Challenges and Prospects of Hydro-Pumps for Small Scale Irrigation

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Abstract. Escalation of small-scale irrigation is supposed to be an essential requirement for the growth of the agricultural sector in developing countries. In Ethiopia intensification of small-scale irrigation has got a policy priority for rural poverty mitigation, growth, and building climate adaptation economy. The irrigated land in Ethiopia is not far from 5% of irrigable land, and only around 5% of available water resources are utilized annually. To maximize the effort deploying an environmentally friendly and less expensive technological alternative needs attention. In this regard, pressurized irrigation schemes that operate on renewable energies such as hydro-powered pumping contribute more. Even though the technology has an obvious advantage over the other pumping technologies, they are not been used gradually through time and are mostly ignored. The objective of this study was to conduct strengths, weaknesses, opportunities, and threats analysis on prospects of a hydro-powered pumping system for small-scale irrigation in Ethiopia. In this regard, important small-scale irrigation pump problems were examined and prospects and barriers of hydro-powered small-scale irrigation pumping systems were identified. A comparative study was conducted for comparative between existing pump types (Engine powered, Motor powered, and Manual) deployed in the community for small-scale irrigation. According to the study result, the hydro-powered pumps have better prospects for small-scale irrigation.

Keywords: Irrigation pump · Hydro-pump · Pump as turbine · Pump power · Renewable energy

1 Introduction

Escalation of small-scale irrigation schemes is supposed to be an essential precondition for the growth of the agricultural sector in Ethiopia. In Ethiopia intensification of small-scale irrigation has got a policy priority for rural poverty alleviation, growth, and building climate adaptation economy [1, 2]. The irrigated land in Ethiopia is not far from 5% of irrigable land [3], and only around 5% of available water resources are utilized annually [4]. A study revealed small-scale irrigation scheme operated and managed by a farmer is quite impressive and popular in recent years due to the rapid return and poverty alleviation. Therefore, the numbers of small irrigation schemes are increasing rapidly in

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sub-Saharan Africa and South Asia [5]. Even though there are a lot of influencing factors in agriculture, improving irrigation water access and control is a principal factor to improve smallholder farm production and consequently improving their livelihoods [6]. A way to achieve this goal is to intensify irrigation base farming using pumping facilities and increase production and productivity in the sector. However, many current irrigation systems operate on diesel-based pumping technologies. As a result, it is suffering from high operation and maintenance costs and it is strongly linked to air pollution due to the continuous use of expensive fossil fuel [7], thereby becoming cost-intensive for smallholder farming. Renewable energies, solar, wind, and hydropower, or a combination of them are an environmentally sound and less expensive substitute for small-scale irrigation [8]. From renewable energy-based pumping systems, hydro-powered pumping (HPP) systems have further advantages over other renewable energy (RE) based counterparts. These benefits include: I their energy source is typically more localized, concentrated, and predictable; (ii) they have a higher power-to-size ratio, making them more cost-effective; (iii) they are mechanically less complex and robust, requiring less maintenance and lasting longer; and (iv) they are typically more efficient (up to 85%) [9]. Despite these obvious advantages, most hydro-powered pump (HPP) technologies have not been used steadily over time, and are largely ignored [10]. There have been few studies on water turbine pump (WTP) design since the beginning of the twenty-first century, and the literature prior to 2000 is mostly theoretical study and design selection [11]. The objective of this study was to conduct a strength, weaknesses, opportunities, and threats (SWOT) analysis on the prospects of a hydro-powered pumping system for small-scale irrigation in Ethiopia.

