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Scope and Options of Solar Energy Use in Agriculture in Eastern region of India

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ABSTRACT

Groundwater abstraction to meet irrigation demand and application of water and energy efficient irrigation technologies is becoming a difficult affair due to significant energy poverty and pervasive electricity deficits in Eastern region of India. This undermines the production and productivity of small holders. This paper discusses the energy scarcity and possible remedy by the use of solar energy as this region receives abundance solar radiation due to its geographical location and 250 -300 bright sunny days per year which can be year round source of energy for agricultural use.

Keywords: Food security, Groundwater, Small farm holder, Solar Energy

INTRODUCTION

There are about (84.3%) small farm holders who cultivate land of an area less than 2 ha. These small holders are highly susceptible to poverty and hunger because neither they get sufficient food production nor income to ensure household food security,though from the efficiency point of view small holdings are equal or better than large holdings due to adoption of high yielding modern varieties of dominant food staples(NCEUS 2008; Sen, 1962 and 1964; Mazumdar, 1965; Berry, 1972).Typically, smallholders' staple production systems in India are often both risky and relatively of low return, as the low commercial value of staple crops are exacerbated by poor yields and erratic rainfall—the two problems that could be exacerbated under climate change (Held *et al.*, 2005). In the era of globalization and greater integration of global marketsmallholders can play a major role in increasing food production, generating additional income as well as employment, if they had the access of key ingredients in crop production (Lipton, 2006). Secured water supply could provide ample opportunitiesto these farmers to grow higher valued crops and crop diversification. This will generate employment even to landless people since more people are required to be involved in harvesting, processing and marketing the farm inputs and outputs, as promotion of irrigation is frequently cited as a strategy for poverty reduction, climate adaptation, and promotion of food security. Therefore, the future of sustainable agriculture growth and food security in India depends on the performance of small holders.

Energy in groundwater use

India is the biggest user of groundwater for agriculture in the world. The number of groundwater irrigation structures is around 27 million with every fourth rural household owning at least one such irrigation structure. These ground water irrigation structures are operated by diesel or electricity. Due to lack of electricity about 84 % pumps, i.e. by 4.28 million were diesel operated pumps (Shah, 2009). In this region general, irrespective of their land holding sizes farmersuse 5HP pump for ground water pumping. The average annual duration of operation per pump is about 462 hours (Shah *et al.*, 2003). The diesel consumption per horsepower per hour is 0.231 liters and carbon emission by combustion of one liter is 0.732 kg, therefore, total annual emission of carbon in Eastern region alone could be 1.67 million tons (MT) per year.

Despite bourgeoning in dieseland electric pumps, smallholders' irrigationin India particularly Eastern region is under siege from an energy squeeze with three sides: (a) deteriorating farm power supply; (b) embargo on new electricity connections; and (c) many-fold increase in diesel prices. Thisenergy squeeze undermines the adoption of broad range precision irrigation technologies and stable and profitable productivity of small holders. Further, the country faces a formidable challenge in providing adequate energy to all its users. About 84 million households do not have access to electricity (Kuppam, 2012) and most of the deprived households belong to Eastern region. The households those having electricity ,are suffered by frequent power cut and voltage fluctuations. Due to these many associated problems farmers are unable to run their pump for required hours for irrigation.

India's energy requirements are constrained by country's energy resources and import possibilities. India is not well endowed with natural energy resources. Reserves of oil, gas and Uranium are meagre. While coal is abundant but it is regionally concentrated and is of low calorie and high ash content and limited extraction technology. Hydro potential is significant, but small compared to India's needs and its contribution in terms of energy is likely to remain small. Providing energy access and energy security for the poor, particular in agriculture in terms of electricity and fossil fuels at affordable cost would, therefore, continue to be a major issue and problem. Solutions to this may be the renewable energy, mainly the solar energy. Solar energy could play a key role in energy access in ground water pumping and pressurised irrigation and also in pursuing low carbon developmental pathway.

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Solar energy potential in India

Indian endowed with a very large solar energy potential. The average solar radiation incident over India varies from 4.5-6.6kWhm-2 day-1 (Fig.1) with 250 -300 bright sunny days. This could be a year round reliable source of energy (Sharma *et al*., 2012).Promoting renewable energy in India has assumed greater importance in view of high growth rate of energy consumption (Bhattacharya and Jana, 2009). Renewable energy can have the advantage in providing off-grid electricity to rural area, particularly in Eastern region where billion liters of diesel are being used forgroundwater pumping and irrigation (Alkhamis, 2002).

