

Empowering Women of Rural India for Renewable Energy Adoption – An Exploratory Factor Analysis

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Abstract

Background: The availability of electricity in rural India is poor and by and large weak in power generation and distribution. Several improvement programs for rural India could have positively affected with better availability of electricity. Poor and discontinuous supply of electricity, being a natural component of areas with poorer services and infrastructure, has resulted in the problem being accepted as a mere inconvenience. The slow improvement of rural India continues with its struggle. In particular, women in rural areas are the most affected in this scenario. The adoption of locally generated renewable energy has been encouraged by the government of India through many projects and rural-sensitive technologies. The proposed projects often come to a standstill and were found to be unsustainable. One of the key factors that influence sustainability was the involvement of women in such projects. Objectives: To highlight the importance of women empowerment as a possible solution in the above-mentioned scenario. Women empowerment has been a successful strategy in many social aspects such as microfinance, cottage industry development, prevention of abuse etc. **Methods:** The inclusion of women empowerment was surveyed in order to study the feasibility and adoption of rural renewable energy projects in south-eastern Maharashtra. NGOs and examples of rural women were considered, to identify regions where women's self help groups were active. Their previous successes and ability to lead social changes in their surrounding villages add a useful background to the topic of research. Analysis and **Findings:** We conducted an Exploratory Factor Analysis using the maximum likelihood factor analysis method, with direct Oblimin rotations. Some of the key factors that evolved were: Investment readiness, learning towards rural RE project, awareness towards financing rural RE project. **Improvement:** Renewable energy policy makers may use this research as a reminder to build capacity upon existing microfinance skills before commencing rural renewable energy projects..

Keywords: Exploratory Factor Analysis, Microfinance, Political Awareness, Renewable Energy, Rural India, Social Change, Women Empowerment

1. Introduction - Socio System in Rural Maharashtra

Unlike other states of India, rural women of Maharashtra are much more oppressed due to forces of nature as underlined in research by well-known environmental activist Vandana Shiva on eco-feminism¹. It was noticed by many researchers that many rural families are either headed by women or their men are out of town searching for a job or have migrated to cities. As a result, the burden of taking care of the rural family is entirely on the women. They are oppressed by nature's hazards and the absence of men adds to their extra burden. This forces the need for alternate sources of income. Herein, rural community renewable energy projects can be a viable source. In their effort to sustain, they are assisted by various agencies, political parties and social workers through organizing self-help groups, fund-raising for various activities, such as cottage industry etc. The challenge is to reduce gender inequality and both poverty while attempting alternate income generation².

2. Women Empowerment and Microfinance

Through a field study of Tamil Nadu, Kumar³ argues that Microfinance has not contributed to women's empowerment as it enables entrepreneurial talent or develops the abilities to manage the investments. She also argues that women are deprived of control over property and resources. They are not usually allowed equal rights in important decisions of the family unit. Therefore, a consumption pattern noted does not indicate well-being of rural women, nor does an increased income indicate empowered. Kumar cites multiple studies that claim that micro-credits help women improve household incomes and is also linked with other associated benefits like increased livelihood diversification, more labour market activity, more education and better health⁴⁻⁶. She

explains that there is little consensus on the empowerment potential of microcredit whereas studies have made diametrically opposite claims⁷⁻¹⁰. She further argues that economic independence is not a prerequisite for women empowerment in India considering many other socio-psychological factors.

