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Impact of solar irrigation on farm incomes in Ananthapur district of Andhra Pradesh

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Abstract
The average size of the farm was 3.26 ha on solar and 3.12 ha on non-solar farms. The entire farm holding was irrigated dry under solar farms and rainfed in the case of non-solar farms. Cent per cent of farmers with solar pumpsets were growing mango orchard, whereas the rest of the farmers who still depended on rainfall confined to mono-cropping of groundnut in only Kharif. Cost of establishing mango on solar farms was found to be Rs. 62, 792.34 as on current rates. High density planting of 175 grafts per ha was adopted by the solar farms. Fencing was not planned on all the mango farms resulting in yield losses due to non-insect pests. Commercial cost of cultivation (cost C_2) of mango on solar farms was Rs. 76,928.73 per ha during current period, 2016-17. The average yield on solar farms was found to be 10.87 tonnes per ha. With an average selling price Rs. 11,000 per tonne solar farmers realized a net income of Rs. 42,641.27 per ha. The returns per rupee of investment was Rs.1.55. Commercial cost of cultivation (cost C_2) of groundnut on non-solar farms was Rs. 46,592.48. The average yield on non-solar farms was found to be 13.50 quintals per ha. With an average selling price per quintal Rs. 4,450 non-solar farmers realized a net income of Rs. 21,357.52. The returns per rupee of investment was Rs.1.46.

Keywords: solar irrigation, government organizations, non-governmental organizations

Introduction
The Government of India has set a target of doubling farmers' income by 2022. It has also set an ambitious target of 100 GW of solar power generation by 2022. Sharing the same time period, the twin goals are very much in tandem with each other. In the growth of agriculture in India, the role of irrigation, especially groundwater irrigation, is well documented and hence to enhance farmers' income, groundwater irrigation has to play a major role. The groundwater extraction for irrigation now totally depends on electric and diesel sources of energy, which plays a crucial role in breaking the vicious cycle of poverty by providing food and income security. There are around 26 million irrigation pumps in India. Of which, about 8 million pumps are diesel-run and 18 million are electric pumps. Agricultural sector shared 17.30 per cent of the total electricity consumption in India during 2015-16 (MOSPI, 2017) [1] and accounted for about 13 per cent of total diesel consumption in India (PPAC, 2013) [2]. It has been estimated that the replacement of existing diesel and electricity based pumpsets can lead to a reduction of 62 billion kilogram equivalent of carbon dioxide ($kgCO_2e$) emissions and savings of USD 11.5 billion per annum (Infraline Energy, 2014) [3].
In Andhra Pradesh, Ananthapur district required a boost of electricity for irrigation of crops, which was limited in the region, and thus affecting the farming community. Addressing this concern, an NGO Rural Development Trust (RDT), Ananthapur introduced pumpsets, driven by solar power and systems of drip irrigation, which supplied water to horticulture crops timely and efficiently to reduce the use of fossil fuel powered conventional electricity. RDT, Ananthapur had its own program running for solar pumpsets to the farmers of Ananthapur from 2005 and till March, 2016, 518 (each for 10 acres) solar pump sets has been granted covering 2208 ha in 317 villages. With information and assistance from RDT, farmers had shifted their cropping pattern from groundnut to horticulture and vegetable crops. Considering the above facts, the present study entitled "Impact of solar irrigation on farm incomes in Ananthapur District of Andhra Pradesh" has been taken up with following specific objectives.

Objectives
1. Investment required for installing solar pumpsets by the farmers
2. Change in cropping pattern
3. Economics of mango orchard and groundnut

Methodology

The present study was conducted in Ananthapur district of Andhra Pradesh state. Purposive-cum-random sampling technique was employed for the selection of sample in the present study. Ananthapur is an arid zone with frequent droughts where rainfed and dry land agriculture is predominent, wherein the need for electricity for irrigation purpose is very high. Government and NGOs are trying to transform the district into a horticulture hub with subsidies on saplings and solar irrigation pumps and on drip irrigation system. Hence, Ananthapur district was purposively selected for present study. The list of the mandals along with corresponding number of solar pumpsets was prepared. Four mandals with highest number of solar pumpsets was identified and purposively selected. The list of all villages covered under four mandals was prepared and analogously one village from each mandal with highest number of solar pumpsets was purposively selected. All the farmers in the selected four villages with solar pumpsets were listed out and 50 farmers were randomly selected. Another set of 50 farmers without solar pumpsets from the same villages were also randomly selected to serve as a control group. The information related to the present study was collected using a well-defined and pre-tested schedule through personal interview method. Detailed information was collected and it pertained to the agricultural year 2016-17.

