

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

**MANUAL TUBE WELL TECHNOLOGY PACKAGE**

**HHMIT Package-4**

**Small Scale Irrigation Directorate**

**November, 2019**

**Addis Ababa**

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1. **INTRODUCTION**
   1. **Background and Rationale**

As a means of improving agricultural production and productivity, Irrigation development is one of the key prioritized areas 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 needs 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 strategies 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.

* 1. **Package Objective**
     1. **General Objective**

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

* + 1. **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
  1. **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.

* 1. **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.

* 1. **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. So, this package is River pumping HHMI technology package.

## Irrigation Water Source

The following water sources are considered:

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

## 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 applications are considered:

* Drip irrigation
* Furrow irrigation
* Water can

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.

# MANUAL TUBE WELL PACKAGE

## Manual Tube Well

Manual tube well drilling presents a proven technique that has many advantages over traditional hand dug wells and it is ten times less costly than machine drilling. The main benefit of manual drilling is that it can penetrate deeply into the water table to a high yielding sand/gravel aquifer, providing higher and more reliable yield than hand-dug wells.

The technique has a large scope to serve as a low-cost solution to the burden of water scarcity on the lives of small holder farmers. When a borehole is drilled, different types of geological formations can be encountered. To drill through all these different types of formation, a range of different manual drilling techniques have been developed. Therefore, it may be possible that two or more different drilling techniques must be used to drill a borehole if different formations are encountered on top of each other. While each of them has its advantages and disadvantages, good combination of two or more techniques has proven very effective in overcoming some of the limitations imposed by internal or external factors as may relate respectively to the technique itself or the lithology of the well sites. Tube wells can yield water ranging from 0.1 to 1 l/s for depths from 4m to 30m.

The Simple sludge tube well for small-scale irrigation purpose is expected to be implemented in individual level or in small group of farmers where members are not more than 6 HHs and the total irrigated area is not more than 2.5 ha.

Where is manual drilling feasible?

A given location proposed for tube well drilling for small-scale irrigation with simple sludge drilling technique should satisfy the following requirements:

* Development of manual tube well is relatively simple and cheap as compared to the development of surface water harvesting
* Access for irrigable land recommended to be not less than 0.25ha
* The existence of groundwater with static water level (SWL) up 20 m for using lift pumps,
* Static water level not deeper than 6 meter, if suction pump is proposed
* The demand for irrigation water is high
* Availability of basic drilling tools, equipment and materials at local market
* Availability of sufficient labor (minimum 4 people per well) for well drilling and pump house excavation
* Ease access for getting drilling water close to the proposed drilling site
* Subsoil condition not stony or rock formation (or drillers need to have percussion) Soft formation area
* Approved go-ahead permission from responsible government institution and local community.

The level of the water table fluctuates up and down according to the seasons as the inflows and outflows vary with the seasons of the year and the utilization by humans. Hence, this technology enhances the knowledge and skill of woreda experts and DA’s MTW on tube well development, enables the woreda non-geologist experts to select sites and well construction for tube wells confidently. For in-depth planning, design, construction, operation, and maintenance techniques of Tube well, please refer HHMI training manual and tube well guide line

Table 1 Estimated cost of manual tube well drilling including casing and gravel

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table-2 Scenario** | **Descriptions** | **Unit** | **Qty** | **Drilling cost in Birr** | **Casing and gravel cost.** | **Total cost in Birr** |
| 1 | 10m depth with full PVC casing, well inner diameter 110mm | Meter | 10 | 2,193 | 1,075 | 3,268.00 |
| 2 | 15m depth with full PVC casing, well inner diameter 110mm | Meter | 15 | 3,140 | 1,613 | 4,753.00 |
| 3 | 20m depth with full PVC casing, well inner diameter 110mm | Meter | 20 | 4,087 | 2,150 | 6,237.00 |
| 4 | 25m depth with full PVC casing, well inner diameter 110mm | Meter | 25 | 5,033 | 2,687 | 7,720.00 |
| 5 | 30m depth with full PVC casing, well inner diameter 110mm | Meter | 30 | 5,980 | 3,225 | 9,205.00 |
|  | Average Cost | | | | | 6,236.60 |

## N.B The cost should be updated.

## Water Lifting Devices

Water-lifting devices are used to lift water to a height that allows users easy access to water. Lifting devices can be used to raise groundwater, rainwater stored in an underground reservoir, and river water. 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. For example, water lifting involves additional O&M activities and potential problems, compared to gravity systems, and the latter are often preferred if they are available and applicable to the situation.

