

Evaluation of traditional water-lifting devices in India

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Water is a vital component for all living beings. It has played an essential role in the evolution of civilizations across the world. Modern agriculture has expanded in coverage due to improvement in the infrastructure and invention of technologies in the domain. The demand for agricultural produce has been continuously increasing, and thus more water would be needed to meet the crop water requirements. This water can be withdrawn from surface water sources or lifted from groundwater through open/bore wells. The adaptability of the traditional water-lifting techniques and devices used or being utilized in different parts of India has been discussed. The examples of water lifting technologies discussed explain the historical evolution to the present status of the art in water engineering.

Keywords: Agriculture, Indigenous, Irrigation, Water lifting devices

WATER lifting devices have been existing since 3000 BC in many parts of the globe. Traditional water-lifting devices were either manually operated or animal-drawn. Animals were used to drive the wheels in the early devices like water wheels and chutes. Water lifting devices can be categorised into four types based on the power source: manual power, animal power, mechanical power and devices that use hydropower, wind power, or solar energy. The article discusses human and animal-operated water-lifting devices. These devices are eco-friendly, do not cause pollution, and are suitable for delivering a small quantity of water for irrigation, drinking, and other uses.

Indigenous technologies

Several traditional water-lifting devices continue to be used in India for irrigation and domestic purposes, such as the scoop (one of the oldest man-operated devices) and counterpoise lift (human-powered water-lifting device that lifts water up to 1.2–4 meters), chain pump, hand operated reciprocating

pump, treadle pump, water wheel etc.

Hand operated reciprocating pump: Hand operated reciprocating pump was one of the most commonly used water-lifting devices for drinking and domestic water need in the 19th century. These are manually operated, have positive displacement type pumps and offer the mechanical advantage to lift the water. The manually operated piston pump is widely used for installing

domestic water supply from shallow tubewells. The main benefit of this pump is that the suction pipe may be placed in a shallow bore to lift water. This pump is said to be capable of supplying water at a rate of 7 litres/second (lps) with a head of 6 meters. Due to advancements in drilling technologies, the power-operated tubewell pumping system has been replacing these hand-operated reciprocating pumps. The use of these pumps is decreasing



Hand pump



Rahat



Persian Wheel

due to the decline of groundwater tables.

Persian wheel: Desert animals like bullocks, camels, and buffaloes are frequently used to operate the Persian wheel, also known as *Araghatta*. *Araghatta* is a sanskrit word that comes from the word *ara*, which means smoke and *ghatta* meaning pot. It is also known as *Rahat* in some parts of Rajasthan, where a number of small pots are attached to a long chain that distributes the water evenly through an intricate network of troughs in the cropped field. Persian wheel irrigation system was not only the traditional system of agriculture but was also used to produce cash crops like sugarcane, tobacco, field vegetables, and fruits. The key benefits are the tough construction and reasonable discharge. The parts are very sturdy and low-maintenance. The optimum lift of this method is 5–10 meters with an average discharge of 14,000–18,000 litres/hour. Persian wheel is commonly used for irrigation in North Indian states.

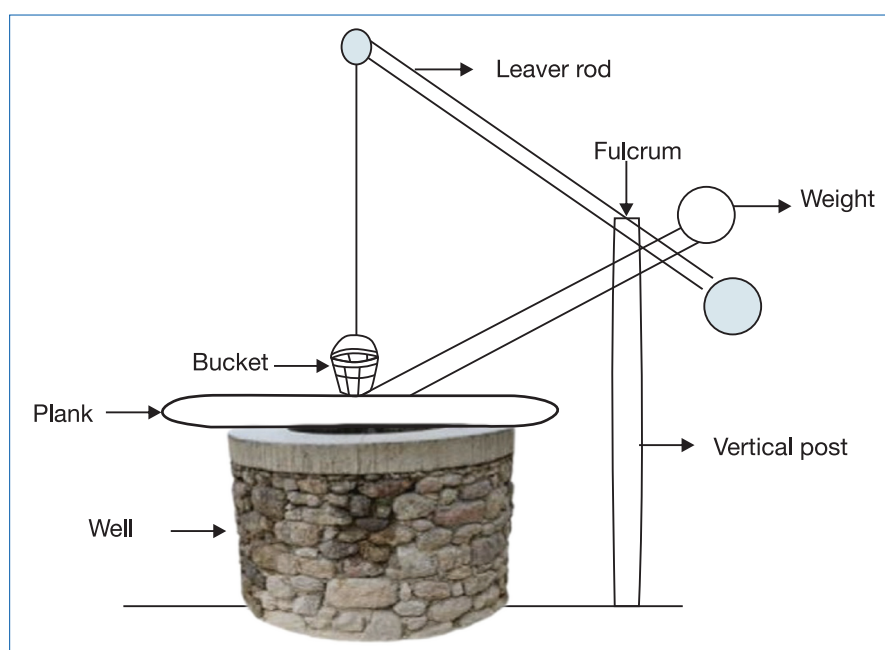
Rope, pulley and bucket method: In this, a rope is passed over a pulley. A bucket is attached to one end of the rope in the well, and a man on the surface holds the other end. After being filled with water, the bucket lowered into the well is lifted out with the help of a rope and pulley. This approach is only appropriate when the well is

