



Hand Dug Well Technology Package

HHMIT Package-3

**Small Scale Irrigation Directorate**

**November 2019**

**Addis Ababa**

** HOUSEHOLD MICRO IRRIGATION TECHNOLOGY (HHMIT) PACKAGE**

Table of Contents

[1. Introduction 3](#_Toc26015155)

[1.1 Background and Rationale 3](#_Toc26015156)

[1.2 Package Objective 4](#_Toc26015157)

[1.2.1 General Objective 4](#_Toc26015158)

[1.2.2 Specific Objectives 4](#_Toc26015159)

[1.3 Scope of the Package 4](#_Toc26015160)

[1.4 Where to Implement? 5](#_Toc26015161)

[1.5 Beneficiaries 5](#_Toc26015162)

[2. HHMI Package Components 5](#_Toc26015163)

[2.1 Irrigation water source 5](#_Toc26015164)

[2.2 Water lifting devices 5](#_Toc26015165)

[2.3 Irrigation water application 5](#_Toc26015166)

[3. Hand dug well Technology Package 6](#_Toc26015167)

[3.1 Water source 6](#_Toc26015168)

[3.2 Water Lifting 8](#_Toc26015169)

[3.2.1 Rope and Bucket with Pulley 8](#_Toc26015170)

[3.2.2 Rope and Washer pumps 8](#_Toc26015171)

[3.2.3 Treadle pump 9](#_Toc26015172)

[3.2.3.1 Pressure Treadle pump 9](#_Toc26015173)

[3.2.3.2 Suction-only Treadle pump 10](#_Toc26015174)

[3.2.4 Hand Pump 10](#_Toc26015175)

[3.2.5 Engine pump 11](#_Toc26015176)

[3.2.6 Solar pump 12](#_Toc26015177)

[3.3 Water application 13](#_Toc26015178)

[3.3.1 Watering Canning 13](#_Toc26015179)

[3.3.2 Low Cost Family Drip 14](#_Toc26015180)

[3.3.3 Furrow System 15](#_Toc26015181)

[3.3.4 Basin Irrigation 16](#_Toc26015182)

[3.4 Crop Selection 16](#_Toc26015183)

[3.5 Command area 18](#_Toc26015184)

[3.6 Irrigation Scheduling 20](#_Toc26015185)

[4. Extension and Market Strategy 22](#_Toc26015186)

[4.1 Extension Strategy Intervention 22](#_Toc26015187)

[4.2 Market Strategy 23](#_Toc26015188)

[4.3 Access to Credit 24](#_Toc26015189)

[5. Financial Feasibility Analysis 24](#_Toc26015190)

[5.1](#_Toc26015191) ~~[Why analysis?](#_Toc26015191)~~ [24](#_Toc26015191)

[6. Monitoring and Evaluation (M&E) System 28](#_Toc26015192)

**List of Tables**

[Table 1- HDW Technical Characteristics 6](#_Toc26534678)

[Table 2-Cost of construction 7](#_Toc26534679)

[Table 3. Rope and Washer Technical Details and Cost 9](#_Toc26534680)

[Table 5- Pressure Treadle Pump Technical Details and Cost 10](#_Toc26534681)

[Table 6-Suction treadle pump Technical details and Cost 10](#_Toc26534682)

[Table 7-Hand pump parameters 11](#_Toc26534683)

[Table 8-Engine pump technical details 12](#_Toc26534684)

[Table 9 Surface (centrifugal) pump characteristics and cost 12](#_Toc26534685)

[Table 10- Solar Pump Technical Details and Cost 13](#_Toc26534686)

[Table 11-Recommended Water application Methods for HDW 13](#_Toc26534687)

[Table 12-Water can technology conditions and constraints 14](#_Toc26534688)

[Table 13-Drip Irrigation technology conditions, requirements and constraints 14](#_Toc26534689)

[Table 14-Summary of Drip Kit (FDK) Specification and Cost of installation 15](#_Toc26534690)

[Table 15-Furrow slope, stream size and Irrigation depth for different soil types 16](#_Toc26534691)

[Table 16- Crop selection based on agro ecology zone 17](#_Toc26534692)

[Table 17-Sensitive growth period of vegetable crops for water shortage 18](#_Toc26534693)

[Table 18- Command area for different well discharge for Highland, midland and Low land agro ecology for different irrigation hours 18](#_Toc26534694)

[Table 19-Irrigation interval 21](#_Toc26534695)

[Table 20-Agronomic recommendation of cabbage cultivating by furrow and drip irrigation at high and mid land with hand dug well yield capacity of 0.1 l/sec (sample) 23](#_Toc26534696)

[Table 21 Summary of participatory Extension Communication method & Tools to promote farm pond 24](#_Toc26534697)

[Table 22 Financial analysis of hand dug well motor r pump lifting technology and drip application 26](#_Toc26534698)

[Table 23 HDW+ Hand pump + Drip 27](#_Toc26534699)

[Table 24 HDW+ Engine pump +Low cost drip 28](#_Toc26534700)

[Table 25 HDW + Solar pump + Drip 29](#_Toc26534701)

[Table 26- M&E tools for Hand dug well (Water source) 29](#_Toc26534702)

[Table 27-Water lifting technology 31](#_Toc26534703)

[Table 28-Water application Technology 36](#_Toc26534704)

# Introduction

## Background and Rationale

As a means of improving agricultural production and productivity, irrigation development is one of the key prioritized area of intervention in Ethiopia. As part of irrigation development, Household micro irrigation (HHMI) is equally considered as an important opportunity to transform the lives of smallholder farmers, increasing incomes and ensuring food security at the household level.

The overall objective of HHMIT is to promote irrigated farming at the household level by introducing suitable household micro irrigation systems, including selecting sustainable water sources, low cost and effective water lifting and irrigation application technologies. The HHMI system is referred to household-level micro irrigation practiced by an individual household (up to 0.5 ha) or a group of smallholder households covering an area up to 5 ha. The command area can be under subsistence or cash crops.

This package clearly defines the water sources, water lifting devices, irrigation methods, crop to be grown, area to be irrigated, and technology dissemination mechanism highlighted with the possible benefits in terms of socio economics, environment and gender.

It is also aligned with the government policy “*to let every rural household have at least one alterative water source for irrigation*” to improve their food security status and increase their household income.

It is also believed that frequently asked question and challenges during planning and implementation as well as across its value chain can be answered. These are the following but not limited to:

1. What are the most commonly used types of water sources for household irrigation development?
2. What are the possible and feasible water lifting devices to be used for household irrigation development based on the available type of water source?
3. What are the possible and feasible irrigation application technologies to be used for household irrigation development based on the available type of water source and water lifting devices?
4. How large area a single household or group of household can irrigate based on the type of water source, type of water lifting device and type of irrigation method adapted?
5. Which crop/s need to be considered to make HHMI development be feasible?
6. Is HHMI financially feasible? Or what feasibility indicators we should consider while promoting/developing HHMIT?
7. What irrigation extension tool needed to follow in order scale out HHMIT intervention
8. What are the possible marketing strategy with respect to HHMIT intervention?
9. What are the possible M&E tools to be used in this intervention?

This package is, therefore, prepared to introduce and provide users’ guidelines how appropriately integrate different household micro irrigation technologies for sustainable development and extension intervention. The effort will be able to improve the livelihoods of smallholder farmers by contributing to Ethiopia’s overall vision of achieving middle income level by 2025.

## Package Objectives

### General Objective

Introducing and implementing best combined HHMI technologies in Ethiopia to improve agricultural productivity and living standard of smallholder farmers.

### Specific Objective

The specific objective of the package includes to:

* Introduce and promote best bet HHMI systems, technologies, practices for good outcome
* Develop HHMIT intervention extension and monitoring tools as to the national standard
* Develop HHMI social and financial evaluation tools

## Scope of the package

This package presents how successfully HHMI technologies can be implemented at individual households and group of households. In this regard, the package outlines technology combinations, which are largely practiced in Ethiopia. These combinations include; household irrigation water sources, appropriate and low-cost water lifting devices and water application system.

Based on these combinations, the package recommends possible command area to be irrigated and crops to be grown. The package will also include the required irrigation extension tools, marketing strategy, social and economic analysis. The package also includes indicators and tools for monitoring and evaluation of Household micro irrigation intervention.

## Where to implement?

The HHMI package could be implemented all over in Ethiopia where irrigation is viable and where irrigation water resources both surface (river, spring, lake, and rain) and groundwater are easily taped and used for irrigation purpose by individual or group of households.

## Beneficiaries

Directly or indirectly, all individual households and group of households living in all agro ecology of Ethiopia and engaged in crop production, livestock development or mixed farming.

# HHMI package components

HHMI technology package will have the following three basic components:

## Irrigation water source

The following water sources are considered:

* Farm pond
* Roof top rainwater harvesting
* Hand dug well
* Manual tube well
* Spring
* River

## Water lifting devices

The following water lifting devices are considered:

* Treadle pump
* Engine pump
* Rope and washer pump
* Rope and bucket lifting
* Pulley
* Solar

## Irrigation water application

The following irrigation water application are considered:

* Drip irrigation
* Furrow irrigation
* Water can
* Pitch irrigation

To enable beneficiaries to use appropriate technology options from the above package components, in the next sections a package combination based on water resources are presented.