In India,farmers use traditional method flood of irrigation in cropsproduction, whichputadditional stress on ground water resources. Therefore, water management on scientific lines in has become inevitable for its sustainability in the short and long-run. As per Hillel (1989) adoption of modern irrigation technologies-well suited when the farmers depend on groundwater sources-could stretching their scarce supply of water, enable them to expand their cultivated area, increase yield, diversification of crops, diversified production and generate more income and employment.

The solar photovoltaic (SPV) technology canbe a good option in mitigating persistence energy crisis in agriculture.Further, the combination of pressurised irrigation systems viz. drip and micro sprinklers with solarpowered ground water pumping system could reduce the over-exploitation of groundwater, environmental problems like waterlogging and salinity associated with the surface method of irrigation. This will increase the water-use efficiency, products quality, crop yields and fertilizer-use efficiency (Qureshi *et al*., 2001; Narayanamoorthy, 1997 and Dhawan, 2000). The comparative irrigation efficiencies under different methods of irrigation, and impact of dripirrigation on water saving and increase in yield are given in Table 1 and Table2.

Table1: Extent of Water Saving and Increase in Yield with Drip Irrigation Systems

Crops	Water Saving (%)	Increase in Yield (%)	Crops	Water Saving (%)	Increase in Yield (%)
Sugarcane	50	99	Ground nut	40	152
Tomato	42	60	Mulberry	22	23
Watermelon	66	19	Banana	45	52
Cucumber	56	45	Grapes	48	23
Chili	68	28	Sweet lime	61	50
Cauliflower	68	70	Pomegranate	45	45
Okra	37	33			

Source : INCID(1994)

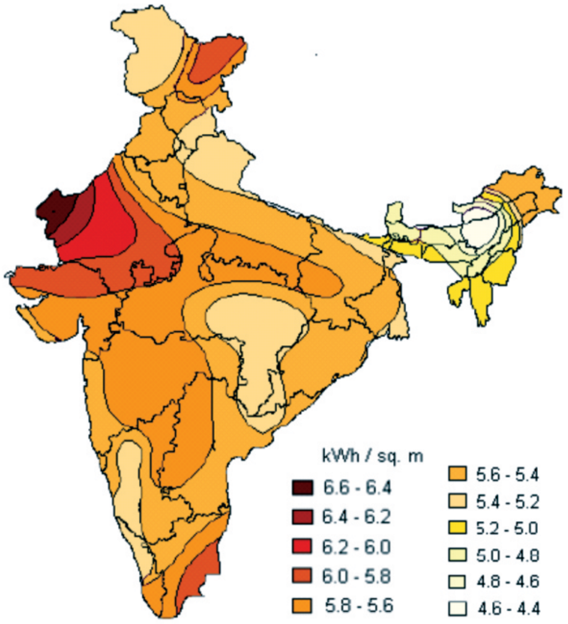

Fig.1: Solar radiation map of India

Table 2: Potential and actual area under Micro irrigation in Eastern region (Area in 000 ha)

State	Drip			Sprinkler		
	Potential	Actual	%	Potential	Actual	%
Bihar	142	0.16	0.11	1708	0.21	0.01
Chhattisgarh	22	2.65	16.58	189	59.27	31.6
Jharkhand	43	0.13	0.31	114	0.37	0.32
Odessa	157	3.63	2.31	62	23.47	37.85
Uttar Pradesh	2207	10.68	0.48	8582	10.59	0.12
West Bengal	952	0.15	0.02	280	150.03	53.58

Source: Palanisami (2011)

Despite these many benefits in water saving and yield increase, adoption and diffusion of pressurised irrigation system, particularly in Eastern region of India is far below the potential (Table 3). The main reason behind this shortfall can be attributed to lack of energy access and technical knowhow;otherwise many states provide subsidy assistance, ranging from 50% to 90%,for promoting micro irrigation.