Tools and techniques of analysis

Cost structure

Mango is a perennial crop with an economic life span of 40 years and starts yielding from 5th year onwards. The cost incurred in raising mango orchards can be classified into two types *viz*., (i) establishment cost and (ii) maintenance cost.

Establishment cost included all the expenses incurred in the first year for establishment of mango orchard. Items like land preparation, digging of pits and filling, cost of manures, fertilizers, plant protection chemical, expenditure incurred on different farm operations, *viz*., fencing, weeding, laying of irrigation and drainage channels, irrigation, gap filling, repairs and maintenance were considered as establishment costs.

Expenses incurred on input services like human labour utilized for clearing of basins, weeding, application of manures and fertilizers, irrigation, channel maintenance, services of machinery and on material inputs *viz*., manures, fertilizers, plant protection chemicals, and other maintenance charges were regarded as maintenance costs from second year onwards till the end of its economic life period.

Cost Concepts

Cost A_1

This cost includes value of purchased material inputs (seed, insecticides and pesticides, manure, fertilizer), hired human labour, animal labour (owned and hired), machinery labour (owned and hired), depreciation on farm implements and farm buildings, irrigation charges, land revenue, cess and other taxes and interest on working capital.

Cost A_2

Cost A_1 + rent paid for leased in land.

Cost B_1

Cost A_1 + interest value of owned capital assets (excluding land).

Cost B_2

Cost B_1 + rental value of owned land (net of land revenue) + rent paid for leased-in land.

Cost C_1

Cost B_1 + imputed value of family labour.

Cost C_2

Cost B_2 + imputed value of family labour.

Cost C_3

Cost C_2 + 10 per cent of Cost C_2 (on account of managerial functions performed by the farmer).

Farm efficiency measures

Farm business income = Gross income-Cost A_1

Family labour income = Gross income – Cost B_2

Net income = Gross income-Cost C_2

Farm investment income = Farm business income-imputed value of family

(or)

Net income + imputed rental value of owned land + interest on owned fixed capital invested.

Results and Discussion

The average size of the farm (Table 1) was 3.26 hectare on solar and 3.12 hectare on non-solar farms. The entire farm holding was irrigated dry under solar farms and rainfed in the case of non-solar farms.

1. Investment required for installing solar pumpsets by the farmers

Table 2 shows various components required in installing solar pumpsets by the farmers. Solar PV modules takes the largest share of 48 per cent with other supply components like solar inverter, hot dip Galvanized Iron (GI) mounting structure with manual tracking, DC motor pump and High density poly-ethylene (HDPE) pipe contributing 12, 11, 8.50 and 3.50 per cent respectively. Civil works and all other necessary materials required for installing and commissioning including transport charges, insurance *etc*. contribute 7 per cent. And 10 per cent share is from comprehensive annual maintenance charges for 5 years of free service in case of repairs to the farmer. According to Hossain *et al*. (2015) [4], it was also revealed that the major cost of about 45% was shared by panels.

Till December, 2016 Rural Development Trust (RDT), Ananthapur is the sole organization that was granting solar submersible pumps (3 HP, 1800 Wp DC) worth Rs. 5,25,000 for Rs. 15,000 (for SC and ST farmers) and Rs. 30,000 (for BC and OC farmers). But from January, 2017 RDT supported the farmers with Rs. 40,000 (for SC and ST farmers) and Rs. 25,000 (for BC and OC farmers) of Rs. 55,000 to be paid for solar pump sets through Ministry of New and Renewable Energy (MNRE), New and Renewable Energy Development Corporation of Andhra Pradesh Limited (NREADCAP) and Andhra Pradesh Southern Power Distribution Company Limited (APSPDCL).

2. Cropping pattern on sample farms

Predominated by rainfed and dryland agriculture, farmers in the district rely on mono-cropping of water thirsty crop like groundnut mainly under monsoon-fed during Kharif. Now, farmers are shifting their cropping pattern to high value crops

like mango with the help of solar pumpsets and by drip irrigation apart from adopting water harvesting techniques.