# Hand dug well Technology Package

# Water source

Hand dug well (HDW) is the most common structure created to access water from underground aquifers where the water is collected and concentrated in the well for several purpose. As the name implies, excavation is done by hand and the well may be lined using masonry and concrete lining, both reinforced and unreinforced, precast and cast in-situ. Beyond a certain depth, the option of mechanical drilling of Dug wells (DW) may be considered as preferable in terms of safety, cost (both capital and maintenance), and time. Yield of existing hand-dug wells may be improved by increasing the depth of HDW. The system can be easily constructed and maintained by the rural communities. Development of HDW is essential for all purposes including irrigation, crop and livestock production and domestic purposes. It also saves time and energy particularly for women farmers traveling long distance in search of water for domestic purposes. Most of the HDWs have depth in the range of 3 to 15 meter and in most cases the depth is about 3m under manual digging condition with a diameter of 1.0-1.5m.

The level of the water table fluctuates according to the seasons as the inflows and outflows vary with the seasons of the year and the utilization by humans. Nevertheless, the water quantity that can be obtained from a single HDW varies from 8.64 to 86.40 m3. Therefore, this HDW based irrigation technology and extension package enables woreda experts and DAs to select site and execute the construction on the actual field. For in-depth planning, design, construction, operation, and maintenance techniques of HDW, please refer HHMI training manual.

Table 1- HDW Technical Features

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Water source** | **Soil type** | **Depth** | **Advantages** | **Constraints** |
| Hand-dug well | All soil types except solid rock | Up to 30m | * Simple technology * Low maintenance costs * Well may be left open or closed * The community of users can become involved from the very beginning of the process (community participation) * Construction and maintenance do not require very sophisticated equipment * Apart from cement, the materials needed for construction are normally available locally | * Excavation can be dangerous * Water level can fluctuate * An open and unprotected well can be dangerous for the users. Small children, especially, can fall in. |

Table 2-Cost of construction

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **Descriptions** | **Estimated cost (Birr)** | **Remark** |
| HDW-10-Ф1m | Less than 10 m depth HDW with full casing well inner diameter 1m | 23,916.61 | Cement, Qtl, 10qtl; Sand, 1.14m3; Gravel, 4.64m3 (concrete), Reinforcements (ɸ 6 mm) 53.37kg, eucalyptus wood post 5 |
| HDW-15-Ф1m | 10-15 m depth with full casing well inner diameter 1m | 31,564.42 | Cement, Qtl, 15qtl; Sand, 1.7m3; Gravel, 3.41m3 (concrete), Reinforcements (ɸ 6 mm) 80.05kg, eucalyptus wood post 5 |
| HDW-20-Ф1m | 15-20 m depth with full casing well inner diameter 1m | 46,599.89 | Cement, Qtl, 20qtl; Sand, 2.5 m3, Gravel 4.70m3 (concrete), Reinforcements (ɸ 6 mm) 106kg, eucalyptus wood post 5 |
| HDW-25-Ф1m | 20-25 m depth with full casing well inner diameter 1m | 57,855.33 | Cement, Qtl, 25qtl; Sand, 3m3; Gravel, 5.70m3 (concrete), Reinforcements (ɸ 6 mm) 133kg, eucalyptus wood post 5 |
| HDW-25-Ф0.6m | 25 m depth with full casing well inner diameter 0.6m | 52,291.63 | Cement, Qtl, 16qtl; Sand, 2 m3; Gravel, 3.7m3 (concrete), Reinforcements (ɸ 6 mm) 81.56kg, eucalyptus wood post 5 |

Box 1 Cross Cutting Issues of HDW

|  |
| --- |
| **Environmental Consideration:** The most associated environmental consideration is the quality of well water and the types of contaminations. The well close to abattoir, pit latrine, domestic refuse dumps, stagnant water & drainage showed higher amounts of bacteria formations. This creates favorable environment for water born disease that affects human health. Testing your well frequently to ensure that the water it is providing is safe and of a good quality.  It is better to maintenance which involves protecting your well head by checking the well head for damage, and making sure that the ground surrounding the well head is protected. In general, for sustainability of a scheme proper management of the hand dug well by the beneficiaries such as inspecting, safety against the entrance of animas and children into the hand dug well is very important.  The other main consideration is the depletion of ground water table as abstraction of water exceeds the discharge rates. Withdrawing ground-water may cause the land to subside, aquifers to become saline, or may accelerate other types of ground-water pollution. Here considers the intake – outtake as well when used for irrigation purposes.  **Gender**  The technologies locating near the home enables multiple uses and further reduces the workload of women and children.  Improvements to work related for domestic purposes and to increase work efficiency and technologies located near the household, this is significant for domestic plus irrigation use. |

# 

# Water Lifting Devices

Water-lifting devices are technologies used to lift water to a height that allows users easy access to water from its sources to final destination. Communities should be able to choose from a range of water-lifting devices, and each option should be presented with its advantages, disadvantages and implications. Among suitable water-lifting devices for hand-dug wells, under this package the following are considered: pulley, rope and washer pumps, hand-pump, treadle pump, motorized pump, electric pump and solar pumps.

# Rope and bucket with Pulley

This device is a very basic and widely used method where water can be added on very specific points using a water can at each side facilitates the irrigation work. A bucket on a rope is lowered into the water. When the bucket hits the water it dips and fills, and is pulled up with the rope. The rope may be held by hand, run through a pulley, or wound on a windlass. Sometimes, animal traction is used in combination with a pulley. Improved systems use a rope through a pulley, and two buckets – one on each end of the rope. For water less than 10 m deep, a windlass with a hose running from the bottom of the bucket to a spout at the side of the well can be used. Initial cost is from 300 Birr for a plastic bucket and 5 m of rope, to 500 with a windlass, hose and closed superstructure.

# Rope and Washer pumps

Rope and washer pump is a simple and affordable technology that can meet the needs of small-plot farmers. It can be made from locally available materials such as wood, rope and vehicle tires in local metal workshops. Most farmers prefers this pump due to low cost, ease of operations, manufacturing and maintenance by local technicians/workshop and ease of transport. If properly produced, installed and maintained, over 90% of the installed pumps may be expected to remain functional, even many years after installation, they can last for 20 years or more. Compared to other low cost lifting devices, the Rope and washer has a high capacity and can raise from wells of 1 to 30 meter deep.

Table 3. Rope and Washer Technical Details and Cost

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Discharge | Water Level | | up to 10m depth:35 liter/min | |
|  |  | | up to 20m depth:20 liter/min | |
|  |  | | up to 35m depth:10 liter/min | |
| Maximum depth | 35 meter (water level) | |  | |
| Input power | Approximately: 50 Watt-the discharge is based on an input power of 50 Watt, which is the power that women and children can deliver for longer periods | | | |
| Discharge level | 1m above ground level (no pressure condition) and with an additional wheel and structure up to 6m above ground level is possible | | | |
| Application | 1-10 households (approximately 50 users maximum) | |  | |
| Cost | Variable (e.g. by the support of Sustainable Land Management Project-SLMP it is distributed at the cost of Birr 3500 for the hand dug well excluding the head work) | | | |
| **Max Lifting head, (m)** | **Discharge (l/ m)** | **Cost, birr** | | **Remarks** |
| 0-10 | 35 | 2944 | | Irrigation, Domestic Use, Livestock |
| 10-20 | 20 | 3184 | |
| 20-30 | 10 | 3221 | |



# Treadle pump

A treadle pump is a human-powered suction pump that sits on top of a well and it is used for irrigation and other domestic use. After the pump is installed on top of a well, the farmer operates it by stepping up and down on two long levers called “treadles” which are approximately 30cm, installed on a small wooden or metal platform. These treadles drive pistons which create suction in the well casing (PVC piping) that extends into the water table. It is designed to lift water from a depth of seven meters or less. They are commonly two types, viz. pressure and suction-only treadle pumps.

# Pressure Treadle pump

The Pressure Treadle Pump is a foot-operated option for delivering pressurized water for depth to water less than 7 m. The pressure treadle pump is a simple foot-operated for small-scale irrigation. It is a modification of the suction-only treadle pump, using suction to draw water to the surface but which can then force the water out of the pump under pressure. This allows water to be moved a distance of up to 50 m across the ground, or to a height of 6 m above the pump.

Table 4 Pressure Treadle Pump Technical Details and Cost

|  |  |
| --- | --- |
| **Descriptions** | **values** |
| Pump cost (ETB)  (including inlet and outlet hoses) | 4025 |
| Above ground level delivery height (m) | 9 |
| Total Dynamic Head (m) | 16 |
| Pumping water level (m) | 7 |
| Pumping (hrs.)/day | 4 |
| Maximum Water Output (L/minute) | 1m: 80 L/min  7m: 30 L/min |

# Suction-only Treadle pump

The suction-only pump uses suction to lift water from up to 6m below ground to be used to irrigate crops or carried to a storage container. This low-lift pump is relatively low cost, easy to use, provides a good yield, and can be operated for 4 hours a day. The suction pulls water upwards and delivers it out of the top of the pump, where it can be directed through furrows or into a container to irrigate a small plot of land.

