Impacts of Sponge iron industries on the socioeconomic fabric of Asuriya, Sahebdihi, and Bisanpur villages in Bankura, West Bengal, India: A Comparative study

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Abstract

The villages of Asuriya, Sahebdihi, and Bisanpur in Bankura, West Bengal, have been greatly affected by sponge iron factories. While these industries boost economic growth and job opportunities, they also threaten public health and safety due to air and water pollution. Local authorities must establish strict regulations and monitoring systems to address these challenges. Investing in sustainable practices and alternative industries can help diversify the local economy and lessen dependence on polluting sectors. The research shows a link between household income and education levels, but jobs in the sponge iron sector often involve poor conditions and health risks. Expanding access to education and vocational training can help residents pursue healthier employment options. The environmental damage from these industries harms public health and agricultural productivity, deepening economic inequalities. This study emphasises the need for strong policy interventions to promote equitable economic benefits and sustainable practices, ensuring a better future for all community members.

Key words : Socio-Economic, Industrialization, industries, Sustainable Development, Environmental Degradation.

The rapid industrialisation of emerging countries, as shown by the expansion of the sponge iron industry, has proven to be a doubleedged sword. While stimulating economic growth and infrastructure development, it also heavily strains neighbouring communities' socioeconomic and environmental fabric. Individuals from formerly isolated villages have

urged an increase in industrialization following World War II, citing the material benefits of modern technology. As a result, pollution levels have surged, and habitat deterioration has accelerated drastically⁸. The exponential development of industrialisation in the 2020s has sparked severe concerns about environmental sustainability and the depletion of natural

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resources.

Indian Small Scale Industries (SSI) have emerged with a lion's share of energy consumption¹⁰. Among such small and a few large-scale industries, the Sponge iron industry plays the role of a major consumer as well as in most demand. Larger industries require people with higher educational backgrounds. But in cases of these smaller scale plants, the people working in higher positions get promoted according to their work ethics and not degree or qualification⁶.

According to a study done³, People who were for generations employed in farming primary produce crops, have slowly reduced or lost interest in farming. As a result, crops have become harder to come by. The farmers are more inclined towards working in smallscale industries which have minimal pay but a fixed pay every month, over, farming, which earns them less and less and sometimes even causes uncertainty over their earnings. The iron industry bears the responsibility of fulfilling both economic and social obligations. It is essential that its operations not only contribute positively to economic growth but also address the societal and environmental impacts associated with its activities¹.

In this study, we aim to understand the impacts sponge iron industries have on society. That includes the way the industries affect the economy of the area as well as its impact on the social environment. Generally, when there is an industry, there is a demand and a high increase in employment. We aim to study and understand those effects. The economy of an area dictates the well-being of the residents of that place and affects the social environment as well.

The City of Barjora has a lot of sponge iron industries spread out in the area. There are severe negative consequences for the environment of that area⁵ as a result. For this study, three villages were chosen based on their proximity to the sponge iron industries. Studies were conducted in these villages in the form of household surveys. Of every single resident.

Study site :

The study is mainly concentrated in the area of the village of Asuriya and its surrounding villages. The surrounding villages of Sahebdihi and Bisanpur are near sponge iron industries as well. The villages have approx. 5000 residents each and most of them are more inclined to be into physical labour and farming than being into regular office jobs. The village of Bisanpur is only accessible through rocky earthen roads and/or via bicycle or by foot. It is nearest to one of the sponge iron industries

Methodology :

Structured interviews were conducted with residents of Asuriya, Sahebdihi, and Bisanpur villages to gather detailed socioeconomic data. Key variables included household income, educational attainment, family size, number of dependents, modes of transportation, primary occupations, age of household heads, and housing conditions. These interviews aimed to capture a comprehensive socioeconomic profile and identify any correlations between these variables and the impacts of nearby sponge iron industries. The



Fig 1: GIS map of the District of Bankura

interviews aimed to gather comprehensive data about the socio-economic profile of the villages' residents. This data would provide valuable insights into the overall standard of living, economic disparities, and demographic composition of the villages. By collecting information on household income, educational qualifications, and other factors, the interviews aimed to capture a holistic understanding of the residents' socio-economic status. This data would not only shed light on the economic disparities within the villages but also help identify potential areas for improvement and development. Additionally, analyzing the demographic composition of the villages would enable policymakers to tailor interventions and allocate resources effectively, ensuring a better quality of life for all residents. Additionally, it would help identify any specific challenges or needs that may exist within the community, enabling targeted interventions and policy decisions to improve their well-being. Additionally, the interviews also explored any specific challenges or needs that the households may be facing to inform potential support or development initiatives.