shallow and the volume of water to be pulled is little.

Dhenkli / Lever method Counterpoise-bucket lift / Piccottach: Several ancient civilizations employed the *dhenkli* or *shaduf* as the earliest device for elevating water. Several names have been given to it across the globe but in India, it is known as *dhenkli*. Single man can operate this, and optimum lift of this method is 1.2–4 meters with an average discharge of 8,000–11,000 litres/hour. It is used in some parts of southern India, Bihar and the Deccan region. It is a hand-operated wooden contraption used to lift water from a

well, a river, or a canal. A bag and a rope are tied to one end of the pole, while a counterbalance is linked. The operator lowers a rope tied to the long end, fills the container, and raises the filled container with the counterweight. Typical water-lifting rate is 2.5 m³/day. A single *shaduf* could thus irrigate 0.1 hectare of land in 12 hours. It is generally advantageous for lifting water from unlined wells, streams, or ponds for irrigating small fields.

Mote/Chadas method (Rope and Bucket lift): *Chadas* means the one that lifts. Using draught animals, it lifts water from wells and irrigates



Dhenkli or shaduf

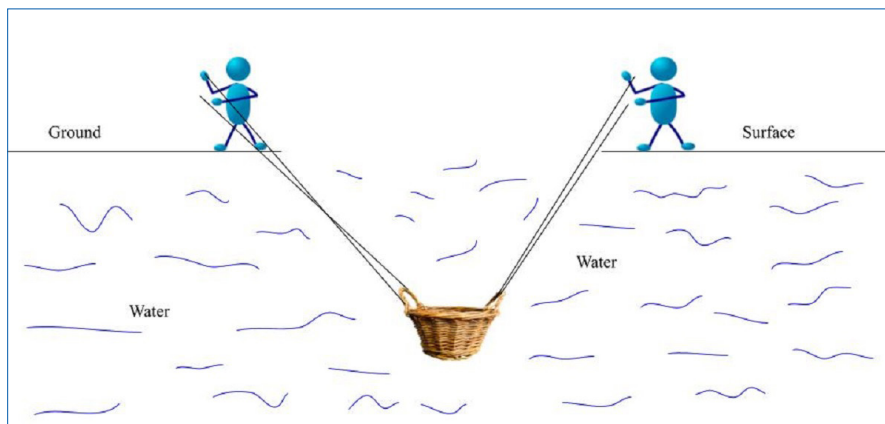
fields. This method is still in function at some parts of Rajasthan like Udaipur, Pratapnagar and Pali. In the local language, it is also called *Lavchadas*. This method can lift around 100 litres of water in one go, but it depends on animal capacity or species. A pulley is installed on the well on two uprights in this technique. On one end of the rope is a huge leather bag called Mote or Chadas. The opposite end is used to hoist a water-filled leather bag. This method is employed when the well's water level is relatively high and irrigation is required for a larger area. This technology is capable of irrigating around 1.5 hectares of land.

Doon method: It is used to lift water to relatively low heights, such as 1 meter. A *doon* is a conduit made of wood or metal that is closed at one end and open at the other. It is held up by a wooden bulldog that serves as its fulcrum. This practice is extremely popular in Bengal.