Table 5 Suction Treadle Pump Technical Details and Cost

|  |  |
| --- | --- |
| **Description** | **value** |
| Pump cost (ETB) including suction hose | 1500 |
| Pumping water depth (m) | 6 |
| Groundwater depth (m) | 10m |
| Pumping hour/ day | 4 |
| Maximum Water Output (L/minute) | 1m: 90 L/min  7m: 34 L/min |

# Hand Pump

A manual hand pump is low cost water lifting technology, which has cylinder and plunger (or piston) located above the water level, usually within the pump stand itself. These pumps must be

primed by pouring water on the plunger. On the up-stroke of the plunger, the pressure inside the suction pipe is reduced and atmospheric pressure on the water outside pushes the water up into the pipe. On the down-stroke, a check valve at the inlet of the suction pipe closes and water passes the plunger through an opened plunger valve. With the next upstroke, the plunger valve closes and the water is lifted up by the plunger and flows out at the top of the pump, while new water flows into the suction pipe. The operational depth of this type of hand pump is limited by barometric pressure and the effectiveness of the plunger seals to about 7 m at sea level, less at higher altitudes. It can easily be maintained by local technicians and trained farmers. It is a “gender friendly” technology in that it can provide increased economic opportunities for women farmer. Manual (hand) pump is applied in the area where shallow ground water is available. It is environmentally friendly.

Table 6 Hand pump Technical Details and Cost

|  |  |  |  |
| --- | --- | --- | --- |
| Pump cost (ETB), including 10 m galvanized iron drop pipe  and a foot valve, and a suction pipe | 15,000 | **Pumping capacity** | |
| Maximum well depth for irrigation (m) | 30 | liters/s at 7 m depth | liters/s at 12 m depth |
| **Suction Pumps (m):** | 0 - 7 | 0.4–0.6 |  |
| **Low Lift Pumps (m):** | 0 - 15 | 0.4–0.6 | 0.25–0.42 |
| **Direct Action Pumps (m):** | 0 - 15 | 0.4–0.6 | 0.25–0.42 |
| **Intermediate Lift Pumps (m):** | 0 - 25 | 0.4–0.6 | 0.25–0.42 |
| Pumping hour /day | 4-6 |  |  |
| Average Water Output (L/minute) | 16.4 |  |  |

# 

# Engine pump

Engine pump is a motorized pump operating using benzene or diesel fuel to lift water from depth of not greater than 7m below underground. Small low-cost motorized engine pumps, make attractive and successful technology suitable for an individual farmer or a group of small-scale farmers. Individual farmers may extend their garden plots to irrigate a larger area because of the motorized pump, while groups of farmers can irrigate a common or collective area. It requires good conveyance and distribution systems, preferably with lined canals or low-pressure Polyvinylchloride (PVC) pipe and flexible hose outlets for smaller pump systems. Since HDW is subjected to seasonal fluctuation, to maintain optimum static water level and the suction head, it is recommended to excavate a pump house at reasonable depth as per the recommended formula depending on type of subsoil and Static Water Level (SWL) to determine depth and width of excavation.

Table 7 Engine Pump Technical Features

|  |  |  |
| --- | --- | --- |
| **Technical conditions** | **Requirements** | **Constraints** |
| * Adequate surface or groundwater sources available in the vicinity of irrigated areas * Suction head minimum 6\* m * Opportunity for extension of irrigated area for single farmers | * Engine pump is commercially available with maintenance services and spare parts * Access to regular supply of fuel at affordable price * Access to markets for product * Advisory services on selection and installation | * High investment costs * Availability of fuel * Operational costs * Management problems |

\* N.B. The altitude at which a pump is operated will enhance or diminish its performance. At higher elevations atmospheric pressure is decreased reducing suction lift. For this reason the pump should be located as close to the water source as possible. Altitude affects engine performance as well. **A rule of thumb** is that benzene and diesel engines will lose 3% of their power for every 304.8m (1000ft) of elevation. This is due to the "thinner air" or lack of oxygen at higher altitudes. The reduced engine speed results in reduced flow and head (see Table 8 and Table 9 below).

Table 8 Suction Lift at Various Elevation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Suction Lift At Various Elevation | | |  |  |
| **Altitude** | **Suction Lift in Meter** | | | |
| Sea Level | 3.05 | 4.57 | 6.10 | 7.62 |
| 609.60 | 2.68 | 4.02 | 5.36 | 6.71 |
| 1,219.20 | 2.38 | 3.57 | 4.75 | 5.94 |
| 1,828.80 | 2.10 | 3.17 | 4.21 | 5.27 |
| 2,438.40 | 1.89 | 2.83 | 3.78 | 4.72 |
| 3,048.00 | 1.74 | 2.62 | 3.47 | 4.36 |

Many engine manufacturers offer methods of overcoming this loss by offering high altitude cylinder heads, as well as carburetor jets and air cleaners designed for use at higher elevations.

Table 8 Performance Loss at Various Elevations

|  |  |  |
| --- | --- | --- |
| Performance Loss at Various Elevations | | |
| **Altitude, M** | Discharge Flow | Head |
| Sea Level | 100% | 100% |
| 609.60 | 97% | 95% |
| 1,219.20 | 95% | 91% |
| 1,828.80 | 93% | 87% |
| 2,438.40 | 91% | 83% |
| 3,048.00 | 88% | 78% |

* + - 1. Centrifugal pumps

Centrifugal pumps are widely used in agriculture and are a good example of the roto-dynamic pump group. However, for small systems requiring pump discharges of less than 2 liters per second, positive displacement pumps can be used under certain conditions. In irrigation terms, a pumping rate of 2 L/s is a very low flow and would be applicable to nurseries with misting jets, vegetable growers using drip irrigation, and domestic irrigation situations (see Table 8)……..

Table 8 Centrifugal Engine Pump Features and Cost

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Centrifugal pump Features** | **Inlet diameter** | **Outlets diameter** | **Impeller diameter, mm** | **At nominal Duty Point, 1450rpm** | | **At nominal Duty Point, 1900rpm** | | **Pump Cost (ETB)** |
| **inch** | **inch** | **Q, l/s** | **H, m** | **Q, l/s** | **H, m** |
| Option 1 | 2 | 1.26 | 125 | 1.75 | 5 | 3.47 | 20 | 10,000 |
| Option 2 | 2 | 1.26 | 160 | 1.75 | 8 | 3.47 | 32 | 14,000 |
| Option 3 | 2 | 1.26 | 200 | 1.75 | 12.5 | 3.47 | 50 | 16,000 |
| Option 4 | 2 | 1.26 | 250 | 1.75 | 20 | 3.47 | 80 | 20,000 |

# Solar pump

Solar pump is a pump powered by a solar/ sun light to lift water beneath the ground surface for different purposes. It is environmentally friendly and more reliable alternative to use for farmers in irrigation, which provides free energy once an initial investment is made. This is an appropriate business models that can boost micro irrigation development, reducing cost of fuel, and manage natural resources more sustainably. Women farmers can also generate income by providing an opportunity to earn extra income by supplying water to neighbors, by charging mobile phones and bulbs with the power generated by solar pump. With no fuel inputs and simple operation, solar powered irrigation systems are cleaner and more reliable alternative for farmers in the present state of energy crisis. The solar pump unit includes solar panels, a battery pack with current regulator unit for energy storage, and an electric motor linked to the water pump and on some other pumps, the electrical energy will be converted directly to reciprocating mechanical energy and that will be connected to the pump. To irrigate effectively, water needs to be stored in a water reservoir or tank and connected to a low-pressure pipe system or drip system.

Table 9 Solar Pump Technical Features and Cost

|  |  |
| --- | --- |
| **Case 1. Small-Scale Surface Portable Solar Pump** | |
| Pump cost (ETB) | 20,000-30,000 |
| Maximum well depth for irrigation (m) | 4 – 20 |
| Average irrigated area (m2)  Maximum 16m3/day lifting from 4m and 4m3/day lifting from 20m | 800 – 3.000 |
| Average Water Output (L/minute) | 16.4 |
| Groundwater depth (m) | 7 – 20 |
| System power (kW) | 1.1 |
| Typical lift range (m) | 5 – 200 |
| Typical flow rate (m3/day) | 10 – 400 |
| Average irrigated area (m2) (at 1m depth, 12,000 L/day and at 6m, 3600 L/day, 6 hours pumping) | 500 – 1000 |
| Daily pumping (L/day) | 3,600-12,000 |
| Maximum Water Output (L/day), Small-scale portable pump | 6m: 15 L/min; 1m: 33 L/min |
| **Case 2 Small-Scale Submersible Solar Pump** | |
| PV panels Installed at site | 40 to 60 ETB/Watt |
| Maximum well depth for irrigation (m) | 30 |
| Solar pump International brand | 30,000 ETB |
| Pump controller (\*)International brand | 30,000ETB |
| Electric cables Depending on pump depth and distance to PV panels | 150 to 450 ETB/m |
| Pump installation Cost up to 30 m | 6000 ETB |
| Small-scale portable pump, Up to 12 000 l/day, with 80 W panel and 24-month labor and spare parts guarantee | 20,000 |

Table 10 Estimation of Command Area Vs Recommended Water Application Methods

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Depth ofHDW (m) | Well Yield  l/s | Command Area (m2) | Water cans | Family Drip | Surface irrigation | |
| Furrow | Basin |
| 4 - 25 | 0.007-0.014 | 100-200 | x | x |  |  |
| 0.014-0.034 | 200-500 |  | x |  |  |
| 0.034-0.068 | 500-1000 |  | x | x | x |
| 0.068-0.135 | 1000-2000 |  | x | x | x |
| 0.135-0.169 | 2000-2500 |  | x | x | x |
| 0.169-0.338 | 2500-5000 |  | x | x | x |
| 0.338-0.675 | 5000-10,000 |  | x | x | x |
| 0.675-1.013 | 10,000-15,000 |  | x | x | x |

*N.B. The HDW yield is assumed from 0.001 – 1.0 liter per second*

# Water application

# Watering Can Irrigation

Water cans application system is one of the hand watering system suitable with HDW that you can easily avoid over watering. It is the simplest and most accessible irrigation technique that is understandable and widely practiced by stallholder farmers for vegetable production. The technology requires low investments but is labor intensive and allows irrigation of only a small garden/area (50 to 100 m2.) When water stops being absorbed into the ground, move to another location. Wait an hour, and then plunge a long screwdriver or space into the ground to check that the soil is moist to a depth of six to ten inches.