2.1 Socio Political History of Women Empowerment

Since the 1970s based on feminist movements, initiatives to empower women ensued. Continuous droughts had spurred numerous people's movements across India, which became the platform for women's rights movement. Many leftist organized struggles discussed women's movement. It was observed that the worst victims of various natural calamities such as droughts, flood, diseases, were all women. Though such struggles did not produce concrete changes to the affected people, it leads to better awareness and stimulated legislations to address women's needs. In the 70s and 80s, people's movement and NGOs helped women in creating productive assets and employment. The early 1990s saw the proliferation of self help groups across India. The 1990s was a difficult period due to the economic downturn and continuous droughts in rural India. This resulted in many men migrating to the cities and farmers committing suicide¹¹. Thus was born the new realities of female-headed families. Natural resources for their daily needs like water, firewood, fodder etc. were depleting. In addition, they were now responsible for taking care of family member's agricultural activities and social relationships. Based on these issues Vandana Shiva elaborates on ecofeminism where the women now are burdened much more than ever in their history¹.

Women empowerment depends on some essential attributes such as economic independence, political rights and social acceptance¹². Earlier the government tried to include more women into the political system by reserving seats for them. In 1993, a constitutional amendment

was passed in India that reserved 33% seats for women in village panchayats, rural governing boards. In 2010, the Women's Reservation Bill was passed that reserved 33% of seats for women in Parliament and state legislative bodies. Together with such positive movements economic independence received more momentum through women centered cottage industry infrastructures programs. The most popular of these were rural Self Help Groups (SHGs). With such initiations of economic independence, rural India women have moved on to new trends of women group entrepreneurship¹³.

2.2 Women's Self-help Groups and Rural Renewable Energy

These SHGs are also linked to the local banks and loan worthiness of rural women increased¹⁴. These micro-loans developed into a backbone support for many women's groups. This reduces dependence on local money lenders and educates rural women to develop savings, and to choose investments in projects. Studies show that rural Maharashtra with severe drought-prone regions has increasing female-headed households due to increasing divorces, due to a socio-cultural desire for a male heir, farmer suicides and urban migration of men in search of jobs¹⁵. Thus, increasing the socio-economic strengths of rural women SHG could help in reducing aforesaid adverse effects. Some NGOs have started politically empowering women, educating them about the functioning of the panchayat, the political and administrative aspects¹⁶. One such NGO is Mahila Rajyasatha Andolan operating in rural Maharashtra¹⁷. Women oriented NGOs hold the opinion, that cottage industries could certainly use renewable energy supply¹⁸. Further, a group of women making financial decisions enhances decision-making skills and develop independence¹⁹.

The newer varieties of cottage industries powered by women require a steady source of electricity. Given the opportunities for making small components in plastic,

cloth, small assemblies, agro-processing etc. the labor-intensive nature of such cottage industries could greatly enhance their productivity by aiding it with adequate lighting and powering small machinery with electricity. For such uses, one cannot categorize them as commercial, but a sort of homemade industry. When the multitude of such small and tiny industries is added, this becomes a significant portion of the economy. It is of more importance for the local economy. Thus, the small supplements of steady electric supply are a key attribute to successful rural women's industries. Further, the rural women self-help groups' activities need not be curtailed due to daylight availability. Meetings, communal activities such as rural childcare, health camps, learning activities, social support, and cultural activities all could use a steady supply of electricity.

The supply of electricity in rural India is abysmal. Frequent shutdowns, illegal usage, lack of technical support and theft of equipment all make rural India the worst affected victims of poor electrification²⁰. Among the affected rural population, women are the worst affected. Apart from responsibilities of family care, added the responsibility of "no-men" in the family due to migration, droughts, and one can say that women are triply oppressed with such critical constraints. One may argue that the apt remedy for this decrepit situation is the inclusion of small renewable energy projects managed by rural women.

3. Research Methodology

3.1 Rural Survey

We conducted a rural survey in 10 villages of Marathwada region, located in 4 southeastern districts of Maharashtra, India. Of the 120 surveys sent out, the incident responses were 100. 100% of our respondents were rural women by domicile with literacy skills and some were higher in

educational qualifications. Of them, 19% are illiterate, 58% are up to 10th class educated, and 23% are above 10th class. Given the lack of working knowledge of English, the method of assisted surveying was vital, enabled by an NGO.

