ENVIRONMENTAL RISK ASSESSMENT IN THE LIGNITE MINING TOWNSHIP IN INDIA

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ABSTRACT

Lignite mining has often been associated with positive economic benefits; however, it may also result in negative impacts on the environment and human health. It is essential that communities understand the risks and benefits associated with mining, particularly in developing countries where there is often a lack of legislation governing the environmental performance of mining corporations. The perceptions of local people regarding the risks and benefits of mining may differ significantly. Examination of the complex social, economic, psychological, political, and cultural factors influencing risk perception in mining communities is thus important for successful risk communication and management.

Here the methodology what adopted is Delphi Method. In this situation a small monitor team designs a questionnaire which is sent to a larger respondent group. After the questionnaire is returned, the monitor team summarizes the results. Then SPSS 20.0, a statistical analysis software package was used to conduct univariate and bivariate analysis of the survey questions. This study conducted first hand empirical research into the perception of environmental and health risks in the communities surrounding the Neyveli Lignite Mine in Tamil Nadu. Concurrently, environmental samples were collected to assess the extent of environmental impacts at the study site. The results of this study may thus also serve as a preliminary step in the development of a more effective audience-tailored risk communication program.

Keywords—Environmental Risk Management, Neyveli Lignite Mine, Environment Risk Assessment, SPSS 17.0, Delphi Method, Quantitative and Qualitative methods, Simple Random Sampling.

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1. INTRODUCTION

Ecosystem disturbance caused due to mining is an evitable fall out of industrialization and modern civilization. The rate and the intensity of land use pattern change are very high in developing countries because of various human activities. Mining of coal both surface and subsurface causes enormous damage to the flora, fauna, hydrological relations and soil biological properties of the systems. Destruction of forests during mining operation is invariably accompanied by an extensive damage and loss to the system. The overburden of coal mines when dumped in unmined areas creates mine spoils which ultimately affects the surrounding vegetation.

Mining operations, which involve minerals extraction from the earth's crust tends to, make a notable impact on the environment, landscape and biological communities of the earth.

Coal mining is one of the core industries that contribute to the economic development of India but deteriorate the environment. Coal is the primary source of energy and it became essential to meet the energy demand of India. Seventy percent of total electricity generation in India is from coal based thermal power plants. Due to mining various allies industries have been develop around the area. Demands of lands have been increased with increased in industries.

Environmental risk assessment (ERA) involves the examination of risks resulting from natural events (flooding, extreme weather events, etc.), technology, practices, processes, products, agents (chemical, biological, radiological, etc.) and industrial activities that may pose threats to ecosystems, animals and people. ERA is predominantly a scientific activity and involves a critical review of available data for the purpose of identifying and possibly quantifying the risks associated with a potential threat.

2. ABOUT THE STUDY AREA:

Neyveli Lignite Mines play a major role in generating the energy needs of the states of South India. Lignite mining at Neyveli commenced about half a century ago by Neyveli Lignite Corporation Ltd (NLC), a Government of India Enterprise. Continuous mining technology using Bucket Wheel Excavators (BWE), Belt conveyors and Spreaders was adopted.Unlike coal, lignite is a low calorific fossil fuel for producing electricity. About38.93 billion Tones (BT) of lignite reserves of various categories have been identified in India, (Table. 1) mostly in the states

of Tamil Nadu, Pondicherry, Rajasthan, Gujarat, Jammu & Kashmir and Kerala. Tamil Nadu and Pondicherry possess 31.74BT of lignite.

State	Lignite Reserves in Million Tonnes
Tamil Nadu	31327.02
Rajasthan	4485.43
Gujarat	2662.75
Puducherry	416.61
Kerala	9.65
Jammu & Kashmir	27.55
West Bengal	1.15
Total	38930.16

Table: 1 Lignite resources of India.

