A MULTICRITERIA ANALYSIS ON SOLAR AND TRADITIONAL TECHNOLOGIES IN IRRIGATION DEVELOPMENT

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ABSTRACT

Bangladesh is an agricultural country, where almost 70% of the population earns their livelihood through cultivation. Irrigation is a major input to agriculture. A good harvest can never be produced without a proper irrigation system. Since high-yielding varieties of rice are very susceptible to drought, they need very frequent irrigation. Usually, we are familiar with two types of pumps used for irrigation in our country; electric pumps and diesel pumps. However, in recent years, we have been introduced to a new system for irrigation, which is the solar irrigation system. 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 for irrigation development. We have collected the necessary data from field and farmer surveys about initial, operating, and maintenance costs, major benefits, and limitations. We carried out the project mostly during the BORO season of 2019-20. We have made a cost comparison for all the technologies. Then we have done an economic analysis for all these technologies to determine which technology will cost less considering a 25-years lifespan. Since cost is not the only factor in choosing the best technology, we have considered some other factors and performed a multi-criteria analysis on solar and other conventional irrigation systems. The initial cost comparison found that solar technology requires higher capital, whereas electric and diesel pump costs are relatively lower. But operation and maintenance cost is relatively lower in solar pumps compared to other conventional irrigation systems. The cost analysis of the three technologies showed that the cost is minimal for solar technology compared to electric and diesel technologies. Aside from the cost, other factors such as farmer satisfaction, required land for installation, technology accessibility, and so on were considered in the multi-criteria analysis. Based on that analysis, electric irrigation technology is the superior choice over solar and diesel technologies.

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

1 INTRODUCTION

The net Cultivable area in Bangladesh is more than 8.5 million hectares, whereas about 65% of the net cultivable area is irrigated (BADC, 2019). Currently, there are more than 1.58 million pumps used in irrigation systems where 78.5% are operated by diesel engines; 21.4% are operated by electricity; 0.2% are operated by the solar system (BADC, 2019). It is necessary to know about irrigation's modern technologies to introduce the farmers to a more economical and cheap irrigation system. It will be beneficial for both farmers and the ecology. With increasing reliance on water pumping, climate change, limited access to reliable electricity for many farmers, development of irrigation systems is becoming mandatory. Cost-effective irrigation technology can be a good solution for higher yield and reasonable profit for Bangladeshi farmers.

As the use of electricity-run and solar-powered irrigation pumps are rising 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 fuels 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 pump followed by installation cost (18%), motor cost (16%,) and pump cost (10%). Still, investment in solar pumps is more risk-free than diesel engine-operated pumps. The life cycle cost of a diesel engine-operated pump is lower up to 5 years. After five years, the life cycle cost of the solar pump became lower than that of the diesel engine-operated pump. The BCR of solar pumps (1.91) is higher than diesel-operated pumps (1.31). Internal rate of return of solar pump (80 %) was also found higher than diesel-operated irrigation pump (71 %).

Solar irrigation requires higher initial investment and its payback period is about 14.58 years. A combination of solar and diesel systems which is 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 mini-grid, solar system costs 3,500Tk/bigha/season, whereas, with the mini-grid, the cost reduces to 2,368Tk/bigha/season.

SWP systems costs have dropped by 50 percent over the past decade still 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 pump). 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% of them have land for the establishment of a PV framework. The total number of pump sets in the solar resource region and have 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 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 concept of net present value (NPV). As 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 had collected data from four areas. We have collected data about solar, electric, and diesel-based irrigation costing. As costing depends on pump capacity, we have selected those places where pump capacities are quite similar. We have collected data from Nandiasangon, Sreepur, Gazipur and Boterdola, 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 Upazilla, 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 8 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. For electric system, considering a 10 HP electric submersible pump, approximately BDT 4,00,000–4,50,000 is required. Setting up this structure takes 12–15 m^2 of land. For the diesel system, considering a 10 HP diesel submersible pump, around BDT 3,50,000–4,00,000 is required. To set up this system, about12–15 of m^2 land is required.

