Rural Water Supply Network

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How Three Handpumps Revolutionised Rural Water Supplies

A brief history of the India Mark II/III, Afridev and the Zimbabwe Bush Pump

Summary

The India Mark II/III, the Afridev and the Zimbabwe Bush Pump are three of the most successful and widespread handpump designs in the world. Over the last quarter of a century, hundreds of thousands, if not millions, have been built and installed in wells and boreholes around the world.

While the failure rate of handpumps is a common topic of debate in rural water supply circles, this should not diminish the success that these designs have had and the benefits they have brought. This publication gives a concise overview of how these handpumps came into being and how they passed through the "Valley of Death" from piloting to widespread use. These three stories hold important lessons for other aspirant technologies for Water, Sanitation and Hygiene that are looking at how to ensure that they are adopted successfully. This is a challenge being tackled by an EU-funded project called WASHTech http://www.rural-water-supply.net/en/projekts/details/56

The challenge today is how these handpump designs continue to evolve and improve, and whether there is still a role for the standards of public domain pumps.

Glossary

BIS	Bureau of Indian Standards
ISI	Indian Standards Institution
HTN	Handpump Technology Network
MERADO	Mechanical Engineering Research & Development Organization
NAC	National Action Committee, Zimbabwe
NGOs	Non-Governmental Organisation
O&M	Operations and Maintenance
TWAD	Tamil Nadu Water Supply and Drainage Board
UNDP	United National Development Programme
UNICEF	United Nations Children's Fund
WASH	Water, Sanitation and Hygiene

Contents

1. Introduction

Handpumps in the public domain are not protected by patents or royalty rights. Everybody is free to produce these pumps. The pumps were developed with support from public entities, either by governments or by support agencies. The Rural Water Supply Network (RWSN) has prepared international specifications that are freely available to any manufacturer who wishes to produce these pumps. The most popular deep-well handpumps in the public domain are the India Mark II/Mark III, the Afridev and the Bush Pump. Each of these pumps has its own development history. This publication tries to sketch in brief the reasons and philosophies behind the efforts to develop these pumps. It also points out succinctly the specific properties of the pumps.

The pumps covered in this note are community pumps, i.e. they normally serve larger user groups of 200 to 500 people and are not designed to be installed by individual households (for more on those see *Low Cost Handpumps*, Baumann 2011). Thus they have to be strong and tough and need a management organisation for operation and maintenance (O&M).

Many people and organisations were involved in designing, testing and manufacturing the three pumps described here and not all can be mentioned in such a short note. However, the authors would like to thank Arun Mudgal and Peter Morgan, who have documented the development of the India Mark II and the Bush Pump respectively. Some of their material has been drawn on for the compilation of this note.

Why are these pumps standardised?

It may be argued that standardisation is an intervention by the government that interferes with free and liberal markets. This is surely true, and therefore, decisions to standardise should not be taken lightly. It should however be noted that in most developing countries, the economic environment is not conducive to all free market developments. It might be necessary for governments to control the brands and types of equipment used in order to:

(i) create an enabling environment for the private sector to achieve large-scale production, and

(ii) avoid market fragmentation.

Standardisation of equipment on a national level offers significant benefits, most importantly that pumps are manufactured to clearly defined technical specifications and performance criteria. Although this may lead to there being fewer private sector players they should be stronger and deliver a better service than a completely unregulated market.

An important factor for any rural water supply programme is to keep it simple and comprehensible. Standardisation of technologies and approaches are means to achieve this. All "stakeholders" (governments, private industries and users) get familiar with the equipment and can adapt themselves to the technologies with the result that the sustainable supply chains can be established and local capacity is generated.

2. The India Mark II – Mark III Pumps

Why was the India Mark II pump developed?

The persons and organisations which were involved in the development of the India Mark II tried to create a handpump that was a reliable workhorse.

