ECONOMICAL DESIGN & ANALYSIS OF SOLAR WATER PUMP SYSTEM FOR IRRIGATION PURPOSES IN RURAL AREAS: A CASE ANALYSIS & DESIGN OF VILLAGE- BAKHTIYARPUR, BLOCK-HASPURA, AURANGABAD, BIHAR-824114-INDIA.

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Abstract: This paper presents PV solar water pumping system for irrigation in developing countries. Many of us are exploitation non renewable energy sources in high quantity of their desires. Some Minerals are exhausting with the high usage, thus it's obvious to depend upon the renewable sources like star & wind etc. electrical phenomenon (PV) water pumping system has been turning into more and more vital in remote, isolated, and non-electrified population, wherever either accessibility to the grid is tough to ascertain or implementation value is so terribly high. In such location, PV water pumping application is critical space of interest for property development. Programmed water system framework utilizes elective vitality that drives water pumps to pump water from bore well to a tank and during this method the outlet valve of tank is of course managed abuse controller. A wet locater is employed to manage the stream of water from the tank to the water system field that upgrades the work of water. Since our nation positions second in farming and it gets sunlight systematically, it's educated use sun-based vitality for water system capacities.

Keywords: Automated irrigation’s mobile, humidity sensor, Solar Panel.

I. Introduction:

Agriculture is an important part of Indian economy. The rapid growth in agriculture has helped Indian agriculture mark its presence at global level. India is one among top countries in terms of production of various agricultural commodities like paddy, wheat, vegetables, fruits etc. In India more than 60% of the population earns their livelihood from agriculture. As we approach a new millennium, there are growing concerns and repetitive warnings of water scarcity. With increasing demand for food and competing use within irrigation professionals to manage water effectively. Irrigation plays a master role in the following scenarios like: reduced rainfall, uneven distribution of rain fall, development of agriculture in desert area etc. Irrigation has some of the advantages like: increase food production, optimum benefits of domestic water supply etc. Meanwhile some of the drawbacks of irrigation include: water-logging, dampness in weather, loss of valuable lands etc.

In order to overcome the drawbacks of irrigation user can make use of the automatic solar water pump. In solar water pump control a farmer can reduce his manual efforts. Solar powered water pumps can deliver drinking water as well as water for livestock or irrigation purposes. Solar photovoltaicity is been widely used in different applications. Despite of various limitations of several energy sources, one of the most appropriate and simplest uses of photovoltaicity is water pumping [1].

Solar water pumps may be useful in small scale or community based irrigation. As large scale irrigation requires large volumes of water that in turn require a large solar panel and batteries for storage purpose. The main problem of agricultural development on dry land is the limited availability of water, especially in the dry season. One of the solutions to increase land productivity is by providing water for supplementary irrigation through optimizing the potential of existing water resources in the region. Farmers who are using water for supplementary irrigation often use pumps, both electric pumps and fuel pumps.

The use of water pumps that are driven by electricity or fossil fuels results in environmental damage due to high carbon dioxide emissions, which significantly contribute to global warming [2]. When viewed from the financial side, both in the development and maintenance stages, this irrigation technology creates problems at the field level, especially for farmers and farmer groups, as they often face difficulties in operating and maintaining their irrigation facilities and infrastructure. Therefore, it is necessary to find and develop a model of irrigation technology that is both energy-efficient and water efficient. Since not all lands have electrical energy infrastructure due to remote location constraints and/or limited electricity supply and/or high fuel prices, solar energy can become the solution to drive pumps. Solar power pumps take advantage of free solar radiation as an energy source for irrigation [3].

II. Literature survey:

1. Mr. M. A. Murtaza, Mr. Mragank Sharma, Rohit Yadav, "Solar Powered Automatic Irrigation System" International Journal of Engineering Science and Computing, vol. 7, issue no. 4, April 2017.