ANOVA was selected as the method for statistical analysis, because, it allows the comparison of mean difference across various groups. It helps us understand the relation between socio-economic outcomes and demographic groups and how they relate to or contradict each other statistically. Using different forms of comparison like the T-test, poses a risk of Type 1 error aka false positives. In the case of a t-test, there are only two values that can be tested which requires individual testing of various factors the risk of False positives might increase. Thus, ANOVA is by far the most appropriate and suitable choice for this paper In certain situations, Multiple Logistic Regression presents itself as the superior choice, as it facilitates the simultaneous control of multiple variables. This capability is particularly valuable for identifying the most

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significant predictors of income or health outcomes. Linear Regression is appropriate when the dependent variable is continuous, such as household income. Conversely, Logistic Regression is more applicable when the outcome is binary, such as the presence or absence of a health condition.

At first, to understand, if there is any relation between the *educational qualification in the study site*, Hypothesis testing was conducted.

ANOVA Statistics Hypothesis

 H_0 : There is no significant difference between the experimental groups among the four different levels of education

H_A: There is a significant difference between the experimental groups among the four different levels of education Multiple Comparison Test Hypothesis (using Tukey HSD):

H₀: There is no significant impact of Educational Qualification on Household earnings H_A: There is a significant impact of Educational Qualification on household earnings

A statistical significance test is a procedure for determining the most likely outcome from two contradictory hypotheses. It gives a null hypothesis and an alternate hypothesis for data probability distribution. If the probability of the sample is less than the pre-specified threshold, the difference between it and the null hypothesis is statistically significant⁹.

Keeping that in mind the collected data from the study sites were tested to see if they have any statistical significance.

Table-1. ANOVA Statistics table

Household Income

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11196569596	3	3732189865	4.759	.003
Within Groups	1.584E+11	202	784235044.3		
Total	1.696E+11	205			

With a Significance value of p < 0.05, we can fail to reject the null hypothesis. Thus we can conclude that there is no significant difference between the experimental groups among the four different levels of education

From the tabulated data in the Pairwise comparison of the educational group, we can infer that almost all of the pairs have a value of p>0.05 except 8 pass: graduate thus we

can reject the null hypothesis for all the pairs concluding that there is a significant effect of educational qualification on the family earnings. In the case of the pair 8pass: graduate there is a significant statistical difference in this educational group based on the amount of income in their household. That is, the people with 8 pass have an income level statistically vastly different from those with a graduate or higher degree.

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Table-2. Pairwise Comparison of Educational Group Means

Multiple Comparisons

Dependent Variable: Household Income Tukev HSD

_		Mean Difference (I			95% Confidence Interval		
(I) Educational Qualifications	(J) Educational Qualifications	J)	Std. Error	Sig.	Lower Bound	Upper Bound	
8 pass	12 Pass	12.500	8762.972	1.000	-22688.37	22713.37	
	graduate	-16509.868	5446.723	.015	-30619.85	-2399.89	
	No Education	1812.500	11685.073	.999	-28458.20	32083.20	
12 Pass	8 pass	-12.500	8762.972	1.000	-22713.37	22688.37	
	graduate	-16522.368	7579.035	.132	-36156.20	3111.46	
	No Education	1800.000	12818.577	.999	-31407.10	35007.10	
graduate	8 pass	16509.868	5446.723	.015	2399.89	30619.85	
	12 Pass	16522.368	7579.035	.132	-3111.46	36156.20	
	No Education	18322.368	10825.572	.330	-9721.76	46366.50	
No Education	8 pass	-1812.500	11685.073	.999	-32083.20	28458.20	
	12 Pass	-1800.000	12818.577	.999	-35007.10	31407.10	
	graduate	-18322.368	10825.572	.330	-46366.50	9721.76	

*. The mean difference is significant at the 0.05 level.

