(Amended)

सत्यमेव जयते

Government of India

Form GST REG-06

[See Rule 10(1)]

Registration Certificate

Registration Number :29AAFCD9655A1ZJ

1.	**Legal Name**	DRILLBIT SOFTTECH INDIA PRIVATE LIMITED			
2.	**Trade Name, if any**	DRILLBIT SOFTTECH INDIA PRIVATE LIMITED			
3.	**Additional trade names, if any**				
4.	**Constitution of Business**	Private Limited Company			
5.	**Address of Principal Place of Business**	**Floor No.:** 2 **Building No./Flat No.:** No 361/1 **Road/Street:** 2nd main road 7th Block **Nearby Landmark:** Allahabad And Indian Bank Opposite **Locality/Sub Locality:** Nagarbhavi 2nd Stage **City/Town/Village:** Bengaluru **District:** Bengaluru Urban **State:** Karnataka **PIN Code:** 560072			
6.	**Date of Liability**	01/07/2017			
7.	**Date of Validity**	From	01/07/2017	To	Not Applicable
8.	**Type of Registration**	Regular			
9.	**Particulars of Approving**	Karnataka Goods and Services Tax Act, 2017			

Signature

Signature Not Verified
Digitally signed by DS GOODS AND SERVICES TAX NETWORK 07
Date: 2024.03.18 22:15:19 IST

Name	RANGANATHA
Designation	Assistant Commissioner
Jurisdictional Office	LGSTO 060 - Bengaluru
Date of issue of Certificate	18/03/2024

Note: The registration certificate is required to be prominently displayed at all places of Business/Office(s) in the State.

This is a system generated digitally signed Registration Certificate issued based on the approval of application granted

Annexure A

Goods and Services Tax Identification Number: 29AAFCD9655A1ZJ

Details of Additional Place of Business(s)

Legal Name	DRILLBIT SOFTTECH INDIA PRIVATE LIMITED
Trade Name, if any	DRILLBIT SOFTTECH INDIA PRIVATE LIMITED
Additional trade names, if any	

Total Number of Additional Places of Business(s) in the State **0**

e-Galactic

B - 302, Supreme Palms,
Balewadi,
Pune - 411045
Phone: +919689889311
Email: nishasarda@egalactic.in

Credit Note

INVOICE No: 2019/EG/CN/1016

DATE: 10-Mar-20

Customer Information

AKS University
Panna Road,
Sherganj
Satna -
Madhya Pradesh

Client GST No.: NA

S.No.	Particulars	Tax rate	Amount
1	Credit Note for URKUND Anti Plagiairism Licenses		73,073
	IGST @ 18%	18%	13,153
	TOTAL		**86,226**

Amount in words: Rupees eighty-six thousand two hundred twenty-six only.

E & OE

FOR eGalactic

Authorised Signatory

1. Payment within 10 days from invoice date
2. Cheque to be issued in favor of "eGalactic"
3. HDFC Bank, Account No: 50200032330418
4. IFS Code: HDFC0000223
5. PAN No. AVRPS3430L
6. GST No: 27AVRPS3430L3ZW
7. HSN Code: 998399

DrillBit
Anti Plagiarism Software

Date: 01 April 2024

To Whomsoever it May Concern

This is to certify that **Balani Infotech Pvt Limited** is the Exclusive Agent of DrillBit for the calendar year 2024-2025.

If you have any questions regarding this business relationship between **DrillBit** and **Balani Infotech Pvt Limited**, please do not hesitate to contact me via telephone or email. My contact information is below.

Thank you for your support and best wishes to you.

Sincerely

DRILLBIT SOFTTECH INDIA PRIVATE LIMITED ★ BENGALURU 560 072

Jayanna Belavadi – Director

DrillBit SoftTech India Pvt Ltd

Email: Jayanna.belavadi@drillbitplagiarism.com

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AKS UNIVERSITY

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DrillBit - Plagiarism Detection Software - Brochure & Authorization Letter -AKS University, Satna

1 message

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To: librarian@aksuniversity.com

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2) **DrillBit Tutorial video link: DrillBit Pro** - https://www.youtube.com/watch?v=pL2S4yKvrNM&t=7s

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We look forward to hearing from you soon regarding the proposal and please inform us if you have any further questions or concerns.

