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Reclamation and Community Dynamics: Assessing Socio-Environmental Impacts of Mining in Manikpur, Chhattisgarh

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Abstract

This study presents a comprehensive analysis of community perceptions regarding the impacts of reclamation strategies for abandoned coal mines in India, with a specific focus on the Manikpur Coal Mine. Through a structured survey administered to residents in the vicinity of the mine, the research investigates the economic, socio-cultural, and environmental impacts of reclamation efforts. Utilizing Structural Equation Modeling (SEM), the study identifies key factors influencing community perceptions, including the perceived benefits of reclamation, levels of community involvement, and overall satisfaction with mining operations. The findings reveal significant relationships among these factors, such as the positive influence of reclamation availability/requirement (path coefficient = 0.633) on satisfaction and the negative impact of involvement on satisfaction (-0.805). Indirect effects highlight the interplay between constructs, with experience positively influencing involvement (0.673) and satisfaction (0.162) while negatively affecting reclamation availability/requirement (-0.194). Variations in latent variable scores for satisfaction (-1.63 to 3.031) and reclamation availability/requirement (-1.42 to 1.903) underscore the diverse respondent experiences. These insights emphasize the importance of effective community engagement and tailored reclamation strategies. Policy recommendations are provided to enhance the sustainability and effectiveness of reclamation efforts, emphasizing the need for holistic approaches that integrate economic viability, socio-cultural acceptance, and environmental sustainability. The study contributes to the field of mine reclamation by offering valuable insights into resident perceptions and practical guidelines for improving reclamation practices in mining-affected areas.

1. Introduction

Mining activities have historically played a pivotal role in economic development across various regions, particularly in resource-rich areas like Korba District in Chhattisgarh, India. This study specifically focuses on coal mining due to its significant prevalence in the region and the unique environmental and social challenges it presents compared to other minerals. The choice of coal mining as the focal point of this research is driven by its dominant role in the local economy and the acute adverse effects it imposes on both the ecological landscape and the socio-economic conditions of surrounding communities. Recent studies have highlighted that coal extraction often leads to severe land degradation, loss of biodiversity, and disruption of local livelihoods [1]. By concentrating on coal mining, this research seeks to fill a critical gap in understanding how these specific impacts manifest in communities heavily reliant on this resource. In the Korba district, where coal mining is a dominant industry, these adverse effects are particularly acute, affecting both the ecological landscape and the socio-economic conditions of the surrounding communities [2]. The necessity for effective reclamation practices following mining operations has become increasingly critical [3, 4]. Reclamation is not merely a regulatory requirement; it is essential for restoring ecosystems, improving land usability, and

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enhancing the well-being of local communities [5]. Effective reclamation can mitigate the negative consequences of mining such as soil erosion, water contamination, and habitat destruction [6]. However, the success of these reclamation efforts is heavily influenced by stakeholder perceptions and involvement [7, 8]. Stakeholders including local residents, mining companies, regulatory authorities, and environmental organizations, possess diverse interests and concerns that shape the reclamation process [9]. Engaging stakeholders early and meaningfully is crucial for understanding their needs, aspirations, and potential grievances [10]. Research indicates that proactive stakeholder engagement can lead to improved project outcomes, social acceptance, and the achievement of sustainable development goals [11]. Furthermore, effective engagement practices can help identify and prevent conflicts, foster trust, and enhance the overall reputation of mining companies [12]. In contrast, neglecting stakeholder perspectives can exacerbate tensions and lead to resistance against mining operations, ultimately jeopardizing the social license to operate [13-15].

The novelty of this research lies in its integrated approach that combines both qualitative and quantitative data to assess the current reclamation practices and stakeholder perspectives. This study builds on recent literature that emphasizes the importance of community engagement in reclamation efforts, and highlights the need for tailored strategies that consider local contexts. By investigating community perceptions alongside reclamation effectiveness, this research aims to contribute valuable insights into sustainable mining practices that prioritize ecological restoration and social equity.

This paper aims to assess the impact of mining on local communities in the Korba district by examining current reclamation practices and stakeholder views. The study seeks to provide a comprehensive understanding of how mining activities affect local livelihoods and the effectiveness of reclamation efforts by integrating the qualitative and quantitative data. The findings will contribute to the discourse on sustainable mining practices and underscore the importance of community engagement in reclamation initiatives. Ultimately, this research aims to inform policy and practice in the mining sector, promoting a more sustainable and equitable approach to resource extraction in the Korba district and beyond.

Following this introduction, the paper will delve into several critical issues and sections. The literature review will synthesize the existing research on mining impacts, focusing on environmental degradation, socio-economic challenges, and effective reclamation strategies. This section will highlight the recent studies that underscore the need for sustainable practices in mining operations. Next, the methodology section will outline the mixed-methods approach employed in this study, detailing how qualitative interviews and quantitative surveys were conducted to gather comprehensive data from various stakeholders. This section will emphasize the importance of integrating diverse perspectives to understand the complexities surrounding mining activities and their impacts. The subsequent section will present the findings, which will detail community perceptions regarding reclamation practices and their effectiveness. This analysis will reveal the key themes related to stakeholder engagement, satisfaction with reclamation efforts, and overall community well-being. Following the findings, a discussion section will contextualize these results within broader sustainability frameworks, exploring how effective stakeholder engagement can enhance reclamation outcomes and promote social acceptance of mining activities. Finally, the paper will conclude with recommendations, offering actionable insights for policy-makers and industry stakeholders aimed at improving reclamation practices and fostering equitable resource extraction methods in the Korba district and similar regions.

2. Literature Review

The literature on mining and its impacts on local communities has expanded significantly in the recent years, highlighting the complex interplay between resource extraction, environmental sustainability, and social dynamics. This section reviews key themes in the existing literature, focusing on the environmental impacts of mining, reclamation practices, and stakeholder engagement.

Recent studies have increasingly focused on refining mine reclamation criteria to enhance the effectiveness of restoration practices. This growing body of research recognizes that successful reclamation is not merely a regulatory obligation, but a vital component of sustainable mining that can significantly influence local ecosystems and communities. Hajkazemiha et al. [16] employed a Delphi-Fuzzy approach to evaluate various reclamation criteria, emphasizing the importance of stakeholder involvement in determining priorities for post-mining land use. Their findings illustrate that integrating expert opinions through fuzzy logic allows for more nuanced and adaptable reclamation strategies that are sensitive to local environmental conditions and community needs. By utilizing this approach, stakeholders can collaboratively identify the most pressing reclamation challenges, and develop tailored solutions that address both ecological restoration and socio-economic revitalization. Similarly, Alavi et al. [17] proposed a new technical and economic framework for selecting optimal plant species for open-pit mine reclamation, underscoring that appropriate vegetation choices are crucial for restoring ecological balance and promoting biodiversity in disturbed areas. Their research highlights the necessity of considering local flora and fauna when planning reclamation efforts, as well as the economic implications of selecting plant species that can thrive in post-mining environments. Collectively, these studies contribute to a growing literature advocating for innovative methodologies that enhance the sustainability of reclamation efforts, while addressing the specific challenges posed by different mining contexts. Moreover, the application of fuzzy Multi-Attribute Decision-Making (MADM) models has proven valuable in defining optimal post-mining land uses. Bangian et al. [18] demonstrated how fuzzy analytical hierarchy processing can clarify reclamation costs associated with various land use scenarios in open-pit mining. This approach allows stakeholders to make informed decisions that balance economic viability with environmental restoration by systematically evaluating multiple criteria and their interrelationships. By employing fuzzy logic, the decision-makers can account for uncertainties and complexities inherent in the reclamation process, leading to more effective outcomes. Basu and Mishra [19] further expanded this discourse by providing a comprehensive literature review on post-reclamation strategies applied to abandoned mines, emphasizing the need for adaptive management practices that consider both ecological outcomes and community perspectives [20]. Their review highlights that successful reclamation requires not only technical expertise but also an understanding of local socio-cultural dynamics and stakeholder engagement processes. Collectively, these studies underscore the critical role of integrating stakeholder engagement and advanced modeling techniques in developing effective reclamation strategies that promote sustainable mining practices. By fostering collaboration among stakeholders including local communities, regulatory bodies, and mining companies; it becomes possible to create reclamation plans that are not only environmentally sound but also socially equitable, thereby enhancing the overall sustainability of mining operations.

2.1. Environmental Impacts of Mining

Mining activities are known to have profound environmental consequences including land degradation, water pollution, and loss of biodiversity [21, 22]. The extraction of minerals, particularly coal, often leads to significant alterations in land use and ecosystem services [21]. Blondeel & Van de Graaf [1] emphasize that coal mining can result in an extensive deforestation, soil erosion, and habitat destruction, which collectively threaten local flora and fauna. Furthermore, Edrisi, Tripathi, & Abhilash [2] note that mining operations can lead to the contamination of water bodies due to the leaching of heavy metals and other pollutants, posing severe risks to both human health and aquatic ecosystems. The socio-environmental impacts of mining extend beyond immediate ecological concerns [23-25]. Local communities frequently face health risks associated with air and water pollution, leading to long-term public health challenges [5]. For instance, studies have shown that communities living near mining sites often report higher incidences of respiratory diseases and other health issues linked to dust and chemical exposure [6]. Additionally, the displacement of communities due to mining activities creates social tensions and economic instability, as families are uprooted from their ancestral lands and livelihoods [10]. This displacement often leads to a loss of cultural identity and social cohesion, further exacerbating the challenges faced by affected populations [24, 25]. Moreover, the environmental degradation resulting from mining can have cascading effects on local economies [26, 27]. Many communities in mining regions rely on agriculture and natural resources for their livelihoods [28-30]. The degradation of land and water resources can diminish agricultural productivity, leading to food insecurity and increased poverty [13, 27-29]. Therefore, understanding the environmental impacts of mining is crucial for developing effective reclamation strategies that prioritize ecological restoration and community well-being.

2.2. Reclamation Practices

Reclamation practices are essential for mitigating the adverse effects of mining and restoring ecosystems post-extraction [31]. The literature emphasizes that effective reclamation can enhance soil fertility, promote biodiversity, and improve land usability for agricultural and recreational purposes [11, 21-22]. Various reclamation techniques such as reforestation, soil amendment, and water management have been explored in different contexts [1, 2, 23-25]. For example, Edrisi, Tripathi, & Abhilash [2] provide a comprehensive review of reclamation practices in coal mining, highlighting the importance of adaptive management strategies that consider local ecological conditions and community needs. Despite the potential benefits of reclamation, challenges remain in implementing effective practices [5]. Many studies indicate that reclamation efforts are often inadequate due to insufficient funding, lack of technical expertise, and poor regulatory enforcement [12, 31-33]. In many cases, mining companies prioritize short-term economic gains over long-term environmental stewardship, resulting in poorly executed reclamation projects that fail to restore ecosystems adequately [10]. Furthermore, the success of reclamation initiatives is heavily influenced by stakeholder perceptions and participation [34]. Engaging local communities in the reclamation process can lead to more sustainable outcomes and foster a sense of ownership over restored lands [13]. Research by Favas, Martino, & Prasad [5] indicates that when local communities are involved in decision-making processes related to reclamation, the resulting projects are more likely to meet their needs and expectations.

2.3. Stakeholder Engagement

The role of stakeholder engagement in mining operations has garnered increasing attention in the literature [35]. Stakeholders including local communities, mining companies, regulatory bodies, and environmental organizations possess diverse interests and concerns that shape the mining landscape [9]. Effective stakeholder engagement is crucial for understanding these perspectives and addressing potential conflicts [31-34]. Research indicates that proactive engagement can enhance project outcomes and social acceptance of mining activities [11]. For instance, Chipangamate et al. [10] argue that meaningful stakeholder participation in decision-making processes can lead to improved trust and collaboration between mining companies and local communities. Conversely, neglecting stakeholder perspectives can result in resistance to mining operations and damage to the social license to operate [5]. The social license to operate refers to the ongoing approval and acceptance of a company's operations by local communities and other stakeholders [13]. Companies that fail to engage with stakeholders risk facing protests, legal challenges, and reputational damage, which can ultimately hinder their operations [5]. Effective stakeholder engagement strategies, therefore, are essential for fostering positive relationships and ensuring the long-term sustainability of mining projects [35-37]. Additionally, the literature highlights the importance of transparency and communication in stakeholder engagement [38]. Studies have shown that when mining companies are transparent about their operations, potential impacts, and reclamation efforts, they are more likely to gain community support [11]. This transparency can help build trust and mitigate fears among local populations, facilitating a more collaborative approach to mining and reclamation [13, 38].