3.2 Questionnaire Design

In studies encompassing ecological, social, political and economic factors, it was concluded that the contributions of women are usually underestimated²¹. Activities of caring for family and children in addition to supportive work in the farm and other duties are usually excluded as a resource. Noting that women's contributions towards market-oriented activities receive less credit, we avoided such an error in questionnaire design and included Women's self help group's microfinance capabilities. These survey questions pertain to two forms of funding for future rural renewable energy projects. A) Measuring number of responses of women who are willing to contribute investment i.e. expecting returns from the project, hence their motivation towards profitable returns influences their investment readiness. B) Measuring number of responses of women who are willing to contribute cash i.e. expecting no returns on investment, hence their commitment by way of donations to a rural community renewable energy project. When new economic opportunities from unconventional domains are offered to rural women, the cooperation of both spouses is likely to be preferred²². This inclusion of men in decision making was observed during our survey, where women respondents who had received new small business or technical training earlier had requested their husband's cooperation. Women preferred to develop community cooperation than to undertake it independently which may cause elders and men to deplore them.

In a study comparing selected emerging economies of China, India, and Vietnam, it was concluded that addressing disparities in development between rural poor, urban and middle classes are the foundations for

reducing poverty, empowering women and economic development²³. A study comparing financial inclusions of the poor in India, South Africa, and Australia advises culturally appropriate policies that encourage micro-savings at the household level and uses collected money for caring for the community^{24,25}. Another study appraising the effects of energy inclusion for rural poor in India and Afghanistan found improved social power and enhanced self-efficacy for rural women²⁶. Research on education for renewable energy articulates the need for well-structured curricula, competent trainers and employment prospects for civil societies engaged in rural development^{27,28}. In India, given the well-established background of self-help groups, rural women stand to gain much by extending their empowerment with renewable energy projects. These studies were included to form the basis for the four survey questions regarding women empowerment.

Given the critical need for social welfare programs to tackle the non-affordability issues of rural poor first, a foresight research article²⁹ indicates that a well-organized appraisal of existing development programs including rural microfinance and women empowerment are necessary. An analysis of social significance value notes the value of early adoption of renewable energy project helps to make the individual make a distinction in the community³⁰. In India, this sense of belonging and positive influence of rural leaders was found to be essential in rural electrification projects. The cultural value of rural women holding their leaders in high regard was an essential component of winning leadership roles in women empowerment schemes in rural Maharashtra. Women are inclined towards projects with high social returns and place even higher confidence upon income generation benefits demonstrated in their previous learning experiences. A review of India's solar mission indicated that for the propagation of renewable energy in India, empowerment of women is essential³¹. The unique nature of India's rural self-help groups calls for healthy financial transactions within the group, trust on leadership capability for

progressing into bank linkages and to leverage further reinvestment³². Therefore, rural women's active participation as end users and a gender role shifting into strong leadership are highlighted in survey questions on micro-finance awareness.

4. Data Analysis

4.1 Exploratory Factor Analysis

We conducted an Exploratory Factor Analysis (EFA) using the Maximum Likelihood Factor Analysis Method (MLFA), with direct Oblimin rotations. Our original survey consisted of 22 variables. These were addressing the needs of two important research questions regarding women empowerment and capacity building. We retained 10 out of 22 variables on the basis of their higher values extracted communalities in comparison to initial communality values. This further defines the scope of this research paper. Further, on observing scree plot with two distinct elbows, it may be concluded that partitioning the data into two sets of variables is appropriate. This indicates that the remaining 12 variables can form the dataset for another factor analysis corresponding to the research question on capacity building.

