signature of the caretaker of the hand pump. The supervisor agreed with each maintenance man a routine for visiting each well once per month. During the month, while on other duties, the supervisor checked the condition of three or four hand pumps chosen at random. If more than one hand pump was found, requiring attention, it was taken as evidence that the maintenance man was failing in his duty. The mechanic was aware that his job could be terminated for cause. The information on each hand pump visited, was returned each day to a card index system in the office of the supervisor. After six months over 90 per cent of the hand pumps in the area were in operating condition, Having overcome the backlog of work and bringing the hand pumps up to a superior condition it was found possible to reduce the frequency of the visits to once every two months and service a greater number of wells. It should be mentioned that by reason of his strong personality the supervisor was able to ensure that he always had a stock of spare parts from the central stores. It also required a literate maintenance man - not always the case with government staff. The experiment, while showing that the maintenance system could be made to work, did not demonstrate that it could be made to work on a country-wide basis with the available quality of staff.

Table 2-1 Maintenance Man's Report and Card Index File Card

Hand Pump Maintenance Report

Well location ---------

Thana --------- Union ------ Village ------ Caretaker -----

Hand pump type ---------

Date visited	Hand pump condition	Maintenance man signature	Spare parts fitted	Comments	Caretaker signature
Dec. 10 '77	good		1 bolt+1 cup		

(12 lines of data - for one year)

It is sometimes difficult to judge the adequacy of a system by results. It may be that the system is adequate except for one or two aspects. In the example shown, the system failed in that, the staff appointed to maintain the hand pumps was not competent, and/or the government organization was unable to secure adequate performance from its staff. The failure of the people in the villages to demand and obtain better hand pump maintenance service is another important factor and is an indication of the political development of the society and would differ from one country and time to another.

For comparison, a contrast to the maintenance report sheet shown by table 2-1, table 2-2 gives a report sheet developed under different circumstances.

TAMILNADU WATER SUPPY & DRAINAGE BOARD

Hand pump Maintenance Record

VILLAGE .....
PANCHAYAT .....
UNION .....
DISTRICT .....

PUMP No:
DEPTH OF BORE :
WATER LEVEL :
DATE OF INSTALLATION :

DETAILS OF REPAIRS	DATE OF REPAIR	DATE OF INTI-MATI-ON	NAME OF MACHANIC	REPAIR ATTEN-DED DATE	DETAILS OF REPAIRS ATTENDED	DETAILS OF SPARES USED	REMARKS

Table 2-2 Maintenance Report Sheet from Tanzania (Shinyanga Project).

Periodical Check-up								
Date of check/repair	Controlled/ repaired by	Well dry?	General impression of well cover	well surrounds	pump	Pump repaired	Water sample	Remarks/ action taken
30-2- 76	maintenance	no	ok	mess	ok	-	yes	drain cleared out

To asses the relative performance of hand pump maintenance systems world-wide, it would be valuable to have a country survey covering many of the relevant points discussed. The survey could be conducted by circulating a form to be completed and with an example or examples of how the form should be completed in one of the major languages spoken in the area.
On collection of the data, it would be possible to more thoroughly assess the performance of the different systems and compare results with the system selection model, proposed in chapter 3. A suggested questionnaire is presented in table 2-3 (the table shown would have to be considerably reworked and tested before it could be used).

Some data are available on the cost of some hand pump maintenance systems mainly in South-East Asia. There are summarized in table 2-4.

Table 2-3 General contents possibly included in a questionnaire survey of hand pump maintenance systems - world wide

Survey of Hand Pump Maintenance System

A. Country data

Country — Area — Population
Gross national product — Per capital income
Annual rainfall — Population with 5-10 yr education — %
Topography — Population with 10- yr education — %
Political system — Literacy rate — %
Religions (give percentages)

(It is suggested that before circulating the form, the known data from other published sources such as much of the above be inserted - check data, incountry only)

Table 2-3 (continued)

B. Hand pump details (fill out data for each main hand pump category)

Number of hand pumps: ———— privately owned, and ———— government owned

Types of hand pumps in use (enclose drawings, if available)

Names of manufacturers
Deep well pump (raises water more than 9 meters)
Shallow well pump (raises water less than 9 meters)
Pump stand material (castiron/steel/wood/plastic/fibre glass/concrete/ other (specify) ————)
Pump cyliner material (castiron/steel/wood/plastic/fibre glass/ other specify) ————)
Cost of hand pump (incl. of cylinder and riser pipe)
Average length of riser pipe

Hand pump manufactured (a) in many parts of country
(b) in a few places in country
(c) in one location in country
(d) imported

Spare parts (a) all made in country
(b) mostly made in country
(c) some made in country
(d) all imported

What is the average depth of wells ———— meters

What is the average depth to water table ———— meters

C. Maintenance of hand pumps on wells financed by private persons

Does the government assist private persons to construct wells for hand pump supplies (if so, in what way) ————

Does the government help service privately owned wells ————

Where do private persons obtain spare parts for hand pumps ————

Who services the privately owned hand pumps ————

What would be the annual cost of maintenance for each privately owned well ————

D. Maintenance of hand pumps on wells financed by government

Who owns the hand pump? (a) government (b) other (specify) ————

Who has principal responsibility for hand pump service? (a) government (b) user

Who pays for spare parts fitted to hand pumps? (a) government (b) user (c) ————

Who carries out daily hand pump care? (a) none (b) user (c) government employee

Table 2-3 (continued)

Who installs small spare parts? (a) user (b) government) (c) other ——— (specify

Who repairs major breakdowns of hand pump (a) user (b) local govt. team (c) other ——— (specify

How many persons are employed by govt. with responsibility for the maintenance of hand pumps ———

Who: purchases hand pumps initially ———
purchases replacement hand pumps ———
purchases hand pump spare parts ———
stores hand pumps centrally ———
distributes hand pumps to local stores ———
locally stores hand pumps ———
transports spare parts to the hand pump ———
has a set of tools for hand pump maintenance ———
maintains the platform or area around the hand pump ———
replaces or renovated the well in case of failure ———

Generally describe the division of responsibility for hand pump maintenance between central government, regional government, local government, the hand pump users, and any other groups involved in maintenance.

_____

_____

_____

_____

How many people on average use each hand pump ———

What is the average separation between hand pumps in areas where hand pumps are in use ———

How many hand pumps are there per 100 hectares (?) in areas where hand pumps are in use ———

What is the average quantity of water per minute produced by the average hand pump _____ l/min

Table 2-3 (contined)

E. Financial Aspects of Hand Pump Maintenance System

What is the annual government budget for purchasing hand pump spare parts ————

What is the annual government budget for maintenance staff ————

What is the annual government budget for stores for hand pump sites ————

What is the annual government budget for transportation of materials to hand pump sites ————

What is the annual government budget for other hand pump spares materials ————

Overall, how much money annually does the government spend on hand pump maintenance ————

Does the government collect money from hand pump users for maintaining wells and hand pumps yes/no

If yes, how much anually ————

Is any money collected from hand pump users to pay for the cost of replacing the well at the end of its service life yes/no

If yes, how much and by what method ————

————

————

F. Results of Maintenance System

(i) For government wells

What is the average age of wells in the system ————

What is the average age of hand pumps in the system ————

What percentage is at present in operating condition ————

Of those not working, what percentage is not working

due to (a) well failure ————
(b) hand pump failure ————
(c) other (specify for substantial numbers) ————

(ii) For privately owned wells

What is the average age of wells in the system ———— years

What is the average age of hand pumps in the system ———— years

What percentage is at present in operating condition ———— per cent

Of those not working, what percentages is not working

due to (a) well failure ————
(b) hand pump failure ————
(c) other (specify for substantial numbers) ————

Country	Typical Cost ($) Well + Pump	Persons Served	Percapita ($) Annual Maintenance Cost	Maintenance Responsibility	Percent Wells In Operation %	Comments
Bangladesh	$ 200	100	$ 0.05	Government	80	Shallow well pumps. Bicycle service men.
Burma	200	150	0.05	Government	?	Serviced by mobile units.
Ghana (Upper Region)	300-2000	200	0.35 ± (1)	Project	90 ±	Test project for maintenance costs.
India (1)	800	500	0.04	Most Government Part Local	85 ±	Three tier system.
India (2)	700	500	Local Choice	Local	20	Old system.
Indonesia	200-400	100	?	Not defined	?	Price range for shallow/ deep pumps
Nepal	200-500	100	0.07	Local	?	Higher capital for artesian wells.
Tanzania	1500 ±	200	0.6 (1)	Project	90 ±	Project at present-future split Governmen and people.
Thailand	$ 900	150	?	Local/Government	?	Responsibility split various (6) government agencies plus local people.

Note (1) The very much higher maintenance costs for the two African examples (Tanzania and Ghana) are notable. This may be due to: (a) More accurate consideration of overhead costs in these two projects, (b) Greater transportation due to low well density, (c) Inflated effect of expatriate involvement on salaries, and (d) Inefficient system of maintenance (Too much transport from a distance-not local stores with local labour).

CHAPTER 3

MAINTENANCE STRATEGIES AND MANAGEMENT STRUCTURES

Introduction

Presented in this chapter is a procedure for deciding which category of hand pump maintenance organization will be most effective under any given set of conditions, and how the outlines of the organization may be filled out after taking the basic decisions. There are so many factors to be considered that decision making is complex. But the complexity may be reduced by approaching the problem in stages as follows;

1. Select a strategy, including:
   - the type of pump(s) to be used
   - the type of maintenance organization
   - the way maintenance will be financed

2. Determine the specification of the organization; that is, decide how the maintenance system will be staffed and trained, and how the practical problems of obtaining and moving maintenance materials will be conducted.

