



Environmental Impact Assessment (EIA) Of Solar Power Plant in India: A Case Study Of 300 Mw Solar PV Power Project at Bhadla Solar Park, Phase III

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ABSTRACT

The proliferation of renewable energy has necessitated the inclusion of solar energy in the list of means of sustainable development in India. The current research examined the environmental and socio-economic impacts of the 300 MW Solar Photovoltaic (PV) Power Project at Bhadla Solar Park, Phase III, Rajasthan using Environmental Impact Assessment (EIA). The study adopted a descriptive cross-sectional survey design where 150 respondents were selected along with observation points. Information was obtained from respondents using structured questionnaire, field observation, and secondary sources. It was evident that 61.3% of the project area consisted of barren or wasteland, indicating the right choice of site selection with minimal damage to agricultural land or natural habitats. Environmental assessment identified positive impacts of the project on the quality of air (78.7%), water resources (74.7%), soil quality (73.3%), and noise environment (70.0%) while minimal negative impact was identified on the biodiversity. Of the measures for mitigation of environmental impact, it was noted that occupational safety (81.3%) and waste management (78.7%) were the most effective measures. It is also evident that there are notable socio-economic impacts of the project including provision of employment (81.3%), raising environmental awareness (76.0%), enhancing local infrastructure (74.7%) and improving household income (72.0%). In conclusion, the 300 MW Solar PV Power Project had an admirable balance between energy production, environmental conservation, and socio-economic benefits. Thus, it can be concluded that EIA is very important in ensuring the sustainability of solar energy projects in India.

Keywords: Environmental Impact Assessment (EIA); Solar Power Plant; Bhadla Solar Park; Renewable Energy; Environmental Sustainability; Socio-economic Impact.

INTRODUCTION

The rising need for energy and the associated threat of climate change and environmental destruction have hastened the shift towards renewable energy on a global scale. In this regard, solar energy has proven to be one of the most environmentally sustainable sources of energy as an alternative to fossil fuels that are used to produce power conventionally. Given that India has abundant sunshine due to its ideal climatic conditions, it has invested heavily in solar power plants through the National Solar Mission to boost energy security and minimize carbon emissions. Bhadla Solar Park in Rajasthan is one of the biggest solar parks in the world.



While the implementation of projects related to solar energy generation is viewed to be environmentally friendly activities, such projects can have implications for issues such as land utilization, biodiversity, soil, water, and the local community members. In light of this, the need to carry out an Environmental Impact Assessment (EIA) exercise becomes necessary. This is because an EIA helps in the evaluation of the potential environmental and socio-economic impacts of the project among other things.

This study is dedicated to evaluating the environmental and socio-economic impact of the 300 MW Solar PV Power Plant located at Bhadla Solar Park, Phase III, Rajasthan. More precisely, the study will examine such aspects as the land use features, key environmental factors, environmental impact mitigation measures, and socio-economic benefits produced by the project. The results of the analysis may be helpful for understanding the environmental impact of such projects and can help promote sustainable development of renewable energy in India.

LITERATURE REVIEW

Supe (2024) analyzed the progress of India in the move towards sustainable energy through an examination of the interactions among agriculture, land use, water, and the generation of solar energy. In the paper, the rapid growth of solar energy facilities was considered to be a key factor in the attainment of the country's renewable energy targets; at the same time, it was pointed out that proper land utilization was important to avoid conflicts between solar energy facilities and other uses, including agriculture and water use. Thus, the author came to the conclusion that appropriate land selection was crucial for sustainability.

Gawande and Chaudhry (2019) examined the environmental and social impacts that are linked with solar energy projects in India. It was found that the construction of large solar energy projects resulted in significant reduction in the release of greenhouse gases and reliance on fossil fuel resources as well as generated employment opportunities and infrastructure development. Nevertheless, it was also observed that solar energy projects may impact the pattern of land use, biodiversity, and neighbouring communities if appropriate measures are not taken in terms of environment protection.

Pawłowski (2021) explored the role of renewable energy resources in sustainable development and environmental conservation. It was found out in the research that renewable energy sources, especially solar energy, led to the reduction of pollution levels, increased energy security, and promoted sustainable economic development through the reduction of carbon emissions and resource conservation. It was also stated in the discussion that the integration of renewable energy systems with environmental management strategies was very necessary for sustainable development and environmental sustainability.

