Simple Technology of Shallow Wells

by ***Eustace S. Gondwe***
Department of Civil Engineering,
University of Dar es Salaam,
P.O. Box 35131,
Dar Es Salaam,
Tanzania

ABSTRACT

Provision of clean and safe water to all people is a major preoccupation of governments of developing countries. Owing to limited resources some countries have opted for the simple technology of shallow wells particularly for rural water supply schemes. One such country is Tanzania where shallow wells have now been in use for over 10 years.

It is shown from Tanzania's experience that shallow wells are much cheaper to construct than any of the alternative systems. Two types of shallow well are in use, namely the hand-dug and the hand-drilled well with the latter preferred in high yielding aquifers. The characteristic problem of a shallow well is its relatively limited yield. Hand pumps fitted on some of the wells pose serious problems at times due to frequent breakdowns.

Results of some of the shallow well programmes have shown that investigations prior to sinking of a well are important. The villagers should be fully involved in the shallow well programmes. Countries should share their knowledge of shallow well technology. Indeed shallow wells will become increasingly important in developing countries especially during the test period of the International Water and Sanitation Decade.

INTRODUCTION

In most developing countries a greater percentage of the population lives in rural areas. For this reason such countries have placed much emphasis on rural water supply schemes. A number of investigators, among them Feachem *et al.* [1], have pointed out the relationship between improvement of water supply and reduction of diseases. Thus improving rural water supply in effect cuts down a nation's health bill. Conventional water supply systems are expensive and require skilled manpower to build them. This has called for development of simple, inexpensive technology of water supply for rural areas of developing countries. One such technology which is gaining ground is that of a shallow well. Experience of the author's own country, Tanzania, indicates a great potential for shallow well technology in rural areas.

Provision of water supply to rural areas is beset with problems and limitations. The budget allocation to water supply development is often limited. To give but one example, Tanzania has set a target to supply all its people with clean water by 1991. By 1980 only 3 million people of the rural population had access to a source of clean drinking water [2]. The population of Tanzania in 1991 is expected to be 23 million people. Therefore, in order to meet the 1991 target, about 2 million additional people have to be provided with water supply annually. In the whole of 1979 the new supplies provided for a population of only 400 000 or approximately 20% of the annual target. The shortfall is mainly due to limited funds and lack of skilled manpower. In order to meet the target, Tanzania needs to spend US $29 million annually in water supply development programmes. However, actual allocations over the last ten years were US $15.5 million annually [3]. Unless there is a speedy recovery of economies, developing countries will continue to experience great difficulties in meeting targets set within the International Water and Sanitation Decade.

Shallow wells are suitable for developing countries because they are cheap to construct and do not require maintenance by highly skilled personnel. Nonetheless, shallow wells also have their problems. Since Tanzania has provided most of the case studies cited in this paper, it is appropriate to discuss briefly its demography.

DEMOGRAPHY OF TANZANIA

Mainland Tanzania with an approximate surface area of 885 000 sq km is divided into 20 administrative regions as shown in Fig. 1. According to the population census of 1978 Tanzania has about 17 million people [4]. The growth rate of the population is between 1.7–4.6 percent with a national average of 3.3 percent. About 85 percent of all the households are located in rural areas.

The consequence of the national villagization programme is that practically all the people are now living in villages. The national census of 1978 indicated that 96 percent of all the households are in villages. The average number of people per household is 4.2 and 4.8 for urban and rural areas respectively. Population density varies between 7–70 people per sq km. The national average density is 19.

SHALLOW WELL TECHNOLOGY

Shallow wells are preferable to other water supply systems in rural areas because they are comparatively cheaper and take relatively shorter periods to construct. The experience of Tanzania [5] shows that the estimated unit cost per capita for a shallow well and a borehole are US $9 and US $78 respectively. Thus the cost of a conventional borehole is about nine times more expensive than a shallow well. The saving in costs by construction of shallow wells is significant for

