Role of Rural Electrification and Renewable Energy on Poverty in India: A State Wise Analysis

Asia Pacific Journal of Multidisciplinary Research
Vol. 6 No.4, 74-83
November 2018
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com
CHED Recognized Journal
ASEAN Citation Index

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Date Received: March 12, 2018; Date Revised: August 21, 2018

Abstract - *The paper tests the hypothesis that rural electrification and increasing deployment of renewable energy in rural areas affect the agricultural income which in turn reduces the level of poverty for the sixteen selected states for the year 2011. An index of rural electrification and renewable energy is constructed using appropriate indicators by the method of Principal Component Analysis (PCA). The impact of these indices on agricultural income and later the impact of these variables on rural poverty are visualized using two regression models. Rural electrification in all states is much higher than the deployment of renewable energy sources while Rajasthan represents the state using maximum amount of renewable energy. The regression results reveal a significant positive impact of rural electrification on agricultural income and a significant negative impact of renewable energy on agricultural income for the selected year 2011. Agricultural income plays a positive role in reducing rural poverty. The study recommends that renewable energy deployment must be focused on those states that are deprived of grid connectivity in rural areas. Enhancing agriculture productivity through renewable energy deployment should be targeted along with the reforms in structure of subsidy and tariffs.*

Keywords: *Rural electrification, Renewable energy, Energy Transition, Rural poverty, Climate Change.*

INTRODUCTION

Power is an essential requirement for all facets of our life and has been recognized as a basic human need. It is the critical infrastructure on which the socio-economic development of the country depends. The growth of the economy and its global competitiveness hinges on the availability of reliable and quality power at competitive rates. The demand of power in India is enormous and is growing steadily. Power is the basic building block for socio-economic development. Future economic growth crucially depends on long-term availability of energy in increasing quantities from sources that are accessible, affordable, and socially acceptable and environment friendly.

Rural electrification emerges as one of the aspects of power sector reform process and therefore it is important to assess the current status of rural electrification in power sector reforms. Theoretically rural electrification constitutes an important factor in determining the agricultural output. It forms a crucial part of infrastructural base to agriculture sector, enhancing growth in agricultural income. In rural areas a large number of population is engaged in agriculture, therefore the income from agriculture sector enhance rural incomes Thus it is intuitively understandable that an increase in the level of agricultural income should have an effect on the level of poverty. In order to explore these linkages it is important to understand the state of poverty prevailing in rural India. Poverty and inequality has been a crucial point of discussion ever since India moved on path of planning since 1950s. It was picked up as an objective only after the third plan. In 2017, based upon 2011-12 MRP consumption, the percentage of rural population below poverty line was highest for Chattisgarh (44.61%) followed by Jharkhand (40.84%) and Arunachal Pradesh (38.93%) while Goa had the lowest percentage of rural population below poverty line only 6.81% [1].

The rural inequality started declining while the urban inequality started rising during nineties [2]. The incidence of poverty is higher in rural areas than in the urban areas. The rural urban inequality in income and consumption expenditure exists in India since Independence and even before. During the nineties this disparity has been sharpened after the new economic policy was adopted. According to Census of India 2011, approximately 597,464 villages have been electrified. However, there is a vast difference between the urban and rural areas in regard of access to electricity. Electrification varies dramatically between the urban poor (33% without connection) and rural poor (77% without connection). This inequity impedes the development of poor rural population and underscores the fact that India's rural electrification programs have not reached the most marginalized and needy people.

While large-scale reforms have repeatedly been attempted in the past, India's achievement in the field of rural access to electricity leaves much to be desired. India is home to 35% of the global population without access to electricity, and only 44% of all rural Indian households are electrified. Although the number of electrified villages has increased rapidly, the number of households electrified has not matched in pace. The Ministry of Power's figures [3] on rural electrification (RE) states that 87% of villages are electrified, while only 42-44% of rural households are electrified. As per [4] 5, 91,376 villages (98%) have been declared electrified by February2017. The pumps sets energization potential in the country is 16.59 million. The investment in pumps sets is effectively an infrastructure investment which in turn results in increase in productivity and income generation. This builds up the foundation for the primary objective of the paper to comprehend the impact of rural electrification on agricultural income and in turn its consequent impact on poverty.