In summary, the literature underscores the importance of considering environmental impacts, effective reclamation practices, and stakeholder engagement in the context of mining. This review highlights the need for a holistic approach that integrates these elements to promote sustainable mining practices, and enhance the well-being of local communities. By addressing the environmental, social, and economic dimensions of mining, stakeholders can work towards a more sustainable future that balances resource extraction with ecological and community health.

3. Methodology

This study employs a mixed-method approach to assess the impact of mining on local communities in the vicinity of the Manikpur Coal Mine in the Korba district, Chhattisgarh. The methodology consists of three main components: qualitative interviews, a mass survey, and data analysis, allowing for a comprehensive understanding of the complex dynamics between mining operations, reclamation practices, and community perspectives. Qualitative interviews were conducted with various stakeholders to gain deeper insights into their perspectives. These stakeholders included local community members, mining company representatives, regulatory bodies, and environmental organizations. Residents living in proximity to the Manikpur Coal Mine including farmers, laborers, and women's groups were interviewed to understand their experiences and concerns regarding mining activities and reclamation efforts. Interviews with officials from South Eastern Coalfields Limited, the operator of the Manikpur Coal Mine, provided insights into their reclamation practices, challenges faced, and engagement strategies with local communities. Additionally, representatives from government agencies responsible for mining regulation and environmental protection in Chhattisgarh were consulted to understand the regulatory framework and enforcement mechanisms in place. Interviews with representatives from Non-Governmental Organizations (NGOs) focused on environmental conservation in the Korba district offered perspectives on the ecological impacts of coal mining and advocacy for sustainable practices. A semi-structured interview format was employed to allow for flexibility, while ensuring that key topics were covered. Each interview lasted approximately 45 to 60 minutes, and was recorded with the participants' consent for accurate transcription and analysis. A mass survey was conducted to gather broader data on community perceptions regarding the Manikpur Coal Mine and reclamation practices. The survey was designed to capture demographic information and assess key areas including awareness of mining activities, perceptions of reclamation practices, and stakeholder engagement. Participants were asked about their knowledge of mining operations at the Manikpur Coal Mine and their perceived impacts on the environment and community, as well as their satisfaction with the restoration of land and resources. The survey also assessed the level of community involvement in decision-making processes related to mining and reclamation at the Manikpur Coal Mine. A sample of 459 residents in the vicinity of the Manikpur Coal Mine was selected using stratified random sampling to ensure representation across different demographics, including age, gender, and occupation. This sample size exceeds the required sample size of 384 based on the population size, as well as the sample size of 430 recommended by the Structural Equation Modeling (SEM) rule. Data collection was conducted through both online and paper-based surveys to accommodate varying levels of access to technology. The survey was designed using a Likert scale to quantify responses and facilitate statistical analysis. Qualitative data from interviews were analyzed using thematic analysis, which involved coding the transcripts to identify recurring themes and patterns related to stakeholder perspectives on mining and reclamation at the Manikpur Coal Mine. This approach allowed for the identification of key issues, concerns, and suggestions for improvement. Quantitative survey data were analyzed using statistical software (e.g. SPSS or R) to perform descriptive statistics and inferential analyses including calculating frequencies, percentages, and correlations to identify trends and relationships between variables. Ethical considerations were paramount throughout the research process. Informed consent was obtained from all participants prior to interviews and surveys, ensuring that they were aware of the study's purpose and their right to withdraw at any time. Confidentiality was maintained by anonymizing participant data and securely storing all records. This methodology provides a comprehensive framework for assessing the impact of the Manikpur Coal Mine on local communities in the Korba district. By integrating qualitative and quantitative approaches, the study aims to capture a holistic view of stakeholder perspectives and the effectiveness of reclamation practices at the Manikpur Coal Mine, ultimately contributing to the discourse on sustainable mining and community engagement in the context of coal mining operations in Chhattisgarh.

In evaluating sustainable mining practices, several key criteria were considered including impact, involvement, experience, availability/requirement, satisfaction level, and expected outcome. These criteria were selected based on their relevance to understanding the multifaceted nature of mining's effects on local communities. The assumption underlying this framework is that each criterion contributes uniquely to assessing sustainability in mining operations. For instance, impact assesses the environmental and social consequences of mining activities; involvement reflects the degree of community engagement in reclamation processes; and satisfaction level gauges community contentment with reclamation outcomes. The experience criterion encompasses historical interactions between communities and mining operations, while availability/requirement evaluates the resources necessary for effective reclamation. Lastly, expected outcome projects the anticipated benefits of reclamation efforts on community well-being. By incorporating these diverse criteria, the study aims to provide a comprehensive evaluation of sustainable mining practices that align with community needs and environmental stewardship.

4. Case Studied Area: Manikpur, Korba

Manikpur village is situated in the Pali tehsil of the Korba district in Chhattisgarh, India (refer to Figure 1). It is located 45 km from the district headquarters in Korba, and 20 miles from the sub-district headquarters in Pali. Manikpur village is also a gramme panchayat, according to 2009 statistics. The village has a total geographic area of 443.09 hectares [39, 40]. As per the 2011 Census, there are 830 people living in Manikpur, with 421 men and 409 women. The literacy rate in Manikpur Village is 62.53%, with 73.63% of men and 51.10% of women being literate. The village has approximately 195 households [39-42]. The closest town to Manikpur for significant economic activity is Pali, which is around 20 kilometres distant. Sixty-four percent of the people living in Manikpur village were working, with 31.07% engaged in marginal activity and 68.93% identifying their work as main work (employment or earning more than six months). The workforce includes 205 agricultural labourers and 216 cultivators (owners or co-owners). Since the population size in Manikpur is relatively small, but the Manikpur mines influence a total of 9 settlements around it, all these settlements have been taken into account for the survey sampling. The total population of these settlements is 198746, as per the 2011 Census data. Manikpur is well-connected to nearby transport services, with public and private bus services available within the village. The nearest railway station is located within a 10+ km distance.

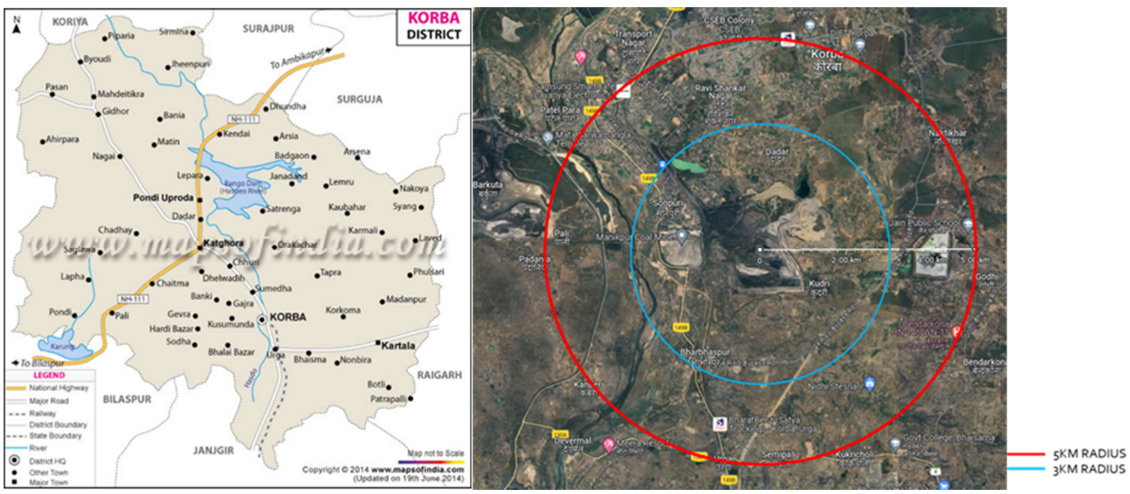

Figure 1. Manikpur mine location and survey area maps-Korba district (Source: Author's extraction).

4.1. Manikpur Mine Background

The Manikpur coal mine is an opencast mine located in Tehsil Korba, district Korba, State Chhattisgarh, India [39-43]. It is operated by South Eastern Coalfields Limited, a subsidiary of Coal India, and has a production capacity of up to 5.25 million tonnes per annum. The mine started operations in 1966, and was initially planned with the assistance of Soviet consultants for a rated output of 1.0 MTPA [42]. However, in its early years, the mine encountered challenges when an underground water source was discovered after 24 years of excavation, leading to significant water inflow that could not be drained out even with the aid of motor pumps. There are plans to develop the Manikpur Pokhri coal mine, which is part of the Manikpur mine complex, into an eco-tourism spot in Korba district [40-42]. South Eastern Coalfields Limited (SECL), in collaboration with the Municipal Corporation Korba, will invest more than Rs 11 crores in the development of Manikpur Pokhri into an eco-tourism destination [43].

4.2. Manikpur Analysis

The analysis of the Manikpur survey focuses on several key aspects: survey specifics, criteria for assessment, reliability assessment, chi-squared analysis, ANOVA, correlation, and covariance analysis. Each of these components contributes to a comprehensive understanding of community perceptions regarding the Manikpur Coal Mine and its reclamation practices.

4.2.1. Survey Specifics

The survey was meticulously designed to gather insights into the community's perceptions regarding the Manikpur Coal Mine and its reclamation practices. It included a diverse range of criteria categorized into six main themes: Impact, involvement, experience, availabi lity/requirement, satisfaction level, and expected outcome. Table 1 illustrates the specific criteria assessed in the survey.

The responses to these criteria were measured using a Likert scale ranging from 1 to 5, where 1 indicates "strongly disagree" and 5 indicates "strongly agree." This scale allowed participants to express varying degrees of agreement or disagreement with each statement, providing a nuanced view of community sentiments. The average scores for each criterion were calculated to determine the overall sentiment of the community toward the mining operations and reclamation efforts.

Table 1. Specific criteria assessed in the survey (Source: Authors).

IMPACT	INVOLVEMENT	EXPERIENCE	AVAILABILITY / REQUIREMENT
A31: Impact of mine closure over residents' lives A32: Impact of mine reclamation over economic output A33: Impact of mine reclamation over health A40: Impact of mine reclamation over neighbourhood	A4: Level of involvement in reclaimed mine activities A7: Influence of reclamation over economic generation A29: Inducing of non-mining activities upon reclamation A41: Involvement between environment and reclamation strategy formulation	A1: Dependence between mine surroundings and non-mine-related activities A2: Satisfaction of experience with residence near mines A3: Influence of reclamation on daily lives of residents	A35: Influence of reclamation on living experiences of residents A39: Requirement levels of reclamation A42: Requirement level of economic activity provision for reclaimed sites
SATISFACTION LEVEL			**EXPECTED OUTCOME**
A5: Support of residents for mine closure A6: Connection of resident participation to mine activities A8: Satisfaction with reclamation over economic generation A9: Influence of mine development on resident satisfaction A10: Dependence between reclamation strategies and mine type A11: Reuse sufficiency A12: Reuse requirement of closed mines A13: Influence of environment surroundings over reclamation A14: Influence of temperature over reclamation A15: Influence of climate over reclamation A16: Influence of water quality over reclamation A17: Influence of water availability over reclamation A18: Influence of air quality over reclamation A19: Influence of soil quality over reclamation A20: Influence of land fertility over reclamation A21: Influence of land availability over reclamation A22: Influence of rainfall quantity over reclamation A23: Influence of rainfall quality over reclamation A24: Influence of agricultural yield over reclamation A25: Influence of agricultural quality over reclamation A26: Influence of socio-economic change over reclamation A30: Influence of expenditure dependence over mining activities A34: Impact of mine reclamation over facility availability in residing areas A36:Impact of mine reclamation over livelihood availability in residing areas A37: Impact of mine reclamation over livelihood sustainability in residing areas A38: Dependence between reclamation benefits and residing population			A27: Inducing of improvement upon reclamation A28: Inducing of stakeholder involvement upon reclamation A43: Use levels of reclaimed sites

4.2.2. Criteria for Assessment

The criteria for assessment were carefully selected to encompass a broad range of factors influencing community perceptions regarding the Manikpur Coal Mine and its reclamation practices. Each criterion was designed to capture specific aspects of the mining experience and its aftermath, ensuring a comprehensive evaluation of stakeholder perspectives.

