A Field based Study to Emphasize the Need of Water and Energy Conservation by Harnessing Solar Powered Micro Irrigation Potential

Neeraj Sharma[1], Rakesh Chauhan[2], Sumit Kumar[1], and Barjinder Singh[1]
[1]CAD Division, HIRMI Complex, Dhand Road, Kurukshetra, Haryana, India
[2]CADA, Haryana, Panchkula, Haryana, India
**Corresponding author e-mail id: xenkurukshetracad@gmail.com*

Abstract: Agricultural sector is the largest user of water, followed by the civil sector and the industrial sector. There is a major concern whether the present practice of ground water use which is directly proportional to energy consumption can be sustained as the depth of ground water level continues to drop because crops like paddy and sugarcane consume more than 60% of irrigation water. Electricity is not being used efficiently because of flood irrigation and subsidized electricity to farmers. Devising policies to incentivize farmers to improve water use by the adoption of energy and water efficient technologies like solar power and micro irrigation may help in saving significant amount of electricity and water along with increase in quality and quantity of the produce. This study is an effort to calculate the saving of electricity and water by carrying out field experiments on the community based solar/grid and stand alone solar powered pressurized water supply to the agriculture fields, an initiative undertaken by command area development authority (CADA), Haryana. This study has been carried out in Kurukshetra and Ambala districts of Haryana considered as paddy bowl of India. Data has been collected by conducting field experiments along with farmers who cultivated crops of paddy and wheat. In order to find out the impact of solar power and micro irrigation four different plots have been selected which falls under the canal water, sewage treatment plant (STP) treated water and overflowing village ponds (OFVP) water. Results for full crop period for paddy crop at outlet RD-5775/R of Mallaur distributary under canal command covering 138 acres (56 hectares) show that approximately 3800-KWh electricity has been saved costing 948647/- rupees. Saving of water is approximately 55.68 crore liter. In Wheat crop electricity saving is 13512 KWh costing 97962/- rupees and water saving is approximately 5.74 crore liter. Results for paddy crop at outlet RD-25220/L of Sandhola Minor under canal command covering 148 acres (60 hectares) show that approximately 133835-KWh electricity has been saved costing 970306/- rupees and saving of water is approximately 67.16 crore liter. Electricity saving in Wheat crop is 20041 KWh costing rupees 145299/- and water saving is approximately 10.05 crore liter. Results of the study carried out at Sewage Treatment Plant (Shahabad) for one month show that in Kharif crops covering 373 acres (151 hectares) saving of water is approximately 79.97 crore liter and approximately 188320-KWh electricity has been saved costing 1365317/- rupees. Study carried out at Overflowing Village Pond (Bir Mathana) covering 57 acres (23 Hectares) area for 90 days in Kharif crop show that approximately 4.86 crore liter water has been saved and saving of electricity during this period is 10071 KWh costing 73015/- rupees.

Keywords: Electricity, Micro Irrigation, Water Saving, Solar Power, Water Use Efficiency

1. Introduction

The problem of rising groundwater depletion and continued groundwater resource degradation can only be tackled by two folds in India. The first is the supply side management practices by water resources development. The second is demand management by efficient use of the water through micro irrigation and other improved practices. The micro irrigation in common and drip irrigation in specific has received appreciable attention from researchers, policy makers

economists etc. for its sensed ability to contribute importantly to groundwater and surface water resources development, economic growth, environmental sustainability and agriculture growth. In this study, the affect of drip irrigation in rice has been concluded on farming system in Haryana. The drip method of irrigation has been found to have a significant impact on yield of crops and resource saving and now it has become the common policy agenda particularly in India being a developing economy. Rice is the main grain that is in demand in India and South Asian countries. Research shows though conventional total water requirement is 1200–1400 mm but in practice, farmers use much more water. In many areas rice fields throughout the season always flooded with 8 to 10 cm of water.

Solar/Grid powered community based infrastructure for installing Micro Irrigation Systems has been provided with network of HDPE Pipes/Hydrants at fields and community water storage rank, pumping units (Solar/Grid), Filtration Unit etc. near water outlet head in the command area as per general layout plan Figure-1. Further individual farmer after availing subsidy of Government will install drip/sprinkler sets. It is proposed to take water from outlet through underground pipeline with gravity and to store the same in the tank of suitable size for construction of which the land shall be made available by the shareholders of the outlet. This infrastructure will be connected through net metering with proper filtration systems to avoid any chocking in the pipes. Water has been carried to entire area of the chak of the outlet through HDPE pipe line network under pressure buried underground at 3 feet deep. Water with the desired pressure for running of the drip/sprinkler set has been made available to each shareholder at his farm holding. The common infrastructure will be maintained by association of farmers.