RESEARCH METHODOLOGY

The study made use of a descriptive cross-sectional Environmental Impact Assessment (EIA) on the 300 MW Solar PV Power Project, Bhadla Solar Park, Phase III, Rajasthan, comprising of 150 participants. The data was gathered through the use of questionnaires, field observation and other secondary sources and was analyzed using Microsoft Excel and IBM SPSS Statistics Version 26.0.



Study Area

The current research study was carried out at the 300 MW Solar Photovoltaic (PV) Power Project in Bhadla Solar Park, Phase III, in Rajasthan, India. Bhadla Solar Park is based in the Thar Desert and possesses high levels of solar radiation, an arid climate, low rainfall, and bare land, thus becoming one of the best-suited places for solar energy production on a large scale. The site was chosen for the study of the effects caused by the creation and functioning of the solar power plant.

Research Design

The study utilized the descriptive cross-sectional Environmental Impact Assessment (EIA) approach. Quantitative as well as observational methods were used to evaluate the environmental and socio-economic impacts associated with the project. The evaluation was concerned with key environmental elements such as land, air, water, soil, biodiversity, environmental mitigation, and socio-economic impacts on adjacent communities.

Study Population and Sample Size

The sample size used in the research comprised 150 subjects and observation points ($n = 150$). The sample population comprised the local residents residing around the solar park, project workers, environmental workers, and the sites that were randomly selected for environmental assessment. Simple random sampling was employed in selection of the subjects for the survey process.

Data Collection

The data collection process involved the use of both primary and secondary sources. The primary data were gathered through questionnaire surveys, field observation, and site inspection in and around the area where the development project took place. Data were collected on land use attributes, perceived environmental effects, effectiveness of mitigation techniques, and socioeconomic benefits. The secondary data sources involved the EIA report, EMP, project documents, government documents, and scientific literature.

Study Variables

The study considered the following factors:

- Use of land and environment of the project area.
- Impacts of the environment on air, water, soil, noise, and biodiversity.
- Efficacy of the environmental mitigation measures such as dust control, waste management, water conservation, planting, and occupational safety.
- Socioeconomic benefits in terms of employment, infrastructure development, income, business opportunities, and awareness about environment.

Data Analysis

Data collection involved the use of Microsoft Excel and IBM SPSS Statistics version 26.0 in analysing the information gathered. Statistical analysis methods were applied to provide descriptive statistics, which included frequencies and percentages. The results obtained were presented in tabular form and visual presentation for the purpose of analysing the impact of the solar energy project.

RESULTS

Table 1 shows the land uses and environmental features of the study area of the 300 MW Solar PV Power Project at Bhadla Solar Park Phase III. Of the 150 observation points, wastelands formed the highest number of observation points at 92 (61.3%) while the lowest was agriculture at 6 (4%). Sparse vegetation had the second-highest number at 24 observations (16.0%), rocky surface third at 18 (12.0%), and existing infrastructure fourth at 10 (6.7%). The graphical representation of the above land uses is shown in Figure 1.

Table 1: Land Use and Environmental Characteristics of the Project Area

Environmental Parameter	Observation (n)	Percentage (%)
Barren/Wasteland	92	61.3
Sparse Vegetation	24	16.0
Rocky Surface	18	12.0
Existing Infrastructure	10	6.7
Agricultural Land	6	4.0
Total	150	100.0