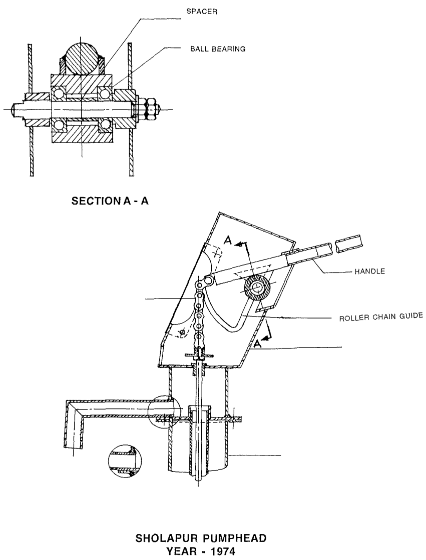
The main concerns were to reach an operating period of one to four years before repairs became necessary.

At the time when the pump was conceived, much less emphasis was given to the ease of repairs

India Mark II in Africa (K. Erpf)

Background of the design development

In 1967, a severe drought hit the Indian states of Bihar and Uttar Pradesh. UNICEF imported pneumatically operated drill rigs to speed up the relief work. The arrival of these down-the-hole (DTH) hammer rigs initiated a rural water supply programme that was to become the largest of its kind in the world, in terms of both area covered and people served. Traditional cast-iron 'family' handpumps were fitted on the drilled bore-wells. These pumps were designed to meet family needs of a few hundred litres per day, in contrast to community pumps which supply several thousand litres daily. The severe operating conditions took their toll, and consequently, the 'family' pumps had a very high breakdown rate as they were operated almost continuously for more than ten hours a day.



Sholapur pumphead (A. Mudgal)

NGO's such as the War on Want project, in Jalna and Sholapur Well Service, tried improve the handpump design. The new all-steel handpumps had a single pivot handle with sealed ball bearings. The connecting rod was kept aligned and in a state of constant tension through a linked chain running over a quadrant. Several hundreds of these pumps were produced over the next few years. Little coordination took place between the NGOs, so that the pumps were invariably different from each other, and even more critically, pump components of the same design were not interchangeable either. This made maintenance rather difficult.

UNICEF took a keen interest in these developments and supported both NGO and government projects. In 1974, UNICEF carried out a survey of handpumps fitted on bore-wells. The results were disastrous. About 75% of the cast-iron handpumps were inoperative. When these unacceptable results were presented, UNICEF even considered stopping support to the drilling programme.

A partnership between UNICEF and two Government of India organisations, the Mechanical Engineering Research & Development Organization (MERADO) and Richardson & Cruddas (both in Chennai, previously known as Madras), started more by chance than by a strategic intent. The initiative was based on the common desire to develop an improved handpump suitable to meet the situation in rural India. Using the experience reported by the NGOs, they started to work on the India Mark II (there was never a Mark I pump).

The Sholapur pump was the point of reference during development of the India Mark II. In 1975, UNICEF purchased 6,500 Sholapur 'conversion heads' and provided them to various state governments. The 'conversion heads' (i.e. the top part of the Sholapur pump) replaced the multi-pivot handle pump head of the cast-iron handpump. The successful outcome of this hybridisation changed the Government's attitude to the handpump industry.

UNICEF played a key role in bringing the various ideas together and acted as a coordinator and facilitator in the development work. MERADO provided design support, while Richardson & Cruddas were responsible for manufacturing the various prototypes. The partnership that evolved was quite unique as the Indian partners invested considerable financial and human resources without ever entering into a contract with UNICEF. The Handpump Project was based on the mutual understanding that India needed an improved handpump and that all parties would work towards this goal. It was clear to everyone that once the research work was finished, the design would be made available in the public domain.

The India Mark II development focused on the following key aspects:

- Development of a sturdy and reliable community handpump that could work without failure for a year;
- Large-scale local production in simply-equipped workshops at low cost (less than USD 200);
- Use of materials and components available in the country;
- Reducing pumping effort to minimise the burden on women;
- Demonstrating that a better-designed handpump, standardisation and quality control could facilitate a more effective maintenance system;
- Demonstrating that a more reliable supply of potable water could reduce the incidence of water-borne and water-related diseases.

Field-testing was carried out over the period 1976-1977 in Coimbatore district of Tamil Nadu State under the joint supervision of the Tamil Nadu Water Supply and Drainage Board (TWAD) and UNICEF. The results were very encouraging; the pumps had an extremely low breakdown rate and were easy to operate and widely appreciated by communities and government. With an extensive testing programme completed, it was now time to introduce the new pump in large numbers.

