THE BHUNGROO: A GROUNDWATER HARVESTING AND SUPPLY TECHNOLOGY FOR IRRIGATION PURPOSES

A Technical Guide for Agricultural Extension Agents

Submitted by

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Preface

Bhungroo is a word in Gujarat, India, for a straw that can suck out fluid from a closed container. It has become the name for a type of borehole sunk in a flood-prone area that helps drain and store the flood water for future use. Bhungroo is an access tube bored into the earth's surface to access groundwater. It is an **innovative water harvesting technique which** frees flood water from a flood-prone and waterlogged farmland. With the aid of a water-lifting device, the stored water can be lifted back to the soil surface for use, either for domestic or irrigation purposes. When the Bhungroo is fitted with accessories for irrigation purposes, the set-up is called Bhungroo Irrigation Technology (BIT).

BIT has the advantages of draining flood water, thus reducing waterlogging in farmlands, recharging water-bearing formations (aquifer), and releasing the stored water for future use. It thus serves three purposes: water harvesting, storage and abstraction. It is a technology that should be promoted to enhance groundwater exploration for irrigation of high valued crops economic crops in areas where water is limited. Bhungroo may also be regarded as a flood disaster preparedness technology.

This technical guide explains the Bhungroo as a water management technology, the working principles, operation and maintenance, and its application with a solar-powered pump to irrigate vegetable crops during the dry season. It is targeted to guide Agricultural Extension Agents who will cascade the lessons to farmers to help them explore the use of Bhungroo Irrigation Technology.

1. Introduction

1.1 Bhungroo in Brief

The Bhungroo is an access tube that serves both as a conduit for infiltrating flood water into the soil and as a tube for extracting water from the aquifer. It is a water conservation technology that can take large quantities of water from the land surface and store it in the soils as groundwater. Figure 1 is a typical illustration of the concept of Bhungroo.

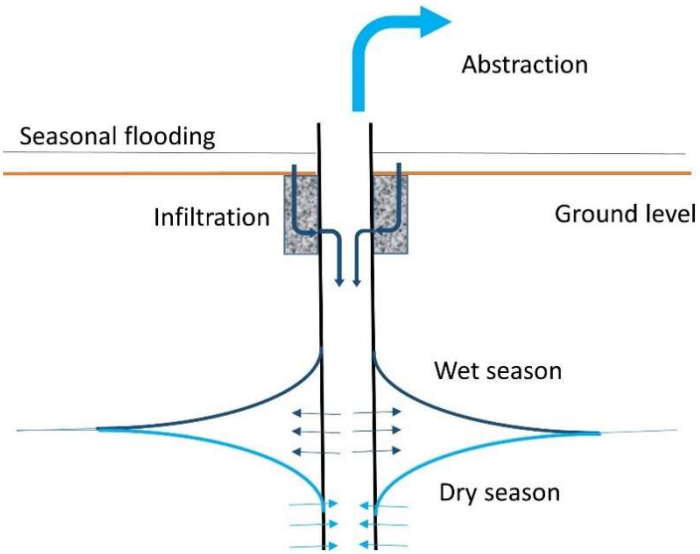

Figure 1: Bhungroo technology concept: (Adopted from: Owusu et al., 2017)

The Bhungroo can be equipped with a water-lifting device (e.g., a solar-powered water pump) and deployed for irrigation purposes (See Figure 2). When the Bhungroo is used for irrigation, the entire set-up is called Bhungroo Irrigation Technology (BIT).

The uniqueness of BIT is its ability to absorb water, store, and recover the water for various uses when needed. Owusu et al. (2017) reported that the BIT could infiltrate as much as 40,000 m^3 (4,000 Poly tanks of 10,000 litres capacity) of water underground. The water can later be recovered to irrigate 8 to 12 ha of vegetable crops. Bhungroo may be regarded as a flood disaster preparedness and adaptation technology. Some States in India have successfully explored the BIT to utilize floodwaters from farmlands for dry-season farming, generating good income and improving the livelihoods of smallholder farmers.