With the onset of climate change, clean energy or renewable energy sources have emerged as new policy agenda of all developed and developing nations. India has a target to produce 40 percent of its total energy through renewable sources by 2030 [5]. A target of 100GW from solar power by 2022, 60 GW from wind, 10 GW from biomass and 5 GW from small hydro power [6]. India is aggressively pushing for solar power with 100 GW target for 2021-22. The adoption of new technology of solar pumps by villages aims at improving both utilization of solar pumps and providing irrigation access to marginal farmers. Such solar pumps deployment is a major support for farmers who are deprived of grid connection. Stand-alone solar pumps should be targeted for marginal farmers with smaller pumps or the farmers planning greater cropping cycles requiring more irrigation each year. This policy of deploying large scale solar pump sets has great decentralized technology, maximizing socio-economic impact and environmental impacts as well [7]. This brings forth the role of renewable energy investments in affecting agricultural income and consequently affecting poverty across states which constitutes another focus of this study.

Accessibility constitutes not only a crucial component of energy security but also one of the significant components of sustainable development goals for developing countries. In this context accessibility, rural electrification and renewable energy are two significant aspects. As a result, it becomes imperative to visualize the role renewable energy investment in reducing inequality and poverty. This further provides rationale for the present study to incorporate the component of renewable energy investment in agriculture sector in various states, considering the number of solar pumps installed as an indicator of renewable energy investment. The present study examines the role of these two variables on agricultural income in rural areas which in turn would reduce the level of poverty. This hypothesis is tested for sixteen selected states for the year 2011 using two regression models.

MATERIALS AND METHODS

The paper deploys two methods for attaining the objectives of the study. The first objective of establishing the relationship between rural electrification, use of renewable energy and agricultural income requires construction of indices of rural electrification and renewable energy using a method of Principal Component Analysis (PCA). Later the computed indices are regressed on agricultural income along with gross irrigated area addressed as Model 1. The second objective of identifying the impact of agricultural income on poverty, the selected variables literacy rate, infant mortality rate, farm income and agricultural income of state are regressed on rural poverty, addressed as Model 2.

Principal Component Analysis: PCA Methodology

There are two indicators for rural electrification in the study. A composite index has been calculated for rural electrification using the two indicators namely percentage of village electrified and Agricultural electricity consumption. The composite index has been calculated using Principal Component Analysis. PCA method enables one to determine a vector known as the first principal component/factor, linearly dependent on the constituent variables, having the maximum sum of squared correlations with the variables. The eigen vector corresponds to the maximum eigen value of the correlation matrix gives the required factor loadings (weights). The composite index for a particular geographical unit may be obtained by linearly combining the standardized variable values, the weights being the corresponding elements of the eigen vector.

Using the computed indices, the following models are run to examine the linkages between rural electrification, use of renewable energy consumption, agricultural income and finally impact on poverty.

Regression Models

To assess the impact of rural electrification on poverty the following models have been used.

Model 1

$$\ln PCNSDP_i = \beta_1 + \beta_2\, PCA\ rur\ elec_i + \beta_3\, PCA\ RE_i + \beta_4\, GIA_i + u_i$$

where:
ln $PCNSDP_i$: log of per capita net state domestic product for each state
$PCA\ rur\ elec_i$: Principal Component Index of rural electricity
$PCA\ RE_i$: Principal Component Index of Renewable Energy
GIA_i: Gross Irrigated Area

Model II

$$PBLPL_i = \beta 1 + \beta_2 \ln PCNSDP_i + \beta_3\, rur\ lit_i + \beta_4\, IMR_i + \beta_5\, farmincome_i + u_i$$

where:
$PBLPL_i$: Percentage of Population Below poverty line in rural areas
$rur\ lit_i$: Rural Literacy rate
IMR_i : Infant Mortality rate
$farmincome_i$: Farm Income