2.1 About the Township

Neyveli Township established in February 1959 has grown into a self-contained unit with all infrastructural facilities. This Township spread over 50 Sq.kms. with about 21,000 residential quarters has a total population of about 1,50,000 and has all facilities which includes schools, college, sophisticated general hospital, library, swimming pools, air-conditioned auditorium, stadium, community welfare centre's, recreation clubs, reading rooms, parks, banks, shopping complexes,etc.

Environmental Challenges and Its Management:

NLC handles the challenges posed by different environmental factors sagaciously. The details relating to the challenges posed by individual environmental factors viz. air, water, land, humans etc. and the environmental management measures adopted by NLC to handle these challenges are described in the following pages.

a) *Air pollution Control Measures:*

NLC has been able to maintain these good air quality standards by adopting proper control measures for preventing air pollution, which are enumerated below.

b) *Deploying machineries with Electrical power:*

Most of the machineries used in mines are electrically operated and hence the emission of noxious gases, which is usual with diesel-operated machines, has been substantially reduced.

c) *Dilution of gaseous emissions:*

The Neyveli lignite mines are spread over a large area and have a normal width to depth ratio, which develops adequate natural ventilation and dilution of gaseous emissions through wind sweeping and vertical mixing of air.

d) *Green belt development:*

NLC had raised171 lakh trees in the region over a periodof time. Dense foliage has been created in the township, which has yielded multiple benefits to the community. Besides being a barrier against dust penetration into the township, the dense foliage has reduced the mean temperature by about 2 degree Celsius, attenuated the noise generated from the adjoining mines and thermal power plants and reduced the levels of sulphur dioxide in air. It is found that a tree-belt of 10 metres has the capability to bring down the noise level by 10 decibels and a cluster of trees in an acre of land has the potential to absorb six tons of sulphur dioxides.

e) *Sharp teeth for Bucket Wheel Excavator*

Adequate precautions are taken in using sharp tooth for bucket wheel excavators to reduce dust production.

f) *Chutes at transfer points:*

Necessary chutes are provided in all the conveyor transfer points. Wipers/ cleaning devices are provided underneath the conveyor belt.

g) *Water spraying at BWE excavation face:*

High-pressure jet of water is sprayed at active face where lignite is extracted by BWE, which prevents generation of dust at source.

h) *Water spraying on haul roads by mobile and fixed sprinklers:*

The lignite transport road and access roads of overburden benches are regularly sprayed with water with the help of mobile and static water sprinklers.

i) *Dust extractors and wet drilling:*

All blast hole drills have been equipped with dust extractors. Wet drilling is practiced for drilling Ground Water Control (GWC) wells

3. ENVIRONMENTAL RISKS

It is important that individuals accurately understand the risks and benefits associated with mining, so that they may make informed decisions about living and working in a mining community. However, community perceptions of risk can differ significantly from those of company representatives, policy makers, and the scientific community (Hadden, 1991). Thus, examination of the unique and complex social, economic, political, psychological and cultural factors influencing public risk perception is essential for successful risk management.

3.1 Risk Perception

The constructivist view of risk perception holds that risks are not purely a product of the existing environmental reality, but rather, they are formed on both an individual and societal level in a complex setting of contextual factors (Jasanoff, 1999; Kasperson & Kasperson, 1996). Slovic, Fischhoff, and Lichenstein conducted some of the earliest studies quantifying risk perception beginning in the late 1970s (P. Slovic, Fischhoff, & Lichtenstein, 1980). They developed a methodology which they later termed the psychometric paradigm, using a survey instrument to quantify a wide variety of social, cultural, and psychological factors which they found to influence what an individual subjectively understands as risk.

The present study extends this line of research, by examining the relationship between economic dependence and perception of risk in the differing context of a mining facility in a developing country. The role of women in risk-analysis and decision making processes has been another important area of inquiry in many risk perception studies. Women have traditionally had limited access to the employment and business opportunities related to mining, while assuming much of the social and environmental burden.