The incident dataset collected consisted of 100 respondents. The sample of size 100 is suitable for the 10 variables selected. since the data size is 10 times that of variables, thus a justified sample. Further, for the 10 variables selected the measure of sampling adequacy was at least 0.7, as reported in the anti-image matrix. The Pearson correlation coefficient values for these 10 variables were non-significant, with respect to other variables. This eliminates the chances of multicollinearity. Multicollinearity reduces the explanatory power of the dependence relationships between the observed variables³³. If multicollinearity exists, then one or more amongst the variables in multicollinearity needs to be eliminated since they explain the same phenomenon. Among the 10 variables

thus selected, we found no significant multicollinearity which would invalidate our selection of variables. Chi-square test was done in Maximum Likelihood Factor Analysis (MLFA) to identify the number of factors to be extracted is just about significant when three factors are extracted. For more than three factors extracted, the chi-square test was non-significant. Thus, the extraction of a three-factor solution is justified. For each of the three factors drawn, Eigen value more than 1 was observed; ranking above all the remaining factors with Eigen values less than one. Various combinations of a number of factors and resulting factor loading matrix were attempted to reassure the choice of three-factor solution. The cumulative total variance of 58.3% is explained by just three factors, as reported in the Total Variance Explained table. This was also observed in the scree plot.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA) values ranges between 0 and 1, where values between 0.7 and 0.8 are considered good. The KMO-MSA close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors³³. The KMO-MSA value obtained in above EFA was 0.7, thus distinct and reliable estimates of factors have arisen. Oblimin rotation splits the factor matrix into a pattern matrix and structure matrix. For orthogonal rotation, these matrices are the same. Oblimin rotation does not assume independence of factors. In Oblimin rotation, the correlation between factors is permitted³³. Thus, variables get appropriately loaded on the factors in oblimin rotation.

4.2 Identified Factors

Residual is the difference between the observed correlation value and the reproduced correlation value. 66 Residuals were computed for a 12*12 correlation matrix. There are 10 out of 66 non-redundant residuals with absolute values greater than 0.05. This means only 15% residuals are having value more than 0.05. In other

Table 1. Interpretation of output from Exploratory Factor Analysis

Survey Question	Variable description	LPM**	Identified Factors	TVE*
I will contribute investment	Investment	0.989	Investment readiness	26.551 %
I will contribute cash	Contribution	0.649		
I believe that if we use RE methods in our village, it gives our WSHG a chance to learn new things about RE.	Willingness to Learn	0.749	Women Empowerment	18.157 %
If proper training is given, I believe our WSHGs can manage all the responsibilities of an RE project in our village.	Confidence to undertake responsibility	0.720		
I have the power to make my own decisions about MF in my home	Financial decision-making	0.533		
I can learn technical skills relating to RE if somebody can teach me.	Willingness to develop new skills	0.450		
I am aware of MF schemes in my area	Awareness	0.645	Microfinance Awareness	13.559 %
My WSH Leader is considerate	Awareness about leadership	0.615		
I have previously learned new skills from WSHG	Previous learning experience	0.362		
Money saved by using RE methods can help our MF schemes	Application of thought in new approach	0.334		

Extraction Method: Maximum Likelihood. Rotation Method: Oblimin with Kaiser Normalization.

LPM** = Loadings in the Pattern Matrix, TVE* = Total Variance Explained,

WSHG = Women's Self-help Group, RE = Renewable Energy, MF = Microfinance.

words, it can be stated that this is a good model, where 85% residuals are less than 0.05³³. The purpose of the reproduced correlations output is to confirm that MLFA conducted is the appropriate factor analysis method. The SPSS Pattern matrix output contains information about the unique contribution of a variable to a factor. The values in the pattern matrix show the strength of the relationship between the variables within a factor. Each of the variables grouping into factors was found relevant to the following constructs: Investment, Empowerment, and Microfinance shown in Table 1. Thus, these factors were named as Investment Readiness, Women Empowerment, and Microfinance Awareness.