3. Select the structural characteristics of the maintenance organization, and distribute responsibility.

Figure 3-2 illustrates this procedure.
Before proceeding to this three stage approach, some general observations on factors influencing the structure of the maintenance system are introduced.

Many of the individual factors which influence a decision about the maintenance strategy may be contradictory. For example, the necessity of using deep well pumps may suggest that a pump be selected which has a long interval between maintenance periods. But a high density of population may suggest that maintenance should occur at short intervals of time. Therefore, when deep well pumps are required in a densely populated community, one must decide whether to seek a pump which requires service at long intervals of time or a pump which requires frequent service. Increasing community participation in hand pump maintenance often results both in better maintenance of the hand pumps and the development of a capacity for other activities such as the dissemination of health education concepts and information literature. Therefore, although a government sponsored

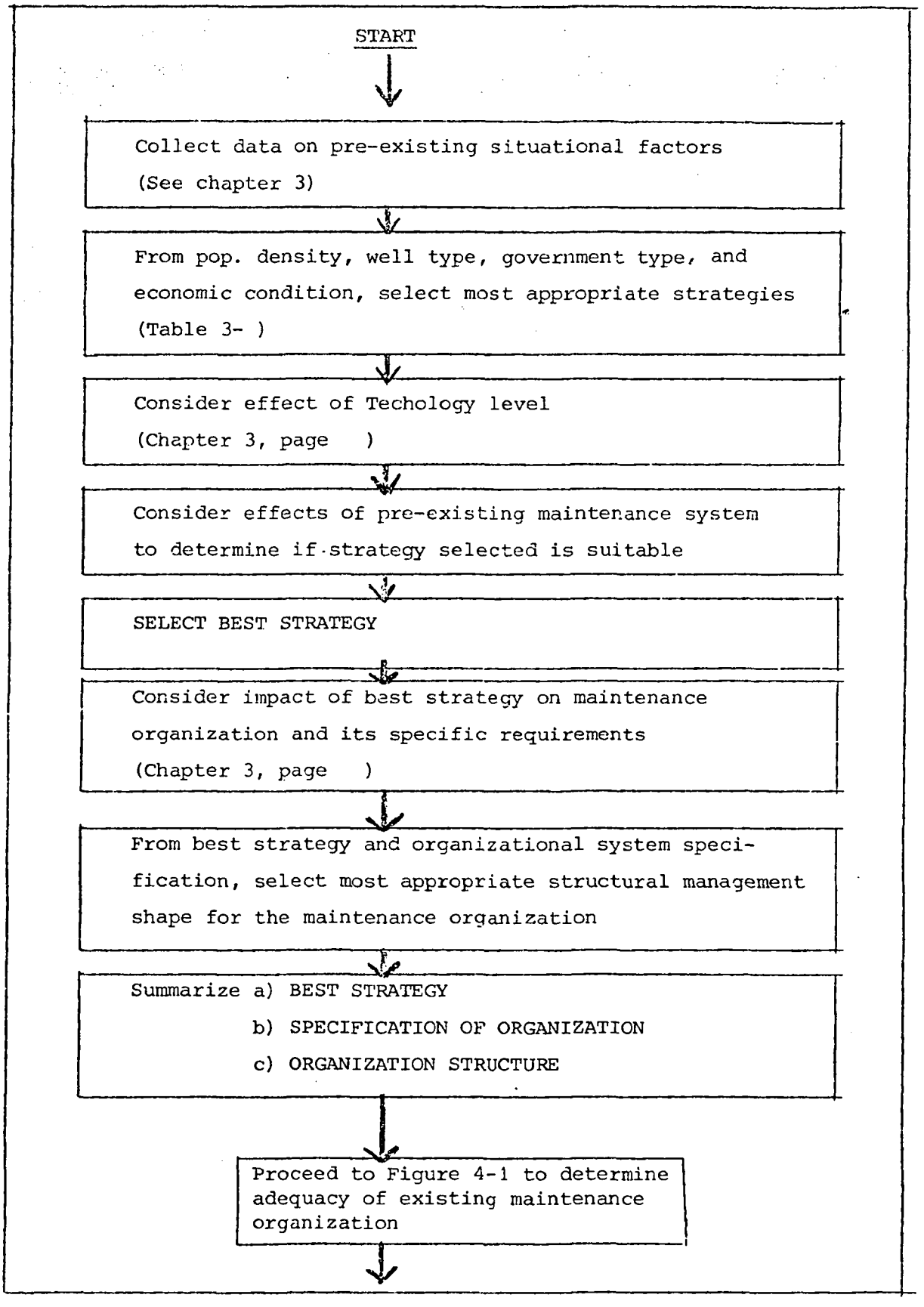


Figure 3-2 Flow procedure to determine best organizational characteristics

maintenance system may seem to be the best system available under the existing conditions, on general principles, increased community participation may be preferred in order to obtain long-term maintenance improvements and improved health educational capacities.

Community participation may mean a contribution of labour by the local community to construct a well, to maintain the pump, and to cooperate with government in health education activities. Or community participation may mean involvement in the site selection process and the contribution of money towards the cost of constructing and maintaining the well and hand pump. The contribution of physical labour is the most direct form of community participation, but, in developed countries this kind of community participation is minimal. Water systems are financed, constructed, and maintained through taxation processes. It is often difficult for the citizen to connect the taxation process with construction and maintenance of the water supply system. Developed countries have found community participation in the physical sense to be less appropriate than financial participation and some political involvement. Therefore, it is not appropriate to limit the concept of community participation to mean only the voluntary contribution of labour.

The relationship between the government and private industry is an important factor in each country. In an advanced market economy private industry may conduct much of the business which in a less developed economy or in a socialist society would be conducted by the government. For example, the distribution of hand pump spare parts may be conducted by local businessmen, manufacturing and distributing spare parts throughout the country. Similarly, the government may manufacture spare parts at government owned factories and distribute them through a system of government stores to the villages. These systems may operate in parallel. Government installed wells may be serviced by the government system and privately installed wells may be supplied by the private sector. The actions of government can sometimes stifle the development of the private intiative, while in other areas a well developed private sector may discourage government involvement. However, in some cases the introduction of hand pumps by government programmes may stimulate the private sector to become involved in hand pumps and if permitted, the private sector may take over the further expansion and maintenance of the hand pump system. Opinions differ on the benefits of competition between the government and the private sector but where private citizens are able to finance their own wells and hand pumps, this will reduce the cost to the government of providing water for all its citizens.

One question is whether maintenance should be a responsibility of the government or of the community. The extreme positions of all government or all local responsibility would be unusual. In most cases partly central government, partly local government and partly village level inputs will be most suitable. There are some things such as the procurement of spare parts which are best handled by the government. There are some things such as cleansing the hand pump platform and surrounding areas which are best handled by the community.

Prior to further analysis five assumptions are stated.

1. There are a large number of factors contributing to the choice of maintenance strategy but it is possible to weigh these factors to determine which of the possible strategies will be most appropriate.
2. There are advantages to be gained from increased community participation, providing that the community accepts increased participation.
3. Where private citizens organize themselves to maintain their own hand pumps this should be encouraged.
4. The management of hand pump maintenance should be handled at the lowest organizational level, commensurate with efficient operation.
5. In selecting the mix between government and a local involvement there will be areas in which central government can act most efficiently, areas where intermediate level government can have the greatest impact and areas where local involvement is essential.

The three stage analysis procedure first considers the choice of strategy involving the mix of pumps, organisational level and maintenance funding.

Analysis Procedure

In this analysis two types of factors are considered a) situational factors, and b) choice factors.

Situational Factors

These factors are the basic data situation in the area and will determine what kind of maintenance strategy will be most effective, they are:

- the type of pump required
- the population density in the area
- the government structure
- the economic circumstances of the community
- the technological level of the society
- the pre-existing maintenance system in use

Choice Factors

Pump design - the pump may be designed to endure for a long or a short interval between services

Maintenance organization - may be unified, i.e. operated from a centralized level, or dispersed, i.e. operated at a local level

Financing - may be by government or by user

Each situational factor may be examined to determine with which extreme of each of the three choice factors it may be most appropriately linked. For example, where the situational factor is a dense population around the well, the choice factors would be as follows:

1) The maintenance period between servicing should be short.
2) Sufficient population exists to have a dispersed form of maintenance organization.
3) Sufficient population exists to expect that local taxation of users will be sufficient to cover the cost of maintenance.

Similarly, with a sparse population density one can visualize a maintenance system which requires:

1) Long intervals between hand pump servicing.
2) A centralized or unified maintenance organization.
3) Government financing because of insufficient population to locally support the cost of the maintenance organization.

Relationship between Situational and Choice Factors

Two extreme conditions are listed for each factor:

Situational Factors:

Pump type - suitable for a simple shallow well or a complex deep well

Population density - dense or sparce

Government structure - central or local government

Economic circumstances of the community - rich or poor

Technological level - high or low technology

Pre-existing maintenance system - this will be considered after other factors have been decided for the choice factors

Table 3-1 summarizes for each pre-existing situational condition the three most appropriate choice conditions. Figure 3-1 presents a model for visualizing the eight possible choice factors for a hand pump maintenance organization.

