### 2.1.3 Pumps

Although it may not be immediately obvious, pump selection is a specialised task and there are many factors to be considered. Relevant factors identified by UNESCO (1991) include flow rate (based on design demand); total lift or head; source of supply (e.g., well, borehole, stream, or reservoir); water quality; maintenance, including spare parts availability; level of technical expertise of local personnel; and, types and amounts of energy consumed. To meet these often highly specific combinations of factors, many types, kinds and sizes of pumps are available for use in water systems. On small, high islands, where groundwater is abstracted from deep wells, motor-driven pumps are generally used. In contrast, hydraulic ram pumps may be applicable in the rural, inland areas of small, high islands.

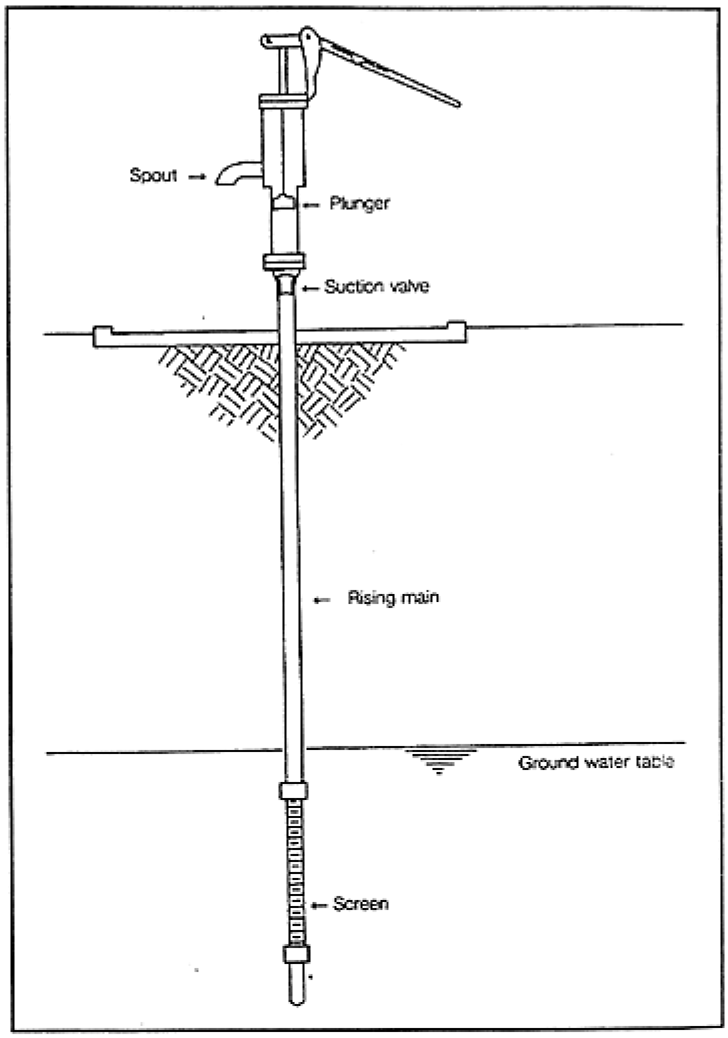


Figure 24. Schematic of a suction pump (Pickford, 1991)

#### Technical Description

This section covers those pumping technologies that are most applicable to SIDS; namely, technologies that may be used on very small, low islands (handpumps and solar pumps), and technologies that may be used on small, high islands (hydraulic ram pumps).

**Handpumps**

There are many classes of handpumps in general use. The type most frequently used for potable water pumping on small islands is the reciprocating (plunger) pump. The following variations on this pump design are the most widely used; namely, the suction pump which is generally installed in shallow wells; and, the lift pump or the so-called deep-well pump. In the suction pump, the plunger and cylinder are located above the water level, usually within the pumpstand itself (Figure 24). The suction pump relies on atmospheric pressure to push the water upwards into the cylinder: this type of pump does not "lift" the water up from the source, instead the pump reduces the atmospheric pressure on the water column in the suction pipe and the atmospheric pressure on the water outside the suction pipe pushes the water up. In the lift pump (or deep well pump), the cylinder and plunger must be submerged or located within the suction lift of the water (Figure 25). Since the water level normally changes with season throughout the year, or even daily with tidal variations, the cylinder should be submerged at all times (Dali, 1990). The choice of which handpump to use in a given situation will depend on depth to water; cost; location of the well in respect to the user; amount of use anticipated; quality of water; and, cultural requirements.

