UNICEF RURAL WATER SUPPLY WORKSHOP

Bangladesh Rural Water Supply Programme

An Outline of Choices Associated with Handpump Tubewell Programmes and Handpump Design

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OUTLINE

1. Health versus other sectors of development
2. Water versus other elements of health sector
3. Implementing agency choices
4. Funding sources
5. Personnel required : HPTW programmes
6. Sources of specialized personnel
7. Single wells versus piped systems
8. Handpump tubewells versus other wells
9. How to begin
10. Shallow, deep, or multi-purpose handpump
11. Output of pump desired
12. How much to spend?
13. Imported versus local pump
14. If local made pumps - then what?
15. Imported pumps
16. Handpump research and development work : who should do it?
17. Details of pump design
18. Considerations in site selection
19. Installation
20. Maintenance options
21. Continued development
22. Pump production

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N O T E

This outline may be helpful to UNICEF Programme Officers becoming involved with handpump tubewell programmes for the first time. Perhaps this type of outline could be amplified by others as time permits to include more details, and perhaps cover more topics.

Bangladesh Rural Water Supply Programme

Choices Associated with Handpump Programmes and Design

1. Health versus other sectors of development

   (a) Health and disease as a constraint on economic development.

   (b) Public demand for better health.

2. Water versus other elements of health sector

   (a) Disease patterns affecting children.

   (b) Proportion of water related diseases as percent of total.

   (c) Water resources available to supply safe, potable water.

   (d) Institutional arrangements to instal and maintain public water systems.

   (e) Public demand for and utilization of improved water systems.

   (f) Resources available - material, financial, manpower.

3. Implementing agency choices

   (a) National water authority

   (b) Provincial water authorities

   (c) Local water boards

   (d) Rural development departments

   (e) Cooperatives

   (f) Private sector

   (g) Public works departments

   (h) Health ministries

   (i) Others

4. Funding sources

   (a) UNICEF regular resources

   (b) UNICEF special assistance projects

   (c) Bilateral donars

   (d) Multilateral agencies

   (e) NGO's

   (f) United Nations or UNICEF special emergency appeals

   (g) Self-help, reimbursed payment schemes

5. Personnel required : HPTW programmes

(a) Ground water engineers

(b) Tubewell technicians

(c) Managers

(d) Logistics: coordinators; procurement; follow up on end use - storage, books.

(e) Pump technicians - depending on type of pump

(f) Mechanical engineer, Metalurgical engineer for pump design, production.

(g) Communications, sociological, educators

6. Sources of specialized personnel

(a) UNICEF; country office, regional office, other country offices, NYHQ

(b) UN agencies; UNDP, WHO, FAO, ILO, etc.

(c) International Consultants: ground water, water resources planning, management

(d) Local consultants: technical, management, etc.

(e) Technical faculties of Engineering Universities and Technical Institutions.

(f) Government agencies, departments, resource centres, technical assistance centres, research organizations.

(g) Voluntary agencies; within the country, in developed countries but interested in development.

(h) Specialized personnel and consultants of bilateral donors and multi-lateral funding institutions.

(i) Foundations

(j) Retired personnel - especially logistics, retired from armed forces but anxious to work.

(k) Through advertisement

(l) Private industry: advice on a wide variety of technical matters related to supplies.

7. Single wells versus piped systems

(a) Demographic-sociological factors - how people are arranged in settlements. If highly compressed into concentrated settlements, then piped schemes feasible. If dispersed in hamlets, then single well systems preferable.

(b) State of technology - ability to maintain, operate and finance mechanized piped systems versus single well systems.

..... 3/

(c) Financial and other considerations:

1. Piped systems require relatively higher per capita capital investments, recovered over a long time, if ever.

2. Piped systems often take several years to instal.

3. Financial management/maintenance problems often mean low utilization of piped scheme investments.

4. Single well systems require smaller capital investment, short installation time, relatively easier to maintain and operate.