1. **Impact:** This theme examines how mining activities and subsequent reclamation efforts affect various dimensions of residents' lives, including their health, economic stability, and overall quality of life. The criteria under this theme aim to quantify the perceived changes resulting from mine operations and the effectiveness of reclamation strategies.
2. **Involvement:** This theme focuses on the community's engagement in reclamation

activities and the perceived influence of these activities on local economic development. It assesses the extent to which residents feel involved in decisions related to reclamation and whether they believe these efforts foster non-mining economic opportunities.

3. **Experience:** This theme captures the lived experiences of residents living near the mine, including their satisfaction with their proximity to mining operations and the perceived influence of reclamation on their daily lives. It aims to understand how mining and reclamation have shaped residents' experiences and interactions with their environment.
4. **Availability/requirement:** This theme evaluates the community's perceptions regarding the need for reclamation and the availability of economic opportunities in reclaimed areas. It assesses whether residents feel that reclamation efforts adequately address their economic needs and provide sufficient resources for sustainable living.
5. **Satisfaction level:** This theme measures residents' overall satisfaction with mining operations and reclamation efforts. It explores how these factors influence their support for mine closure and their participation in related activities, providing insights into community sentiment regarding the mining sector.
6. **Expected outcome:** This theme investigates the anticipated benefits of reclamation efforts including environmental improvements and economic opportunities. It examines how various environmental factors such as soil quality and water availability, influence residents' expectations, and perceptions of reclamation success.

The survey aimed to provide a holistic view of community perceptions, allowing for a nuanced analysis of the various factors that contribute to residents' experiences and expectations regarding the Manikpur Coal Mine by categorizing the criteria in this manner.

4.2.3. Reliability (Cronbach's Alpha)

To ensure the reliability of the survey instrument, Cronbach's alpha coefficient was employed as a statistical measure of internal consistency. This coefficient assesses how well the items within the survey correlate with each other, indicating the degree to which they measure the same underlying construct [44]. Cronbach's alpha values range from 0 to 1, with higher values indicating greater internal consistency. Typically, a Cronbach's alpha above 0.6 is considered acceptable for research purposes, while values above 0.7 are preferred as they suggest a higher level of reliability [45]. In this study, the survey yielded a Cronbach's alpha coefficient of 0.644, which is considered acceptable for assessing internal consistency (refer to Figure 2). This result indicates a moderate level of reliability, suggesting that the items in the survey scale are reasonably consistent in measuring the same underlying construct. The reliability of the survey instrument is crucial, as it enhances the validity of the findings and supports the overall conclusions drawn from the analysis.

Case Processing Summary

		N	%
Cases	Valid	459	100.0
	Excluded[a]	0	.0
	Total	459	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.644	43

Figure 2. Cronbach Alpha of Manikpur Survey (Source: Authors).

4.2.4. Chi-Square analysis

To further analyze the survey data, a chi-squared test was employed. The chi-squared test is a statistical hypothesis test used in the analysis of contingency tables, particularly when sample sizes are large [46, 47]. This test examines whether two categorical variables are independent in influencing the test statistic. By applying the chi-squared test (Refer to Figure 3), the study aimed to identify any significant relationships between demographic factors and community perceptions regarding the Manikpur Coal Mine and its reclamation practices. This analysis provides additional insights into how different segments of the community perceive the impacts of mining and reclamation efforts, allowing for a more comprehensive understanding of stakeholder perspectives.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
Chi-Square	52.326[a]	59.939[a]	45.432[a]	39.333[a]	1.154E2[a]	70.697[a]	1.198E2[a]	32.212[a]	64.750[a]	44.788[a]	1.057E2[a]	95.356[a]
df	4	4	4	4	4	4	4	4	4	4	4	4
Asymp. Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 52.8.

b. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 44.0.

A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35
1.610E2[a]	1.328E2[a]	1.359E2[a]	1.133E2[a]	55.242[a]	51.417[a]	28.765[a]	90.583[a]	59.788[a]	1.100E2[b]	75.811[a]	94.598[a]	1.026E2[b]
4	4	4	4	4	4	4	4	4	5	4	4	5
.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

A13	A14	A15	A16	A17	A18	A19	A20	A21	A22
1.296E2[a]	56.644[a]	82.212[a]	70.356[a]	45.583[a]	1.407E2[a]	81.076[a]	51.265[a]	1.047E2[a]	1.378E2[a]
4	4	4	4	4	4	4	4	4	4
.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

A36	A37	A38	A39	A40	A41	A42	A43
61.871[a]	54.220[a]	38.614[a]	70.659[a]	55.508[a]	1.361E2[b]	44.939[a]	59.068[a]
4	4	4	4	4	5	4	4
.000	.000	.000	.000	.000	.000	.000	.000

Figure 3. Chi-Square of Manikpur Survey (Source: Authors).

4.2.5. ANOVA analysis

ANOVA, or Analysis of Variance, is a statistical method used to determine whether there are significant differences between the means of three or more independent groups [48]. ANOVA helps researchers understand if the observed differences in sample means are due to actual differences in the populations or merely due to random chance by analyzing the variance within and between these groups [49, 50]. In the context of the Manikpur survey, a single-factor ANOVA was employed to analyze the perceptions of various community segments regarding mining operations and reclamation practices (Refer to Table 2). This approach allows for a comprehensive comparison of the means across different groups, facilitating the identification of any significant differences in perceptions. The study aims to uncover insights that can inform tailored strategies to address the unique concerns and perspectives of each community group, ensuring that their specific needs are recognized and considered in future planning and decision-making processes by using ANOVA.

4.2.6. Correlation analysis

Correlation analysis is a statistical method used to evaluate the strength and direction of the relationship between two or more variables [51]. It helps in understanding how closely related different factors are, and can indicate whether changes in one variable might correspond with changes in another. This analysis is particularly useful in social sciences, where understanding relationships between community perceptions and various influencing factors is essential [52]. A correlation analysis was conducted for the 459 participant responses to understand the level of relationship between each criterion assessed in the survey. This analysis helps to identify how closely related the various factors are in influencing community perceptions regarding the Manikpur Coal Mine and its reclamation efforts. The correlation analysis results for the Manikpur survey participants are shown in Table 3. Understanding these relationships is essential for identifying key drivers of community sentiment and for informing future reclamation strategies.

4.2.7. Covariance analysis

In addition to correlation, a covariance analysis was performed to understand the direction of the relationship between each criterion [53]. The covariance analysis results for the Manikpur survey participants are presented in Table 4. This analysis provides insights into how changes in one variable may affect another, further enriching the understanding of stakeholder perspectives on mining and reclamation practices. By examining covariance, the study can identify potential areas for intervention and improvement in reclamation strategies.

Table 2. ANOVA Analysis of Manikpur's survey on selected 43 criteria (Source: Authors).

Groups	Count	Sum	Average	Variance
A1	459	917	3.486692	1.388181
A2	459	921	3.501901	1.541027
A3	459	897	3.410646	1.723856
A4	459	916	3.48289	1.494935
A5	459	930	3.536122	1.00537
A6	459	898	3.414449	1.174905
A7	459	845	3.212928	1.931588
A8	459	849	3.228137	1.466839
A9	459	891	3.387833	1.200157
A10	459	873	3.319392	1.347981
A11	459	909	3.456274	1.073462
A12	459	926	3.520913	1.059675
A13	459	910	3.460076	0.898209
A14	459	885	3.365019	1.309001
A15	459	891	3.387833	1.20779
A16	459	916	3.48289	1.204859
A17	459	902	3.429658	1.368125
A18	459	931	3.539924	0.913476
A19	459	897	3.410646	1.082634
A20	459	871	3.311787	1.322265
A21	459	917	3.486692	1.136273
A22	459	919	3.494297	0.915044
A23	459	907	3.448669	0.820828
A24	459	921	3.501901	0.899806
A25	459	932	3.543726	0.867356
A26	459	936	3.558935	1.010826
A27	459	920	3.498099	1.403622
A28	459	922	3.505703	1.426494
A29	459	850	3.231939	1.675007
A30	459	911	3.463878	1.081706
A31	459	938	3.56654	1.452617
A32	459	836	3.178707	1.689316
A33	459	871	3.311787	1.238296
A34	459	948	3.604563	1.041506
A35	459	882	3.353612	1.488985
A36	459	882	3.353612	1.214176
A37	459	910	3.460076	1.363858
A38	459	882	3.353612	1.519519
A39	459	927	3.524715	1.135837
A40	459	902	3.429658	1.513163
A41	459	839	3.190114	1.528604
A42	459	877	3.334601	1.406699
A43	459	891	3.387833	1.299393

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	126.8229	42	3.019592	2.367519	1.59E-06	1.385019
Within Groups	14368.94	11266	1.275425			
Total	14495.76	11308				

Table 3. Correlation Analysis of Manikpur's survey on selected 43 criteria (Source: Authors).