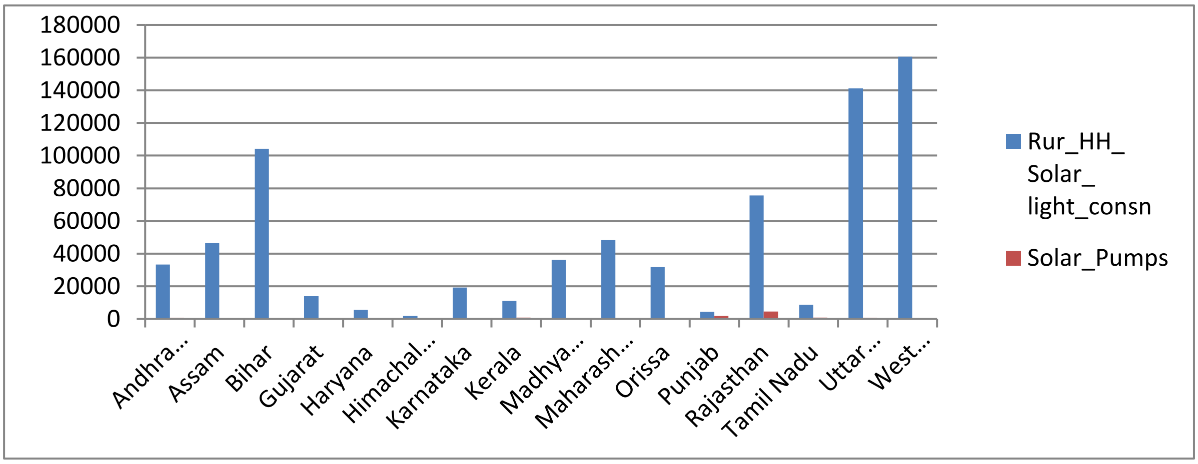
The following section discusses the significant findings of the indices and regression models and their implications.

RESULTS AND DISCUSSION

In most of the developing countries, power supply to the urban sector receives more attention than the rural sector as most of the economic activities are concentrated in urban areas. Rural electrification becomes a preferred program for promoting equity and development in developing countries. It increases efficiency by reducing the time spent on collecting fuel, leading to more productive uses by enhancing social life and facilities community based development. Besides, provision of electricity opens up the possibility of providing various social infrastructure like street lighting, better equipped hospitals and schooling facilities. Therefore, access to electricity leads to overall socio-economic development of rural areas.

Good infrastructure helps in raising productivity and lowering the unit cost in the production activities of the economy. The World Development Report (1994) which focuses on infrastructure for development brought out a strong positive relationship between the level of GDP and infrastructure stock per capita. The pay-off from better infrastructure services goes beyond reducing technical inefficiencies and financial losses [8]. He further states that many people, especially the rural poor, and backward areas do not have access to even minimal infrastructure services. According to [9] the government spending must be directed to protecting poor through targeted social spending, strengthening their infrastructure.

The extent of inter-state differences was examined in the pace of economic growth in the past decade by [10] concluding that the provision of certain infrastructure and to some extent also literacy, are associated with variations in growth. The study also concluded that improved agricultural performance was definitely associated with reduced incidence of rural poverty and there was no underlying time trend in the incidence of rural poverty even after allowing for changes associated with agricultural performance.



Source: Author's Calculations
Graph 1: State wise use of solar lights by rural households and use of solar pump sets in agriculture

It is crucial to visualize that status how each state is deploying the renewable energy sources in rural areas and if there is any linkage between the rural electrification and deployment of renewable energy. The following charts clearly depict the status or scenario of rural electrification and use of renewable energy in the selected states.

The above graph indicates that rural population using solar light for household purpose is more than the solar pumps used for agriculture purpose. The use of solar energy in solar households is much higher in West Bengal, followed by Uttar Pradesh and Bihar. While Haryana and Punjab showing less use of solar lights by households while Himachal Pradesh showing the lowest use of solar lights. As far as solar pumps are concerned Rajasthan exhibits the largest use of solar pumps, followed by Punjab. While Himachal Pradesh showing the lowest number of solar pumps.