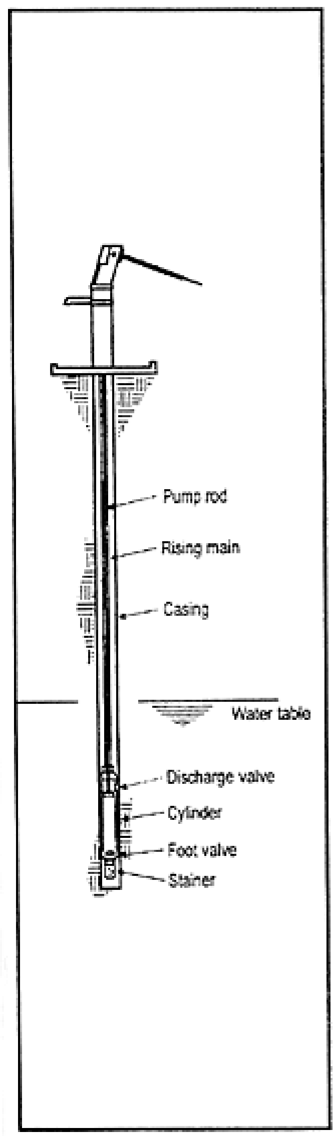


Figure 25. Schematic of a lift pump (Pickford, 1991)

**Solar Pumps**

The simplest solar pumping system consists of a solar module, or array of modules, wired directly to a pump. This type of solar pumping system is called an array-direct, solar pumping system because no batteries are required. Whenever the sun is shining, an array-direct, solar pumping system will operate and supply water to storage tanks. It will not operate during rainy weather. To overcome this limitation, another solar pumping system is the solar system with battery back-up. The primary components of this type of solar system are a solar module or array, a charge controller, a battery or bank of batteries, and the pump. In a system with battery back-up, the batteries play the same role as the storage tank in the array-direct system. Electricity is stored rather than water. This system operates just the same as any electric pumping system except that 12 or 24 volts direct current is generally used. The pump can either be switched on and off manually, or a pressure switch or float can be used to provide automatic pumping whenever a faucet is opened. Solar pumping systems in remote areas can serve a variety of residential areas, including individual households, groups of households, or communities. The choice of the level of service to be provided to residential areas is mostly a function of population density. In sparsely populated areas, a household system is the logical choice; however, as population density increases, it becomes more appropriate to use solar-powered pumps in more centralised systems.

**Hydraulic Ram Pumps**

Hydraulic ram pumps are water pumping devices that are powered by falling water. The pump works by using the energy of the falling water to lift a small amount of that water to a much greater height. Although hydraulic ram pumps come in a variety of shapes and sizes, all have the same basic components (Figure 26). Ram pumps have a cyclic pumping action that produces their characteristic beat during operation. The cycle can be divided into three phases: acceleration, delivery and recoil (Figure 27). As the water accelerates into the pump, the pressure rises until it is higher than that in the air vessel, when it forces water through the delivery valve (a non-return valve). The delivery valve stays open until the water in the drive pipe has almost completely slowed down and the pressure in the pump body recoils or drops below the delivery pressure. The delivery valve then closes, stopping any backflow from the air vessel into the pump and drive pipe. Throughout the cycle the pressure in the air vessel steadily forces water up the delivery pipe. The air vessel smooths the pulsing inflow through the delivery valve into an even outflow up the delivery pipe. The pumping cycle happens very quickly, typically 40 to 120 times/minute. While each pumping cycle delivers only a very small amount of water, over 24 hours, a significant amount of water can be lifted (Jeffery et al., 1992).