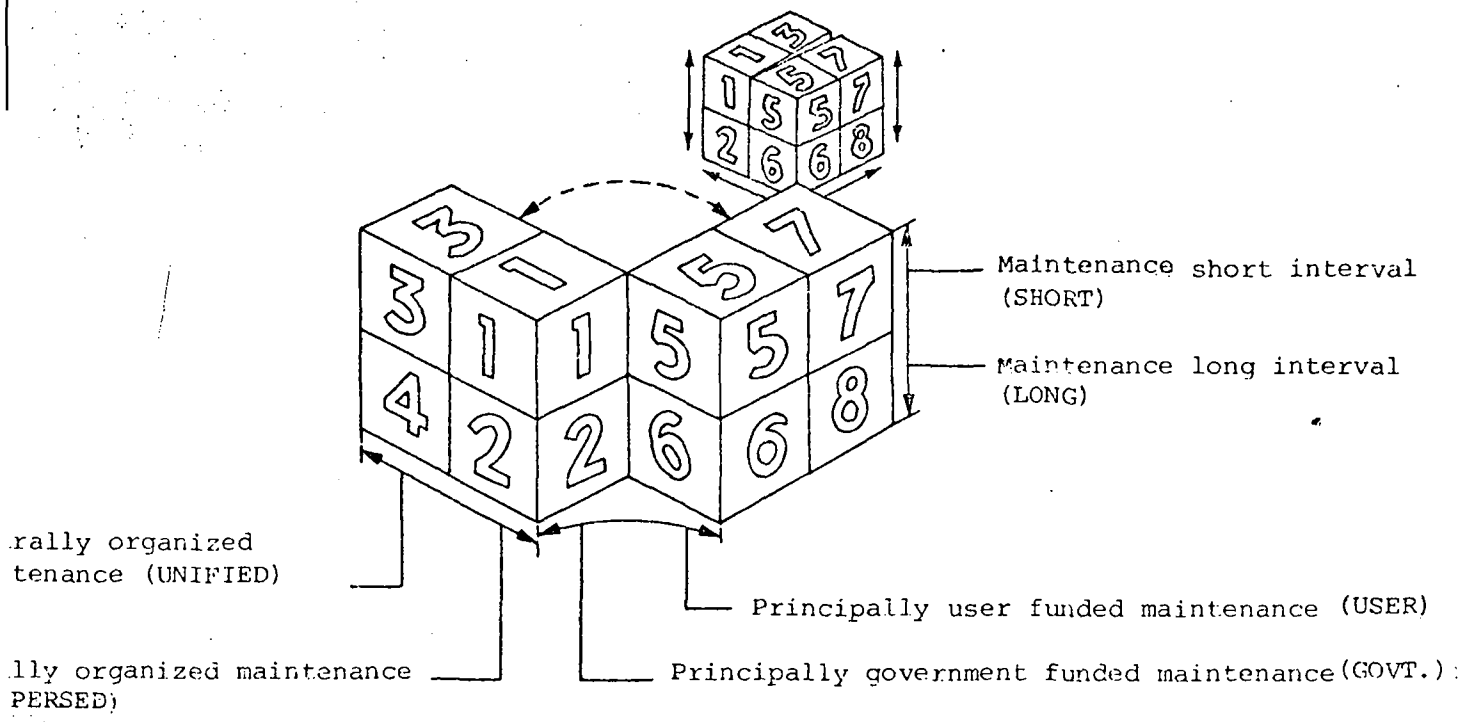
Table 3-1 Relationship between situational factors and choice factors

	Most appropriate choice factors for pre-existing situation		
Situational Factor	Maintenance period	Organization type	Financing
complex deep well pump	long	unified	government
simple shallow well pump	short	dispersed	user
dense population	short	dispersed	user
sparse population	long	unified	government
central government	long	unified	government
local government	short	dispersed	user
poor community	short	unified	government
rich community	long	dispersed	user
high technology		dispersed	
low technology		unified	
Pre-existing maintenance system	either helpful or not helpful in each case		

In table 3-1 only four pairs of the situational factors may be directly indentified with a complete set of choice factors. The pre-existing condition and the technology level cannot be generally associated with a set of choice factors. The pre-existing conditions may be used as a final guide after other factors have been considered.

The level of technology is relevant to the selection of choice factors only to the extent of suggesting that with a high technology system a dispersed form of maintenance organization is feasible, whereas with a low technology system a unified form of maintenance organization would be preferable.

In table 3-1 each situational factor is linked with the most appropriate of the three choice factors. Each choice factor can have two possibilities. Three sets of two choice factors may be combined into eight possible choice factor packages. However, examination of table 3-1 shows that only four different combinations of the three choice factors have resulted from the association between situational factors and choice factors. These are summarized in table 3-2 and shown on figure 3-1.



Permutations of three Sets of two Maintenance Choice Factors

Permutation	Maintenance Period	Maintenance Type	Maintenance Funding
1 (5)	short	dispersed	government
2 (5)	long	dispersed	government
3 (2)	short	unified	government
4 (3)	long	unified	government
5 (4)	short	dispersed	user
6 (1)	long	dispersed	user
7 (3)	short	unified	user
8 (5)	long	unified	user

Notes: (1) Strategy for more wealthy areas

(2) Strategy for less wealthy areas

(3) Strategy for sparsely populated and/or areas requiring deep well pumps and/or where the government power is very centralized

(4) Strategy for densely populated areas and/or areas requiring shallow well pumps, and/or where government power is delegated to local authorities

(5) Strategy not generally appropriate

FIGURE 3-1 MODEL FOR CLASSIFYING CHOICE FACTOR STRATEGIES IN HAND PUMP MAINTENANCE

Selection of Maintenance Strategy

Table 3-2 Feasible maintenance strategies

Pre-existing situational factors associated with strategy	Maintenance Strategy Indication Number	Strategy choice components		
		Maintenance Period	Maintenance Org. type	Maintenance Financing
rich	1	long	dispersed	user
poor	2	short	unified	government
sparse, deep, centralized	3	long	unified	government
dense, shallow, localized	4	short	dispersed	user

The analysis concentrates on four situational factors each having two conditions as follows:

Pump type - deep or shallow
Population density - dense or sparse
Government organization type - centralized or localized
Economic conditions - rich or poor

These four situational factors each having two conditions may be combined in the sixteen different ways summarized in table 3-3.

Table 3-3 Possible permutations of four most relevant situational factors

Hand pump type	Population density	Government type	Economic circumstances
deep	dense	centralized	poor
deep	dense	centralized	rich
shallow	dense	centralized	poor
shallow	dense	centralized	rich
deep	dense	local	poor
deep	dense	local	rich
shallow	dense	local	poor
shallow	dense	local	rich
deep	sparse	centralized	poor
deep	sparse	centralized	rich
shallow	sparse	centralized	poor
shallow	sparse	centralized	rich
deep	sparse	local	poor
deep	sparse	local	rich
shallow	sparse	local	poor
shallow	sparse	local	rich

By comparing the choice factor strategy indicated in table 3-2 with each of the possible sets of situational factors shown in table 3-3 it is possible to determine for each situational factor which choice factor strategy is most applicable to each of the pre-existing situational factors. These are indicated in table 3-4. For example the first set (deep, dense, centralized, poor) from Table 3-2 the strategy for deep is 3, for dense is 4, for centralized is 3 and for poor is 2. The appropriate maintenance strategies are therefore listed as 3,4,3 and 2.

Table 3-4 Best choice factors for each situation

Case	Pre-existing situation factors	Appropriate maintenance strategies
1	deep - dense - centralized - poor	3, 4, 3, 2
2	deep - dense - centralized - rich	3, 4, 3, 1
3	shallow - dense - centralized - poor	4, 4, 3, 2
4	shallow - dense - centralized - rich	4, 4, 3, 1
5	deep - dense - local - poor	3, 4, 4, 2
6	deep - dense - local - rich	3, 4, 4, 1
7	shallow - dense - local - poor	4, 4, 4, 2
8	shallow - dense - local - rich	4, 4, 4, 1
9	deep - sparse - centralized - poor	3, 3, 3, 2
10	deep - sparse - centralized - rich	3, 3, 3, 1
11	shallow - sparse - centralized - poor	4, 3, 3, 2
12	shallow - sparse - centralized - rich	4, 3, 3, 1
13	deep - sparse - local - poor	3, 3, 4, 2
14	deep - sparse - local - rich	3, 3, 4, 1
15	shallow - sparse - local - poor	4, 3, 4, 2
16	shallow - sparse - local - rich	4, 3, 4, 1

Table 3-4 shows that although there are sixteen possible sets of situational factors and eight possible sets of choice factors with only two alternative strategies, it is possible to indentify a possible maintenance strategy in every case. These two strategies are as shown in Table 3-2 and are as follows:

Strategy 3:
A long period between maintenance visits, a unified maintenance system and a government financed maintenance system.

Strategy 4:
A short period between maintenance visits, a dispersed form of maintenance organization and a user financed maintenance system.

Strategies 1 and 2 are less usable but may be feasible as discussed below.

In some cases shown in table 3-4 almost all pre-existing situational factors point towards choice of the same maintenance strategy. For example Case 9, where the pump is of the deep type, the population is sparse, the government organization is centralized, and the people are poor. Almost all these four factors suggest that the kind of maintenance strategy which should establish should be type 3, i.e. a long period between service, a unified system and government financing. Similarly Case 8, when the well is shallow, population is dense, there is a local form of government, and the people are rich, the recommended type of maintenance strategy would be type 4, i.e. short periods between maintenance visits, a dispersed form of organization and user financing.

The situation is not always so clear cut. For example in Case 1 in table 3-4 (deep, dense, centralized, poor) the combination of situational factors favours maintenance strategy 3 in two cases, strategy 4 in one case and strategy 2 in one case. Closer examination of the relative weights of each choice factor indicates that either strategy 2 or strategy 3 would be the best choice. In Case 2 in table 3-4 (deep, dense, centralized, poor) only long maintenance periods are clearly desirable and this would imply either strategy 1 or strategy 3 is acceptable.