Operation and Maintenance Cost: There is no operation cost for solar systems; only a little maintenance cost is required. For the electrical framework, maintenance costs are about BDT 500/season/year, and electricity costs are BDT 26,000/season/year. For diesel systems, maintenance costs are BDT 1,500/season/year, lubricant cost is about BDT 1,500/season/year and fuel (diesel) costs are BDT 1,26,000/season/year.

2.3 Data Collection from Farmer's Survey

We had talked 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.

2.4 Performing a Cost Comparison

Using the initial cost, operation and maintenance cost, fuel cost, space requirement, and land requirement, a 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 worth (NPV) is the contrast between the current worth 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 charge of electricity where both electric and diesel technology will cost fuel and electricity every year.

Benefits from solar irrigation can be calculated through this equation:

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

The costs of electric/diesel irrigation can be calculated through this equation:

$$\text{Cost} = \text{Pump capacity (kW)} \times \text{Operation hour} \times \text{Electricity/Diesel cost} \times \text{Operation days} \quad (2)$$

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

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

The present value factor can be determined through this equation:

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

Here, i = discount rate (considered 5% in this case).

n = number of years.

By multiplying the present value factor and net benefit/cost, we get the present value. The summation of all present values shows what will be the total benefit or drawback of those technologies.

$$Total\ net\ present\ value = \sum_{1}^{n} (\ Present\ value\ factor \times Net\ benefit\ ) \quad (5)$$

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

2.6 Analysing 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 bunch of objectives or goals and afterward tries to recognize the compromises between those targets for various strategies or various methods of accomplishing a given approach. Multi-criteria analysis is done in these steps:

Scoring:
Performance concerning criteria. It shows the range of data.

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

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

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

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

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’.

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 strategy.

3 DATA ANALYSIS

3.1 Cost Comparison of Different Irrigation Technologies

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

Pumping System	Solar Pump	Diesel Pump	Electric Pump
Initial Cost (BDT)	16,27,000/=	3,70,000/=	4,20,000/=
Maintenance Cost (BDT)	100/=	1,500/=	500/=
Fuel Cost (BDT)	00	1,26,000/=	26,200/=
Lubricant cost (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

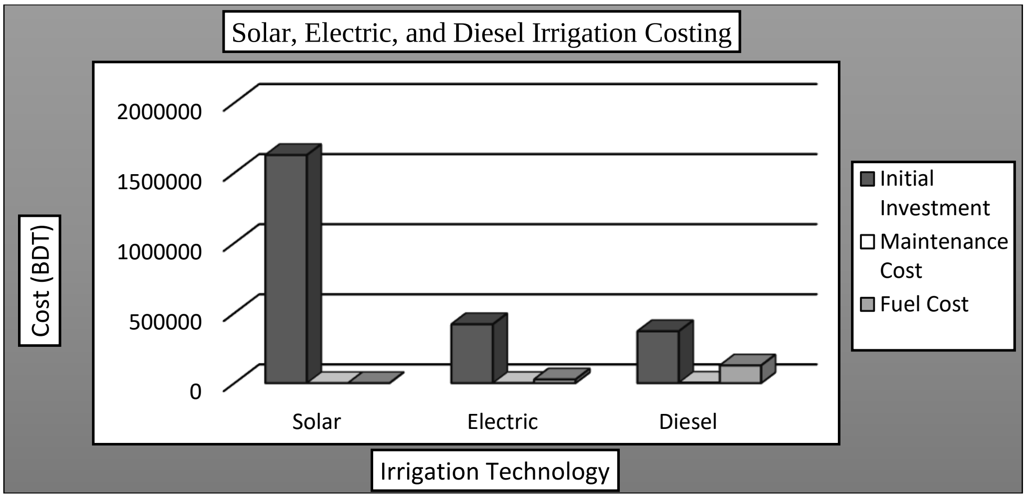

Fig 1: Graphical representation of cost comparison

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 to be simple to them, and they have been using them for a long time. Though the initial cost is the main 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. So we can say, for higher initial costs, solar technology is still not feasible for most Bangladeshi farmers. However, in the future initial investment will be reduced and solar technology will be the top choice.