4.3 Reliability Analysis

We conducted reliability tests and computed cronbach's alpha, to validate the questionnaire. Three factors existed, so we calculated cronbach alpha separately to items relating to different factors variables³³. Here the use of cronbach alpha test of reliability is not done to report the extent to which the scale measures one underlying factor or construct, called Unidimensionality variables³³, shown in Table 2. We observe that the cronbach's alpha, for the first and second factors are more than 0.7, a desirable attribute and indicator of questions that are internally consistent to measure that factor according to Kline³⁴.

However, the variables loaded on the third factor produced a cronbach's alpha below the desired threshold of 0.7. This implies that third construct is not reliably measured using the associated four variables. Thus, for the next stage of research with expanded geographical locations and larger sample sizes, the consistency of the questionnaire can be made more reliable, when the questions on microfinance are tuned further.

5. Discussion

Referring the analysis of a pilot survey shown in Table 3, it was observed that a readiness for investment by rural Indian women does not have a directly positive effect on their empowerment. Nevertheless, their keenness to engage in new projects was strongly observable. It may be argued that increasing their skills in microfinance would serve as a useful addition to financial risk taking ability of rural women's self-help groups. Therefore, rural women's self-help groups would need to develop further abilities to manage investments. This indicates that in order to enhance the feasibility of adoption of rural renewable energy projects, keenness to engage in new projects can be a good starting point, further emboldened by readiness for investment. However, to enable the feasibility of adoption of rural renewable energy projects, improving

Table 2. Internal reliability of the factors using Cronbach's Alpha

Factors	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Investment readiness	.774	.774	2
Women Empowerment	.704	.726	4
Microfinance Awareness	.520	.548	4

Table 3. Factor Correlation Matrix

Factor	Investment readiness	Women Empowerment	Microfinance Awareness
Investment readiness	1.000	-.024	.032
Women Empowerment	-.024	1.000	.352
Microfinance Awareness	.032	.352	1.000

Extraction Method: Maximum Likelihood. Rotation Method: Oblimin with Kaiser Normalization.

existing microfinance skills serves as the crucial ingredient for rural renewable energy adoptions. Future renewable energy policy makers and project leaders may take this research discussion as a caution to build the capacity of rural women, upgrading their existing microfinance skills before commencing rural renewable energy projects.

6. Future Scope of Research

We submit the inputs for future research: The questionnaire may be redesigned to collect data more specific to significant and relevant variables as evident from the above EFA, depending on future theoretical backgrounds. For further tuning of the survey, we suggest that the words be made simple and easy to understand, as per the local language or dialect. The rural masses surveyed need not be limited due a lack of working knowledge of English language; instead assisted surveying may be used to enhance understanding through local dialect. In our assisted survey, the presence of NGO surveyors helped to build comfort levels of respondents, without inducing bias. They helped to translate the English survey into Marathi and further explaining questions to respon-

dents without inducing bias. Thus, future research may consider the unique difficulties of local regions. We have found the previously mentioned as latent variables. For establishing the causal relationships between identified latent variables, we suggest confirmatory factor analysis using structural equation modeling. After reviewing literature, it has been found that quantitative multivariate dependence techniques can be used to test a variety of inferential test procedures. Then proposed hypotheses can also be tested with appropriate techniques.

7. Conclusion

It may be further examined if the apt remedy for existing weak patterns of renewable energy adoption in India is the propagation of small renewable energy projects managed by rural women. To explore in the future, the potential benefits of rural RE projects of women are listed as follows: a) Utilizing a free renewable source for lights, instead of kerosene lamps b) providing sustainable supply of electricity for tiny industries, an important source of income c) Non-dependence on men to provide for the key raw material for rural power d) An opportunity to

work on new projects – RE could become another tiny industry e) Opportunities to develop skills in microfinance, basic electrical and electronics work.

Given the keen interests of India in enhancing renewable energy adoption across the country, one of the useful approaches could be NGOs involved in empowering women to encourage the adoption of renewable energy projects lead and maintained by rural women. This approach benefits a developing country's attempt to participate in eco-friendly power generations, well aligned with sustainability goals.

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