In summary, although one of two major maintenance strategies can be identified as feasible in every case, it is not possible to firmly pre-determine which of the two other strategies might be preferable if a wider range of pre-existing conditions were to be examined. Table 3-5 summarizes conclusions relating pre-existing situational factors and choice factor strategies for the conditions investigated.

Table 3-5 Most acceptable maintenance strategies

Pre-existing situational factors

Handpump type	Population density	Government system	Economic circumstances	Feasible maintenance strategies(1)
deep	dense	centralized	poor	2 or 3
deep	dense	centralized	rich	1 or 3
shallow	dense	centralized	poor	2 or 4
shallow	dense	centralized	rich	1 or 4
deep	dense	local	poor	4
deep	dense	local	rich	4
shallow	dense	local	poor	3
shallow	dense	local	rich	3
deep	sparse	centralized	poor	2 or 3
deep	sparse	centralized	rich	1 or 3
shallow	sparse	centralized	poor	2 or 3
shallow	sparse	centralized	rich	1 or 3
deep	sparse	local	poor	2 or 3
deep	sparse	local	rich	1 or 3
shallow	sparse	local	poor	2 or 4
shallow	sparse	local	rich	1 or 4

Note (1) Maintenance strategies as described in Table 3-2.

The above discussion relates four situational factors with three choice factors and the summary suggests that two alternative maintenance strategies are feasible in every case and two other strategies are feasible in a number of cases. The strategies involve choosing the type of pump, the type of maintenance system, and the methods of financing the maintenance system.

The analysis therefore permits identification of one or two feasible maintenance strategies for sixteen sets of pre-existing conditions. The selection should also take into account the technological level in the community and the pre-existing maintenance system. The effects of high technology would be to favour strategies including a dispersed organization type (strategies 1 and 4), and low technology would favour unufied organizational systems included in strategies 2 and 3.

A final consideration is the effect of any existing maintenance system on the most appropriate maintenance strategy. The final selection of maintenance strategy should give considerable weight to the existing maintenance strategy. Abrupt changes in strategy are unlikely to be successful. For example if the government presently finances all the costs of the maintenance system a sudden change to user financed system would be inadvisable. However, if all the various factors described above suggest that user financing would be advantageous, then a gradual change towards user financing would probably be desirable. On the contrary, if there is a successful situation where users are financing the maintenance system but the factors analyzed above suggest that the government should be financing the system, it is suggested that the existing system be preferred This is, because as stated earlier the desirable situation is for user financing and a movement towards government financing would be a retrograde step. The impact of pre-existing conditions may also be felt in the type of pump selected. If, for example, a very robust pump is in use at present with long periods between maintenance visits, but analysis suggest as shorter period between maintenance; the question of introducing a less robust non-standard pump would require careful consideration. In summary, the impact of pre-existing maintenance systems on possible changes would have to be very carefully assessed, because where existing maintenance organizations are successful, changes should be made only with extreme caution. The forgoing analysis describes a method for determining the most suitable maintenance strategy including selection of the maintenance period, the type, and method of funding handpump maintenance, for any given situation. The analysis is conducted by considering the extreme cases. The kind of multi-level structure discussed for India in chapter 2, represents further stage of organizational design which may be a suitable maintenance structure for a specific case Synthesis of existing institutional systems with this analysis is detailed in chapter 4.

Specification of Maintenance Set-up

The foregoing section permits the general selection of an outline strategy to determine an appropriate pump type, organizational type, and a method of funding handpump maintenance. But it does not specify what facilities equipment and staff the maintenance system requires. As described in the introduction to chapter 2, all maintenance systems have some general requirements in common.

Briefly repeated these are:

1. Someone close to the well to conduct local, generally frequent, cleansing, and small scale attention
2. Someone equipped to replace worn parts
3. A team for larger scale maintenance and repair
4. A spare part purchasing and distribution organization with storage facilities
5. Spare part manufacturing ability or an importation system for spare parts
6. Raw materials procurement for spare parts
7. Inspection procedures for spare parts production
8. The financial resources to operate the system
9. Operations staff and management ability
10. A code of work rules and procedures

In each case the details of how the requirements are filled will differ dependent on the overall strategy selected (pump,organization type,funding) and on the way work is conducted in the society. It is not possible to examine in detail all the combinations possible but a general outline showing how systems may be developed based on basic decisions is presented.

Technical Factors

Very different organizations will be developed if the following pumps are selected (1) Imported, company patented product (b) In-country manufactured pump for national use - very robust (c) Simple shallow well pump, made in many locations within the country with local materials

(a) Imported pump:

All spares must be imported. Organization will have to center around a distribution system based on one or two ports or railheads and spreading out to all parts of the country. No local manufacturing or inspection capacity required. Extensive government or private distribution and servicing network. Local involvement in maintenance probably restricted to lubrication and cleaning.

(b) Nationally manufactured robust pump:

Extensive local purchasing, inspection, and storage capacity is required. Some private development is possible. Possibly raw materials importation is required with government assistance. Maintenance base on mobile teams covering large areas at long intervals. Local maintenance minimal probably restricted to cleaning.

(c) Simple village pump:

Maintenance largely conducted locally. Possibly major well or pump replacement by government. Large local involvement. Centralized industrial development less essential. Government involvement may be largely absent where well construction is also feasible at village level.

Organizational factors

Naturally, if the organizational system used is (a) National (b) Regional, and (c) Local, the internal organizational requirements will be very different for each case although, in some way, all the necessary maintenance functions must be fulfilled.

(a) National organization:

With a national organization it is possible to manage all aspects of maintenance system under any pump or payment type from top to bottom. Or some aspects can be handled by the national organization and some left for lower level government or individual initiative. With a national organization, considerable flexibility exists with regard to payment for spares, the cost for which can included under the general taxation or spare part rates charged at anything up to the cost of alternative spare parts sources. With a national organization the structure must be designed to cope with difference in requirements between one area at the country and another, as in almost every case a single pump design will not be appropriate for all cases in the country, and other geographical factors affect the organization.

(b) Regional organization:

A regional organization will have fewer variations within the area than a national organization. But will be dependent on outside sources for imported pumps. A pump manufactured within the region would be most appropriate. In some countries (e.g. India) a regional organization may serve a larger area or lager population than some national organizations in other countries. But it is often ill-placed to manage its affairs because it does not have the independence of a national organization nor it is close enough to the people to easily obtain full and adequate local involvement. Therefore, all aspects of regional organizations need careful thought, and coordination with the national authority is most important.

(c) Local organizations:

These will be most effective where a simple pump is in use and where the maintenance is user financed. The success of local organizations will depend on the full development of community participation in particular in selecting areas for development and depending largely on local contributions for development. In this system, the pump will either be locally produced or brought in from another area. The production and inspection aspects are therefore simplified, although in the case of pumps manufactured outside the area the provision of spare parts becomes more difficult and may require considerable local stockpiling of spares. Smaller trucks and other transport will be possible but transportation requirements will not be eliminated.

Financing factors

The method of paying for maintenance and spare parts has an impact on organizational structure dependent on whether (a) The government pays all costs (b) The government* subsidizes the cost or (c) The people pay all costs.

(a) Government pays:

Where the government pays for maintenance and spare parts the maintenance organization must extend down to the village level although it is quite practical for a villager to be employed as a maintenance person. With the government paying all costs extension of the handpump system may be stunted through financing limitations and this may lead to more wealthy private citizens establishing their own well and handpump system. Competition for available spare parts between parallel public and private systems may be a feature of this system.

(b) Government subsidises cost:

Most frequently this is achieved through the government providing a maintenance and delivery organization but the people paying all or part of the cost of spares. They may also pay a below cost service charge for having government staff maintain the handpumps. Alternatively, the local people may carry out the most simple maintenance tasks while the government finances major repairs.

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* In this instance the term government may also mean local government.

The government organization must be able to collect charges and recycle these funds for purchase of spare parts. Quite often in developing countries handling such details can be a major administrative and accounting problem and it may not be possible to directly link revenue and expenditure and reserves have to be paid to a central account.

(c) The people pay directly:

In this case the people may either (i) pay a charge for a service provided by a government maintenance organization, or (ii) they may through their own efforts and by hiring local maintenance and repair people take responsibility for the maintenance of the wells. In the first case, a complete government organization is required including the capacity to handle the financial aspects as discussed before. In the second case a well developed system of private contractors or a very elementary pump will be necessary. In this case the government involvement will normally be minimal. However, the government may act at the national level to ensure that sufficient spare parts are produces or imported and that production standards are adequate (quality standards). In this case further distribution would be through the private market mechanism.

From the above discussion it may be observed that every decision regarding the main choice factors has an effect on details of the maintenance organization. In practice, these must be developed gradually as a comprehensive handpump maintenance system cannot be developed overnight. The details must be filled out as the handpump system develops and as requirements occur. However, each major decision has an inevitable effect on the organizational requirements necessary if the maintenance system is to function effectively.

Structural characteristics of the maintenance organization

Once the basic details of the maintenance organization have been determined - i.e. the pump type, organization type, and financing determined, and once the practical performance specification of the maintenance organization has been determined - then the question of how the system is to be managed and how responsibility is to be distributed must be considered.

