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A MULTI-CRITERIA ANALYSIS ON SOLAR AND TRADITIONAL TECHNOLOGIES IN IRRIGATION DEVELOPMENT

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ABSTRACT

The main aim of this study is to conduct an economic analysis and a multi-criteria analysis of electric, diesel, and solar irrigation pumps to find the best irrigation technology. After collecting the necessary data, a cost comparison is made between solar and conventional irrigation technologies. The cost of each technology is then compared using a 25-year lifespan to determine which one will be less expensive. Since there are additional important factors to consider while selecting the optimal technology, a multi-criteria analysis is done too. The cost comparison reveals that, in contrast to the other two, the solar system has higher startup expenditures but lower ongoing operating and maintenance costs. According to the cost analysis of the three technologies, solar technology is significantly less expensive than electric and diesel alternatives. Aside from the cost, electric irrigation technology appears to be a better option than solar and diesel technologies when considering other aspects like farmer satisfaction, necessary installation land, technology accessibility, weather obstruction, etc.

Keywords: *Irrigation technologies, Multi-criteria analysis, Net present cost analysis.*

1. INTRODUCTION

Bangladesh has more than 8.5 million hectares of arable land, although only about 65% is irrigated (BADC, 2019). Currently, more than 1.58 million pumps are used in irrigation systems, where diesel engines operate 78.5%, 21.4% are operated by electricity, and 0.2% are driven by the solar system (BADC, 2019). Knowing about irrigation's modern technologies is necessary to introduce farmers to a more economical and cheap irrigation system. It will be beneficial for both farmers and the environment. With increasing reliance on water pumping, climate change, and limited access to reliable electricity for many farmers, the development of irrigation systems is becoming mandatory. Cost-effective irrigation technology can be a good solution for higher yields and reasonable profit for Bangladeshi farmers.

As electricity-run and solar-powered irrigation pumps rise in Bangladesh, diesel consumption has reduced from 4.3 million tons to 3.4 million tons in 2018. At present, Bangladesh has 1.34 million diesel-run pumps that consume fuel worth over $1 billion every year. The number of electric-run pumps is about 2,40,000, and solar pumps are about 1446, generating 31 MW per hour. The Infrastructure Development Company Ltd (IDCOL), a state-owned non-banking financial institution, has targeted installing 50,000 solar irrigation pumps by 2025 (Sajid, 2020).

According to Hossain et al. (2015), solar panel cost is the individual highest cost (45%) in solar pumps, followed by installation cost (18%), motor cost (16%), and pump cost (10%). Still, investment in solar pumps is risk-free compared to diesel engine-operated pumps. The life cycle cost of a diesel engine-operated pump is lower for up to five years. After five years, the life cycle cost of the solar pump became lower than that of the diesel engine-operated pump. The benefit-cost ratio (BCR) of solar pumps (1.91) is higher than diesel-operated pumps (1.31). The internal rate of return of solar pumps (80%) was also higher than diesel-operated irrigation pumps (71%).

Solar irrigation requires higher initial investment and its payback period is about 14.58 years. A combination of solar and diesel systems, a hybrid technology, can reduce the payback time to 7 years. This hybrid system has a higher NPV and IRR than the general solar system (Hasnat et al., 2015). According to the present scenario of solar irrigation in Bangladesh, Al-Amin et al. (2018) suggested a design of a new irrigation model for the solar irrigation system. They have proposed a new model of solar irrigation, including a mini-grid. Without a mini-grid, the solar system costs BDT 3,500/bigha/season, whereas with the mini-grid, the cost reduces to BDT 2,368/bigha/season.

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SWP systems costs have dropped by 50 percent over the past decade but require higher capital. The life cycle cost analysis shows that the energy cost from a grid-tied SWP system is about half of current electric tariffs amortized over 25 years at the cost of about BDT 2.2 per kWh. The main challenges of solar technology are lack of awareness about the technology, upfront capital costs, and the absence of technical repair services. (Sayeed et al., 2020).

According to Arora (2013), about 9 million irrigation pumps are run by diesel in India (considering 5HP pumps). Out of these 9 million diesel pumps, 75% (6.75 million) are thought to be in solar-powered asset areas. Out of 6.75 million diesel pumps, 70% have land to establish a PV framework. The total number of pump sets in the solar resource region and land for solar PV installation comes to 4.725 million, which is around 16,785 MW (half of the diesel pumps). If it is possible to replace 4.5 million diesel pumps with solar pumps, it will save 2,23,800 million liters of diesel and 470 billion kg of carbon dioxide per annum.