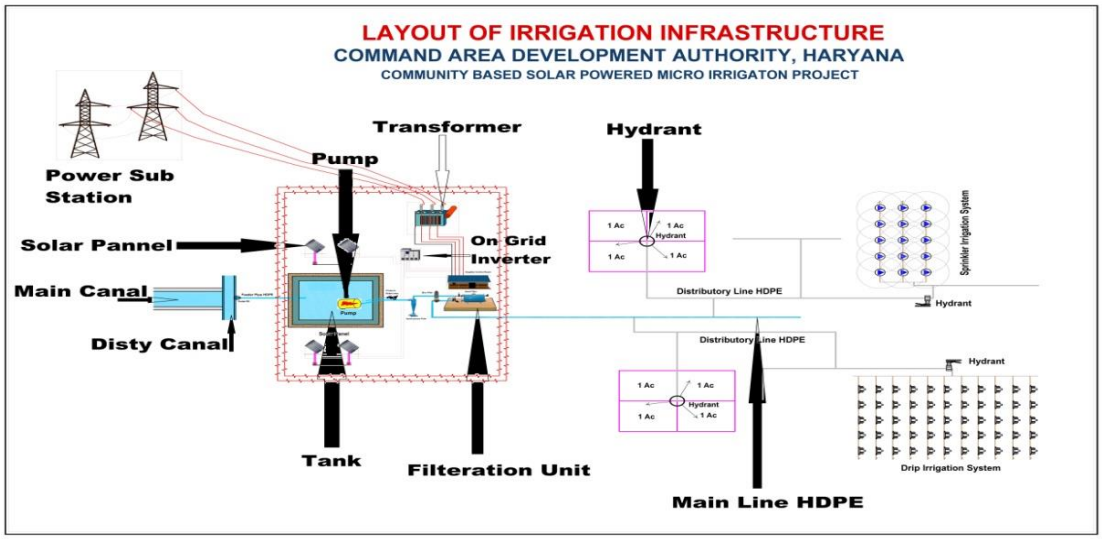

Figure -1 (Layout Plan)

2. Methodology and Study Area

Modified penman method has been used to find out crop water requirement and computed the peak water requirement in rabi & kharif season. In these schemes average water requirement of

2mm/day has been considered. Design of canal outlet scheme is based on actual culturable command area (CCA), approved discharge normally 2.4 cusecs/000 acres and schedule of running of canal outlet by collecting the authenticated data from the Canal Authorities. The design of Sewage Treatment Plant scheme is based on capacity of Plant and design of overflow pond scheme is based on the daily availability of water from various sources. Each component of this scheme shall be designed in such a manner that minimum operating pressure of 2.5Kg/cm^2 available to the farmers on their farm gate. Size of the storage tank has been designed by considering discharge capacity of the outlet of plant and volume of water accumulated in 24 hours in case of canal based schemes and only retention tank is provided in case of STP. A feeder pipe of required size in appropriate length has been provided from canal outlet to the storage tank by gravitational flow. Solar pumping system is a vital part of this scheme and in this scheme grid connected solar powered pump has been considered to reduce the cost of electricity of appropriate size. At least one pump is provided in a block of area 40 to 50 Hectare. Solar pumps of the capacity up to 10 to 20HP is preferred with average working of 14 hours/day. Total head and design discharge decided the HP of the pump required. The total operating head is sum of static head, friction loses worked out with hazen-williams equation in pipeline network and losses in filtration unit. Pipes in main line and sub-main shall not be below 110 mm (OD) and the size shall be decided based on the criteria to limit the friction loss in the main & sub main keeping the minimum flow velocity in the pipeline as 0.6m/sec.

$$\text{Horse Power of pump set} = \frac{QxH}{75e}.$$

Q = discharge (in Litre Per Second)
H = head (in meter)
e = efficiency of pump

Solar PV array of at least 1100wp capacities has been installed per HP rating of pumping sets and total capacity of the Solar pv array for operation of solar pumping sets has been worked out in such a manner that total annual solar energy generation from the PV power system in no case be lesser than the total energy requirement to run the Micro Irrigation System and there is no net import of energy from the utility grid on annual basis. For working out the total annual energy requirement of the Micro Irrigation System likely days of running of canal outlet in a year has been considered based on the actual schedule of canal running, but total running days of the canal in year shall not be any case be less than 180.