The form or shape of the management organization is an important determinent in the operational efficiency and character of an organization. There is a very large literature on organizational structure. Briefly stated, there are three main structural shapes for an organization:

- tall
- flat
- matrix

The tall structure receives its name from the many levels of authority between top management and the lower levels of the organization. Information and instructions pass up and down the chain of command through many levels of authority. Each supervisor will have a relatively small number of assistants. One advantage of the tall management structure is that each person knows his place, he receives instructions, carries them out, and, if necessary, passes on instructions to a lower level. Information from the lower levels is passed up through the chain of command to an appropriate level for decision and, for important decisions, information may pass up to the top. Where the work is routine, tall structures have a number of advantages. Where the work situation is not routine, too much time may be required for information to pass up and down the chain of command. Where staff are inefficient, loss of information may lead to apparent insensitivity of the organization.

The flat structure is so called, because there are relatively few levels of authority between the top and the bottom. This is achieved by each level manager having a large span of control, i.e. a large number of people working directly inder his authority. One advantage of flat structures is that is leaves more room for individual decision and is generally preferred by persons with more initiative and of higher educational attainment. The flat structure has an advantage when the work conditions are turbulent and rapidly changing. Information can quickly pass to an appropriate level of decision and instructions can be issued in a short time. One disadvantage of the flat structure is that employees without the necessary level of initiative or interest may fail to contribute to the general organizational goals or may not receive the degree of instruction which they require to perform satisfactorily. In such circumstances they will have the feeling of being left out of the organization and their performance may further deteriorate.

The matrix structure is a special kind of organization which has received attention in recent years and is used generally for special projects. This structure is not considered appropriate for maintenance organizations in developing countries and will not be further discussed here.

In summary, there are two basic structural shapes which may be used for controlling the maintenance organization, tall and flat, each have adavantages under some conditions. The top level at which the organizational structure starts is important. Is it a nation-wide maintenance organization, or a regional maintenance organization, or an organization run and managed from the local level? The relevant point is the level of decision, controlling the expenditure of revenue, recruitment of staff, and general policy formulation. Where these functions are combined within one guiding group, then this forms the apex of the structure.

In practical terms the flat structure is preferable where the situation is varying and the educational levels are high. The tall structure is preferable with staff of lower educational attainment and with more routine work. In a national maintenance organization in a developing country a combination of these two structures might be advantageous. The upper level of the national maintenance organization structure might be relatively flat with well trained and qualified staff taking considerable responsibility and with relatively few structural levels down to the local mangement level. At some lower level the structure could become more rigid and tall with the less qualified local maintenance staff receiving more supervision than the management staff.

If the centre of control is already at a low level, the entire organization might fall under the tall classification and have sufficiently few levels that control could be maintained without undue delay in transmitting instructions and information.

GUIDELINES FOR EFFECTIVELY ORGANIZING HAND PUMP MAINTENANCE

Introduction

For many developing countries small wells fitted with hand pumps provide the only economically feasible hope for supplying the rural population with safe water. Hand pump wells have been introduced to some countries for the first time, and in other countries the number of hand pumps used in rural water supply is greatly increasing. Experience demonstrates that unless adequate provisions are made for maintaining hand pumps, breakdown of the pump will normally occur long before the useful life of the well has been reached and, in a year or so of installation, the hand pump will be useless. Even when maintenance is arranged, unless it is organized effectively, a large proportion of hand pumps will soon become inoperable.

The preceeding chapters show that maintenance must be planned from the inception of any water project based on hand pumps. But there are many ways in which maintenance may be organized. It is not possible to provide information which will clearly establish what provisions should be made for maintenance in each country. But general guidelines and procedures are provided for assessing the adequacy of existing or proposed organizational systems of maintaining hand pumps, and the measures necessary to establish an effective maintenance organization.

Adequacy of existing maintenance arrangements

For hand pump systems which have existed for several years, the simplest test of maintenance adequacy is the proportion of hand pumps in operation. Table 4-1 provides a general guide.

Table 4-1, Assessing Maintenance Adequacy by Results

Hand pumps in operation*, percent	Apparent maintenance adequacy
More than 90	Excellent, efforts may be made to maintain performance but to reduce cost
70 to 90	Satisfactory, but some improvement possible
50 to 70	Indication of flaws in some part of the organization of hand pump maintenance
Less than 50	Indication that maintenance is inadequately managed and/or insufficient resources are channelled to hand pump maintenance

* In old systems the condition of the well may reduce the percentage, and in new systems the impact of newly installed units may increase the percentage of hand pumps in operation.

A reasonably effective hand pump maintenance system should succeed in keeping at least seventy percent of the pumps in operation. But is this system efficient and are the costs of maintaining the wells reasonable? A developing country which finances maintenance of its own hand pumps and succeeds in keeping an acceptable proportion in operation will generally have developed a cost effective method of organizing hand pump maintenance. However, there are cases where 'demonstration projects' or externally financed assistance projects through disproportionately large expenditures, maintain hand pumps in good condition although maintenance is not organized in a manner suited to the requirements of the country. Some indication of whether this process is occurring may be obtained as follows: by examining the strategy used against the strategies suggested by the model in chapter 3; by considering whether full advantage has been made of community participation; and by considering whether the purchasing arrangements for pumps and spare parts is organized to get good returns at minimum cost. Even if the maintenance system succeeds in keeping the pumps in operating condition and the costs are not excessively high, there remains the question of whether full benefit is obtained from the wells and whether the people are adequately educated regarding health habits and use of well water. Specifically, in this context, whether the maintenance organization is used solely for maintenance or whether maintenance staff could also be used to provide health education insights to the village during maintenance inspections. Where an existing maintenance system is not satisfactory on all these three counts, the guidelines presented below may be useful. Figure 4-1 suggests a flow sheet technique for assessing and improving system adequacy.

Organization of maintenance for new hand pump systems

Where a new water supply system, based on hand pumps, is proposed there are many aspects to consider. But from the very start it is essential that:

1. A plan be made of how hand pumps are to be maintained.
2. Estimates of the cost of maintaining the hand pumps are made , and provision is made for raising this sum of money regularly.

By carefully planning how the maintenance is to be conducted and financed, the chances of success are considerably enhanced. But the chances will be further enhanced if:

3. Prior to the selection of a maintenance system or systems to be used nationally, two or three alternative systems of hand pump maintenance are tested on a pilot scale for a period of two or more years.