The following water-lifting devices are described in these packages: rope and bucket (loose through a pulley or on a windlass), bucket pump, rope pump, engine pumps, the treadle pump.

While considering the design parameters for water lifting devices, low capital and running cost, high water yield, hard wearing, manual back-up, other applications, maximise local manufacturing and assembly. 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 can use with tube well wells for irrigation. 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. However, the hygiene of this system is poorer, even if the well is protected. Initial cost is from 500 Birr for a plastic bucket and 11 m of rope, pulley to 800birr to 500birr 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 that can usually be made from with locally available materials such as wood, rope and vehicle tires in local metal workshops. Most farmers prefer this pump due to low cost, ease of operations, manufacturing and maintenance by local technicians/workshop and ease of transport. It can lift water at a rate of 0.315 l/s from a depth of 17 meter. It delivers 0.33 l/s from 10-meter water level and halve of that for water levels of 20m. One person can draw water from 10 m deep. It fits on hand-dug wells of 6 cm diameter or bigger. The Rope pump is fit for families but also for small communities with a recommended maximum of five households based the discharge of theMTWtube well and the irrigation application methods efficiency. Compared to other low cost hand pumps, the Rope pump has a high pump capacity and can pump from wells of 1 to 35 meter deep. 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.

### Treadle pump

A treadle pump is a human-powered suction pump that sits on top of a well and is used for irrigation and other domestic use. It is designed to lift water from a depth of seven meters or less. The pumping is activated by stepping up and down on a treadle, which is levers, which drive pistons, creating cylinder suction that draws groundwater to the surface.

1. **Pressure treadle Pump**

The Pressure Treadle Pump is a foot-operated option for delivering pressurized water for depth to water less than 7 m. These pumps are especially versatile and can be used for a large variety of irrigating conditions, and only limited use for drinking water. The pressure treadle pump is a simple foot-operated foot 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 up to 50 m across the ground, or to a height of 6 m above the pump. The pump is a suction pump where a pedal works the two pistons. The stepping movement makes it easy to pump for prolonged periods. The pump has limited use for drinking water as the spout is at ground level.

Table 3 Pressure Treadle Pump Technical Details and Cost

|  |  |
| --- | --- |
| **Financial Option** | **Medium-cost** |
| Pump cost (ETB)  (including inlet and outlet hoses) | 5500 |
| Cost of irrigation (ETB/ha) |  |
| Maximum tube well depth for irrigation (m)  up to 10m | 6 (suction hose) |
| Type of well | MTWtube well |
| Static water level (m) | 4 |
|  |  |
| Average irrigated area (4 hours pumping/day) (m2) | 400 |
| Daily one time pumping (minutes)  Water depth 5m; irrigated area 200m2 | 100-120 |
| Maximum Water Output (L/minute) | 1m: 80 L/min  5m: 50 L/min |
| Sustained flow rate at average depth (L/second)  Depending on depth | 0.33-0.7 |

1. **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 lift enough water to irrigate a 2500 m2 plot of land if operated for 4 hours a day. 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. Treadles can be made of Eucalyptus poles. These treadles drive pistons which create suction in the well casing (PVC piping) that extends into the water table. 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 4 Suction only Treadle Pump Technical Details and Cost

|  |  |
| --- | --- |
| **Financial Option(General items)** | **Low-cost** |
| Pump cost (ETB) | 4000 |
| Cost of irrigation (ETB/ha) |  |
| Maximum well depth for irrigation | 4.5 |
| Type of well | MTW |
| Static water level (m) | 4 |
|  |  |
| Average irrigated area (4 hours pumping/day) (m2) | 400 |
| Daily one time pumping (minutes)  Water depth 7m; irrigated area 200m2 | 100-120 |
| Maximum Water Output (L/minute) | 1m: 50 L/min  5m: 30 L/min |
| Sustained flow rate at average depth (L/second)  Depending on depth | 0.33-0.5 |

### Hand pump

A manual hand pump is low cost water lifting technology and important tool for resource poor farmers. 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. It can be linked to rural job opportunity by both directly benefiting from irrigation and also by involving in the production, distribution, and maintenance of its replaceable parts.