Archimedian Screw method: It is formed by a cylinder into which a screw is inserted. To lift the cylinder, it is kept tilted with its lower end immersed in water. The upper end is preserved adjacent to the irrigated field. Additionally, in this scenario, the lift of water is rarely greater than 1 meter. The cylinder is angled at approximately 30 degrees with respect to the horizontal line. The machine is portable and is operated by one or two person in a sitting position facing each other. In India, this method is used in Andhra Pradesh.

Yeta or Joto: Yeta or Joto or Dhon/Don water-lifting method is still used by farmers in Orissa, parts of Bihar and West Bengal for irrigating paddy fields. This method is suitable when the depth to water surface from the ground does not exceed 1.2 meters and optimum lift is 0.5–1 meters with an average discharge of 9,000–13,000 litres/hour.

Swing Basket: The swing basket, which consists of a basket-like scoop tied to four ropes, is one of the oldest water lifts. Two people face each other while swinging the basket to fill it with water. The



Swing basket method

basket is lifted and emptied into the field channel. The swing basket can be used up to a lift of 1 meter. Its average discharge is 14,000–19,000 litres/hour and is occasionally used in the rice-growing belts of eastern and southern India. The advantage of this device is that it is created from a basket made of inexpensive materials such as woven bamboo strips, leather, or iron sheet.

Comparison of water lifting devices with modern lifting techniques

In many developing countries, man and animal power are the primary energy sources for small-scale irrigation pumping and domestic water supply. Engine-powered pumps are around 15–25% more expensive than electric motor-powered pumps. The cost of lifting water by animal power is about 10–20 times more than electric motors. Manually-operated water lifts are the costliest, 3–4 times more than animal operated devices. Despite the economic disadvantage, man and animal power continue to be significant energy sources in domestic water supply and small-scale irrigation in developing countries. Low economic status of the rural masses often necessitates the use of man and animal power in water lifting in developing countries. The discharge capacity of traditional water-lifting devices is comparatively less than modern water-lifting techniques. Most traditional water-lifting devices are limited to head up to 10 meters except rope and pulley bucket. The modern water-lifting devices are suitable for lifting water when

the lift exceeds 10 metres and have higher discharge rates. The energy consumption using traditional water-lifting devices is less than modern water-lifting technologies. The working principle is easy and thus does not require high skills to operate, therefore, a layman can also operate easily. Modern water-lifting technologies are either electricity operated or diesel engines are used and hence, consume a high amount of energy and cause pollution.

In contrast, traditional water-lifting devices are eco-friendly, easy to operate, do not cause any pollution. Traditional water-lifting devices are usually made up of wood or similar other locally available items and are cheaper. Therefore, the initial cost for the creation/construction/development of these is comparatively lesser than modern irrigation pump sets/water-lifting techniques. As these devices are simple in construction and have fewer mechanical/rotating components, the maintenance cost is low compared to modern lifting techniques. Traditional water-lifting devices are suitable for small landholding farmers to irrigate lawn/vegetable/row crops and to meet the household water requirements. However, these devices are not suitable for the places where groundwater tables are at a greater depth and no surface water sources are available to withdraw water.

Present status of traditional water lifting devices

It is true that archaic pumping systems are still in use in many developing world regions today.

Priorities for research should be set for the development of cost-effective ways and practices based on upgrading low-cost historical waterlifting technologies by replacing muscle power (human or animal) with natural sources of energy. Persian wheel is still used in India for irrigation of small fields. The reactivation of ancient irrigation methods, many of which are dormant but still exist, could assist to lower the high energy consumption and emission from irrigation systems.

SUMMARY

Traditional water-lifting techniques/devices have many benefits. These devices are energy efficient and do not cause environmental pollution. As today, we have renewable energy sources like solar energy, we can utilize these energy sources for water-lifting with traditional techniques. Another advantage is the adaptation of the traditional water wheel, which is a simple structure that may be used to provide a long-term answer to rural agricultural

water demands. The rediscovery of historic technology can help achieve climate action and reduce GHG emissions. Additionally, these technologies perform a variety of activities and services necessary for a sustainable living on land, which must be evaluated holistically.

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