This study was to present the benefits of an automatic agricultural irrigation system, operated by current obtained from the Sun. The system may profit the country's economy if it may be extended for use within the large irrigated lands of the east and southeast. With technological advances, the system might provide farmers, worker, water, time and potency blessings. If the system is employed for landscaping in town parks and green areas, it should bring different blessings. With the system, water waste and therefore they would like for human power might be attenuated. The system is economical and simple to use. If future studies can augment it sensible mobile device applications and remote controlled RF systems, it'd be also potential to observe the system on-line.

2. Er.Upendra Singh, Mohit Vyas, Gaurav Sharma, "Solar Based Smart Irrigation System" International Journal of Recent Research Aspects, vol. 3, issue no. 1, March 2016.

In this paper implementing the projected system there are numerous benefits for the government and therefore the farmers. For the government an answer for energy crisis is projected. By using the automated irrigation system it optimizes the usage of water by reducing wastage and reduces the human intervention for farmers. The surplus energy produced mistreatment solar panels also can tend to the grid with little modifications within the system circuit, which can be a supply of the revenue of the farmer, thus encouraging farming in India and same time giving a solution for energy crisis. Projected system is straightforward to implement and atmosphere friendly resolution for irrigating fields. The system was found to achieve success when enforced for bore holes as they pump over the whole day. Solar pumps conjointly provide clean solutions with no danger of borehole contamination. The system requires stripped-down maintenance and a focus as they're self-starting. To more enhance the daily pumping rates tracking arrays may be enforced. This technique demonstrates the practicability and application of mistreatment solar PV to supply energy for the pumping necessities for mechanical device irrigation. Even if there's a high capital investment needed for this technique to be implemented, the edges are high and in long run this technique is economic.

3. Kalaskar, Prof. Yashoda A. Kale, "Solar Powered Automated Irrigation System", International Journal for Scientific Research & Development, vol. 5, issue. 10, 2017.

The Photovoltaic systems area unit particularly designed offer to provide to produce water and irrigation in areas wherever there is not any mains electricity supply. Their main blessings over hand pumps or internal combustion engine pumps area unit their much zero maintenance, their long helpful life, that they don't need fuel, that they don't contaminate, and eventually that they're easy to
put in. Another necessary characteristic is that, as they use the sun as their energy supply, the periods of most demand for water coincide with the periods of most radiation. Once compared to diesel supercharged pumping systems, the value of star PV water pumping system with none grant works bent be sixty four.2% of the price of the diesel pump, over a life cycle of 10 years. Star pumps area unit accessible to pump from anyplace within the vary of up to two hundred m head and with outputs of up to 250 m^3/day. In general electrical phenomenon pumps area unit economic compared to diesel pumps up to or so three kWp for village water and to around one kWp for irrigation. Star electrical phenomenon (SPV) sets represent Associate in Nursing environment-friendly, lowmaintenance and price effective various to irrigation pump sets that run on grid electricity or diesel. It's calculable that India's potential for solar PV water pumping for irrigation to is nine to seventy million solar PV pump sets, that is, at least 255 billion litres/year of diesel savings. A star irrigation pump system strategies must understand of the reality that demand for irrigation system water can varythroughout the year. Peak demand throughout the irrigation system seasons is usually quite double the typical demand. This means thatthat star pumps for irrigation area unit under-utilized for many of the year. Attention
ought to be paid to the system of irrigation water distribution and application to the crops. The irrigation pump system ought to minimize water losses, while not imposing vital extra head on the irrigation pumping system and be of low value.

4. Photovoltaic water pumping system involves the technique in which the energy produced by the panel is fed to the motor trough a converter with two power stages: a DC/DC stage to boost the voltage of the panels and a DC/AC three-phase inverter to convert the DC voltage to three phase AC voltage set [4]. The three phase induction motor has a high degree of robustness, low cost, higher efficiency and lower maintenance cost compared to other types of motors and hence it is used. It uses a single PV panel which is used to drive low powered water pump.