Bhungroo well in Gorogo *(Picture by H.E. Igbadun)*

Testing Bhungroo depth *(Picture Source: Owusu et al., 2017)*

Soil Panel with Overhead tanks *(Picture by H.E. Igbadun)*

Drip irrigation system *(Picture by H.E. Igbadun)*

Figure 2: Bhungroo Irrigation Technology

1.2 Bhungroo Irrigation Technology in Ghana

The BIT was introduced in Ghana in 2015 by the Conservation Alliance in collaboration with Naireeta Services (www.naireetaservices.com) from India under the Bhungroo Project and the International Water Management Institute (IWMI). There are six (6) Bhungroo located in Gorogo Sepaat and Baare in Upper East Region and Jagsi, Kpasenkpe, and Weisi in the Northeast Regions of Ghana, which were drilled and tested under two projects. The first was "Bhungroo Project: Water management solutions to support diversified cropping systems for men and women in Northern Ghana", funded by the CGIAR Research Program on Water, Land and Ecosystems. The second project was " Securing Water for Improved Seed and High-Value Vegetable Production in Flood-prone areas of Northern Ghana (SecureWater)", funded by the USAID in "The Feed the Future Ghana Agriculture Technology Transfer" program.

2 Components of Bhungroo

Bhungroo has the following components (Figure 3)

1) The hole bored into the earth's crust

2) The filtration system
3) The aquifer/groundwater

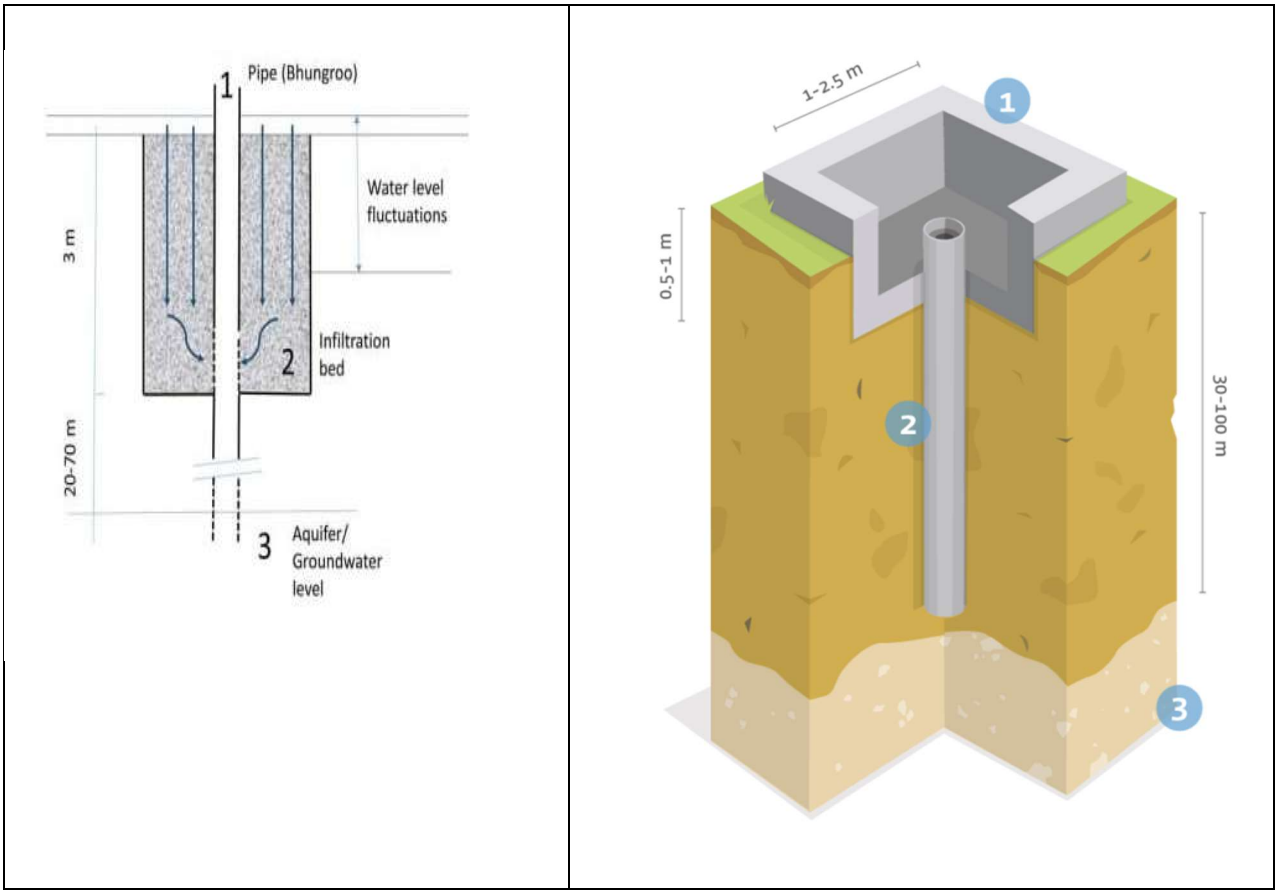

Figure 3: Schematic diagram of the components of Bhungroo (*adapted from Engineering for Change, 2022)*