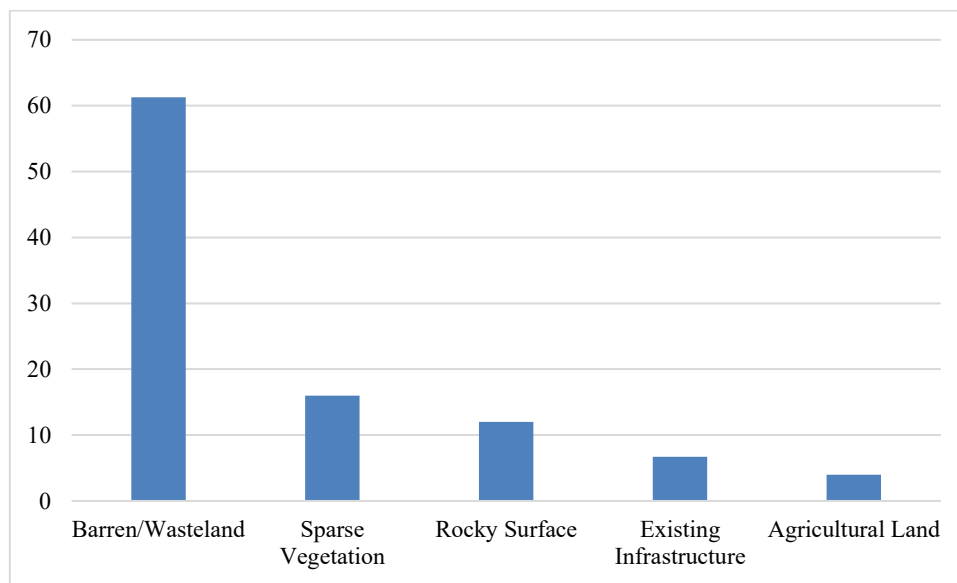


Figure 1: Graphical Representation of Land Use and Environmental Characteristics of the Project Area

Based on the results, the project area consists largely of barren and unproductive areas. Hence, the project site can be considered highly appropriate for developing solar energy generation plants. This is because of the presence of very little agricultural land (4.0%), which makes the project have little effect on agriculture. In addition, the low level of vegetative cover reduces the risk of biodiversity loss. Generally, the land use composition indicates that the selected location is in line with the principles of EIA.

Table 2 below gives the results of the Environmental Impact Assessment of the main environmental factors involved in the implementation of the 300MW Solar PV Power Project at Bhadla Solar Park Phase III. Air quality had the highest level of positive impact (78.7%) followed by water resources (74.7%), soil quality (73.3%) and noise environment (70.0%).

Biodiversity also registered a positive impact as 65.3% respondents perceived it as a positive factor. The negative impacts on all the environmental factors were lower with air quality having the lowest (8.0%) and biodiversity having the highest (14.7%). The negligible impacts had values from 13.3% to 20.0%.

Table 2: Environmental Impact Assessment of Major Environmental Components

Environmental Component	Positive Impact	Negative Impact	Negligible Impact
Air Quality	78.7%	8.0%	13.3%
Noise Environment	70.0%	13.3%	16.7%
Water Resources	74.7%	12.0%	13.3%
Soil Quality	73.3%	10.0%	16.7%
Biodiversity	65.3%	14.7%	20.0%

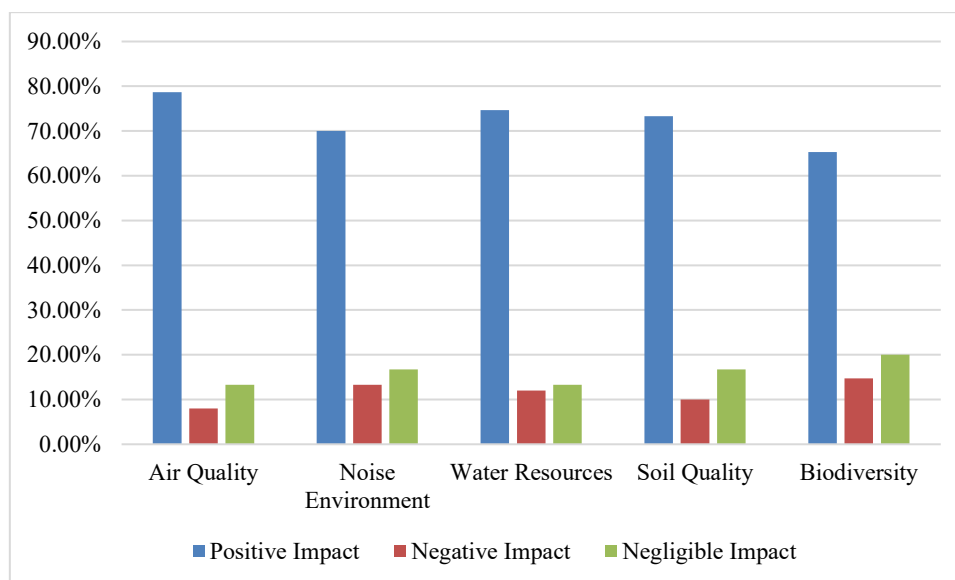


Figure 2: Graphical Representation of Environmental Impact Assessment of Major Environmental Components

These results show that there is a generally positive environmental performance of the solar power project, with improvement in the quality of air, water, soil, and reduction in noise pollution. The highest positive effect on the quality of air is attributed to the positive environmental effects of substituting dirty fossil fuel-generated electricity with the green solar energy. While biodiversity shows the least positive effect (65.3%) and the highest negative effect (14.7%), these figures are still acceptable, indicating minimal ecological disruptions. In all, the results suggest that the project has yielded significant environmental gains without creating serious negative effects.