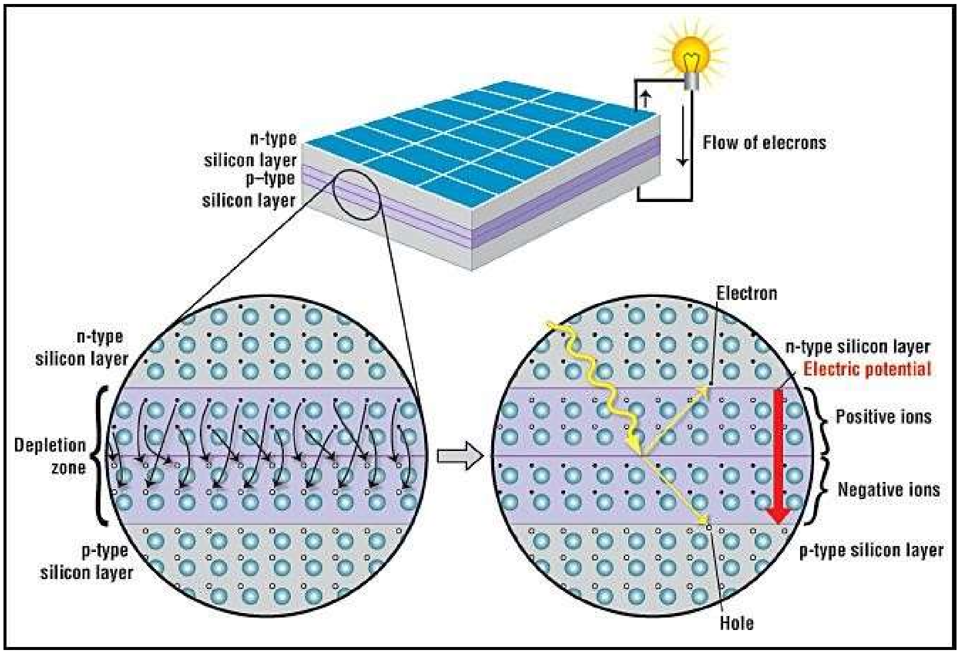


Fig 1. Schematic representation of a solar cell, showing the n-type and p-type layers, with a close-up view of the depletion zone around the junction between the n-type and p-type layers.

Solar panel produces direct current.

$$E = E_0 + E_V \quad \text{(eq. 1)}$$

Where, E = Total incident energy from sunlight in the form of pocket of photon.
E_0 = Work function of type of semiconductor material used.
E_v = Kinetic energy of ejected electron from semiconductor materials.

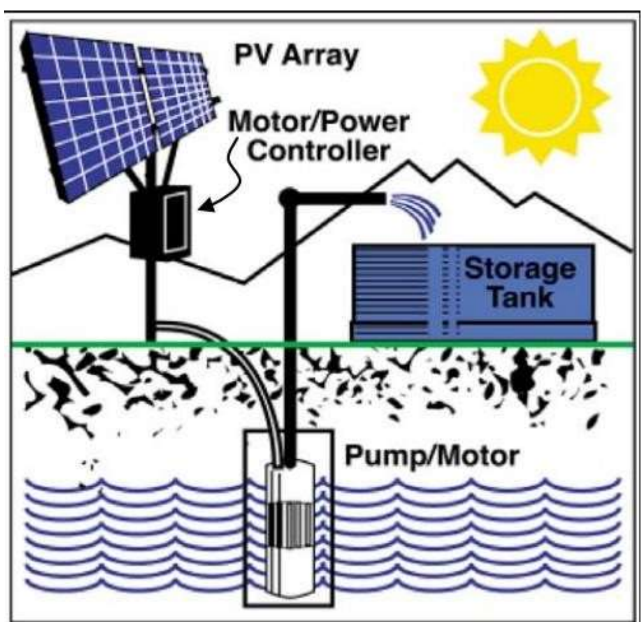


Fig 2. Schematic diagram of solar panel system for irrigation.

Fig 3. Solar panel system used in land.

Fig. 4. Solar panel used to discharge water from ground in field.