3.2 Risk Communication

Risk communication is a dynamic process of interaction between individuals, communities, groups, and institutions. The process involves not only information about risks, but also the concerns, opinions and reactions that people have to risk information (Committee on Risk Perception and Communication & National Research Council, 1989). However, the multifaceted nature of risk communication requires that the strategies used in any particular case must be adapted so that they are appropriate for the unique community and industry stakeholders involved.

3.3 Risk Communication Challenges

Messages about risk, by their very nature, simplify and condense technical information, creating the potential for confusion and/or distrust. Risk messages also invariably contain some level of uncertainty, further complicating their delivery. Many of the challenges that arise in the risk communication process can be broadly categorized into two general types, including

problems arising between risk communicators, recipients, and intermediaries; and problems arising from the political or institutional systems related to risk management

3.4 Best Practices in Risk Communication

Contributions to risk communication have come from many different disciplines; this discussion of best practices will draw on a wide variety of approaches to risk communication, which can all offer insight depending on the unique audience and situation at hand. The best practices are compiled into two categories: 1) recommendations relating to the *process* of risk communication 2) recommendations related to the *content and presentation* of risk messages. In general, risk managers have traditionally focused on improving the accuracy of message content, however, it has been demonstrated that both risk communication procedures and message content must be improved.

4. RESEARCH METHODOLOGY

A combination of quantitative and qualitative methods was used for this study. This approach of methodological pluralism allowed the research design to be comprehensive yet flexible, while working within a large community where reliable demographic information was difficult to obtain prior to travel to the study site (Sechrest & Sidani, 1995). A quantitative risk-perception survey, including the collection of health data, and environmental sampling were accompanied by qualitative semi-structured interviews.

Simple Random Sampling:

In statistics, a simple random sample is a subset of individuals (a sample) chosen from a larger set (a population). Each individual is chosen randomly and entirely by chance, such that each individual has the same probability of being chosen at any stage during the sampling process, and each subset of *k* individuals has the same probability of being chosen for the sample as any other subset of *k* individuals. This process and technique is known as simple random sampling, and should not be confused with random sampling. A simple random sample is an unbiased surveying technique.

Microsoft Excel has a function to produce random numbers. The function is simply=***RAND ( )*** Type that into a cell and it will produce a random number in that cell. Copy

the formula throughout a selection of cells and it will produce random numbers between 0 and 1.In this case the population of Neyveli Township is above 100,000 and it consists of 21,000 individual housing units, hence a sample of 384(The Research Advisors, 2006) with a confidence level of 95% can be adopted.

Neyveli City	**Total**	**Male**	**Female**
Population	**105,687**	53,442	52,245
Literates	**90,114**	47,876	42,238
Children (0-6)	**6,634**	3,496	3,138
Average Literacy (%)	**90.98**	95.86	86.01
Sex ratio	**978**		
Child Sex ratio	**898**		

Table: 2 Neyveli Township Data.

Hence the wanted random numbers is from 1 to 384, so the following formula can be used.

=INT (21000*RAND ()) +1

The INT eliminates the digits after the decimal, the 21000* creates the range to be covered, and the +1 sets the lowest number in the range.

Risk-Perception Survey:

A survey questionnaire was designed to quantify and evaluate environmental and health risks as they are perceived by Neyveli residents, and build upon prior environmental risk assessments. The survey aimed to assess how people understand and utilize information about environmental and health risks, including but not limited to, potential for contamination of water, soil, and air, potential for acute environmental disasters land use conflicts and risk to future generations. The survey also included questions about health symptoms experienced by mine workers and their families focusing on symptoms that are known to occur with exposure to the mining operations and their by-products.

The target population for this study consisted of all people living within thelarger community surrounding the Neyveli Lignite Mine, including current and former mine employees and their families. For organizational purposes, the target population was divided in accordance with 30 blocks. Many of these settlements are located in very close proximity or are adjacent to each other.

