

Social, Economic and Environmental Sustainability as Perceived by Inhabitants: A Mixed Method Study of Impact Assessment

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Abstract: Sustainability is the buzzword in the national agenda of almost all the countries, specifically in terms of its three dimensions. The purpose of this research was to investigate the sustainability aspects of Udupi Power Corporation Limited (UPCL), which is a 2x600 MW imported coal-based thermal power plant, situated in a village in Karnataka State of India. The social, economic and environmental impact of UPCL on the surrounding villages as perceived by its inhabitants on the sustainable growth of the power plant has been studied based on mixed methods approach. The research is a longitudinal study and follows an explanatory sequential design, based on questionnaire survey and in-depth interviews of inhabitants of the villages surrounding the Thermal Power Plant (TPP), employees of the TPP, and other stakeholders. The results have clearly identified the measures the TPP authorities have taken to ensure the sustainable growth and the Corporate Social Responsibilities (CSR) exhibited by the plant.

Keywords: Thermal power plant, Environmental sustainability, Social sustainability, Economic sustainability, Explanatory sequential design

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1. Introduction

Increased power demand is result from the rapidly growing industries and urban infrastructure, which is a global phenomenon; however, the growth should be sustainable in terms of social, economic and environmental aspects. In order to meet the power requirements of modern technology, natural traditional power sources have inherent limitations. Eighty percent of India's electricity is produced by TPP's (Adappa, Tiwari, Kamath and Guddattu, 2017). Over the past few decades the increasing demand for energy has seen a steady increase across all segments, like agriculture, industry, commercial and residential, and is anticipated to continue to increase. However, per capita energy consumption of India stands at 30% of the average energy consumption of the world. India has to explore all obtainable energy resources and types of fuel, both traditional and

unconventional, in order to meet these requirements. Furthermore, in addition to adopting solutions that optimize energy efficiency, it has to leverage all energy sources and search for novel and existing energy resources. The importance of hydropower, nuclear and renewable power sources is becoming significant. There are environmental aspects and impacts of hydro power, too. A significant social concern is the difficulty in the relocation and rehabilitation of the people who are affected by these projects. The involvement of nuclear energy to the electrical energy mix of India, even if it rises twentyfold by 2031-2032, will at best be 7% to 9%. Wind energy has become a significant renewable energy resource, but it gives the idea and impression that coal will be India's most important energy source until 2031–2032, and possibly even longer as quoted by Sahay (2008).

Udupi Power Corporation Limited (UPCL) is the first independent power project (IPP) in India using 100% coal

that is imported as fuel. The state of Karnataka receives 90% of the power that is generated by UPCL. The TTP is located in Yelluru village in the Padubidri industrial area (Geographical Coordinates 1309'00" N 74047'00" E 13010'30" N 74048'40" E). The plant has all latest pollution control equipment which includes, High Efficiency ESPs, Flue gas desulphurization plant, Low NOX burners and 275 m height chimney. UPCL has received environmental clearances from Ministry of Environment & Forest (MoEF & CC), Consent to Establish and Consent for Operation (CFO) from Karnataka State Pollution Control Board (KSPCB). UPCL has also received all the necessary statutory clearances. Ambient Air quality Monitoring Stations were established in 4 locations inside the plant area for continuous monitoring of Ambient Air Quality. One meteorological station has also been installed for monitoring of meteorological data. UPCL has been monitoring the environmental parameters through NABL accredited Laboratory in and around the plant area. Although the measures to ensure sustainability are in place as initiated by the management of the TPP, this study is undertaken to understand the sustainability issues further at the dimensional levels, as perceived by the inhabitants in the neighboring area of the plant.

2. Literature review

"The UPCL power plant generates 1200 megawatts of electricity by burning bituminous coal imported from Indonesia" (Aithal and Sanna, 2012, p. 329). Earlier research (Aithal and Sanna, 2012) shows that through the images taken using the multi-frequency remote sensing around the UPCL, TPP, shows that the percentage of flora has decreased from around eight to four percent over a period of seven to eight years after UPCL has started its operations. Current investigation done by principal author (Gune, 2019) noted existence of thermal plant emissions of polycyclic aromatic hydrocarbons settled in this region.