In this study, we have made a cost comparison between solar and conventional irrigation systems; with the help of costing data, we have performed a cost analysis using the net present value (NPV) concept. Since cost is not the only factor, we have also done a multi-criteria investigation that centers on the expenses and other significant elements like a farmer's satisfaction, weather obstruction, availability of irrigation technology, etc.

2. METHODOLOGY

2.1 Selection of Study Area

For this study, we collected data from four areas. We have collected data about solar, electric, and diesel-based irrigation costs. As cost depends on pump capacity, we have selected those places where pump capacities are pretty similar. We have collected data from Nandiasangon, Sreepur, Gazipur and Chokpara, Kalupara, Rangpur for solar irrigation pumps. For the electric irrigation pump, we have collected data from Balarampur, Mahadebpur, Naogaon, and for the diesel irrigation pump, we have collected data from Kalighati, Tangail.

2.2 Data Collection by Field Survey

For this study, seven hectares of land were considered. The total initial cost includes the cost of the submersible pump, solar panel, solar inverter, transformer, boring, pump house, required area cost to set a pump, etc.

Initial Cost: For the solar system, considering a 10 HP submersible pump, an 8kW solar inverter, and 15.75 kW of PV cells, the total cost of this project was BDT 31,34,000 (IDCOL, 2020). However, IDCOL provides 50% of the cost as a grant and the other 35% as soft loans with an interest rate of 6% and eight years of tenure. Considering eight years of tenure, farmers have to invest approximately BDT 16,27,000. About 110–120 m^2 of land is required to set up this structure. Considering a 10 HP electric submersible pump, approximately BDT 4,00,000–4,50,000 is required for electric systems. Setting up this structure takes 12–15 m^2 of land. Considering a 10 HP diesel submersible pump for the diesel system, around BDT 3,50,000–4,00,000 is required. About 12–15 m^2 of land is required to set up this system.

Operation and Maintenance Cost: Solar systems require very little maintenance and have no operating costs. Every season, electricity expenditures for the electrical framework are BDT 26,200, and maintenance costs are roughly BDT 500. For diesel systems, the cost of maintenance is BDT 1,500, the cost of lubricants is BDT 1,500, and the cost of fuel (diesel) is BDT 1,26,000 per season. All these figures are approximations; they vary depending on the amount of irrigation needed.

2.3 Data Collection from Farmer's Survey

We spoke with the farmers about their satisfaction with their present irrigation system, what sorts of issues they are facing during irrigation, which innovation they prefer, and whether they have any will to change their irrigation system framework. Based on those opinions, we have rated those criteria in accordance with how important they are to the farmers.

2.4 Performing a Cost Comparison

Using the initial cost, operation and maintenance cost, fuel cost, land requirement, and equipment lifespan, the comparison is made between solar and other conventional irrigation technologies.

2.5 Performing a Cost Analysis Based on Different Irrigation Technologies

In this section, considering 25 years of the project's lifespan, we have calculated the project's net present value. Net present value (NPV) is the contrast between the current value of money inflows and the present value of cash outflows throughout some time frame.

With solar irrigation, we will benefit by not paying any extra charges for electricity. Benefits from solar irrigation can be calculated through this equation:

$$Benefit = Pump\ capacity(kW) \times Operation\ hour \times Electricity\ cost \times Operation\ days \quad (1)$$

Both electric and diesel-based technology will cost fuel and electricity every year. This calculation can be used to determine the costs associated with electric or diesel irrigation:

$$Cost = Pump\ capacity(kW) \times Operation\ hour \times Electricity\ or\ Diesel\ cost \times Operation\ days \quad (2)$$

The net benefit or net cost is calculated through this equation. The net benefit is found only for solar technology, while additional charges are found for both electric and diesel technology.

$$Net\ Benefit/Cost = (Initial\ cost + Operation, maintenance\ \&\ replacement\ cost) - Benefit \quad (3)$$

The present value factor is a formula to estimate the current value of money to be received at some future date. This factor is determined through this equation:

$$Present\ Value\ factor, e = \frac{1}{(1+i)^n} \quad (4)$$

Here, i = discount rate (considered 5% in this case).
n = number of years.