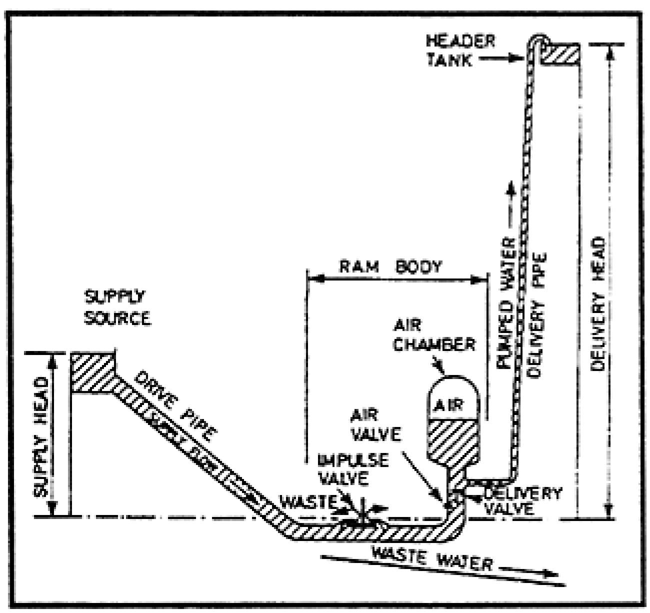


Figure 26. Diagram of a typical ram assembly (Dali, 1990)

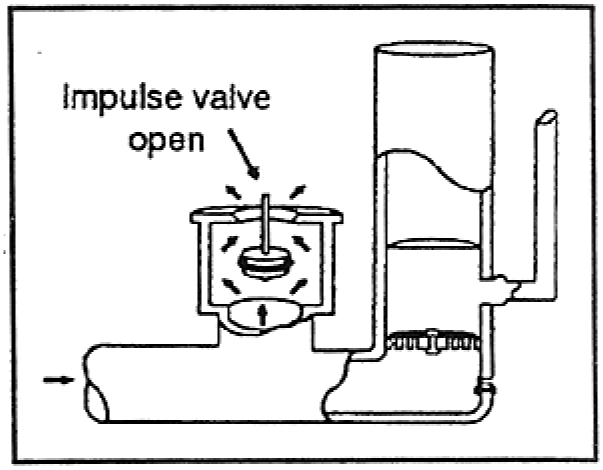


Figure 27a. Acceleration
When the impulse valve is open, wateraccelerates down the drive pipe and discharges through the open valve.
The friction of the water flowing past the moving parts of the valve cause a force on the valve acting to close it.
As the flow increases it reaches a speed where the drag force is sufficient to start closing the valve. Once it has
begun to move, the valve closes very quickly.

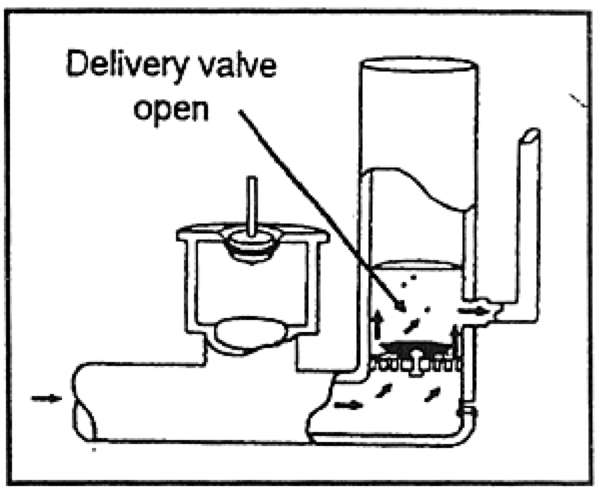


Figure 27b. Delivery
As the impulse valve slams shgut, it stops the flow of water through it. The water that has been flowing in the drive
pipe has considerable momentum which has to be dissipated. For a fraction of a second, the water in the body of
the pump is compressed causing a large surge in pressure. This type of pressure rise is known as water hammer.