2 Literature Review

Ethiopia is a country located in the East of Africa lies between 3° to 15°N latitude and 33° to 48°E longitudes, with a land area of about 1.097 million km^2. According to the World population review report, currently, Ethiopia has a population of about 105 million of which 83% live in rural areas [12]. Ethiopia has a diverse range of renewable energy resources that can be used to satisfy the country's electrification goals. Hydropower has a 45GW potential, the wind has a 10GW potential, geothermal has a 5GW potential, and sun irradiation ranges from 4.5 kWh/m^2/day to 7.5 kWh/m^2/day. [13]. Currently, Ethiopia has one of the lowest electricity consumption per capita in Africa. Distinguishing energy access and security is a critical factor for development; Ethiopia needs to handle key challenges associated with energy security and diversification of energy supply. Nowadays Ethiopia's total installed capacity of electric generation is about 4.5 GW (2019) mainly generated by hydro (90%) and followed by wind energy (7.6%) [14]. According to Ethiopia's country report in 2019, only about 45% of the country's population has access to electricity. The urban population has 97% access to electricity, while in rural areas electricity access remains extremely low at about 31% [15]. Nowadays, there is a severe deficiency of public finance for power expansion of African Governments from the World Bank and other multilateral and bilateral aid agencies, which had financed mega hydropower project development in the past [16]. So the countries have to focus on small and micro-hydropower development and direct applications, such as hydro-pumping.

2.1 Small Scale Irrigation

To persist with the rapid population growth and the corresponding need for food production, developing countries give great attention to affordable irrigation development. Since large-scale irrigation development needs huge finance, small-scale and on-farm water development and efficient use of water are receiving special attention. Many such small-scale farm water development projects depend on groundwater and low-level surface water for their water resources, and water lifting is a vital part of their use. Inexpensive small-scale irrigation can successfully build the flexibility of vulnerable farming households by reducing their dependency on erratic and unpredictable rainfall. While there is a tendency to replace some of the traditional devices with modern pump equipment, the majority of developing countries feel that the improvement of traditional facilities, which are locally produced, repaired, and used by farmers, must receive due attention. Furthermore, because of food shortage and the rising cost of energy, a modern means of lifting water with renewable energy is becoming increasingly important. One of these alternatives is a hydro-power pumping system.

One of the key causes for Ethiopia's sluggish agricultural growth is the sector's low percentage of total investment capital, which represents only 4.2% of the country's total investment capital [17]. As a result, land and labor productivity, as well as farm household income, are all at historically low levels. Furthermore, agriculture is reliant on natural rainfall and is susceptible to drought, which has a detrimental impact on farmer productivity and production. As a result, rural areas have a comparatively high poverty rate, with an average of 25.6%, compared to 14.8% in urban areas [17]. Additionally, World Bank data show that Ethiopian farmers have the lowest gross per capita farm income of 721.28 (USD) as compared to 4137.98 (USD) in china and 82,283.64 (USD) of Canada [18]. Therefore, Ethiopian farmers must make more efforts to transform the agriculture sector so that it reaches the level of modern agriculture and set long-term targets to achieve higher incomes.

2.2 Pump Power for Irrigation

The introduction of appropriate, sustainable, and successful small-scale irrigation [17] schemes requires attention to improving water management. A pump is the heart of most irrigation systems and if not properly selected leads to excessive pumping costs. In small-scale irrigation pumps are used to raise water from a lower to a higher elevation from which the water then flows through canals to the field requiring irrigation or to raise the water pressure head so that it can b transmission line e sprayed on the field using a sprayer. There are numerous types of pumps designed for various purposes. Surface centrifugal pumps installed above the water level are the most commonly used pumps. It is a mature technology. The basic difference that brings economical significance is the power drive. The most commonly used drive options are engine, motor, and manual.

Engine-driven (petrol and diesel) water pumps are still popular because they appear to be the most cost-effective alternative to solar pumping. However, there are other recurring costs associated with these pumps that drive up their price over time. They have short lifespans, require constant maintenance, and consume a lot of fuel.

Furthermore, they are extremely polluting, degrading air quality and emitting carbon dioxide, both of which contribute to climate change. Manual water pumps, such as Afridev, Pedal, Rope and Washer, and treadle pumps, are another option in addition to engine drive. A manual drive is required for these. These sorts of water pumps, while inexpensive, require a lot of time and labor to install and have a limited capacity. In addition, motor-driven (electric and solar) pumps are used as a small-scale irrigation pumping alternative. Even though electric-driven pumps are the most cost-effective choice, their use is limited due to the lack of power infrastructure. According to the international energy agency 2019 report, in Ethiopia, only 47% of the population has access to electricity as shown in Fig. 1. In contrast, with a solar water pump, the solar panels will keep providing free and clean energy. It doesn't need electricity or fuel and has a low maintenance requirement. Contrary to this the upfront cost of the solar water pumps barrier restricts its applicability.