The season and distance wise allocation of the heavy metals was investigated in this research. Studies conducted worldwide have shown that thermal power plants run by coal are known to have dangerous effects on the surrounding region's environmental sectors (Pokale, 2012). Around 2/3rd of the electricity produced in totality is supplied from coal powered thermal power plants globally. It is imperative that nations with stringent pollution controls have exhibited low emissions of gases that cause greenhouse effect. For example the emission of NOx gases in the year 2000, along the Ohio river in six states consisting of Pennsylvania, West Virginia, Illinois, Ohio, Indiana and Kentucky decreased by 50 percent according to Frost et al. compared to the previous decade (Frost, 2006).

"There are more than 100 thermal power plants in India producing 66% of electricity, with coal accounting for 50-55% of total power generation as the primary fuel option" (Chikkatur, Chaudhary and Sagar, 2011, p. 101). Power generated through these means entails enormous

environmental costs (Guttikunda, Chaudhary and Sagar, 2011). An expense that an operation imposes on an individual/society that is not a part of the operation is an additional cost or negative externality. Due to discharge of Sulphur dioxide, Carbon dioxide, Nitrogen dioxide, and particulate matter, an effort is done to quantify the unit of electricity's external cost per unit produced from TPP's in India. Emissions have resulted in a total external cost of INR 19.5 trillion for nine states in India with more TPPs in 2018, and a unit external cost of INR 2.92 trillion for coal-fired electricity generation. It can be predicated till 2030, the price of generation of power from TPPs in India considering and without considering the external cost. Contrast has also been made between the power generated by using solar energy and the cost related to it with the thermal power generated using coal. Forecast shows that the cost associated with generation of power by means of solar energy without storage of energy is low-priced than the power generation from power plants using coal if the external price of power generation is included in the cost (Srinivasan and Shekhar, 2020).

"The accepted objectives of sustainable development are social equity, economic efficiency, and environmental performance" (Labuschagne and Brent, 2005, p. 159). There is a pressing need for industries and big businesses, particularly corporations, to integrate financial, ecological and societal performances in their strategies, principles and policymaking endeavors (Labuschagne and Brent, 2005). Businesses are, nevertheless, gradually giving additional consideration to the societal aspect of sustainable development, primarily owing to a knowledgeable transference in pressures from stakeholders from societal to concerns related to environment (Holliday, Schmidheiny and Watts, 2004; Lehtonen, 2004). The socio-economic impacts of Rajiv Gandhi Thermal Power Plant (RGTPP) situated in the locality of Khedar village in the Hiasr district of Haryana, India was investigated by (Bishnoi, Lohchab and Bishnoi, 2021). The components of examination of socio-economic influence were social, education, health, environment, and production level, which were further divided into sub categories. Respondents in the study area who accounted for 40% and more stated that RGTPP had a good impact on their economic, production, and social levels. According to the majority of respondents, RGTPP has no significant environmental or health consequences (Bishnoi, Lohchab and Bishnoi, 2021).

Taylor et al., (1995) state that all environmental alterations have social implications. Socio-economic studies depict economic and social life of habitants of the area under study and can be considered as an indicator of progress, stagnancy or regression of a society. Therefore assessing the impact of social, economic and environmental aspects on the people living in the region around the TPP is very essential to study both the positive and negative influence of the power plant on the life of the people. The present research focuses on studying the perception of the villagers that UPCL has on their social, economic and environmental aspects. The results will be significant when considering implementation of similar

projects in future in and around the industrial area of Padubidri or any other region with similar geographical conditions.

2.1. Research questions

1. What is the impact of UPCL on the social aspect of the villages surrounding the plant as perceived by its inhabitants?
2. What is the impact of UPCL on the economic aspect of the villages surrounding the plant as perceived by its inhabitants?
3. What is the impact of UPCL on the environmental aspect of the villages surrounding the plant as perceived by its inhabitants?
4. What suggestions can be given to improve the above dimensions in case the TPP has an adverse effect on them?

2.2. Hypothesis

The following hypotheses (alternative hypothesis) regarding social, economic, and environmental impact were postulated to address the research questions and meet the stated objectives:

H01: There is a significant improvement in the social aspects in the villages surrounding UPCL.

H02: There is a significant improvement in health facilities and health of the people in the villages surrounding UPCL.

H03: There is a significant improvement in infrastructure in the villages surrounding UPCL.

H04: There is an impact of education on the social dimension of the villages surrounding UPCL.