5. Access to piped water systems often restricted to those able to afford house connections.

6. Piped schemes often become disease distribution systems if contaminated by cross-connections.

7. Piped water system service is often intermittent.

(d) Hydrogeological factors:

1. Single well systems depend on availability of groundwater:

   a. depth
   b. quality
   c. aquifer yield

2. Where safe surface water is abundantly available under gravity pressure, piped systems may be the most practical solution.

8. <u>Handpump tubewells versus other wells</u>

(a) Handpump systems are relatively sanitary. Open wells are rather easily contaminated, either by the air, or water lifting device - bucket, rope, etc.

(b) Handpumps require more maintenance than some simpler, indigenous systems.

(c) In alluvial formations, HPTWs are easy to install, but require casing and filter.

(d) In rock, holes are harder to drill, but filter and casing may not be required.

...... 4/

(e) Handpumps must usually be centrally manufactured, whereas some other systems can be made in the village.

9. How to begin

Whether you are choosing an imported pump, designing a new pump or redesigning an old one, there is only one way to start: start small. Experience by trial and error will then be the most reliable guide for further choices. Believe it or not the handpump choice problem is now very complicated - due to a veritable maze of options of designs, models, materials and assembly processes. To order large quantities of untried designs could lead to disaster.

An equal danger is to do nothing at all. One is apt to bog down in a quagmire of choices. It is necessary to make a start. Not all the factors can be known in advance. By proceeding slowly and cautiously, new factors can be dealt with as they arise. The main point is to avoid over commitment to one design, the performance and production problems of which are not fully known.

Perhaps the starting point should be the observation of available models already in use. Then choose an option which seems appropriate, order a few, field test it, produce a few, redesign, retest, etc., etc., etc., enough times until decision making becomes more refined. The design should gradually begin to converge around an appropriate solution.

10. Shallow, deep, or multi-purpose handpump

(a) Depends on depth of water table, and uniformity of ground water conditions.

(b) Where water level is normally 25' or less, shallow well may be used exclusively.

(c) Where water level is normally more than 30', deep well must be used.

(d) Where water table varies considerably - say between 10-40 feet within small geographical area, a flexible design, multi-depth setting pump may be used.

(e) Where water tables are likely to steadily drop, a design which can later be converted from shallow to deep may be worthwhile.

11. Output of pump desired

Designing a handpump tubewell is like designing a water system, because it is a water system - having inlet, rising main, pump, reservoir (the upper part of pump body) and distribution outlet (spout). Therefore, it is not too surprising that handpump design procedures should take into account criteria also considered in the design of piped water systems, such as mapping of the served area, ground water resources, local usage patterns, calculation of average demands and peak flows, financial status of the executing authority and the users, etc. These are outlined further below.

All these factors taken together will give an indication of the performance desired by the pump. Performance desired is determined by two factors:

(a) Water per person per day needed to satisfy optimum, minimum, or practical median water requirements.

(b) Persons per pump.

These two figures can be more clearly determined by consideration of the following:-

(a) Intended water use

1. Drinking water only
2. Drinking, cooking, washing utensils
3. Full domestic use
4. Micro-irrigation
5. Domestic use plus small garden
6. Or other combinations

(b) Intensity of use

1. Availability of other wells and/or other water sources.
2. Is well to serve 10, 50, 100, 1000 or more people?

   Type of site:-

   a) Single family unit
   b) Extended family, hamlet or small village
   c) Large village
   d) Urban fringe area
   e) Market place, bus station, boat landing, or other high density public site.
   f) School, health center or other institution

3. Queue factor: Will people draw water intermittently throughout the day, or will there be peak demands at sunrise, noon, sunset or other periods? If the queue factor is significant, as it is in most traditional societies, then the real test of how well the pump satisfies the performance criteria may well depend upon how well it can meet these periods of peak demands.