Principal Component Index for rural electrification (PCI rur elec) and Principal Component Index for Renewable energy (PCI RE) are computed using the SPSS statistical package by normalizing the selected indicators of the two variables. The following are the account of variables and their corresponding indicators used to compute the principal component index for rural electrification and renewable energy

Table 1: Variables and Indicators for Principal Component index.

S. no.	Variables	Indicators	Variable symbol	Units	Source	
1.	Villages Electrified	% of villages electrified	% Vill Elec	%	Central Electricity Authority (CEA)	
2.	Consumption of electricity by agriculture sector	Agriculture Electricity Consumption	ln_Agri_Elec_Con	Proportion		Principal Component Index for Rural Electricity (PCI rur elec)
3.	Electricity Consumption by Rural Households	Rural Household Light consumption	ln_Rur_Elec	Proportion		
4.	Renewable energy used by households in rural areas.	Solar light used by households in rural areas.	Rur_HH_ Solar_ light_consn	%	Census of India 2011	
5.	Renewable energy used in agriculture sector	Number of solar pumps installed	Solar_Pumps	Number	Ministry of New and Renewable Energy	Principal Component Index for Renewable Energy (PCI RE)

The descriptive statistics of variables has been compiled in the table below to assess various indicators their mean, standard deviation etc. are given in Table 3.

The descriptive statistics of various indicators used in the construction of principal component indices namely Principal component of rural electrification (PCI RE) and principal component of renewable energy (PCI rur elec) are depicted in Table 2. Standard deviation indicating variation about mean is highest in case of solar light consumption of rural households followed by number of solar pump sets indicating a large variation in the use of solar lights and solar pump sets across the rural areas. While a value of Kurtosis less than 3 indicate not many outliers in case of solar lights but a value greater than 3 indicate more outlier as compared to normal distribution in case of solar pump sets. Both solar lights and solar pump sets are positively skewed indicating asymmetric distribution of the data.

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Table 2 Descriptive Statistics of Variables used in Principal Component Index

Summary Statistics	*% of villages electrified*	*ln_Agri_Elec_Con*	*ln_Rur_Elec*	*Rur_HH_ Solar_ light_consn*	*Solar_Pumps*
Mean	97.12375	8.152288	10.10853	46405	681.875
Standard Error	1.420866	0.550176	0.324449	12339.92	354
Median	99.91	9.143627	10.39273	32630.5	
Mode	100	#N/A	#N/A	#N/A	#N/A
Standard Deviation	5.683465	2.200704	1.297797	49359.69	1123.691
Sample Variance	32.30177	4.843097	1.684278	2436379230	1262682
Kurtosis	7.318491	0.369906	-0.50294	0.938566	9.771722
Skewness	-2.64931	-1.29897	-0.39156	1.369775	2.984672
Range	21.1	6.41219	4.511826	158735	4495
Minimum	78.9	3.589059	7.474205	1762	6
Maximum	100	10.00125	11.98603	160497	4501
Sum	1553.98	130.4366	161.7365	742480	10910
Count	16	16	16	16	16

Source: Author's Calculations

Similarly percentage of villages electrified also reflects a large number of outliers indicated by the value of kurtosis greater than 3 with negatively skewed asymmetric distribution of villages electrified. However the data reveals that agriculture electricity consumption is does not vary much across the mean. It is also negatively skewed, asymmetric distribution. The corresponding computed values of the principal component indices are given in Table 3.