Large-scale handpump production

India Mark II Production (E. Baumann)

The India Mark II design was established by end of 1977 when UNICEF ordered 1000 pumps from Richardson & Cruddas for large-scale field-testing. The design found acceptance by the Government of India and a number of state governments. Demand started to rise. Already by 1978, Richardson & Cruddas manufactured about 600 India Mark II per month.

UNICEF helped to identify and develop new manufacturers. The thrust towards the private sector was chosen because UNICEF realised that the traditional NGO's could not provide the necessary production base for the large numbers required. India needed to quickly set up a mass production capacity for handpumps. Therefore, UNICEF focussed on established companies. The choice to concentrate on the private producers was definitely a good one in order to achieve quick tangible results.

Crown Agents, a well-established international inspection agency, was engaged by UNICEF to carry out works inspection at potential manufacturers. These inspections served to verify the technical and financial capability of the companies that had applied to become India Mark II manufacturers. Once the competence was ensured, UNICEF placed trial purchase orders with these companies. UNICEF and the inspection agency provided technical assistance to manufacturers. Crown Agents helped to define production processes and in the design of jigs and fixtures. It was mandatory for the producers to establish a functional internal quality control management. This process enabled many of the private sector companies to improve their production with an effective in-house quality control system. Only with this in place did they become qualified as UNICEF-approved handpump suppliers.

The pragmatic policies pursued and promoted by UNICEF on standardisation, local capacity building and quality assurance paid rich dividends, and within a few years, the handpump programme expanded phenomenally. The private sector's response to meet demand for handpumps was excellent, and a number of Indian companies soon became major players in the handpump industry, both in India itself and abroad. The total production capacity reached over 100,000 units by 1982. By 1984, UNICEF had awarded licenses to manufacture India Mark II pumps to 36 companies, and the annual production capacity had grown to over 200,000 units. All the qualified manufacturers had undergone rigorous works inspections for assessment of their capacity and capability to meet the stringent standards.

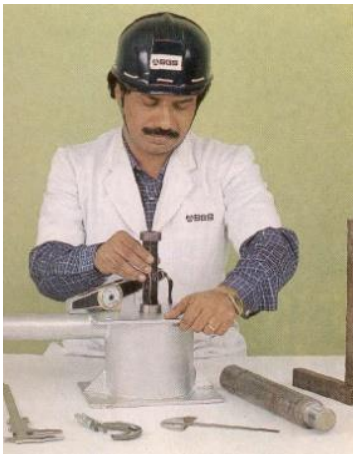
The Government of India played a crucial and decisive role in the accomplishment of the handpump programme. By 1984, more than 600,000 handpumps had been installed, and by 2010, some four million India Mark II handpumps were providing water to the rural and urban population across India, reaching coverage of about 92% (WHO-UNICEF 2012).

The days of striving for numbers have ended. It is now essential to manage the assets that were built up over the last 20 years. To improve, expand and sustain the existing infrastructure will be a formidable task for India.

Although the India Mark II was primarily designed for Indian rural conditions, it was soon found to be suitable for application abroad. The Indian industry ventured to conquer export markets and competed successfully in international tenders. Over the years, Indian companies became the main suppliers to the African continent. Production of India Mark II pumps started in various countries e.g., Mali, Togo, Nigeria, Uganda and also in Germany and Italy.

To date, well over five million India Mark II pumps have been produced, and several countries in Asia and Africa have chosen this type as their standard pump.

Standardisation and handpump quality in India



Checking Quality (SGS, India)

A key factor to the success of both the domestic handpump programme and the export sales of Indian handpumps was UNICEF's strict commitment to quality. The Government of India and UNICEF realised that large-scale manufacture of standardised India Mark II pumps in several different companies would have the great potential of bringing prices down thanks to competition. At the same time, producing pumps not conforming to uniform standards posed a serious threat to the product. To counteract this potential problem, UNICEF insisted on strict quality control of all pumps to ensure longevity and inter-changeability between pumps and parts produced by the various manufacturers. For 15 years, it arranged and paid for pre-delivery inspections of all handpumps purchased by Indian State water boards through independent inspection agencies (Crown Agents and the Société Générale de Surveillance - SGS). The technical support provided to manufacturers to improve production techniques and to strengthen internal quality control systems was instrumental in creating a durable and quality-conscious local production capacity.