As Table 3 shows, cent percent of farmers with solar pumpsets were growing mango orchards, whereas the rest of the farmers who still depends on rainfall confined to groundnut in Kharif only. The average land holding of solar farmers was 3.26 hectare and it was 3.12 hectare for non-solar farmers. According to Sharada (2015) [5], it was estimated that 17,169 hectares of additional land was brought under irrigation with solar pump scheme in 2012-13. Many farmers even had three crops, and they have diversified to more remunerative horticulture. Additionally, two crops were grown each year, rather than having just one monsoon-fed crop over a whole year.

3. Economics of mango orchard and groundnut

On an average 64.51 mandays were utilized per ha for establishment of mango orchard. Among different operations of labour use, digging of pits was the maximum labour absorbing operation followed by planting. About 170-175 pits were required as per density of planting adopted by the farmers. The pits were dug with the dimension 3'X3'X3' and filled with soil, BHC and farm yard manure. On an average, 16.25 mandays per ha (25.19 per cent) were required for this operation.

Machine power of 6.25 was employed for land preparation and inter-cultivation in establishment of mango orchard.

The material inputs used in raising the mango orchard were plant material, FYM, fertilizers, plant protection chemicals. A plant population of 175 grafts per ha was used for the establishment of mango orchard. The quantity of manures applied was about 3.4 tonnes. The use of N, P, K nutrients through fertilizers stood at 16, 18.75 and 15 kg. Plant protection chemicals were applied in the form of powders (sulpher, carbendazem + mancozeb) and liquids (dichlorvos, imidachloprid). The total quantity of plant protection chemicals used stood at just around 3.2 kgs of powder alone during its establishment period.

The total costs (Table 4) incurred during the establishment of mango orchard amounted to Rs. 62,792.34. Out of the total costs, operational and fixed costs worked out to Rs. 33,353.70 (53.12 per cent) and Rs. 29,438.64 (46.88 per cent) respectively.

Among operational costs the labour charges formed the major item with Rs. 16,127.50 (25.68 per cent). The operations such as land preparation, making of lines, digging of pits, planting, gap filling, stalking, weeding and watering required more human labour, hence the higher expenditure.

Next to labour charges, cost of plant material formed the major item of operational expenditure which worked out to Rs. 6,125 (9.75 per cent) followed by manures Rs. 2,720 (4.33 per cent), fertilizers Rs. 1,300 (2.07 per cent), interest on working capital Rs. 1,136.20 (1.81 per cent), plant protection chemicals Rs. 820 (1.31 per cent), transportation Rs.750 (1.19 per cent). The farmers procured plant material on subsidy from either Government organizations or from NGOs at Rs.35 per plant. The farmers adopted high density planting (175 plants per ha).

Machine power was used for land preparation for raising the orchard. No cattle power was used for land preparation because it is difficult to remove deep rooted weeds from soil with cattle power. The expenditure towards this item was Rs. 4,375 (6.97 per cent).

Among the fixed costs, rental value of owned land formed the major item of total cost amounting to Rs. 15,000 (23.89 per cent) followed by interest on fixed capital Rs. 8,805.30 (14.02 per cent), depreciation charges Rs.5,483.34 (8.73 per cent) and land revenue Rs. 150 (0.24 per cent).

During current period, 2016-17 the total labour utilization stood at 83.52 mandays per hectare.

Machine power of 1.25 hours was used for the purpose of inter-cultivation during current period 2016-17.

The input utilization on mango orchard during current period showed that manuring accounted for 14.03 tonnes. In the case of chemical fertilizers, the use of N, P, K nutrients stood at 101 kg, 80.5 kg and 75 kg per ha respectively. The total quantity of powders and liquids applied to control pests and diseases was 2.75 kgs and 0.725 liters respectively.

The total costs (Table 5) incurred during the current period of mango orchard amounted to Rs. 76,928.73 on solar farms. Out of total costs, operational and fixed costs worked out to Rs. 45,920.28 (59.69 per cent) and Rs. 31,008.45 (40.31 per cent) per ha respectively.

Among operational costs the labour charges formed the major item with Rs. 20,880 (27.14 per cent). The operations such as watch and ward, harvesting, weeding, plant protection, irrigation, manuring and fertilizer application required more human labour and hence the higher expenditure.