H05: There is a significant improvement in the economic aspects in the villages surrounding UPCL.

H06: There is a significant improvement in the income levels and employment in the villages surrounding UPCL.

H07: There is a significant improvement in the land value in the villages surrounding UPCL.

H08: There is a significant improvement in the environmental aspects in the villages surrounding UPCL.

3. Materials and methods

A cross-sectional study was performed earlier on the social, economic and environmental impact of UPCL on the surrounding villages (Patil, 2014). Therefore the present research is essentially a longitudinal study.

Explanatory sequential mixed method design has been employed in this study (QUANTITATIVE → qualitative = explanation), which included an initial quantitative survey followed by qualitative interview with the priority on the quantitative phase.

By definition, mixed methods research is a way of gathering, analysing, and combining or integrating quantitative and qualitative data at some point during the research process within a single study in order to acquire a

better knowledge of the research problem (Kervin, Abbas and Teddlie, 2000; Creswell and Clark, 2003). In some cases, neither quantitative nor qualitative methodologies are sufficient to capture the trends and subtleties of a situation on their own. This lays the groundwork for combining both types of data in a single study. When quantitative and qualitative methods are combined, they complement each other and allow for a more robust study that takes advantage of each method's strengths (Kervin, Abbas and Teddlie, 2000). In the literature, there are roughly forty mixed-methods research designs (Kervin, Abbas and Teddlie, 2000). The mixed-methods sequential explanatory design, for example, is quite popular among researchers because it involves gathering and analysing quantitative and qualitative data in two phases within one

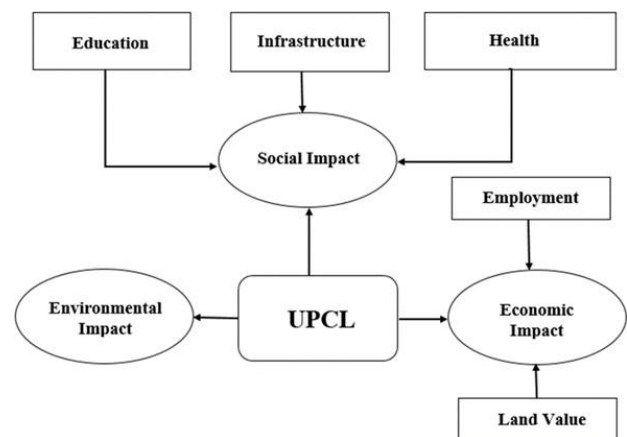


Figure 1: Conceptual Framework of the study study. As a result, the explanatory design was best suited

for this study because 1) the researchers wanted to gain a deeper understanding of the survey results through a follow-up interview, and 2) the researchers needed to purposefully select interview participants based on the preliminary quantitative findings.

The population of the five villages surrounding the UPCL plant, namely Nandikur, Yellur, Belapu, Mudarangadi, and Padubidri, serves as the study's sampling frame. All of the major stakeholders, including farmers from neighboring villages and UPCL personnel, are included in the study's population. The investigation was conducted using a stratified random sampling method. The total population of five villages surrounding the UPCL plant are as follows:

$$\begin{aligned}
 N_p &= \text{Size of sample i.e. total population of the five villages} \\
 &= \text{Population of Nandikur} + \text{Yellur} + \text{Belapu} + \\
 &\quad \text{Mudrangadi} + \text{Padubidri} \\
 &= 2932 + 6404 + 4965 + 7476 + 12694 \\
 N_p &= 34,471
 \end{aligned}$$

The sample size is calculated using the equation (1) (Kothari, 2009)

$$n = \frac{(Z^2 * p * q * Np)}{(e^2 * (Np - 1))} + (Z^2 * p * q) \tag{1}$$

where,

Z = 1.96 (the table scores for normal distribution within selected range of z for a confidence level of 95%) p = proportion of the defects in the universe (2% defect is assumed)

$$q = (1 - p)$$

Np = total finite population 34,471

e = acceptable error (error 2% of the true value is assumed) n = 188 (minimum sample size).