2.1 The bored hole and pipe connections

a) The hole bored into the earth's crust should go into the aquifer, an unconsolidated material that stores most of the water taken down from the soil surface by the Bhungroo.
b) The depth of the bored hole may vary from 30 to 100 m, depending on the depth of the aquifer. The bore must get to the aquifer to ensure a continuous water supply from the Bhungroo.
c) The diameter of the hole ranges from 10 to 20 cm.
d) After the hole is bored, an array of pipes is inserted into the hole to form a continuous column from the bottom to the surface above the ground. The pipes form the inner lining of the Bhungroo.
e) Screen pipes or serrated pipes wrapped with a lining cloth to serve as a screen/filter are connected either at different sections or towards the lower portion of the column of pipes. Through the screen or serrated pipes, water enters the pipe column.

2.2 The Filtration System

The filtration system filters the surface water that is entering the Bhungroo (Figure 4). It consists of\:

a) A built infiltration bed with surface area ranging from 2 to 6 m^2 and 2 to 3 m deep
b) The bed may be filled with boulders, grades of pebbles, sea sand and fine sand, arranged in layers based on their particle sizes, in a mesh wire cover to keep each layer intact and compact.
c) Layers of activated charcoal may also be placed in the infiltration bed, which help to purify and remove odor from the water entering the Bhungroo
d) The quantity and quality of the water entering the Bhungroo depend on the filtration system's effectiveness. The filter materials should be well arranged to minimize the system's clogging and low infiltration rate.

Figure 4: Typical filtration system of the Bhungroo (source: Engineering for Change, 2022):

2.3 The Aquifer

a) An aquifer is an unconsolidated parent material that can store and transmit water. The water that the Bhungroo takes down is stored in an aquifer.
b) The aquifer may have an underneath impervious stratum, enabling the infiltrated water to be held with unconsolidated material.
c) The water in the aquifer may be recharged from different water sources (e.g., surface floodwater, a nearby perennial stream, river, or any body of water within the vicinity of the Bhungroo.

2.4 Difference between Bhungroo and regular Boreholes

Bhungroo well is different from the regular deep borehole wells.

a) While regular boreholes can be sunk anywhere, Bhungroo wells are sunk in cultivable flood plains.

b) Regular boreholes are not designed to infiltrate floodwater or runoff water from the soil surface into the well. Bhungroo well functions as a filtration unit which infiltrates the floodwater into the aquifer.
c) Regular boreholes are not water harvesting structures, but Bhungroo are designed to harvest excess flood/surface water and store the water for future use.

3. Technical Requirements and considerations for Bhungroo Irrigation Technology

Table 1 shows some technical requirements and important considerations for the Bhungroo irrigation technology

Table 1. Technical requirements for the Bhungroo technology.

Technical requirements	Important Considerations	Description
Water source	Floodwater and groundwater, in good volume and quality, to recharge the Bhungroo and available for abstraction for a considerable period or duration.	The Bhungroo should be constructed in a localized flood plain or flood-prone lands with agricultural activities. These considerations will ensure the reliability of water supply.
Depth	Aquifer depth with good water quality (.20 m depending on the geology of the area)	The depth should penetrate an aquifer to guarantee good quality and reliable water supply.
Recharge method	Natural recharge	Recharge from floodwater, surface water sources like a perennial stream, large water bodies (pond, lake, dam, etc.), and groundwater from the perched aquifer.
Infiltration method	Ease to constructed;availability of land; consider the using local filter materials	A well-built filtration tank of 4 to 6 m2 surface area and 2-3 m deep, with layers of locally available filter materials.
Nature of aquifer	High storability and transmissivity	A water-bearing formation can hold and transmit water sufficient for continuous pumping.
Water abstraction and use	Domestic and agricultural water needs	Highly suitable where the water can be used for agricultural purposes. Use the most efficient irrigation water management technologies
Environmental impact	Environment (community, farmlands) Ecosystem	Minimum impact on the environment and the ecosystem