..... 6/

(c) Cultural factors

1. Will the pump be used by men, women and children alike?

2. Or will one sub-group predominate in well use? This determines the mechanical leverage desired, and volume of water which can be lifted per stroke.

3. How far are people willing to walk to draw water? Sometimes people will walk a great distance to fetch their minimal drinking water requirements, but will tend to use more convenient surface or other traditional water sources (if they exist) for other needs such as bathing.

4. Health awareness. The degree to which people will expend energy to obtain water from protected sources may depend upon their awareness of the cause-effect relationship between water and health/disease. In the overall equation, this factor is a variable, which may be increased by educational efforts.

(d) Depth of water table and water quality may determine the practical output of a pump, which may be much less than the total desired. That is, the performance of the pump cannot be considered independently of the design and construction of the well. A number of economic considerations influence this choice also. For any given set of ground water conditions, there is a maximum theoretical yield, but the optimum economical yield may be considerably lower. In well design in relation to HPTW programmes, three general levels of output should be defined:

1. Maximum possible
2. Minimum desirable
3. Maximum practical

The practical output would normally fall somewhere between the minimum desired and the maximum possible. Generally it is desired to provide as much water, as conveniently as possible, within economic constraints.

Within these social and economic considerations, the well design is normally determined by the following hydro-geological factors:

1. Depth to water table,
2. Aquifer yield,
3. Degree of development of well, if in unconsolidated formations,
4. Water quality may also be a factor in water use.

The design considerations are as follows:

1. Diameter of filter
2. Diameter of rising pipe

   Technical considerations aside, these two choices are largely economic.

3. Filter slot size
4. Gravel packed, shrouded well or naturally developed.

   These are largely technical decisions, requiring the expertise of a ground water engineer. They will, however, have a direct bearing on the output performance of the pump.

5. Type, design and configuration of the filter. This is a rather complex interaction of technical and economic considerations. Generally, there are various trade-offs to be considered - largely economic - such as first cost versus yield and/or length of service. Water quality factors, such as encrustation by carbonates, bacterial slimes, or corrosion, acidity, etc. may be overriding considerations.

6. Most suitable aquifer. This is a complicated technical-economical decision. There may be a series of aquifers at different depths having various yields and water quality. It is normally desired to use the shallowest aquifer which will adequately satisfy the needs of the programme. Yield and water quality considerations may lead one to utilize a deeper layer.

   However, this is a self limiting process, economic considerations becoming overriding at a certain stated depth. At some point it may be necessary to choose a water quality or yield which is less than desirable, but is the best yield or quality practical within economic limitations.

   At this point, adaptability and taste preferences of the local people become critical. Most people are ready to make do with less if that is all which is available. They may also be willing to drink water of less than ideal taste.

(e) The static water level is an important factor in pump and and well design. But equally, if not more important, are the annual fluctuations of the water table and/or special variations, i.e. the water table depth may vary considerably from place to place within a relatively small geographical area. Implications of these factors on pump design have been mentioned above (10).

12. <u>How much to spend?</u>

How much should be spent on the pump?

The amount should be related to how much has been invested in constructing the well. In Bangladesh, the materials used in constructing a 1½" diameter tubewell 150 deep cost about \$60 - \$70. These wells are easily constructed, and are being installed by the tens of thousands in every village and for every two or three hundred people. The pump is presently costing about \$20 (after the recent devaluation of the Taka). This seems in line with the overall cost.

In other countries, water levels may be several hundred feet deep through solid rock requiring a major capital investment and the use of sophisticated drilling rigs to construct the well. In such cases the well may serve several hundred to a thousand people or more, some of whom may come miles to draw drinking water on which their life depends.

In Bangladesh there are usually many alternative sources of surface water or shallow ground water if the pump fails. But in many places, the UNICEF well may be the only source of water supply. Such wells will be severely stressed by intensive use.

Normally such wells would be constructed in relatively fewer numbers and it is imperative that a very high percentage of them be in good working order at all times. In such circumstances, a considerably higher investment is justified in the pump. The desirability of improving the design as much as possible would be equally great.