As per the above sample size calculation, 188 is the minimum sample size to be collected. However, for better representation number of samples considered in the present study was 404. Village wise distribution of the samples is as shown in the Table 1 below:

Table 1: Stratified distribution of sample village wise

S. No.	Name of the village	Proportion	Number of samples collected
1	Belapu	0.144	58
2	Mudrangadi	0.216	84
3	Nandikur	0.186	75
4	Padubidri	0.368	129
5	Yellur	0.144	58
Total		1.0	404

In-depth voice recorded interviews were conducted with the help of a structured interview schedule. The interview was conducted in local languages Tulu and Kannada for six people belonging to different villages around UPCL. All the participants chosen had lost their lands to the UPCL project. These participants were chosen to gather information on the rehabilitation and resettlement plans of UPCL. The digitally recorded interviews were then transcribed to English to perform the analysis. Identity of the participants was kept confidential.

4. Results and Discussion

4.1. Hypothesis Testing

Hypotheses were tested using independent sample t-test. Results for independent sample t-test for the health facilities and health of the people and infrastructure which provides basis to assess the social impact of UPCL on the neighbouring villages are given as follows. Table 2 shows the group statistics and Table 3 gives independent sample t-test result.

Table 2: Group Statistics

Factor	No. of Respondent	Mean	S.D
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Health Facilities and Health of the People	Group 1	400	2.86	0.678
	Group 2	404	3.11	0.978
Infrastructure	Group 1	400	2.54	0.775
	Group 2	404	3.33	0.799

Table 3: Results from independent sample t test for social impact factor

Factor	t-statistic	p-value	Mean Difference
Health Facilities and Health of the People	-4.16	0.000	-0.251
Infrastructure	-14.12	0.000	-0.792

The result of the independent sample t-test for the hypothesis H02 indicate that the health facilities and health of the people in the villages surrounding UPCL has significantly improved. (Group 2: $\mu = 3.11$, t is -4.16, $p < 0.05$). Hence, the null hypothesis H02 is rejected at 5% significance level. The result for the hypothesis H03 showed that infrastructure in the villages surrounding UPCL has significantly improved. (Group 2: $\mu = 3.33$, t is -14.12, $p < 0.05$). Hence, the null hypothesis H03 is rejected at 5% significance level. The factor related to education was not considered in the previous study. The present study has taken into consideration the role of education in making a social impact. Therefore, hypothesis H04 was tested using one sample t-test with the test value of three which corresponds to neither agree nor disagree according to the questionnaire which is used for the data collection. Table 4 shows the one sample t-test results for the factor education.

Table 4: Results from one sample t-test for the factor education

Factor	No. of Respondent	Mean	S.D	t-statistic	P-value
Education	404	3.86	1.23	13.97	0.000

Again, the null hypothesis H04 is rejected at 5% significance level and the result of one sample t-test for this hypothesis confirms that education has an impact on the social dimension of the villages surrounding UPCL ($\mu = 3.86$, t is 13.97, $p < 0.05$).

To test the hypothesis for social impact, three hypothesis were tested. All three hypotheses show there is a significant improvement in the dimensions considered: health facilities and health of the people, infrastructure, and education. Since there is a significant improvement in all the three factors related to the social impact of UPCL on the surrounding villages, the null hypothesis H01 is rejected; thus there is a significant improvement in the social dimension in the villages surrounding UPCL when compared to the earlier study.

Results of independent sample t-test in connection to the income levels and employment of people and land value through which we can assess the economic impact

of UPCL on the neighboring villages are given as follows. Table 5 shows the group statistics.

The result of the independent sample t-test for the hypothesis H06 showed that the income levels and employment of people in the villages surrounding UPCL has significantly improved. (Group 2: $\mu = 2.92$, t is -8.94 , $p < 0.05$). Hence, the null hypothesis H06 is rejected at 5% significance level.

Table 5: Group Statistics - Economic Impact Factors

Factor		No. of Respondent	Mean	S.D
Income levels and employment of people	Group 1	400	2.28	1.09
	Group 2	404	2.92	0.89

Results of economic impact factor are shown in Table 6.

Table 6: Results from independent sample t-test for economic impact factor

Factor	t-statistic	P-value	Mean Difference
Income levels and employment of people	-8.94	0.000	-0.64
Land value	-7.97	0.000	-0.587

The result for the hypothesis H07 showed that land value in the villages surrounding UPCL has significantly improved. (Group 2: $\mu = 3.08$, t is -7.97 , $p < 0.05$). Hence, the null hypothesis H07 is rejected at 5% significance level. To test the hypothesis for economic impact, two hypotheses were tested. Both the hypotheses show there is a significant improvement in the dimensions considered: income levels and employment of people and land value. Since there is a significant improvement in both the factors related to the economic impact of UPCL on the surrounding villages, the null hypothesis H05 can be rejected; thus, there is a significant improvement in the economic dimension in the villages surrounding UPCL when compared to the earlier study.