III. Power inverter-an inverter circuit is employed for converting the DC to AC converter.

The converter is a power electronic device, used to convert DC to AC. These devices use switching devices. The DC to AC conversion can be done among 12V, 24V, 48V to 110V, 120V, 220V, 230V, 240V with supply frequency 50Hz/60Hz.

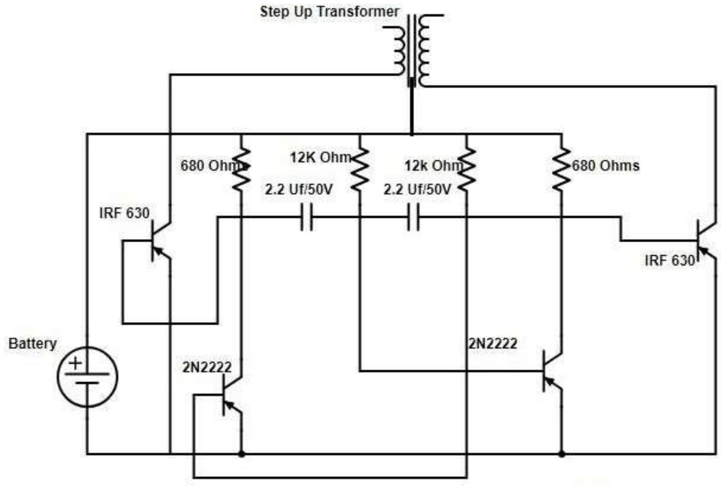
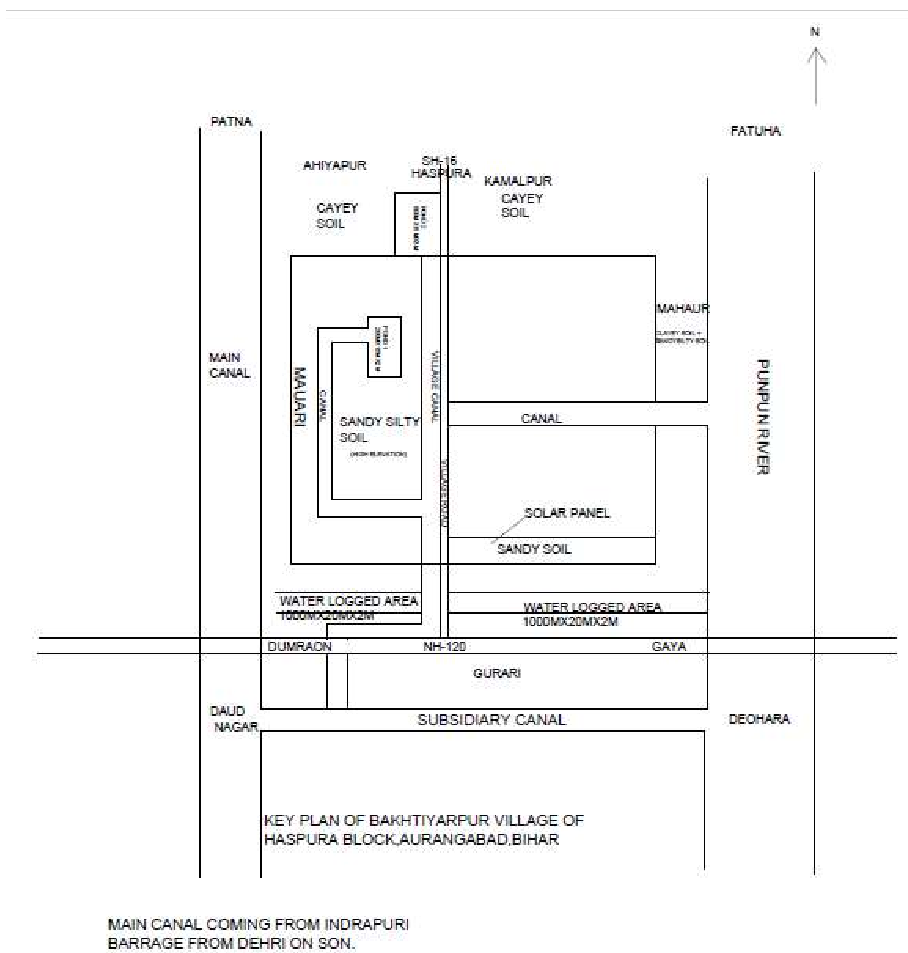


Fig. 5. DC to AC converter.