Manuring was the next major component in the cost structure with Rs. 11,224 (14.59 per cent), followed by fertilizers amounted to Rs.6,300 (8.19 per cent), watch and ward Rs. 3,000 (3.90 per cent) and interest on working capital with Rs. 1,663.28 (2.16 per cent).

Machine power was used for inter-cultivation on which Rs. 875 (1.14 per cent) was spent.

Among the fixed costs, rental value of owned land with Rs. 15,000 (19.50 per cent) stood as a major item. It was followed by interest on fixed capital with Rs. 8,805.30 (11.45 per cent), depreciation charges with Rs. 5,483.34 (7.13 per cent), annual share of establishment costs with Rs. 1,569.81 (2.04 per cent) and land revenue with Rs.150 (0.19 per cent).

It is clear from Table 6 that there was no leasing in activity among the selected farmers and hence the cost A_1 and cost A_2 were the same. On an average, the total cost of cultivation (cost C_2) was amounted Rs. 76,928.73. The average total cost (ATC) (Table 7) to produce one tonne of mango was Rs. 7,077.16. The selling price per tonne was Rs. 11,000. The returns per tonne was Rs. 3,922.84.

On an average, the yield of mango per hectare was 10.87 tonnes (Table 8). Solar farms were able to secure Rs. 1.55 per every rupee spent.

The solar farms realized a gross income of Rs. 1,19,570. The net income was Rs. 42,641.27. Though the gross income was a measure to assess the efficiency of the farm business, but it alone does not help us to read the success of the farm business. Therefore, another measure namely farm business income which indicates returns to owned resources like land, capital and labour was estimated. Farm business income (Table 9) on solar farms was Rs. 70,691.38.

Family labour income was another measure of farm efficiency which represents returns to farmers own labour and family labour. The family labour income on solar farms was Rs. 46,886.08.

Farm investment income was a measure that indicated returns to fixed capital. It was Rs. 68,016.38 on solar farms.

Non-solar farms were operated under rainfed conditions. Groundnut was the sole crop grown by the non-solar farmers.

On an average, 70.68 mandays per ha were utilized in groundnut of non-solar farms.

A total of 10.62 cattle pair days per ha was used in the cultivation of groundnut for land preparation, inter-cultivation, transportation and sowing.

Machine power of 3.83 hours per ha was employed in the operations like ploughing, transportation and threshing.

Farm yard manure was used as organic manure to improve the fertility of the soils. Groundnut being the legume and an oilseed crop has greater requirement for sulphur and phosphorous. About 4.53 mandays were employed in the application of manures and fertilizers in the cultivation of groundnut on one hectare.

On an average, seed rate of 116.25 kg per hectare in the cultivation of groundnut were adopted by the non-solar farms. On an average, 3.52 tonnes of farm yard manure was used. The application of N, P and K through chemical fertilizers was in the order of 27 kg, 57.5 kg and 45 kg per ha respectively. Plant protection chemicals were applied as preventive and remedial measure against the attack of pests and diseases. The per hectare use of plant protection chemicals was 1.25 liters of liquids and 0.62 kgs of powder.

On an average, the total cost of cultivation per ha (Table 10) of groundnut was Rs. 46,592.48. The breakup of total costs into operational and fixed costs indicated that operational cost were Rs.41,252.28 (88.54 per cent) and fixed costs were Rs.5,340.20 (11.46 per cent).

Of the total operational costs, human labour was the highest costing input service in the cultivation of groundnut on non-solar farms. The expenditure incurred towards this resource service was Rs. 17, 670 (37.92 per cent).

Of the total costs, human labour was the highest costing input service in the cultivation of groundnut on non-solar farms. The expenditure towards cattle labour was Rs. 6,372 (13.68 per cent) and that of tractor services was Rs. 2,681 (5.75 per cent). The seed cost was Rs. 5,231.25 accounting for 11.28 per cent of the total cost.

Plant nutrient management is an important factor for getting good harvest of any crop. On an average, farmers had spent Rs. 2,816 on manures and Rs. 3,792 on fertilizers accounting for 6.04 per cent and 8.14 per cent of the total cost respectively. Groundnut crop is prone to pests and diseases. Therefore, farmers resorted to protective care. Normally the crop is prone to leaf miner, red hairy caterpillar, root grub, early and late leaf spots, rust, stem rot *etc*. The expenditure towards plant protection chemicals was Rs. 1,776.74 per ha (3.81 per cent), whereas the interest on working capital amounted to Rs. 913.28 (1.96 per cent).