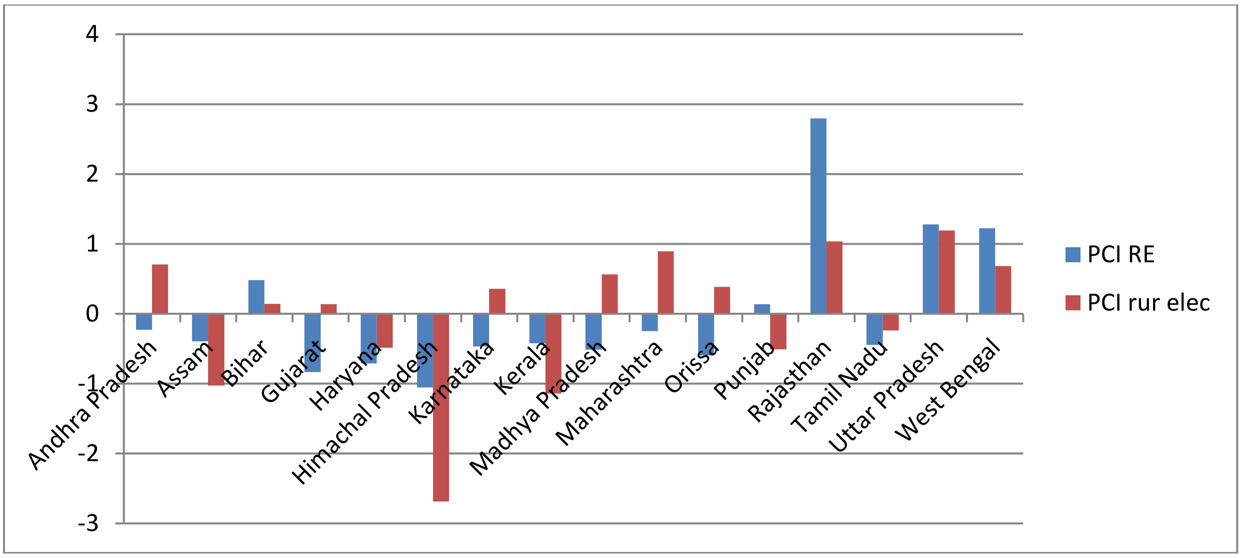
Table 3. Computed values of Principal Component index

States	**PCI RE**	**PCI rur elec**
Andhra Pradesh	-0.22772	0.70412
Assam	-0.39542	-1.0281
Bihar	0.48081	0.13974
Gujarat	-0.83409	0.13603
Haryana	-0.71163	-0.48547
Himachal Pradesh	-1.05531	-2.68535
Karnataka	-0.46804	0.35688
Kerala	-0.4228	-1.13973
Madhya Pradesh	-0.51481	0.5652
Maharashtra	-0.24637	0.89318
Orissa	-0.59668	0.38367
Punjab	0.13693	-0.50831
Rajasthan	2.796	1.03758
Tamil Nadu	-0.44327	-0.24014
Uttar Pradesh	1.27788	1.18957
West Bengal	1.2245	0.68112

Plotting the computed principal component indices of rural electrification and renewable energy consumption in bar graph Graph 2 reveals the differences across states.

The principal component index for both renewable energy and rural electrification is negative for the states such as Assam, Haryana, Himachal Pradesh Kerala and Tamil Nadu. This indicates that the factors that affect rural electrification like agriculture electricity consumption and rural electrification are negatively related , Himachal Pradesh showing the maximum inverse relation indicating as more and more electricity is used in agriculture sector less is available for rural . Similarly a negative value of index of renewable energy depicts an inverse relationship between the factors like use of solar lights for household purpose and solar pumps used in agriculture. It further implies that if the investment in solar pumps is more than the use of solar lights by households is reduced.

However for states such as Rajasthan, Uttar Pradesh and West Bengal, the index of both rural electrification and renewable energy is positive implying that all the factors are positively related. Rajasthan depicts the highest index for renewable energy as compared to rest of the states and also represents a huge gap between the index of renewable energy and rural electrification. The gap is smaller for West Bengal while the index values for both renewable energy and rural electrification are almost at similar level for Uttar Pradesh.



Graph 2: Principal Component Index for Rural Electrification and Renewable energy in rural areas
Source: *Author's Calculations*

A composite index of rural infrastructure state wise is constructed to examine the relationship between infrastructure development and levels of production and growth in agriculture [11]. Bhatia's paper aims at examining the pattern of development of rural infrastructure in India and the relationship between infrastructure development and level of production and growth in agriculture. Overall index of infrastructure is highest in Punjab followed by Kerala, Tamil Nadu and Haryana, the infrastructure index is lowest in Rajasthan and only slightly higher than this in the states of Bihar and Madhya Pradesh as concluded by [11]. In an empirical analysis it was examined whether the developing countries invest more in less favored areas of rural India [12] .The study revealed that overall index of infrastructure is highest in Punjab followed by Kerala, Tamil Nadu and Haryana. The infrastructure index is lowest in Rajasthan only slightly higher than the states of Bihar and Madhya Pradesh. Rural electrification and education have their biggest productivity impacts in rain fed areas, and they also impact favorable on the poor in these areas.