The effectiveness of several mitigation measures for the environment used in the execution of the 300 MW Solar PV Power Project at Bhadla Solar Park, Phase III is provided in Table 3 below. The most effective mitigation measure was found to be occupational safety measures with 81.3%, then waste management (78.7%), dust suppression (74.7%), water conservation (73.3%), and plantation programme (64.0%). The measures of moderate effectiveness were

14.7% for occupational safety measures, 22.0% for waste management, 19.3% for dust suppression, 15.3% for water conservation, and 28.0% for plantation programme. On the other hand, the number of people that rated these measures as less effective were very few ranging from 4.0% to 8.0%.

Table 3: Environmental Mitigation Measures and Their Effectiveness

Mitigation Measure	Highly Effective	Moderately Effective	Less Effective
Dust Suppression	74.7%	20.0%	5.3%
Waste Management	78.7%	16.0%	5.3%
Water Conservation	73.3%	21.3%	5.4%
Plantation Programme	64.0%	28.0%	8.0%
Occupational Safety Measures	81.3%	14.7%	4.0%

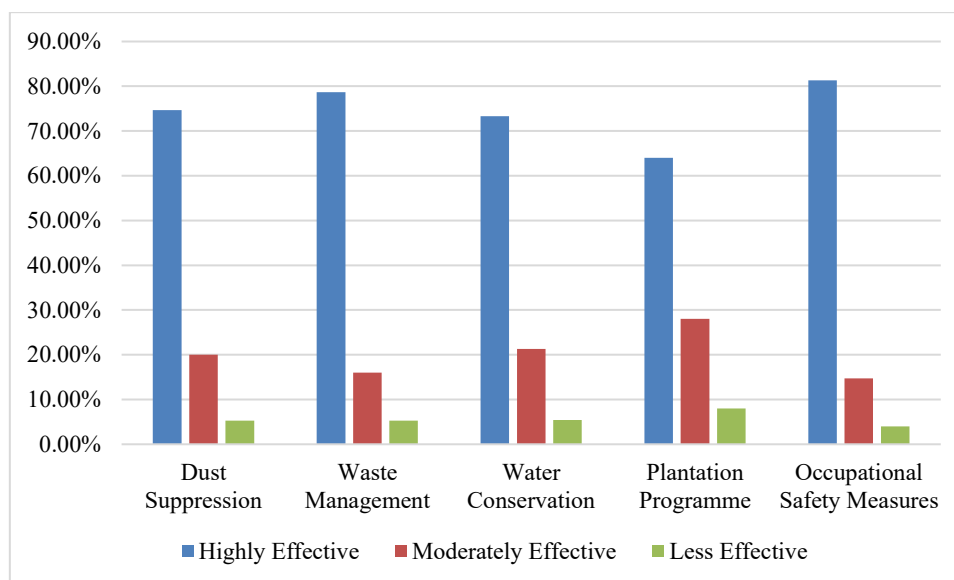


Figure 3: Graphical Representation of Environmental Mitigation Measures and Their Effectiveness

Based on the findings, it is clear that the environmental mitigation strategies used in the development of the project have proven to be very effective in ensuring minimal environmental impact on the environment. Occupational safety and waste management strategies have proven to be the most effective because there has been a very high level of compliance with regard to environmental and safety issues in the whole course of the project life cycle. The dust control and water conservation strategies have proven to be effective, and this has improved environmental performance within the construction process. Though the planting strategy has not proved to be highly effective compared to others, it has been rated positively by the majority of the respondents due to the dry climatic condition in which the project was done.

Table 4 displays the socio-economic advantages gained from the 300 MW Solar PV Power Plant Project at Bhadla Solar Park, Phase III, using data collected from 150 respondents. Employment became the highest advantage, since 122 respondents (81.3%) mentioned the

positive side of this project. The increased environmental consciousness among the citizens was noted by 114 respondents (76.0%), whereas the improvement of infrastructure in the area was stated by 112 respondents (74.7%). Household income growth was mentioned by 108 respondents (72.0%), whereas 104 respondents (69.3%) reported about the emergence of business opportunities. Community development programs such as improvement of public services and local welfare programs were positively assessed by 95 respondents (63.3%).