Among the fixed costs, rental value of owned land was the major item. It was Rs. 3,000 accounting for 6.44 per cent. The other item of fixed costs were interest on fixed capital (2.45 per cent), depreciation charges (2.25 per cent) and land revenue (0.32 per cent).

There was no leasing in activity (Table 11) among the selected farmers and hence the cost A_1 and cost A_2 were the same. On an average, the total cost of cultivation (cost C_2) was amounted Rs. 46,592.48. The average total costs (ATC) (Table 12) to produce one quintal of groundnut was Rs. 3,451.29. The price per quintal was Rs. 4,450. The returns per quintal was Rs.998.71. Non-Solar farms were able to secure Rs.1.46 per every rupee spent.

The gross income realized on non-solar farms was Rs. 67,950 (Table 13) and net income was Rs. 21,357.52. Though the gross income was a measure to assess the efficiency of the farm business, but it alone does not help us to read the success of the farm business. Therefore, another measure namely farm business income which indicates returns to owned resources like land, capital and labour was estimated. Farm business income (Table 14) on non-solar farms was Rs. 31,112.52.

Family labour income was another measure of farm efficiency which represents returns to farmers own labour and family labour. The family labour income on non-solar farms was Rs. 26,972.52.

Farm investment income was a measure that indicated returns to fixed capital. It was Rs. 25,497.52 on non-solar farms.

Conclusions

The proportionate area for mango on solar farms was 3.26 hectare as against 3.12 hectare of groundnut on control non-solar farms. The expenditure incurred by the farmers for installing 3 HP DC 1800 Wp submersible solar pumps was Rs. 30,000 and Rs. 15,000 for OC and BC farmers and SC and ST farmers respectively. Cost of establishing mango on solar farms was found to be Rs. 62,792.34 as on current rates. Commercial cost of cultivation (cost C_2) of mango on solar farms was Rs. 76,928.73 per hectare. The average yield on solar farms was found to be 10.87 tonnes per hectare. The returns per rupee of investment was Rs.1.55. The average total cost of production per tonne of mango on solar farms was Rs. 7,077.16. The solar farms realized a gross income of Rs. 1,19,570. The net income was Rs. 42,641.27. Commercial cost of cultivation (cost C_2) of groundnut on non-solar farms was Rs. 46,592.48. The average yield on non-solar farms was found to be 13.50 quintals per hectare. The returns per rupee of investment was Rs.1.46. The average total cost of production per quintal of groundnut on non-solar farms was Rs. 3,451.29. The gross income realized on non-solar farms was Rs. 67,950 and net income was Rs. 21,357.52.

Suggestions and policy implications

1. In the study area, solar pumps with low pumping capacity backed up by water harvesting techniques and use of micro-irrigation can help farmers shift their cropping pattern to high value more remunerative horticultural crops.
2. Appropriate steps should be taken to connect solar tubewells to the grid with a provision for buy back of surplus power to discourage over-exploitation of groundwater and realization of additional income by the farmers.
3. For efficient use of groundwater through solar submersible pumps, adoption of water harvesting techniques and micro-irrigation should be promoted by providing appropriate awareness and subsidy to the farmers.
4. Solar irrigation cooperatives of 40-50 members at each village can be formed where farmers can sell surplus solar power to DISCOM by connecting solar pumps to grid.

Table 1: Average size of land holding of sample farms (in hectare)

S. No.	Particulars	Solar farmers	Non-solar farmers
1.	Rainfed land	-	3.12 (100)
2.	Irrigated dry	3.26 (100)	-
Total		3.26 (100)	3.12 (100)

Note: Figures in parentheses indicate percentages to the total.