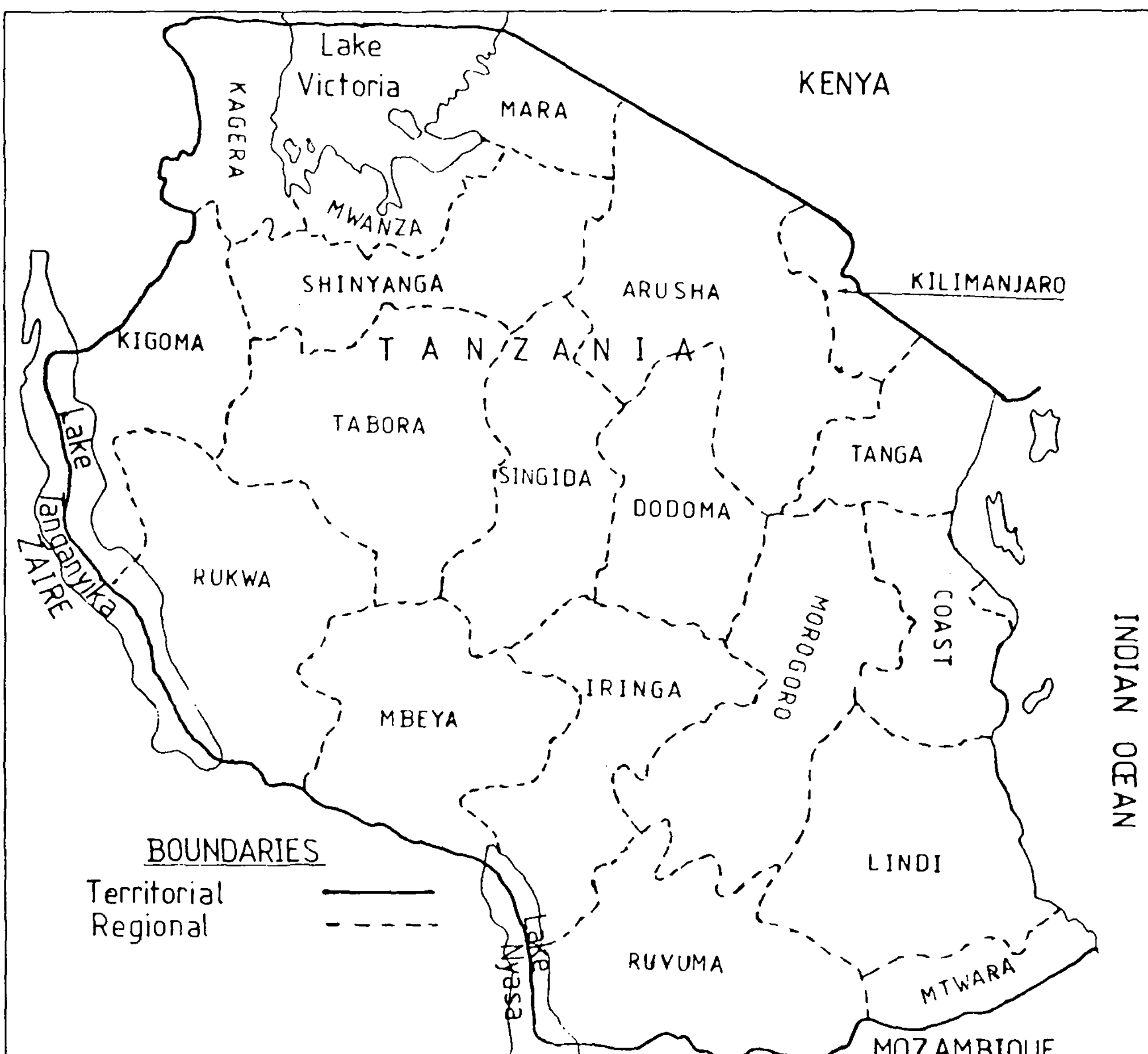

Fig. 1. United Republic of Tanzania, administrative regions.

developing countries having limited financial resources. The level of technology is such that the villagers themselves could easily construct and maintain a shallow well. A minimal degree of training is needed to enable the rural population to do this. To cut costs even farther it is better to involve villagers in the construction through a self-reliance programme.

The level of technology is such that the villagers themselves could easily construct and maintain a shallow well

Two types of shallow wells are prevalent in Tanzania. The first one is made by sinking concrete rings of height 0.5 m and diameter 1 m. The depth of this well could be up to 10 m. The excavation is done either manually or by a small tractor and a handpump is fitted in some cases. The second type of shallow well is, strictly speaking, a borehole sunk using inexpensive technology. Ordinary hand augers are used to drill this type of borehole. Machine augering is sometimes employed. The well is provided with PVC screen and casing of much smaller diameter than a hand-dug well. This hand-drilled type of shallow well is suited to aquifers with yields of more than 1000 litres per hour. Hand-drilled wells have proved successful in the Morogoro Region (see Fig. 1).

Blankwaardt [6] made a survey of construction costs of wells in Morogoro, Tanzania. The respective cost estimates for hand-dug and hand-drilled wells not exceeding 6–7 m depth are US $1000–1550. The hand-drilled shallow well is cheaper because the short duration of construction cuts down labour costs. For interested readers, the technology of shallow wells based on Tanzania experiences has been well documented by the Dutch consulting engineers DHV [7].