The results were:

- Awareness was created among implementing agencies about the need for the procurement of quality handpumps and spare parts.
- The manufacturer's consistency in quality control was monitored on a continuous basis.
- The effectiveness of the quality control mechanism was monitored through consignee end inspections.

UNICEF entered into a longstanding partnership with the Indian Standards Institution (ISI, later named Bureau of Indian Standards, BIS). Standardisation of the product was essential to prevent that imitations of substandard quality would appear in the market. It also fitted well into the economic environment, with closed protected markets, in India at the time. In 1976, the Government of India and UNICEF decided to give the drawings and specifications of the handpumps to ISI so that it could formulate a national standard on the deepwell handpump.

The National Conference on Deepwell Handpumps, held in 1979 at Madurai, Tamil Nadu, endorsed the need for standardisation and strict quality control. In 1980, the first ISI specification for the India Mark II was published. Even though very rigid, the specification allowed continued refinement by UNICEF, government and manufacturers of the technology through Research and Development and field-testing to improve reliability, durability and ease of maintenance. The national standards were reviewed and modified in 1982, 1984 and 1990. Cooperation between UNICEF and the national Bureau of Standards created the necessary authority for the efforts by UNICEF to maintain the quality. The effect of standardisation and the private-sector production of handpumps led to fierce competition that brought prices of pumps down considerably.

In 1996 the responsibility for licensing of manufacturers and batch inspection of handpumps was taken over by the BIS. Recognising the need for continued quality control, Government departments purchase only from the BIS-approved manufacturers, with pre-delivery inspection at the manufacturer's works by a BIS inspector. The handpump inspection cost is now included in the purchase price to the state governments.

Many manufacturers considered UNICEF's withdrawal from inspection and quality control as a clear step backwards. They reasoned that BIS had neither the capacity nor the internal management capability to ensure factual unbiased inspection in the same way as the international inspection agencies.

The India Mark III development

Maintaining the large numbers of India Mark II pumps under the management of the state water boards was a heavy burden on the government, so there was interest in community based operation and maintenance (O&M) of handpumps. It was proposed to introduce a system in which the responsibilities are shared between the government and the users.

The UNDP/World Bank's Handpump Project and UNICEF set up a field-testing project near Coimbatore in Tamil Nadu for a period of 4½ years between 1983 and 1988 to identify and test potential improvements that could reduce maintenance costs.

The India Mark III pump was tested. It is pump fitted with an open top cylinder and a 2½" galvanised iron riser pipe. The above-ground mechanism was modified to facilitate withdrawal of the extractable piston and foot valve without having to remove the rising main. The Coimbatore project made a wealth of data comparing India Mark II and Mark III pumps available. The data indicated that repairs to the India Mark III took 67 % less time than for the India Mark II. Further, it was believed that community based O&M had the potential to shorten the downtime of the handpumps.

The capital cost of an India Mark III is about a third higher than that of the India Mark II, and due to the larger and heavier rising main, the maximum installation depth was limited to 30m. Higher capital expenditure could only be justified if it was offset by lower maintenance costs.

Operation & Maintenance by the Users (E. Baumann)

Many demonstration projects using Mark III concentrated on the training of communities, particularly women, in performing the necessary repairs. However, the potential offered to establish new roles for the technical departments/water boards was not explored. Spare parts still had to be obtained through the old government channels. The number of mobile teams per handpump did not change. The reliability of the pumps was not improved, and maintenance costs did not come down.

But did the India Mark III actually achieve its objectives? It was found that ease of maintenance is not a decisive factor for the O&M of handpumps - village communities who can maintain their diesel/electric irrigation pumps would be well capable of repairing a handpump, may it be Mark II or Mark III. Over the last decade it has become clear that in many areas of the world, community water management rarely succeeds on its own. Installing a pump and training a village water committee is not enough: there need to be regular external support and viable supply chains to make a rural water service sustainable.

On the other hand, a good idea sometimes needs a tangible piece of hardware to go with it. From this point of view, the India Mark III has opened a door and remains a viable technology for community-based management, where conditions are favourable.

Today, many of the challenges around training, supply chains and manufacturing quality remain for the India Mark II and III, and it is important that there is continued investment in this handpump design. It changed the lives of millions of people over the last three decades.