We get the present value by multiplying the present value factor and net benefit/cost. The summation of all present values shows what will be the total benefit or drawbacks of those technologies.

$$Total\ net\ present\ value = \sum_1^n (Present\ value\ factor \times Net\ benefit) \quad (5)$$

Here, a lower total net present value indicates a higher economic advantage.

2.6 Analyzing Water Pumping Technology through Multi-Criteria Analysis

Multi-criteria analysis is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision-making. It is a two-stage decision procedure. The first stage distinguishes a set of objectives or goals and, afterward, tries to recognize the compromises between those targets for various strategies or methods of accomplishing a given approach. Multi-criteria analysis is done in these steps:

Step 1: Scoring

It is the performance concerning criteria. It displays the data range. It can be a monetary value, a condition, a positive or negative effect, and so on.

Step 2: Standardization

It is reducing scores on the same scale. This scale is from 0 to 1. Here, 0 indicates the worst choice, and 1 indicates the best option. Other scores are expressed as a fraction between 0 and 1. To standardize other scores (X), we will use this formula:

$$Standardized\ score = \frac{|\ Actual\ score - Worst\ score\ |}{|\ Best\ score - Wors\ \ score\ |} = \frac{|X\text{-}0|}{|1\text{-}0|}$$

$$X = \frac{|\ Actual\ score - Worst\ score\ |}{|\ Best\ score - Wors\ \ score\ |} \quad (6)$$

Step 3: Ranking

After standardization, the criteria are ranked according to their importance. Important criteria get a higher ranking, and less essential criteria get a relatively lower ranking.

Step 4: Weighting

Based on ranking, the criterion gets a weight value. Here, higher-ranked criteria get higher weightage, whereas lower-ranked criteria get relatively lower weightage. It is denoted by 'W'.

Step 5: Multiplication & Summation

$$Total\ Score,\ S = \Sigma(W \times X) \quad (7)$$

Here, W = Weightage assigned to a criterion.

X = Standardized value assigned to the criterion.

The strategy that holds the maximum total score (S) indicates the best approach.

3. DATA ANALYSIS

3.1 Cost Comparison of Different Irrigation Technologies

Comparison improves comprehension by emphasizing important information, making abstract concepts more apparent, and removing any ambiguity between related ideas. A cost comparison (one season) between solar and traditional irrigation technologies is given below:

Table 1: Summarized cost (BORO Season, Jan–May).

Pumping System	Solar Pump	Diesel Pump	Electric Pump
Initial Investment (BDT)	16,27,000	3,70,000	4,20,000
Maintenance Cost (BDT)	100	1,500	500
Cost of Fuel (BDT)	00	1,26,000	26,200
Lubricant Price (BDT)	00	1,500	00
Required Space (m^2)	112	13	13
Equipment Lifespan (Year)	Solar panel = 20 – 25 Pump = 8–10 Solar inverter = 5–8	Diesel generator = 8–10 Pump = 8–10	Pump = 8–10