Results for independent sample t-test for the impact of UPCL on the environment of the neighbouring villages are given as follows. Table 7 shows the group statistics data.

Table 7: Group Statistics - Environmental Impact Factor

Factor		No. of Respondents	Mean	S.D
Environment	Group 1	400	2.08	1.25
	Group 2	404	2.82	1.03

Results from independent sample t-test for environmental impact factor are shown in Table 8. The result of the independent sample t-test for hypothesis H08

showed that the environmental aspects in the villages surrounding UPCL have significantly improved. (Group 2: $\mu = 2.82$, t is -9.05 , $p < 0.05$). Hence, the null hypothesis H08 is rejected at 5% significance level; thus, there is a significant improvement in the environmental aspects in the villages surrounding UPCL compared to the earlier study.

Table 8: Results from Independent Sample t-test for Environmental Impact Factor

Factor	t-statistic	P-value	Mean Difference
Environment	-9.05	0.000	-0.738

The Table 9 presents a bird’s eye view of the results that are obtained from the quantitative followed by the qualitative study. The entire qualitative study has been divided into eight themes: Corporate Social Responsibility (CSR) of UPCL, Preserving Green Cover, Providing Clean Water, Rehabilitation and Resettlement, Infrastructure Development, Rise in Economic Activities, Promoting Sports and Culture and Suggestions for Improvement.

Corporate Social Responsibility (CSR) of UPCL

UPCL is executing its CSR activities in ten grama panchayaths namely, Yellur, Mudrangadi, Uchila/Bada, Tenka, Padubidri, Palimar, Belapu, Inna, Kuttyar and Hejamadi (Alegowda, 2020). Interviewees mentioned UPCL has several CSR activities related to development of infrastructure, medical facilities, education, encouragement to sports and cultural activities and developing sanitation facilities.

Education: As part of the CSR activity to promote education UPCL provides scholarships to academically bright students depending on their scores. Scholarships are also provided to economically backward students to aid them in their study. These scholarships are provided from primary education to undergraduate level. In addition to this books, stationery, umbrella and other study materials are also provided to school children. Computers are provided to schools on request. Laptops have been given to students to help them learn betterdigitally. One of the interviewees was of the opinion that more emphasis needed to be given to promoting higher education among the students in the villages. This would enable them to fetch better job opportunities.

Medical Facilities: With regard to the medical facilities under the CSR initiative, interviewees mentioned about the health cards that were provided to the families in the villages. These health cards were distributed panchayat wise. The beneficiaries get a medical cover up to INR. 50,000. Medical camps are also conducted periodically to the villagers. Mobile health care units visit each village as per a schedule. Everyday two villages are covered. The villagers can use this facility to avail treatment for minor health problems and regular monitoring of their health

status. The interviewees mentioned that this facility was very useful especially in remote parts where the villagers found it difficult to access the primary health centres or hospitals. One of the participant was hopeful that few initiatives like providing prosthetics to the handicap and optical glasses could be launched.

Sanitation: To promote sanitation and hygiene, bins were provided in schools and public areas to collect and segregate waste. When asked about the waste management, the interviewees responded that there was no such system in place yet. However they mentioned that few toilets were constructed wherever there was a need.

Preserving Green Cover

From the interviews it could be inferred that UPCL has taken several measures to maintain and protect the green cover around the plant's surroundings and also in the neighbouring villages. The interviewees mentioned about the different initiatives that were taken to preserve the green cover. Twice a year programmes were organised by UPCL to plant new saplings around the TPP. Saplings were also distributed to nearby schools and village panchayths to encourage afforestation. Officials from UPCL were appointed to regularly inspect the green belt around the plant. This was mentioned by one of the participants during the interview.

Providing Clean Water

In order to provide clean drinking water, RO plants are set up in different villages. According to the details obtained from the interviews, a total of five RO plants are operational at Yellur, Belapu, Mudarangadi, Tenka and Bada. Water supply lines are also laid for supplying water to the houses. This facility is providing clean drinking water round the clock for the villagers of these five villages. One interviewee mentioned about the earlier problems of water seepage into the ground which was contaminating the ground water. The interviewee also mentioned that this problem was resolved after UPCL took measures to prevent the seepage. The officials from the plant are involved in testing the water periodically from test wells that are present in certain villages. This enables them to find out if the water is contaminated and take actions appropriately.