3. The Afridev Pump

Why was the Afridev pump developed?

Afridev in Malawi (K. Erpf)

From the start, the aim was to produce a deep-well handpump that was very easy to maintain at village level and could be manufactured in countries like Malawi, where industrial resources are limited.

The design of the pump head featured easy repairing by the users as the first priority. This represented a significant step forwards, and away from the India Mark II philosophy that aimed at several years of operation without failure.

Background of the Afridev design development

Maldev Pumphead Malawi (E. Baumann)

During the 1980s, the concept of community management of maintenance was introduced. The involvement of the users in repairs required pumps that allow interventions with a minimum of tools.

The Afridev started life in Malawi in early 1981, and in the initial stages, the pump was named Maldev. The Maldev pump went into production in early 1982.

Early in the field-testing of Maldev pumps, the ball bearings caused problems, and the first pump head, which featured plastic bearings, was installed in Malawi in late 1982.

The focus of Afridev development shifted to Kenya in early 1983, when the UNDP/World Bank Handpump Project set up a team to engage in the improvement of the design. The Handpump Project staged international handpump design meetings in Kenya in late 1984 and early 1986, and throughout this period, design and testing of pump heads, cylinders, rods and rising mains continued. Major efforts to resolve the "bearing problem" continued up to early 1985, when the plastic bearing design was finalised. Designers eventually settled for a simpler and more dependable plastic bushing design for the rod hanger and fulcrum, providing an inexpensive and durable alternative to ball bearings.

Operation and maintenance by users, Pakistan (E. Baumann)

Local experts from Africa and a small group of engineers collaborated with local industries in the design and production of prototypes. Organisations in Europe provided specialist advice. Plastics research and development played an important role in the final design; DuPont Plastics were very helpful in the application of engineering plastic materials, and Skat provided a vital link to Swiss tool-making and injection moulding companies. Plastics research and development has played a crucial role in the success of this project, the outcome of which is the Afridev pump system. The Consumer Research Laboratory in the UK conducted laboratory tests. The first prototypes were manufactured in Kenya and sent to Malawi, where field testing continued.

With support from Sweden’s Sida, a larger-scale field testing project was established in Kwale district, in the Southern Province of Kenya. About 300 pumps were installed and closely monitored. Other countries were included in the testing. This was also the time when the name of the pump was changed from Maldev (Malawi development) to Afridev (African development), because important contributions to the design were now being made by field workers in several East African countries.

At all times, the development of the Afridev focused on simplicity of maintenance and minimum quality control requirements to simplify manufacture.

The following parameters were the main design objectives:

Simple maintenance

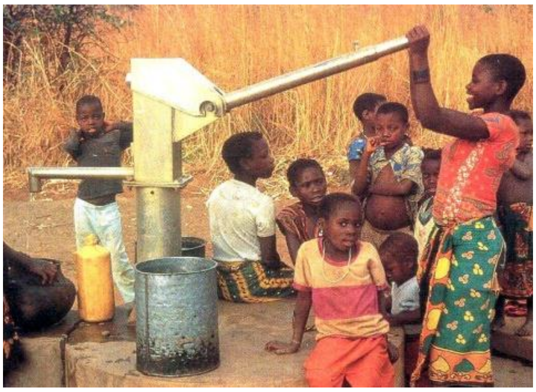
- Villagers can carry out all routine maintenance after a few hours of training.
- Only one spanner is needed to open the pump head, replace the bearings and give access to the pump rods.
- Schedule Maintenance, a planned annual replacement of all wearing parts, is recommended. This can be done quickly and is inexpensive.
- Minimised forces, based on an open-top cylinder design and a longer stroke offset the reduced cylinder diameter, ensuring satisfactory discharge.
- The number of spares can be minimised by using the same cylinder size for all depths.

Modern materials and technology to simplify mass production and minimise corrosion

- Modern plastics are ideal materials for many pump components.
- High-quality plastic components can be mass-produced at a low cost.
- All wearing parts of the pump are either plastic or rubber.

Local manufacture

- Local manufacture means local distribution of pumps and spare parts without foreign exchange and import licenses.
- Local distribution means that villagers can buy parts for their pumps.
- Straightforward pump design uses off-the-shelf materials wherever possible and simple manufacturing processes, with simplified quality control.
- Pump design is adaptable to take account of local needs and resources.