From the data analysed, we can form the following pairs-

8 pass: No education- *p*=0.9

8 pass: graduate- *p*=0.015

graduate: No Education- p=0.33

graduate:12pass- *p*=0.132 8 pass: 12 pass- *p*=1 12 pass: No Education- *p*=0.9

From the whole analysis, we can further conclude that there is a significant effect of education on household income in the surveyed study area.

This also poses the question: Does the Type of Job, Household Income and number of dependent members in the household determine the household's Financial stability?

Regardless of income or family size, elements that affect financial stability in a home include household income, the type of employment, the size of the family, housing, healthcare, debt commitments, and unforeseen occurrences like job loss or medical issues. These elements may have a substantial influence on a family's capacity to pay bills and preserve their standard of living. Longterm financial stability may also be attained with the help of possibilities for job progression, access to inexpensive and high-quality education, and other factors. Furthermore, having a reliable support system and access to social services can contribute to the overall stability of a home. Additionally, maintaining a healthy work-life balance and having opportunities for personal and professional growth can also play a significant role in achieving long-term financial stability.

One sample KS test was performed and it was determined that the distribution of data was normal (p>0.05). Thus we proceed to conduct the one-way ANOVA. If hypothesis testing is performed based on how a household's financial stability is influenced by the overall household income, type of job, and number of family members, the two hypotheses drawn would be as follows:

H₀: There is no significant relationship between a household's financial stability and the overall household income, type of job, and number of family members.

H_A: There is a significant relationship between a household's financial stability and the overall household income, type of job, and number of family members.

Table-3. Analysis of Variance Turkey Model of the Job Type and Household Income Household income

Tukey HSD^{a.b.c}

		Sub	set
Job Type	Ν	1	2
0	2	1500.00	
1	43	5953.49	
3	37	6027.03	
5	16	6375.00	
2	84	22440.48	22440.48
4	16		50000.00
6	8		53125.00
Sig.		.460	.075

From the statistical analysis performed, we can determine the value of p>0.05. Thus we fail to reject the null hypothesis and draw the conclusion that there is no significant relationship between a household's financial stability and the overall household income, type of job, and number of family members.

Determining if there is a relation between Employment type and Educational qualification :

Logistic regression is a statistical method that calculates the likelihood of an event by examining the relationship between independent factors and a categorical dependent variable. There are two types: binary logistic regression, used when the dependent variable is dichotomous and the independent variables are continuous or categorical, and multinomial logistic regression, used when the dependent variable has multiple categories and is not binary⁷. Binary logistic regression is commonly used in fields like psychology, medicine, and social sciences to predict outcomes like success or failure, disease presence or absence, or voting preferences. Multinomial logistic regression, on the other hand, finds its applications in various fields such as market research, political science, and sociology to predict outcomes with more than two categories, like consumer preferences, political party affiliation, or social class. Both types of logistic regression models are valuable tools for analyzing and predicting categorical outcomes in different domains of study.

Hypothesis For Model-Fit:

 H_0 : The regression model does not significantly predict the Employment Type as compared to the base/null model β =0

 H_A : The regression model significantly predicts the Employment Type as compared to the base/ null model $\beta \neq 0$

Hypothesis For The Relationship Between The Variables:

H₀: There is no significant effect of the Educational Qualification on the Employment Type

H_A: There is a significant effect of the Educational Qualification on the Employment Type

Model Fitting Information								
	Model Fitting Criteria	Likelihood Ratio Tests						
Model	-2 Log Likelihood	Chi-Square	df	Sig.				
Intercept Only	64.821							
Final	37.139	27.682	40	.930				

Table-4. Model Fitting Information

From the model fit chart, we can determine that the value of p>0.5 but also p<1. Thus with the value of 0.93, which is quite high, we fail to reject the null hypothesis and can conclude that the regression model does not significantly predict the Employment Type as compared to the base/null model $\beta=0$.