Table 11 Water Can Technology Features and Constraints

|  |  |
| --- | --- |
| **Technical conditions** | **Constraints** |
| * Hand dug well is recommended in immediate vicinity (< 50m) * simple and accessible * women friendly * low cost * applicable both in rural and Urban areas | * High labour input * Access to a nearby water source * Cover Small area (50-100m2) * Application for small vegetable production * Labor intensive |

# Low cost Family Drip

Drip irrigation system is a method of watering plants at the plant location, frequently and at a volume of water approaching the consumptive use of the plant, thus enabling the farmer to grow crops with much less water compared to other irrigation methods. It is the most efficient of all methods of irrigation in terms of water use and application and ideal for hand-dug wells.

Table 12 Drip Irrigation Technology Features and Constraints

|  |  |  |  |
| --- | --- | --- | --- |
| **Irrigation**  **Technology** | **Technical conditions** | **Requirements** | **Constraints** |
| **Family Drip Systems** | * Optimizing the available scarce water resources (dry season or arid region) * Water supply available from open well, hand pump or other water source * High efficiency, 90% * Used for row crops, vegetables and fruits * Women friendly | * Dripper equipment commercially available * Family drip elevated tanker, 300-2000 Liters capacity * Bucket drip elevated tanker, 20-200liters * Adequate provisions for lifting water in reservoir (treadle pump) * Technical advice on operation of drip system and frequency of irrigations Good water quality (clean) | * Small area to irrigate(<1000m2) * Labor to fill water reservoir * Clogging of drippers * Cleaning of filters * High investment Cost |
| **Bucket Drip**  **Irrigation** | * Small vegetable garden (50–100m2) * Water from well or drinking water source | * Equipment fabricated from local materials * Technical advice on operation of the system | * Very small irrigated area (50m2) * Frequent filling of the bucket * Unfamiliarity with dripper system |

Table 14-Summary of Family Drip System Specification and Cost

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Specification** | **Bucket Drip Kit (50 m2)** | **Bucket Drip Kit (100m2)** | **Family Drip Kit (200m2)** | **Family Drip Kit (250m2)** | **Family Drip Kit (500m2)** | **Family Drip Kit (1000m2)** |
| Emitters tubes No @0.30m spacing | 165 | 330 | 670 | 835 | 1670 | 3340 |
| Number and Length of drip Laterals@1m spacing, LDPE, 16mm | 10 lines  5m long | 10 lines  10 m long | 20 lines  10 m long | 20 lines  12.5 m | 25 lines  20 m | 40 lines  25 m |
| Sub-main Outer  Diameter and  Length, HDPE | 25-mm OD  10 m | 25-mm OD  10 m | 25-mm OD  20 m | 25-mm OD  20 m | 25-mm OD  25 m | 25-mm OD  25 m |
| Screen Filter Size | 25mm inlet  & outlet | 25 mm inlet & outlet | 25 mm inlet & outlet | 25 mm inlet & outlet | 25 mm inlet & outlet | 25 mm inlet &  outlet |
| Operating Head  (Height of Tank) | 1 meter | 1 meter | 1-2 meter | 2 meter | 2 meter | 2.5 meter |
| Emitter Flow | 2.2 liters/hour | 2.2 liters/hour | 2.2 liters/hour | 2.2 liters/hour | 2.4 liters/hour | 2.4 liters/hour |
| Water Storage | 20 liters | 200 liters | 300 liters | 500 liters | 1000 liters | 2000 liters |
| Crops |  |
| **Estimated cost (ETB\*)** | **2000** | **6000** | **12000** | **14000** | **16000** | **28000** |
| **\*1USD=27.2Birr** | | | | | | |

# Furrow Irrigation System

In furrow irrigation, only a part of the land surface (the furrow) is wetted thus minimizing evaporation loss. Furrow irrigation is adapted for row crops like corn, banana, tobacco, and cabbage. It is also good for grains. Irrigation can be by corrugation using small irrigation streams.

The width of the furrows varies from 250-400 mm, the depth from 150-300 mm and the spacing between the furrows from 0.75-1.0 m, Slope 0.05-2%, furrow length depending on soil type, crops and stream size to be applied to the furrow. From farmers practice the furrow length should be limited to less than 10m.

Table 15-Furrow slope, stream size and Irrigation depth for different soil types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Furrow slope (%)** | **Maximum stream size (l/s) per furrow** | **Clay** | | **Loam** | | **Sand** | |
| **Net irrigation depth (mm)** | | | | | |
| **50** | **75** | **50** | **75** | **50** | **75** |
| 0.0 | 3.0 | 100 | 150 | 60 | 90 | 30 | 45 |
| 0.1 | 3.0 | 120 | 170 | 90 | 125 | 45 | 60 |
| 0.2 | 2.5 | 130 | 180 | 110 | 150 | 60 | 95 |
| 0.3 | 2.0 | 150 | 200 | 130 | 170 | 75 | 110 |
| 0.5 | 1.2 | 150 | 200 | 130 | 170 | 75 | 110 |

# Basin Irrigation

In basin irrigation, water is flooded in wider areas. It is ideal for irrigating rice. The area is normally flat. In basin irrigation, a very high stream size is introduced into the basin so that rapid movement of water is obtained. Water does not infiltrate a lot initially. At the end, a bond is put and water can pond the field. The opportunity time difference between the upward and the downward ends are reduced. Get the advance curves using sticks to monitor rate of water movement. Plot a time versus distance graph (advance curve). Also plot recession curve or assume it to be straight. It is ensured that water reaches the end of the basin at T/4 time and stays T time before it disappears. At any point on the advance and recession curves, get the contact or opportunity time and relate it to the depth-time graph above to know the amount of water that has infiltrated at any distance. Check the deficiency and decide whether improvements are necessary or not. The T/4 time can be increased or flow rate changed. The recession curve may not be a straight line but a curve due to some low points in the basin.

# Crop selection

Hand dug well can supply water throughout the year. With this water it is possible to cultivate crop more than one round by full irrigation on selected crops. It is also possible to cultivate by supplementary irrigation and seeding production. It is advisable to grow that are:

* Low water consumption crops
* High Value crops
* Early maturing crops
* Nutritionally dense crops
* The crops that the farmers prefer and production experience
* Tolerance to water stress and pests

The following vegetables and fruit are recommended for this technology.

Vegetable: Tomato, Potato, onion, garlic, shallot, cabbage, lettuce, swiss chard, cauliflower, Ethiopian kale, green beans, pepper, carrot, beetroot,

Fruit: - papaya, mango, avocado,

Seedling production: Onion, tomato, pepper, cabbage

Cereals: - maize

Pulses: Snap bean

Table 16- Crop selection based on agro ecology zone

|  |  |  |  |
| --- | --- | --- | --- |
| Crop category | High land (>2300masl) | Mid (1300-2300masl) | Lowland <1300masl) |
| Vegetable | Potato, cabbage, garlic, lettuce, carrot, beet root, swiss charge, cauliflower, broccoli, Ethiopian kale, shallot, hot pepper | Cabbage, potato, carrot, beet root, Swiss chard, cauliflower, broccoli, Ethiopian kale, Tomato, onion, pepper | Tomato, onion, pepper |
| Fruit | Apple, peach, | Apple Peach, Guava, Pina apple | Papaya, mango, avocado, banana, Guava, |
| Cereals |  | maize | maize |
| Pulse |  | Snap beans/green beans | Snap beans/ green beans |

Table 17-Sensitive growth period of vegetable crops for water shortage

|  |  |
| --- | --- |
| Crop | Growth periods sensitive to water deficit |
| Cabbage | During head enlargement and ripening |
| Carrot | Throughout the growth period |
| Onion | Bulb enlargement, particularly during rapid bulb growth > vegetative period (and for seed production at flowering) |
| Pepper | Throughout but particularly just prior and at start of flowering |
| Potato | Period of stolonization and tuber initiation, yield formation > early vegetative period and ripening |
| Tomato | Flowering > yield formation > Vegetative period, particularly during and just transplanting |

# Command area

To determine the command area: well discharge and crop water requirements for each crop type is considered. The area shown below are calculated for vegetables and fruits at Highland (>2300 masl), Mid land (1300-2300 masl), and Low land (<1300 masl) agro ecology. The application efficiency for furrow & basin, watering can and drip irrigation is taken as 60%, 75% and 90% respectively. However, for seedling production high area can be developed.