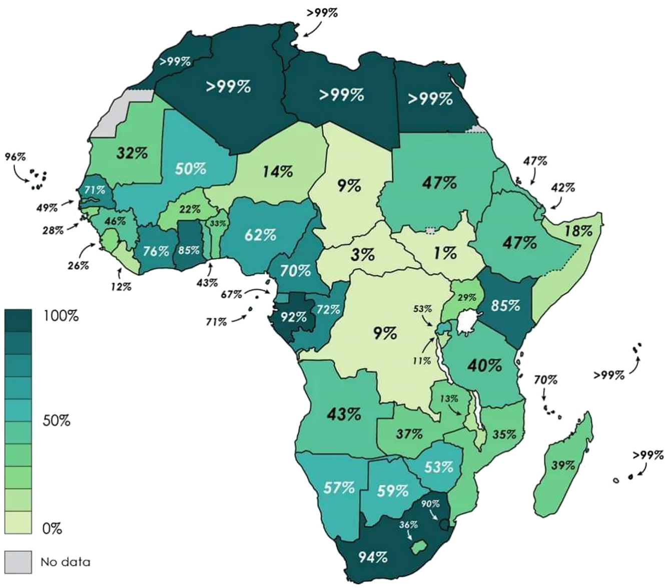


Fig. 1. Access to electricity in Africa by the proportion of the population, 2019 data (Source: the international energy agency)

In today's pump power research work hydro-power pump gets great attention. It is a water-lifting device in which the turbine and pump are coaxial or conjugating as a whole through gear transmission or designed as single equipment. The whole or part of the unit is submerged in water during operation. The turbine is the prime mover; the pump follows the turbine rotation under the action of definite water flow and head. Water is thus pumped to the upland areas where irrigation is needed. Simply considering the utilization of hydraulic energy, the water-turbine pump is a device of the highest hydraulic efficiency [19]. Water energy is applied directly to do work for lifting water, and no intermediate energy is lost through turbine transmission. Obviously, under the same condition of hydraulic energy, lifting water by electrical power generated will inevitably cause a series of energy losses within the generator, transformer, power transmission line, and electrical motor. So, the efficiency is much lower than that of the water-turbine pump using the same hydraulic energy (Fig. 2).

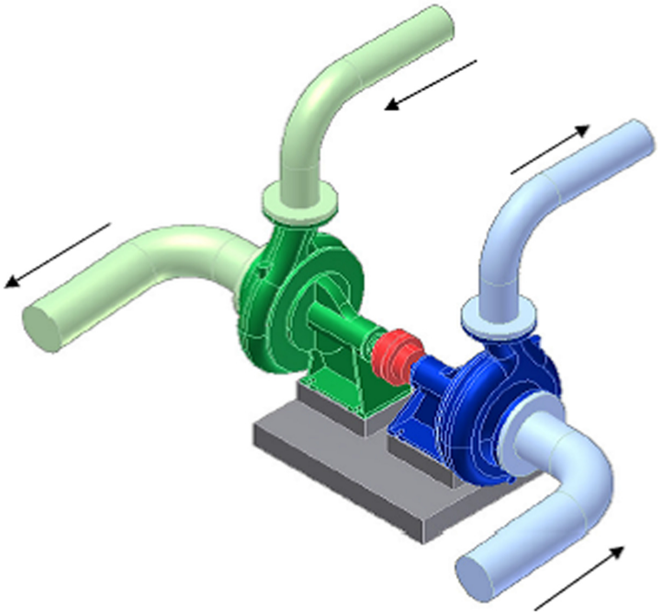


Fig. 2. Pump directly connected to the turbine (PAT)

