EXECUTIVE SUMMARY

ENGINEERED SOLAR IRRIGATION DISTRIBUTION SYSTEM

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The purpose of this project was to research and design an off-grid drip irrigation distribution system to accommodate the nursery located at Harbu Chulule, Ethiopia. This design will help increase the efficiency and capacity of trees grown to aid in local reforestation initiatives to combat erosion and deforestation in Ethiopia. The main criteria considered included the feasibility of building and operating the system in a village where technical knowledge is not readily available and sought to minimize cost and complexity while efficiently servicing the nursery. The selected design includes five main components: Water intake from a stream, pumping, solar panels and wiring, water storage, and distribution.

1. Water Intake System

The intake system is specifically designed to accommodate the low water depth and flow of the adjacent river near the nursery. A short diversion channel with a wing dam is designed to direct water to the pump, also making sure that unused water can go back to the main river to reduce disruption in the flow as much as possible. Sections of the intake include a wing dam to direct water flow in the channel, a two-step filter using gravel and a filter sheet and a PVC pump casing to prevent sediment from damaging the pump, and a weir upstream of the pump to ensure flow level is maintained in the channel.

2. Pump System

The pump system uses a positive displacement pump that can operate at low voltage and is DC powered, therefore no need for batteries or inverters. This pump can provide the required static head at a flow rate near to 0.28 L/s. The submersible pump will be attached to a polyethylene pipe that connects to a PVC lay flat hose that can sustain about 80 PSI of pressure. The hose will lead from the river to the nursery tank and connect to a permanent setup of rigid PVC piping. The system is set up to fill up the 1500L tank in 1.5 hours.

3. Solar Panels

The photovoltaic array system is designed to supply consistent off-grid power to the irrigation system. One key design focus for the electrical system was to reduce component costs as much as possible. This was achieved by having a DC system with no additional batteries or inverters required. Therefore, only when there is sufficient solar irradiance incident on the solar panels will the pump be capable of operating.

4. Storage

The storage system Is designed to hold sufficient water for the system to operate in the dry season, this includes contingent storage to allow for operation during overcast days with low precipitation, where the solar panels will be unable to operate, and the amount of precipitation is insufficient to water the saplings. Water is to be stored with at least 6m elevation gain above the nursery, requiring a hill behind the nursery. This arrangement is ideal for nurseries located adjacent to a larger riverbank.

5. Distribution

The distribution system takes water from the storage tanks on the hill to the saplings that need watering. A large lay flat hose mainline carries the water to multiple sub-mains that are individually opened and closed to water the saplings. Drip tape is used to apply water to the saplings at low pressure and low flow rates, resulting in more efficiency where water is not wasted during application.

On the following page is a look up table where users planning a similar nursery setup in another location can see the changes in components or cost required for their unique setup.

Table 1 below considers a variety of scenarios that our type of system could be used in and what types of irrigation products would be required. The first row was the scenario designed for, given the Harbu Chulule site at maximum capacity.

Table 1: Design Options for various Nursery Configurations

Scenario	Inputs						Outputs				
	Trees in Bags	Trees in Ground	Distance to River	Slope to River	Slope along Nursery	Slope Behind Nursery	Pump Needed	Solar Panels needed	Distribution setup	Storage Desired	Total Cost
Given Location (Max Capacity)	70,400	55,200	50m	3%	3%	16%	Sun Pumps SDS Series	355 W, 24 V	Gravity Fed 37.5mm Mainline 1x 37.5mm servicing bags 2x 37.5mm servicing ground	8000L	$9,500
Given Location (Current Capacity)	19,200	6,900	50m	3%	3%	16%	Sun Pumps SDS Series	355 W, 24 V	Gravity Fed 37.5mm Mainline 1x 37.5mm servicing bags 1x 37.5mm servicing ground	3000L	$6,400
All trees in ground	0	105,800	50m	3%	3%	16%	Sun Pumps SDS Series	355 W, 24 V	Gravity Fed 50mm Mainline 2x 37.5mm servicing ground	8000L	$8,100
All Trees in Bags	151,800	0	50m	3%	3%	16%	Sun Pumps SDS Series	355 W, 24 V	Gravity Fed 37.5mm Mainline 2x 50mm servicing ground	13000L	$12,000
Large distance to water source	70,400	55,200	500m	10%	3%	16%	Grundfos 5SQF-8	355 W, 24 V	Gravity Fed 37.5mm Mainline 1x 37.5mm servicing bags 2x 37.5mm servicing ground	8000L	$10,300
High Capacity with Low Slopes	70,400	55,200	50m	3%	3%	<7%	Sun Pumps SDS Series	Battery System	Pump fed	NA	$11,500