Table 18- Command area for different well discharge, application system and Agro-ecology

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Command area (ha) for each well Discharge for 12 hr irrigation | | | | | | | | | |
| Well discharge (l/sec) | Furrow and Basin | | | Watering Can | | | Drip | | |
| Highland | Mid | low | Highland | Mid | low | Highland | Mid | low |
|  | Irrigation Duty (l/sec/ha) for 12 hr full irrigation | | | | | | | | |
|  | 1.5 | 1.87 | 2.24 | 1.2 | 1.5 | 1.79 | 1 | 1.25 | 1.5 |
| 0.10 | 0.07 | 0.05 | 0.04 | 0.08 | 0.07 | 0.06 | 0.10 | 0.08 | 0.07 |
| 0.20 | 0.13 | 0.11 | 0.09 | 0.17 | 0.13 | 0.11 | 0.20 | 0.16 | 0.13 |
| 0.30 | 0.20 | 0.16 | 0.13 | 0.25 | 0.20 | 0.17 | 0.30 | 0.24 | 0.20 |
| 0.40 | 0.27 | 0.21 | 0.18 | 0.33 | 0.27 | 0.22 | 0.40 | 0.32 | 0.27 |
| 0.50 | 0.33 | 0.27 | 0.22 | 0.42 | 0.33 | 0.28 | 0.50 | 0.40 | 0.33 |
| 0.60 | 0.40 | 0.32 | 0.27 | 0.50 | 0.40 | 0.34 | 0.60 | 0.48 | 0.40 |
| 0.70 | 0.47 | 0.37 | 0.31 | 0.58 | 0.47 | 0.39 | 0.70 | 0.56 | 0.47 |
| 0.80 | 0.53 | 0.43 | 0.36 | 0.67 | 0.53 | 0.45 | 0.80 | 0.64 | 0.53 |
| 0.90 | 0.60 | 0.48 | 0.40 | 0.75 | 0.60 | 0.50 | 0.90 | 0.72 | 0.60 |
| 1.00 | 0.67 | 0.53 | 0.45 | 0.83 | 0.67 | 0.56 | 1.00 | 0.80 | 0.67 |
|  |  |  |  |  |  |  |  |  |  |
|  | Command area (ha) for each well Discharge for 10 hr irrigation | | | | | | | |  |
| Well discharge (l/sec) | Furrow and Basin | | | Watering Can | | | Drip | | |
| Highland | Mid | low | Highland | Mid | low | Highland | Mid | low |
|  | Irrigation Duty (l/sec/ha) for 10 hr full irrigation | | | | | | | | |
|  | 1.8 | 2.24 | 2.69 | 1.44 | 1.8 | 2.15 | 1.2 | 1.5 | 1.76 |
| 0.10 | 0.06 | 0.04 | 0.04 | 0.07 | 0.06 | 0.05 | 0.08 | 0.07 | 0.06 |
| 0.20 | 0.11 | 0.09 | 0.07 | 0.14 | 0.11 | 0.09 | 0.17 | 0.13 | 0.11 |
| 0.30 | 0.17 | 0.13 | 0.11 | 0.21 | 0.17 | 0.14 | 0.25 | 0.20 | 0.17 |
| 0.40 | 0.22 | 0.18 | 0.15 | 0.28 | 0.22 | 0.19 | 0.33 | 0.27 | 0.23 |
| 0.50 | 0.28 | 0.22 | 0.19 | 0.35 | 0.28 | 0.23 | 0.42 | 0.33 | 0.28 |
| 0.60 | 0.33 | 0.27 | 0.22 | 0.42 | 0.33 | 0.28 | 0.50 | 0.40 | 0.34 |
| 0.70 | 0.39 | 0.31 | 0.26 | 0.49 | 0.39 | 0.33 | 0.58 | 0.47 | 0.40 |
| 0.80 | 0.44 | 0.36 | 0.30 | 0.56 | 0.44 | 0.37 | 0.67 | 0.53 | 0.45 |
| 0.90 | 0.50 | 0.40 | 0.33 | 0.63 | 0.50 | 0.42 | 0.75 | 0.60 | 0.51 |
| 1.00 | 0.56 | 0.45 | 0.37 | 0.69 | 0.56 | 0.47 | 0.83 | 0.67 | 0.57 |
|  | command area (ha) for each well Discharge for 8 hr irrigation | | | | | | | |  |
|  |
| Well discharge (l/sec) | Furrow and Basin | | | Watering Can | | | Drip | | |
| Highland | Mid | low | Highland | Mid | low | Highland | Mid | low |
|  | Irr Duty (l/sec/ha) for 8 hr full irrigation | | | | | | | | |
|  | 2.25 | 2.81 | 3.36 | 1.8 | 2.24 | 2.69 | 1.5 | 1.87 | 2.24 |
| 0.10 | 0.04 | 0.04 | 0.03 | 0.06 | 0.04 | 0.04 | 0.07 | 0.05 | 0.04 |
| 0.20 | 0.09 | 0.07 | 0.06 | 0.11 | 0.09 | 0.07 | 0.13 | 0.11 | 0.09 |
| 0.30 | 0.13 | 0.11 | 0.09 | 0.17 | 0.13 | 0.11 | 0.20 | 0.16 | 0.13 |
| 0.40 | 0.18 | 0.14 | 0.12 | 0.22 | 0.18 | 0.15 | 0.27 | 0.21 | 0.18 |
| 0.50 | 0.22 | 0.18 | 0.15 | 0.28 | 0.22 | 0.19 | 0.33 | 0.27 | 0.22 |
| 0.60 | 0.27 | 0.21 | 0.18 | 0.33 | 0.27 | 0.22 | 0.40 | 0.32 | 0.27 |
| 0.70 | 0.31 | 0.25 | 0.21 | 0.39 | 0.31 | 0.26 | 0.47 | 0.37 | 0.31 |
| 0.80 | 0.36 | 0.28 | 0.24 | 0.44 | 0.36 | 0.30 | 0.53 | 0.43 | 0.36 |
| 0.90 | 0.40 | 0.32 | 0.27 | 0.50 | 0.40 | 0.33 | 0.60 | 0.48 | 0.40 |
| 1.00 | 0.44 | 0.36 | 0.30 | 0.56 | 0.45 | 0.37 | 0.67 | 0.53 | 0.45 |

Note: For household irrigation, the command area for drip and watering can is up to 1000m2 and 100m2 command area respectively.

# Irrigation Scheduling

For irrigation interval calculation, soil water holding capacity (Heavy, medium and light), effective crop root depth, crop development stage and manageable allowable depletion is taken into account.

Table 20 Irrigation Scheduling







Table 21 Agronomic recommendation for cabbage production (sample)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Description | | Unit | Furrow | | Drip/ watering can | |
| High land | Mid land | High land | Mid land |
| Area | | m2 | 1000 | 1000 | 1000 | 1000 |
| Seed (kg) | | gm | 40 | 40 | 40 | 40 |
| Fertilizer (kg) | NPS | kg | 24 | 24 | 24 | 24 |
| Urea | kg | 20 | 20 | 20 | 20 |
| Insecticide | Dimatot | ml | 200 | 200 | 200 | 200 |
| Fungicide | Mancozeb | gm | 200 | 200 | 200 | 200 |
| Spacing | | cm | 60 X40 | | 60 X 40 | |
| Irrigation Interval | |  |  |  |  |  |
| Heavy soil | Initial/dev't | days | 5 | 4 | 5 | 4 |
| Mid/late | days | 7 | 6 | 7 | 6 |
| Medium soil | Initial/dev’t | days | 5 | 4 | 5 | 4 |
| Mid/late | days | 7 | 5 | 7 | 5 |
| Light soil | Initial/dev’t | days | 4 | 3 | 4 | 3 |
| Mid/late | days | 5 | 4 | 5 | 4 |
| Crop water requirement | | M3 | 583 | 708 | 214 | 260 |
| Estimated Yield | | qt | 40 | 40 | 50 | 50 |

NB. For agronomic practice related to different crops, refer Horticultural Production Package (MoA) 2018

# Extension and Market strategy

# Extension strategy intervention

Promoting hand dug well technologies play a great role in improving the livelihood income and enable the small scale household to achieve food security and to improve nutritional status of farmers through the implementation of participatory extension system by providing demand-driven, and market-oriented extension services to male, female and youth farmers.

The unequal power relationships between men and women, must be understood to achieve equitable development and full participation of women. Interventions must be developed based on a comprehensive understanding of the needs that women and men identify to improve their situations. In most cases the close distance of hand dug wells to the farmers house, make it more accessible to female farmers. However, the adoption and use of new technologies and inputs are strongly affected by who controls and owns a given resource. Failure to understand and address these and other socioeconomic dimensions of technology adoption means that interventions are certain to fail.