WATER SUPPLY FROM SHALLOW WELLS

In Tanzania, shallow wells have been constructed in various regions such as Lindi, Mtwara, Morogoro, Shinyanga and Mwanza. Consultants and contractors for regional shallow well programmes in Tanzania normally come from the donor country or agency. Consequently each region has its own modifications incorporated into the construction technology. A case in point here is the handpump; there are more than three types of handpump in use.

The relative low yield of a shallow well makes it ideal for rural areas where consumption is minimal; water is used for domestic purposes, mainly drinking, cooking and occasional laundry. Rural population in most developing countries does not apply water-borne sanitation practice. A shallow well is normally designed to supply a population of 200 people, on the average. For Tanzania this population corresponds to 40 households based on the census of 1978. In general, the average consumption of water in rural areas of East Africa is 15–35 litres per capita per day [8]. At the high range one shallow well should yield 7000 litres per day to supply 200 people. This yield is equivalent to about 290 litres per hour. For such a yield a hand-dug shallow well is sufficient.

Table 1 gives the proportions of population served by shallow wells in some regions of Tanzania. Data to compile Table 1 were taken from the Proceedings of the National Conference on Wells, Morogoro, Tanzania, August 18–22, 1980.

TABLE 1

Population using shallow wells in regions of Tanzania*

Region	Population	Number of wells	Pop. served	% Served	Donor
Shinyanga	1.323	1000	0.293	22	Netherlands
Lindi/Mtwara	1.300	600	0.120	9	Finland
Morogoro	0.939	2500	8.750	80	Netherlands
Mwanza	1.443	540	0.162	11	World Bank

*Population figures in millions

Figures given in Table 1 for the number of wells in the Mwanza region are only target figures. It is reported that 63 percent of all villages of the Singida region in Central Tanzania obtain their water from shallow wells located in the river alluvium [9]. The Morogoro region is most successful in terms of the proportion served by shallow wells. The hydrogeology, with the earlier experience of the Dutch experts in the Shinyanga region, contributed to successful developments in shallow well technology in the Morogoro region. One such notable success is the handpump developed by Dutch experts in the Morogoro region which is the most reliable in use in Tanzania at present.

Shallow well technology is being developed in other countries as well. For instance an efficient handpump is reported to have been developed in Zimbabwe [10]. The pump is available in a kit form for less than US $75. From tests carried out in Zimbabwe the pump has been found efficient to depths of up to 15 m. The pump can lift 20 litres per minute. This makes the pump operative for hand-dug as well as hand-drilled wells. It is to be hoped that other countries would adopt this Zimbabwean pump. The Lutheran World Federation (LWF) has a project in Zimbabwe, which has a target of sinking 1000 wells by the end of 1984 and supplying enough clean water for half a million people. To date the LWF has been able to sink more than 70 wells [11]. It is not known what proportion of the wells is going to be constituted of shallow wells. What is known, though, is that the LWF project is going to depend a lot on participation by the rural population itself through self-reliance. At least the idea of utilizing simple technology for water supply is catching on in a number of developing countries.

It is to be hoped that other countries would adopt this Zimbabwean pump

LIMITATIONS AND PROBLEMS

The major limitation of a shallow well is its relatively low yield. A properly designed shallow well is capable of yielding about 7000–10 000 litres per day, a yield sufficient for about 200 people at the high range of consumption, i.e. 35 litres per capita per day. This limits the application of shallow wells to small villages in rural areas. For large villages a number of wells would have to be sunk. In this case benefit-cost ratio analysis would favour other more sophisticated water supply systems. The high growth rate of population in rural areas of developing countries means that the population of even a so-called small village may increase considerably in a 10-year period. The yield from a shallow well may not then be sufficient. This poses a serious question to planners; should shallow wells be regarded only as a short-term solution for rural water supply?

The hydrogeology is responsible for limitation of yield from shallow wells. Shallow aquifers can not be found everywhere. Therefore, only certain regions or areas in a country can use shallow wells. The limited thickness of aquifers implies limited storage capacity, which could be depleted in case of excessive exploitation or in the absence of direct recharge of the aquifer by rainfall. High evapo-transpiration rates, typical of tropical regions, greatly limit the amount of direct recharge and hence thorough investigations are necessary before siting of shallow wells. A number of shallow wells sunk by Finnish experts in Mtwara region, in south-east Tanzania, dried up in 1981.