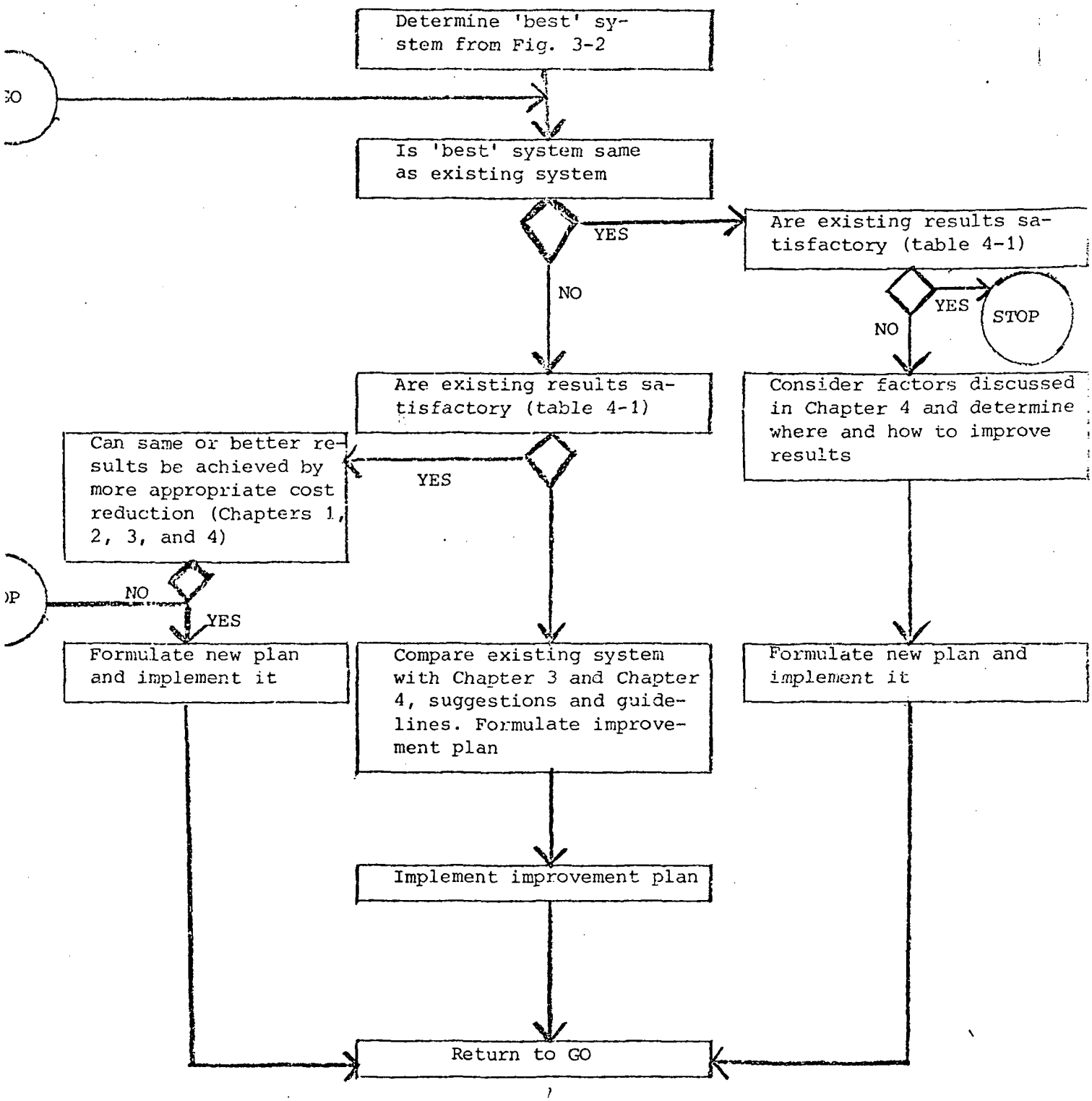
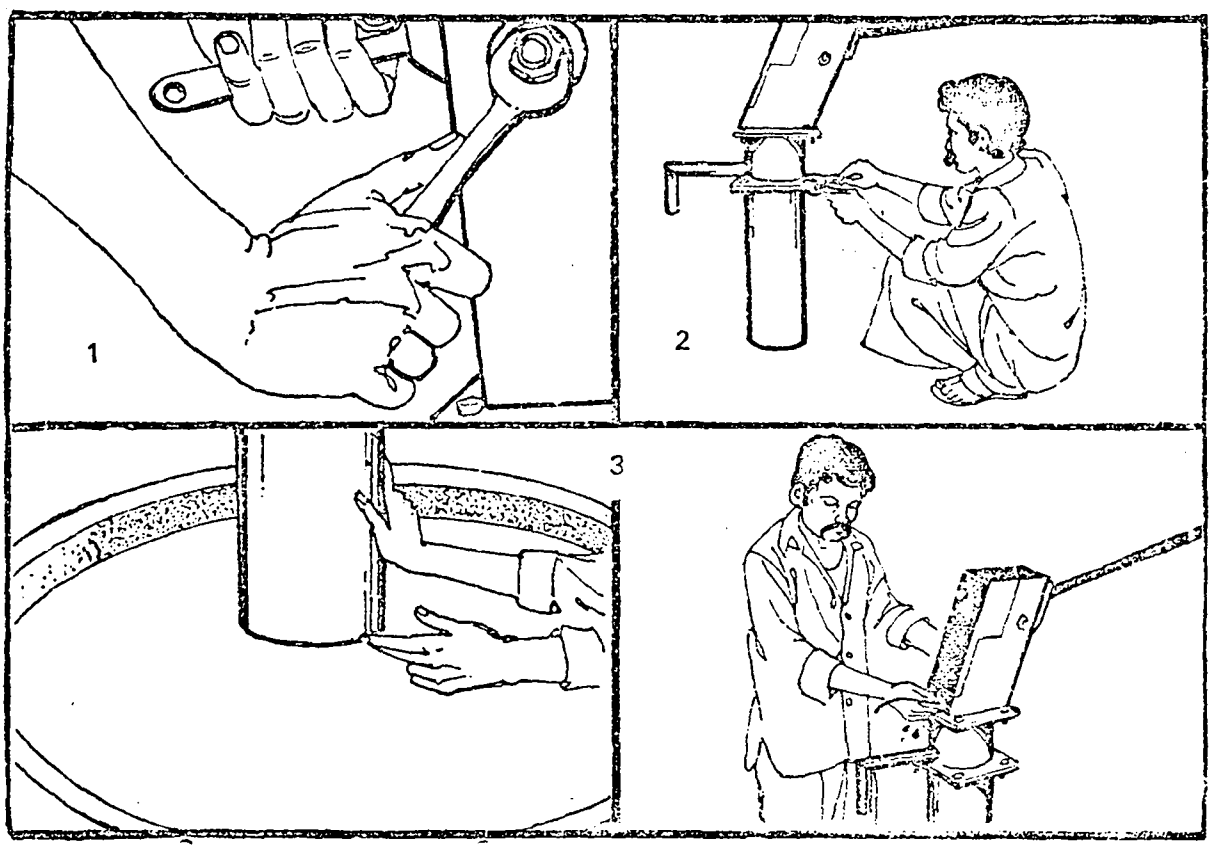


Figure 4-1. Procedure to determine and improve existing maintenance system


1
2
3

As a further general note, the rate of expansion of the hand pump system is quite important. There is a danger of trying to expand too quickly. It takes years to train staff, arrange for procurement of pumps and spare parts and provide for spares and distribution systems, build organizations, build facilities and most difficult of all, educate the people with regard to their role in the maintenance system and the importance of well water to their health. Working continuously and starting from a zero base it could take as long as ten years before a country otherwise suitable for hand pump water supply systems is able to absorb a massive hand pump programme aimed at reaching say half the population in a further ten years. During the first decade the choices of hand pump, organization type, and method of financing would be established. The distribution networks and local manufacturing capacity would be built up. Staff would be trained, equipment purchased and the maintenance and replacement of that equipment organized. Wells and hand pumps would be installed in this period at a geometrically increasing rate, but from a very low base. The overall system would in this way be developed sufficiently to absorb later massive investment.

In creating an organization to control hand pump maintenance it is possible to either create an entirely new organization, or to expand the duties of an existing organization. Generally establishing a new department within an existing organization is the easier solution in most practical situations.

It should be recalled at this point that the unit costs of maintenance, particularly with a centralized government controlled system, are related to the number of hand pumps and the density of their installation. When planning new systems it is important to appreciate that as the work progresses economies of scale and density become more significant. When the first hand pumps are installed costs will be much higher because the unit costs of locally providing hand pumps and constructing wells is initially high. But as production increases, costs will be reduced. More important from the maintenance viewpoint is as wells increase in number, the distance between hand pumps is reduced and materials may be stockpiled locally to service a reasonable number of wells. The importance of the density of hand pumps should not be overlooked in planning the organization of maintenance. At some points it may be possible to change from distant stockpiling and maintenance dependent on motorized maintenance men, to local stockpiling and less capital intensive servicing.

CERTIFICATE

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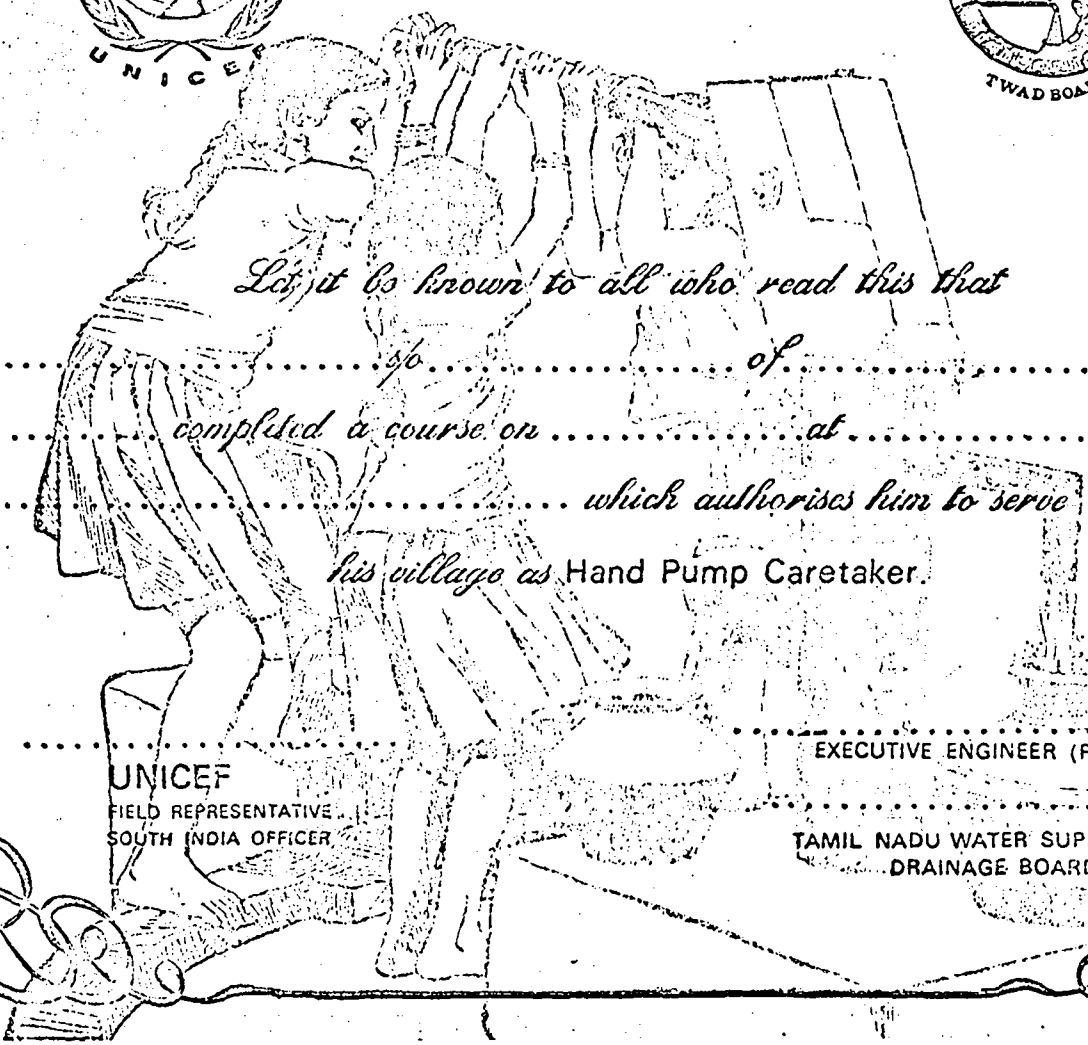

Let it be known to all who read this that

..... *s/o* ..... *of* .....

..... *completed a course on* ..... *at* .....

..... *which authorises him to serve*

his village as Hand Pump Caretaker.

4 - 6

.....

UNICEF
FIELD REPRESENTATIVE
SOUTH INDIA OFFICER

.....