**MTW**

Table 5 30-meter-deep manual tube well with AFRIDEV hand pump

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Description | Unit | Quantity | Unit price | Total Price |
| 1 | Earth work |  |  |  |  |
|  | Excavation/digging to 30m deep well with one meter diameter well head & working area. | m | 30 | 600.00 | 18,000.00 |
| 2 | Concrete casing 1diameter by 1m depth |  |  |  |  |
|  | Production of reinforced Concrete Casing 80cm diameter, 1m length and 5cm thick using mould | no | 1 | 800.00 | 800.00 |
|  | Casing installation | no | 6 | 1,500.00 | 9,000.00 |
| 3 | Head work construction (2mX2m) | Ls | 1 | 4,000.00 | 4,000.00 |
| **4** | **Supply and installation of Afridev pump** | **No** | **1** | **10,000.00** | **13,000.00** |
| 5 | Supply of plastic tube | m | 50 | 100.00 | 5,000.00 |
| 6 | Other miscellaneous costs |  |  |  | 2,000.00 |
|  | **Total for one manual tube well** |  |  |  | **51,800.00** |

### Engine pump

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 as a result of the motorized pump, while groups of farmers can irrigate a common or collective area. Equipment has proved reliable provided that adequate maintenance is undertaken and spare parts are available. However, fuel costs and access to fuel constitute a constraint for small-scale farmers. 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. Technically, adequate surface or groundwater sources available in the vicinity of irrigated areas, water level not to exceed 7 m at pump site, opportunity for extension of irrigated area for single farmers, assurances for good management and cooperation of farmers in pump users group.

Motor pump commercially available with maintenance services and spare parts available, access to regular supply of fuel at affordable price, access to markets for produce, advisory services on selection, installation, field irrigation practices and maintenance. Adequate attention to conveyance system (canal lining or low-pressure pipe system). Its constraint includes high investment costs, availability fuel, operational costs, management problems, low irrigation efficiencies due to unfamiliarity with water conveyance and field irrigation practices. Many small-scale and village irrigation schemes have been equipped with motorized pumps for areas of 5 to 200 ha, but organizing farmers into Irrigation Water Users Associations (IWUA) to ensure adequate operation and maintenance (O&M) has been difficult: many pump schemes have failed due to poor cooperation among farmers.

The small low-lift motorized pumps driven by small petrol or diesel engines with a capacity of 2 to 5 horsepower (hp) and a typical discharge of 2–15 l/second have proved cost-effective. The price of this centrifugal pump has substantially decreased as the result of imports from China and India, and is typically between US$200 and US$500, which more established small-scale farmers can afford, and allows them to irrigate a substantial area of 1 to 5 ha. The operational costs are mainly fuel costs, which are estimated at US$500/ha per season. Since MTWmanual tube well 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 SWL to determine depth and width of excavation.

Table 6 Recommend pumps for manual tube wells are 2” or 3” with head and discharge.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No | Description of Items | Discharge (l/s) | Qty | Total Head (m) | Engine | | | Remark |
| hp | kw | No of cylinders |
| 1 | Diesel engine driven Centrifugal Pumps | 0.1-1 | 1 | 25 | 1.8 | 1.35 | 1-cylinder | 2 Inch suction hose |
| 1-5 | 1 | 25 | 3.68 | 2.75 | 1-cylinder | 2 Inch suction hose with trolley/wheel for moving the pumps |
| 5-10 | 1 | 26 | 4.8 | 3.5 | 2-Cylinder | 2 Inch suction hose with trolley/wheel for moving the pumps |

### Solar pump

With no fuel inputs and simple operation, solar powered irrigation systems are cheaper, cleaner and more reliable alternative for farmers in the present state of energy crisis, which provides free energy once an initial investment is made. Energy outputs of solar panels are limited, however, and in most cases, a solar-driven electric pump may irrigate only a small garden area of 0.3 to 1 ha. 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. 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.