The above graph clearly indicates that there is huge gap between the rural electrification and use of renewable energy in rural areas. In most of the states, rural electrification is higher than the use of renewable energy sources. The impact of the two indices and gross irrigated area are observed on the agricultural income by Model I and in Model II the impact of agriculture income, infant mortality rate, rural literacy and farm income is observed on the poverty in rural areas.

Table 4. Correlation between Principal Component Index for Rural Electrification (RE) and use of Renewable Energy in Rural areas

	PCI rur elec	*PCI RE*
PCI rur elec	1	
PCI RE	0.549749	1

It is observed that across all the states there is a considerable positive correlation between rural electrification and use of renewable energy in rural areas , suggesting that a high degree of use of renewable energy is positively related to high amount of rural electrification.

The description of selected variables used in the model is given in the table 5.

Table 5: Variable and Indicators for Regression Models.

S. no.	**Variables**	**Indicators**	**Variable symbol**	**Units**	**Sources**
1.	Agriculture Income	Per Capita Net State Domestic Product from agriculture sector for each state	*ln* $PCNSDP_i$	proportion	Handbook of statistics on states, RBI 2016-17
2.	Index of Rural Electricity	Principal Component Index of rural electricity	*PCA rur* $elec_i$	Index	

Table 5 (cont): Variable and Indicators for Regression Models.

S. no.	Variables	Indicators	Variable symbol	Units	Sources
3.	Index for Renewable energy	Principal Component Index of Renewable Energy	*PCA* RE_i	Index	
4.	Total area irrigated	Gross Irrigated Area	GIA_i		Source: Directorate of Economics and Statistics, Ministry of Agriculture.
5.	Proportion of rural population below poverty line	Percentage of Population Below poverty line in rural areas	$PBLPL_i$	%	Government of India, Planning Commission , 2014
6.	Status of literacy	Rural Literacy rate	*rur* lit_i	%	Office of Registrar General, Ministry of Home Affairs and National Commission on Population , Government of India
7.	Health Indicator	Infant Mortality rate	IMR_i	%	SRS Bulletin , Sample Registration System , Registrar General , India, 2016
8.	Income from farms	Farm Income	$farmincome_i$		WRRI, Water Resource Research Institute.

As per author 'selection of variables

A description statistics of the variables used in the models have been compiled in the Table 6.

Table 6. Descriptive Statistics of Variables used in Model 1 and Model 2

	PBLPL	*ln PCNSDPAgr*	*Rur Lit*	*IMR rural*	*Farm Income*	*GIA*
Mean	21.39375	14.88128	74.83063	36.3125	199.3125	5562.375
Standard Error	2.578137	0.172197	1.966621	3.024509	22.34255	1243.67
Median	22	15.05254	75.46	40	179.5	4850.5
Mode	35.7	#N/A	#N/A	48	139	#N/A
Standard Deviation	10.31255	0.68879	7.866485	12.09804	89.37018	4974.678
Sample Variance	106.3486	0.474431	61.88158	146.3625	7987.029	24747422
Kurtosis	-1.51243	1.182452	1.106081	-1.02742	6.704278	4.7124
Skewness	0.117576	-1.03373	0.664479	-0.29697	2.305201	1.813113
Range	28	2.742751	32.2	41	375	20203
Minimum	7.7	13.17545	61.8	13	108	200
Maximum	35.7	15.9182	94	54	483	20403
Sum	342.3	238.1004	1197.29	581	3189	88998
Count	16	16	16	16	16	16

The descriptive statistics given in Table 6 reflects gross cropped area across states varies significantly around the mean as depicted by a very high value of sample variance followed by farm income and infant mortality rate. The proportion of population below poverty line in rural areas across states also varies substantially around mean. The kurtosis value indicates that there are not many outliers in case of proportion of population below poverty line, agricultural income, rural literacy, infant mortality rate while farm income depicting larger outliers with value of kurtosis exceeding the value 3. Farm income is more skewed followed by gross irrigated area as compared to rest of the variables and that too positively skewed.