Socia-economic benefit	Accessibility Acceptability by the community	Establish community interest and usage for social and economic accessibility
Irrigation system	Drip irrigation Sprinkler Surface (least recommended)	The efficiency of drip irrigation is the best effective management of Bhungroo water. Use of Bhungroo water for surface irrigation is least recommended.
Water lifting device	Solar-based pumps Electricity-based pumps Fossil fuel pumps	The solar-based pump is environmentally friendly and economical in the long run, even though the initial investment may be high.
Agriculture	Type of soil Type of crops Crop water requirement Optimal crop growing season	The Bhungroo should be located in a cultivable field with soil depth that can support crop production during the dry season. Highly sandy soils are not recommended.. It should yield water sufficient to meet the requirement of the crops to be planted The crop should be carefully selected so that the growth duration is within the period the Bhungroo has sufficient water. High valued crops (on the community) are strongly recommended to maximize economic crops.

4. Use, Operation and Maintenance of Bhungroo

4.1 Use

Bhungroo is particularly used for irrigation purpose. With the aid of a pump, the stored water is lifted to the irrigation facilities. The irrigation facility may be drip irrigation or sprinkler/shower/sprinkler hose system. For gravity-based drip irrigation system, the system, the water is lifted to the overhead tanks which supply water to the driplines.

Two types of the drip irrigation system may be used for the Bhungroo

a) Pump-based drip irrigation system: the Bhungroo is connected directly to a network of drip lines so that the pump supplies the drip lines directly.
b) Gravity-based drip irrigation system: the water is lifted into water storage containers placed at an elevation well above the field level (usually 2 to 4 m height). The water flows from the height into the drip lines by gravity. Figure 5 shows a typical Bhungroo-Gravity-based drip irrigation set-up.

The sprinkler irrigation system is usually pump-based because more pressure is needed to rotate the sprinkler head, which can only come from the pump.

Bhungroo is not advisable for gravity-flow surface irrigation systems because of the high conveyance losses. Bhungroo may be used for surface irrigation if the outflow (discharge) is high and sufficient to meet crop water requirements under surface irrigation. Moreover, consider using pipes or plastic hose/tubings to convey the water to the application point, thus eliminating conveyance losses.

Bhungroo may be used for animal and domestic purposes but with caution. A routine water quality test should be carried out at the beginning of the season to determine its suitability for human and animal consumption. This is because the Bhungroo water is largely flood water trapped and infiltrated into the storage system.

The water lifting device (water pump) used for the Bhungroo may be surface or submersible pumps powered by fossil (petrol or diesel). A more environmentally friendly and less operational cost means of lifting water now is the use of solar power. An array of solar panels can provide enough energy to lift water from any depth of Bhungroo. However, there is high initial installation cost and requirement for specialized manpower for maintenance of solar power pumps.

Figure 5: Bhungroo-Gravity-based drip-irrigated fields in Gorogo and Sepaat *(Pictures: H.E. Igbadun)*

4.2 Operation and Maintenance

1) For the higher performance of the filtration system, ensure that it is free of weeds before flooding begins in the area.

2) The filtration materials should be excavated and changed if the system has become so silted and settled.

3) The Bhungroo catchment area should also be prepared to capture more runoff/flood water before the rainy season. Ensure that the surrounding is cleared and free of weed.

3) The water pump may be removed and serviced when there is a drop in the pump's performance (Figure 6). The depth of the Bhungroo should be sounded to ensure that there is no cavity or

collapse underneath, which will eventually entrap the submersible pump and make it deliver less water.

5) If the solar system is used to power the water pump, the solar panels should be secured and cleaned/washed with water on the surface panels before and after the season of use.

6) Employ the services of technical experts to remove the water pump from the Bhungroo and service it.

Figure 6: Servicing the submersible solar-based pump *(Picture by H.E. Igbadun*)

5. Reference

Engineering for Change 2022. http://www.engineeringforchange.org/solutions/product/bhungroo/

Owusu, S., Cofie, O., Osei-Owusu, P.K., Awotwe-Pratt, V., and Mul, M.L., 2017. Adapting Bhungroo Artificial Storage and Recovery Technology to the flood-prone areas of Northern Ghana for dry season irrigation. IWMI working paper 176.