IV. Data collected for designs, calculations and analysis:



A. Bakhtiyarpur Population - Aurangabad, Bihar:

Bakhtiyarpur is a medium size village located in Haspura Block of Aurangabad district, Bihar with total 254 families residing. The Bakhtiyarpur village has population of 1282 of which 633 are male while 649 are female as per Population Census 2011. In Bakhtiyarpur, village population of children with age 0-6 is 183 which makes up 14.27 % of total population of village. Average Sex Ratio of Bakhtiyarpur village is 1025 which is higher than Bihar state average of 918. Child Sex Ratio for the Bakhtiyarpur as per census is 1288, higher than Bihar average of935. Bakhtiyarpur village has higher literacy rate compared to Bihar. In 2011, literacy rate of Bakhtiyarpur village was 83.26 % compared to 61.80 % of Bihar. In Bakhtiyarpur Male literacy stands at 91.32 % while female literacy rate was 75.09 %.As per constitution of India and Panchyati Raaj Act, Bakhtiyarpur village is administrated by Sarpanch (Head of Village) who is elected representative of village. Our website, don't have information about schools and hospital in Bakhtiyarpur village.

Particulars	Total	Male	Female
Total No. of Houses	**254**	-	-
Population	**1,282**	633	649
Child (0-6)	**183**	80	103
Schedule Caste	**240**	124	116
Schedule Tribe	**0**	0	0
Literacy	**83.26 %**	91.32 %	75.09 %
Total Workers	**439**	320	119
Main Worker	**344**	-	-
Marginal Worker	**95**	16	79

Table 1. Bakhtiyarpur data.

B. Caste Factor

Schedule Caste (SC) constitutes 18.72 % of total population in Bakhtiyarpur village. The village Bakhtiyarpur currently doesn't have any Schedule Tribe (ST) population.

C. Work Profile

In Bakhtiyarpur village out of total population, 439 were engaged in work activities. 78.36 % of workers describe their work as Main Work (Employment or Earning more than 6 Months) while 21.64 % were involved in Marginal activity providing livelihood for less than 6 months. Of 439 workers engaged in Main Work, 61 were cultivators (owner or co-owner) while 244 were Agricultural labourer.