Table 2: Investment required for installing 3HP DC 1800 watt peak submersible solar PV pumpset (in rupees)

S. No.	Item	Costs (≠)	
A.	**Supply component**		
1.	Solar PV Modules	2,52,000 (48.00)	
2.	Solar Inverter / VFD with remote monitoring arrangement	63,000 (12.00)	
3.	DC Motor Pump	44,625 (8.50)	
4.	Hot dip Galvanized Iron (GI) mounting structure to withstand load of modules and high wind velocities up to 150 km per hour with manual tracking	57,750 (11.00)	
5.	HDPE pipe of 10 kg. cm^{-2} - minimum 63 mm OD-PE 100 grade of 150 ft. length with 3 core 2.5 mm^2 flat cable as per ISI standards of 170 ft. length	18,375 (3.50)	
B.	**Installation & Commissioning component**		
6.	Civil works and all other necessary materials required for installation and commissioning including transport charges, insurance *etc.*	36,750 (7.00)	
C.	**Comprehensive Maintenance charges (CMC)**		
7.	Comprehensive Annual Maintenance contract for 5 years period payable @ 2% every year	52,500 (10.00)	
D.	Total Amount	5,25,000 (100)	
E.	**Subsidy to the farmer**		
8.	Rural Development Trust (RDT), Ananthapur contribution	4,95,000 (94.29)	5,10,000 (97.14)
9.	Farmer's share (OC and BC)	30,000 (5.71)	-
10.	Farmer's share (SC and ST)	-	15,000 (2.86)

Note: Figures in parentheses indicate percentages to the total.

Table 3: Cropping pattern on sample farms (in hectare)

S. No.	Particulars	Perennial crop	Season		Total area
			Kharif	Rabi	
1.	Solar farms	Mango (100)	-	-	3.26 (100)
2.	Non-solar farms	-	Groundnut (100)	-	3.12 (100)

Note: Figures in parentheses indicate percentages to the total.

Table 4: Establishment cost of mango on solar farms (in rupees per hectare)

S. No.	Particulars	Costs (≠)
1.	**Operational costs**	
a.	Human labour	16,127.50 (25.68)
	Owned	3,812.50 (6.07)
	Hired	12,315.00 (19.61)
b.	Machine power	4,375.00 (6.97)
	Owned	1,150.00 (1.83)
	Hired	3,225.00 (5.14)
c.	Plant material	6,125.00 (9.75)
d.	Manures	2,720.00 (4.33)
e.	Fertilizers	1,300.00 (2.07)
f.	Plant protection chemicals	820.00 (1.31)
g.	Transportation	750.00 (1.19)
h.	Interest on working capital	1,136.20 (1.81)
	Total operational costs	33,353.70 (53.12)
2.	**Fixed costs**	
a.	Depreciation	5,483.34 (8.73)
b.	Land revenue	150.00 (0.24)
c.	Rental value of owned land	15,000.00 (23.89)
d.	Interest on fixed capital	8,805.30 (14.02)
	Total fixed costs	29,438.64 (46.88)
3.	Total costs	62,792.34 (100)

Note: Figures in parentheses indicate percentages to the total.

Table 5: Cost of cultivation of mango on solar farms during current period, 2016-17 (in rupees per hectare)

S. No.	Particulars	Costs (≠)
1.	**Operational costs**	
a.	Human labour	20,880.00 (27.14)
	Owned	2,675.00 (3.48)
	Hired	18,205.00 (23.66)
b.	Machine power	875.00 (1.14)
	Owned	236.25 (0.31)
	Hired	638.75 (0.83)
c.	Manures	11,224.00 (14.59)
d.	Fertilizers	6,300.00 (8.19)
e.	Plant protection chemicals	1,978.00 (2.57)
f.	Watch and ward	3,000.00 (3.90)
g.	Interest on working capital	1,663.28 (2.16)
	Total operational costs	45,920.28 (59.69)

2.	**Fixed costs**	
a.	Depreciation	5,483.34 (7.13)
b.	Land revenue	150.00 (0.19)
c.	Rental value of owned land	15,000.00 (19.50)
d.	Interest on fixed capital	8,805.30 (11.45)
e.	Annual share of establishment costs	1,569.81 (2.04)
	Total fixed costs	31,008.45 (40.31)
3.	Total costs	76,928.73 (100)

Note: Figures in parentheses indicate percentages to the total.