Afridev (K. Erpf)

The result of all these research and development activities was the final design concept of the Afridev handpump. It is a conventional lever action piston pump, with an "open top" cylinder design, allowing the pump rods, piston and foot valve to be removed for maintenance without lifting out the riser main pipes. It is designed to lift water from a depth no greater than 45 metres.

Large-scale handpump production and international specification

In 1989, Skat published the first international standard specification of the pump. When the Handpump Technology Network (HTN) was founded in 1991, the network took it on to further develop the pump and has since published several revisions of the specifications as well as many supporting documents like "Quality Control Manual", "Installation and Maintenance Manual" and maintenance cards in English, French and Portuguese. When the network was renamed the Rural Water Supply Network (RWSN) in 2003, work on these standard specifications continued and remains an on-going process.

The Afridev handpump was well received, and African countries like Mozambique, Nigeria, Ghana, Tanzania, Ethiopia and many others have standardised on this pump. Thanks to its easy manufacture, it is locally produced in many of these countries. Not all of the ventures were successful, and some of the African industries had to give up because the handpump industry in India soon started to expand to this pump type for the export market. Indian producers are strong contenders and cover a large proportion of the market. However, today there are still several African companies that produce the Afridev pump for their local markets.

The Afridev design was also adopted in Pakistan and Afghanistan, and local industries started to produce derivatives for the local market. In Afghanistan, the government asked RWSN to produce national standards for the Indus, Pamir and Kabul pumps. All of them are based on the original Afridev design. These pumps are modified to meet the specific conditions in these Asian countries, where the cost of the pumps has become very competitive.

Thanks to the successful design and the strong international partnership approach, the Afridev pump has become the second most popular community handpump in the world, after the India Mark II.

Afridev (Indus) Production, Afghanistan (E. Baumann)

Community management of O&M

The Afridev pump demonstrated that deep-well handpumps can be maintained by village men and women, can be locally produced and can still be affordable and reliable. Unfortunately, the concept of community management has not had the desired impact on the functionality of the pumps. Water users are expected to form water committees to manage the upkeep of their new communal water facilities and collect money to pay for maintenance. Community mobilization and training is not always carried out, or may be of poor quality. The committees need continued backup support to remain motivated. Also, their efforts are often hampered by lack of access to spare parts or skilled technical services.

The technology of the pump has not solved problems of O&M management. It has put supply chain management issues at the core of sustaining investments in water supply and sanitation.

4. The Zimbabwe Bush Pump

Background of the Bush Pump development

Unlike other handpumps used across the world, the Bush Pump has a long history. It was born in Zimbabwe in 1933, and designed by Tommy Murgatroyd, a Government Water Supply Officer in Matabeleland. Murgatroyd established the basic components of all later Bush Pumps – a wooden block, a strong pump stand and heavy-duty components. Three main variants can be found in Zimbabwe that reflect its history of development:

- The Murgatroyd Pump
- The Anderson-type Pump
- The "B"-type Bush Pump

The Murgatroyd Pump

Murgatroyd-type Bush Pump (P. Morgan)

Compared to "modern" handpump designs, the Murgatroyd pump was over-engineered, and it looks ungainly at first sight. In fact, its sturdiness is a major reason why some of the early pumps continue to operate to the present day.

Because welding was not known at the time, the pump was made of standard pipes and plates, which were bolted together. Some basic features were:

- The pump head was embedded in a large block of concrete.
- The handle was connected to the wooden bearing block.
- The rising main was a 50mm steel pipe, and the pump rods had a 16mm diameter.
- A large 75mm brass cylinder was used with in combination with a heavy duty foot valve.

The Anderson-type model

Anderson-type Bush Pump (P. Morgan)

The initial models remained almost unchanged for about 40 years until Cecil Anderson, an Engineer of the Ministry of Water, made the first major changes in the mid-60s. He replaced some of the bolted parts with components that were welded together. The remarkable idea to use U bolts to attach the pump head directly to the well casing dates back to that time. The improved pump was given the name of Bush Pump. It became the National Standard and was spread all over the country. After Independence in 1980, the government of Zimbabwe insisted on retaining its own national handpump, but many variations of the pump were built by NGOs, and also by some government departments. These were used alongside the standard Anderson model.