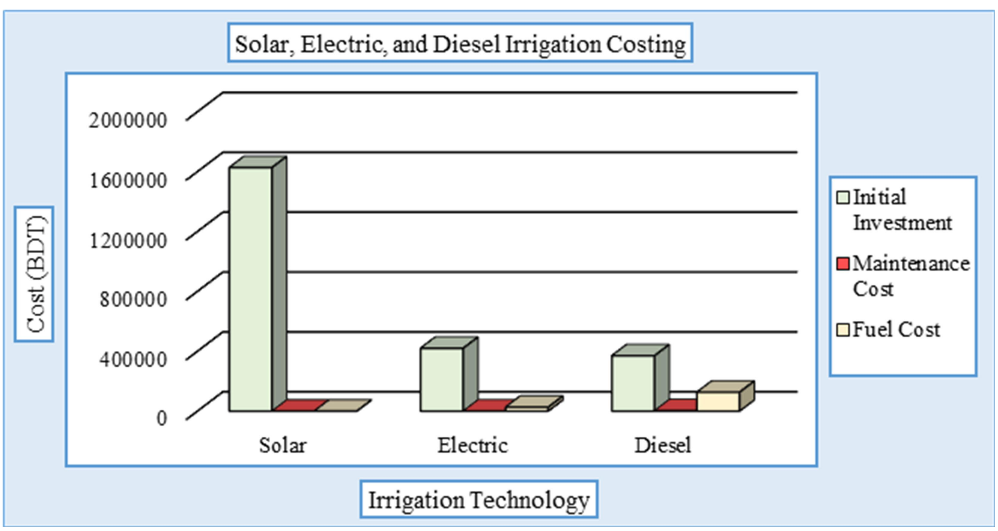


Figure 1: Graphical representation of cost comparison

If we focus on the initial investment in Table 1, solar irrigation requires a higher investment (almost four times higher than the traditional system) due to the higher price of PV cells. For higher investment, a lot of farmers do not like to shift to solar technology. They still prefer their traditional systems because operating them appears simple to them, and they have been using them for a long time. Though the initial cost is the primary headache of the solar system, if we look at the PV module prices of recent years (Fig. 2), we can see PV module prices are falling dramatically. Therefore, we can conclude that due to higher initial expenses, solar technology is still out of reach for most Bangladeshi farmers, who instead favor irrigation systems powered by electricity. However, the initial investment will be reduced in the future, and solar technology will be the top choice.

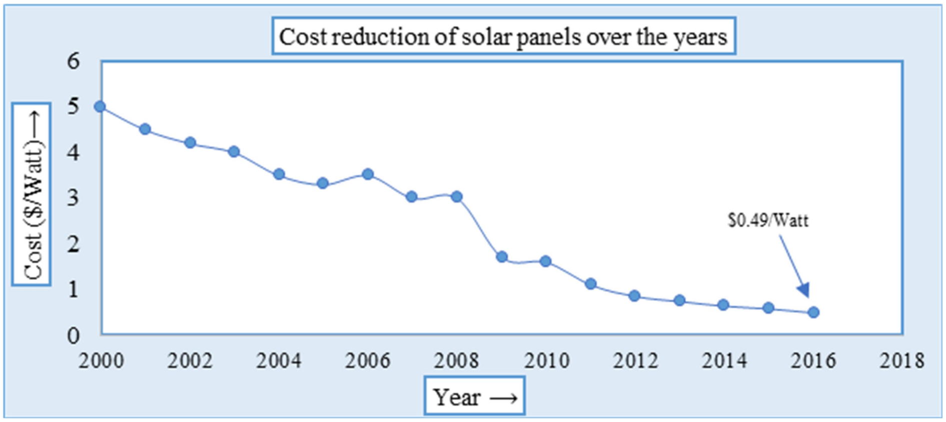
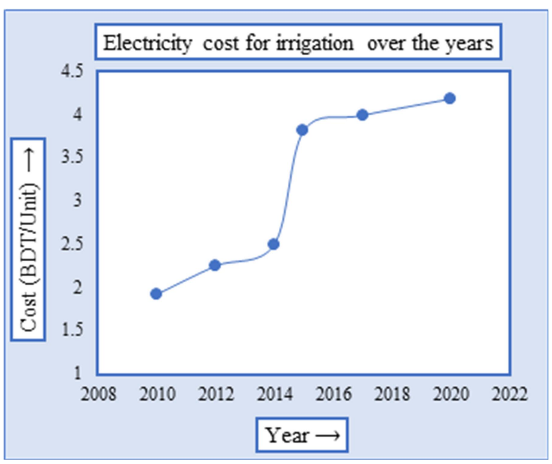


Figure 2: Cost reduction of PV modules (Shahan, Z., 2016).

In solar irrigation, the radiation from the sun is the fuel source at no cost. Besides, the extra energy generated in the off-season can be sold or used in other sectors. In the case of electric irrigation, the pump consumes a massive amount of electricity. Though the price of electricity is not very high nowadays, the price of electricity is rising every year. At present, electricity costs are approximately BDT 450–500/bigha/season. But this price will increase in the future. The increase in electricity costs is shown in Figure 3.

The efficiency of a diesel pump is very low, which is one of the major reasons for the high amount of diesel consumed by running a pump. At present, diesel costs are approximately BDT 2200–2,400/bigha/season. This price will increase more in the future. The price of diesel has increased three times in the past 15 years. The increase in diesel fuel prices in Bangladesh is shown in Figure 3.

Considering the current fuel pricing, fuel consumption, and future fuel prices, we can say solar irrigation is the best choice.