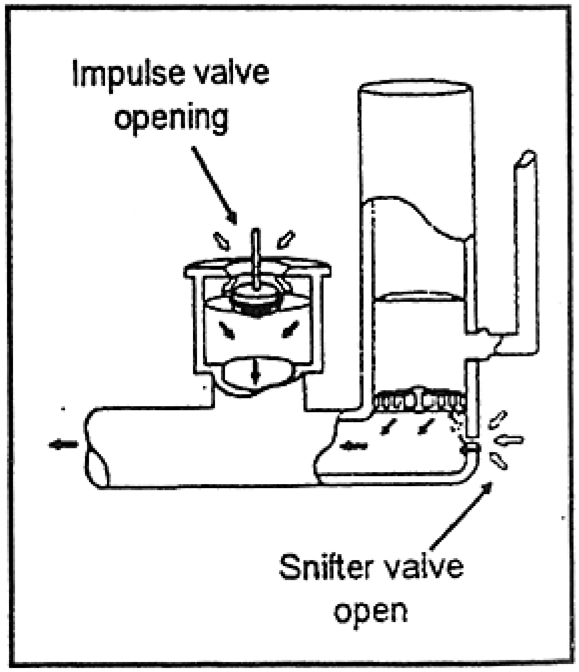


Figure 27c. Recoil
The remaining flow in the drive pipe recoils against the closed deliverey valve - rather like a ball bouncing back.
This causes the pressure in the body of the pump to drop low enough for the impulse valve to reopen. The recoil
also suvks a small amount of air in through the snifter valve. The air sits under the delivery valve until the next cycle
when it is pumped with the delivery water into the air vessel. This ensures that the air vessel stays full of air. When
the recoil energy is finished, water begins to accelerate down the drive pipe and out through the open impulse
valve, starting the cycle again.

**Extent of Use**

Handpumps are used on a large number of the very small islands throughout SIDS. A recent study on the use of handpumps in the Pacific region (Mourits and Depledge, 1995) showed that locally-produced, shallow well handpumps can be found in Papua New Guinea, Solomon Islands and Kiribati. Their low cost and simple design makes them an appropriate technology and fairly successful. Popular shallow-well handpumps are the Southern Cross KDC from Australia and the NIRA AF85 from Finland. These pumps have a higher cost and are usually supplied through aid-funded projects with government support. Deep-well pumps are not common, as most of the population in the Pacific region live in the coastal areas where groundwater is relatively shallow.

The technology of solar pumping systems has improved, and the cost has been reduced considerably in recent years. Hence, use of solar-powered pumping systems is therefore becoming more common, with examples of solar-powered pumping systems for village water supplies being found on some islands in the Torres Straits, between Australia and New Guinea, and on Chuuk, Federated States of Micronesia. In French Polynesia, solar-powered pumping systems have been installed on six atolls and three high islands, although on the high islands, the solar-powered systems were later replaced by electrified pumping systems. On Kiribati, solar-powered pumps were installed in places where the distance from the village to the well and galleries exceeded 750 m.

Hydraulic ram pumps are used on some high islands, such as the Solomon Islands and Vanuatu.

**Operation and Maintenance**

Handpumps are generally operated with some type of lever system and are designed in such a way that even children can draw water. Maintenance requirements are limited and can generally be performed by the user with minimal training. However, it is important that spare parts are readily available or the pump can rapidly become useless. Solar pumps require little operation or maintenance, especially for the array-direct, solar systems. Maintenance mainly consists of keeping the equipment in order (especially the batteries) and ensuring that the array is clean and not shaded by trees or other objects. Once an hydraulic ram pump has been started, it will operate automatically and continuously. Maintenance consists of inspection of all the threaded and flanged joints to check for leaks; removal of the air vessel to check the delivery valve rubber for signs of wear or damage; and, annually dismantling the pump to completely and thoroughly clean the inside.

**Level of Involvement**

The installation and maintenance of handpumps can be undertaken at village level. Women should be trained in this task as they tend to use the pumps the most. Solar pumps similarly do not require an high-level of training to install, operate and maintain, while, with some training, hydraulic ram pumps can be operated and maintained at village-level.

**Costs**

Prices of handpumps vary considerably. For example, in 1995, a plastic-bodied pump from E & B Marine, Edison, New Jersey, sold for around $55, while a diaphragm pump like the Southern Cross KDC sold for approximately $120 to $160, and a direct-action pump such as the NIRA AF-85 sold for about $450 to $465.

Commercially-available solar pumping systems range from relatively small ones, pumping about 10 $m^3$/d over a 3 m head, to medium-sized systems pumping about 100 $m^3$/d over an 80 m head. During the past decade, the cost of solar-powered pumps has approximately halved due to technological improvements in the photovoltaic cells and increased sales. Indicative prices in 1995 ranged from $2 100 for the Photocomm Submersible Pump 9300 system, which delivers up to 0.13 l/s from well depths of 75 m, to $13 000 for an A.Y. Macdonald 211012 DK submersible pump, which delivers up to 0.35 l/d from well depths of 40 m.

