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Solar and electric irrigation system in kinnow orchard of Rajasthan: Comparative evaluation

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ABSTRACT

The photo voltaic (PV) solar device for pumping water from underground and from other source of water for irrigation has been recognized as very new initiative. Three year (2015–18) socio-economic study sponsored by Ministry of Human Resource under higher education scheme has been conducted in two districts, viz. Sri Ganganagar and Bikaner of Rajasthan applying standard methodology to assess comparative advantages of PV solar device for irrigation of kinnow orchard. Hence, study found that solar irrigation system has enhanced the returns of farm and played a partial catalyst role to enhance the income of the farm. Therefore, the economic as well as environment benefits need to realizefor popularization the solar device for betterment of farming society which would reduce the dependency on electricity of farmers for irrigation specially and other works depend on electricity generally. Hence, provision of incentives on solar devices should be made to the farmers.

Keywords: Electricity, Feasibility, Income, Kinnow, PV, Rajasthan, Solar

Energy is a partial tool for economic growth and social progress of any of country and the region (Anonymous 2012). Initially, solar PV was implemented through economic incentives by many of countries. Consequently, economies of scales declined significantly (Woodford 2018). The net irrigated area of India has increased by 20.10% from 2001 to the year of 2019-20 (GoI 2019).The first Solar pumping system in India started during 1992 (MNRE 2016). Among the states of India the state of Punjab was the first statein which solar irrigation pumps were initiated, where surface irrigation was extensively available (Tewari 2012). India has first rank in operation of solar water pumps with 62000 units (Chandrasekaran 2016). The government of India recent ambitious initiative brought installation as a mission at larger scale (MNRE 2016).

In the state of Rajasthan establishing the solar unit programme was started in 2008-09 with a target of 14 solar pumps. Further, in 2010-11 the target of 50 units to 500 in 2011-12, 2200 solar units in 2012-13 and to 10 thousand units in 2013-14 to cover all the 33 districts of the state (Singh *et al.* 2017). In respect to solar the state of Rajasthan is blessed highest numbers of sunny days (325) which produces of 6-7 kWh/m^2 per day solar radiation on earth (Lal *et al.* 2013). Presently, out of without electric connection for irrigation about 75% of farmers have withdrawn their application for electricity connection. It became possible because of novelty of the PV solar pump (Panwar *et al.* 2011 and IRENA 2015). Among the orchard crops kinnow crop has been recognized as major crop in the state. The PV solar system improved yields indirectly of crops and enlarged profits (IRENA 2015). The state of Rajasthan, kinnow fruit crop covered 8.8 thousand ha, 189.48 thousand MT and 21.48 MT per ha area, production and yield, respectively in the year 2016-17 (GoR 2016). Therefore, keeping in view the economic importance of PV system in kinnow; present paper is an effort to assess the benefits of irrigation through PV solar in comparison to electric in Kinnow orchard in Rajasthan.

MATERIALS AND METHODS

The site for present investigation was in Sri-Ganganagar block of Sri-Ganganagar and Khajuvala block of Bikaner districts of Rajasthan state as highest number of solar units were installed to irrigate the kinnow orchard in these blocks under districts. The temperature of these districts ranges from 35–40^{0}C with 325 numbers of sunny days (Goyal 2013) which is highest in our country. For investigating the apparent impact of solar energy for acceleration of income of the farmers a total of 200 kinnow growers were selected and categorized into two groups, viz. irrigation system of solar (160 adopters) and electric (40 Non-solar-adopters)

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from both the districts under investigation. Primary data comprising of fixed costs like cost of solar pump, cost of electric pump, cost of well or tube well construction, cost of pond (diggi) construction, cost of drip system, depreciation of tools and implements, interest accrued on fixed cost, salvage and rental value of assets and land, respectively, life span of solar and electric pump, establishment cost of kinnow orchard, cost of seedlings, plant protection, manures and fertilizers, training or pruning, intercultural operation, gap filling, irrigation, harvesting of kinnow and cost of ward and watch and others like repair and maintenance cost of the systems like, diesel, solar system, drip system, tube-well and pond (diggi) were collected for the crop year of 2015–18 (Consecutive three years) from selected solar adopters and non-adopters.

The data were analyzed to draw an apparent inferences of impact of solar irrigation system over traditional system (diesel) by applying standard techniques like cost concepts (GoI 1979), the comparative life cycle cost analysis (Narale *et al*. 2013), Net present value (NPV), Benefit – Cost ratio (BCR) and Break – Even point (BEP) analysis (Reddy and Raghu 1996).

The comparative life cycle cost worked out as;

LCC = CC + MC + EC + RC – SC

where, CC, Capital cost; MC, Maintenance cost; EC, Energy cost; RC, Replacement cost; SC, Salvage cost.