One of the hydro-powered pumping systems is a pump as turbine (PAT) based pumping system. It is innovative pumping technology. Currently, several emerging types of research are conducted to investigate the performance of pumps as a turbine for micro-hydropower plants in which pumps are coupled with generators externally. In this indirect mode of operation, the water energy converted to shaft power using PAT and transfer to a generator. Then the generator converts the mechanical energy to electrical energy and transmits it to the pump motor. Finally, the electrical motor coupled to the pump converts the electrical energy and transfer to pump shaft. On the other hand, the direct method of connecting two pumps one as a turbine and the other as a lifting device eliminates the need for hydroelectric power generation and the loss of electric energy during intermediate energy conversion and transmission processes. Furthermore, with a reasonable water turbine pump integration (WTP) design, the energy utilization can be even higher than with other forms of water-lifting machinery [20]. At the same time, it also saves a considerable amount of mechanical and electrical equipment installation, and the corresponding infrastructure cost [21]. Figure 3 represents types of hydro-powered pumping (HPP) technologies.

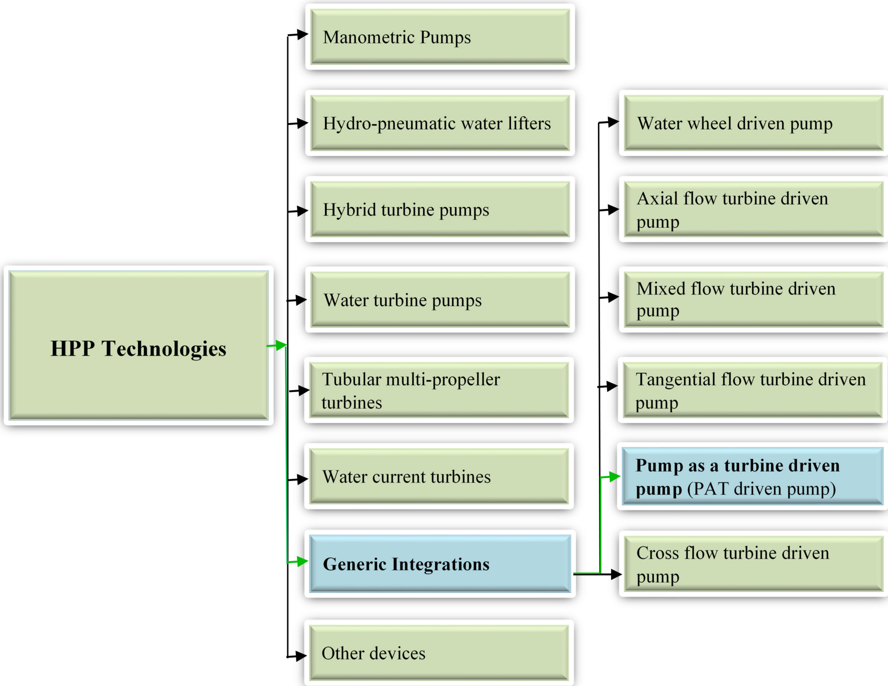


Fig. 3. Classification of hydro-powered pumping (HPP) technologies [10]

2.3 Pumps Suitable for PaT Application

The selection of the correct type and size of pump to use as a turbine is based on technical (head and flow rate available at the site) and economic issues (initial and operating cost). There are research results that testified that major types of centrifugal pumps can be used for reverse mode application [22]. The appropriate type and size of pump to be used for reverse mode application selected based on head and discharge required, as shown in Fig. 4 [23]. It is visible that axial pumps are suitable for low head and high flow rates; whereas, multistage radial pumps are appropriate for high head and low discharge sites. Recent evidence suggests that single-stage centrifugal and axial flow pumps are suitable for PAT application as compared with Francis, Pelton, and Kaplan turbines respectively [24, 25]. Even though it is possible to use double suction and in-line pumps for turbine mode application, they are less efficient than other pump types. But self-priming and Wet-motor submersible borehole pumps are not appropriate for turbine mode application due to the existence of a non-return valve. Likewise, dry-motor submersible pumps with fin cooling arrangements, are not suitable for turbine mode application due to overheating issues [26]. Despite the fact that the pump performs best when the head is between 13 and 75 m, the pump's lifetime cost lowers as the head increases [27].