Rehabilitation and Resettlement

Since all the interviewees had lost land during the process of the establishment of the plant, understanding the policy of rehabilitation and resettlement was crucial. The interviewees mentioned that as land losers they were provided with 12.5 cents of land in the R & R colony which is around 2 kilometres from the plant. As per one interviewee the compensation that is provided to the displaced villagers in terms of money has increased over the years standing at 1.4 million INR (approx. 19,000 US\$) per acre presently as compared to 0.4 million INR (approx. 5,400 US\$) per acre earlier. Another interviewee

also mentioned their family had lost 10 cents of land but had received 12 cents as compensation. In addition to this, the displaced villagers were offered employment at UPCL which could be availed by any one member of the family. All the interviewees were satisfied with the compensation that was provided to them, because the employment had improved their livelihoods.

Infrastructure Development

As a part of infrastructure development, the interviewees stated the improvement in the condition of roads over the years. They said that concrete roads were laid even to remote parts of the villages. This made movement of people and goods easy especially during rains. There were a few areas where roads are yet to be laid and they are hopeful that this will be taken up soon by UPCL. UPCL also provided assistance in rejuvenating and repairing a school in the village as stated by one of the interviewee. There has also been improvement in mobile connectivity with a mobile transmission tower being set up within the plant. Power cuts have reduced and are encountered only during rainy season. The participants mentioned that a lot of upgradation to the infrastructure has taken place in the past four to five years.

Rise in Economic Activities

As mentioned by the interviewees after the establishment of the plant and thereafter there has been a rise in small businesses and petty shops around the plant. Many small scale industries have also come up which are providing employment to many villagers. Special mention was made of brick manufacturing units that have come up due to the availability of ash coming from the power plant which is the raw material that is readily available for these brick manufacturing units. These units have also employed several people from the neighbouring villages as stated by an interviewee.

Promoting Sports and Culture

UPCL promotes sports like cricket and volleyball and are the main sponsors of these tournaments when they are conducted in any of the neighbouring villages as per the statement of one of the interviewee. UPCL also promotes local sport Kambala, which is very close to the hearts of the villagers as it represents the cultural identity of Udipi and Dakshina Kannada. The interviewees also stated there were many cultural programmes that were arranged by UPCL for school children and the villagers.

Suggestions for Improvement

The interviewees also had few suggestions which UPCL could adopt to improve the condition of people living in the villages. The suggestions given by them are presented individually as follows:

Interviewee 1: Education and road connectivity can be improved. Medical facilities can be extended to more

number of village panchayaths. Incentives could be provided for the poor living in the villages helping them get basic education. UPCL can help villagers suffering from chronic diseases like cancer which incurs heavy financial burden to them.

Interviewee 2: No suggestions. Even after losing land I got employment which has improved our livelihood. So, I don't have any problem as such. The R&R colony can be equipped with better facilities.

Interviewee 3: UPCL can offer financial aid to the villagers affected by the pandemic. The company can support livelihood of villagers by educating them on different schemes and ways of being self-employed. They can also encourage villagers to start cottage industries and help them to procure materials and also market their products. This can help the villagers to be self-reliant. Animal husbandry and poultry activities can be encouraged by means of education and training programmes.

Interviewee 4: There has been around 300% to 400 % overall improvement in all aspects after Adani's took over the plant operations. So, I am very happy with the way the

things are right now. But few villagers feel that things can be bettered. There has been a lot of improvement in our villages and living condition but many of the villagers are unaware. This can be changed with UPCL spreading awareness about the changes and measures that have been undertaken. Under the Udaan scheme school children are provided the opportunity to visit the plant and know more about the plant. There is a need to educate the villagers too in order to reduce the misconception they have about the plant operations.

Interviewee 5: Roads to be built to villages where connectivity needs to be improved. Essential commodity shops can be set up in R&R colony which can help the residents. Currently residents in the colony having own vehicles can manage to get the essential commodities from nearby villages, but for the elderly it is difficult to buy essentials. This problem can be solved if there are shops within the colony. Other than this issue all other facilities are satisfactory in the colony.