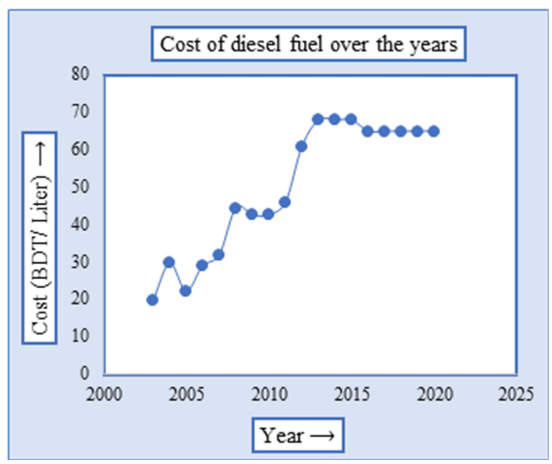


Figure 3: Increase in electricity (DPDC, 2020) and diesel (BPDB, 2020) cost.

3.2 Cost Analysis of Different Types of Irrigation Technologies

In this section, we have performed a cost analysis of irrigation technologies considering 25 years of their lifespan. For this, we have assumed that the pump will run 200 days/year (2 seasons); therefore, the operation and maintenance costs have changed. Fuel and electricity costs have been calculated considering the average pump runs 7 hours daily. As electricity and diesel costs rise frequently, we have considered those costs as percentages according to the previous year's cost-increasing data. We have also assumed that solar inverters and submersible pumps require replacement every 7 and 10 years respectively. The solar panel does not require replacement within 25 years.

Table 2: Net present value of solar irrigation technology.

Year	Initial/ Maintenance /Replacement Cost (BDT)	Energy production (kW)	Electricity Costs (BDT/Unit) (Increases by 2.3% each year)	Benefit = kW × Hour × Electricity Cost × Operation Days (BDT)	Net Benefit (BDT)	Present Value Factor, $e = \frac{1}{(1+i)^n}$ (Discount rate, i=5%)	Net Present Value (BDT)
0	1627000	7.50	4.16	43680	-1583320	1.00	-1583320
1	300	7.50	4.26	44684	44384	0.95	42271
2	300	7.50	4.35	45712	45412	0.91	41190
3	300	7.50	4.45	46763	46463	0.86	40137
4	300	7.50	4.56	47839	47539	0.82	39110
5	300	7.50	4.66	48939	48639	0.78	38110
6	300	7.50	4.77	50065	49765	0.75	37135
7	300	7.50	4.88	51216	50916	0.71	36185
8	80000	7.50	4.99	52394	-27605	0.68	-18684
9	300	7.50	5.10	53599	53299	0.64	34357
10	300	7.50	5.22	54832	54532	0.61	33478
11	150000	7.50	5.34	56093	-93906	0.58	-54905
12	300	7.50	5.47	57383	57083	0.56	31786
13	300	7.50	5.59	58703	58403	0.53	30972
14	300	7.50	5.72	60053	59753	0.51	30179
15	300	7.50	5.85	61435	61135	0.48	29407
16	80000	7.50	5.99	62848	-17151	0.46	-7857
17	300	7.50	6.12	64293	63993	0.44	27920
18	300	7.50	6.26	65772	65472	0.42	27205
19	300	7.50	6.41	67285	66985	0.40	26508
20	300	7.50	6.56	68832	68532	0.38	25829
21	300	7.50	6.71	70415	70115	0.36	25167
22	150000	7.50	6.86	72035	-77964	0.34	-26652
23	300	7.50	7.02	73692	73392	0.33	23894
24	80000	7.50	7.18	75387	-4612	0.31	-1430
						Total (BDT) =	**- 1072000**

Regarding net present worth, a cost analysis of three different irrigation systems is displayed in Table 2, Table 3, and Table 4. Net present value is a monetary concept that attempts to capture the total value of a potential investment. The idea behind NPV is to project all the future cash inflows and outflows associated with an investment, discount all of those future cash flows to the present, and then add them all up. After adding all the positive and negative income, the investment's net present value is the resulting number. For this situation, the positive value addresses income, and the negative value addresses cost.

From the above tables, the net present value of those three technologies shows that, considering the costs incurred during the project's life, solar technology costs BDT 10,72,000, whereas electric and diesel technology cost BDT 14,10,070 and BDT 45,38,620 respectively. Since solar technology costs are minimum, it has a higher economic benefit. Moreover, enabling net metering on the solar system can generate revenue by selling extra energy to the national grid. Although an electricity-based system is more expensive than a solar system, it can still be a viable option for the time being. The diesel-based irrigation system is nearly four times more costly than the other two, indicating that it is the most inefficient method of irrigation and should be avoided.