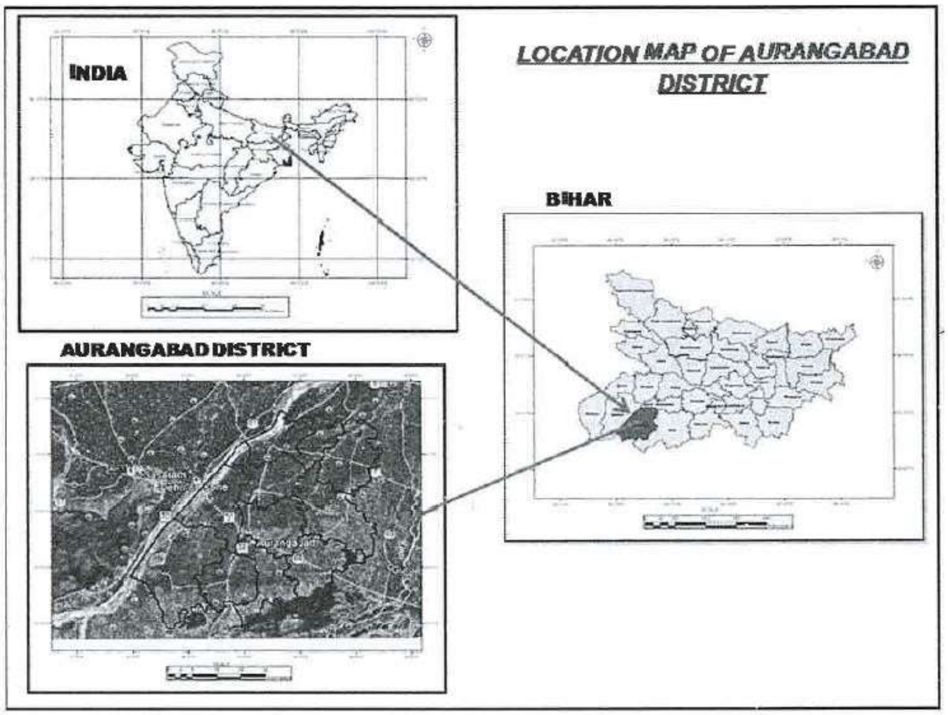


Fig. 6. Location map of Aurangabad district.

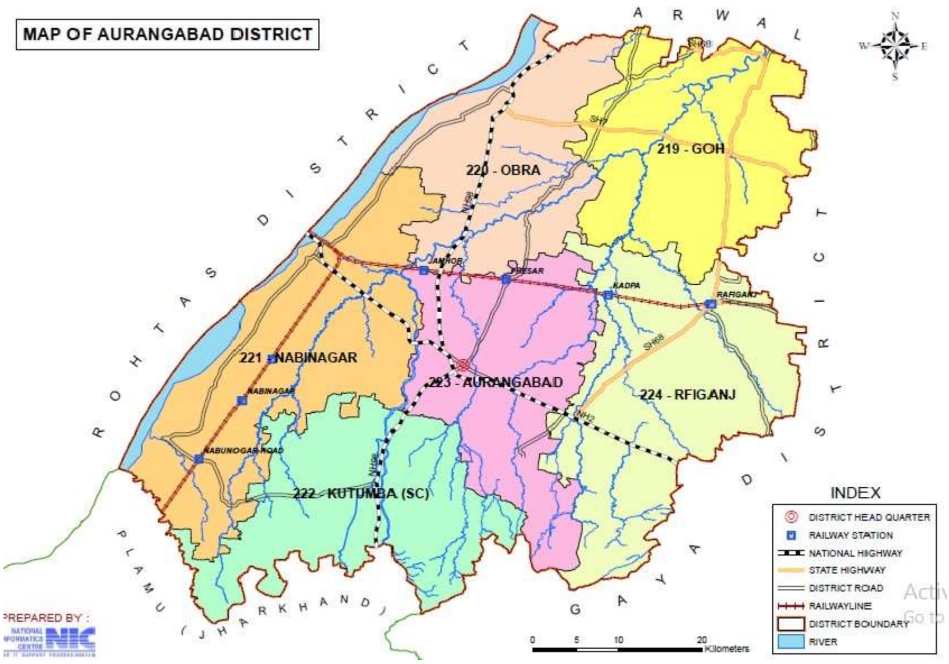


Fig. 7. Map of Aurangabad district.