A solar powered pump works like any other available and commonly used water pumps as both surface pumps and submersible pumps. PV Pumps pump water from hand-dug wells directly onto fields or into a storage tank for gravity-based irrigation and, in some cases, for drinking water. It has the following major parts, a solar array, a set of solar modules, which are to be connected in series, and possibly strings of modules connected in parallel to get the required power to operate the pump. The controller is an electronic device that matches the power output from the solar array to the pump motor and regulates the operation of the pump according to the input from the solar array and the solar pump which comprises of the motor which drives the movement (prime mover) and the pump impeller which moves the water under pressure. Additionally, the solar powered pump set might include accessories like cabling and fittings, a battery, and an inverter.

Table 7 Solar Pump Technical Features and Cost

|  |  |
| --- | --- |
| Description | Quantity |
| Pump cost (ETB) | 30,000 |
| Maximum well depth for irrigation (m) | 4 – 20 |
| Solar array size (m2/kW)  Silicon PV panels | 6 – 10 |
| Panel Lifetime (years) | 20 |
| 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)  Maximum 16m3/day lifting from 4m and 4m3/day lifting from 20m | 800 – 3.000 |
| Daily pumping (L/day) | 12.000 |
| Maximum Water Output (L/day) | 6m: 15 L/min , 1m: 33 L/min |
| Product Lifetime (years) | 5 – 10 |

WATER APPLICATION

Table 8 Recommended Water Application Methods for MTW

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| S/N | Depth of MTW in Meter | Capacity of well | | Command Area (M2) | Water cans | Family Drip | Surface irrigation | |
| l/s | m3/ day | Furrow | Basin |
| `1 | 4 - 30 | 0.007-0.014 | 8.64-86.4 | 100-200 | x | x |  |  |
| 2 | 0.014-0.034 | 200-500 | x | x |  |  |
| 3 | 0.034-0.068 | 500-1000 | x | x | x | x |
| 4 | 0.068-0.135 | 1000-2000 | x | x | x | x |
| 5 | 0.135-0.169 | 2000-2500 | x | x | x | x |
| 6 | 0.169-0.338 | 2500-5000 | x | x | x | x |
| 7 | 0.338-0.675 | 5000-10,000 | x | x | x | x |
| 8 | 0.675-1.013 | 10,000-15,000 | x | x | x | x |
| 9 | 0.1 – 1.0 | 0.15-1.5 | x | x | x | x |

N.B. The MTW yield is assumed from 0.1 – 1.0 liter per second

### Water cans Irrigation

Water cans application system is one of the hand watering systems suitable with MTW 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. A 10–15 L bucket reservoir is placed at an elevated height (1–2 m) above the field, and is connected to the small tubes to irrigate a small vegetable garden area of 50 m2.

Irrigation by watering can or bucket provides many farmers household with a simple way of growing irrigated crops. In some cases, locally sourced natural materials (e.g. bottle gourds) are used, but in most cases, the watering can is locally produced from galvanized iron or plastic. Carrying the cans from the water source to the crop is labor-intensive and daily watering is required. In general, the water source should: not be more than 50 m away from the area to be irrigated; not be too deep; and allow easy access for filling the watering can. A reservoir filled by small pump is sometimes constructed to facilitate access). Normally, irrigated gardens are found along rivers and streams or where surface and groundwater can easily be reached. The amount of labor required to carry water from source to field limits the area that can effectively be irrigated by a household, which is typically between 50 and 100 m2. Watering cans have been supplied in many emergency interventions, usually for small-scale vegetable production in groups – often women’s groups. To help generate additional income, nearby markets are important for the sale of the vegetables; therefore, most irrigated vegetable gardens are usually found around urban centers and settlements. It costs 80-150 Birr or less for a watering can that irrigates around 100 m2. Sometimes additional costs are incurred when a water source has to be made accessible, for instance via a pump, reservoir or open well.

### 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. It substantially saves water, fertilizer, operating cost (labor and energy) and reduces weed infestation due to wetting of lesser soil volume as well as enhances plant growth and yield. It is the most suitable in areas where crop value is very high or topographical and other conditions might preclude the successful use of other types of irrigation systems. Field reports indicate that farmers are irrigating 1 – 3 mm per day in area where the crop water requirement is 4 - 5 mm per day and still making profit. The savings in water cost could be 40 to 80% compared to sprinkler and furrow. A pump or sufficient head (gravity) is required to create the required pressure. Low cost drip irrigation systems usually have a raised reservoir to create the pressure at a relatively low operating pressure (0.1-1 bar/1-10 meter) and a discharge rate of usually ranges from 0.2 l/h/emitter to 4 l/h/emitter. The family drip system can cover area by single kit ranging from 2 m2 for nursery systems to 1,000m2 for vegetables and fruit trees. A 200–300 L fuel drum is placed at an elevated height (1–2 m) above the field, and is connected to the drippers to irrigate a small vegetable garden area of 250–500 m2. The basic components of a drip system are emitters, water delivery and distribution pipes, filter, control unit and raised reservoir or pump. To determine the design, the following parameters are required: percentage of wetted area, depth of irrigation, emitter spacing, emitter discharge, emitter selection and preliminary system discharge. A well-designed drip irrigation system loses practically no water to runoff, deep percolation, or evaporation.