Survey Instrument:

The final survey instrument consisted of 46 questions, including 1-7 point Likert-type scale questions, multiple choice questions, and open-ended questions. Questions aimed to evaluate risk perception variables such as ability, sufficiency, level of concern, and knowledge of risks. Questions also aimed to quantify the degree to which participants utilize systematic vs. heuristic processing in evaluating risks.

Data Analysis

SPSS 20.0, a statistical analysis software package was used to conduct univariate and bivariate analysis of closed-ended survey questions. Chi-Square and Mann-Whitney tests were conducted to assess variation in responses according to gender; Kruskal-Wallis tests were conducted to assess variations between ordinal variables such as knowledge of risks and nominal demographic variables such as ethnicity; Spearman correlation coefficients were calculated to assess correlation between multiple ordinal variables and scale vs. ordinal variables. One-way ANOVA and Bonferroni tests were conducted to assess variation between scales demographic variables such as age, and nominal variables. For ordinal variables, "don't know" responses were treated as missing values during bivariate and multivariate tests to ensure accuracy of results. Finally, PLUM ordinal regression analysis was conducted to assess the relative influence of two independent variables, gender and employment at the mine on the dependent variable knowledge of risks.

The final survey question was open-ended, asking respondents to rank the three environmental or health issues that concerned those most. Responses to this question were translated, coded, and compared to quantitative results obtained with SPSS 20.0.

5. RESULTS AND DISCUSSION

5.1 Profile of Respondents

Three hundred and ninety people were randomly selected to participate in the survey. A total of 384 completed survey questionnaires were collected, representing 30 blocks, and resulting in a response rate of 95%.Respondents were given the choice to complete the survey in

English language. Our sampling technique successfully captured a fairly even representation of demographic profile which is given below:

		where did your work mostly take place	Were you born	How long have you lived in Neyveli area	male or female	ever worked at the Neyveli Lignite Mine	ethnicity	highest level of education	current age
N	Valid	214	389	251	390	390	390	390	390
	Missing	176	1	139	0	0	0	0	0
Mean		1.03	1.54	2.73	1.09	1.55	1.00	4.04	35.54
Median		1.00	2.00	3.00	1.00	2.00	1.00	4.00	36.00
Mode		1	2	3	1	2	1	5	37
Std. Deviation		.178	.499	.874	.293	.499	.000	1.154	9.341
Range		1	1	3	1	1	0	4	58
Sum		221	600	686	427	603	390	1575	13860

Table: 3 Statistics of Demographic profile

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ABOVE GROUND	207	53.1	96.7	96.7
	BELOW GROUND	7	1.8	3.3	100.0
	Total	214	54.9	100.0	
Missing	System	176	45.1		
Total		390	100.0		

Table: 4 Working Areas

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	178	45.6	45.8	45.8
	NO	211	54.1	54.2	100.0
	Total	389	99.7	100.0	
Missing	System	1	.3		
Total		390	100.0		

Table: 5 Place of Birth

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 YEARS OR LESS	32	8.2	12.7	12.7
	BETWEEN 6 AND 10 YEARS	42	10.8	16.7	29.5
	BETWEEN 11 AND 20 YEARS	138	35.4	55.0	84.5
	MORE THAN 20 YEARS	39	10.0	15.5	100.0
	Total	251	64.4	100.0	
Missing	System	139	35.6		
Total		390	100.0		

Table: 6 Years lived in Neyveli area

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MALE	353	90.5	90.5	90.5
	FEMALE	37	9.5	9.5	100.0
	Total	390	100.0	100.0	

Table: 7 Gender.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NO	177	45.4	45.4	45.4
	YES	213	54.6	54.6	100.0
	Total	390	100.0	100.0	