Table 4: Socio-economic Benefits Generated by the Solar Power Project

Socio-economic Indicator	Positive Response (n)	Percentage (%)
Employment Opportunities	122	81.3
Improvement in Local Infrastructure	112	74.7
Increase in Household Income	108	72.0
Business Opportunities	104	69.3
Community Development Activities	95	63.3
Environmental Awareness	114	76.0

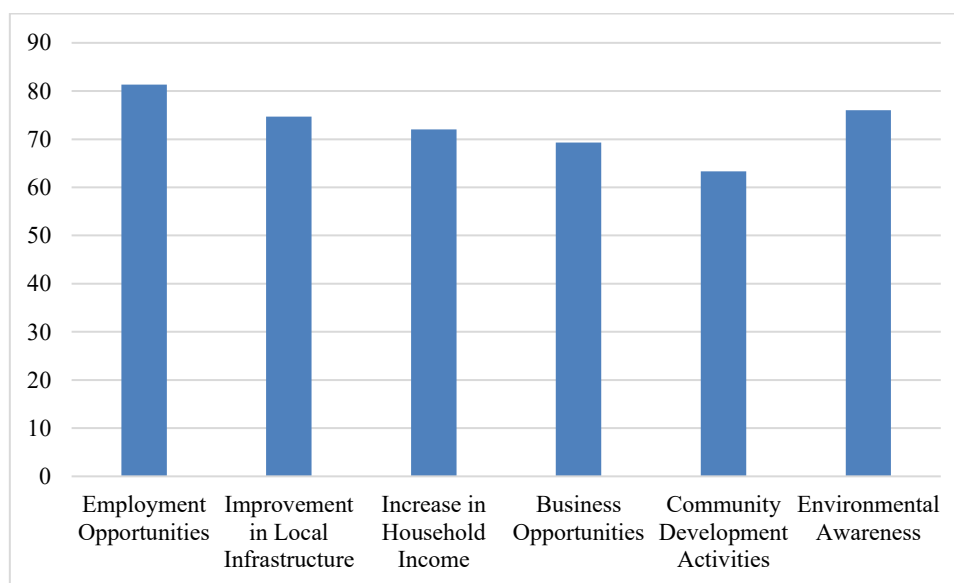


Figure 4: Graphical Representation of Socio-economic Benefits Generated by the Solar Power Project

Based on the findings, it can be observed that the solar energy project has provided significant contributions towards the socio-economic development of the region where it is located. The creation of employment opportunities was seen to be one of the major contributions that this project has brought forth, which clearly shows that it is not only contributing to the environment but also helping in the socio-economic development of the region. This, along with increased environmental awareness and improved infrastructure in the region, shows that the project has contributed significantly towards the development of the region in an environmentally sustainable manner.

DISCUSSION

The study shows that the 300 MW Solar PV Power Project, Phase III at the Bhadla Solar Park is environmentally positive. High proportion of barren lands (61.3%) shows that the project was set up in an area where the land had no much agricultural or ecological value. The high environmental impact is shown by the level of positivity in air quality (78.7%), water resources (74.7%), soil quality (73.3%) and noise environment (70.0%). It can be noted from the study that although the biodiversity received relatively low positive feedback (65.3%) but the negative impacts are minimal.

Further, this study shows that the mitigating measures and socio-economic impact of the project have been highly effective. Occupational safety (81.3%) and waste management (78.7%) have been the most effective environmental measures. Additionally, this project has generated substantial employment (81.3%), raised awareness about the environment (76.0%), provided better infrastructure (74.7%) and raised household income (72.0%). All this indicates that this project has contributed to environmental sustainability along with socio-economic development of the region.

CONCLUSION

The current Environmental Impact Assessment (EIA) of the 300 MW Solar PV Power Project located at Bhadla Solar Park, Phase III, Rajasthan, clearly shows that the development of large-scale solar energy can be carried out with the least environmental impact if proper site selection and adequate mitigation is done. The existence of plenty of barren land, positive impacts in terms of air, water, soil, and noise pollution, and the high efficacy of mitigation practices like occupational safety and waste disposal show good environmental performance of the project. Further, the project has made good socio-economic contributions by creating employment opportunities, improving infrastructural facilities, increasing the household income of locals, and raising their environmental consciousness. Thus, overall, it can be concluded that the project has balanced the use of renewable energy with the conservation of environment and socio-economic development, thus emphasizing the importance of Environmental Impact Assessment.

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