Table 3-Summary of Drip Kit (FDK) Specification and Cost of installation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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** |

### Surface irrigation

Water is applied to the field in either the controlled or uncontrolled manner. If the MTW yield is high, the controlled system could beconsidered. In this system, the water is applied from the head ditch and guided by corrugations, furrows, borders, or ridges. Surface irrigation is entirely practiced where water is abundant. The low initial cost of development is later offset by high labor cost of applying water. There are deep percolation, runoff and drainage problems.

1. **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.

Furrow irrigation is adapted for irrigating on various slopes except on steep ones because of erosion and bank overflow. There are different ways of applying water to the furrow. Siphons are used to divert water from the head ditch to the furrows. There can also be direct gravity flow whereby water is delivered from the head ditch to the furrows by cutting the ridge or levee separating the head ditch and the furrows. Gated pipes can also be used. Large portable pipe(up to 450 mm) with gate openings spaced to deliver water to the furrows are used. Water is pumped from the water source in closed conduits. The openings of the gated pipe can be regulated to control the discharge rate into the furrows. Its design parameters includes, storing the readily available moisture in the root zone, if possible; obtaining as uniform water application as possible; minimizing soil erosion by applying non-erosive streams; minimizing runoff at the end of the furrow by using a re-use system or a cut -back stream; minimizing labor requirements by having good land preparation, good design and experienced labor and facilitating land preparation, cultivation, furrowing, harvesting etc.

The specific design parameters of furrow irrigation are aimed at achieving the above objectives and include: shape and spacing of furrows, that is heights of ridges vary between 15 cm and 40 cm and the distance between the ridges should be based on the optimum crop spacing modified, if necessary to obtain adequate lateral wetting, the range of spacing commonly used is from 0.3 to 1.8 m with 1.0 m as the average depending on the recommended crop spacing. Selection of the advance or initial furrow stream: in permeable soils, the maximum non-erosive flow within the furrow capacity can be used so as to enable wetting of the end of the furrow to begin as soon as possible. The maximum non-erosive flow (qm) is given by: qm = c/s where c is a constant = 0.6 when qm is in l/s and s is slope in %. The actual stream size should be determined by field tests. It is desirable that this initial stream size reaches the end of the furrow in t/4 time where t is the total time required to apply the required irrigation depth. The cut-back stream is the stream size to which the initial stream is reduced sometime after it has reached the lower end of the field. This is to reduce soil erosion. Field slope allowed to reduce costs of land grading, longitudinal and cross slopes should be adapted to the natural topography, small cross slopes can be tolerated. To reduce erosion problems during rainfall, furrows (which channel the runoff) should have a gentle slope. The furrow length, very long lengths lead to a lot of deep percolation involving over-irrigation at the upper end of the furrow and under-irrigation at the lower end. The field widths are flexible but should not be of a size to enclose variable soil types. The widths should depend on land grading permissible. A plot of land with total irrigable area of 2.5 ha is being irrigated using an irrigation canal with a discharge rate of 5 liters per second and water application efficiency of 70%. What is the time required to apply 35 mm of irrigation water and if the crop water requirement is assumed to be 120 mm per month what is the frequency of irrigation assuming no percolation and drainage.

1. **Basin irrigation**

Description: 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

Since manual tube well has continuous water supply throughout the year it is possible to cultivate crop more than one time by full irrigation. It is also possible for supplementary irrigation and seeding production. The crop that selected for manual tube well should be:

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

The following crops technologies are recommended for this technology.