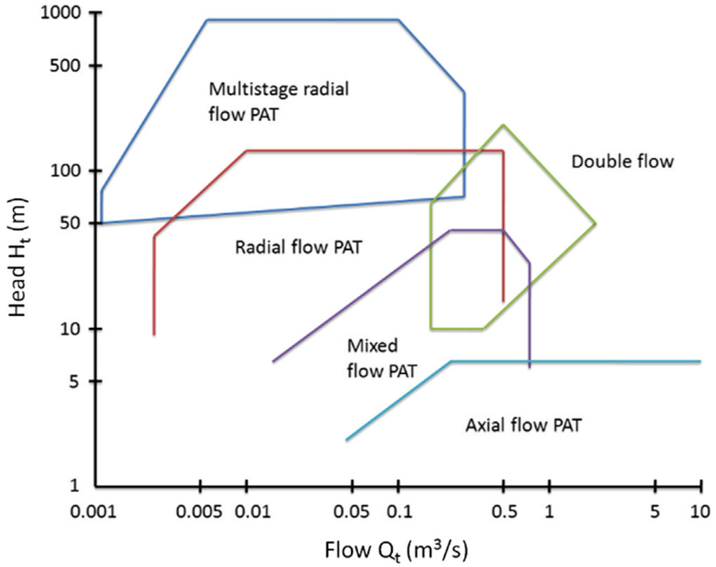


Fig. 4. Recommended range of different types of pumps to work as turbines [23].

3 Methods

To understand the scenario, along with the literature review, other documents of the case had been reviewed. In this study considering various reasons, the survey was conducted previously on different organizations, professionals, and small farm holders.

3.1 Assessment Areas

The purpose of this survey is to identify the gap in intensifying pump-based small-scale irrigation in selected woredas. The assessment area comprised Estie, Fogera, and Fareta woredas in the south Gondar zone and Bahir Dar Zuria, Semien Achefer, and Sekela woredas in the west Gojjam zone, Amhara Regional State of Ethiopia.

3.2 Sampling Method and Sample Sizes

The purpose of this survey was to measure customer satisfaction on existing pumping technology and the need for a new product, it didn't necessarily rely on having a statistically significant sample size. While it's important that the responses were accurate and represent how customers feel, taking a closer look at each answer in a customer satisfaction survey was taken. Table 1 presented the distribution of the sample. Quantitative and qualitative information was gathered from 322 small-scale farm holders who are using pump-based irrigation, 92 maintenance service providers, and 47 pump manufacturers and retailers. Individual household interviews were held with a total of 89 households. Focus group discussions (FGDs) were held with 5 groups having 8,12,8,11 and 10 members respectively. Both the household interviews and the FGDs were rearranged and held on sites.

Table 1. Distribution of sample

Woreda	Questioner		Interview	
	Male	Female	Male	Female
Estie	61	26	12	1
Fogera	67	29	16	0
Fareta	39	17	8	0
Bahir Dar Zuria	74	32	23	2
Semien Achefer	39	17	13	1
Sekela	42	18	13	0

The survey sample size determined as;

$$\text{Sample size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Where;

N = Population size, the number of farmers who are using a pump for small-scale irrigation.

e = Margin of error (percentage in decimal form),

z = z-score, it is the number of standard deviations a given proportion is away from the mean. for a confidence level of 99%, a z-score was taken at a value of 2.58.

Table 2 presented the Percentage share of pump types used by small farm holders for small-scale irrigation. Based on the survey result petrol engine pumps, rope and washer pumps and diesel engine pumps have 65%, 16%, and 12% share respectively.