Table 21 Summary of participatory Extension Communication Methods & Tools

|  |  |  |  |
| --- | --- | --- | --- |
| **Technology promotion and implementation stages** | **Extension approach and method** | **Extension tools** | **Key issues** |
| Awareness creation | Individual - Contact | * House to house visit | * Inform the meeting time and place on time * Make group member small number (20-30) * Have women only group to let them actively participate * Group farmers with common problems |
| Group - contact | * FTC Demonstration * Field days * Group meetings * Training * Experience sharing   (model farmers, best practice) |
| Technology selection | Individual - Contact | * Farm visit * Personal experience sharing (model farmers) | * Knowledge differences between men and women must be understood to know the technologies and select * Facilitate farmers to address important issues and allow them to develop their own indigenous ideas |
| Group - contact | * FTC Demonstration * Field days * Experience sharing |
| Farmers and site selection | Individual - Contact | * Farm visit | * Understand their priorities & commitment, engage widely and recognize local context * Women farmers should have to be deliberately targeted to have access to the technologies considering Female headed household (FHH) and Male headed household (MHH) |
| Group - contact | * Group meeting * Model farmer * Gender Model Family (GMF) |
| Technology dissemination and adoption | Individual - Contact | * Personal experience sharing | * Show with visual aid women using different technologies, * Women enjoy learning from success story of other model women farmers to share their life experience on public gatherings. |
| Group - contact | * Demonstrations * Field days & Farm walks * Experience sharing |
| Mass - contact | * Billboard and posters * Printing media * IVR (8028) |
| Technology feedback | Individual - Contact | * Farm visit * Interview | * Identify how women and men farmers uptake and adoption of the technologies and able to use independently. * Technology feedback has to be collected separately from male and female farmers. * Encourage women to participate through women only group formation * Develop gender sensitive checklist to record gender disaggregated data |
|  | Group - contact | * Field days * Group meetings * Create linkage |

# 

# Market strategy

The extension system needs to provide market demanded HHMI technologies, link producers with buyers, input and credit suppliers, providing market information, and promoting collective marketing through harnessing vibrant linkage among potential actors.

# Access to credit

In order to cover the purchase costs of HHMI technologies and to finance operational and maintenance costs of the irrigation equipment, farmers need to have access to credit. Although consideration can be given to initial subsidies in post-emergency situations, micro-credit institutions should be involved in establishing a sound rural credit system to make irrigated agriculture economically viable.

# Financial Feasibility Analysis

Financial and economic analyses have similar features. Both financial and economic analysis estimate the net-benefits of a project investment based on the difference between the with-project and the without-project situations.The basic difference between them is that the financial analysis compares benefits and costs to the enterprise; a financial analysis estimates the profitability of a project, from an investor's perspective. In a financial analysis one compares the costs of the project to the expected revenue over the technology package lifespan. This includes costs of financing and taxes/subsidies. While the economic analysis compares the benefits and costs to the whole economy.

Economic analysis is concerned with the true value a project holds for the society as a whole. It incorporates all members of society and measures the project’s positive and negative impacts. In addition, economic analysis would also cover costs and benefits of goods and services that are not sold in the market and therefore have no market price. While financial analysis uses market prices to check the balance of investment and the sustainability of a project, Economic analysis uses economic prices that are converted from the market price by excluding tax, profit, subsidy, etc. to measure the legitimacy of using national resources to certain projects.

Financial and economic analyses also differ in their treatment of external effects (benefits and costs), such as favorable effects on health environment etc. Economic analysis attempts to value such externalities in order to reflect the true cost and value to the society. The inclusion of externalities raises difficult questions of their identification and measurement in terms of money. Having these differences in mind we would try to undertake viability analysis of proposed packages of micro irrigation technologies mainly based on its financial feasibility.

As it has been frequently stated by many economists, resources used for production of desirable output are very scarce and demand for output from these resources are unlimited. This paradox phenomenon leads producers and investors to choose where to invest these scare resources so as to get maximum output in order to maximize benefits earned from these resources. Irrigation resources particularly irrigable land and water are extremely scarce and current demand for these resources’ development is alarmingly growing. This paradox is the cause for undertaking financial and economic analysis using different decision-making techniques such as **Cost –Benefit analysis, Net present value analysis, payback period**

In the analysis the two discounting evaluation criteria are used to come up with feasible conclusions i.e. Net Present Value (NPV), and Benefit Cost Ratio.

**The Net Present Value (NPV)** is the discounted net benefit where the net benefit is the difference between total benefit and total cost. The criteria of the NPV are: - If NPV>0, then accept the project, If NPV<0, then reject the project and If NPV=0, accept most of the time.

**Benefit cost ratio:** The benefit cost ratio is the present value of total benefit divided by the present value of total cost. The larger B/C ratio, the more attractive is a project. In general, the B/C ratio is higher than 1 indicates that a project is viable. Conversely, with a ratio of less than 1, a project would be uneconomic; with a ratio of close to 1, a project’s economic value would be marginal. The overall **concepts and frameworks** for financial analysis are presented in the figure below.

IDENTIFYING BENEFITS

VALUING of FINANCIAL BENEFITS

1

2

VALUING of FINANACIAL COSTS

IDENTIFYING COSTS

Figure 1 Frameworks of Financial analysis

With the above rationalities for household micro irrigation technology package such as farm pond of different scenarios, roof top, and hand dug well, manual tube well, spring development and river pumping financial analysis with selected high value crop has been done as follows.

**Secenario-1: Water source: - Hand dug well Water lifting: - pulley, Rope & washer or treadle**

Application method: -

Table 23 Financial Feasibility Analysis- HDW + Pulley with Rope & washer + treadle

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop | Average fixed cost ( HDW with pulley, Rope & washer and treadle) | Average Variable cost ETB | Average Revenue ETB | Marginal profit | NPV | B/C Ratio | Payback period (year) | Advisable Decision |
| Onion | 42,446 | 8,700 | 38,500 | 29,800 | 183,438 | 3 | 1.4 | Financially viable |
| Tomato | 42,446 | 17,051 | 80,000 | 62,949 | 192,150 | 5 | <1 | Financially viable |
| H. Cabbage | 42,446 | 4,728 | 7,200 | 2,472 | (23,709) | <1 | 17 | Needs economic analysis |
| Potato | 42,446 | 6,720 | 48,000 | 41,280 | (38,805) | <1 | 44 | Needs economic analysis |
| Maize | 42,446 | 1,500 | 15,000 | 13,500 | 59,884 | 2 | 3 | Financially viable |
| Papaya | 42,446 | 10,000 | 30,000 | 20,000 | 80,434 | 2 | 3 | Financially viable |
| Avocado | 42,446 | 13,440 | 123,006 | 109,566 | 535,751 | 5 | <1 | Financially viable |

**Decisions**

As it has been depicted on the above table hand dug well with command area 1000m2 in all proposed crops except head cabbage and potato under suitable agro ecology is found to be financially feasible. Because fixed cost of hand dug well is much less than farm pond and water supply is more sustainable in the production system. As resource is very limited farmers is advised to allocate these scarce resources for the first best alternative. Based on this principle, avocado followed by tomato is the most prioritized in hand dug well package.

**Scenario 2**

Water source: - Hand dug well

Water lifting: - Hand pump

Application method: - Drip

Table 23 HDW+ Hand pump + Drip

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop | HDW + Hand pump +Drip | Average Variable cost ETB | Average Revenue ETB | Marginal profit | NPV | B/C Ratio | Payback period (year) | Advisable Decision |
| Onion | 70,445 | 87000 | 385000 | 298,000 | 2,188,395 | 4 | <1 | Financially viable |
| Tomato | 70,445 | 170506 | 800000 | 629,494 | 4,701,120 | 4 | <1 | Financially viable |
| H. Cabbage | 70,445 | 47280.75 | 72000 | 24,719 | 116,927 | 1 | 3 | Financially viable |
| Potato | 70,445 | 67196.75 | 480000 | 412,803 | 3,058,604 | 6 | <1 | Financially viable |
| Onion seedling | 70,445 | 7264 | 24000 | 16,736 | 56,414 | 1 | 4 | Financially viable |
| Maize | 70,445 | 15000 | 150000 | 135,000 | 952,855 | 6 | <1 | Financially viable |
| Papaya | 70,445 | 100000 | 300000 | 200,000 | 1,711,315 | 14 | 3 | Financially viable |
| Avocado | 70,445 | 134400 | 1230060 | 1,095,660 | 6,661,290 | 8 | 3 | Financially viable |

**Decision.**

Investment in this technology package of irrigation it is found to be feasible for all proposed. Hence the farmer is advised to invest on the first best alternatives that brought the highest NPV provide that it is found in the suitable agro ecology of proposed crops.

c. Water source: - Hand dug well

Water lifting: - Engine pump

Application method:- Drip

Table 24 HDW+ Engine pump +Low cost drip

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop | HDW+ Engine +drip | Average Variable cost ETB | Average Revenue ETB | Marginal profit | NPV | B/C Ratio | Payback period (year) | Advisable Decision |
| Onion | 85445.58 | 87000 | 385000 | 298,000 | 2,173,394 | 4 | <1 | Financially viable |
| Tomato | 85445.58 | 170506 | 800000 | 629,494 | 4,686,119 | 4 | <1 | Financially viable |
| H. Cabbage | 85445.58 | 47280.75 | 72000 | 24,719 | 101,926 | 1 | 4 | Financially viable |
| Potato | 85445.58 | 67196.75 | 480000 | 412,803 | 3,043,603 | 6 | <1 | Financially viable |
| Onion seedling | 85445.58 | 7264 | 24000 | 16,736 | 41,413 | 1 | 5 | Financially viable |
| Maize | 85445.58 | 15000 | 150000 | 135,000 | 937,854 | 6 | <1 | Financially viable |
| Papaya | 85445.58 | 100000 | 300000 | 200,000 | 1,696,314 | 12 | 3 | Financially viable |
| Avocado | 85445.58 | 134400 | 1230060 | 1,095,660 | 6,646,289 | 8 | 3 | Financially viable |