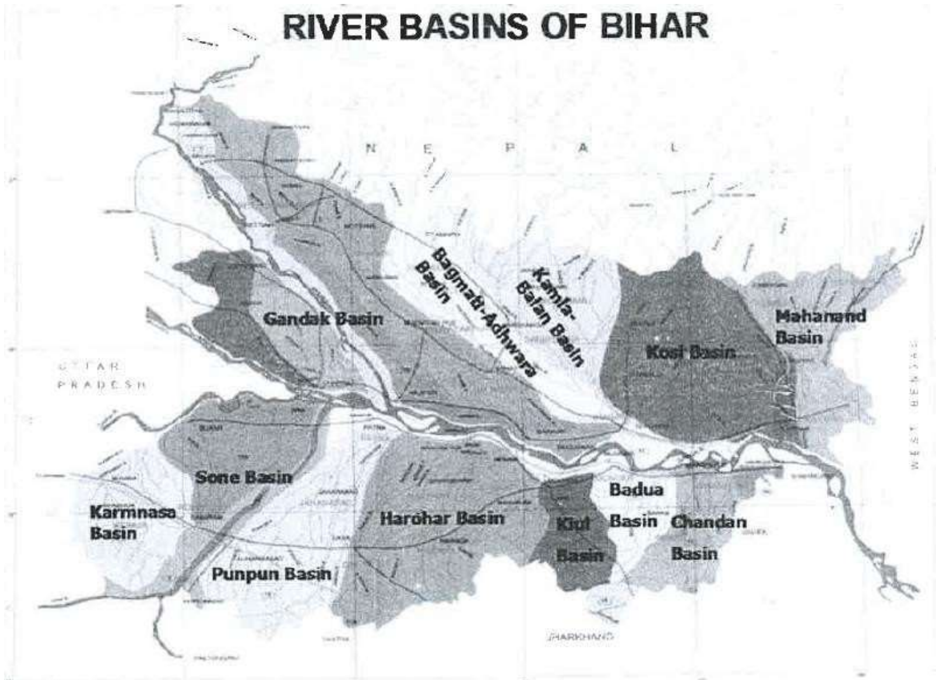


Fig. 8. River baisins of Bihar.

- Total land area of village = 100 hectares
- 1 hectares = 10000 square meter.
- Assuming approximately 10% of total area of village has been used for the residential houses, street roads, Khalihan, ponds, school, Panchayat Bhawan etc.,
- Assuming 10% of land area is not sown with paddy & left for other purposes like Animal’s food etc.,
- Then net area need to be irrigated = 81 hectares.

Main crop which is sown there is as follows:
1. Kharif: mainly paddy, some amount of sugarcane.,
2. Rabi: wheat, pulses, mustered etc.,
3. Zaid: watermelon, muskmelon, cucumber, vegetables and fodder crops.

Water requirement for paddy crop in total growing period=450-700mm

- Growing period of paddy = 90-110 days.
- Taking average growing period as 100 days.
- Taking water requirement for growing of paddy in total growing period=600mm.
- Maximum total head need to be considered as per site condition if we withdraw the water from pond=4m.
- Maximum total head need to be considered as per site condition if we withdraw the water from ground=30m.
- When exposed to direct sunlight a typical home solar panel produces about 300 watt in one hour.

V. Design Calculations and Data Analysis:

Minimum Water storage capacity of pond number 1 = 200 m x 15 m x 2 m = 6000 cubic meter.

Minimum Water storage capacity of pond number 2 = 500 m x 15 m x 3 m = 22,500 cubic meter.

Minimum Water storage capacity of pond number 3 = 1000 m x 20 m x 2 m = 40,000 cubic meter.

Total minimum water stored in pond number 1 + pond number 2 + pond number 3 = 6000 + 22,500 + 40,000 = 68,500 cubic meter.

Maximum water requirement will be for paddy or sugarcane crop. Main crop is paddy there.

Maximum water requirement for paddy crop = 600 mm/total growing period.

So, water demand per day = (81000 x 600)/(100 x 1000) = 4860 cubic meter per day.

Extra water stored in pond for = 68,500/4860 = 14.09 (approx 14 days).

Assuming 4 days water stored is percolating through soil or doing the ground water recharge. Then, minimum water storage will be for 10 days.

VI. PUMP POWER CALCULATION:

1. TO DELIVER OF WATER FROM POND
Pump power required = (4860 x 1000 x 9.81 x 4)/(24 x 36 x 100000) = 2.20 kW per hour.
Assuming pump efficiency = 70%
So, required motor power will be, P=2.20/0.70=2.4kW per hour
Taking standard power available in market =2.5kW per hour.

2. TO DELIVER OF WATER FROM GROUND

Pump power required = (4860 x 1000 x 9.81 x 30)/(24 x 36 x 100000) = 16.55kW per hour.
Assuming pump efficiency=70%
So, required motor power will be, P=16.55/0.70=23.64kW per hour. Taking standard value as 24kW per hour.