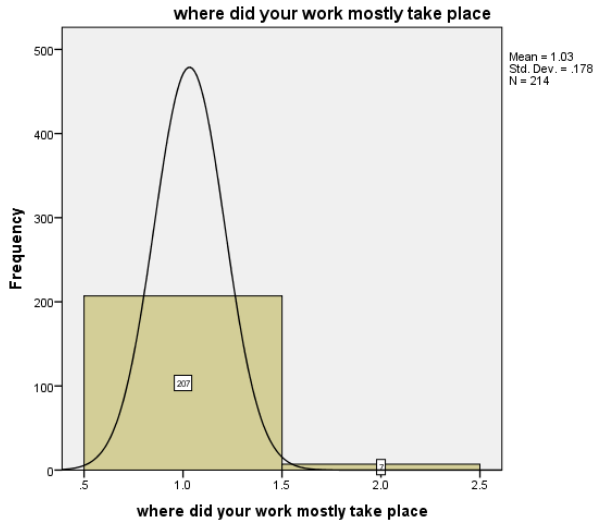
Table: 8 Worked at the Neyveli Lignite Mine

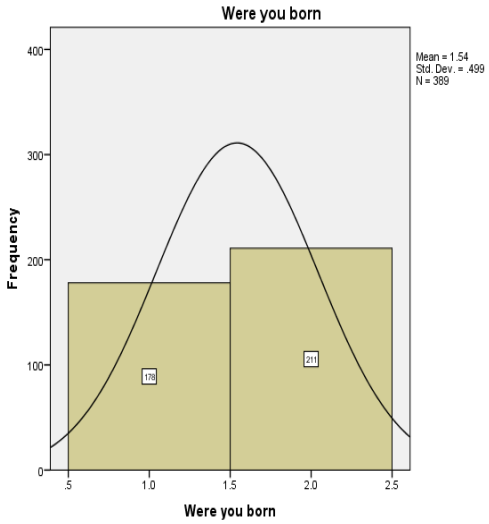
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	INDIAN	390	100.0	100.0	100.0

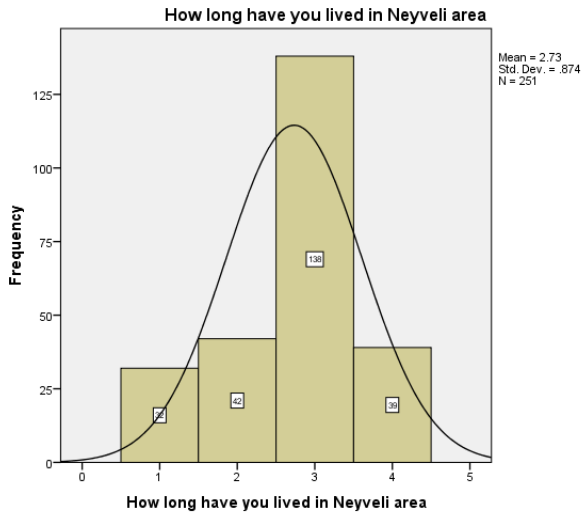
Table: 9 Ethnicity

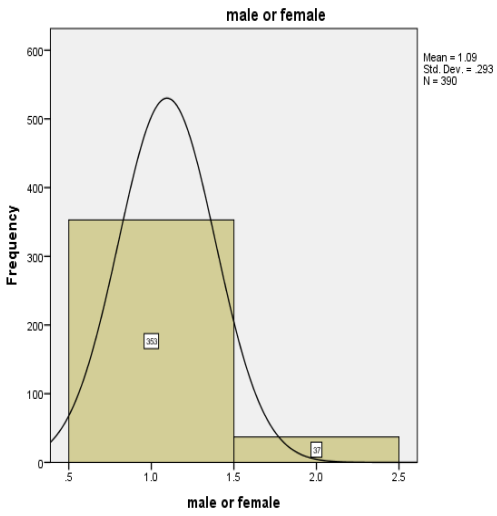
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NO SCHOOLING	23	5.9	5.9	5.9
	PRIMARY SCHOOL	20	5.1	5.1	11.0
	SECONDARY SCHOOL	54	13.8	13.8	24.9
	VOCATIONAL/ TRADE SCHOOL	115	29.5	29.5	54.4
	UNIVERSITY/ COLLEGE	178	45.6	45.6	100.0
	Total	390	100.0	100.0	