In solar irrigation, the radiation from the sun is the fuel source that has no cost. Besides, the extra energy generated in the off-season can be sold or be used in other sectors. In the case of electric irrigation, the pump consumes a huge amount of electricity. Though the price of electricity is not very high nowadays but 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 cost 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 present fuel price, fuel consumption, and future price of fuel, we can say solar irrigation is the best choice.

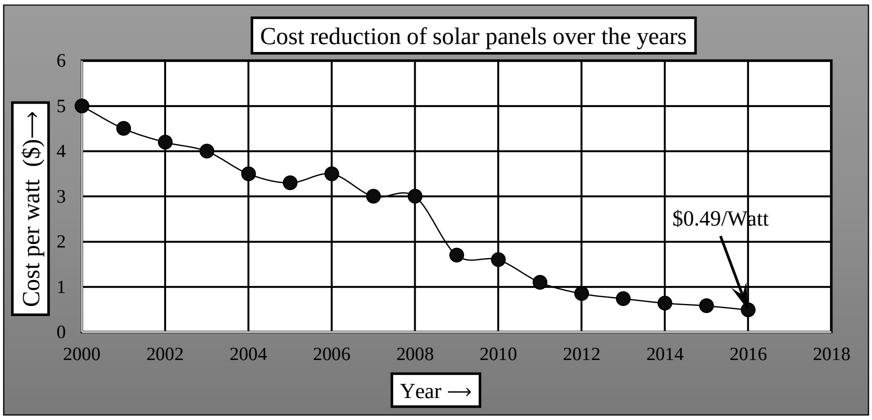

Fig 2: Cost reduction of PV modules (Zachary Shahan, 2016)

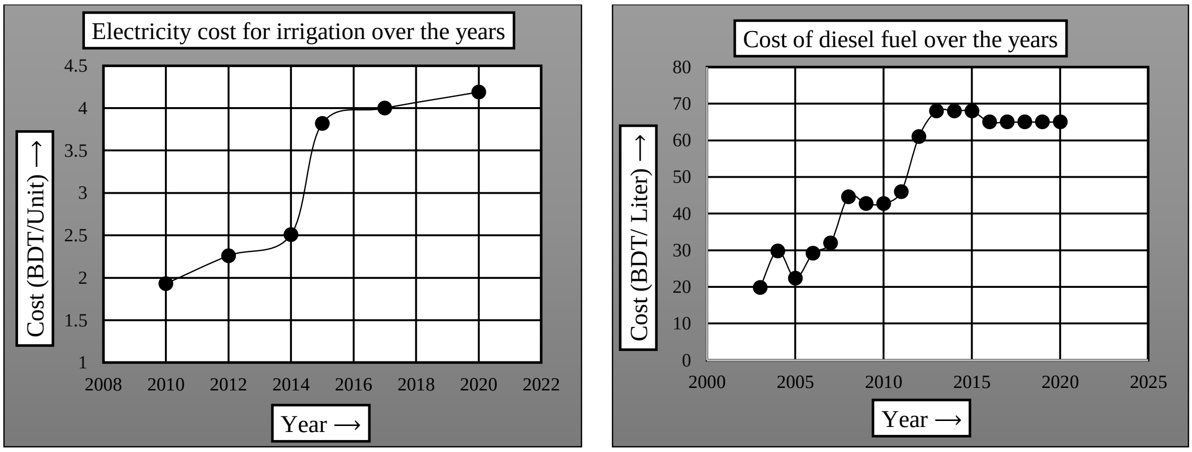

Fig 3: Increase of electricity (DPDC, 2020) and diesel (BPDB, 2020) cost.