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A11	A11	A12	A13	A14	A15	A16
A1	1	-0.05022	0.097304	0.244258	0.114295	-0.10176	0.00873	0.012835	0.125252	-0.00525	0.048767	-0.09969	-0.03039	0.051752	0.024635	-0.0201
A2		1	0.168126	0.357734	0.399345	0.233429	0.216566	-0.00029	0.024715	0.253805	0.023064	0.057465	0.159841	-0.01393	-0.00334	-0.08331
A3			1	0.132783	0.029279	0.389522	0.209174	0.101678	0.103792	-0.08136	0.305052	0.061397	-0.08493	0.024336	-0.00234	-0.07191
A4				1	-0.02207	0.06729	0.213286	-0.02828	0.02492	0.111413	0.096575	0.202705	-0.07388	-0.14286	-0.14275	-0.11753
A5					1	0.135426	-0.06854	0.008903	-0.07882	0.104804	-0.218	0.009434	0.225443	-0.00821	0.021875	-0.03498
A6						1	0.123617	0.22135	0.076262	0.012697	0.116458	-0.03345	-0.03771	0.336125	0.066408	0.094202
A7							1	0.077604	0.286482	0.135096	0.123118	0.159612	0.006478	0.303784	0.293072	0.054938
A8								1	0.13155	0.08913	0.150939	0.149229	0.117697	0.173804	0.177014	0.330246
A9									1	0.151307	0.31764	0.290616	0.092169	0.075423	0.090163	0.246766
A10										1	0.090978	0.115744	0.285661	0.230839	0.073054	0.046234
A11											1	0.155637	0.003074	0.077913	0.031711	0.03374
A12												1	0.105511	-0.00327	-0.01057	0.060275
A13													1	0.277489	0.044239	0.218561
A14														1	0.060006	0.421364
A15															1	0.128917
A16																1
A17																
A18																
A19																
A20																
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	A17	A18	A19	A21	A21	A2	A23	A24	A25	A26	A27	A2W8	A29	A31	A31	A32
A43																
A42																
A41																
A40																
A39																
A38																
A37																
A36																
A35																
A34																
A33																
A32																1
A31															1	0.354202
A30														1	-0.03994	0.093734
A29													1	-0.0292	0.277578	0.075101
A28												1	0.316433	0.016298	0.139601	0.219396
A27											1	0.015518	0.247967	-0.03955	0.421754	0.222062
A26										1	-0.01032	0.002103	-0.10294	0.086909	-0.06388	0.107282
A25									1	0.17965	-0.18067	-0.00451	-0.13353	0.022324	0.071356	0.130682
A24								1	-0.04222	-0.01513	0.045003	0.078318	0.007412	0.091953	0.044124	0.134389
A23							1	0.158886	0.003801	-0.01657	0.082583	0.12108	0.102963	-0.04349	0.028482	-0.0327
A22						1	0.113065	0.015786	0.052764	-0.06612	-0.06989	0.054316	0.03961	-0.05871	-0.04188	-0.03448
A21					1	0.152458	0.199861	0.172718	-0.00998	0.008748	0.097448	0.099741	0.222192	-0.0013	0.078677	0.01963
A20				1	0.031423	0.046732	-0.02122	0.160416	0.008605	0.069882	0.008842	-0.10413	-0.0257	0.111579	-0.09214	0.031529
A19			1	0.170116	0.238951	-0.03215	0.010299	0.084282	-0.05799	0.002317	-0.10773	0.041106	-0.01715	0.05961	-0.2471	-0.17301
A18		1	0.110106	-0.08083	0.003333	0.015905	0.19081	0.040963	0.029119	-0.06502	0.011022	0.204596	0.20385	0.042733	-0.0048	-0.12713
A17	1	0.116043	-0.05771	0.00218	0.073481	0.201757	0.004684	0.031941	0.149117	0.012464	0.037775	-0.00586	-0.0333	-0.11426	0.081172	0.007045
A16	0.289652	0.012478	0.03291	-0.05019	0.013668	-0.05371	-0.14577	0.030273	0.145413	0.041555	-0.04185	-0.15496	-0.09257	-0.0532	0.040533	-0.05804
A15	0.202425	0.155988	0.040434	-0.00846	0.069584	-0.03419	0.081404	0.006613	0.031846	-0.05185	-0.0522	-0.03077	-0.02592	0.06907	-0.08295	-0.11284
A14	0.247428	0.025017	0.040327	0.151058	-0.05859	-0.01902	-0.09232	0.059145	0.088843	0.034317	0.099067	-0.06577	-0.08059	-0.02737	0.059821	-0.02607
A13	0.223839	0.16294	-0.01815	0.179575	0.034419	0.131312	0.012051	-0.10499	0.16955	-0.02256	-0.11649	0.080285	0.040251	-0.03148	-0.10877	-0.12277
A12	0.000434	0.194088	0.116673	-0.0023	-0.00583	-0.02604	-0.08786	-0.01079	-0.15722	-0.03162	0.00551	0.00844	-0.03374	-0.06257	0.028869	-0.12404
A11	0.054931	0.108729	-0.01514	0.069153	-0.0636	-0.1129	-0.00342	-0.05526	-0.06822	0.069353	0.044241	-0.1039	-0.06214	0.011811	0.100912	-0.01543
A10	0.322959	0.108851	0.036352	0.073788	-0.04898	-0.04647	0.070073	-0.01788	0.047043	0.072097	-0.01621	0.163829	-0.02155	0.031717	0.050217	-0.09867
A9	0.11073	-0.01849	-0.05989	-0.03879	-0.00537	-0.04523	0.020134	-0.0154	0.050652	0.058871	0.056444	-0.03087	-0.09599	0.049191	0.038195	0.063722
A8	0.108366	-0.01779	-0.00496	0.074799	-0.00947	0.007716	-0.11103	0.059422	0.031728	0.035934	0.170544	-0.12228	-0.13859	-0.05403	0.172594	-0.0066
A7	0.023336	0.07403	-0.04222	0.068161	0.009649	-0.09669	0.096618	-0.02057	-0.19005	-0.00902	0.215822	0.132628	0.252535	0.089837	0.178354	0.048581
A6	-0.11992	-0.0363	-0.06687	0.208278	-0.06953	-0.20201	0.008143	0.079042	-0.02747	0.059806	0.088295	-0.01805	0.015559	0.042108	0.035781	0.112489
A5	0.050177	0.091089	-0.01793	0.029919	0.058481	-0.0744	0.08713	-0.03519	0.070852	0.087801	0.002468	0.04365	0.01852	-0.02711	-0.01542	0.081426
A4	-0.19901	-0.06392	-0.12346	0.115113	-0.22201	-0.19507	0.013848	0.092996	-0.08062	0.133558	-0.01386	0.119643	0.124324	-0.00274	0.137402	0.10881
A3	-0.07556	0.01426	-0.03171	0.064028	-0.03971	-0.04675	0.033831	-0.06499	-0.01162	0.036533	0.287588	-0.04774	0.190812	0.055625	0.214216	0.012748
A2	-0.16223	-0.03625	-0.05675	0.117232	-0.11031	-0.23543	-0.01773	-0.17908	-0.08508	0.098534	-0.04347	0.147371	0.055553	0.07322	0.082186	0.083767
A1	0.155107	-0.16646	-0.07025	0.076321	0.08723	0.168412	-0.00511	0.02649	0.067491	-0.10486	0.153788	-0.13488	-0.04427	0.011286	0.12225	0.137396

	A33	A34	A35	A36	A37	A38	A39	A41	A41	A42	A43
A43											1
A42										1	0.236776
A41									1	0.32606	0.120808
A40								1	0.390289	0.322278	0.204625
A39							1	-0.02123	-0.0731	-0.00355	-0.10531
A38						1	-0.04299	0.229163	0.108488	0.023188	0.024261
A37					1	0.331979	-0.0015	0.217894	0.259045	0.067548	0.109157
A36				1	0.056986	0.04528	0.042907	0.076147	0.059729	0.046384	0.142611
A35			1	0.227416	0.030032	0.091638	0.129728	0.170473	0.031167	0.131552	0.137012
A34		1	0.229183	0.162156	0.037942	0.123713	-0.0366	0.169301	-0.07934	-0.00379	0.060155
A33	1	-0.16997	0.118067	0.024914	-0.00507	-0.06677	0.115774	0.02166	0.026107	-0.01283	0.039711
A32	0.293837	0.013195	0.174188	0.150255	0.021063	0.148606	0.080839	0.001924	-0.02122	-0.03646	0.105035
A31	0.328819	0.009061	0.262929	0.058375	0.012063	0.08301	-0.13723	-4.9E-05	0.063197	-0.00495	0.083936
A30	-0.06278	0.22742	-0.02448	0.20935	0.024733	0.106756	0.006834	0.028586	0.144867	0.06553	0.069811
A29	0.151011	-0.01988	0.187134	-0.05773	-0.02542	-0.00854	0.088528	0.006691	0.115456	0.105899	0.039692
A28	0.280092	-0.00441	0.164911	-0.00299	0.037789	0.095842	0.309485	0.085355	0.136254	0.017509	0.020797
A27	0.177052	0.046727	0.189237	-0.00679	0.046152	0.108922	-0.15942	-0.00337	0.057573	-0.08918	0.037289
A26	0.116563	0.167876	-0.07772	0.179218	-0.00205	0.055493	-0.02897	0.064316	-0.11652	-0.0006	-0.0067
A25	0.075184	0.082514	0.048476	-0.06533	-0.03085	0.018064	-0.11934	-0.07477	-0.10338	-0.13424	0.016322
A24	-0.03672	-0.05442	0.043933	-0.14123	0.12841	-0.08055	-0.05007	-0.10701	0.028981	-0.00735	-0.06422
A23	0.053793	-0.06332	-0.03358	0.020163	0.103571	0.055617	0.063577	-0.04692	0.036005	-0.11893	-0.12848
A22	0.001677	0.118883	-0.05549	-0.018	0.072398	0.006572	-0.13183	0.182113	0.068692	0.132891	0.019538
A21	-0.10911	0.019704	-0.07706	-0.14383	-0.07325	-0.03271	0.019609	0.043673	0.071433	0.045801	-0.04285
A20	-0.10311	0.121725	-0.03535	-0.00903	0.014989	-0.07269	0.049748	0.039849	-0.07944	-0.0404	0.015135
A19	-0.18682	-0.01902	-0.22303	-0.08719	-0.01787	-0.06901	0.121606	-0.01015	0.063694	0.055248	-0.21202
A18	-0.06558	0.098422	0.005849	-0.06963	0.077518	0.073822	0.035562	-0.07795	0.113062	0.163257	-0.08083
A17	-0.03	0.104507	0.077663	0.080081	-0.07541	0.031877	-0.11725	-0.00942	-0.11476	-0.00223	0.169396
A16	-0.15185	0.07571	0.025907	0.085491	-0.10549	-0.11258	-0.20111	-0.13446	0.013656	-0.00731	0.148694
A15	-0.22721	0.161083	0.076651	0.053365	0.026979	0.135043	0.014596	0.025904	0.018563	-0.01795	-0.0017
A14	-0.06875	0.153513	0.05209	0.072822	-0.09189	-0.11623	-0.09194	-0.04677	-0.03036	-0.06504	0.204181
A13	-0.04244	0.184871	0.007304	0.019052	-0.0299	0.017031	0.009483	0.055694	-1.2E-05	0.1104	0.035585
A12	-0.0357	0.022434	0.013841	0.136464	0.171347	0.067843	0.028229	0.123994	0.353736	0.091158	-0.0167
A11	-0.10069	0.034121	0.059071	-0.01817	-0.03536	0.121233	0.065793	0.046242	0.003535	0.039906	0.043499
A10	0.026026	0.013583	0.049293	0.105305	-0.1116	-0.03121	0.228026	-0.14456	-0.06107	-0.14997	-0.16028
A9	-0.07139	0.038695	0.025501	0.126257	-0.0147	0.186346	0.05714	-0.05332	-0.00674	-0.04738	-0.12091
A8	-0.05581	0.079442	0.045928	0.01368	0.208852	0.025011	-0.10197	0.005689	0.139155	-0.0374	0.043488
A7	0.053159	0.073045	0.218752	0.189908	-0.02531	0.091783	0.189695	0.149444	0.089635	0.005238	-0.01378
A6	0.03802	0.059011	0.116745	-0.02411	-0.00045	-0.03869	0.045615	-0.07967	-0.07326	-0.0964	0.060936
A5	0.154065	0.096071	0.025395	0.076487	0.094947	0.018963	-0.0178	0.131264	0.120672	0.118177	0.101235
A4	0.155421	-0.12474	-0.00488	0.071084	-0.03857	-0.12386	0.150441	-0.0192	0.047608	0.135563	0.029426
A3	0.045265	0.167228	0.190134	-0.07437	0.072964	0.079733	-0.1573	0.15502	0.118663	0.043783	0.125252
A2	0.010621	0.072902	0.018452	0.087401	-0.01245	-0.00169	0.14349	0.130686	-0.03754	-0.00303	-0.03019
A1	-0.01138	0.119404	-0.05379	-0.02429	-0.11897	-0.04537	-0.04609	-0.00789	-0.08996	0.120646	0.228366

Table 4. Covariance Analysis of Manikpur's survey on selected 43 criteria (Source: Authors).