With Regards

Anurag Gupta – Research & Solution Sales

Balani Infotech Pvt Ltd.

| B-116, Sector 67, Dist. Gautam Budh Nagar,

Noida-201 301 Uttar Pradesh, India.

Mobile: 9595-05-9995 –WhatsUP ENABLED

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balaniinfotech.com

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2 attachments

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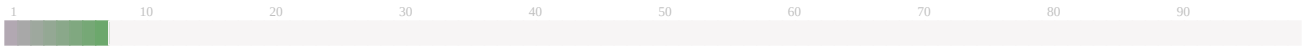

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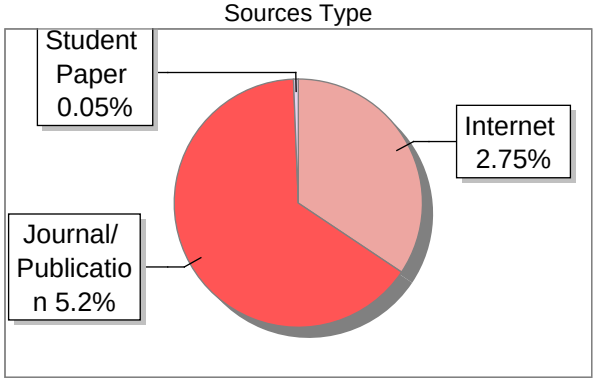

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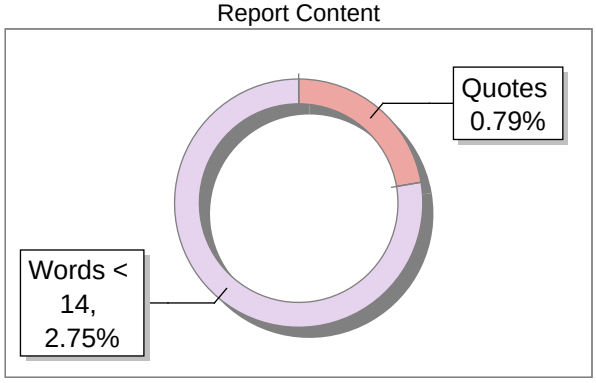

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1.1 Background of the study:

Financial inclusion, the procedure of ensuring get right of entry to economic products and services for all participants of society, has emerged as a important issue of inclusive economic boom and poverty reduction techniques international. In India, the idea of monetary inclusion has won prominence during the last few many years, with diverse projects aimed at bringing marginalized sections of society into the formal economic device.

Over the years there had been numerous progressive measures for monetary inclusion undertaken by way of the authorities to serve the financially excluded sections of the populace. The most high-quality one of these is the credit score orientated Self-Help Group (SHG) scheme. The present examine examines the banks' lending and financial savings mobilization sports beneath SHG-BLP, and the level of economic inclusion performed via SHG-BLP in 20 major taking part states for the length 2007-08 to 2017-18. Although SHG-BLP are well dispersed across the states, there exists a big variant amongst the states in the usage of formal banking offerings along with savings and credit score facilities. Results display that public area banks and Regional Rural Banks (RRBs) are greater intensively worried within the SHG-BLP tasks. Karnataka, West Bengal, Kerala, Chhattisgarh and Bihar rank excessive in the monetary inclusion index of all states built the usage of SHG-BLP related assessment. Further, our econometric estimates find that across the 4 specific bank based totally financing schemes, there exists a sizeable and advantageous affiliation of both the general public sector banks and RRBs offering financial offerings to SHG-BLP throughout the states. Applying fixed effects panel regression framework we discover that each public region banks and RRBs are more intensively concerned in economic inclusion activities specifically for sections underneath the poverty line. These sports are in particular in phrases of extra saving accounts and accelerated number of dispensed loans. However, in recent years we additionally discover that private region banks actually have a great number of initiatives for financial inclusion activities a few of the bad.

One of the top notch mechanisms for promoting financial inclusion in India has been the status quo and empowerment of Self-Help Groups (SHGs). These organizations, typically

resources and have interaction in collective financial savings and credit activities. SHGs have verified to be effective contraptions for fostering financial area, entrepreneurial capabilities, and socio-monetary empowerment amongst their members.

While SHGs have made enormous strides in promoting economic inclusion at the grassroots level, their sustainable integration into the formal monetary gadget requires the guide and participation of banking institutions. In this context, private zone banks play a pivotal position in extending monetary services to SHGs, thereby facilitating their inclusion into the mainstream banking quarter.