Interviewee 6: More employment opportunities can be offered to locals which can help them have a better life.

Table 9: Bird's Eye View of Mixed Method Analysis

Dimension	Factor	Quantitative	Qualitative	Interpretation
Social	Health facilities and health of the people	The result of the independent sample t-test for the hypothesis H02 showed that the health facilities and health of the people in the villages surrounding UPCL has significantly improved.	<ul style="list-style-type: none"> • UPCL has provided health cards with a medical cover of INR 50,000. • Medical camps being organized regularly. • Mobile health care unit plying in villages weekly. 	The CSR initiatives focusing on the health infrastructure could be attributed to the improving health of the people.
Social	Infrastructure	The result of the independent sample t-test for the hypothesis H03 showed that infrastructure in the villages surrounding UPCL has significantly improved.	Laying of concrete roads even to remote parts of the villages. Aid in repairing old schools. Electricity connectivity has improved. Mobile connectivity has improved with the installation of new tower within the plant.	CSR initiative towards providing better infrastructure could be the reason for the significant improvement in the infrastructure of the villages surrounding UPCL.
Social	Education	The result of one sample t-test for this hypothesis showed that education has an impact on the social dimension of the villages surrounding UPCL	Scholarships up to undergraduate level. Books, stationery, laptops, umbrellas provided to students. Computer aids are provided to schools.	With the different CSR initiatives related to education it can be interpreted how education is improving the social dimension of the villagers around the UPCL plant.

Economic	Income levels and employment of people	The result of the independent sample t-test for the hypothesis H06 showed that the income levels and employment of people in the villages surrounding UPCL has significantly improved.	Small businesses are gaining after the plant has come up. Small scale industries have been set up providing employment to local villagers. Land losers have gained employment in the plant.	There has been an increase in the economic activity around the plant to cater to the growing employee base. This could have led to the increase in the income levels of the people.
Economic	Land value	The result of the independent sample t-test for the hypothesis H07 showed that land value in the villages surrounding UPCL has significantly improved.	Value of one acre of land is 1.4 million INR (approx. 19,000 US\$) per acre presently as compared to 0.4 million INR (approx. 5,400 US\$) per acre earlier.	The increase in the compensation provided to land losers for the land shows that the land value has increased over the years.
Environment	Green Cover	The result of the independent sample t-test for hypothesis H08 showed that the environmental aspects in the villages surrounding UPCL have significantly improved.	Twice a year programmes organized by UPCL to plant new saplings around the plant. Saplings distributed to nearby schools and village panchayths to increase the green cover. Officials from UPCL regularly inspect the green belt around the plant.	Preserving and maintaining the green cover could be the reasons for the improvement in the environmental conditions around the plant.

5. Conclusion

The goal of this study was to evaluate the impact of UPCL plant operations on the villages within 10 kilometer radius based on social, economic, and environmental factors.

With the use of data collected from 404 respondents via structured questionnaire and interviewing local people from the impacted villages, this study examines the effects of UPCL operation on the livelihood of the villagers. The data was analyzed using statistical tests, and the results were interpreted.

Each dimension i.e., social, economic and environment were assessed with the help of factors. The social dimension had the factors - health facilities and health of the people, infrastructure and education. Income levels of people and employment of the people and land value were considered as factors for the economic dimension. Environment dimension was evaluated based on questions related to air, water and soil conditions around the plant and also the presence of green cover. Sequential explanatory design was followed wherein quantitative data was gathered and analyzed first followed by interview with the villagers to gather the qualitative data which was then analyzed.

The results obtained using independent sample t-test for social dimension show that there has been a significant improvement in the social dimension of the villages under study. The economic and environmental dimensions have

also shown a significant improvement in these villages. These statistical results have been substantiated with the interviews that were conducted with six villagers. The interviews throw more light on how the social, economic and environmental conditions have improved over the years. All the interviewees have the opinion that CSR activities conducted by UPCL have led to the overall improvement in the livelihoods of the villagers. Suggestions were also given by the interviewees to further improve the condition of the villages and the people residing in them. The study signifies how the adverse effects from a thermal power plant can be mitigated with appropriate measures and CSR activities in place and provide a healthy and comfortable lifestyle to the dwellers in the area.

Further, results obtained by qualitative and quantitative methods can be used to make some specific suggestions to the management of UPCL.