The output power of SPV would be fed to the inverters for conversion of the DC produced by SPV array to AC for operation of the motor pump sets and feeding the same into the nearest electricity grid through 11KV, 24 hours energized HT independent line after synchronization when in excess of requirement. A hydrant assembly has been provided with minimum 110 size for the land holding of every share holder with provision of at least one hydrant for every 04 acres or less.

3. Study Area/ Results/ Discussions

A) Canal based Micro Irrigation scheme:

(i) ***Demonstration Plot in District Ambala*****:** At one of the scheme of ongoing Micro Irrigation Pilot Project installed at canal outlet RD-5775/R of Mallour Distributory in village Mallour of District Ambala, Following studies have been carried out where in case of Rabi it had been examined as under:

- ***Rabi Crop (Wheat*****): -**

  In year 2018 during rabi season a experiment on 40 acres had been conducted on wheat crop by using sprinkler irrigation. Appreciable amount in water and electricity saving had been noticed.

  Water Saving**:**

  Net saving of underground water in full crop period on 40 acres is 1.66 crore liters, which can be used in 68 acres more area with sprinkler irrigation. The total area of the chak is 138 acre, accordingly total water saving will be 5.74 crore liter.

  Electricity Saving**:**

  Net saving of electricity on Tube-wells in full crop period on 40 acres is 3916 KWh, Which cost to the Government approximately Rs.28391/- at the rate of (7.35-0.10) 7.25 Rs. per unit. It is also estimated that if whole 138 acres under this chak is irrigated by sprinklers then approximately Rs.97949/- can be saved.

- ***Kharif Crop (Rice):***

  This year in June 2019 on paddy crop an experiment was conducted by using sprinkler irrigation in 4 acres. This experiment had run for a period of 21 days from 21 June to 16 July. Rewarding results have been obtained towards saving of precious ground water and valuable subsidized electricity. Results are summarized as below: -

  Water Saving**:**

  (i)-Net saving of underground water in 21 days in 4 acres is 50.8 lakh liters, which can be used in 2.82 acres more area with sprinkler irrigation.

  (ii)- It is further assumed that by considering total crop period of 110 days and based on farmers traditional practice of water application in this area, gross water saving on 4 acres for full crop period will be 1.61 crore liters which will irrigate 9 acres more area with sprinklers or 3 acres by flood irrigation .If sprinkler irrigation is used in 138 Acres, the total water saving in Kharif season will be 55.68 crore liters.

  Electricity Saving**:**

  (i) Net saving of electricity on Tube-wells in 21 days on 4 acres is 1197.30KWh, Which cost to the Government approximately Rs.8680/- at the rate of (7.35-0.10) 7.25 Rs. per unit in 21 days.

  (ii) Based on this analogy of saving electricity and considering total crop period of 110 days, approximately 3800 Kwh total electricity will be saved on 4 acres. The amount Rs. 27497/- will be saved from Government exchequer. It is also estimated that if whole 138 acres under this chak is irrigated by sprinklers then approximately 948647/- can be saved.

Above results are concluded on the basis of the farmers experience and 21 days experiment where farmers have found the satisfactory use of sprinkler systems as per crop water requirement.

(ii) ***Demonstration Plot in District Kurukshetra*****:** At another scheme of this project installed at canal outlet RD-25200/L Sandhola Minor in district Kurukshetra a demonstration plot is under way from last two years at 9 acres under Paddy and wheat crops to motivate the farmers towards Micro Irrigation Technology. Keeping more stress on paddy a most water guzzling crop, Out of 9 acres 3 acres are being sown by Direct Seeding Rice (DSR), 3 acres by mechanical trans-planter and 3 acres by traditional manual methods. Irrigation is being done in every three acres of plot by Sprinkler Irrigation, Drip Irrigation and Flood Irrigation methods. State Government allowed this experiment for consecutive three years so that Scientists of CCSHAU Hisar can practically establish and circulate this fact of use of micro irrigation systems on Paddy Crop amongst farmers. As expected this experiment is disseminating the encouraging results from last two years of water saving and yield increase in paddy crop which will definitely actuate the farmers of Haryana for effectively adopting the sprinkler & drip systems.

- ***Rabi Crop (Wheat): -***

  In year 2018 during rabi season a experiment on 9 acres had been conducted on wheat crop by using sprinkler irrigation. Appreciable amount in water and electricity saving had been noticed.