**Decision**

Investment in this technology package of irrigation it is found to be feasible for all proposed. Hence the farmer is advised to invest on the first best alternatives that brought the highest NPV provide that it is found in the suitable agro ecology of proposed crops.

d. Water source: - Hand dug well

Water lifting: - solar pump

Application method: - Drip

Table 25 HDW + Solar pump + Drip

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop | HDW+ solar + Low cost drip | Average Variable cost ETB | Average Revenue ETB | Marginal profit | NPV | B/C Ratio | Payback period (year) | Advisable Decision |
| opinion | 155445 | 87000 | 385000 | 298,000 | 2,103,395 | 4 | <1 | Financially viable |
| Tomato | 155445 | 170506 | 800000 | 629,494 | 4,616,120 | 4 | <1 | Financially viable |
| H. Cabbage | 155445 | 47280.75 | 72000 | 24,719 | 31,927 | 1 | 6 | Financially viable |
| Potato | 155445 | 67196.75 | 480000 | 412,803 | 2,973,604 | 5 | <1 | Financially viable |
| Onion seedling | 155445 | 7264 | 24000 | 16,736 | (28,586) | <1 | 5 | Needs economic analysis |
| Maize | 155445 | 15000 | 150000 | 135,000 | 867,855 | 4 | 1.15 | Financially viable |
| Papaya | 155445 | 100000 | 300000 | 200,000 | 1,626,315 | 8.5 | 1 | Financially viable |
| Avocado | 155445 | 134400 | 1230060 | 1,095,660 | 6,576,290 | 7.7 | 3 | Financially viable |

**Decision**

Investment in this technology package of irrigation it is found to be feasible for all proposed crops except onion seedlings. Hence the farmer is advised to invest on the first best alternatives that brought the highest NPV provide that it is found in the suitable agro ecology of proposed crops.

# Monitoring and Evaluation (M&E) System

Table 26- M&E tools for Hand dug well (Water source)

| **Criteria** | **Indicator** | **Unit** | **Data Source** | **Data Collection Method** |
| --- | --- | --- | --- | --- |
| **Performance** | Well yield | Litre/sec | On-situ at well/Farmer | Pump test/interview |
| Service life[[1]](#footnote-1) | Years | On-situ at well/Farmer | Interview and site observation |
| Water quality for irrigation (salinity, TDS PH) | PPT (EC)/PPM | On-situ at well/lab result | Field test/lab test |
| Water level variation[[2]](#footnote-2) | Litre per depth | On-situ at well/Farmer | Interview and site observation |
| Water level variation | Depth per season  (three seasons) | On-situ at well/Farmer | Interview and site observation |
| **Simplicity** | Ease of water abstraction | Simple/Moderate/  Difficult | Farmers/Users | Interview |
| Ease of construction | Yes/No | Site Visit/Farmers | Site Visit/Interview |
| **Safety** | Safety (fence, cover, etc.) | Yes/No | Site Visit/Farmers | Site Visit/Interview |
| **Operation & Management** | Use of local construction material | Yes/No | Site Visit/Farmers | Site Visit/Interview |
| **Affordability** | Cost of construction | Affordable/Expensive | Site Visit/Farmers | Site Visit/Interview |
| Cost of maintenance | None/Low/Medium/  High | Site Visit/Farmers | Site Visit/Interview |
| **Maintainability** | Local maintainability | Yes/No | Site Visit/Farmers | Site Visit/Interview |
| **Reliability** | Frequency of maintenance | None/Low/Medium/  High | Site Visit/Farmers | Site Visit/Interview |
| **Gender Responsiveness** | Gender responsive | Labour, time, empowerment | Site Visit/Farmers | Site Visit/Interview |
| **Environmental Impact** | Environmentally friendly | Yes/No | Site Visit/Farmers | Site Visit/Interview |
| **Availability** |  |  |  |  |
| **Demand Generation** |  |  |  |  |
| **Satisfaction** |  |  |  |  |
| **Documentation/User Manual** |  |  |  |  |

Table 27-Water lifting technology

| **Motor Pump** | | | | | **Solar Pump** | | | | **Rope (and Washer[[3]](#footnote-3)) Pump** | | | | **Treadle Pump** | | | | **Pulley System** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Areas** | **Indicator** | **Unit** | **Data Source** | **Data Collection Method** | **Indicator** | **Unit** | **Data Source** | **Data Collection Method** | **Indicator** | **Unit** | **Data Source** | **Data Collection Method** | **Indicator** | **Unit** | **Data Source** | **Data Collection Method** | **Indicator** | **Unit** | **Data Source** | **Data Collection Method** |
| **Performance** | Water discharge | Litre/min | On-situ at Pump | Discharge Measurement | Water discharge | Litre/min | On-situ at Pump | Discharge Measurement | Water discharge | Litre/min | On-situ at Pump | Discharge Measurement | Water discharge | Litre/min | On-situ at Pump | Discharge Measurement | Water discharge | Litre/min | On-situ at Pulley System | Discharge Measurement |
| Total Head | Meter | On-situ at Pump | Head Measurement | Total Head | Meter | On-situ at Pump | Head Measurement | Total Head | Meter | On-situ at Pump | Head Measurement | Total Head | Meter | On-situ at Pump | Head Measurement | Total Head | Meter | On-situ at Pulley System | Head Measurement |
| Power Requirement | KW (Hp) | On-situ at Pump | Power Measurement | Power Requirement | KW (Hp) | On-situ at Pump | Power Measurement | Power Requirement | Person per hour[[4]](#footnote-4) | On-situ at Pump | Power Measurement | Power Requirement | Person per hour | On-situ at Pump | Power Measurement | Power Requirement | Person per hour | On-situ at Pulley System | Power Measurement |
| Speed | RPM | On-situ at Pump | rpm Measurement | Speed | RPM | On-situ at Pump | rpm Measurement |  |  |  |  | Weight | Kg | On-situ at Pump | Measurement |  |  |  |  |
| Fuel Consumption | Litre/hr | On-situ at Pump | Measurement |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pump efficiency | % | On-situ at Pump | Measurement | Pump efficiency | % | On-situ at Pump | Measurement | Pump efficiency | % | On-situ at Pump | Measurement | Pump efficiency | % | On-situ at Pump | Measurement | Pump efficiency | % | On-situ at Pump | Measurement |
| **Operation Management** | Operational duration[[5]](#footnote-5) | Hours/month | On-situ at Pump | Measurement | Operational duration | Hours/month | On-situ at Pump | Measurement | Ease of use (through bearing or bushing) | Yes/No | On-situ at Pump | Measurement | Ease of use (especially for women sensitivity) | Yes/No | On-situ at Pump | Measurement | Ease of use (especially for women sensitivity) | Yes/No | On-situ at Pulley System | Measurement |
| Safety (fence, cover, etc.) | Yes/No | On-situ at Pump | Measurement | Safety (fence, cover, etc.) | Yes/No | On-situ at Pump | Measurement | Proper construction of pump wrt to design (spacing for washer (piston) including slab, handle, delivery point, etc.) | Standard/Non-standard | On-situ at Pump | Observation | Proper construction of pump wrt to design | Standard/Non-standard | On-situ at Pump | Observation | Proper construction of pump wrt to design | Standard/Non-standard | On-situ at Pulley System | Observation |
| Weight | Kg | On-situ at Pump | Measurement | Weight | Kg | On-situ at Pump | Measurement | Proper installation of the pump as per the design | Yes/No | On-situ at Pump | Measurement | Proper installation of the pump as per the design | Yes/No | On-situ at Pump | Measurement | Proper installation of the pulley system as per the design | Yes/No | On-situ at Pulley System | Measurement |
| Easy of operation (starting) | Easy/Not Easy | On-situ at Pump | Measurement | Easy of operation (with respect to light intensity and direction) | Easy/Not Easy | On-situ at Pump | Measurement |  |  |  |  |  |  |  |  |  |  |  |  |
| Cost of ownership | Affordable/Expensive | On-situ at Pump | Measurement | Cost of ownership | Affordable/  Expensive | On-situ at Pump | Measurement |  |  |  |  |  |  |  |  |  |  |  |  |
| Cost of operation | Affordable/Expensive | On-situ at Pump | Measurement | Cost of operation | Affordable/  Expensive | On-situ at Pump | Measurement |  |  |  |  |  |  |  |  |  |  |  |  |
| Storage quality[[6]](#footnote-6) during idle time | Poor/Good | On-situ at Store | Observation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Oil and fuel Usage[[7]](#footnote-7) | Standard/Non-standard | On-situ at Store | Observation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Maintenance** | Local maintainability | Yes/No | On-situ at Pump | Measurement | Local maintainability | Yes/No | On-situ at Pump | Measurement | Local maintainability on rope, bushing, bearing, etc. | Yes/No | On-situ at Pump | Measurement | Local maintainability on piston, hose, etc. | Yes/No | On-situ at Pump | Measurement | Local maintainability on rope, pole, pulley, etc. | Yes/No | On-situ at Pulley System | Measurement |
| Frequency of maintenance | None/Low/Medium/  High | On-situ at pump | Measurement | Frequency of maintenance | None/Low/Medium/  High | On-situ at pump | Measurement | Frequency of maintenance on rope, bushing, bearing, etc. | None/Low/Medium/  High | On-situ at pump | Measurement | Frequency of maintenance on piston, hose, etc. | None/Low/Medium/  High | On-situ at pump | Measurement | Frequency of maintenance on rope, pole, pulley, etc. | None/Low/Medium/  High | On-situ at Pulley System | Measurement |
| Cost of maintenance | None/Low/Medium/  High | On-situ at Pump | Measurement | Cost of maintenance | None/Low/Medium/  High | On-situ at Pump | Measurement | Cost of maintenance on rope, bushing, bearing, etc. | None/Low/Medium/  High | On-situ at Pump | Measurement | Cost of maintenance on piston, hose, etc. | None/Low/Medium/  High | On-situ at Pump | Measurement | Cost of maintenance on rope, pole, pulley, etc. | None/Low/Medium/  High | On-situ at Pulley System | Measurement |
| Spare part availability | None/Low/Medium/  High | Local market survey | Interview | Spare part availability | None/Low/Medium/  High | Local market survey | Interview | Spare part availability on rope, bushing, bearing, etc. | None/Low/Medium/  High | Local market survey | Interview | Spare part availability on rope, bushing, bearing, etc. | None/Low/Medium/  High | Local market survey | Interview | Spare part availability on rope, pole, pulley, etc. | None/Low/Medium/  High | Local market survey | Interview |
| Cost of spare parts | None/Low/Medium/  High | Local market survey | Interview | Cost of spare parts | None/Low/Medium/  High | Local market survey | Interview | Cost of spare parts on rope, bushing, bearing, etc. | None/Low/Medium/  High | Local market survey | Interview |  |  |  |  |  |  |  |  |
| **Cross cutting** | Gender responsive | Yes/No | Site Visit/Farmers | Site Visit/Interview |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Environmentally friendly | Yes/No | Site Visit/Farmers | Site Visit/Interview |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 28-Water application Technology