VII. Calculation of number of solar panel for above power requirement area of land to be covered by it:

1. TO DELIVER WATER FROM POND:
Assuming on an average ‘6’ hour of daily sunlight.
Then, a typical home solar panel can produce = 300 x 6 = 1800 Watt = 1.8 kW.
That is a solar panel can produce = 0.3 kW/hour

Number of solar panel required = 2.5/0.3 = 8.33

Taking nine solar panels:
Length of one 300 watt/hr solar panel = 1.67 m.
Breadth of one solar panel = 1.06 m.
Area of one solar panel = 1.06 x 1.67 = 1.77 square meter.
Area of nine solar panels required = 9 x 1.77 = 15.93 square meter, taking it as a maximum of 16 square meter.
The price of one solar panel of 300 watt and 24 volt is on an average maximum upto = 15000 INR.
Cost of 2.5kW/hr DC series motor =25000 INR/unit.
Other cost of suction pipe and delivery pipe approximately=10,000 INR (maximum)
So, total cost=1, 35, 000 +25000+10, 000=1, 70, 000 INR.
Assuming 20% maintenance cost., then total cost of photovoltaic solar system equipped with motor, pump, suction and delivery pipe=1, 70, 000x1.2=2, 04, 000 INR.
No's of households (farmer) in Bakhtiyarpur village they are using motor for irrigation purpose=at least 60% of total no's of houses=0.60x254=152.4 taking it as 153 number.
Money charged by the Bihar government for using a single motor per year for irrigation purpose=10,000INR/YEAR.
Total money taken by the Bihar government from village farmers = 10,000x153=15,30,000 INR
So, money saved by village farmers per annum=15, 30, 000-2, 04, 000=13, 26, 000 INR/year.
Here there is no need to calculate payback period because this case is already in huge profit for farmers.

2.TO DELIVER WATER FROM GROUND
No's of solar panel required=24/0.3=80 no's.
Land area required for solar panel=80x1.06x1.67=141.616 taking it as 142 square meter.
Cost of solar panel=80x15, 000 =12, 00000 INR
Assuming 10% maintenance cost, then total cost to occur=12, 00000x1.1=13, 20, 000 INR
So, money saved per year by village farmers=15, 30, 000 -13, 20, 000=2, 10,000INR/year.
Payback period=15, 30, 000/2, 10, 000=7.28 years, taking it as maximum of 8 years.
Life cycle of the photovoltaic solar system= 25 years (at least)
So, total profit for village farmers in 25 years=17x2, 10, 000=35, 70, 000INR.

CONCLUSION:

Solar based irrigation pump with irrigation method is one of the most important agricultural development technologies. The required energy is calculated using land conditions, energy generation with maximum daily sunlight conditions. The results show that respectable outcomes are achieved in terms of efficient use of water for irrigation, capital, operational cost, and adoption of renewable energy in the smart irrigation system. Thus if electricity needs for rural regions can be fulfill by the solar energy, we can save huge amount of money which normally expenses on its transmission and distribution to long distance, besides this we have to purchase electricity by neighboring states or by private firms, which result in the wastage of huge amount as it cost much to us. Else we can stop the problem of migration by providing enough water supplies and by electrifying the villages. By using above mentioned commune system for irrigation in rural area especially for villages we can save huge amount of money for our farmers. As approx 12000 our Indian farmers are already doing suicide per year due to financial crisis and debt trapped by government and private money lender so this system can help them to come out from this problem. This system will also balance the socio-economic culture with environment friendly. It can replace the diesel system of non- renewable energy resource dependency to renewable energy resource dependency. With the money saving this system is also saving the ground water by doing ground water recharge. Storage capacity of 10 days will reduce the dependency on monsoon too. Renewable energy system offers an alternative way for sustainable development of a country. This project indicates that the solar water pumping system can be integrated to irrigation systems in rural area as it is feasible solution for longer period. For twenty-five years of life cycle, solar PV system will cost half of the diesel engine operated system.

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