The Vindhya place of India, encompassing components of Madhya Pradesh and Uttar Pradesh, gives a unique setting for reading the dynamics of monetary inclusion, in particular concerning the position of private area banks in SHG development. Despite the area's rich cultural history and herbal resources, it continues to grapple with diverse socio-economic demanding situations, together with poverty, limited access to formal financial services, and gender disparities.

Against this backdrop, this have a look at seeks to adopt an analytical exam of the function performed by means of private sector banks in promoting monetary inclusion amongst SHGs inside the Vindhya vicinity. By focusing on this particular geographic region, the take a look at targets to offer insights into the challenges, opportunities, and first-rate practices related to personal quarter bank interventions in SHG development.

Through a complete evaluation of the experiences, techniques, and consequences of private area financial institution projects inside the Vindhya place, this have a look at endeavors to make contributions to both instructional understanding and practical policymaking in the discipline of monetary inclusion. By identifying key success factors and areas for improvement, the findings of this study aim to tell stakeholders, such as policymakers, banking institutions, NGOs, and SHG members, closer to enhancing the effectiveness and sustainability of economic inclusion efforts inside the vicinity and past.

1.2 Introduction of the issue:

Finance can be very essential for every financial pastime. Without top enough finance no hobby may be undertaken. Finance is also required by way of the use of each section of the society. But from the beginning of the civilization, best the economic wishes of the pinnacle segment of the society were catered. Access to finance thru the terrible and weaker groups may be very difficult. This is due to the numerous motives at the side of loss of banking centers for this phase, unawareness about the schemes to be had for them, loss of a everyday or vast profits and many others. Moreover, banks also supply extra significance to fulfill their financial goals. So that they popularity on large debts. It is not worthwhile for banks to provide small loans and make a earnings. Hence, the want for monetary inclusion is felt by way of the Government of India, the insurance makers and Reserve Bank of India.

India has, for a long term, recognized the social and economic imperatives for broader monetary inclusion and has made a substantial contribution to monetary improvement via locating innovative strategies to empower the terrible. Starting with the nationalization of banks, precedence zone lending requirements for banks, lead bank scheme, status quo of nearby rural banks (RRBs), company area technique, self-assist group-monetary organization linkage programme, and so on. The Reserve Bank of India (RBI) over time to growth get right of entry to the poorer segments of society. Despite some of these efforts, a significant proportions of the households, specially in rural areas, still remained outdoor the coverage of the formal banking device. It is estimated that approximately 40% of Indians lack get entry to even to the first-rate sort of formal economic offerings.

While India has enjoyed developing home demand and globally identified prowess in the areas of facts generation, automobile, life sciences, telecommunications or even vicinity exploration, its persevered fulfillment and boom as an monetary energy (in not unusual with one of a kind growing economies) can best be assured if concrete steps are taken to make certain that the social and economic development is inclusive. Financial inclusion denotes shipping of financial offerings at a much less steeply-priced price to the huge

sections of the deprived and espresso-earnings groups. The numerous economic offerings include credit score, financial savings, insurance and bills and remittance centers. The goal of monetary inclusion is to increase the scope of sports of the prepared financial machine to encompass within its ambit humans with low incomes. Through graduated credit score, the try should be to elevate the poor from one degree to some other in order that they arrive out of poverty. Financial inclusion specially makes a forte of the terrible that do now not have formal financial institutional help and getting them out of the clutches of neighborhood cash creditors.

An inclusive monetary device facilitates green allocation of productive assets and as a end result can probably lessen the charge of capital. Also financial inclusion protects unbanked humans from casual sources of credit, who fee higher interest fees and often lodge to unethical/harsh restoration practices. Access to a bank account gives avenues for at ease and safe saving practices. A financial institution account can also provide a passport to enormous ranging monetary offerings together with overdraft facilities, debit card and credit cards. A range of financial offerings, along side insurance and pension, constantly require get admission to to a financial institution account. Thus, an inclusive financial device enhances efficiency and welfare of a society. There are deliver factor and contact for side factors the use of Inclusive Growth. Banks in large part are expected to mitigate the supply aspect processes that prevent bad and deprived social organizations from getting access to the monetary device. Despite the chance, financing of first time marketers is shall for financial inclusion and increase. Apart from the deliver aspect factors, calls for facet factors, including lower income and asset holdings without a doubt have a superb regarding economic inclusion. Owing to difficulties in gaining access to formal resources of credit score score, poor individuals and small and macro companies typically rely upon their non-public economic savings or inner assets to spend money on health, training, housing, and entrepreneurial sports to utilize boom opportunities.