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

**Fruit (supplementary irrigation):** - papaya, mango, avocado,

**Seedling production:** onion, tomato, pepper, cabbage

**Cereals**: Maize

**Pulses**; Snap bean

Table 9.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 |

## Deficit, alternative irrigation and mulch

It is advisable to use deficient irrigation in area where there is serious water shortage. The stage of the crop that we minimize irrigation water application should be the stage that crop demanded minimum water with minimum impact on yield. This stage is at non-sensitive growth stage of crop as shown on the table above. We can also save irrigation water by mulching which reduce evaporation.



Figure 1 Alternative irrigation

Table-10. Agronomic recommendation of tomato seedling production using watering can by Manual tube well

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description** | | **Unit** | Mid land | low land |
| land preparation | | frequency | 4 | 4 |
| Seed bed size | | m2 | 5 | 51 |
| Number of seed beds | | no | 56 | 52 |
| Seed (gm/bed ) | | gm | 10 | 10 |
| Seed for total bed | | gm | 560 | 520 |
| Seed depth | | cm | 1-1.5 | 1-1.5 |
| Spacing | | cm | 15 x 1.5 | 15 x 1.5 |
| fertilizer | NPS | kg | 13.5 | 12.5 |
| Urea | kg | 5.6 | 5.2 |
| Irrigation interval and amount | Pre-planting irrigation per bed | lit | 250 | 250 |
| 20 lit/day/seed bed for the first 15 days | Lit | 300 | 300 |
| 30 lit/day/seed bed for the next 20 days | lit | 600 | 600 |
| Total irrigation water | m3 | | 67 | 62 |
| Seedling produced  enough for area of | ha | | 2.2 | 2 |

Table 11.Agronomic recommendation of cabbage cultivating by furrow and drip irrigation at high and mid land with manual tube well

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 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' | days | 5 | 4 | 5 | 4 |
| Mid and late | days | 7 | 6 | 7 | 6 |
| Medium soil | Initial and dev | days | 5 | 4 | 5 | 4 |
| Mid and late | days | 7 | 5 | 7 | 5 |
| Light soil | Initial and dev | days | 4 | 3 | 4 | 3 |
| Mid and lat | days | 5 | 4 | 5 | 4 |
| Crop water requirement | | M3 | 583 | 708 | 214 | 260 |
| Yield | | Qt | 40 | 40 | 50 | 50 |

Table 12.Agronomic practice recommendation of onion production by manual tube well

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Activity description | |  | Furrow | | Drip | |
| Unit | Mid land | low land | Mid land | low land |
| Area | | ha | 0.25 | 0.25 | 0.25 | 0.25 |
| Land preparation | | freq | 4 | 4 | 4 | 4 |
| Seed | | kg | 1.75 | 1.75 | 1.75 | 1.75 |
| Fertiizer (kg) | NPS | kun | 0.6 | 0.6 | 0.6 | 0.6 |
|  | Urea | kun | 0.25 | 0.25 | 0.25 | 0.25 |
| Insecticide | Dimatot | lit | 2 | 2 | 2 | 2 |
| Fungicide | Mancozeb | kg | 2 | 2 | 2 | 2 |
| Spacing | | cm | 20 X 10 x 5 |  | 20 X 10 x 5 | |
| Cultivation | | freq | 3 |  | 3 |  |
| Irrigation Interval | |  |  |  |  |  |
| heavy soil | Initial/dev't | days | 4 | 3 | 3 | 2 |
| Mid/late | days | 6 | 4 | 3 | 2 |
| Medium soil | Initial/dev’t | days | 4 | 4 | 3 | 2 |
| Mid/late | days | 5 | 5 | 3 | 2 |
| Light soil | Initial/dev’t | days | 3 | 3 | 3 | 2 |
| Mid/late | days | 4 | 4 | 3 | 2 |
| Irrigation requirement | M3 | | 1875 | 2292 | 688 | 840 |
| Yield | Qt | | 87 | 87 | 110 | 110 |

## MARKET, CREDIT AND TECHNOLOGY EXTENSION STRATEGY

### 3.5.1. Extension strategy

In promoting river pump technology to farmer, appropriate extension approach is important for success full promotion, dissemination and adoption of the technology to beneficiaries.

Participatory extension approach and methods – In using these method male and female farmers have the chance of selecting the technology and participate in planning process with development agent during introduction and implementing period.