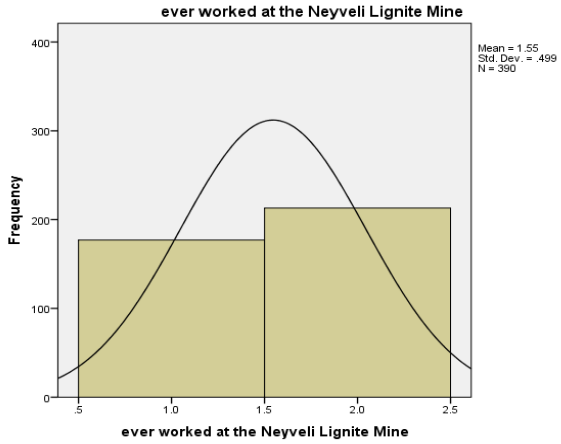
Table: 10 Highest level of education

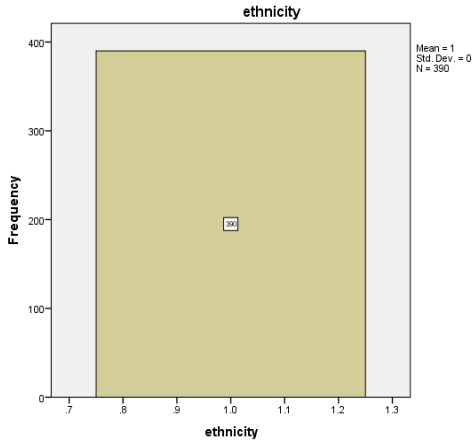


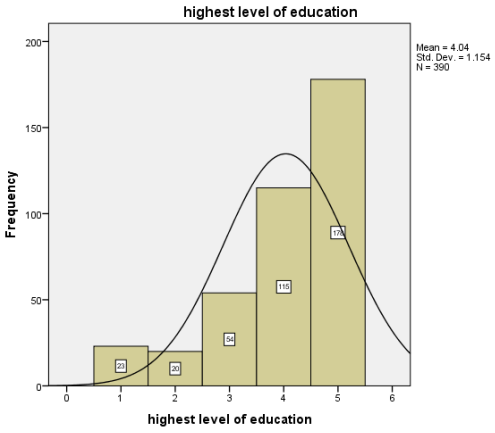



How long have you lived in Neyveli area
Mean = 2.73
Std. Dev. = .874
N = 251
Frequency
How long have you lived in Neyveli area


male or female
Mean = 1.09
Std. Dev. = .293
N = 390
Frequency
male or female


ever worked at the Neyveli Lignite Mine
Mean = 1.55
Std. Dev. = .499
N = 390
Frequency
ever worked at the Neyveli Lignite Mine