Possibly as a general rule of thumb for such deep well situations the amount spent on the pump should not become a major financial constraint significantly reducing the total number of wells. But on the other hand, the amount spent should be sufficient so that the pump is not out of order more than 10% of the time. If there is no existing design which fits within this criteria, then high priority may be given to developing an appropriate design, before mounting a major programme to construct new wells, which will then may be left without a satisfactory pump.

.... 9/

13. Imported versus local pump

a) Ultimate goal of UNICEF assistance?

If the goal is to develop a self-sustaining water programme, local production of pumps may be a high priority.

b) Availability of local pumps : Industrial Base. Some countries have almost no industrial base whatsoever. In such cases, it may not be practical to hope for a locally produced pump. In such case, decision-making is limited to selecting the most appropriate import model.

On the other hand, even in countries with very little industry, it may be possible to develop a water pumping device fabricated out of locally available materials. In such cases, emphasis should be given to developing village level appropriate technology.

c) Foreign exchange position of the country.

d) Volume of demand : For a small number of pumps, it may not be worthwhile setting up local production.

e) Raw materials : Unavailability of raw materials should not necessarily prevent local development of a handpump industry, provided the necessary materials can and will be imported. Japan for example has very few raw materials. Interest, initiative and management are more essential.

14. If local made pumps - then what?

a) Use traditional design? Introduce brand new design? Or modify traditional design? A new or improved design may be needed if:

(1) Existing pumps are out of order more than 30% of the time (shallow wells), or more than 10% of the time (deep wells).

(2) There is no design available which can give 90% trouble-free operation within the price range appropriate for the investment made in constructing the well.

Depending on programme priorities, it may be necessary to begin with local varieties of pumps. Improvements can then be introduced gradually. If at all possible, design development should be separated from programme implementation, so that programmes do not become dependent on unproven designs still in the development stage. On the other hand, traditional pumps originally designed for single family use should either be replaced or reinforced as soon as possible, to prevent the institutionalization of an underdesigned pump.

... 10/

Experience has shown that successful pump design is more often achieved by starting with an indigenous design and then improving it, rather than by trying to introduce a totally new design. In order to be successful, a design should be capable if being produced locally, and operatedd and maintained by the beneficiaries. Local acceptance, both by the user and the producer seems to play a key role in good design development.

Similarly, if redesign of an existing pumps is the order of the day, then improvements can be classified according to urgency: I - urgent-immediate; II - as soon as practical; III - for further consideration.

"Urgent-immediate" changes are usually also simple by nature - design aspects which can greatly improve the service life of the pump, but requiring little major changes. Using larger diameter pivots is an example. Enlarging castings for greater bearing surface or to reduce breakage is an example of category II. Redesigned valve systems may be category III.

Establishing such design priorities helps to bring greatest returns on time invested, while at the same time allowing major programmes to get off the ground. Further design work can proceed parallel to programme execution, rather than hold it up. Improved designs can be substituted as they become available.

b) Design objectives

The overall design objective is SIMPLICITY - the simplest, most economical design which will satisfy the functional requirements of the programme.

In general nearly all aspects of pump design fall into four general objectives. These categories can form the basis for the analysis of almost any pump design. They are not necessarily listed in order of priority. In fact, it is difficult to consider anyone aspect completely independently of the others. There is a high degree of interaction among them.

(1) Performance

Does the pump provide water easily enough, adequate to the needs?

(2) Maintainability

Is the design sufficiently robust to provide relatively continuous operation, presuming a basic routine maintenance service?

There is an economic trade off here between first cost and overall service life. In situations where government maintenance systems are weak, and/or the local capacity to maintain and repair pumps is marginal, the long term objectives of the project will probably be better served by increasing first cost, to provide a more robust design which will minimize the maintenance problem over the years.