Table 2. Percentage share of pump types used by small farm holders for small scale irrigation

S.N	Pump type	Share %
1	Electric motor pump	1.5%
2	Diesel engine pump	12%
3	Petrol engine pump	65%
4	Pedal pump	3%
5	Treadle pump	2%
6	Rope and washer pump	16%
7	Others	0.50%

3.3 Data Collection Methods

The assessment was conducted both in Amharic and English languages and data was gathered through Interviews, Focus group discussions, and structured questionnaires. The data focused on factors restricting farmers from using a water pump for small-scale irrigation, small-scale irrigation pump problems, factors which attribute more for poor performance and reliability of radial centrifugal pumps in small-scale irrigation, more vulnerable parts of pumps, and perception of the community on different types of pumps. Secondary data were gathered from current records of enterprises, government technology transfer offices, agriculture extension workers, farmer cooperatives and unions, NGOs & financial institutes.

3.4 Data Analysis

The data generated through the questionnaire was analyzed by employing the Statistical Package for Social Science (SPSS version 20) and MINITAB version 14. To analyze the data collected, descriptive methods such as frequency, percentage, average, and standard deviation were used. The Pearson correlation (r) was used to measure the linear association between the dependent and independent variables. It describes the strength of the relationship between the two variables. Multiple regressions were also used to allow additional factors to enter the analysis separately so that the effect of each independent variable can be estimated. quality function deployment (QFD) was used to define customer requirements and convert them into detailed engineering specifications and plans to produce the products that fulfill those requirements.

4 Results and Discussions

4.1 Assessment Findings

The client will usually specify the desired pump head and flow rate. The type and speed of the driver may also be specified. Speed is governed by considerations of cost and efficiency as well as drivers available to the client. Given these parameters, the task of the engineer is to minimize cost. Which cost to minimize, first cost or life-cycle cost, however, is an important consideration too. These considerations call for optimizing efficiency, reliability, and maintainability. For this reason, a survey was conducted to identify the customer's requirements in small-scale irrigation pumps. In the communities studied, most of the small farm holders as presented in Table 3 agreed on the pump based small-scale irrigation restricted by the serious quality problem in the sector (93.34%); high maintenance cost (96.81%); high Initial cost (82.61%); the energy source is not readily available and the cost is high (91.30%); awareness gap, there is a problem to select and use the right technology (74.47%); limited experience sharing culture with successful farmers (61.11%); important farm machinery is not properly introduced by the relevant body (71.74%); lack of quality water pump supplier (79.12%) and shortage of qualified maintenance experts (65.17%). However, significantly disagreed on government laws, policies and regulations are not conducive (81.52%); inadequacy of infrastructure such as power, water, road, etc. (86.18%) has influence; Lack of access to finance and loans and banks and credit institutions overstated requirement to finance on the sector (70.33%); the agriculture practice doesn't require it (95.50%); farmers who have already started using it in our area are not as effective as expected (98.86%) (Fig. 5).

Fig. 5. Small farm holders waiting for fuel (Left) and Treadle pumps disposed of due to quality defect in Ethiopia (Right) (Source: a survey on February 2021)

During the physical survey, the small-scale farmers have been hit by a severe fuel shortage in Ethiopia. long queues have been formed outside fuel stations waiting for hours and days to buy fuel for their pumps. Similarly, a huge number of Treadle pumps disposed of due to quality defects have been observed in manufacturing shops.

Table 3. Analysis of factors restricting small farm holders from deploying pump-based small-scale irrigation and users. (Source: a survey on February 2021)

S.N	Questionnaire	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	This is because government laws, policies, and regulations are not conducive	59.78%	21.74%	7.61%	8.70%	2.17%
2	Inadequacy of infrastructure such as power, water, road etc.	64.89%	21.28%	7.45%	6.38%	0.00%
3	Because the pumps on the market have a high maintenance cost	1.06%	2.13%	0.00%	68.09%	28.72%
4	Lack of access to finance and loans; Banks and credit institutions overstated requirement to finance in the sector	21.98%	48.35%	25.27%	3.30%	1.10%
5	Due to the awareness gap, there is a problem with choosing and use the right technology	5.32%	19.15%	1.06%	46.81%	27.66%
6	Limited experience sharing culture with successful farmers	7.78%	18.89%	12.22%	36.67%	24.44%
7	It is because our agriculture practice doesn't require it	62.92%	32.58%	1.12%	1.12%	2.25%
8	This is because farmers who have already started using it in our area are not as effective as expected	78.41%	20.45%	0.00%	1.14%	0.00%
9	This is because the technologies we need have not been properly introduced by the relevant body	18.48%	7.61%	2.17%	42.39%	29.35%
10	Neither the pumps nor their accessories aren't widely available in the area	3.30%	7.69%	9.89%	51.65%	27.47%
11	The quality problem in the sector is so serious that we are afraid to buy and use it (They are not long-lasting)	3.33%	2.22%	1.11%	55.56%	37.78%
12	This is because it is not easy to find a professional who can provide qualified maintenance and professional support	26.97%	4.49%	3.37%	2.25%	62.92%
13	It's because of the high initial cost of the pumps we can't afford it	2.17%	11.96%	3.26%	51.09%	31.52%
14	The energy source is not readily available and the cost is high (They work with fossil fuel)	1.09%	2.17%	5.43%	63.04%	28.26%