EXECUTIVE ENGINEER (R.W.S.)

..... DIVISION

TAMIL NADU WATER SUPPLY AND
DRAINAGE BOARD

Considerations in organizing hand pump maintenance

The following paragraphs are generally more applicable to organizations based on government organized maintenance systems.

4.1 Pump selection

The three step procedure described in chapter 3 suggests in a general way whether the pump selected should be simple or complex, short service period or long, shallow or deep. There are of course many more considerations and the choice of pump must rate as one of the most important in designing the maintenance system. Mistakes sometimes made in selecting a pump are as follows:

- using an imported pump when an adequate pump could be locally produced at similar or lower cost, or given time the cost would become lower than foreign competition
- using whatever pump is low bidder on each occasion resulting in use of several different pumps over a number of years and requiring too great a selection of spare parts as a consequence
- using whatever pump is made in the country even though it is unsuitable for heavy public use

In general, the larger the project the greater the importance of standardizing on one or two pump designs and producing the pump in the country. A suitable solution in such instances might be to make a foreign design under licence or local partnership,or to select a well tried standard design such as the Bangladesh New No. 6 (UNICEF/DPHE shallow well pump), India Mark II (deep well pump) or AID/BATTELLE latest model (shallow or deep) for local production. Where a simple village design is desirable then standardization would be less appropriate although if achievable it would still be advantageous.

4.2 Staff Numbers

Where the government arranges hand pump maintenance the number of people directly employed on maintenance activities will depend on the extent to which responsibility for maintainance is shared with other functions such as construction, the use made of general facilities such as state railways for transportation, and the extent work is contracted out. Another important factor is the density of wells in an area. While no firm conclusions on staff needs, the ratios found in India, Bangladesh and Tanzania provide some insight. The approximate numbers of staff employed on hand pump maintenance in India, Bangladesh and Tanzania are shown in Table 4-2. In addition each well has someone responsible for ensuring that the well is not misused. This is an unpaid voluntary position- the "Caretaker".

Table 4-2 Typical Ratios of Staff Employed for Maintenance

Staff level	Labour, Technical and Management Employees per 10.000 hand pumps (4)		
	Tanzania (4)	Bangladesh (1)	India (2)
Executive level and above	30 (3)	1	1
Middle level	60	10	20
Lower level	240	50	160
	330	61	181

Note: 1. Existing system - not thana stores system
2. Tamil Nadu (3 Tier system), not existing system
3. Large proportion of executive staff probably due to relatively small size of existing hand pump system
4. Tanzania does not have 10.000 hand pump- proportions pro-rated

Table 4-2 indicates that for maintenance alone between 6 and 33 employees are required for every 1000 hand pumps maintained. This number is in addition to the voluntary caretakers at the rate of one per hand pump. Clerical and administrative positions in the maintenance organization are required but not shown in Table 4-2 and in addition other government positions would be developed through the additional manpower and activity generated by the maintenance programme. It is estimated that the effect of these would be to raise the ratio of staff employed to between 10 and 50 persons employed on maintenance per 1000 wells. This may be conveniently expressed as between 1 and 5 persons per 100 hand pumps. The lower end of the range would be more appropriate for high density well developed hand pump system such as Bangladesh, the higher end for newly developed systems and systems with widely seperated hand pumps such as is found in Tanzania.

4.3 Staff Training

The general educational levels for staff employed in maintenance organizations should be general as follows: Executive level- University graduate or post-graduate with several years of experience, or training in management 2. Middle level-at least ten years education plus specilist training as necessary. 3. Lower level - literate and with training and experience in hand pump maintenance or specialist skill such as mechanic.

In starting a new system, the development of the skills and the know-how for the middle and lower level employees can be extremely difficult to develop. Training

programmes, importation of outside consultants and 'trial and error' form part of the learning process. Staff training should be an on-going programme with annual refresher course organized internally and with outside exchanges of information.

4.4. Financing

As was indicated in Table 2-4, the annual costs of hand pump maintenance range from $ 5 per hand pump to $ 125 per hand pump. Higher density development would normally be in the $ 10 to $ 30 range, and lower density development would be somewhat more than $ 20 but unlikely to exceed $ 100 per hand pump. Based on 100 persons served by well, per capita maintenance costs are in the range of $ 0.1 to $ 1. These may not seem large amounts but as hand pumps are most frequently used in subsistance economy areas, raising such sums locally is often very difficult. According to the World Bank Village Water Supply Paper, a maximum of 5 percent of family income may be charged for water. However even when considerably less than this amount is required for pump maintenance the mechanisms to collect the money often do not exist in many countries, except for funds raised through the general taxation process. As discussed in Chapter 3 there is a case for government taxation to cover all or part of the cost of maintenance. There is also a good case expecting the village to pay for spare parts and having the government provide the spares distribution and installation system. In addition to the cost of maintenance there is the cost of the eventual replacement of the well to consider, The well generally costs several times as much as the pump and needs to be replaced all at one time rather than in the phased way normal with pump maintenance Replacement of the well is therefore likely to be almost always something handled by the government as the technical skills and lump sum capital expenditure will normally be greater than the village can provide although in some cases a village contribution of labour may be appropriate. In most cases provision for well replacement is therefore something which the goverment should finance from general revenue with preferably some partial payment by the village. Attempts to get the village to repay the cost of the well over a number of years are likely to fail as once the government has installed the well the threat of removal or closing is unconvincing and self-defeating.

4.5 Transport

The amounts and types of vehicles required by a government maintenance organization will largely depend on the topography of the country and on the infrastructure within the country. For example, use of railways and shipping for moving spare parts may be feasible in one country whereas in another, most movements will be by road or even mountain tracks. The kind of transport required excluding railway and shipping which are part of the basis infrastructure of the country would be varied. For moving hand pumps and spare parts trucks would be required. The number and size

of the trucks would be dependent on the distances involved and the store locations and the size of the maintenance programme. For general supervision, the senior levels of the maintenance organization would require vans or cars and/or possibly four wheeled drive vehicles. Dependent on the type of maintenance conducted and the weight of the equipment moved, four wheeleddrive pickups or trucks may be required for maintaining the hand pumps. In remote and difficult country such as part of Nepal, where roads do not exist in many areas, the maintenance organization may require animal transportation Wher ever possible, the size of transport vehicles should be minimized and if possible, motorcycles and bicycles should be provided in preference to four wheeled vehicles. In some countries highly dependent on water transport boats with diesel engines or outboard motors may be useful. It should be noted that all these transport modes themselves require maintenance and therefore the government system if it to operate efficiently, must also make provisions for the provision of spare parts for trucks, four wheel drive vehicles, vans, cars, motor cycles, and bicycles etc. and provide the necessary skilled maintenance people and repair facilities to keep the transport fleet in operating condition. The costs of maintaining this fleet and vehicle depreciation also probably form a part of the estimate of maintenance costs.

4.6 Equipment

The maintenance organization will require equipment to carry out routine maintenance on the wells and to make any repairs necessary. The kind of equipment required would be wrenches, lifting gear, screwdrivers, hammers, hacksaws and whatever other specialist equipment is required for the kind of hand pump in use. In addition, it might be advisable, dependent on the type of hand pump installed, to provide the hand pump care-taker with a very basic tool set to carry out the simplest kinds of maintenance, such as bolt-tightening and possibly in the case of shallow well pumps a replacement of the piston cups. In a more developed system the caretaker might be provided with grease for application to the moving parts. However, this would depend largely on the society as, in some instances, such general issue of this kind of material would result in improper use. Provision of this equipment and replacement costs form part of the estimate of maintenance costs.

4.7 Advice and Technical Assistance

Raising the initial capital and obtaining advice and technical assistance is a problem each country faces when commencing in the hand pump water supply field. However, the cost of initial investigations and feasibility studies is not high compared to the cost of the project. In many cases UN-agencies, multilateral bodies, regional associations and regional assistance banks, bilateral assistance, voluntary agencies and private companies are prepared to advise and sometimes to finance the initial investigations of the financial implications including the capital costs, replacement costs and maintenance costs of the project. The total capital investment required is likely to be substantial for any project planned to establish hand pump water supplies as a significant factor in a country. To serve 10 million people in a country where hand pump supplies are feasible the capital investment required will be in the range of $ 50-250 million with an annual hand pump maintenance cost of $ 1-10 million. Countries able to operate towards the lower end of this scale would be favoured and should find it easier to obtain construction loans.

4.8 Public Information

An effective public information programme can do much to ease the way for and improve hand pump maintenance. Obtaining the cooperation of all segments of the population but particularly the village level is most important in obtaining the best return from a hand pump project. Use of public information channels can be a very effective technique for improving the performance of the hand pump project. Within a country information on a hand pump programme can help smooth implementation of the project by informing the adminstrators at all levels of the objectives of the programme and necessity of cooperating with the programme It can inform the people of their responsibilities in the hand pump programme and it can even provide a check on the activities of contractors and government employees by informing the public of the duties of these persons. Public information is an important aspect in promoting health education, and the same channels of communication can be used for both aspects of the information programme.

The main information channels used are as follows:

1. radios;
2. newspapers;
3. advertisements;
4. visits to the area by the government employees, political and religious leaders, who may make speeeches, and direct demonstrations regarding the duties, responsibilities, and use of clean water;

5. other media can be used, such as television and film, when appropriate.

Each of the methods has advantages in certain situations and a public information programme should be planned with the advice of an expert.