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 |

Identification and documentation of best practices needs Female and male farmer’s indigenous Knowledge and experience in adopting technologies are important and need to be identified and documented for scaling out of the technology where it is not reached yet. So, for the dissemination and scale out of best practice extension agent can use experience sharing methods and mass media technology**.**

### 3.5.2. Access to Credit and Market Strategy

In order to cover the purchase costs of river pumping 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. In addition to this, the government of Ethiopia is considering develop strategy to access HHMI technologies to have tax free for the rural farmers and this make the technology affordable to the farmers in order to ensure sustainable HHMI development.

## ECONOMIC AND FINANCIAL ANALYSIS

Currently irrigation development of any scale is the major focus areas of government and other development partners. This is because; irrigation development is the first best alternative agricultural operation in boosting production and productivity of resources and ensures food security. Moreover, it provides inputs forever expanding industrial park in the country that enables the country to realize structural transformation. House Hold Micro Irrigation (HHMI) is important scale of irrigation which enables to access large number of households, facilitates to realize inclusive irrigation development, ease to apply with reasonable affordability. Moreover; House hold micro irrigation ease youth and women mobilization for economic development as the scale of irrigation is easily applied in the nearby residential areas and manageable with minimum requirement of knowhow of these target groups.

Based on this rationalities and importance of the scale of this irrigation, Ministry of Agriculture and Natural resources develop technology package development for Household Micro Irrigation Technology National Specification:

Promoting irrigated farming at the household level through introducing suitable household and micro irrigation systems, needs under taking financial and economic analysis so as to ensure its sustainability. This analysis includes all supply chain of this development such as, introducing appropriate micro irrigation technology, selecting sustainable water sources, low cost and effective water lifting technologies, irrigation application technologies, farm inputs and first best alternative that yield maximum returns from this investment.

Based on the above rationalities, financial and economic analysis of these micro irrigation technologies based on the national specification manuals has been done as follows.

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 compare 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.

### 3.6.1. Why Analysis?

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 scares 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 (BCR):** 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 BCR 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 both financial analyses are presented in the figure below.

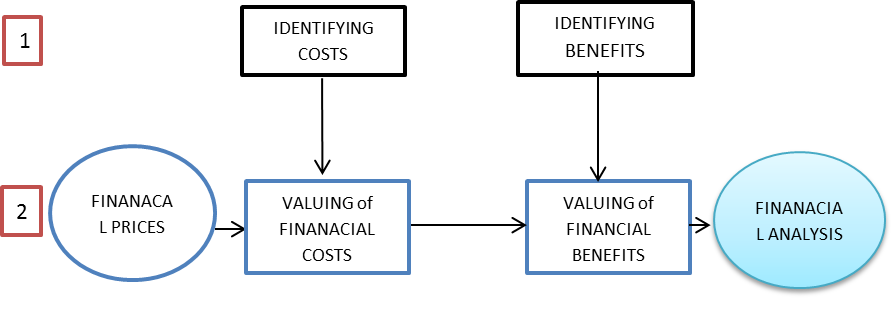


Figure 2 Overall concepts and frameworks for both financial analyses

### 3.6.2. Financial & Economic Analysis of Manual Tube Well Technology Package

In this package development, with the above rationalities for house hold micro irrigation technology package of manual tube well has been tried to analyses financially with selected high value crops. The cost of materials in 2018/19 in Ethiopia current for tube well fixed investment cost analysis can be used as indicated in the Table 10.

Table 13 Manual Tube Well (MTW) package Technology

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Scenario | Descriptions | Unit | Qty | Drilling cost in Birr | Casing and gravel cost. | Total cost in Birr |
| 1 | 10m depth with full PVC casing, well inner diameter 110mm | Meter | 10 | 2,193 | 1075 | 3268 |
| 2 | 15m depth with full PVC casing, well inner diameter 110mm | Meter | 15 | 3,140 | 1613 | 4753 |
| 3 | 20m depth with full PVC casing, well inner diameter 110mm | Meter | 20 | 4,087 | 2150 | 6237 |
| 4 | 25m depth with full PVC casing, well inner diameter 110mm | Meter | 25 | 5,033 | 2687 | 7720 |
| 5 | 30m depth with full PVC casing, well inner diameter 110mm | Meter | 30 | 5,980 | 3225 | 9205 |
|  | Average Cost | | | | | 6236.6 |