Table-5. Relation between Variables

Goodness-of-Fit							
Chi-Square df S							
Pearson	.792	10	1.00				
Deviance	1.304	10	.999				

From the above (Table-4) we can safely conclude that with a significance of 1 and 0.99, where p>0.5 but also $p\leq l$, we fail to reject the null hypothesis thus concluding that there is no significant effect of the Educational Qualification on the Employment Type.

Determining if Age, Number of Children and Number of Family members have an impact on Household income using Multiple Regression Analysis:

Research shows that children from low-income households perform better in various developmental areas, including academics and social skills². However, the true impact of wealth and the extent of hidden inequities between wealthy and less affluent households remain unknown. Access to appropriate healthcare, education, and settings significantly influences a child's development. Understanding the intricate connections between wealth and other injustices is crucial for effective interventions and addressing the underlying causes of inequality.

To understand how Age, Number of Children and Number of Family members have an impact on household income Multiple Regression analysis was performed on the collected data and the results were noted as follows:

Hypothesis assessing the Relationship between the variables

H₀: No significant correlation exists between Household Income and age, number of family members and number of children or the slope of the gradient is equal to zero $\rho=0$

H_A: There is a significant correlation between Household Income and age, number of family members and number of children or the slope of the gradient is not equal to zero $\rho \neq 0$ Hypothesis for Model-Fit

 H_0 : The regression model does not predict the outcome variable significantly as compared to the base model.

H_A: The regression model predicts the outcome variable significantly as compared to the base model.

Table-6. Model Summary Statistics: Multiple Linear Regression Model Summary^b

						Change Statistics					
			Adjusted R	Std. Error of	R Square					Durbin-	
Model	R	R Square	Square	the Estimate	Change	F Change	df1	df2	Sig. F Change	Watson	
1	.203*	.041	.027	28371.955	.041	.041 2.902 3 202 .036					
a. Predictors: (Constant), Number of children, Age of the Individuals, Number of Dependant members											

b. Dependent Variable: Household Income

Multiple Correlation Co-efficient (R): It denotes a link between all of the predictor and dependent variables. The value ranges between 0 and 1. The bigger the value, the stronger the explanatory ability of the regression model to assess the dependent variable.

The model summary reveals a medium but positive correlation coefficient. The value of R-square indicates 4% variances in numbers of Household Income is explained by the three predictors in the model.

Durbin-Watson statistics: A Durbin-Watson value close to 2 like the obtained value of 1.289 which when rounded up approximately stands at 2, suggests that there is little to no first-order autocorrelation in the residuals. In other words, the assumption of independence of residuals is not seriously violated. This is generally a good sign for the validity of a multiple linear regression model. Standard Error

Estimate: A standard error of 28,371.955114 suggests that, on average, the predicted values for the Household income in the model may vary from the actual values by approximately 28,371.955114 units. A smaller standard error is generally preferred because it indicates a more precise model. A larger standard error suggests the model may have more variability, making its predictions unreliable. The meaningfulness of this standard error value depends on the specific context of the data. If the dependent variable (aka the household income) has a wide range and is measured in large units, a standard error of this magnitude might be reasonable. However, if the dependent variable has a narrower range or is measured in smaller units, this standard error could be considered large. In our case, the Household income ranges from Rs 1000 up to Rs 30000 which is a wide range thus the standard error of this magnitude is reasonable.

Table-7. ANOVA ststistics table

AN	0	/Aª	3
	-		

Mode	el	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7008545467	3	2336181822	2.902	.036 ^b
	Residual	1.626E+11	202	804967837.0		
	Total	1.696E+11	205			

a. Dependent Variable: Household Income

 b. Predictors: (Constant), Number of children, Age of the Individuals, Number of Dependant members The significance value is p=0.036 which is less than 0.05. Thus we fail to reject the null hypothesis which states that no significant correlation exists between

Household Income and age, number of family members and number of children or the slope of the gradient is equal to zero $\rho=0$.