The performance of a pump from the maintenance point of view may depend significantly on the habits of the people. For example, if they are in the habit of lubricating mechanical equipment, the pump parts may last considerably longer than places where no lubrication is given. Also a conscientious caretaker who really looks after the pump, detering vandalism, arranging maintenance, etc. will help to improve the service of the pump.

(3) Cost

Is the cost appropriate to the amount of money invested in the well and the degree to which people depend on it for their welfare?

(4) Produceability

Can the pump be produced locally, relatively fast, easily and economically?

Specifically, a pump should be designed as follows:

(1) Reduce maintenance breakdowns to manageable frequency, so that maintenance system can keep pump in nearly continuous operation. Spare parts should be few in number, simple, easily replaceable.

(2) Design should be simple, economical, locally reproducable.

(3) Ease of lifting water may be a key objective.

(4) Minimize expensive, or imported materials.

(5) Discharge appropriate for needs in relation to water resources available.

...12/

c) Specific design improvements (mainly for shallow wells)

(1) Increased bearing surfaces (wider, bigger diameter). One practical tip is that in village use, nearly all parts move. A drawing may specify some parts as fixed and others as moving, but usually they all begin to shake loose sooner or later. Therefore, all parts of the design should be reinforced as much as economically practical. Field observations of pumps under very heavy use will reveal the most critical stress points requiring maximum reinforcement.

(2) Smoother bearing surfaces (round pins, instead of threaded bolts).

(3) Harder bearing surfaces (heat treatment).

(4) Lubricated bearing surfaces.

(5) Reduced number of parts.

(6) Standardized size fasteners.

(7) Stronger structural design to resist breakage.

(8) Reduced weight where possible.

(9) Use of most appropriate materials.

The design improvements needed may depend greatly upon whether a shallow or deep well pump is being used. Experience has shown that a shallow well pump can be made quite satisfactory by reinforcing bearing surfaces and other basic, common sense improvements of traditional models. However, in deep set well pump installations especially where the water table is particularly deep (say 100 feet or more), simply strengthening the traditional models may not be sufficient to prevent excessive breakdowns caused by the severe stresses on bearing points. For these situations more innovative approaches may be necessary to find a solution. (UNICEF New Delhi has done just this).

Also design objectives may be different if designing for micro-irrigation. Each person may use a public pump as little as five minutes a day. The objective is to have a pump producing 5-10 gallons per minute and which will need parts replaced less than once a year. The situation for a hand operated irrigation pump is quite different. One or two people may operate a pump continuously for 8-12 hours a day.

Therefore greater outputs will be required. Ease of pumping and mechanical leverage will be critical. Replacement of parts will be less of a problem because the pump is owned and maintained by the farmer.

..... 13/

Beware: Beware of new ideas advocated by "experts", but which have not been thoroughly tested under actual field conditions. Field tests almost always result in rougher, more excessive wear patterns than laboratory tests. It has been learned that there is generally no easy instant solution for handpump problems.

d) Design procedures

(1) Design criteria

(2) Sketch designs

(3) Sample prototypes

(4) Production models

(5) Analysis of production techniques

(6) Field test

(a) accelerated testing in high density use areas.
(b) normal testing in typical village site.

(7) Analysis of wear patterns.

(8) Modified-improved design

(9) Production drawings

(10) Tolerances

(11) Raw materials specifications

(12) Inspection guidelines. Quality control criteria.

(13) Tender documents

(14) Contract documents

e) Type of production

(1) Cast iron

(2) Fabricated from steel pipe, standard fittings, etc.

(3) Constructed at site

This decision will depend upon the type of industry in the towns, the raw materials available, and the skill of craftsmen

.... 14/

at village level. A cast iron or pre-fabricated pump requires little engineering at the installation sight. Water pumping devices assembled or constructed in the village are able to utilize local skills and materials thus economizing on materials. The resulting unit is usually locally understood and maintainable.

f) Multipurpose unit versus single design options

It may be necessary to begin a programme with a single multipurpose design pump which will serve a variety of purposes, even if not particularly well. As the programme gains momentum, routine operational problems become reduced, R & D capacities expanded, it may become possible to branch out into several design options - each one appropriate for a single use. For example one pump may be designed specifically for single family use, another for small hamlets of say 50-100 people, and another more robust model for 100-200 people or more.