  Water Saving:

  Average saving of underground water in full crop period on 9 acres is 6.79 lac liters/acre. The total area of the chak is 148 acre, accordingly total water saving will be 10.05 crore liter.

  Electricity Saving**:**

  Net saving of electricity on Tube-wells in full crop period on 01 acre is 135.41 Kwh, Which cost to the Government approximately Rs.981.72/- at the rate of (7.35-0.10) 7.25 Rs. per unit. It is also estimated that if whole 148 acres under this chak is irrigated by sprinklers then approximately Rs.145299/- can be saved.

- ***Kharif Crop (Rice):***

  Last year in June 2018 on paddy crop an experiment was conducted by using sprinkler & Drip irrigation in 9 acres. This experiment had run for full crop period. Rewarding results have been obtained towards saving of precious ground water and valuable subsidized electricity. Results are summarized as below: -

  Water Saving:

  Average saving of underground water in 9 acres is 4.53 lakh liters/acre. It is further assumed that if drip/sprinkler installed in full chak of 148 acres, the total water saving in kharif season will be 67.16 crore liters.

  Electricity Saving:

  (i) Net saving of electricity on Tube-wells in full crop period on 01 acre is 904.29 Kwh, Which cost to the Government approximately Rs.6556/- at the rate of (7.35-0.10) 7.25 Rs. per unit. Based on this analogy of saving electricity and considering total area of 148 acres approximately 133835 Kwh will be saved. The amount Rs.970306/- will be saved from Government exchequer.

B) Micro Irrigation Infrastructure on Sewage treatment plants

With a view of augmenting water for assured supply to the every field, a new intervention has been proposed for the reuse of treated waste water from the existing Sewage Treatment

Plants for the use of water in the best alternative which will help in enhancing the irrigation. Working on these lines this pilot project has been executed on Sewage Treatment Plants **of Ladwa, Shahabad and Pehowa** towns of district **Kurukshetra** for irrigation.

Study at Shahabad STP: A study has been carried out on one of the scheme at Shahabad STP for evaluating its performance towards saving of precious ground water and valuable subsidized electricity on tube-wells. This study has been done for a period of 31 days from 15 June to 16 July 2019 by selecting 3 acres one each of rice, sugarcane and vegetable crop. Only flood irrigation is being done in this area. The encouraging results have been obtained as described below.

Water Saving:

Average saving of underground water in 31 days in 373 acres is 79.97 crore liters, which can be used in 74 acres more area of Paddy with flood irrigation.

Electricity Saving:

Average saving of electricity on Tube-wells in 31 days on 373 acres is 188320 KWh, Which cost to the Government approximately Rs.1365317/- at the rate of (7.35-0.10) 7.25 Rs. per unit in 31 days.

C) Micro Irrigation Infrastructure on Overflowing Village Ponds

Command Area Development Authority (CADA) has initiated a Pilot Project for utilizing surplus water from overflowing ponds in the villages. In the first instance, execution work on 11 no. ponds i.e. Kirmach, Jirwehri, Dhurala, Bir Mathana, Kishangarh, of Kurukshetra district, village Kaul of Kaithal district, Village, Dhurana, Machhonda, Dukheri of Ambala district and village Bal Chhapar & Talakaur of Yamunanagar district has been completed and farmers are using water in the kharif crops of this year (2019).

Study at Overflowing village pond of Bir Mathana: **-** A study has been carried out on one of the scheme at Bir Mathana for evaluating its performance towards saving of precious ground water and valuable subsidized electricity on tube-wells. This study has been done for a period of 90 days from 12 June to 16 September 2019 by selecting 57 acres. Only flood irrigation is being done in this area. The encouraging results have been obtained as described below.

Water Saving:

Average saving of underground water in 90 days in 57 acres is 4.86 crore liters.

Electricity Saving:

Average saving of electricity on Tube-wells in 90 days on 57 acres is 10071 KWh, Which cost to the Government approximately Rs.73015/- at the rate of (7.35-0.10) 7.25 Rs. per unit in 90 days.