Table-8. Estimated Regression Coeffic	cients: Multiple Linear Regression
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Coefficients ^a									
	Standardized								

		Unstandardized Coefficients		Standardized Coefficients			c	Correlations		Collinearity Statistics	
Mod	del	В	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2936.432	8906.393		.330	.742					
	Age of the Individuals	131.761	163.773	.057	.805	.422	.082	.057	.055	.962	1.040
	Number of Dependant members	2211.251	821.399	.235	2.692	.008	.153	.186	.185	.622	1.607
	Number of children	-2918.280	1631.978	- 155	-1.788	.075	- 005	- 125	- 123	.635	1.575
a	a. Dependent Variable: Household Income										

The t-test statistics and their corresponding p-values play a crucial role in evaluating the impact of independent variables on the outcome variable. In the cases of individuals' age (t=0.805 p>0.05, 0.422) and the number of children (t=-1.788 p>0.05, 0.075), the *p*-values exceed the significance threshold of 0.05. This allows us to confidently reject the null hypothesis, signifying that these variables have a significant influence on the outcome. In contrast, the number of dependent members (t=0.235 p<0.05, 0.008) yields a pvalue below 0.05, leading to the failure to reject the null hypothesis. This result indicates that the number of dependent members does not demonstrate a statistically significant effect on the outcome variable. On the other hand, the Age of individuals and Number of children do have a significant effect on the household income.

The Linearity assumption of multiple Regression is examined by plotting residuals against each predictor and checking the pattern. The presence of no specific pattern in the plot confirms the assumption of linearity in the model. Chart 2, Chart 3 and Chart 4 have no specific pattern in the graph thus confirming Assumption of linearity is not violated for the multiple regression model. The assumption of Homoscedasticity defines and describes the assumption of equal variance. The error variance should be constant for all values of the predictors. The assumption



Chart 1. Regression Standardized Predicted Value



Chart 2. Variable X1: Age of individuals



Chart 3. Variable X₂: Number of Dependant Members

Chart 4. Variable X₃: Number of Children

is performed and analysed by plotting regression residuals at the vertical axes corresponding to the regression-predicted values at the horizontal axes. The assumption of Homoscedasticity is not violated in case the residuals are scattered randomly around zero. In Chart 1, we can observe most of the values are scattered around zero on both the horizontal and vertical axes. Thus the assumption of Homoscedasticity is not violated.

The study provides a comprehensive analysis of the socioeconomic impacts a Sponge iron industry has on its surrounding localities which in this case are the villages of Sahebdihi, Asuriya and Bisanpur. The villages are close to each other in proximity and have quite several industries surrounding them. One of them is a plastic manufacturing plant and the others are sponge iron industries. On a detailed and scrupulous study of the results we might come to a few conclusions:

Socio-Economic impacts :

The study concludes that although job prospects in the sponge iron sectors offer certain economic advantages, these advantages do not result in meaningful enhancements to household financial stability. The research found that workers in the sponge iron sector face challenges such as job insecurity and lack of benefits, which ultimately outweigh the economic advantages. This suggests a need for policy interventions to improve job quality and financial security for workers in this industry.

The data demonstrates that although education has an impact on household income, it does not affect the nature of work. Furthermore, the financial stability of a home is not considerably impacted by the number of dependent family members. This highlights the importance of addressing job quality and benefits for workers in the sponge iron sector to truly improve their financial stability. Additionally, it underscores the need for targeted policy interventions that focus on improving job security and benefits in this specific industry. Overall, the study suggests that factors beyond education level and family size play a significant role in determining household financial stability. It highlights the need for further research to identify additional variables that may influence economic outcomes

in the sponge iron sector.

The results indicate that household financial stability is not much improved and that the sponge iron industry's economic gains are dispersed unevenly. These findings suggest that further interventions may be needed to address disparities in economic growth within the sponge iron industry. Likewise, targeted policies could help enhance overall household financial stability in the long term. Initiatives that improve economic diversification and offer substitute job options are required to lessen dependency on the sponge iron sector. This will help to create a more stable and balanced economy that is less vulnerable to fluctuations in the sponge iron industry. On top of that, investing in education and training programs can help prepare workers for new opportunities in other sectors.