	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
A1	1.382903																																										
A2	-0.07317	1.535167																																									
A3	0.149952	0.272984	1.717301																																								
A4	0.350533	0.540907	0.212349	1.489251																																							
A5	0.134511	0.495178	0.038399	-0.02695	1.001547																																						
A6	-0.12947	0.3129	0.552242	0.08884	0.146626	1.170438																																					
A7	0.01424	0.372219	0.380243	0.361058	-0.09514	0.185517	1.924244																																				
A8	0.018245	-0.00043	0.161069	-0.04172	0.010771	0.289479	0.130131	1.461262																																			
A9	0.161055	0.033483	0.148723	0.033252	-0.08625	0.090214	0.43453	0.173878	1.195593																																		
A11	-0.00716	0.364412	-0.12355	0.157556	0.121543	0.015918	0.217164	0.124854	0.191719	1.342856																																	
A11	0.059304	0.029551	0.413393	0.121875	-0.22561	0.13029	0.176611	0.188683	0.359164	0.109023	1.069381																																
A12	-0.12044	0.073154	0.082667	0.25416	0.009701	-0.03718	0.227486	0.185343	0.32649	0.137807	0.165363	1.055646																															
A13	-0.0338	0.187338	-0.10528	-0.08528	0.213419	-0.03859	0.008501	0.134583	0.095332	0.313132	0.003007	0.102546	0.894794																														
A14	0.069496	-0.01971	0.036418	-0.19908	-0.00938	0.415258	0.481213	0.23992	0.094175	0.305469	0.092007	-0.00383	0.299744	1.304023																													
A15	0.031777	-0.00454	-0.00337	-0.19108	0.024014	0.078807	0.445937	0.234715	0.108141	0.09286	0.03597	-0.01191	0.045902	0.075164	1.203198																												
A16	-0.02589	-0.11309	-0.10324	-0.15714	-0.03836	0.111654	0.083491	0.437364	0.295609	0.058697	0.038225	0.067848	0.226503	0.527158	0.154925	1.200278																											

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A																1.682893
A															1.447093	0.552748
A														1.077593	-0.04988	0.126227
A													1.668638	-0.03915	0.431335	0.125851
A												1.42107	0.48727	0.020168	0.200191	0.339285
A											1.398285	0.021874	0.378768	-0.04855	0.599936	0.340644
A										1.006983	-0.01225	0.002516	-0.13344	0.090532	-0.07712	0.139658
A									0.864058	0.167575	-0.19859	-0.005	-0.16033	0.021541	0.07979	0.157585
A								0.896384	-0.03716	-0.01437	0.050384	0.088392	0.009065	0.090373	0.050254	0.165059
A							0.817707	0.136029	0.003195	-0.01504	0.088305	0.130521	0.120271	-0.04083	0.030982	-0.03836
A						0.911564	0.097616	0.014269	0.046827	-0.06335	-0.07891	0.06182	0.048851	-0.05819	-0.0481	-0.04271
A					1.131952	0.154867	0.192283	0.17398	-0.00987	0.009339	0.122598	0.126502	0.305368	-0.00143	0.100695	0.027093
A				1.317237	0.03837	0.051208	-0.02202	0.174312	0.00918	0.080484	0.012	-0.14246	-0.0381	0.132935	-0.12721	0.046943
A			1.078518	0.202764	0.26402	-0.03188	0.009672	0.082869	-0.05598	0.002414	-0.1323	0.05089	-0.023	0.064263	-0.30869	-0.23308
A		0.910003	0.109081	-0.08849	0.003383	0.014486	0.164597	0.036996	0.025821	-0.06224	0.012433	0.232662	0.251196	0.042317	-0.00551	-0.15732
A	1.362923	0.129234	-0.06997	0.00292	0.091269	0.224884	0.004944	0.035305	0.161821	0.014602	0.052148	-0.00815	-0.05022	-0.13847	0.113996	0.01067
A	0.370469	0.013041	0.037445	-0.06311	0.015932	-0.05618	-0.14441	0.031401	0.148087	0.045685	-0.05422	-0.20237	-0.13101	-0.0605	0.05342	-0.08249
A	0.25922	0.163223	0.046061	-0.01066	0.081207	-0.03581	0.080744	0.006867	0.032471	-0.05708	-0.0677	-0.04023	-0.03672	0.078648	-0.10946	-0.16056
A	0.329859	0.027252	0.047825	0.197979	-0.07119	-0.02073	-0.09533	0.063945	0.094305	0.039324	0.133774	-0.08953	-0.11888	-0.03244	0.082176	-0.03862
A	0.247192	0.147031	-0.01783	0.194957	0.03464	0.118594	0.010308	-0.09403	0.149084	-0.02141	-0.1303	0.090532	0.049184	-0.03091	-0.12377	-0.15066
A	0.00052	0.19023	0.124492	-0.00272	-0.00638	-0.02555	-0.08163	-0.0105	-0.15015	-0.0326	0.006694	0.010337	-0.04477	-0.06674	0.035681	-0.16533
A	0.066316	0.107259	-0.01626	0.082074	-0.06997	-0.11147	-0.0032	-0.0541	-0.06558	0.071969	0.054099	-0.12808	-0.08301	0.012679	0.125533	-0.0207
A	0.436915	0.120328	0.043748	0.098136	-0.06039	-0.05141	0.073429	-0.01962	0.050673	0.083838	-0.02221	0.226315	-0.03225	0.038153	0.070002	-0.14833
A	0.141349	-0.01929	-0.06801	-0.04868	-0.00625	-0.04722	0.019908	-0.01595	0.051483	0.064595	0.072981	-0.04023	-0.13558	0.055834	0.050239	0.090387
A	0.15293	-0.02051	-0.00623	0.103775	-0.01217	0.008906	-0.12137	0.068007	0.035652	0.043589	0.24378	-0.17621	-0.21641	-0.0678	0.250979	-0.01035
A	0.037791	0.097963	-0.06082	0.108517	0.01424	-0.12806	0.121196	-0.02702	-0.24505	-0.01255	0.354017	0.219318	0.452515	0.129364	0.297619	0.087424
A	-0.15146	-0.03746	-0.07513	0.258613	-0.08004	-0.20866	0.007966	0.080961	-0.02763	0.064928	0.112955	-0.02328	0.021744	0.04729	0.046567	0.157874
A	0.058625	0.086961	-0.01864	0.034365	0.062268	-0.07109	0.07885	-0.03334	0.065911	0.088175	0.00292	0.052075	0.023941	-0.02816	-0.01856	0.105712
A	-0.28352	-0.07441	-0.15647	0.161228	-0.28825	-0.22728	0.015281	0.107447	-0.09146	0.163556	-0.01999	0.174052	0.195984	-0.00347	0.201709	0.172259
A	-0.1156	0.017826	-0.04316	0.0963	-0.05537	-0.05849	0.04009	-0.08063	-0.01415	0.048042	0.445648	-0.07459	0.323006	0.07567	0.337695	0.021672
A	-0.23466	-0.04285	-0.07302	0.166708	-0.14541	-0.27851	-0.01986	-0.21008	-0.09799	0.122512	-0.06368	0.21767	0.088913	0.094175	0.122497	0.134641
A	0.212942	-0.18673	-0.08579	0.103009	0.109138	0.189088	-0.00544	0.029493	0.073776	-0.12374	0.213853	-0.18909	-0.06726	0.013778	0.172939	0.209603
	A17	A18	A19	A21	A21	A2	A23	A24	A25	A26	A27	A2W8	A29	A31	A31	A32

	A33	A34	A35	A36	A37	A38	A39	A41	A41	A42	A43
A	-0.01486	0.143027	-0.07704	-0.03142	-0.16308	-0.06564	-0.05766	-0.01139	-0.13055	0.167951	0.305541
A	0.014616	0.092007	0.027845	0.1191	-0.01798	-0.00257	0.189117	0.198803	-0.0574	-0.00444	-0.04256
A	0.065882	0.223221	0.30346	-0.10719	0.111452	0.128555	-0.21927	0.249418	0.191892	0.067921	0.186746
A	0.210658	-0.15506	-0.00726	0.095404	-0.05487	-0.18596	0.19529	-0.02877	0.071694	0.195839	0.040856
A	0.171247	0.097934	0.030953	0.084185	0.110758	0.023349	-0.01895	0.161286	0.149026	0.140005	0.115268
A	0.045685	0.065029	0.153826	-0.02868	-0.00056	-0.0515	0.052495	-0.10583	-0.0978	-0.12347	0.075005
A	0.081901	0.103211	0.369573	0.289725	-0.04093	0.156645	0.279909	0.254522	0.153436	0.008602	-0.02174
A	-0.07493	0.097818	0.067617	0.018187	0.294279	0.037199	-0.13111	0.008443	0.207579	-0.05352	0.05981
A	-0.0867	0.043097	0.03396	0.151831	-0.01874	0.25069	0.06646	-0.07158	-0.00909	-0.06133	-0.15041
A	0.033498	0.016033	0.069569	0.134208	-0.15075	-0.0445	0.28108	-0.20567	-0.08734	-0.20573	-0.21132
A	-0.11564	0.035941	0.074397	-0.02066	-0.04262	0.154245	0.072373	0.058711	0.004511	0.048851	0.051179
A	-0.04074	0.023479	0.01732	0.154202	0.205208	0.085761	0.030852	0.156414	0.448496	0.110873	-0.01952
A	-0.04459	0.178129	0.008414	0.019821	-0.03296	0.019821	0.009542	0.064682	-1.4E-05	0.123625	0.038298
A	-0.08719	0.178563	0.072446	0.091457	-0.12231	-0.1633	-0.11168	-0.06558	-0.04278	-0.08792	0.265278
A	-0.27681	0.179979	0.102401	0.064379	0.034495	0.182249	0.017031	0.034886	0.025127	-0.02331	-0.00213
A	-0.18478	0.084489	0.034568	0.103009	-0.13471	-0.15174	-0.23437	-0.18086	0.018462	-0.00948	0.185343
A	-0.0389	0.124275	0.110425	0.102821	-0.10262	0.045786	-0.1456	-0.0135	-0.16533	-0.00308	0.225
A	-0.06948	0.095635	0.006795	-0.07305	0.086195	0.086643	0.036086	-0.0913	0.133094	0.18436	-0.08773
A	-0.21549	-0.02012	-0.28209	-0.09958	-0.02163	-0.08818	0.134338	-0.01294	0.081626	0.067921	-0.25052
A	-0.13143	0.142304	-0.04942	-0.01139	0.020052	-0.10265	0.060735	0.056152	-0.11251	-0.05489	0.019763
A	-0.12893	0.021353	-0.09986	-0.1683	-0.09084	-0.04282	0.022192	0.057049	0.093785	0.057685	-0.05187
A	0.001778	0.115615	-0.06452	-0.0189	0.080571	0.00772	-0.13389	0.213477	0.080932	0.150197	0.021223
A	0.054027	-0.05832	-0.03698	0.020052	0.109167	0.061877	0.061155	-0.05209	0.040177	-0.12731	-0.13218
A	-0.03862	-0.05248	0.050659	-0.14706	0.141711	-0.09383	-0.05043	-0.12439	0.033859	-0.00824	-0.06918
A	0.077621	0.078127	0.05488	-0.06679	-0.03343	0.02066	-0.118	-0.08533	-0.11858	-0.14771	0.017262
A	0.129914	0.171594	-0.09498	0.197791	-0.0024	0.068513	-0.03092	0.079241	-0.14428	-0.00071	-0.00765
A	0.232532	0.056282	0.272535	-0.00883	0.063612	0.158467	-0.20052	-0.00489	0.084012	-0.12484	0.050167
A	0.370845	-0.00535	0.239428	-0.00392	0.052509	0.140569	0.392445	0.124926	0.200437	0.024708	0.028206
A	0.216658	-0.02615	0.294409	-0.08202	-0.03827	-0.01358	0.121644	0.010612	0.184042	0.161937	0.058335
A	-0.07239	0.240469	-0.03095	0.239009	0.029927	0.136347	0.007547	0.036433	0.185574	0.080527	0.08245
A	0.43933	0.011103	0.385216	0.077231	0.016915	0.122859	-0.1756	-7.2E-05	0.093814	-0.00706	0.114878
A	0.423369	0.017436	0.27521	0.214373	0.03185	0.237187	0.111553	0.003065	-0.03397	-0.05599	0.155026
A	1.233587	-0.1923	0.15971	0.030433	-0.00656	-0.09124	0.136781	0.029536	0.035782	-0.01687	0.050181
A		1.037546	0.284318	0.181657	0.045049	0.155041	-0.03966	0.211728	-0.09973	-0.00457	0.069713
A			1.483323	0.304616	0.042635	0.137316	0.168067	0.254912	0.046842	0.189666	0.189854
A				1.209559	0.073053	0.06127	0.050196	0.102821	0.081062	0.060388	0.178447
A					1.358672	0.476095	-0.00186	0.31183	0.372609	0.093206	0.144761
A						1.513742	-0.05627	0.346167	0.164713	0.033772	0.03396
A							1.131518	-0.02773	-0.09595	-0.00447	-0.12746
A								1.507409	0.59132	0.468403	0.285836
A									1.522792	0.476312	0.169614
A										1.40135	0.3189
A											1.294453

In summary, the Manikpur analysis combines survey specifics, criteria for assessment, reliability assessment, chi-squared analysis, ANOVA, correlation, and covariance analysis to provide a comprehensive evaluation of community perceptions regarding the Manikpur Coal Mine and its reclamation practices. This multi-faceted approach enhances the validity of the findings, and supports the overall conclusions drawn from the research. By understanding the diverse perspectives and experiences of the community, stakeholders can develop more effective and sustainable reclamation strategies that address the needs and concerns of those most affected by mining operations.