Table 3: Net present value of electric irrigation technology.

Year	Initial/ Maintenance/ Replacement Cost (BDT)	Energy consumption (kW)	Electricity Costs (BDT/Unit) (Increases by 2.3% each year)	Yearly Electricity Cost (BDT)	Total Cost (BDT)	Present Value Factor, $e = \frac{1}{(1+i)^n}$ (Discount Rate, i = 5%)	Net Present Value (BDT)
0	420000	7.50	4.16	43680	-463680	1.00	-463680
1	800	7.50	4.26	44684	-45484	0.95	-43318
2	800	7.50	4.35	45712	-46512	0.91	-42188
3	800	7.50	4.45	46763	-47563	0.86	-41087
4	800	7.50	4.56	47839	-48639	0.82	-40015
5	800	7.50	4.66	48939	-49739	0.78	-38972
6	800	7.50	4.77	50065	-50865	0.75	-37956
7	800	7.50	4.88	51216	-52016	0.71	-36967
8	800	7.50	4.99	52394	-53194	0.68	-36004
9	800	7.50	5.10	53599	-54399	0.64	-35066
10	800	7.50	5.22	54832	-55632	0.61	-34153
11	180000	7.50	5.34	56093	-236093	0.58	-138039
12	800	7.50	5.47	57383	-58183	0.56	-32399
13	800	7.50	5.59	58703	-59503	0.53	-31556
14	800	7.50	5.72	60053	-60853	0.51	-30735
15	800	7.50	5.85	61435	-62235	0.48	-29936
16	800	7.50	5.99	62848	-63648	0.46	-29157
17	800	7.50	6.12	64293	-65093	0.44	-28400
18	800	7.50	6.26	65772	-66572	0.42	-27662
19	800	7.50	6.41	67285	-68085	0.40	-26943
20	800	7.50	6.56	68832	-69632	0.38	-26243
21	800	7.50	6.71	70415	-71215	0.36	-25562
22	180000	7.50	6.86	72035	-252035	0.34	-86158
23	800	7.50	7.02	73692	-74492	0.33	-24252
24	800	7.50	7.18	75387	-76187	0.31	-23623
						Total (BDT) =	**- 1410070**

3.3 Multi-Criteria Analysis

The multi-criteria analysis shows that electric irrigation system innovation holds the most significant focus (53.7 points). However, it has a higher operating cost. The majority of farmers prefer this innovation because it requires less initial investment and has no weather constraints. As a result, it is the best option.

Solar technology (45 points) is not too dissimilar to electric technology. If we look at three major areas where solar-based innovation is falling short, they are its underlying expense, accessibility, and climate impediment. The underlying cost is consistently decreasing by 10%, and solar technology production is increasing. Several governmental and non-governmental organizations are attempting to spread this innovation throughout the country. As a result, this constraint will be reduced in the future. As per this review, solar irrigation system is a decent option in contrast to an electric irrigation system, and it has a higher capability of becoming the future irrigation system framework.

The marks of diesel-based irrigation systems (32 points) remain far behind the other two advances. Because of higher operation, maintenance, fuel costs, and carbon emissions, farmers generally prefer not to use this irrigation technology.

Table 4: Net present value of diesel irrigation technology.