Impact on Human Beings :

The rapid industrialisation fueled by the sponge iron industries has led to substantial health concerns among the residents in the local area. Extensive research has shown that the release of harmful pollutants, including heavy metals like lead, mercury, and chromium, has worsened respiratory issues and various other health conditions. Consequently, the inhabitants have experienced a surge in cases of lung infections, asthma, and even cancer.

Impact on Environment :

There have been reports of severe declining vegetation cover and diseases in plants caused by to decline in the quality of air. Black spots on paddy reported by the local farmers are a cause for the decline in harvest quality as well as quantity.

In areas like Asuriya, Sahebdihi and Bisanpur, most of the employment types are dominated by either industry-oriented or agriculture-oriented. Very few among the ones surveyed have jobs that do not fall into either category. Such jobs are very hard to come by and statistically do not affect the analysis much. The residents are dependent on the sponge iron industries for their livelihood. The tea shops and pan stalls operating near the factories provide for the labourers and truckers who visit the factory regularly. The totos and rickshaws provide a steady mode of transport for the employees of the factories. The residents suffer a lot from the fly ash and polluted water but on the other hand, people who visit the factories from outside for permanent work provide a steady modicum of financial influx for the residents of the villages. Either by renting houses or purchasing necessities for daily life. This influx of workers also affected the agricultural sales in the area.

From the Statistical analysis performed above we can safely conclude that though education affects the type of income a person(s) earns, there is no effect of Education on the type of employment in the study area. This can occur due to various number of reasons. In some sectors of work, educational background does not mean anything for the person(s) to be employed there. Again in some other sectors, two people of the same educational background might be employed in the same sector/field of work, and one person with a higher education earns a higher wage than the person with a weak educational background.

Similarly, the number of dependent members does not demonstrate a statistically significant effect on the outcome variable and

there is no significant relationship between a household's financial stability and the number of family members. On the contrary, the Age of individuals and the number of children do have a significant effect on household income. Surprisingly, there is no significant relationship between a household's financial stability and the overall household income, type of job, and number of family members. This can occur because, in a single family, two or more members might be employed. But members of a higher seniority in age have a higher probability of having a seniority at work too. The opposites may occur too. A person can have a low-paying job but a higher age but another person can have a higher-paying job in a different sector in a lower age range.

Although the industries indeed provide socio-economic benefits for the people residing nearby, there are non-environmental effects that cause detrimental impacts on the workers and labourers. Inhalation of toxic fumes from the factories along with asbestos dust, SO_X and NO_X has severe health impact on the workers. The sad truth is that the labourers and workers work under such harsh conditions but are not paid accordingly. Most of them earn wages that are minimum or sometimes below minimum. Due to the lack of other sectors in the area, the residents who desperately seek money are forced to work for the sponge iron industries despite the despicable work conditions.

Several policy recommendations can be made based on the findings to mitigate the negative impacts and increase the positive effects of the sponge iron industry:

• Stricter environmental rules should be implemented to regulate emissions and

minimize pollution for health and environmental reasons. This will help to ensure a more sustainable and environmentally friendly operation of the sponge iron industry.

- To reduce environmental harm, the local panchayats should consider the creation of thorough waste management plans that include recycling initiatives and appropriate disposal techniques.
- Encouraging economic diversification by lending a hand to start-ups and ancillary sectors of the economy. To increase work prospects, offer programs for vocational education and training. By investing in renewable energy sources and promoting green technologies, the sponge iron industry can reduce its carbon footprint and contribute to a cleaner environment. Fostering partnerships with environmental organizations and government agencies can help ensure compliance with regulations and promote sustainable practices within the industry.
- Care facilities and regular health monitoring programs should be established to address the consequences for the health of residents.
- Whenever decisions are made about industrial expansion and environmental management, the local community should be involved.
- Promotion of the use of sustainable industrial processes and greener technology.

Conflict of Interest :

The authors do not have any potential or perceived conflict of interest in the study conducted.

A lot of support is required for a successful scientific study. I have received help and support through guidance and advice from

our respected PhD supervisor, Dr. Debnath Palit. I sincerely thank him for his efforts to show me the right direction. I also would like to acknowledge the cooperation and support I received from the village residents of Asuriya, Sahebdihi, and Bisanpur.

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