4. Conclusions

Significant irrigation from tube wells are being done in various districts of Haryana. Canal water use efficiency is very poor and ground water wastage in shape of flood irrigation is being over exploited. It also causes wastage of electricity. Use of micro irrigation infrastructure will reduce the use of tube wells by which ground water will be saved. More area can be brought under canal command, which was otherwise either rain fed or irrigated by tube wells. Hence, by installation

of Solar/Grid Powered Micro Irrigation Infrastructure in the Canal Commands through integrated approach of supply management and demand management, yield & net sown area will increase, dependency of tube well & overexploitation of ground water will decrease, saving of highly subsidized electricity and above all change of the mindset of the farmers towards the use of available water judiciously. It was common belief that there is always risk of yield reduction in water saving irrigation techniques, because the crop will be under drought stress. On this demonstration plot, it has been proved pragmatically beyond doubt that for cultivating rice in water-limited condition and by following advanced water saving techniques such as drip irrigation system has assured to sustain the productivity under water scarce situation. There is huge saving of water up to 50% to tackle the issue of overexploited blocks and increase yield by approximately 12% which is establishing that water can be reduced without compromising the yield even in rice production.

Above saving also shows that an ample amount of electricity used by Tube-wells can be saved under these projects though results are based on the raw method which can be more precisely calculated by researchers working in this field based on the certified methods and analysis.

It is concluded from the above results that adoption of the Micro irrigation techniques in farming will ultimately help in achieving increased irrigation water productivity. The treated water which was otherwise going waste can be used in increasing irrigation intensity and bringing more area under irrigation with appreciable saving of electricity.

References

Batchelor, C., Lovell, C.& Murata, Water User Efficiency of Simple Subsurface Irrigation Systems, In : Proceedings of 7th International Conference on Water and Irrigation, 13-16, May, 1996

Dittoh, Saa; Akuriba, Margaret A.; Issaka, Balma Y.; and Bhattarai, Madhusudan Sustainable Micro-Irrigation Systems for Poverty Alleviation in The Sahel: A Case for "Micro" Public-Private Partnerships? Poster presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010

Drip Irrigation and Fertigation in Direct Seeded Aerobic Rice in Karnataka, India-Research Status: Nagaraju, UAS, Banglaore

Drip Irrigation from Rice Cultivation : Jain's Experiences:

Drip Irrigation in Paddy in Punjab, India: Exploring The New Horizons for Sustainable Agriculture: Rakesh Sharda, PAU, Ludhiana, Punjab

Hanson, B. R., & May, D. M. 2007. The effect of drip line placement on yield and quality of drip-irrigated processing tomatoes. Irrigation Drainage Sys. 21, 109-118.

Hanson, B., & May, D. 2003 Drip irrigation increases tomato yields in salt-affected soil of San Joaquin Valley. California Agriculture. 57, 132-137.

Jeevandas, A., Singh, R. P. & Kumar, R. 2008 Concerns of groundwater depletion and irrigation efficiency in Punjab agriculture: A micro-level study. Agric. Econ. Res. Rev. 21, 191-199.

Johnson, D. E., & Mortimer, A. M. 2005. Issues for weed management in direct- seeded rice and the development of decision- support framework. In ‘‘Direct- Seeding of Rice and Weed Management in the Irrigated Rice- Wheat Cropping System of the Indo Gangetic Plains’’ Y. Singh, G. Singh, V. P. Singh, P. Singh, B. Hardy, D. E. Johnson, and M. Mortimer, Eds., p. 20. Directorate of Experiment Station, G.B. Pant University of Agriculture and Technology, Pantnagar, India.

Micro Irrigation in Rice-Wheat Cropping system as a Paradigm for Saving Water: A Field Experience in Uttarakhand, India: A.K. Bhardwaj, GBPUAT, Pantnagar, Uttarakhand.

New Paradigms of Growing Rice to Address Emerging Shortage of Water and Labor: J.K. Ladha, IRRI, New Delhi.

Raphael Saulter, Jim Watson, Stratigies for the deployment of micro generation: Implications for social acceptance

Thangjam Churachand Singh, Brajkishor Prajapati, Bhardwaj, A. K. 2018 Effect of drip irrigation on growth and yield of direct seeded rice (*Oryza sativa* L.). Int. J Chemical Studies. 6(1):161-164.

Vaibhav Bhamoriya Susan Mathew, An Analysis of Resource Conservation Technology: A Case of Micro-Irrigation System (Drip Irrigation), Centre for Management in Agriculture Indian Institute of Management, Ahmedabad, August 2014

Veeraputhiran, R., Kandasamy, O.S., & Singh, S. S. D., 2002 Effect of drip irrigation and fertigation on growth and yield of hybrid cotton. J Agric Reso Manage. 1, 88-97

Vijayakumar, P. 2009 Optimization of water and nutrient requirement for yield maximization in hybrid rice under drip fertigation system rice (*Oryza sativa* L.) M.Sc. (Ag) Thesis. Agriculture College and Research Institute, (TANU), Madurai.