Similarly, the failure rate of pump components is assessed and presented in Table 4 based on the secondary data obtained from the maintenance service provider. Accordingly, the majority of the pump failure is associated with a prime mover, fitting and fixtures, and impeller which accounts for a failure rate of 30.11%, 29.57%, and 14.52% respectively. Other mechanical failures associated with bearing, casing, diffuser, mechanical seal, and O-ring accounts for a failure rate of 25.80% only. So, an initial focus should be given to improve prime mover than to fitting and fixtures and impeller.

Table 4. Component's failure rate analysis for pumps used for small scale irrigation (Source: a survey on February 2021)

S.N	Problem source	Percentage share
1	Prime mover	30.11%
2	Fitting and fixtures	29.57%
3	Impeller	14.52%
4	Bearing	9.68%
5	Casing	5.91%
6	Diffuser	3.76%
7	Mechanical seal	3.76%
8	O-ring	2.69%

Considerably technical experts agreed that most of the pumps deployed in the community for small-scale irrigation have poor performance and untrustworthiness. Assessment made to point out the root causes of technical complications that affecting the intensification of pump-based small-scale irrigation. According to the assessment result, 75.63% of the technical expert agreed that the problem arises from the type and quality of the material from which they made and 67.79% of them agreed that It arises from inappropriate use. Other factors such as Manufacturing process limitations (35.03%), power source it uses (32.25%), design limitations (27.65%), and assembly limitations (1.88%) have a considerable effect (Table 5).

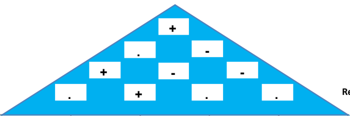
Table 5. Analysis of small-scale irrigation pumps limitation affecting intensification in the community (Source: a survey on February 2021)

S.N	Questionnaire	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	Arise from on the type and quality of the material from which they made (75.63%)	4.73%	13.40%	6.24%	48.84%	26.79%
2	It is caused by inappropriate use (67.79%)	6.55%	19.02%	6.64%	41.74%	26.05%
3	Arise from Manufacturing process limitations (35.03%)	38.61%	22.77%	3.60%	21.44%	13.59%
4	Arise from the power source it uses (32.25%)	35.35%	25.74%	6.67%	18.90%	13.35%
5	Arise from design limitations (27.65%)	1.13%	0.56%	70.67%	26.52%	1.13%
6	Arise from assembly limitations (1.88%)	73.25%	24.49%	0.37%	1.13%	0.75%

4.2 Comparative Study

A survey was conducted for a comparative study of existing pump types deployed in the community for small-scale irrigation. These include engine-powered (diesel and petrol), motor-powered (electric and solar), and manual (Afridev, pedal, rope, and washer and treadle). Small farm holders pump requirements/constraints data collected using **a** market survey from farmers who came to purchase pumps for small scale irrigation, Information from the pump and spare suppliers, Information from maintenance service providers, and farmers complaints organized by agricultural extension workers.