There are still some problems with the hand-pumps fitted on the shallow wells in Tanzania; they breakdown often. Different types of hand-pumps are in use in the country. In the Shinyanga region the Dutch designed a wooden pump which is an improvisation of the UNICEF pump and Uganda pump [2]. This pump requires a lot of maintenance which the villagers are incapable of providing. The Finnish engineers used a pump of their own design in the Lindi and Mtwara regions. This pump seems to have had partial success. In the Morogoro region Dutch engineers designed a pump which appears to be more successful than the other two types mentioned above. This pump, though, needs a lot of force to work. Women and children who often fetch water from the well have to strain their muscles; but compromises have to be made in any design.

Maintenance of the well itself by the villagers is a problem to some extent. For the sake of convenience the villagers prefer to do their laundry and clean their dishes adjacent to the well. This poses a threat of contaminating the water in the well surroundings either directly or by seepage from the surface. The only solution to this problem would be to give public health education to villagers. They should also be trained to do small maintenance jobs on the pump.

Funds allocated towards water supply development often are not sufficient. Fortunately the technology required in shallow well construction does not require much foreign exchange. Hand-drilled wells may not be so appealing because they need PVC casings and screens which introduce an element of foreign exchange in the cost. However, funds so required are insignificant compared to the cost of sinking a conventional borehole using sophisticated rigs or to costs of a system with long lengths of distribution pipe.

CONCLUSIONS

Until such times as developing countries are able to afford more sophisticated water supply systems, shallow wells should be used for rural water supply. Yield capacity of a typical shallow well is sufficient for a village of between 200–500 people at the maximum. Although the construction costs for a hand-drilled well has some foreign exchange involved, it should be preferred to the hand-dug well because of its higher yield capacity. Hand-dug wells have the advantage, in that they do not need formally trained personnel to design them, as is the case with hand-drilled wells. Villagers could easily construct hand-dug wells themselves. The funds and manpower available, together with the hydrogeology would dictate which type of shallow well should be constructed.

Villagers could easily construct hand-dug wells themselves

It is stressed that even in the case of the application of simple technology, investigations are necessary. Money spent on investigations prevents the bad experience of dried up wells. Efforts should be made to involve community participation in shallow well programmes. It is bad to site a well where none of the villagers would feel inclined to use it. Documentation of technology of construction based on experiences in Tanzania and elsewhere is now available. There should be intercountry exchange of such documents to prevent duplication in investigation activities. Perhaps the Information Reference Centre (WHO) could promote such exchange through their publications and newsletters. More research is needed on the handpump.

Insufficient fund allocations hamper the progress of water supply development in developing countries. If countries are serious about providing clean and safe water to all before the turn of next century, additional funds need to be allocated.

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Groundwater Policies in the Agricultural Midwestern United States

by R. Rajagopal and Charlene Carmack
Department of Geography
The University of Iowa
Iowa City, Iowa 52242
U.S.A.

ABSTRACT

Groundwater quality in the agricultural states of Iowa, Kansas, Missouri, and Nebraska (U.S.A.) is found to vary with depth, location and ownership of well, time of sampling, and geological features. Shallow wells are much more susceptible to contamination than deep ones from surface sources. It is observed that depth and non-uniform well construction practices are two major determinants of groundwater quality. Statutes in these states recognize pesticides and herbicides as potential sources of contamination, but at this time do not specifically include any provisions to protect groundwater from contamination by other sources. This paper describes the status of groundwater quality conditions in the states of Iowa, Kansas, Missouri and Nebraska and discusses research priorities and potential policy options for the protection of groundwater in these states. These discussions would be of value to water resource scientists, planners and administrators, especially those in regions of the world where large doses of chemical supplements are used in crop production.

INTRODUCTION

With increased pressure to produce more food, water resource problems could become magnified in those parts of the world where high yield crop varieties are cultivated with large doses of chemical supplements. The worldwide use of commercial fertilizer has increased over six-fold during the last thirty years. The major regions of intensive fertilizer use are located in parts of Western Europe, the United States, Japan, and Eastern Europe. For example, in the early 70s, average fertilizer application rates were in the range of 350 kg of nutrients per arable hectare in Japan followed by 195 in Western Europe, 180 in Eastern Europe, and 85 in the United States [1]. The impact on these region's groundwater quality from such chemical applications and other non-point sources is not a well understood phenomenon. Available scientific evidence is often sketchy and conflicting [2]. There is also a lack of reliable long-term data for interregional comparisons. This study will attempt to illustrate selected issues in groundwater protection by discussing the problems and policies of four states in the agricultural midwestern region of the United States.