5. Model Development TO Manikpur SEM Model

The Structural Equation Modeling (SEM) approach, a statistical technique used to analyze and estimate complex relationships among multiple variables [54], was employed to develop a comprehensive model assessing residents' perceptions of the impacts of reclamation strategies at the Manikpur Coal Mine. SEM is particularly valuable for its ability to simultaneously assess both direct and indirect relationships between the observed and latent variables, making it well-suited for examining how various economic, social, and environmental factors interact to shape community perceptions [55, 56]. In this study, SEM helps capture the intricate interrelationships influencing residents' views on the effectiveness and consequences of reclamation efforts. SEM allows for a more nuanced understanding of the factors driving these perceptions by integrating multiple variables into a unified model.

5.1. Conceptual Framework

The conceptual framework for the Manikpur SEM model was derived from the literature review and the survey findings, which identified key criteria influencing community perceptions. The model integrates six main themes: impact, involvement, experience, availability/requirement, satisfaction level, and expected outcome. Each theme encompasses specific criteria that reflect the multi-faceted nature of the reclamation process and its effects on local communities.

5.2. General Hypothesis for Manikpur SEM Model

Based on the criteria grouping identified in the survey, Figure 4 depicts the general hypotheses proposed to guide the analysis of community perceptions regarding the impacts of reclamation strategies for the Manikpur Coal Mine.

Impact Hypothesis	The perceived impact of mine closure and reclamation efforts on residents' lives, health, and economic output significantly influences community satisfaction and support for reclamation activities. Specifically, residents who perceive greater positive impacts from reclamation efforts are more likely to support ongoing and future reclamation initiatives.
Involvement Hypothesis	Higher levels of community involvement in reclaimed mine activities are positively associated with perceptions of economic generation and the induction of non-mining activities. Increased involvement in reclamation processes fosters a sense of ownership and encourages the development of alternative economic opportunities within the community.
Experience Hypothesis	Residents' lived experiences related to living near the mine significantly affect their perceptions of reclamation efforts. Those with positive experiences regarding the influence of reclamation on their daily lives are more likely to express satisfaction with the reclamation process and its outcomes.
Availability/ Requirement Hypothesis	The perceived requirement for reclamation and the availability of economic opportunities in reclaimed areas are positively correlated. Residents who believe that reclamation is necessary for their economic well-being are more likely to support and engage in reclamation activities.
Satisfaction Level Hypothesis	Overall satisfaction with mining operations and reclamation efforts is influenced by the perceived impacts of reclamation on residents' lives, economic opportunities, and community involvement. Higher satisfaction levels are associated with increased support for mine closure and active participation in reclamation activities.
Expected Outcome Hypothesis	The anticipated benefits of reclamation efforts, including environmental improvements and economic opportunities, significantly influence community perceptions. Residents who expect positive outcomes from reclamation are more likely to support reclamation initiatives and engage in related activities.

Figure 4. Hypotheses on Community Perceptions of Reclamation Impacts at Manikpur Coal Mine (Source: Authors).

These hypotheses will be tested using the SEM model developed for the Manikpur Coal Mine, allowing for an in-depth analysis of the relationships among the identified criteria. The findings from this analysis will provide valuable insights into the factors that shape community perceptions and inform strategies for enhancing the effectiveness of reclamation efforts in the region.

5.3. Model Specification

The SEM model was specified to test the relationships among the identified variables. The hypothesized relationships are based on the premise that positive perceptions of reclamation efforts lead to increased community involvement and satisfaction, which in turn influence the perceived impact of mining activities. The model was constructed to evaluate both direct and indirect effects among the variables, allowing for a comprehensive analysis of how these factors interact (refer to Figure 5).

5.4. Data Collection and Analysis

Data for the SEM model was collected through a structured survey administered to 459 participants in the vicinity of the Manikpur Coal Mine. The survey utilized a Likert scale to measure responses, and the data were subsequently analyzed using the SmartPLS 4 software for SEM analysis. The analysis aimed to assess the validity and reliability of the model including the evaluation of measurement and structural models.

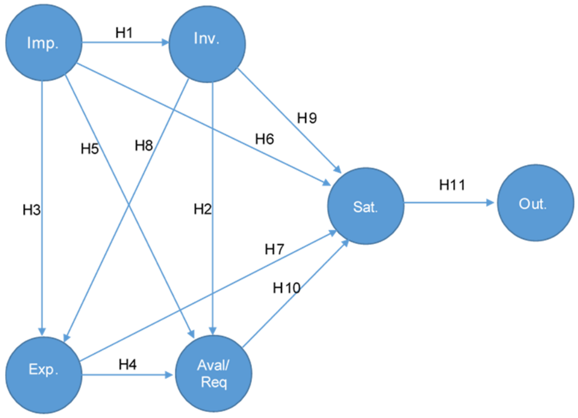

Figure 5. Hypothetical relationships amongst the 6 criteria groups (Source: Authors).

5.5. Model Evaluation

The evaluation of the SEM model involved assessing the goodness-of-fit indices and the significance of the relationships among variables. The results indicated strong support for the hypothesized relationships, with significant path coefficients demonstrating the influence of community involvement and satisfaction on perceptions of reclamation impacts (refer to Figure 6). The model's fit indices confirmed that the model adequately represents the data, providing a robust framework for understanding community perceptions regarding the Manikpur Coal Mine reclamation efforts.

The development of the SEM model for the Manikpur Coal Mine provides valuable insights into the complex interplay of factors influencing community perceptions of reclamation strategies. The model serves as a foundational tool for policymakers and practitioners to enhance reclamation efforts and foster community engagement in the mining sector by integrating multiple dimensions of impact, involvement, experience, and expected outcomes. The findings from this model can inform future reclamation strategies, ensuring they are aligned with community needs and expectations (refer to Tables 5, 6, 7, 8, 9, 10, 11, 12, and 13).

Table 5. Manikpur – PLS-SEM path coefficients-matrix.

	AVAL/REQ	EXPERIENCE	IMPACT	INVOLVEMENT	OUTPUT	SATISFACTION
AVAL/REQ						0.633
EXPERIENCE	-0.593			0.673		0.826
IMPACT	0.482	0.254		0.141		-0.685
INVOLVEMENT	0.593					-0.805
OUTPUT						
SATISFACTION					-0.513	

Table 6. Manikpur – PLS-SEM total indirect effects.

	AVAL/REQ	EXPERIENCE	IMPACT	INVOLVEMENT	OUTPUT	SATISFACTION
AVAL/REQ					-0.325	
EXPERIENCE	0.399				-0.083	-0.664
IMPACT	0.035			0.171	0.205	0.286
INVOLVEMENT					0.22	0.376
OUTPUT						
SATISFACTION						

Table 7. Manikpur – PLS-SEM total effects matrix.

	AVAL/REQ	EXPERIENCE	IMPACT	INVOLVEMENT	OUTPUT	SATISFACTION
AVAL/REQ					-0.325	0.633
EXPERIENCE	-0.194			0.673	-0.083	0.162
IMPACT	0.517	0.254		0.312	0.205	-0.4
INVOLVEMENT	0.593				0.22	-0.429
OUTPUT						
SATISFACTION					-0.513	

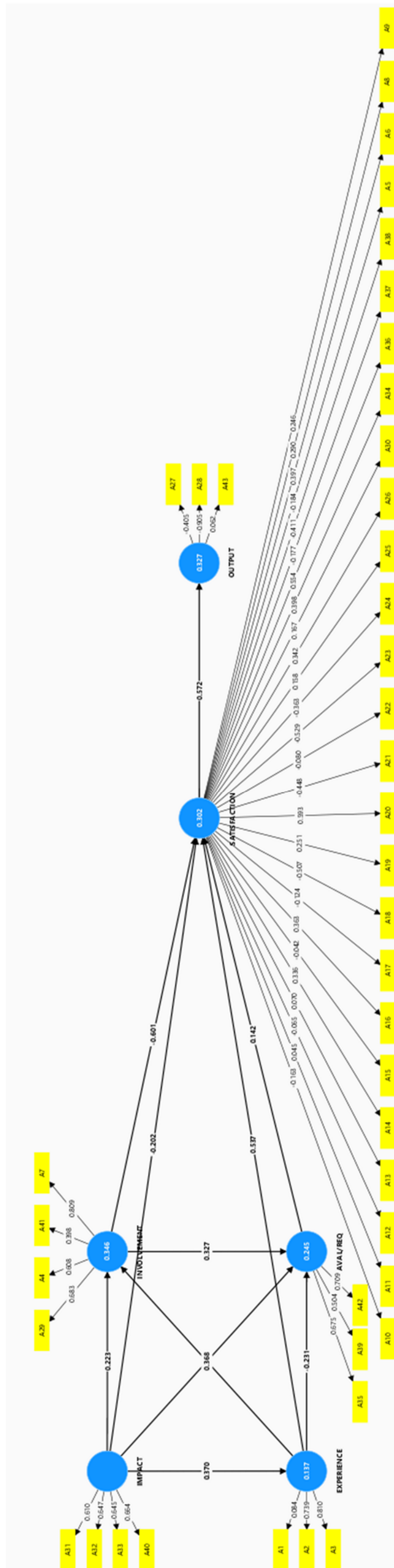

Figure 6. Conceptual SEM model for Manikpur survey analysis (Source: Authors).

Table 8. Manikpur – PLS-SEM Outer loadings.

Outer loadings	
A29 <- INVOLVEMENT	0.734
A3 <- EXPERIENCE	0.765
A30 <- SATISFACTION	0.434
A31 <- IMPACT	0.607
A32 <- IMPACT	0.72
A33 < IMPACT	0.761
A34 < -SATISFACTION	0.49
A35 < AVAL/REQ	0.768
A36 < -SATISFACTION	0.638
A37 <- SATISFACTION	-0.31
A38 <- SATISFACTION	-0.518
A39 < AVAL/REQ	0.546
A4 <- INVOLVEMENT	0.718
A40 <- IMPACT	0.782
A41 <- INVOLVEMENT	0.334
A42 < AVAL/REQ	0.689
A43 <- OUTPUT	0.186
A5 <- SATISFACTION	-0.352
A6 <- SATISFACTION	0.64
A7 <- INVOLVEMENT	0.869
A8 <- SATISFACTION	0.342
A9 <- SATISFACTION	0.386

Table 9. Manikpur – PLS-SEM Outer weights.

Outer weight	
A34 <: SATISFACTION	0.13
A9 <- SATISFACTION	0.122
A43 <: OUTPUT	0.12
A19 < SATISFACTION	0.114
A15 < SATISFACTION	0.104
A11 <- SATISFACTION	0.1
A30 < SATISFACTION	0.093
A26 < SATISFACTION	0.091
A16 < SATISFACTION	0.09
A25 <- SATISFACTION	0.056
A8 <- SATISFACTION	0.052
A24 < SATISFACTION	0.051
A10 < SATISFACTION	0.028
A13 <- SATISFACTION	0.016
A12 <- SATISFACTION	0.002
A17 < SATISFACTION	-0.012
A22 < SATISFACTION	-0.019
A37 < SATISFACTION	-0.04
A23 < SATISFACTION	-0.085
A21 <: SATISFACTION	-0.095
A18 <: SATISFACTION	-0.123
A5 <- SATISFACTION	-0.132

Table 10. Manikpur – PLS-SEM latent variable scores.