The "B"-Type Bush Pump

B Type Bush Pump (P. Morgan)

In 1987 the Government of Zimbabwe's National Action Committee (NAC) - who were charged with overseeing the country's National Rural Water Supply and Sanitation program - decided that a new single standard for the Bush Pump was required and tasked Peter Morgan, of the Ministry of Health's Blair Research Laboratory, to undertake the work. He went on to design a new model which inherited all the sound features of the older Bush Pumps, but reduced the number of wearing parts and was more compact. This new pump head, which used a "floating washer" system, was named the "B" type Bush Pump.

It went through two years of heavy duty endurance testing before it was accepted as the new National Standard Hand Pump for Zimbabwe in 1989. It has been retained as the National Standard hand pump ever since.

The "B"-Type Pump is used with standard below ground components, comprising a 50mm galvanised steel rising main, 16mm mild steel pump rods, a 75mm diameter brass cylinder, a piston with two leather seals, and a heavy duty brass foot valve. Currently about 50,000 Bush Pumps are installed in Zimbabwe.

Research and development

During the 1980's and 1990's, a considerable amount of research and development work was carried out to make the Bush Pump more user-friendly. Open-top cylinder models with 50mm, 63.5mm and 75mm diameters were designed and tested. With pumps of this design, it is not necessary to remove the pipes in order to replace the piston seals, which are the fastest wearing part of the Bush Pump. The 63.5mm version is the most promising and was similar in some ways to the India Mk III pump, although both models evolved independently. Like the India Mk III, the considerable weight of the 65mm NB rising main of the 63.5mm open top cylinder model limits the depth to which it can operate. High Impact PVC and HDPE have also been tested with the Bush Pump. However, the 75mm cylinder model using 50mm NB rising main remained the most commonly purchased version of the Bush Pump throughout the country.

Specifications and drawings

International specifications were drawn up by RWSN in 1999, when the "B" type Bush Pump was internationally recognised and became a Public Domain Pump. These specifications are available on the RWSN website (see below) and from the Standards Association of Zimbabwe.

A number of companies manufacture the Bush Pumps in Zimbabwe, but sadly, the quality of the products varies considerably. V&W Engineering Ltd, based in Harare, set a high a high standard of manufacture based on a mass production process that ensured that all pumps were almost 100% identical. - a considerable achievement. However, poorly made pumps provide unreliable service and have damaged the pump's reputation, but since 2011 there has been renewed efforts to improve quality control across the sector. Several manufacturing companies are now taking advice and improving their standards of manufacture. Stricter controls and inspections are now being activated by Government and the Standards Association of Zimbabwe.

The cost of the pump in Zimbabwe is high by international standards. This is partly the result of the unusual economics and raw materials availability which have been disrupted by the political and economic situation in recent years. However, being a national standard, the pump is well known and understood by both users and technicians, and supply chains are short compared to countries reliant on imported India Mark II and Afridev pumps and parts.

The Government of Zimbabwe and the Standards Association of Zimbabwe, with support from UNICEF, have finalised and endorsed updated specifications for the "B" type Bush Pump as the National Standard that is expected to become a legal requirement for hand pump water supplies in the near future. A series of manuals and inspection charts have been produced by Peter Morgan and these are available for download from the RWSN website (see references).