The deliver-facet mechanism deals with making the monetary tool to be had to the each section through ‘no-frill accounts’, the banking correspondents, micro-rate variety and others. The name for-facet mechanism specially deals with empowerment of the human beings and sectors thereby making them a hit for stressful the services of economic

inclusion. The creation of SHGs (Self Help Groups), financial literacy marketing campaign and others are the decision for-aspect mechanism of economic inclusion. RBI defines Financial Inclusion as “a procedure of ensuring get entry to appropriate economic services and products needed through all sections of the society in fashionable and vulnerable organizations together with weaker sections and occasional earnings businesses specially, at a less high priced cost in a sincere and apparent manner with the aid of regulated mainstream institutional game enthusiasts”. Therefore, the goal of Financial Inclusion (FI) is to increase economic services to the big hitherto unreserved population of the u . S . To loose up its growth potential. In addition, it strives to benefit more inclusive increase by means of using making financing to be had to the poor particularly. Thus, retaining in view of the pastimes of the negative humans, the Government of India (GoI) has taken a amount of measures simply so the underprivileged sections of the society can obtain the blessings of the economic offerings.

Access to formal banking system is suffering from several barriers along with way of life, economic Literacy, gender, profits and property, evidence of identity, remoteness of house, and so forth. Over a time period numerous measures are being taken by way of the banks in India to enhancement access to cheap monetary services thru economic training, leveraging era, and producing cognizance. There are ranges of things affecting get admission to to monetary services via weaker section of society in India. Rural human beings going via the issues like low income, much less protection of belongings, a good deal less literacy, social exclusion, and many others. Banks managing the problems to attain of rural people consists of lack of felony documents for starting economic organization accounts, banking products which aren't attracting to rural mass of respective location, immoderate fee of transaction, bank authentic thoughts-set and language of respective place of rural vicinity. Hence, there is a want for monetary inclusion to assemble uniform monetary development, both spatially and temporally, and ushering in greater financial and social equity.

Presently, the economic system is in a section of hastily rising income, for both rural and urban, bobbing up from the enlargement of present economic sports in addition to the advent of recent sports along with corporate profitability, which has exhibited sustainable developments, and increasing client incomes thereby riding at the boom momentum. All of

these trends characterize that call for 7financial offerings, for savings in addition to manufacturing functions, will generate, with a view to deliver new entrants within the spree of financial and banking industry. Financial inclusion as a topic has attracted international interest in the current past. For our personal country wherein nearly 70 percent of the populace lived in the rural regions, monetary inclusion assumes paramount importance indeed and is an utmost necessity for a country where a huge number of the arena's maximum poverty - troubled population resides.

There are quite a number of factors from demand and supply side affecting get admission to monetary services via weaker section of society in India. Hence, there should be a want for monetary inclusion to construct uniform monetary improvement and ushering in greater financial and social fairness.

1.3 Significance of the Study

In India, amongst all other fashions the SHG-Bank Linkage Program model is considered to be a massive one as reflected by its record of suitable rate of loan repayment along with facilitation of normal banking accessibility.SHG BLP became perceived to fill the prevailing gap in the formal financial network and extending the outreach of banking to the poor. Banks may additionally want to be endorsed as facilitators in extending the SHG movement within the poorer areas. The gift observe tries for an in-depth study Self Help Group their linkage with Bank as an effective tool to provide smooth credit to the poor who otherwise elude the benefits of the economic inclusion. This take a look at contributes to the body of expertise with the aid of locating out the nearby imbalances in terms of economic inclusion among Vindhya region via growing a financial inclusion index. The look at investigates whether or not SHG method has been successful in facilitating financial inclusion of the agricultural human beings in the decided on area. The take a look at has contributes to the mass of knowledge significantly as the findings may be used by the economic establishments, government companies and coverage formulators for higher understanding of the rigors and tribulations faced with the aid of rural people. They have a look at findings will give extra inputs to monetary institutions to take the vital steps to facilitate the accessibility of financial offerings to the rural dreadful The findings of this research will provide a basis for making plans destiny strategies or alternate within the present day/present device. The results of the take a look at could be of sizeable use to the financial institutions and the policymakers with the aid of understanding the local imbalances in terms of monetary inclusion.