ethnicity
Mean = 1
Std. Dev. = 0
N = 390
Frequency
ethnicity

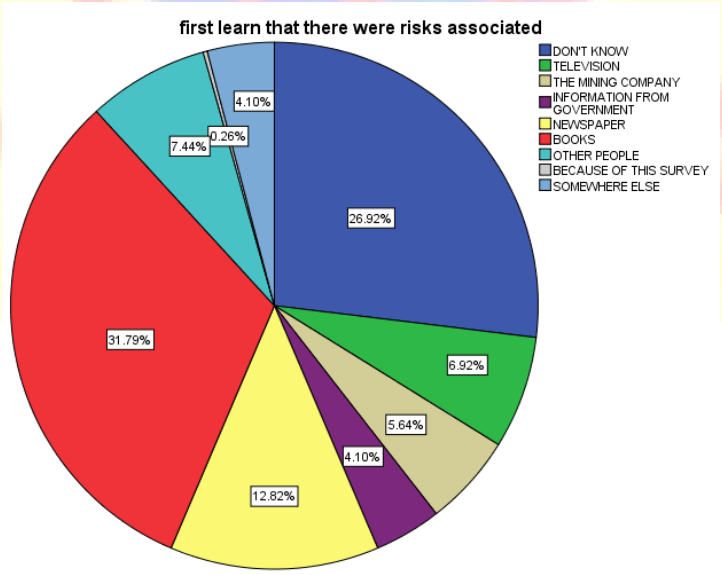

highest level of education
Mean = 4.04
Std. Dev. = 1.154
N = 390
Frequency
highest level of education

5.2 Knowledge of Risks

When asked how they felt about the risks of mining, the majority of the population felt they knew about "some" or "most" of the risks of mining.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DON'T KNOW	105	26.9	26.9	26.9
	TELEVISION	27	6.9	6.9	33.8
	THE MINING COMPANY	22	5.6	5.6	39.5
	INFORMATION FROM GOVERNMENT	16	4.1	4.1	43.6
	NEWSPAPER	50	12.8	12.8	56.4
	BOOKS	124	31.8	31.8	88.2
	OTHER PEOPLE	29	7.4	7.4	95.6
	BECAUSE OF THIS SURVEY	1	.3	.3	95.9
	SOMEWHERE ELSE	16	4.1	4.1	100.0
	Total	390	100.0	100.0	

Table: 11 First learn that there were risks associated

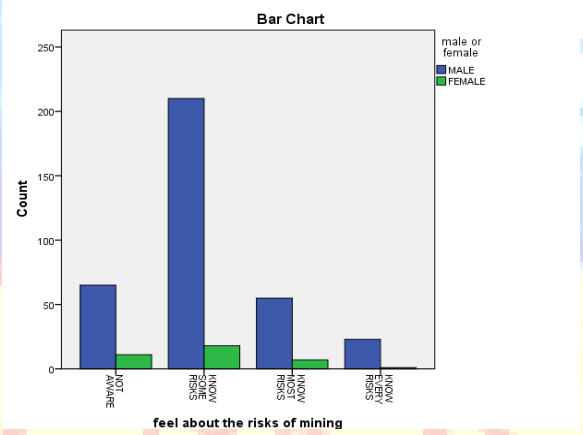


5.3 Level of Concern

Despite their gaps in risk knowledge, Neyveli residents feel a consistently high degree of concern across a range of environmental and health risks and few people question the fact that the risks are impacting their health.

		male or female		Total
		MALE	FEMALE	
feel about the risks of mining	NOT AWARE	65	11	76
	KNOW SOME RISKS	210	18	228
	KNOW MOST RISKS	55	7	62
	KNOW EVERY RISKS	23	1	24
Total		353	37	390

Table: 12 Feel about the risks of mining * male or female by Cross-tabulation



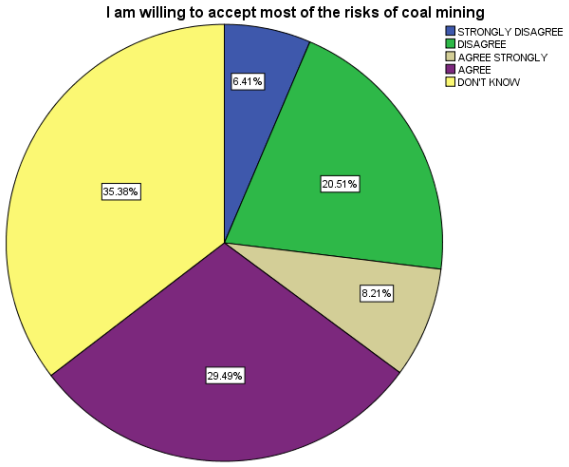
5.4 Weighing Risks and Benefits

Some may argue that by choosing to live and work in Neyveli, residents is making a conscious decision to accept the risks of mining in light of the economic benefits of employment at the mine. However, the results of this study highlight the underlying complexity of such risk/benefit decisions.