5. Summary of design features

Criteria	INDIA Mark II	AFRIDEV	Bush Pump
Ease of installation	Special tools are required for installation.	Few tools are needed for installation. Having to wait for 24 hours to let the solvent cement joint cure is a distinctive disadvantage.	Special tools are required for installation.
Ease of repair	A trained mechanic equipped with special tools is required.	Users can carry out routine repairs with a single spanner and a fishing tool.	A crew of trained mechanics equipped with special tools is required.
Reliability	Reliable with few breakdowns	Does not break down often	Reliable with few breakdowns
Corrosion resistance	Rising mains and piston rod are not corrosion resistant in water with pH values below 6.5.	All below-ground components are corrosion resistant, provided stainless-steel rods are used	Rising mains and piston rod are subject to corrosion in aggressive water.
Abrasion resistance & seal life	The nitrile rubber seals have improved the life of down-hole components.	Wearing components last for about one year, but they are cheap and easy to replace.	High quality leather seals working inside polished cylinder walls help to prolong seal life. Nitrile rubber seals are used on open top cylinders.
Suitability for unlined boreholes	Can be used	Should not be installed in boreholes without casing	Can be used
User preference	The pump has a high discharge and is ergonomically very good	The pump has a high discharge and is ergonomically good.	The pump has a high discharge and is ergonomically good.
Relative cost of pump	Low due to mass production, but more than less robust household pumps (see 'Low Cost Handpumps' field note)	Low	High
Cost of spares	Spares are affordable.	Commonly used spare parts are cheap.	Spares are affordable.
Suitability for local manufacture	It is manufactured in several countries in Africa and Asia.	Production of the plastic components requires special skills and extensive tooling.	It is manufactured in Zimbabwe, South Africa and Namibia.
Maximum Pumping lift	50m and more, extra deep well version available India Mark III limited to 30m	45m	80-100m

6. Summary and Conclusions

With so many different handpump designs available, some even for centuries, why have the above three flourished? In summarising the three stories we see the following:

The India Mark II/III was created from an urgent need (the 1967 drought) that highlighted the chronic problem facing rural water supply and the opportunity presented by groundwater. The handpump development cycle was done as a partnership between an international body (UNICEF), the Government of India and the Indian private sector. This partnership succeeded because it had a clear mutual goal: develop, manufacture and install a handpump that is robust, easy to repair and uses standardised, interchangeable components so that it doesn't matter who the manufacturer is. Not only did this go a long way in addressing the domestic problems, but it also created a strong export industry as well. Having succeeded, the challenge has been to maintain inspection and quality control of manufacturing.

The Afridev emerged in the 1980s as concerted attempt to create a community handpump that could be easily maintained at village level and easily manufactured in Africa. The design was the product of collaboration between many partners in Africa and Europe and was tested extensively between 1981, when it started life, and 1989, when Skat published the first international standard specification. While there were attempts to develop the manufacturing capacity in some African countries, the design was adopted by Indian manufacturers who already had the capacity and customer base from the India Mark II/III handpumps and could thus be more competitive. Despite becoming the second most popular handpump design worldwide, the Afridev did not solve the maintenance and management problems facing handpump technology.

In Zimbabwe, The Bush Pump succeeded largely because it evolved over a long period and was adopted as the standard design by the government. This standardisation makes training, supply chains and many other aspects easier. But there are drawbacks – its uncompetitive costs, the lack of international promotion means that it has not been widely adopted outside Zimbabwe (though is also common in Namibia) and a vibrant manufacturing and export industry has not materialised, as it did in India. However, in the words of Peter Morgan, the Bush Pump is a "tough old cookie" that has continued to serve the people of Zimbabwe through war, collapsing economies, donor vagaries and can even work with several parts missing.

So what is the future of these public domain handpumps? Despite their success, there are challenges: they are not a 'fit and forget' technology. In many African countries, more than a third of handpumps are not working at any one time (RWSN 2009). Sadly, the aspect of a broken India Mark II or a rusting Afridev carcass is all too common in many rural areas of the world. There are improvements that can be made to these designs, and greater controls on the manufacturing quality can be performed. However, the problem of rural water supply is not a technological but an economic and management issue. Therefore, these handpumps need to fit within the context of providing a water service, rather than just being part of a one-off project.

Perhaps the lessons for other WASH technologies are that:

- Development and scaling up works best when done in partnership with government, private sector and international organisations.
- The partnership needs a clear common goal.
- Good design is important, but it is only part of the process. Further aspects are:
  - meeting the water users' needs, ability to pay and cultural preferences;
  - manufacturing skills, quality and capacity;
  - supply chains and retail networks.
- Public domain standards offer a way to get long-term government support and provide an entry point for new manufacturers.

Looking to the future we see that there is still scope for technical innovation with handpump technology – for example in making handpump water points more accessible to those with physical impairments or using of mobile phone communications to improve monitoring of handpump use and functionality.

Meanwhile, there is growing interest in solar pumping and building more piped water systems in rural towns and growth centres. These ventures will have their own challenges and opportunities but whether they prove successful or not, the humble handpump will be supplying safe water to millions of rural water users for decades to come.

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