Also special purpose pumps, such as for micro-irrigation, can be designed as the need arises. Here again there is scope for variety. The aim may be to water a small vegetable garden plot with the household pumps, or micro-irrigate a small field crop of wheat, potatoes, sorghum, etc. with a special pump designed for that purpose.

15. Imported pumps

a) OLGA* may be helpful. But there are other pumps under development which are not yet in OLGA, particularly shallow well pumps in Bangladesh and Deep Well Pumps in India which may be more suitable. HQ may be able to give advice on the most appropriate model. Martin Beyer and Hans Lotje should be the best sources of information.

b) If local production is the ultimate project goal and import is a temporary expedient, then a simple design such as is being produced in a nearby developing country may be the most suitable design to begin developing local capacity.

16. Handpump research and development work : Who should do it?

a) International Consultants. Tend to be expensive, and take a long time getting from the drawing board to prototype. Difficulties in communicating complex technical questions over long distances. May develop solutions which are

* UNICEF GUIDE LIST (OSU-6400 May 1975, UNICEF HQ, NY)

neither technically, socially or economically appropriate. (But usually do have highly qualified engineers. Good for initial studies).

b) Government Agencies. Ideal to involve government in developing its own pumps. But often there is insufficient motivation or technical skill.

c) Local Industry. Usually has technical skill, but lacks initiative in developing improved, better-cheaper technology. Existing technology tends to become institutionalized, even though it may be more expensive, inefficient or both.

d) Beneficiary. For drinking water pumps, technical skills, motivation and resources are not usually available at village level. However, farmers in a famine situation often develop an uncommon ingenuity for developing appropriate means of getting water to the land.

e) UN Specialized Agencies. Do not normally purchase large quantities of final design units, and may have difficulty getting their ideas into production.

f) UNICEF Office. Normally does not have technical staff to initiate technical innovations and follow through into production.

g) OPTIMUM combination for success = purchaser + designer + manufacturer + beneficiary. That is, successful designs develop through continuous interaction between the agency responsible for purchasing the improved design, the designer, the manufacturer, and user of the pump in the field. It is sometimes most effective if the designer and purchaser are one in the same.

Another formula for SUCCESS = 90% perspiration and 10% inspiration. There does not seem to be any substitute for people. People willing to work closely with local manufacturers, make frequent visits to field sites, back to the drawing board, back to the workshops, back to the field, etc., etc., repeated enough times until an appropriate design is evolved. There is no easy solution to long range development.

Another way of saying this is that nothing happens automatically. An idea needs to be pushed and proded, revised and pushed again every step of the way until it actually reaches the field and produces results.

... 16/

17. Details of pump design

A. Dimensions

1. Cylinder size. Along with stroke length, determines the volume of water per stroke. The volume determines the weight of water lifted per stroke. 2½", 3" and 3½" are common pump cylinder diameters.

   A rather small increase in cylinder diameter may give a relatively large increase in discharge, since discharge per stroke depends on the cross-sectional area, which increases as the square of the radius.

   Combinations of diameters and stroke lengths are listed below. These discharges are not theoretical, but are general performance levels from existing designs operating under field conditions:

Cylinder dia.	Cross sectional area	Stroke length	Typical* discharge	Pump type
2½"	5.0 sq.in	4"-5"	4 - 5 gpm	Pak. G.I.
3"	7.1 sq.in	4"-5"	4 - 6 "	B'desh No.4
3½"	9.6 sq.in	6"-7"	6 -10 "	B'desh No.6

   * depends considerably on well.