	Frequency	Percent	Valid Percent	Cumulative Percent

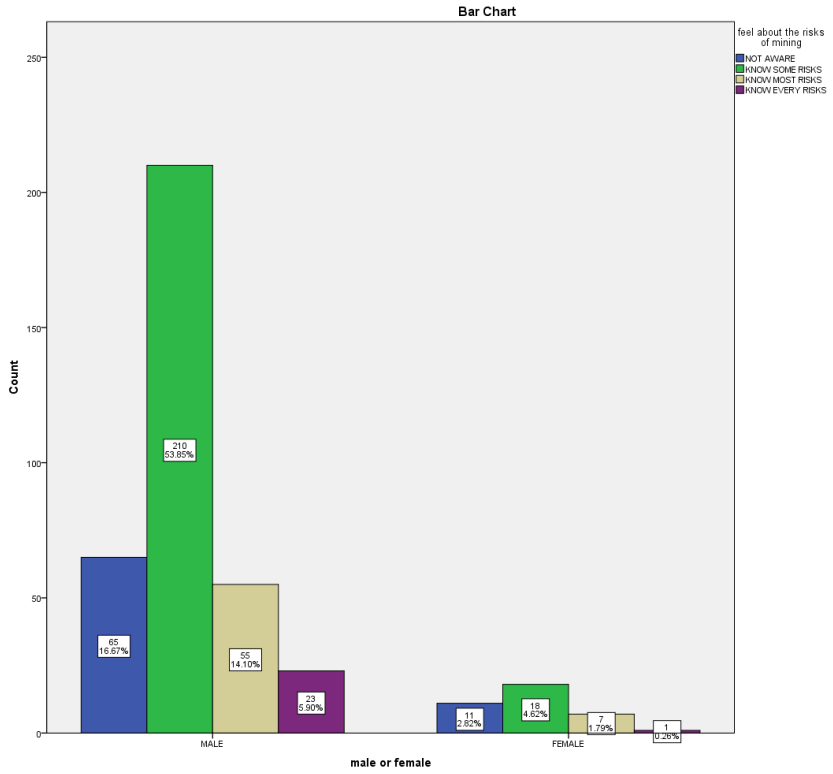
Valid	STRONGLY DISAGREE	25	6.4	6.4	6.4
	DISAGREE	80	20.5	20.5	26.9
	AGREE STRONGLY	32	8.2	8.2	35.1
	AGREE	115	29.5	29.5	64.6
	DON'T KNOW	138	35.4	35.4	100.0
	Total	390	100.0	100.0	

Table: 12 Risks and Benefits



5.5 Gender and Risk Perception

A closer analysis of the responses of men and women revealed that gender is an important variable in risk perception at Neyveli. First, the survey revealed that women and men differ significantly how much they feel they know about mining risks. Women feel they have less knowledge about the risks of mining compared to men ($p<0.001$). More specifically, women are significantly more likely to feel that they know about some or none of the risks, while men are significantly more likely to indicate that they know about most or all of the risks.



6. CONCLUSION

This was the first risk-perception study conducted in both the cultural context of Neyveli Lignite mining. However, nearly all of the people who participated in this study were economically dependent on the mine in some way, if not directly through employment. As such, all of the survey results are valuable to a more informed discussion about risk communication and management at Neyveli Lignite Mine. Furthermore, research has shown that two of the major principles of effective risk communication are: 1) understanding and addressing audience concerns, and 2) whenever possible, account for existing beliefs and perceptions. The results of this study may thus also serve as a preliminary step in the development of a more effective audience-tailored risk communication program.

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