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Drip Irrigation** | | | | | | **Furrow Method** | | | | | **Hose** | | | | | **Water Can** | | | | |
| **Areas** | **Indicator** | **Unit** | **Data Source** | **Data Collection Method** | **Indicator** | | **Unit** | **Data Source** | **Data Collection Method** | **Indicator** | | **Unit** | **Data Source** | **Data Collection Method** | **Indicator** | | **Unit** | **Data Source** | **Data Collection Method** |
| **Performance** | Efficiency[[8]](#footnote-8) | % | Site Visit/Farmers | Site Visit/Interview | Efficiency | | % | Site Visit/Farmers | Site Visit/Interview | Efficiency | | % | Site Visit/Farmers | Site Visit/Interview | Efficiency | | % | Site Visit/Farmers | Site Visit/Interview |
| Service life | Years | Site Visit/Farmers | Site Visit/Interview | Standard furrow size (depth, length and width) | | Yes/No | On-situ | Site Visit/Interview | Standard hose size (length and width) | | Yes/No | On-situ | Site Visit/Interview |  | |  |  |  |
| Quality of Material | Poor/Good | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  | Quality of Material | | Poor/Good | Site Visit/Farmers | Site Visit/Interview | Quality of Material | | Poor/Good | Site Visit/Farmers | Site Visit/Interview |
| Water uniform[[9]](#footnote-9) application | Yes/No | Site Visit/Farmers | Site Visit/Interview | Uniform application | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Service life | | Years | Site Visit/Farmers | Site Visit/Interview | Service life | | Years | Site Visit/Farmers | Site Visit/Interview |
| Water saving | Bad/Good | Site Visit/Farmers | Site Visit/Interview | Water saving | | Bad/Good | Site Visit/Farmers | Site Visit/Interview | Water saving | | Bad/Good | Site Visit/Farmers | Site Visit/Interview | Water saving | | Bad/Good | Site Visit/Farmers | Site Visit/Interview |
|  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| **Operation and Management** | Installation of the drip as per the design | Yes/No | Site Visit/Farmers | Site Visit/Interview | Furrow as per the design | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Hose as per the standard | | Yes/No | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  |
| Ease of use | Simple/Difficult | Farmer | Farm Survey | Construction of the furrow as per the design | | Yes/No | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  | Ease of use | | Simple/Difficult | Farmer | Farm Survey |
| Ease of water abstraction | Simple/Moderate/  Difficult | Farmers/Users | Interview | Ease of use | | Simple/Difficult | Farmer | Farm Survey | Ease of use | | Simple/Difficult | Farmer | Farm Survey |  | |  |  |  |
| Ease of installation | Yes/No | Site Visit/Farmers | Site Visit/Interview | Ease of water abstraction | | Simple/Moderate/  Difficult | Farmers/Users | Interview |  | |  |  |  |  | |  |  |  |
| Use of local[[10]](#footnote-10) construction material | Yes/No | Site Visit/Farmers | Site Visit/Interview | Ease of construction | | Yes/No | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  |  | |  |  |  |
| Cost of drip system/initial investment | Affordable/Expensive | Site Visit/Farmers | Site Visit/Interview | Use of local construction material | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Use of local hose material | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Cost of watering can/initial investment | | Affordable/Expensive | Site Visit/Farmers | Site Visit/Interview |
| Cost of installation | Affordable/Expensive | Site Visit/Farmers | Site Visit/Interview | Cost of furrow/initial investment | | Affordable/Expensive | Site Visit/Farmers | Site Visit/Interview | Cost of hose/initial investment | | Affordable/Expensive | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  |
|  |  |  |  | Cost of construction | | Affordable/Expensive | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  |  | |  |  |  |
|  |  |  |  | Furrow management | | Poor/Medium/Good | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  |  | |  |  |  |
| **Maintenance** | Clogging problem | Low/Medium/High | Site Visit/Farmers | Observation |  | |  |  |  |  | |  |  |  | Clogging problem for sprinkler | | Low/Medium/High | Site Visit/Farmers | Observation |
| Local maintainability | Yes/No | Site Visit/Farmers | Site Visit/Interview | Local maintainability | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Local maintainability | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Watering Can accessibility at local market | | None/Low/Medium/  High | Local market survey | Interview |
| Frequency of maintenance | None/Low/Medium/High | Site Visit/Farmers | Site Visit/Interview | Frequency of maintenance | | None/Low/Medium/High | Site Visit/Farmers | Site Visit/Interview | Frequency of maintenance | | None/Low/Medium/High | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  |
| Cost of maintenance | None/Low/Medium/High | Site Visit/Farmers | Site Visit/Interview | Cost of maintenance | | None/Low/Medium/High | Site Visit/Farmers | Site Visit/Interview | Cost of maintenance | | None/Low/Medium/High | Site Visit/Farmers | Site Visit/Interview |  | |  |  |  |
| Spare part availability | None/Low/Medium/  High | Local market survey | Interview |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| Cost of spare parts | None/Low/Medium/  High | Local market survey | Interview |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| Drip system accessibility at local market | None/Low/Medium/  High | Local market survey | Interview |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| **Cross Cutting** | Gender responsive | Yes/No | Site Visit/Farmers | Site Visit/Interview | Gender responsive | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Gender responsive | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Gender responsive | | Yes/No | Site Visit/Farmers | Site Visit/Interview |
| Environmentally friendly | Yes/No | Site Visit/Farmers | Site Visit/Interview | Environmentally friendly | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Environmentally friendly | | Yes/No | Site Visit/Farmers | Site Visit/Interview | Environmentally friendly | | Yes/No | Site Visit/Farmers | Site Visit/Interview |

1. Refers to the number of years the farmer so far used the well [↑](#footnote-ref-1)
2. To know the recharge of the well, it may also refer to the yield [↑](#footnote-ref-2)
3. Currently these washers (‘rondela’ in local language) are substituted with pistons. The term ‘rope and washer’ could be simply named as ‘rope pump’. [↑](#footnote-ref-3)
4. How many persons operate within one hour to abstract water? Take an average person of 15 years female farmers. [↑](#footnote-ref-4)
5. Motor pumps are required to operate 100 hours before servicing fuel pump, motor oil, etc. [↑](#footnote-ref-5)
6. Good storage refers to proper shade, protection from rodents, animals and the way idle pumps are managed, etc. [↑](#footnote-ref-6)
7. Proper oil types, fuel and their utilization is referred here. [↑](#footnote-ref-7)
8. Efficiency refers to application efficiency where water abstracted is delivered from the source versus amount of water used by the crop. [↑](#footnote-ref-8)
9. Uniformity refers to application of water from head to tail. [↑](#footnote-ref-9)
10. Refers to whether the community uses local materials and indigenous knowledge [↑](#footnote-ref-10)