The midwestern region of the United States has long been known as 'the nation's breadbasket', for it contains some of America's most productive agricultural lands. States in this region (including Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, and Wisconsin) are consistently ranked among the top ten in crop and livestock production. In 1980, nine of the top ten states in total acreage of principal crops harvested were Midwestern States, with Iowa and Illinois being ranked first and second respectively. Also, in cattle and hog production. Midwestern States were in the majority in the top ten during 1980 [3]. While fertility of soil in the Midwest plays an important role in this success, perhaps the greatest contribution to this productivity can be traced to genetic improvements and chemical supplements.

Major pollutants from agricultural watersheds include sediments, nutrients, and pesticides, all of which have significantly increased in surface and groundwater of the Midwest during the last two decades. In this region, the use of fertilizers and pesticides have played an important role in increased crop yield. It is quite likely that a portion of these chemicals not utilized by crops eventually enter ground and surface water through leaching

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Editorial

The World Water '83 conference, which took place in London during July, was a landmark event. As the first truly global meeting on the topic of the United Nations Water Decade programme since its official launching at the U.N. General Assembly in New York on November 10, 1980, the mere convening of this conference made it of extraordinary importance.

Early on in the meeting consultant engineers were catching some heat for their traditional roles in the developing world. I think, however, it is important to point out that the creation of the World Water '83 conference by the Institution of Civil Engineers was made largely through the efforts of consultant engineers. British consultant engineers have been of particular importance in mobilizing support and interest and momentum for the entire Decade programme.

As was eloquently pointed out in the meeting, merely providing the mechanical access to water does not necessarily change people's health status nor necessarily reduce infant mortality with the spectacular rapidity we would like. The quantity of water, in addition to its quality, the concurrent availability of sanitation, the availability of soap and the introduction of hand washing practices as well as a whole variety of other behavioral changes are essential if one is to achieve significant alterations in a population's health. This may take place, additionally, over a much longer time frame than we might wish.

It was perhaps inevitable that the conference should have focussed on the Decade in terms of assessing the progress or lack of progress that has been made. A great deal of focus centered on the shortcomings of the level of financial support. I believe, however, that if one looks at the handicaps under which the Decade was started, and the progress that has in fact been made, we have every reason to feel quite gratified.

It is true that we would like to see more measurable progress in terms of an increase in the number of people served by this point when 25 percent of the Decade is over. On the other hand, we have seen spectacular levels of activity in many countries. Several old hands in the international agencies have expressed to me their astonishment at the level of commitment some governments have given to the Decade.

The World Water '83 meeting revealed profound changes that have been occurring in the water and sanitation field, which are related to the Decade programme, at least occurring concurrently with it. Some of these changes include a shift in priority to increasing access to water for those populations living in rural areas; a shift to using lowcost appropriate technology; and a shift in financial resources where, despite an apparent shortfall in funding for the water sector, many developing countries have significantly increased their own budgets for water projects, and much work is being done under other labels such as integrated rural development.

Overall I feel very encouraged by how much has been achieved so far in the Water Decade. One fact of which we were reminded during the conference is that fifty per cent of all the unserved people in the world live in four countries, India, Pakistan, Bangladesh and Indonesia. Each of those nations has taken the Decade very seriously and all are making significant strides to achieve its goals. As we heard, India is producing 100 000 handpumps a year —a rate that will assure full coverage of the population by the end of the Decade.

Perhaps one of the major shortcomings of the Decade is a lack of any adequate structure for evaluation and monitoring of the progress. I proposed at the conference that the Decade would be well-served by the creation of a completely independent body comprised of prestigious individuals in the water and sanitation field who are unaffiliated with any of the U.N. entities. Hopefully such a body could assess the effectiveness and accomplishments of all of the entities, governmental, inter-governmental and non-governmental, involved in the Decade and would point out areas where improvements could be made and successes or failures identified. I believe the result of such a prestigious independent panel making this sort of assessment would be that there would be a far greater inducement to demonstrate clear progress and to alter policies and programs that were not working because of the global exposure they would receive.

Although we are eager to have a special focus on human use, the political reality in most developing countries is that water will never be separated as a special priority from the more economically consequential aspects of water resource development, such as irrigation and hydroelectric power. It is therefore essential that we address the Decade at the national level within the overall context of water resource development and encourage governments to exploit the entirety of this resource appropriately and for their people's needs.

The Institution of Civil Engineers should be congratulated for producing such a highly successful and much needed event as the World Water '83 conference. I certainly will look forward to World Water '86 with eagerness.

Peter G. Bourne
President, Global Water
Washington, D.C.

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