Table 6: Cost concepts of mango on solar farms during current period, 2016-17 (in rupees per hectare)

S. No.	Particulars	Costs (≠)
1.	Cost A1/A2	48,878.62
2.	Cost B1	57,683.92
3.	Cost B2	72,683.92
4.	Cost C1	60,358.92
5.	Cost C2	76,928.73
6.	Cost C3	84,621.60

Table 7: Cost of production of mango on solar farms during current period, 2016-17 (in rupees per tonne)

S. No.	Particulars	Rupees per tonne
1.	Costs	
a.	Average variable costs (AVC)	4,224.50
b.	Average fixed costs (AFC)	2,852.66
c.	Average total costs (ATC)	7,077.16
2.	Price per tonne	11,000.00
3.	Returns per tonne	3,922.84

Table 8: Output and returns of mango on solar farms during current period, 2016-17 (per hectare)

S. No.	Particulars	Units	
1.	**Yield in physical terms**		
a.	Main product	tonnes	10.87
b.	By-product	-	-
2.	**Monetary terms**		
a.	Price per tonne	Rupees	11,000.00
b.	Main product	Rupees	1,19,570.00
c.	By-product	Rupees	-
3.	Gross returns	Rupees	1,19,570.00
4.	Total cost of cultivation	Rupees	76,928.73
5.	Net returns	Rupees	42,641.27
6.	Returns per rupee of investment	Rupees	1.55

Table 9: Measures of farm income in mango production on solar farms during current period, 2016-17 (in rupees per hectare)

S. No.	Particulars	Rupees per hectare
1.	Gross income	1,19,570.00
2.	Net income	42,641.27
3.	Farm business income	70,691.38
4.	Family labour income	46,886.08
5.	Farm-investment income	68,016.38

Table 10: Cost of cultivation of groundnut on non-solar farms (in rupees per hectare)

S. No.	Particulars	Costs (≠)
1.	**Operational costs**	
a.	Human labour	17,670.00 (37.92)
	Owned	5,615.00 (12.05)
	Hired	12,055.00 (25.87)
b.	Cattle labour	6,372.00 (13.68)
	Owned	2,832.00 (6.08)
	Hired	3,540.00 (7.60)
c.	Machine power	2,681.00 (5.75)
	Owned	924.00 (1.98)
	Hired	1,757.00 (3.77)
d.	Seed	5,231.25 (11.28)
e.	Manures	2,816.00 (6.04)
f.	Fertilizers	3,792.00 (8.14)
g.	Plant protection chemicals	1,776.74 (3.81)
h.	Interest on working capital	913.28 (1.96)
	Total operational costs	41,252.28 (88.54)
2.	**Fixed costs**	
a.	Land revenue	150.00 (0.32)
b.	Rental value of owned land	3,000.00 (6.44)
c.	Depreciation	1,050.20 (2.25)
d.	Interest on fixed capital	1,140.00 (2.45)
	Total fixed costs	5,340.20 (11.46)
	Total costs	46,592.48 (100)

Note: Figures in parentheses indicate percentages to the total.

Table 11: Cost concepts of groundnut on non-solar farms (in rupees per hectare)

S. No.	Particulars	Costs (≠)
1.	Cost A1/A2	36,837.48
2.	Cost B1	37,977.48
3.	Cost B2	40,977.48
4.	Cost C1	43,592.48
5.	Cost C2	46,592.48
6.	Cost C3	51,251.73

Table 12: Cost of production of groundnut on non-solar farms (in rupees per quintal)

S. No.	Particulars	Rupees per quintal
1.	Costs	
a.	Average variable costs (AVC)	3,055.72
b.	Average fixed costs (AFC)	395.57
c.	Average total costs (ATC)	3,451.29
2.	Price per quintal	4,450.00
3.	Returns per quintal	998.71

Table 13: Output and returns of groundnut on non-solar farms (per hectare)

S. No.	Particulars	Units	
1.	Yield in physical terms		
a.	Main product	Quintals	13.50
b.	By-product	Cart loads	1.75
2.	Monetary terms		
a.	Price per quintal	Rupees	4,450.00
b.	Main product	Rupees	60,075.00
c.	By-product	Rupees	7,875.00
3.	Gross returns	Rupees	67,950.00
4.	Total cost of cultivation	Rupees	46,592.48
5.	Net returns	Rupees	21,357.52
6.	Returns per rupee of expenditure	Rupees	1.46

Table 14: Measures of farm income in groundnut production on non-solar farms (in rupees per hectare)

S. No	Particulars	Rupees per hectare
1.	Gross income	67,950.00
2.	Net income	21,357.52
3.	Farm business income	31,112.52
4.	Family labour income	26,972.52
5.	Farm investment income	25,497.52

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