Private Banks play a vital function in advancing monetary inclusion because of several key factors:

Innovative Products and Services: Private Banks are regarded for their capacity to innovate and provide a numerous variety of monetary services and products tailored to the desires of various consumer segments. They increase merchandise including microloans, cellular banking answers, and digital wallets that cater to underserved populations, which includes low-income people and small organizations.

Technology Adoption: Private Banks are often leaders in adopting era-driven answers to decorate accessibility and comfort. Through cell banking apps, net banking systems, and virtual payment structures, private banks expand their services to remote and rural regions wherein bodily bank branches can be scarce. This technological innovation enables economic access for unbanked and under banked populations.

Customer-Centric Approach: Private Banks prioritize patron satisfaction and tailor their services to satisfy the diverse needs in their customers. They offer customized financial recommendation, educational sources, and help to help customers navigate the complexities of banking and improve their financial literacy. This client-centric method fosters believe and strengthens relationships, mainly amongst marginalized groups.

Credit Provision: Private Banks play a vital role in imparting credit to people and companies, including people with constrained get right of entry to to formal credit channels. By offering microfinance loans, small business loans, and consumer credit, non-public banks permit individuals to spend money on income-generating sports, clean intake, and construct property. This get right of entry to credit promotes monetary empowerment and poverty comfort.

Partnerships and Collaborations: Private Banks collaborate with government organizations, non-income agencies, and different stakeholders to increase economic inclusion tasks. Through partnerships, personal banks leverage assets, knowledge, and networks to reach underserved populations effectively. Collaborations with microfinance establishments, community-primarily based agencies, and fintech startups in addition expand their outreach and effect.

Risk Management and Compliance: Private Banks adhere to stringent threat control practices and regulatory compliance requirements to make certain the safety and safety of client funds. By retaining monetary stability and integrity, personal banks instill confidence within the banking system and inspire extra participation from marginalized groups who can also have issues approximately the protection of their deposits.

Investment in Social Impact: Many personal banks combine social effect projects into their enterprise techniques, committing resources to deal with social and environmental demanding situations. Through company social duty (CSR) packages, philanthropic projects, and sustainable finance practices, personal banks contribute to community development, environmental sustainability, and inclusive monetary boom.

1.4 Overview and Progress of Financial Inclusion in India

As on March 2009 India has a totally intensive financial machine with a hundred and seventy business banks of which 166 are scheduled commercial banks. These scheduled industrial banks have 80325 branches, out of which 31796 branches are in rural areas. Apart from those, there are 97782 co-operative banks in India out of which most effective 1721 are running in urban areas the relaxation being in rural regions. Thus, a large community of banks prevails both in urban and rural India. Despite this, rural poor nevertheless depend and technique casual assets including moneylender for his or her monetary wishes, which make the most them in lots of ways. For bringing these negative human beings inside the mainstream of monetary device and developing them, the government of India and the Reserve financial institution of India have set up the objective of a hundred percentage financial inclusion of the negative and backward humans. Financial inclusion implies accelerated get admission to formal monetary machine for financially excluded and thereby accomplishing their financial improvement. For the attainment of the goal of monetary inclusion and inclusive boom it's far assumed that the banking device will perform the relevant assignment in this manner of development. Banks are appearing nicely on this context but for reaching the objective of one hundred percentages financial inclusion banking should be made a family addiction with the bank account in each household. The extensive objective of monetary Inclusion is to increase the scope of activities of the prepared economic machine to encompass inside its ambit people with low incomes. Through graduated credit, the attempts need to be elevating the poor from one level to another so that they come out of poverty. Reduction of poverty and earnings and making sure absolutely everyone a primary minimal fashionable of dwelling are the goal of inclusive boom. In this context get right of entry to finance via the terrible and prone agencies has to be diagnosed as a pre requisite for poverty reduction and social cohesion. It has to emerge as a critical part of the efforts to sell inclusive growth. In truth, imparting access to finance is a shape of empowerment of the vulnerable agencies.