NB: Consider the average cost of MTW for financial feasibility analysis

Consider an area of Minimum 0.3ha and Maximum; 1ha

Table 14 Summary of Scenario Based Technology Packages for Economic Analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No | Average Cost Tube Well | Water lifting technology | Cost of Lifting | Water application technology | Cost of App. | Total cost |
| 1 | 6,236.60 | Pulley | 500 | Watering Can | 500 | 7,236.60 |
| Rope and Washer | 3500 | Watering Can | 500 | 10,236.60 |
| Low cost Drip | 28000 | 34,236.60 |
| Treadle | 3000 | Furrow | 3000 | 12,236.60 |
| Watering Can | 500 | 6,736.60 |
| Low cost Drip | 28000 | 34,236.60 |
| Hand Pump | 15000 | Watering Can | 500 | 21,736.60 |
| Low cost Drip | 28000 | 34,236.60 |
| Engine pump | 15000 | Basin | 3500 | 24,736.60 |
|  | Furrow | 28000 | 49,236.60 |
| Solar Pump | 85,000 | Low cost Drip | 28000 | 119,236.60 |

Investment Cost (infrastructure, technology supply) of Manual tube well package of this HHMI technology will be considered for the following cases of Scenarios of analysis.

1. MTW + Pulley + Water can (hose)
2. MTW + Rope & Washer pump + Water Can (hose)
3. MTW + Rope & Washer pump + Low Cost drip
4. MTW + treadle + furrow
5. MTW + treadle + Water Can (hose)
6. MTW + Treadle + Low Cost drip
7. MTW + Hand Pump + water can (hose)
8. MTW + Hand Pump + Low Cost drip
9. MTW + Engine pump + Basin/Furrow
10. MTW + Engine pump + low cost drip
11. MTW + Solar Pump + Low cost Drip

For this Manual tube well HHMI package, considering highest investment cost of technologies minimum size of command area is recommended for drip irrigation system covering 2500 m2 to 5000 m2 with average command are of 3000m2 and highest investment fixed cost of the associated technology under scenario 11 as described in the Table-12. However, large size of pump can also be used to irrigate additional area by using surface irrigation methods. The estimation of irrigable area in this table is assuming 8hrs working time of pump. Operation and maintenance cost will be calculated by 5% of investment cost for each year.

**Table 15****-Financial feasibility analysis of MTW of scenario 11 (MTW + Solar Pump + Low cost Drip)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crop Production | Average investment Cost of Technology Packages | Average Variable cost ETB | Average Revenue ETB | Marginal profit | NPV | BCR | Payback period (year) | Advisable Decision |
| Oinion | 119,236.60 | 29,580 | 130,900 | 101,320 | 554,791 | 3 | 1 | Financially viable |
| Tomato | 119,236.60 | 57,972 | 326,400 | 268,428 | 1,581,504 | 5 | <1 |
| H.Cabbage | 119,236.60 | 16,075 | 68,000 | 51,925 | 251,307 | 3 |  |
| Potatoe | 119,236.60 | 22,846 | 81,600 | 58,754 | 208,087 | 2 | 1 |
| Onion seedling | 119,236.60 | 8,235 | 30,000 | 21765 | 118,314 | 2 | 3 |
| Tomato seedling | 119,236.60 | 34,145 | 108,800 | 74,656 | 390,964 | 2 | 1 |
| Papaya | 119,236.60 | 9,500 | 272,000 | 262,500 | 1,545,081 | 13 | 1 |
| Avocado | 119,236.60 | 22,846 | 566,666 | 543,820 | 3,273,510 | 17 | 3 |

## 

## MONITORING AND EVALUATION

Table 16.M&E tools for Tube 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 17-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 |  |  |  |  |
| 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 |
| **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 |  |  |  |  |  |  |  |  |

Table 18-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[[6]](#footnote-6) | % | 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[[7]](#footnote-7) 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[[8]](#footnote-8) 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 |  |  |  |  |
| **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. Efficiency refers to application efficiency where water abstracted is delivered from the source versus amount of water used by the crop. [↑](#footnote-ref-6)
7. Uniformity refers to application of water from head to tail. [↑](#footnote-ref-7)
8. Refers to whether the community uses local materials and indigenous knowledge [↑](#footnote-ref-8)