	AVAL/REQ	EXPERIENCE	IMPACT	INVOLVEMENT	OUTPUT	SATISFACTION
0	1.903	-1.008	-0.632	-0.876	-1.553	1.152
1	1.527	0.01	0.5	-0.321	0.057	-0.254
2	0.402	-0.077	-0.311	0.272	0.016	-0.324
3	0.329	1.043	1.475	1.498	-0.645	0.099
4	-0.294	0.733	-0.044	-0.257	-1.354	0.914
5	-0.312	0.604	0.146	0.008	0.619	-0.092
6	1.527	0.231	0.512	0.907	-0.182	-0.55
7	1.17	-1.11	-0.632	0.445	-0.586	-0.958
8	-0.596	-0.196	0.017	-0.97	0.156	0.731
9	-1.42	1.453	-1.261	-0.274	-1.652	1.274
10	0.301	-0.608	1.57	-0.876	-0.043	-1.433
11	-1.42	0.113	-1.261	-0.97	-0.645	0.032
12	-0.12	1.351	0.227	1.808	1.229	-0.893
13	-0.523	-1.11	-0.445	-0.97	0.348	-1.63
14	1.903	1.248	1.475	1.964	1.626	-0.51
15	0.777	1.145	1.722	0.849	1.328	-0.249
16	1.903	-0.905	1.153	-0.505	-0.182	0.133
17	-0.568	1.453	1.722	0.152	1.328	0.447
18	1.454	-1.316	-0.044	-0.721	0.632	-0.132
19	-1.42	-1.213	-1.261	-0.97	-0.645	0.725
20	-1.016	1.351	-0.449	1.314	-0.672	-1.206
21	0.96	-0.093	-0.26	1.498	0.016	0.383
22	-0.568	-1.11	-1.667	-0.97	-1.652	1.312
23	0.777	0.333	-1.261	-0.116	-1.652	3.031
24	-0.852	-1.316	-0.463	-0.97	-1.454	0.145
25	0.109	-0.451	-0.616	-0.274	0.016	-0.257
26	-0.312	1.145	-0.28	0.802	-0.043	-0.364
27	-0.761	0.32	-0.445	0.303	1.328	-0.012
28	-0.165	-1.484	0.663	-1.421	-0.069	-0.513
29	-0.312	-0.532	0.049	0.841	1.023	-1.357
30	1.903	1.043	1.722	1.964	1.626	0.289
31	-0.596	-0.196	0.017	-0.97	0.156	0.731
32	-1.42	1.453	-1.261	-0.274	-1.652	1.274
33	0.301	-0.608	1.57	-0.876	-0.043	-1.433
34	-1.42	0.113	-1.261	-0.97	-0.645	0.032
35	-0.12	1.351	0.227	1.808	1.229	-0.893
36	-0.523	-1.11	-0.445	-0.97	0.348	-1.63
37	1.903	1.248	1.475	1.964	1.626	-0.51
38	0.777	1.145	1.722	0.849	1.328	-0.249
39	1.903	-0.905	1.153	-0.505	-0.182	0.133
40	-0.568	1.453	1.722	0.152	1.328	0.447
41	1.454	-1.316	-0.044	-0.721	0.632	-0.132
42	-1.42	-1.213	-1.261	-0.97	-0.645	0.725
43	-1.016	1.351	-0.449	1.314	-0.672	-1.206
44	0.96	-0.093	-0,260	1.498	0.016	0.383
45	-0.568	-1.11	-1.667	-0.97	-1.652	1.312
46	0.777	0.333	-1.261	-0.116	-1.652	3.031
47	-0.852	-1.316	-0.463	-0.97	-1.454	0.145
48	0.109	-0.451	-0.616	-0.274	0.016	-0.257
49	-0.312	1.145	-0.28	0.802	-0.043	-0.364
50	-0.761	0.32	-0.445	0.303	1.328	-0.012
51	-0.165	-1.484	0.663	-1.421	-0.069	-0.513

	AVAL/REQ	EXPERIENCE	IMPACT	INVOLVEMENT	OUTPUT	SATISFACTION
52	-0.312	-0.532	0.049	0.841	1.023	-1.357
53	-0.596	-0.196	0.017	-0.97	0.156	0.731
54	-1.42	1.453	-1.261	-0.274	-1.652	1.274
55	0.301	-0.608	1.57	-0.876	-0.043	-1.433
56	-1.42	0.113	-1.261	-0.97	-0.645	0.032
57	-0.12	1.351	0.227	1.808	1.229	-0.893
58	-0.523	-1.11	-0.445	-0.97	0.348	-1.63
59	1.903	1.248	1.475	1.964	1.626	-0.51
60	0.777	1.145	1.722	0.849	1.328	-0.249
61	1.903	-0.905	1.153	-0.505	-0.182	0.133
62	-0.568	1.453	1.722	0.152	1.328	0.447
63	1.454	-1.316	-0.044	-0.721	0.632	-0.132
64	-1.42	-1.213	-1.261	-0.97	-0.645	0.725
65	-1.016	1.351	-0.449	1.314	-0.672	-1.206
66	0.96	-0.093	-0.26	1.498	0.016	0.383
67	-0.568	-1.11	-1.667	-0.97	-1.652	1.312
68	0.777	0.333	-1.261	-0.116	-1.652	3.031
69	-0.852	-1.316	-0.463	-0.97	-1.454	0.145
70	0.109	-0.451	-0.616	-0.274	0.016	-0.257
71	-0.312	1.145	-0.28	0.802	-0.043	-0.364
72	-0.761	0.32	-0.445	0.303	1.328	-0.012
73	-0.165	-1.484	0.663	-1.421	-0.069	-0.513
74	-0.312	-0.532	0.049	0.841	1.023	-1.357
75	-0.596	-0.196	0.017	-0.97	0.156	0.731
76	-0.596	-0.196	0.017	-0.97	0.156	0.731
77	-1.42	1.453	-1.261	-0,274	-1.652	1.274
78	0.301	-0.608	1.57	-0.876	-0.043	-1.433
79	-1.42	0.113	-1.261	-0.97	-0.645	0.032
80	-0.12	1.351	0.227	1.808	1.229	-0.893
81	-0.523	-1.11	-0.445	-0.97	0.348	-1.63
82	1.903	1.248	1.475	1.964	1.626	-0.51
83	0.777	1.145	1.722	0.849	1.328	-0.249
84	1.903	-0.905	1.153	-0.505	-0.182	0.133
85	-0.568	1.453	1.722	0.152	1.328	0.447
86	1.454	-1.316	-0.044	-0.721	0.632	-0.132
87	-1.42	-1,213	-1.261	-0,970	-0.645	0.725
88	-1.016	1.351	-0.449	1.314	-0.672	-1.206
89	0.96	-0.093	-0,260	1.498	0.016	0.383
90	-0.568	-1.11	-1.667	-0.97	-1.652	1.312
91	0.777	0.333	-1.261	-0.116	-1.652	3.031
92	-0.852	-1.316	-0.463	-0.97	-1.454	0.145
93	0.109	-0.451	-0.616	-0.274	0.016	-0.257
94	-312	1.145	-0.28	0.802	-0.043	-0.364
95	-0.761	0.32	-0.445	0.303	1.328	-0.012
96	-0.165	-1.484	0.663	-1.421	-0.069	-0.513
97	-0.312	-0.532	0.049	0.841	1.023	-1.357
98	-0.028	-0.014	0.386	-0.29	-0.46	-0.659
99	-0.056	0.423	1.316	-0.461	1.023	1.027

Table 11. Manikpur – PLS-SEM latent variables covariances.

	AVAL/REQ	EXPERIENCE	IMPACT	INVOLVEMENT	OUTPUT	SATISFACTION
AVAL/REQ	1	-0.05	0.517	0.324	0.31	-0.023
EXPERIENCE	-0.05	1	0.254	0.708	0.294	0.05
IMPACT	0.517	0.254	1	0.312	0.674	-0.4
INVOLVEMENT	0.324	0.708	0.312	1	0.482	-0.229
OUTPUT	0.31	0.294	0.674	0.482	1	-0.513
SATISFACTION	-0.023	0.05	-0.4	-0.229	-0.513	1

Table 12. Manikpur – PLS-SEM latent variables descriptives.

	Mean	Median	Observed min	Observed max	Standard deviation	Excess kurtosis	Skewness	Number of observations used	Cramer-von Mises test statistic
AVAL/REQ	0	-0.303	-1.42	1.903	1	-0.712	0.52	100	0.373
EXPERIENCE	0	-0.093	-1.484	1.453	1	-1.419	0.108	100	0.387
IMPACT	0	-0.26	-1.667	1.722	1	-0.871	0.343	100	0.374
INVOLVEMENT	0	-0.274	-1.421	1.964	1	-0.951	0.561	100	0.582
OUTPUT	0	-0.013	-1.652	1.626	1	-0.919	-0.13	100	0.265
SATISFACTION	0	-0.052	-1.63	3.031	1	1.511	0.857	100	0.168

Table 13. Manikpur – PLS-SEM R-Square – Overview

	R-square	R-square adjusted
AVAL/REQ	0.471	0.454
EXPERIENCE	0.064	0.055
INVOLVEMENT	0.521	0.511
OUTPUT	0.263	0.256
SATISFACTION	0.485	0.463

6. Results

The results section presents the key findings from the analysis of the Manikpur survey data including the chi-square test, ANOVA, correlation, and covariance analyses.

6.1. Chi-Square Analysis

The chi-squared test was applied to the Manikpur survey data to examine the relationships between demographic factors and community perceptions regarding the Manikpur Coal Mine and its reclamation practices. The results indicate that there are significant associations between certain demographic variables and specific criteria related to the mining operations and reclamation efforts. For example, the chi-square analysis revealed a strong relationship between age and perceptions of the impact of mine reclamation on livelihood availability and sustainability in the surrounding areas (A36, A37). Younger participants tended to have more negative views on these aspects compared to older residents.

6.2. ANOVA Analysis

A single-factor ANOVA was performed to analyze the variance in perceptions among different groups of survey participants in Manikpur. The analysis revealed a P-value of 1.59E-06 and an F critical value of 1.385019 (refer to Table 2). These results suggest that there are statistically significant differences in the means of the compared groups, implying that the perceptions of various community segments regarding the mining operations and reclamation practices vary considerably. The ANOVA findings highlight the need for tailored strategies that address the specific concerns and perceptions of different demographic groups within the community.

6.3. Correlation Analysis

The correlation analysis conducted for the 459 Manikpur survey participants aimed to identify the relationships between the assessed criteria. The results, presented in Table 3, show varying degrees of correlation among the different factors influencing community perceptions. For instance, a strong positive correlation was found between the level of involvement in reclaimed mine activities (A4) and the inducement of non-mining activities upon reclamation (A29), suggesting that increased community engagement in reclamation efforts may lead to the development of alternative economic opportunities. This analysis helps to identify the key drivers of sentiment and inform future reclamation strategies.

6.4. Covariance Analysis

In addition to correlation, a covariance analysis was performed to understand the direction of the relationships between the criteria. The covariance analysis results for the Manikpur survey participants are presented in Table 4. This analysis provides insights into how changes in one variable may affect another, further enriching the understanding of stakeholder perspectives on mining and reclamation practices. For example, the covariance analysis revealed a negative relationship between the impact of mine reclamation on facility availability in residing areas (A34) and the requirement levels of reclamation (A39), indicating that as the need for reclamation increases; the availability of facilities in the surrounding areas may decrease. By examining covariance, the study can identify potential areas for intervention and improvement in reclamation strategies.

The results of these statistical analyses, combined with the survey specifics and criteria for assessment, provide a comprehensive understanding of community perceptions regarding the Manikpur Coal Mine and its reclamation practices. The findings highlight the need for tailored strategies that address the specific concerns and perceptions of various community groups, while also identifying key drivers of sentiment and areas for improvement in reclamation efforts.