Year	Initial/ Maintenance/ Replacement Cost (BDT)	Energy Consumption (kW)	Diesel price (BDT/Liter) (Increases by 2.25% each year)	Yearly Diesel Cost (BDT)	Total Cost (BDT)	Present Value Factor, $e = \frac{1}{(1+i)^n}$ (Discount Rate, i = 5%)	Net Present Value (BDT)
0	370000	7.50	65.00	214500	-584500	1.00	-584500
1	4500	7.50	66.46	219326	-223826	0.95	-213167
2	4500	7.50	67.96	224261	-228761	0.91	-207493
3	4500	7.50	69.49	229306	-233806	0.86	-201971
4	4500	7.50	71.05	234466	-238966	0.82	-196598
5	4500	7.50	72.65	239741	-244241	0.78	-191369
6	4500	7.50	74.28	245136	-249636	0.75	-186282
7	4500	7.50	75.96	250651	-255151	0.71	-181331
8	4500	7.50	77.66	256291	-260791	0.68	-176513
9	4500	7.50	79.41	262057	-266557	0.64	-171825
10	4500	7.50	81.20	267954	-272454	0.61	-167263
11	150000	7.50	83.03	273983	-423983	0.58	-247894
12	4500	7.50	84.89	280147	-284647	0.56	-158502
13	4500	7.50	86.80	286451	-290951	0.53	-154297
14	4500	7.50	88.76	292896	-297396	0.51	-150205
15	4500	7.50	90.75	299486	-303986	0.48	-146222
16	4500	7.50	92.80	306224	-310724	0.46	-142346
17	4500	7.50	94.88	313114	-317614	0.44	-138574
18	4500	7.50	97.02	320159	-324659	0.42	-134902
19	4500	7.50	99.20	327363	-331863	0.40	-131329
20	4500	7.50	101.43	334729	-339229	0.38	-127851
21	4500	7.50	103.72	342260	-346760	0.36	-124467
22	150000	7.50	106.05	349961	-499961	0.34	-170911
23	4500	7.50	108.44	357835	-362335	0.33	-117966
24	4500	7.50	110.87	365886	-370386	0.31	-114845
						Total (BDT) =	**- 4538620**

Table 5: Performance of the criterion and their standardized scores.

	Performance of The Criterion			Standardized Scores		
Criteria	**Solar Irrigation**	**Electric Irrigation**	**Diesel Irrigation**	**Solar Irrigation (X_1)**	**Electric Irrigation (X_2)**	**Diesel Irrigation (X_3)**
Initial Investment (BDT)	16,27,000	4,20,000	3,70,000	0	0.96	1
Maintenance Cost (BDT)	100	500	3,000	1	0.86	0
Area Requirement (m^2)	112	13	13	0	1	1
Fuel Cost (BDT)	00	26,200	1,26,000	1	0.74	0
Accessibility	Low	Medium	High	0	0.5	1
Green Technology	+ +	0	– –	1	0.5	0

	Performance of The Criterion			Standardized Scores		
Criteria	**Solar Irrigation**	**Electric Irrigation**	**Diesel Irrigation**	**Solar Irrigation (X_1)**	**Electric Irrigation (X_2)**	**Diesel Irrigation (X_3)**
Project Life (Year)	25	10	10	1	0	0
Loan Facility	Yes	No	No	1	0	0
Farmer's Satisfaction	+	+ +	– –	0.75	1	0
Weather Obstruction	Yes	No	No	0	1	1

Table 6: Ranking, weightage, and multiplication.

Criteria	**Rank**	**Point**	**Weight (W)**	**Solar Irrigation (W×X₁)**	**Electric Irrigation (W×X₂)**	**Diesel Irrigation (W×X₃)**
Initial Investment (BDT)	1	10	10	0	9.6	10
Maintenance cost (BDT)	2	9	9	9	7.7	0
Area Required (m^2)	5	6	6	0	6	6
Fuel Cost (BDT)	1	10	10	10	7.4	0
Accessibility	3	8	8	0	4	8
Green Technology	5	6	6	6	3	0
Project Life (Year)	3	8	8	8	0	0
Loan Facility	5	6	6	6	0	0
Farmer's Satisfaction	3	8	8	6	8	0
Weather Obstruction	3	8	8	0	8	8
		Total (S) = Σ (W×X) =		**45**	**53.7**	**32**

4. CONCLUSIONS

Every irrigation technology has some benefits and limitations. Considering both, we have tried to do economic and multi-criteria analysis to find a better technology that Bangladeshi farmers can adopt. The underlying expense correlation observed that solar pump technology requires higher capital, whereas electric and diesel pump costs are somewhat lower. However, the solar system's operation and maintenance costs are lower compared to conventional irrigation systems. The cost analysis of the three technologies shows that, considering the expenses incurred during the life of the project, the cost is minimal for solar technology (BDT 10,72,000) compared to electricity (BDT 14,10,070) and diesel (BDT 45,38,620) technologies. In the multi-criteria analysis, electric irrigation technology is proving to be the best choice (Point 53.7) concerning solar (Point 45) and diesel (Point 32) technologies.

Due to lower investment and good performance, electric irrigation technology is currently the top choice among farmers. But almost 60% of rural areas of Bangladesh have low or no access to electricity for irrigation purposes. As diesel is an uneconomical way of irrigation, solar irrigation can be an excellent alternative to electricity.

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