Table 3 : Irrigation Efficiencies under Different Methods of Irrigation (Percent)

Irrigation Efficiencies	Methods of Irrigation		
	Surface	Sprinkler	Drip
Conveyance efficiency	40-50 (canal)	100	100
Conveyance efficiency	60-70 (well)	100	100
Application efficiency	60-70	70-80	90
Surface water moisture evaporation	30-40	30-40	20-25
Overall efficiency	30-35	50-60	80-90

Source : Sivanappa (1998)

Solar Photovoltaic Technology

The power of solar radiation on per unit area is called irradiance or insolation and measured in watt per square meter (Wm^{-2}). Solar energy can be converted into electrical energy by way of solar cells. An assembly of solar cells is called a solar module and is used to capture energy from sunlight. When multiple modules are assembled together, the resulting integrated group of modules all oriented in one plane is referred as solar panel or solar array. The amount of electricity generation depends upon the duration and amount of sunlight falling on the solar module. The efficiency and power output of a module is given for light condition corresponding to 1000 W/m^2 and at 25 ^0C temperature, known as Standard Test Condition (STC). The rated power of a module is referred as Watt-peak (Wp) or kilowatts-peak (kWp). The peak power of PV module changes with change in falling solar radiation and temperature of the cell under real life conditions. Typically, one does not get the condition corresponding to STC. Solar radiation is normally lower than the STC condition and cell temperature is normally higher than the STC condition. Both of these have effect of decreasing power output from the PV module. Characteristically, the solar radiation intensity varies from morning to afternoon to sunset, i.e. from 0 Wm-2 at the sunrise and sunset to about 0.9 kWm-2 at noon time. The integration of the solar intensity over the time gives solar insolation falling at a unit area over a day and therefore the unit of solar insolation is watt hour per square meter per day (Whm^{-2} day^{-1}) or kilowatt hour per square meter per day ($kWhm^{-2}$ day^{-1}). India is located in the equatorial belt and hence receives abundant sunshine. The average solar insolation in India varies between4-7 $kWhm^{-2}$ day^{-1}.

In solar energy, efficiency of photovoltaic module is important in module size determination required to generate given amount of electrical energy (Table 4). Efficiency of module depends on the material of which solar cells are produced. Efficiency of cells and modules made from different materials and for subcategories within each material grouping (e.g. crystalline, polycrystalline and thin film) are different. For example crystalline silicon modules are much more efficient than amorphous or thin film module. The efficiencies of solar cells of different materials and subcategories within each material are reported by Green *et al.* (2011).

Table 4: Efficiency of different solar cells and modules

Cell material	Max. cell efficiency (lab)	Max. cell efficiency (mass prod.)	Typical Module efficiency	Surface area req. for $1kW_P$ power	Comment
Monocrystalline silicon	24.7%	22.0%	15%	$6.7m^2$	Highest price, affected by temperature
Polycrystalline silicon	20.35	17.4%	14%	$7.2m^2$	Medium price, affected by temperature
Amorphous silicon	12.1%	6.8%	6%	$16.7m^2$	Medium to low price, not affected by temperature
CIS/CIGS	20.0%	11.6%	10%	$10.0m^2$	
CdTe	16.5%	12.0%	7%	$14.3m^2$	
Concentrated cells	41.1%	36.5%	28%	$3.6m^2$	

Source : Quaschning (2010)

In order to maximise the power generation, solar modules should always be kept perpendicular to the sunrays. This requires tracking structure on which solar photovoltaic modules or the array is to be mounted. Tracking can be automatic or manual depending on the need of the user. To avoid extra cost of tracking infrastructure fixed mounting is preferred. In fixed mounting, photovoltaic modules/ array should be fixed at a fixed angle with an optimum tilt, normally equivalent to the latitude angle of the location where the system is to be installed. The advantages of SPV technologies over conventional technologies are lying in the fact that it is reliable, convenient, durable, environmentally benign, low maintenance and responds instantaneously to the solar radiation. SPV technologyis sustainable even in isolated and remote areas.

This technologyis modular in nature and therefore, this system of desired capacity can be designed simply by integrating additional modules. Most of the commercially available solar modules are capable of producing electricity for at least 20 years (Dunlop, 2005). On account of life cycle photovoltaic is economically viable and therefore favourable solution for much small power applications, particularly in ground water pumping where electricity is not available and internal-combustion engines are expensive to operate.

CONCLUSIONS

In view of energy demand in agriculture and lack of grid power connectivity, the promotion of solar energy for agricultural and allied activities in Eastern region is essential to realised second green revolution. State agencies should promote the solar technology among the smallholder at affordable cost to make them self-reliant in terms of food security as well as their economic upliftment.

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