The analysis of the results for the Manikpur case study reveals several noteworthy findings across various matrices. Table 5 illustrates the path coefficients between constructs. AVAL/REQ (availability/requirement) significantly influences SATISFACTION with a coefficient of 0.633. EXPERIENCE has a negative impact on AVAL/REQ (-0.593) but shows strong positive impacts on INVOLVEMENT (0.673) and SATISFACTION (0.826). IMPACT has positive effects on AVAL/REQ (0.482) and EXPERIENCE (0.254), while negatively impacting SATISFACTION (-0.685). INVOLVEMENT contributes positively to AVAL/REQ (0.593) but negatively to SATISFACTION (-0.805). OUTPUT's relationships with other variables are not directly recorded in the path coefficients. The total indirect effects, presented in Table 6, reveal additional nuances. AVAL/REQ indirectly affects OUTPUT negatively (-0.325). EXPERIENCE demonstrates positive indirect effects on IMPACT (0.399), and SATISFACTION (-0.664), although the effect on OUTPUT is slightly negative (-0.083). IMPACT indirectly influences OUTPUT (0.205) and SATISFACTION (0.286), while INVOLVEMENT's indirect effects on OUTPUT (0.22), and SATISFACTION (0.376) are positive. Table 7 highlights the total effects matrix. AVAL/REQ influences OUTPUT negatively (-0.325) but positively impacts SATISFACTION (0.633). EXPERIENCE exerts mixed effects including a negative influence on AVAL/REQ (-0.194), a positive influence on INVOLVEMENT (0.673), and a smaller positive effect on SATISFACTION (0.162). IMPACT displays consistent positive effects on various constructs such as AVAL/REQ (0.517), EXPERIENCE (0.254), and INVOLVEMENT (0.312), although it has a negative effect on SATISFACTION (-0.4). INVOLVEMENT positively affects AVAL/REQ (0.593) and OUTPUT (0.22), while negatively impacting SATISFACTION (-0.429). The outer loadings, as shown in Table 8, provide an understanding of how specific indicators relate to their respective latent variables. For instance, INVOLVEMENT indicators such as A29 (0.734) and A4 (0.718) show strong loadings, while EXPERIENCE is strongly represented by A3 (0.765). IMPACT is reflected by loadings like A40 (0.782), A33 (0.761), and A32 (0.72). SATISFACTION's indicators show mixed loadings, with A36 (0.638) and A6 (0.64) contributing positively, while A37 (-0.31) and A8 (0.342) show weaker associations. AVAL/REQ is strongly represented by indicators such as A35 (0.768). Table 9 highlights the outer weights for SATISFACTION indicators. Indicators like A34 (0.13), A9 (0.122), and A43 (0.12) carry stronger weights, whereas others like A5 (-0.132) and A23 (-0.085) demonstrate weaker contributions. Finally, Table 10 provides latent variable scores for each observation across all constructs. These scores vary significantly, indicating diverse respondent experiences. For instance, AVAL/REQ ranges from -1.42 to 1.903, while SATISFACTION spans from -1.63 to 3.031, reflecting the variation in responses. Overall, this analysis indicates complex interrelationships among the constructs, with both direct and indirect effects shaping the outcomes. Constructs such as SATISFACTION and INVOLVEMENT appear pivotal, as they are influenced by multiple factors and significantly impact the system. The findings underscore the need for a nuanced understanding of these variables to enhance decision-making in similar contexts.

7. Discussion

The findings from the Manikpur survey provide valuable insights into community perceptions regarding the impacts of reclamation strategies associated with the Manikpur Coal Mine. The analysis, which employed various statistical techniques including chi-square tests, ANOVA, correlation, and covariance analyses, revealed significant relationships among the criteria groups, underscoring the complex interplay between mining operations, reclamation efforts, and community responses.

7.1. Community Perceptions and Impacts of Reclamation

The survey results indicate that the perceived impacts of mine closure and reclamation efforts are critical determinants of community satisfaction and support for reclamation activities. Residents who reported positive impacts from reclamation—such as improvements in health, economic output, and overall quality of life—were more likely to express support for ongoing reclamation initiatives [57-61]. This finding aligns with existing literature that emphasizes the importance of perceived benefits in fostering community acceptance of mining-related activities [6]. The chi-square analysis highlighted significant associations between demographic factors, such as age and gender, and perceptions of reclamation impacts. Younger participants tended to have more negative views on the effects of reclamation on livelihood availability and sustainability, suggesting a generational divide in perceptions. This insight calls for targeted communication strategies that address the specific concerns of younger community members, potentially enhancing their engagement in reclamation efforts.

7.2. Role of Community Involvement

The results from the ANOVA analysis revealed statistically significant differences in perceptions among various demographic groups, emphasizing the need for tailored strategies that consider the unique perspectives of different community segments. The positive correlation between community involvement in reclamation activities and perceptions of economic generation reinforces the notion that increased engagement can lead to better outcomes. Residents who actively participated in reclamation efforts reported a stronger belief in the potential for economic diversification and the induction of non-mining activities [62-66]. This finding is consistent with the involvement hypothesis, which posits that higher levels of community involvement are associated with more favorable perceptions of reclamation outcomes. Engaging residents in the reclamation process not only fosters a sense of ownership but also encourages the development of alternative economic opportunities, thereby enhancing community resilience [11, 22-27, 57-66].

7.3. Experience and Satisfaction Levels

The correlation analysis further elucidated the relationships between residents' lived experiences and their satisfaction levels with reclamation efforts. Positive experiences related to reclamation were strongly associated with higher satisfaction levels, indicating that the quality of reclamation efforts directly influences community sentiment. This underscores the importance of implementing effective reclamation strategies that prioritize community needs and expectations. Moreover, the availability and requirement for reclamation were found to significantly influence residents' perceptions of its necessity and effectiveness. Those who perceived a high need for reclamation were more likely to support and engage in reclamation activities, highlighting the critical role of awareness and education in shaping community attitudes.

7.4. Implications for Policy and Practice

The findings from this study have significant implications for policy-makers and practitioners involved in mine reclamation efforts. The need for community engagement and tailored communication strategies is paramount [67-73]. By actively involving residents in the reclamation process and addressing their specific concerns, stakeholders can foster greater acceptance and support for reclamation initiatives. Additionally, the study suggests that reclamation strategies should be designed with a focus on maximizing positive impacts on health, economic stability, and overall quality of life. Policy-makers should consider integrating community feedback into the planning and implementation of reclamation efforts to ensure that they align with local needs and expectations.

7.5. Future Research Directions

While this study provides valuable insights into community perceptions of reclamation strategies, further research is needed to explore the long-term effects of reclamation on community well-being. Future studies could employ longitudinal approaches to assess changes in perceptions over time, as well as the effectiveness of different reclamation strategies in promoting sustainable development [74-76]. Moreover, exploring innovative reclamation methods and advanced modeling techniques could enhance the understanding of the complex dynamics between mining operations and community responses [77-84]. Such research would contribute to the development of more effective and sustainable reclamation frameworks that prioritize both environmental conservation and community engagement [85-91].

The analysis of community perceptions regarding the Manikpur Coal Mine and its reclamation strategies reveals critical insights into the factors influencing resident attitudes and engagement. The interplay between perceived impacts, community involvement, and satisfaction levels underscores the importance of adopting a holistic approach to reclamation that prioritizes community needs and fosters sustainable development. By leveraging these insights, stakeholders can enhance the effectiveness of reclamation efforts and contribute to the long-term resilience of mining-affected communities.

8. Conclusions

The study conducted on the Manikpur Coal Mine provides critical insights into the perceptions of local residents regarding the impacts of reclamation strategies. Through a comprehensive survey and subsequent analysis using SEM, the research highlights the multi-faceted relationships between community involvement, perceived impacts, and overall satisfaction with reclamation efforts. The findings indicate that positive perceptions of reclamation are significantly associated with the perceived benefits to health, economic output, and overall quality of life. Residents who experienced favorable outcomes from reclamation initiatives expressed greater support for ongoing and future reclamation activities. This underscores the importance of implementing effective reclamation strategies that prioritize community needs and foster positive relationships between mining companies and local residents. Moreover, the analysis revealed that community involvement plays a crucial role in shaping perceptions of reclamation efforts. Increased engagement in reclamation activities not only enhances residents' sense of ownership but also encourages the development of alternative economic opportunities. This finding emphasizes the need for mining companies and policy-makers to actively involve local communities in the reclamation process, ensuring that their voices are heard and their concerns addressed. The study also identified significant differences in perceptions among various demographic groups, suggesting that tailored communication strategies are necessary to effectively engage all segments of the community. Younger residents, in particular, expressed more negative views regarding reclamation impacts, indicating a generational divide that warrants targeted outreach and education efforts. In conclusion, the research contributes to the understanding of community perceptions regarding mine reclamation by providing a robust model for evaluating these perceptions and offering practical recommendations for enhancing reclamation strategies. By prioritizing community engagement, addressing specific concerns, and focusing on the anticipated benefits of reclamation, stakeholders can develop more effective and sustainable reclamation frameworks that not only restore the environment but also promote the well-being of local communities. The insights gained from this study can serve as a foundation for future research and policy development in the field of mine reclamation, ultimately contributing to more resilient and sustainable mining practices.

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احیا و پویایی جامعه: ارزیابی اثرات اجتماعی و زیست محیطی معدن در مانیکپور، چاتیسگار

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چکیده:

این مطالعه یک تجزیه و تحلیل جامع از ادراک جامعه در مورد اثرات استراتژی‌های احیای معادن زغال‌سنگ متروکه در هند، با تمرکز خاص بر معدن زغال‌سنگ مانیکپور ارائه می‌کند. این تحقیق از طریق یک بررسی ساختاری که برای ساکنان مجاور معدن انجام می‌شود، اثرات اقتصادی، اجتماعی-فرهنگی و زیست‌محیطی تلاش‌های احیا را بررسی می‌کند. این مطالعه با استفاده از مدل‌سازی معادلات ساختاری (SEM)، عوامل کلیدی مؤثر بر ادراک جامعه را شناسایی می‌کند، از جمله مزایای درک شده از احیا، سطوح مشارکت جامعه، و رضایت کلی از عملیات معدن. یافته‌ها روابط معنی‌داری را بین این عوامل نشان می‌دهند، مانند تأثیر مثبت در دسترس بودن/نیاز احیاء (ضریب مسیر = ۰.۶۳۳) بر رضایت و تأثیر منفی مشارکت بر رضایت (۰.۸۰۵-). اثرات غیرمستقیم تعامل بین سازه ها را برجسته می کند، با تجربه تأثیر مثبت بر مشارکت (۰.۶۷۳) و رضایت (۰.۱۶۲) در حالی که تأثیر منفی بر در دسترس بودن/نیاز احیاء (۰.۱۹۴-) دارد. تغییرات در نمرات متغیر پنهان برای رضایت (۱/۶۳- تا ۳/۰۳۱) و در دسترس بودن/نیاز احیاء (۱/۴۲- تا ۱/۹۰۳) بر تجارب متنوع پاسخ‌دهنده تأکید می‌کند. این بینش‌ها بر اهمیت مشارکت مؤثر جامعه و استراتژی‌های احیای مناسب تأکید می‌کنند. توصیه‌های سیاستی برای افزایش پایداری و اثربخشی تلاش‌های احیا، با تأکید بر نیاز به رویکردهای کل‌نگر که پایداری اقتصادی، پذیرش اجتماعی-فرهنگی و پایداری زیست‌محیطی را ادغام می‌کند، ارائه شده است. این مطالعه با ارائه بینش‌های ارزشمند در مورد ادراک ساکنان و دستورالعمل‌های عملی برای بهبود شیوه‌های احیای معادن در مناطق متاثر از معدن، به حوزه احیای معدن کمک می‌کند.

کلمات کلیدی: درک جامعه، تاثیر اقتصادی، اثرات زیست محیطی، تأثیر فرهنگی-اجتماعی، مدل سازی معادلات ساختاری (SEM).