1.4.1 Concept of financial inclusion in India: Financial inclusion wishes everyone in the society to be involved and take part in financial control judiciously. There are many terrible households in India that do not have any get entry to economic offerings in the country.

They aren't aware of banks and their capabilities. Even if they may be aware of banks, a few of the poor people do now not have the get admission to get services from banks.

They might not meet minimal eligibility criteria laid through banks and for this reason, they may no longer be capable of relaxed a financial institution's services. Banks have necessities inclusive of minimum income, minimal credit score rating, age criteria, and minimal years of work revel in. A bank will provide a deposit or a mortgage to an applicant handiest if she or he meets these criteria. Many of the negative human beings can be unemployed with none preceding employment report because of lack of schooling, lack of resources, loss of money, etc.

These economically underprivileged humans of the society may not have proper files to provide to the banks for verification of identity or income. Every bank has certain obligatory files that need to be furnished all through a loan utility procedure or at some stage in a bank account advent system. Many of these human beings do now not have know-how about the importance of those files. They additionally do no longer have get admission to use for government-sanctioned files.

Financial inclusion pursuits to cast off these boundaries and offer economically priced financial services to the less lucky sections of the society so that they may be financially independent without relying on charity or other manner of getting price range which might be truly not sustainable. Financial inclusion also intends to spread cognizance approximately financial services and monetary control amongst people of the society. Moreover, it desires to expand formal and systematic credit score avenues for the terrible humans.

Financial inclusion broadens the aid base of the economic gadget with the aid of growing a tradition of financial savings amongst massive phase of rural populace and plays its personal function in the process of economic development. Further, by using bringing low income organizations in the perimeter of formal banking zone; economic inclusion protects their monetary wealth and other sources in exigent circumstances. Financial inclusion additionally mitigates the exploitation of inclined sections by way of the usurious money lenders with the aid of facilitating easy get right of entry to formal credit.

1.4.2 Financial Inclusion Schemes in India:

The Government of India has been introducing numerous distinct schemes for the purpose of monetary inclusion. These schemes intend to offer social safety to the less lucky sections of the society. After a lot of planning and studies by numerous monetary experts and policymakers, the government launched schemes keeping financial inclusion in thoughts. These schemes were launched over special years. Let us take a listing of the financial inclusion schemes within the country:

Some of the pinnacle monetary inclusion schemes in India include:

Pradhan Mantri Jan Dhan Yojana: This is a national venture for monetary inclusion initiated in 2014. The scheme aims to make certain clean get right of entry to to financial services together with savings and deposit debts, remittances, credit score, insurance, and pension to every citizen of the country.

Pradhan Mantri Jeevan Jyoti Bima Yojana: A government-sponsored existence coverage scheme for individuals with a financial savings financial institution account.

Pradhan Mantri Suraksha Bima Yojana : This is a government-backed insurance scheme that gives unintentional demise and incapacity coverage scheme for people with a financial savings financial institution account.

Pradhan Mantri Mudra Yojana: This scheme become released in 2015 and provides micro-corporation loans for small agencies and startups.

Aadhaar Enabled Payment System: This machine of digital charge became released in 2010 and uses biometric identity to enable people to acquire and make payments thru their unique Aadhaar quantity.

Direct Benefit Transfer: This scheme changed into launched in 2010 and enables the authorities to immediately switch subsidies and other benefits to the bank accounts of beneficiaries. This scheme has been instrumental in decreasing corruption and enhancing the efficiency of shipping.

Atal Pension Yojana: This scheme became initiated in 2015 and is a central authority-sponsored pension scheme for people in the unorganized sector, such as small farmers, self-employed individuals, and day by day wage workers.

Conclusion: Financial schooling, financial inclusion, and monetary balance are three key factors of financial literacy that in the long run ends inside the development of a kingdom. Financial inclusion works from the deliver aspect with the aid of the usage of presenting precise sufficient and well timed get admission to to various economic services. Financial education, alternatively, works from the call for side via growing and selling cognizance a number of the loads concerning the significance and blessings of financial offerings furnished with the aid of the usage of the banking and the monetary zone. These two techniques in mixture and high-quality sync are vital for the general monetary stability that is essential for any sovereignty.

1.4.3 Financial Inclusion Initiatives:

Financial inclusion measures released in India covers a large variety of measures, which includes the supply of financial institution debts, use of era, appointment of BCs, enlargement of branch networks and many others. Several establishments supported via the government and the RBI is engaged in economic inclusion drives. Following are the main economic inclusion measures over the last fifteen years.