One of the greatest benefits of the hydraulic ram pumping systems is that they have extremely low running costs. The purchase cost of a pump is usually only a fraction of the total system costs; the pump drive and delivery piping are usually the most expensive capital components. Prices of hydraulic ram pumps vary enormously, with the cost increasing significantly if the pump is imported due to the added costs of shipping and customs duty. An hydraulic ram pump of traditional design, manufactured in Europe or North America and imported to a developing country, might cost between $1 500 and $4 000, while the same pump manufactured locally in a developing country, using available materials, is likely to cost only 20% of this amount.

**Effectiveness of the Technology**

Handpumps are an effective method for abstracting water from a well. Overpumping of a well using a handpump would be most difficult. In addition, hand-pumped wells are normally less subject to surface pollution than bailed wells.

The array-direct solar pumping system provides 24 hour per day water because water is always available from the storage tank provided the demand does not exceed the tank capacity. A battery system provides 24 hour per day water because the pump can always be operated by means of electricity stored in the batteries.

Test results of commercially-manufactured hydraulic ram pumps indicate that an overall efficiency of 65% can be obtained, provided that the design, manufacturing, and tuning of the ram installation are optimal. Most hydraulic rams will work efficiently if the supply head is about 30% of the delivery head. Standard hydraulic ram pumps are available in the range of 5 to 400 l/m, with maximum delivery heads of about 125 m.

**Suitability**

In SIDS, handpumps are most suitable for the abstraction of water from shallow wells on small, low-lying islands, as well as in the coastal areas of the small, high islands. Wells fitted with handpumps should be raised and fully covered for protection from surface pollution.

Solar powered systems are suitable for islands where there is sufficient solar energy available and either battery back-up or other energy sources are provided to ensure near-continuous pumping, and/or sufficient water storage is provided to cater for periods of no sunshine. Solar-powered systems also requires sufficient clear space to prevent shading of the solar panels by other objects.

Hydraulic ram pumps are only suitable for use on high, small islands with rapidly dropping water courses that do not run dry during extended periods with no rainfall.

**Advantages**

Handpumps have few operational costs and generally low maintenance costs. There is minimal risk of overpumping a well using an handpump. Use of the pump helps to protect against surface pollution. Handpumps can be maintained by villagers with minimal training.

Solar pumps have no recurring fuel costs, and require little or no maintenance. The systems have few operational requirements, and are silent and pollution-free when in operation.

Hydraulic ram pumps make use of a renewable energy source that helps to ensure low running costs. Because they pump only a small proportion of the available flow, they also have few environmental impacts. This simplicity and reliability result in a low-maintenance requirement. Hydraulic ram pumps have good potential to be locally manufactured. Operation is automatic and continuous, requiring little supervision or human input.

**Disadvantages**

Handpumps require a readily available supply of spare parts. In contrast, solar pumps have an high initial cost. Problems of maintaining batteries still occur, particularly in the tropics (although this problem is specific to those solar system with battery back-ups). Hydraulic ram pumps are limited to use in hilly areas with year-round water sources. They can only pump a small fraction of the available flow, and, therefore ,require source flows much larger than actual water flow delivered to the users. Hydraulic ram pumps can have an high capital cost in comparison to some other technologies, and are typically limited to small-scale applications. Hydraulic ram pumps may require some special skills for design and installation.

**Cultural Acceptability**

No cultural inhibitions have been identified with respect to handpumps and hydraulic ram pumps. However, because solar arrays must be exposed to direct sunlight for them to generate electricity, trees can pose a problem in some location, as trees often are a valuable source of food and building materials and cannot be cut down indiscriminately to reduce shading.

**Further Development of the Technology**

Handpumps are always being improved by developing simpler pumps and using different types of materials to construct them. Likewise, solar-powered pumping can be further improved by improving the design of the solar (or photovoltaic) cells, to provide more a efficient electrical supply. Designs should be developed which are more suitable to local conditions in SIDS. In the case of hydraulic ram pumps, this would specifically involve designing hydraulic ram pumps that could be manufactured locally

http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-8d/pumps.asp