3.2 Cost Analysis of Different Types of Irrigation Technologies

We have performed a cost analysis in this section about irrigation technologies considering 25 years of their lifespan. For this, we have considered that the pump will run 200 days/year (2 seasons) therefore operation and maintenance cost has changed. Fuel/electricity cost has been calculated considering the pump runs 7 hours a day on average. 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 considered that solar inverter and submersible pump require replacement every 7 years 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 Cost (BDT/Unit)** Increases 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

Year	**Initial/ Maintenance/Replacement Cost (BDT)**	**Energy production (kW)**	**Electricity Cost (BDT/Unit)** Increases 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)**
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**

Table 3: Net present value of electric irrigation technology

Year	Initial/ Maintenance/ Replacement Cost (BDT)	Energy consumption (kW)	Electricity Cost (BDT/Unit) Increases 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

Year	Initial/ Maintenance/ Replacement Cost (BDT)	Energy consumption (kW)	Electricity Cost (BDT/Unit) Increases 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)
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

Table 4: Net present value of diesel-based irrigation technology

Year	Initial/ Maintenance/ Replacement Cost (BDT)	Energy Consumption (kW)	Diesel price (BDT/Liter) (Increases 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

As far as 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 idea that tries to catch the complete worth of a potential investment. The thought behind NPV is to project all of the future cash inflows and outflows associated with an investment, discount all those future cash flows to the present day, and then afterward add them together. The resulting number after adding all the positive and negative incomes together is the investment's net present value. For this situation, the +ve value addresses income, and the – ve value addresses cost.

From those above tables, the net present value of those three technologies shows that considering the costs incurred during the life of the project, solar technology costs BDT 10,72,000, whereas electric and diesel technology costs BDT 14,10,070 and BDT 45,38,620 respectively. Since solar technology costs are minimum, it has a higher economic benefit. Moreover, by enabling net-metering on the solar system, it can generate revenue by selling extra energy to the national grid.

3.3 Multi-Criteria Analysis

Table 5: Performance of the criterion and their 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	26,208	1,26,000	1	0.74	0
Accessibility	Low	Medium	High	0	0.5	1
Green Technology	[+ +]	0	[– –]	1	0.5	0
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 ($W \times X_1$)**	**Electric Irrigation ($W \times X_2$)**	**Diesel Irrigation ($W \times X_3$)**
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

Criteria	Rank	Point	Weight (W)	Solar Irrigation ($W \times X_1$)	Electric Irrigation ($W \times X_2$)	Diesel Irrigation ($W \times X_3$)
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) = $\Sigma(W \times X)$ =		**45**	**53.7**	**32**

Through multi-criteria analysis, we can see that electric irrigation system innovation is holding the greatest focuses (53.7 points). However it has a higher fuel cost, in light of lower initial investment and having no meteorological hindrance, the majority of the farmers favor this innovation. So it is the most ideal choice.

Points of solar technology (45 points) are not too far from electric technology. If we check out two fundamental elements where solar-based innovation is slacking, they are its underlying expense, accessibility, and climate impediment. The underlying expense is falling by 10% consistently, and the production of solar technology is likewise rising. Numerous administrative and non-administrative associations are attempting to spread this innovation in the country spaces of Bangladesh. So this constraint will be decreased later on. As per this review, solar irrigation system is a decent option in contrast to 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) are lingering a long way behind the other two advances. Because of higher operation, maintenance, fuel cost, carbon emission, farmers generally prefer not to use this irrigation technology.

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, operation and maintenance cost is lower in the solar system compared to other conventional irrigation systems. The cost analysis of the three technologies shows that considering the costs 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 over the years, electric irrigation technology is currently the top choice among farmers. But almost 60% of rural areas of Bangladesh has low or no access to electricity for irrigation purpose. As diesel is an uneconomical way of irrigation, solar irrigation can be a good alternative to electricity.

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