Basic Savings Bank Deposit Account (BSBDA): This is the financial institution account given to the people that include basic banking services and products. Minimum bouquet of services and products were offered beneath BSBDA, and that they consist of:

- A financial savings cum overdraft account.
- A pure financial savings account, preferably a recurring or variable habitual deposit.
- A remittance product to facilitate EBT and different remittances, and Entrepreneurial credit score merchandise like a GCC or a KCC.
- Financial Inclusion Plan (FIP) for the expansion of branch and branchless banking.

PMJDY: Pradhan Mantri Jan Dhan Yojana.

Adoption of Business Correspondents (BCs): BCs were allowed to offer banking services in rural areas.

Promotion of era for banking and price: Several era-based solutions have been initiated by the RBI to sell financial inclusion. These encompass incentivising banks to trouble RuPay cards etc, supporting internet banking and cell banking with regulatory measures. Business Correspondents need to use ICT even as delivering merchandise in far off areas. Use of the diverse fee infrastructure facilities, which includes the usage of UPI, is a crucial thing. Payments are an important banking service like savings and credit. Here, the RBI designed the NEFT and RTGS except circuitously promoting IMPS, AEPS and so on.

Repay debit cards have been launched in 2012 through NPCI. The RuPay Cards have notably elevated their marketplace proportion to 60 in line with cent (603 mn) of the whole 1017 million debit playing cards in the country to date. The card has been provided to the PMJDY account holders.

Financial Literacy Programme: Financial Literacy Centers had been began by using business banks at the request of RBI to provide attention and training to the public to get entry to monetary merchandise. Here, RBI's coverage is that economic inclusion ought to go along with economic literacy. RBI offers help to Financial Literacy and Credit Counseling Centres (FLCCs).

Simplified KYC norms: the RBI has simplified KYC rules, in particular for small price clients and transactions. This is because, in a country like India, wherein documents and identification evidence are not with many, it's far very tough to attract them to stricter KYC standards.

Liberalised branch license scheme: the RBI has launched this step in December 2009. Here, domestic scheduled business banks had been permitted to freely open branches in tier III to tier VI centres with a population of much less than 50,000 challenge to reporting. In the North-Eastern states and Sikkim, home scheduled business banks can now open branches in rural, semi-urban and concrete centres with the same liberalised manner. Similarly, banks had been asked to open at the least 25 according to cent of the full range of branches in unbanked rural centres.

Kisan Credit Cards (KCC) and General Credit Cards (GCC): Kisan Credit Cards have been issued to small farmers to get problem-loose credit score from banks. Issue of credit score cards to the credit score needy human beings was any other component of the RBI's monetary inclusion power. Under GCC, banks had been requested to introduce standard-reason credit score card facilities as much as Rs 25,000 at their rural and semi-city branches for low-earnings people. The objective of the scheme is to provide hassle-loose credit score to clients based totally at the evaluation of cash flow without insistence on safety, reason or give up-use of the credit.

Bank -SHG linkage programme.

Aadhaar based totally charge infrastructure.

Direct Benefit Transfer (DBT): The launch of direct benefit transfers through the support of Aadhaar and Bank Account is considered one of the most important improvements that activated and retained humans within the newly opened account.

Liberalised policy is closer to ATMs and White label ATMs. To amplify the community of ATMs, the RBI has allowed non-bank entities to start ATMs (referred to as 'White Label ATMs').

EBT: RBI has endorsed Electronic Benefit Transfer for routing social safety bills via the banking channel.

Unified Payments Interface and the BHIM app: UPI is a payment mechanism built with the aid of the NPCI to sell on line cash transactions. In phrases of use and popularity, the UPI has carried out familiar acclaim, and now it's far rated as one of the exceptional price gadgets for the loads inside the complete world.