RESULTS AND DISCUSSION

Life cycle cost of different irrigation system: The economic viability of any assets and technology depends on its life cycle (useful life). The farmers always interested in long lasting technology due to one reason or other. Assuming the life of electric pump of 20 years with its maintenance cost of ₹ 480 per year, working hours (6 h per day minimum and consuming 7 unit per h and 300 days in a year) and price (₹ 2 per unit). It has also been assumed that the initial cost of electric system of ₹ 125000 minimum with its salvage value of ₹ 50000. Similarly, the life of solar irrigation system was also assumed 20 years with its maintenance cost of ₹ 150 per year considering the 6 h per day accounted of 300 days of working in a year. The initial cost of solar system was ₹ 106595 with its salvage value of ₹ 28500.

The life cycle cost of electric system for 20 years has been estimated of ₹ 588600 by taking in account of capital cost or initial cost of ₹ 125000, maintenance cost of ₹ 9600 and electricity charge of ₹ 504000. The salvage cost of electric system has been accounted of ₹ 50000. Contrary to electric irrigation system, the life cycle cost of solar irrigation has been estimated of ₹ 81095 for 20 years of its useful life by taking in account of its cost of capital, maintenance and salvage and amount of ₹ 106595, ₹ 3000 and ₹ 28500, respectively (Table 1).

Hence, the solar irrigation system found to be cost effective (lesser cost) in its maintenance (Singh *et al.* 2017 and Meena *et al.* 2018). The comparison of the life cycle cost like operational, maintenance and fuel costs were higher

Table 1 Life cycle cost of irrigation systems (₹)

Particular	Irrigation Systems	
	Electric	Solar
Capital cost (CC)	125000	106595
Maintenance cost (MC)	9600	3000
Energy cost (EC)	504000	
Replacement cost (RC)		
Total cost (₹)	638600	109595
Salvage cost (SC)	50000	28500
Life cycle cost (LCC)	588600	81095

on diesel than the solar (Zieroth 2005, Narale *et al.* 2013). Consequently, considering the increase in price of fuel in future; the life cycle cost will also go up of diesel irrigation system (Wahyuni *et al.* 2015). In present era of climate change the electric irrigation system should be avoided for neat and clean environment (Armanous *et al.* 2016). Further, it is concluded that life cycle cost analysis of solar system was found to be more long lasting and economical choice over the electric irrigation system (Singh and Mishra 2015, Reca *et al.* 2016).

Economic viability of irrigation systems: For obtaining logical inferences the sampled orchards have been appraised over 17 years taking into account various components of costs and returns. The costs and returns estimates were discounted at an annual rate of interest of 12% for the medium term investment for each year. Comparative returns under solar irrigation orchard estimated to be higher side than the electric irrigation system due to the merit of solar system which supplies energy to pump water un-interrupted as the water is required to maintain fertility of soils in Rajasthan at regular and continuous basis (Hossain *et al.* 2015 and Singh *et al.* 2017).The Net Present Value (NPV) of electric and solar irrigation estimated to be of ₹ 798964, ₹ 842521, respectively in kinnow orchard (Table 2).

The benefit cost ratio has been estimated to be at higher (in range the of 1:1.73 to 1:5.20) than electric (in the range of 1:1.79 to 1:5.61) irrigation system (Khan *et al.* 2013, Meena *et al.* 2018).The break-even point estimated to be less on solar irrigated orchard (5.04 ton) than the electric irrigated orchard (5.15 MT) which shows the ability and efficiency of solar system for more production. Similarly, the payback period under solar system also worked out to be of lower (7.1 years) than the electric (7.2 years) irrigation system (Table 2). Hence, the analysis of different economic indicators showed the solar powered irrigation system as more economically feasible than electric. The higher returns in solar system proved the merit of solar system under orchard has been irrigated without using any energy (electricity) which saved huge amount of operational cost. Consequently, returns of solar irrigated orchard increased compared to diesel irrigation system (Singh *et al.* 2016 and Kaur and Singla 2016).

From the analysis of irrigation systems it was apparent that the solar irrigation system was only long lasting,

Table 2 Economic feasibility analysis of different irrigation system

Feasibility Indicator	Irrigation Systems	
	Electric	Solar
Net present value (₹)	798964	842521
Break-even point (MT)	5.15	5.04
Pay-back period (Year)	7.2	7.1
B:C ratio	2.23	2.36

portable, sustainable and eco-friendly and economically feasible and viable device for irrigation. Further, economic feasibility analysis like pay-back-period, break-even-point, BC-ratio and cash-flow has proved that solar irrigation system has enhanced the returns of farm and played a partial catalyst role to enhance the income of the farm. Hence, provision of incentives on solar devices should be made to the farmers. Solar energy requires no energy cost for pumping water and is a onetime investment reaping long term benefits and maintaining eco-friendly management strategies. The income and profitability of farmers will be enhanced and also attracts youth into agriculture. Thus further research in the field will be helpful to the researcher, extensionist, policy makers, teachers, scholars, bankers and industrialist to decide their way forward regarding solar use to enhance the income of farmers in rural areas thereby reducing the dependency on electricity for irrigation and other day to day activities requiring electricity.

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