The quality function deployment (QFD) study as presented in Fig. 6 at the initial stages were concerned with finding out what the small farm holders need actually in the pump. More than 22 requirements were identified through telephone interviews, face-to-face interviews, and customer complaint history. Then the customer's important requirements rating identified through questionnaires from farm holders, retailers, and maintenance service providers. According to the finding, the small farm holders rated long lasting 15.42%, low initial cost 15.17%, low operating cost 14.48%, low maintenance demand 13.53%, efficient 11.02%, safety 10.39%, low operation & maintenance skill requirement 10.07%, and better capacity (head) 9.92%. Then important engineering characteristics type of prime mover, cost of production, design life, use of standard parts, and several components identified to ensure customer satisfaction. Then the two highlighting conflicting characteristics correlated and target values stetted. According to calculated priority rank cost of production, type of prime mover, several components, use of standard parts, and design life have a high priority rank sequentially.



Correlation:	+	.	-
	Positive	No correlatio	Negative

Relationships:	9	6	3	0
	Strong	Moderate	Weak	None

1: low, 5: high	Desired direction of improvement (↑,0,↓)						Competitive evaluation (1: low, 5: high)				
Customer importance rating	Functional Requirements (How) → / Customer Requirements - (What) ↓	Type of prime mover	Cost of production	Design life	Use of Standard Parts	Number of components	Weighted Score	Satisfaction rating	Solar Pump	Engine Pump	Manual Pump
4.60	Low operating cost	8	7	7	5	0	14.48%	4.5	4.5	1	2.5
4.30	Low maintenance demand	7	7	0	9	3	13.53%	4	4	1	2
3.20	Low operation & maintenance skill	8	0	1	6	9	10.07%	3	2	1	3
4.90	Long lasting	4	5	9	3	6	15.42%	4	3.5	3	4
3.30	Safety	3	3	0	0	6	10.39%	5	5	3.5	4.5
3.50	Efficient	3	6	1	0	9	11.02%	4.5	4	3	4.5
3.15	Better capacity (head)	1	3	1	0	0	9.92%	5	4	5	2
4.82	Low initial cost	7	9	6	9	7	15.17%	4	2	3	4
31.77											
	Technical importance score	169.39	170.53	115.07	138.98	156.14	1				
	Importance %	16939%	17053%	11507%	13898%	15614%	75011%				
	Priorities rank	**2**	**1**	**5**	**4**	**3**					

Fig. 6. Quality function deployment (QFD) to assess farmers pump requirement

The customer importance ratings and competitive comparison data were gathered during the customer requirement survey. Then based on the competitive evaluation result, a pump having a satisfactory rating of 4.5, 4, 3, 4, 5, 4.5, 5, and 4 for long-lasting, low initial cost, low operating cost, low maintenance demand, efficient, safe, low operation & maintenance skill and better capacity (head) respectively needed. When we review different possibilities hydro-powered pumps are the best alternative. Hydro-powered pumps use the energy of water. It does not require any other external sources of energy such as fossil fuel or electricity. As a result, it has zero operating costs and doesn't emit any greenhouse gas. The technology has a great contribution to the health and finances of the farmers and also supports the efforts in preventing environmental degradation.

5 Conclusion

In conclusion, this study shows that small-scale irrigation is restricted by the serious quality problem, high maintenance and initial cost, energy source and cost, awareness gap, limited experience sharing culture, lack of supplier, and shortage of qualified maintenance experts. Besides, the majority of the pump failure is associated with a prime mover, fitting and fixtures, and impeller which accounts for a failure rate of 30.11%, 29.57%, and 14.52% respectively. Other mechanical failures associated with bearing, casing, diffuser, mechanical seal, and O-ring accounts for a failure rate of 25.80% only. Moreover, considerable technical experts agreed that most of the pumps deployed in the community for small-scale irrigation have poor performance and untrustworthiness. The assessment made to point out the root causes of technical complications that affecting the intensification of pump-based small-scale irrigation. According to the assessment result, 75.63% of the technical expert agreed that the problem arises from the type and quality of the material from which they made and 67.79% of them agreed that it arises from inappropriate use. Other factors such as manufacturing process limitations (35.03%), power source it uses (32.25%), design limitations (27.65%), and assembly limitations (1.88%) have a considerable effect.

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