4.9 Basic Facilities

In a government organized maintenance system government staff require living accomodation and, dependent on local custom, it may be necessary to construct housing for these people. It is mentioned to indicate that in estimating the cost of capital investment for a government maintenance system it may be necessary to construct housing. For the very lowest level of staff who will be in the largest numbers, it is highly questionable whether provision of housing should be cosidered a duty of the government. However, if the staff are expected to carry out their duties conscientiously they must either be given sufficient income to purchase or to rent their own accomodation or else they must be provided with staff quarters. Many countries find the providing of staff quarters to be most appropriate, this may be an manifestation of the bias noted earlier towards capital expenditure in place of maintenance expenditure. (That is, the cost of housing may come from external aid while pay comes from internal sources.)

4.10 Offices, Stores, and Workshops

An essential part of any government organized maintenance organization is a system of offices, stores, and workshops. At these locations the government staff will set up their offices, store the maintenance materials and carry out any repair works on pumps, vehicles and equipment. Generally the offices will reflect both the organizational hierarchy and the functional activities of the organization. A head office and regional offices may be physically divorced from the stores and workshops but generally lower down the chain of operation, as work concentrates on the pure maintenance function, stores and offices will be combined. The stores system will equal a system of accounting, record keeping and auditing. An indenting procedure is required to enable materials to flow to areas of need. Each country will plan a spares distribution system dependent on the sources of supply and areas of demand. In planning this stores organization, considerable room exists for obtaining maximum efficiency, or the reverse. Where the exchange system for providing replacement units exists such as described for the Indian Three-Tier Maintenance System, then a suitably equipped workshop is required at some convenient location. Where spare parts are issued it may often be economical to collect the replaced items and collect these for selling as scrap or possibly reconditioning. The stores form a suitable focus for this activity.

4.11 Individual Systems

Where much of the existing water supply with hand pumps lies in the private sector it may be still desired to rapidly increase the coverage of these individual hand pump water supplies. One way is to add a government organization and government assisted construction to the existing hand pump system. However, the decision that might be taken is not altogether helpful and it may be desirable instead, to encourage further extension of the private hand pump systems. This may be achieved by providing loans for the construction of wells and by reducing the cost of well construction by favourable tax breaks and incentives for the importation and local production and distribution of the materials necessary for the construction of hand pump wells. The government can help by ensuring that the raw materials necesssary for pump and spare part production are available within the country in adequate quantities and by excluding hand pumps from import duties and other taxes, and possibly by encouraging the development of a quality pump and or a low price locally produced pump and by establishing a national standard for pumps produced in the country. Another or ancilliary technique would be to increase the public information activities in order to encourage people to purchase their own equipment. The publicity would make known any loan activity sponsored by the government or private banks for the construction and maintenance of wells and hand pumps. This type of development needs careful handling, as parts of the overall economy may be over stressed due to unexpected demands resulting in short supply of some items, and excessive prices developing for these items.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the writer's practical experience; the literature available on hand pump maintenance and on the analysis presented in this report

Conclusions

1. Hand pump maintenance is essential if the socio-economic and health impact of hand pump installation programmes is to continue.
2. In the past, problems of maintaining large numbers of hand pumps in developing countries have been frequently underestimated or inadequately considered.
3. There is an overemphasis on new construction, with inadequate attention paid to maintaining existing hand pumps.
4. When inadequacies in hand pump maintenance are discovered they are too frequently ascribed to one or two aspects of the problem, such as a poorly made pump or lack of community participation instead of a searching examination of the entire maintenance delivery system, its equipment, its financing, its management, and its suitability to the environment.
5. In developing countries where conditions are suitable for drinking water supplies using hand pumps, the cost of maintenance is low and within the capacity of the national economy to adequately finance. Collection of maintenance funds is often difficult. Finance for maintenance may be left for the villagers or directly provided from general revenue. There is a good case for some government involvement in a national hand pump system. However, in principle, it is preferable for the people to directly pay (at least a part of) the maintenance costs. Establishing a suitable sharing of payment and responsibilities is a crucial factor in hand pump maintenance systems.
6. Experiences, systematic evaluation and analysis provide a basis to determine which combination of pump type, organizational structure, and payment system is best suited to the local environment. Examination of methods already in use in various countries for hand pump maintenance also provides a valuable information and insight.

7. For any new hand pump water supply system, maintenance needs should be considered from the start. As the number and density of hand pumps increases, additional staff and equipment will be required. It is important to recognize that the maintenance system may have to be adjusted or changed so as to improve efficiency and reduce costs.
8. Determination of suitable hand pump maintenance should make use of the considerable body of experiences regarding implementation of hand pump programmes, particularly with international agencies such as WHO and UNICEF, and the good literature base from organizations such as World Bank, Oxfam, and the International Reference Centre for Community Water Supply.
9. The choice of the hand pumps to be used and the assessment whether to manufacture locally or import, it are important decisions next to a commitment to provide adequate financing for hand pump maintenance over the long term.
10. Use of the public information channels and local educators to obtain the participation of the community in planning and maintaining the water supply is a vital element in the success of a maintenance project. However, except in unusual cases the community will not be able to fully maintain their pump over the long term and will require outside technical assistance, financial assistance, and access to a steady supply of spare parts.
11. General guidelines may be provided on the organization of hand pump maintenance, and additional information is available which could be processed to provide better guidance. Still most of the decisions will have to be taken in the countries establishing the hand pump system, and these decisions will have to be regularly reviewed, and progress evaluated.

Recommendations

1. Countries with hand pump programmes should pay much more attention to the maintenance aspect and should carefully investigate the financial implications of any water project based on hand pumps.
2. International agencies should be sensitive to the full maintenance and replacement cost implications of hand pump water supply projects. Assistance in building organizations and facilities to manage maintenance programmes could be included as part of the new hand pump projects.
3. Information should be collected on existing organizations for hand pump maintenance, on a country-by-country basis. The data collected could be similar to that presented in Table 2-3.
4. An analysis should be made of the amount of time spent in terms of man-hours and truck-hours for maintenance under different systems. The analysis should include all levels of staff in the maintenance organization and include consideration of manpower used in making spare parts or handling the importation. The objective of this procedure would be to refine the estimates of cost for maintenance organizations by giving the approximate time spent to maintain a certain number of pumps. Local labour costs could then be used to much improve the accuracy of estimates of maintenance cost for any given situation.
5. Noting very large differences in cost between African and Asian maintenance situations, an analysis at the cause of these differences should be made If the effect is found to be mainly one of the density of hand pumps some study of this effect could be of use in making estimates of maintenance costs.
6. Having an efficient hand pump manufacturing capacity in the country is of value from the maintenance viewpoint, but local manufacture of the entire pump is not always feasible. However, manufacture of the fast moving items such as piston cups, and pins may be feasible and of considerable advantage. Consideration of the advantages of import substitution for selected items might be of value.

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APPENDIX A

HAND PUMP MAINTENANCE CLAUSES IN BANGLADESH

Paragraph	Contents
	Objectives
5.1.4	To establish a system whereby the beneficiaries of the new shallow tube wells contribute at least half the construction cost of the wells. The proportion to be paid by the beneficiary may be increased if pilot studies show this to be feasible.
5.1.5	In due course to establish a system in which the beneficiaries assume responsibility for the cost of routine well maintenance(1). Until such system is established government will allocate the sum of Tk.50(2) per well annually for the purchase of spare parts. That is Tk.1.50 crores(3) per annum in 1976 increasing by Tk.0.25 crore per annum and reaching Tk.2.25 crore on completion of this programme.
5.1.6	To improve the well maintenance system so that by 1978, on an average less than 10% of all DPHE(4) wells will be out of order at any moment and in no thana will the number of wells out of order exceed 20% at a time.
	Plan of Action
	Peoples Participation
6.24	6.24.1 The participation of the rural communities in this programme shall be achieved by associating the community as a whole, the union chairman and other local leaders, school teachers, social workers, volunteers, caretakers of wells etc., in respect of well site selections more particularly by realising a cash contribution toward the sinking cost of each well. The circle officer (Dev.), the sub-assistant engineer of the thana, the union chairman and all the field staff connected with the programme should assist in promoting community interest in the provision of safe water facilities under this programme for the continued use of the facilities, their taking good care of the ame-

Paragraph	Contents

nities provided for them, and their keeping them in good use and maintenance fully realising the permanent benefits such facilities bring for them.

6.24.2 In particular the people will be directly involved by the following measures:

(a) They will have to pay for half the cost of installing the well and in this process they must select a suitable site.

(b) In due course of time they will be required to assume responsibility for the cost of maintaining the tube well.

(c) Each caretaker of a new tube well will form the focus for health education activities and training in basic tube well maintenance.

Commitment of Government

10.2 Financing

10.2.1 The government shall provide funds as follows:

	1975-76	1976-77	1977-78	1978-79	total
		Taka	in	lacs(5)	
10.2.2 Sinking 155.000 shallow tube wells	92.57	845.54	1006.54	684.38	2629.03
10.2.3 Sinking 5.000 (10.000 original scheme) deep tube wells	51.10	152.30	152.30	152.30	508.00
10.2.4 Purchase of spare parts for repair of tube wells	150.00	175.00	200.00	225.00	750.00

APPENDIX A (CONTINUED)

Contents

(1) In Bangladesh the term well maintenance is used to mean maintenance of the well and the hand pump. In this context it applies to the hand pump almost entirely.

(2) TK = Takas (approx. TK15 = US $ 1)

(3) crore = ten million

(4) DPHE = Directorate of Public Health Engineering, the agency responsible for well construction and pump maintenance in Bangladesh

(5) lac = one hundred thousand

(6) Some of the objectives in Appendix A were worded in a general way in order to permit the specific actions necessary to achieve stated objectives to be developed during the course of the construction phase.