Model I :

$$\ln PCNSDP_i = \underset{(214.887)}{14.622} + \underset{(10.100)}{0.754}\ PCI\ rur\ elec_i - \underset{(-4.929)}{0.338}\ PCI\ RE_i + \underset{(4.620)}{4.66}\ GIA_i + u_i$$

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.980[a]	.960	.950	.153945764026103	2.362

a. Predictors: (Constant), GIA, PC RE, PCI rur elec

b. Dependent Variable: Ln PCNSDP

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.832	3	2.277	96.094	.000[b]
	Residual	.284	12	.024		
	Total	7.116	15			

a. Dependent Variable: Ln PCNSDP
b. Predictors: (Constant), GIA, PC RE, PCI rur elec

Coefficients	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	14.38164	0.212754	67.59758	7.29E-17	13.91809	14.84519	13.91809	14.84519
PCA rur elec	0.183324	0.147213	1.245299	0.236791	-0.13743	0.504073	-0.13743	0.504073
PCA RE	-0.03225	0.155498	-0.2074	0.839179	-0.37105	0.306551	-0.37105	0.306551
GIA	8.98E-05	3.18E-05	2.826759	0.015267	2.06E-05	0.000159	2.06E-05	0.000159

The above model represents a good fit , indicating that both the principal component index for rural electrification and renewable energy along with the gross irrigated area in rural areas explain around 96% of variations in per capita net state domestic product from agriculture sector. This impact on agricultural income is tested for all sixteen selected states. The results reveal that index of rural electrification is significantly positively related to agricultural income of the state from agriculture.

While index of renewable energy affects the agricultural income negatively and this negative impact is significant. This indicates the fact that deployment of renewable energy in form of solar lights for rural household consumption and solar pumps for agriculture purpose is significantly reducing the agriculture income of the states. This could be attributed that the initial expenditure on the renewable energy reduces the income as the solar energy installment is based on subsidy but later after few years the dependence on subsidy can gradually be withdrawn with the returns on use of electricity for extended socio- economic activities. The gross irrigated area contributes positively and significantly to agricultural income. A very high value of F – statistics indicate the overall significance of the regression equation as observed in the ANOVA table.

Irrigation is another area where government initiative can sustain growth in agriculture sector was proved by [13]. They find that support of new irrigation initiatives, in addition to raising agricultural productivity also encourages private investment into those regions. In the regional analysis of the states [14] conclude that many states have bad consistently high rates of poverty. In last two decades, states such as Kerala, Orissa, Tamil Nadu and West Bengal have made progress in reducing their initial levels of poverty. The future energy transition pathways have been analyzed by [15] under uncertainty conditions and concluded that solar electricity is more attractive option compared to wind electricity. The paper recommended removal of price controls and subsidies from fossil fuels, introducing solar energy, localizing technological progress, improving capacity factor and efficiency of solar installed capacity to increase generation profits.

Model II

$$PBLPL_i = -4.944 - 0.030 \ln PCNSDP_i + 0.350\ rur\ lit_i + 0.373\ IMR_i - 0.065\ farmincome_i + u_i$$
$$(-0.061)\quad (-0.008)\quad (0.715)\quad (1.163)\quad (-1.592)$$

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.736[a]	.542	.375	8.1541	1.525

a. Predictors: (Constant), Farm Income, ln PCNSDPAgr, Rur Lit, IMR rural
b. Dependent Variable: PBLPL

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	863.842	4	215.961	3.248	.055[b]
	Residual	731.387	11	66.490		
	Total	1595.229	15			

a. Dependent Variable: PBLPL
b. Predictors: (Constant), Farm Income, ln PCNSDPAgr, Rur Lit, IMR rural