2. Stroke length. A longer/stroke length gives a greater discharge per stroke for a given cylinder diameter. A given unit of discharge may be achieved by either a fewer number of longer strokes, or a greater number of shorter strokes. From the operational point of view, the optimum configuration will have much to do with the size, strength and work habits of the users. From the maintenance point of view, it is thought that a smoother pumping action results in less wear on the moving parts.

3. Discharge. A combination of cylinder diameter, stroke length, number of strokes per minute, and number of cylinders.

   Note: The discharge of the pump can not be considered apart from the design characteristics of the well. These factors include:-

   a) Diameter of filter and rising pipe
   b) Slot size and open area of filter
   c) Transmissibility of aquifer
   d) Development of aquifer
   e) Depth to water level
   f) Fluctuations of static water level

4. Handle length. Determines the mechanical advantage, which, alongwith cylinder dia., and depth to water table, determines how hard it is to work the pump. Generally, the longer the better. The configuration of the handle also seems to be important in the overall use of the pump.

5. Overall size. Depends upon the size of the people using the pump, and the type of installation.

6. Thickness of bearing surfaces. $1\frac{1}{2}$" usually recommended as total breadth of C.I. bearing surfaces around pivot points.

7. Diameter of pivot pins. $\frac{5}{8}$" - $\frac{3}{4}$".

B. Materials

1. Cast iron
2. Plastics
3. Mild steel
4. Brass - Bronze
5. Wood

These all relate to the particular local economy/technology, and the particular engineering function which each is to perform.

C. Assembly

1. Foundry
2. Workshop
3. At site construction

Depends upon local technology, both in towns and at village level.

D. Security

1. "You can't pump the pump because the vandal took the handle".* Security problems vary from place to place, but are likely to be increased in exposed public places where there is no responsible caretaker. Lock and key arrangements can be devised locally.

2. Stones, pebbles, etc. There seems to be a human impulse to drop pebbles, etc. down a tube sticking up out of the ground. A wire mesh barrier placed in the pump cylinder, or sheet metal cowling over the top may be solutions. This problem is more critical for deep set well pumps where the cylinder mechanism is down the hole.

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* Song by R. Dylan

.... 18/

18. Considerations in site selection

a) Maximizing the number of beneficiaries

b) Responsible caretaker

c) Suitable drainage arrangement

d) Ground not too high to go beyond suction lift (for shallow pumps).

e) Site not too low to become flooded.

f) Far enough away from sources of pollution.

g) Maximizing possibilities of good ground water. (salt or iron concentrations may be localized).

19. Installation

a) A good concrete foundation and surrounding platform helps maintain a sanitary seal and healthy conditions around the pump, thereby increasing well use.

b) Details of design depend on local use patterns, available materials and skills.

20. Maintenance options

a) By caretaker: May be possible depending on skills, tools, spares available in village.

b) By local or union boards: May be able to manage finances and coordination, but may have difficulty arranging spares.

c) Centralized agency.

- Advantages : Bulk purchase of spares
- Disadvantages : Cumbersome, inefficient administration, financial burden on government.

21. Continued development

No design represents the "final" solution. The conscientious designer will restlessly be agitated by the questions.

Can we do it better ?

Can we do it cheaper ?

.... 19/

Nearly always the answer is, "yes". Improved solutions are developed the same way as original designs : continuous interaction between designer - user - producer, as well as a restless look out on the horizon for better/cheaper materials, techniques, designs.

22. <u>Pump production</u>

a) One supplier or many?

b) Centralized production or regional dispersion?

This of course depends on the quantities needed by the programme against any one supplier's capacity to produce them. Dealing with one supplier may be preferable at the beginning since supervision and supply of raw materials and subcomponents is simpler. However having several producers improves UNICEF's bargaining position for price, frees programme of dependence on one source of supply, and helps to institutionalize the design. Possibly, production could start with a single supplier, centrally located and grow to include regional points as the demands of the programme and UNICEF's capacity to manage contracts increase.

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