- Creating more employment opportunities within the UPCL plant for the local community.
- Providing more assistance to the poorest section in the villages in terms of livelihood.
- Encouraging higher education among the villagers.
- Making the villagers self-reliant by conducting various programs to educate and guide them.
- Although the plant is currently equipped with the latest pollution control and monitoring systems,

with advancement in technology, newer equipment can be added to check pollution and conserve water, air and soil on a timely basis.

- Educating the general public on the CSR initiatives to avoid misconceptions about the plant operations.

As a part of future scope, studies can be carried out every five years to compare the status of socio-economic and environment conditions. This will give a picture on how the project has impacted the people over a period of time. It will also help to keep a track on the CSR initiatives that have been offered and check the performance of these initiatives.

As Udupi is growing rapidly, this research can be taken as a template and applied to other mega projects coming up in this region.

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References

- Adappa, S., Tiwari, R., Kamath, R., & Guddattu, V. (2017). Health effects and environmental issues in residents around coal fired thermal power plant, padubidri: A cross sectional study. *Journal of Environmental and Occupational Science*, 6(1), 8.
- Alegowda, C. (2020). Six monthly compliance report of environmental clearance for 2x600 MW thermal power plant and CRZ clearance of sea water pipeline of Udupi Power Corporation Limited. Udupi Power Corporation Limited, Yelluru.
- Bishnoi, S., Lohchab R.K., & Bishnoi, N.R. (2021). Assessment of socio-economic impacts of Rajiv Gandhi Thermal Power Plant (RGTPP). *International Journal of Science, Engineering and Computer Technology*, 7(12), 86.
- Chikkatur, A., Chaudhary, A., & Sagar, A. (2011). Coal power impacts, technology, and policy: Connecting the dots. *Annual Review of Environment and Resources*, 36(1), 101.
- Creswell, J., & Clark, V.P. (2003). Advanced mixed methods research designs: In Handbook on mixed methods in the behavioral and social sciences. Sage, 209.
- Frost et al., G. (2006). Effects of changing power plant NOx emissions on ozone in the eastern United States: Proof of concept. *Journal of Geophysical Research*.
- Gune et al., M. (2019). Occurrence of polycyclic aromatic hydrocarbons (PAHs) in air and soil surrounding a coal-fired thermal power plant in the south-west coast of India. *Environmental Science and Pollution Research*, 26(22).
- Guttikunda, S., & Jawahar, P. (2014). Atmospheric emissions and pollution from the coal-fired thermal power plants in India. *Atmospheric Environment*, 92, 449.
- Holliday, J.O., Schmidheiny, S., & Watts, P. (2002). Walking the talk the business case for sustainable development. 1st ed. Routledge.
- Kervin, J., Abbas, T., & Teddlie, C. (2000). Mixed methodology: Combining qualitative and quantitative approaches. *Relations industrielles*, 55(3), 539.
- Kothari, C. (2009). Research methodology: Methods and techniques. 2nd ed. New Age Publishers.
- Labuschagne, C., & Brent, A. (2005). Sustainable project life cycle management: the need to integrate life cycles in the manufacturing sector. *International Journal of Project Management*, 23(2), 159.
- Lehtonen, M. (2004). The environmental-social interface of sustainable development: capabilities, social capital, institutions. *Ecological Economics*, 49(2), 199.
- Patil, S.M. (2014). Assessment of the socio-economic and environment impact by Udupi Power Corporation Limited (UPCL) in Nandikur.
- Pokale, W. (2012). Effects of thermal power plant on environment. *Scientific Reviews and Chemical Communications*, 2(3), 212.
- Sahay, A. (2008). Perception of pollution and expectation from NTPC's Talcher Super Thermal Power Plant. *Progress in Industrial Ecology*, 5(56), 536.
- Srinivasan, P., & Shekhar, A. (2020). Internalizing the external cost of gaseous and particulate matter emissions from the coal-based thermal power plants in India. *Particulate Science and Technology*, 39 (5), 632.
- Taylor, C., Goodrich, C., & Bryan, C. (1995). Issues-oriented approach to social assessment and project appraisal. *Project Appraisal*, 10(3), 142-154.
- TV, R., Aithal, B., & Sanna, D. (2012). Insights to urban dynamics through landscape spatial pattern analysis. *International Journal of Applied Earth Observation and Geoinformation*, 18, 329.



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