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-4.944	81.325		-.061	.953	-183.938	174.050		
	ln PCNSDPAgr	-.030	3.668	-.002	-.008	.994	-8.104	8.043	.694	1.440
	Rur Lit	.350	.489	.267	.715	.489	-.727	1.426	.300	3.339
	IMR rural	.373	.321	.438	1.163	.270	-.334	1.080	.294	3.407
	Farm Income	-.065	.041	-.563	-1.592	.140	-.155	.025	.333	3.000

a. Dependent Variable: PBLPL

The above results reveal average fit of the regression model around 54.2% of variations in the proportion of people living below the poverty line. Increase in agricultural income reduces the proportion of people below poverty line. Rural literacy rise increases number of people living below poverty line but the result is statistically insignificant. This is typically indicating that there is a positive relation between the people below the poverty line and their literacy rate. It indicates that literacy rate does not play any instrumental role in reducing poverty in rural areas. Infant mortality rate also increases the proportion of people living below poverty line. Finally the increase in farm income reduces the proportion of population living below poverty line. The above model represents overall level of significance which implies that the model is overall significant indicated by F –statistics in the ANOVA table.

CONCLUSION AND RECOMMENDATION

The study observes that the use of solar light by rural household is agriculture in rural areas much more than the use of pump sets in rural areas in all the states and also that variation of solar lights used by households in rural areas is much higher than the solar pumps across states. West Bengal shows the highest use of solar lights by rural households, followed by Uttar Pradesh and Bihar. While Rajasthan exhibits largest use of solar pump sets. There is huge gap between the rural electrification and use of renewable energy in rural areas. In most of the states, rural electrification is higher than the use of renewable energy sources. There is a huge variation in data of gross cropped area across states as compared to other variables. Further the data of farm income is also much skewed indicating that the income from farm is not uniformly distributed across states.

Rajasthan, Uttar Pradesh and West Bengal, the index of both rural electrification and renewable energy is positive. The principal component index for both renewable energy and rural electrification is negative for the states such as Assam, Haryana, Himachal Pradesh Kerala and Tamil Nadu. This indicates that the factors that affect rural electrification like agriculture electricity consumption and rural electrification are negatively related.

The regression results reveal that index of rural electrification is significantly positively related to agricultural income of the state from agriculture. While index of renewable energy affects the agricultural income negatively and this negative impact is significant. This indicates the fact that deployment of renewable energy in form of solar lights for rural household consumption and solar pumps for agriculture purpose is significantly reducing the agriculture income of the states. This could be attributed that the initial expenditure on the renewable energy reduces the income as the solar energy installment is based on subsidy but later after few years the dependence on subsidy can gradually be withdrawn with the returns on use of electricity for extended socio- economic activities.

The results of second model indicate that income of agriculture sector plays a positive role in reducing the proportion of people living below the poverty line. Therefore, it is empirically tested that across all the states status of use of renewable energy has improved but rural electrification is higher than use of renewable energy source namely solar energy. The growth of solar energy in rural areas has witnessed a higher growth where rural electrification is higher. Finally, the role of renewable energy use in rural areas has reduced the agricultural income and agricultural income in turn reduces the proportion of population below the poverty line. The findings of the study hold a great significance for policy implications. The following section gives an account of implications that the study holds in terms of policy formulation.

The above results hold very significant implications for policy. It is evident that in most of the states the situation of rural electrification is considerably poor. Renewable energy use reflects the accessibility of energy to the rural areas that are not grid connectivity, therefore according to the result the states which are deprived of the rural electrification should be targeted by the government to deploy more and more of renewable energy in the rural areas of that state. The use of solar pumpsets being lower than the rural electrification reflects the fact that more efforts are needed to use renewable sources in agriculture sector as the agriculture income is directly affected by increased use of energy. The solar energy owing to its intermittent nature could function well when the electricity supply from grid is not available, hence adding to agricultural productivity and income when it is used efficiently. Though the initial use of renewable energy exhibits a declining impact on agricultural income but subsidies must be carefully planned so that the burden on the government and consumer is reduced to minimum and the return of investment is reaped substantially.

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