1.5 Role of SHGs in Financial Inclusion

India's Self Help Group-Bank Linkage Program becomes launched in 1992 as flagship software through the United States' National Bank for Agriculture and Rural development. The goal is to meet the financial desires of the poor by means of linking SHGs with the formal credit companies. Financial inclusion of India's ladies can be satisfactory ensured via SHGs. This collection incorporates paper that gives treasured insights into the significance and functioning of SHGs to make sure monetary inclusion and therefore monetary empowerment of women in India. An attempt has been made to investigate the progress of the SHG-bank linkage program. Section-A Financial machine in India and Objective of financial inclusion:

Financial Inclusion is a powerful device to advantage inclusive increase. Financial inclusion is the procedure of ensuring get right of entry to to appropriate monetary products and services desired by means of prone corporations which include economically and socially weaker sections and low income groups at a honest and obvious manner via manner of formal economic establishments. The financial improvement and progressed get proper of access to banking and associated offerings no longer simplest accelerate financial growth but additionally lessen earnings inequality and poverty (HM Treasury 2007). Financial inclusion is each cause and impact of economic improvement. Higher the financial inclusion extra may be the monetary development. On the other hand more monetary development leads to higher monetary inclusion. It will create opportunities to every stop all and sundry to take part in and get benefit from developmental sports. In India Multi-Model Approach to financial inclusion have become adopted. With nationalization of business banks in 1969 and 1980, the Reserve Bank of India delivered diverse reformative measures like rural branch increase, department rules, precedence zone lending, differential fee of hobby, hobby charge ceiling, subsidized rate to priority area lending, and so on. Lead Bank Scheme in 1970, set up order of Regional Rural Banks in 1975, SHG-Bank Linkage Programme in 1992, Kisan Credit Card Scheme in 2001 and lately General motive credit score rating card are the important steps taken to reinforce economic inclusion. Beck.Et.Al(2000) disclosed the relationship between economic middleman improvement and monetary development. They show fine effect of basic detail

productiveness with monetary intermediary development and in turn economic development. Khan Committee advocated permitting banks to make use micro finance establishments as commercial enterprise correspondents/business facilitators to growth the attainment of banks for extra financial inclusion. Since 1990 Micro finance approach changed into taken into consideration as best option to attain the unreached segment. Micro credit, micro insurance, micro remittance at an less expensive fee is the 3 principal components of micro finance. Micro finance allows the weaker section to enhance their financial position and preferred of living. The micro finance activities were intensified up with the introduction of Self-Help Group (SHG) and Bank Linkage Programme (SBLP) within the year 1992. SHGs are becoming powerful intermediaries at the grass root degree. They allow voluntary savings; the funded surplus amount is used for intergroup lending. SHGs act as commercial enterprise correspondents to banks for extending monetary inclusion. They help badly through imparting need based monetary offerings.

1.5.1 Concept of SHGs:

Self-Help Groups (SHGs) or Thrift and Credit Groups are usually casual businesses whose participants pool financial savings and relend in the institution on rotational or desires basis. These agencies have a commonplace notion of need and impulse closer to collective movement. Many of these groups were given formed around unique production activity, promoted savings amongst contributors and use the pooled resources to fulfill emergent needs of participants, inclusive of consumption desires. Sometimes the inner savings generated have been supplemented by using external assets loaned/donated through the Voluntary Agency which promoted the SHGs. Since SHGs had been capable of mobilize financial savings from the poor who have been no longer anticipated to have any savings and can also recycle correctly the pooled financial savings amongst participants, they succeeded in acting/imparting banking offerings to their individuals, may be in primitive manner, however in a way which was value effective, easy, bendy at the door step of the members and exceptionally without any defaults in compensation by way of debtors.

Involvement of SHGs with banks should help in overcoming the trouble of excessive transaction expenses in offering credit to the terrible, by using passing on a few banking duties concerning mortgage appraisal, follow-up and healing and so on To the negative

themselves. In addition, the man or woman of SHGs and their members of the family with members presented approaches of overcoming the hassle of collateral, immoderate documentation and bodily access which decreased the ability of formal establishments to serve the poor.

Fig: 1.5.1

Based on neighborhood conditions and necessities, the SHGs have developed their own methods of working. Some of the not unusual traits of functioning of these agencies are indicated under:

- The agencies normally create a commonplace fund by means of contributing their small savings on a normal basis.
- Most of the companies themselves, or with help of NGOs, evolve bendy systems of running and managing their pooled resources in a democratic manner, with participation of every member in selection-making.

- Request for loans are taken into consideration by means of the group of their periodic meetings and competing claims on restrained assets are settled through consensus.
- Loaning is done in particular on agree with a bare minimum documentation and without any security.
- The quantities loaned are small, frequent and for quick length.
- The loans cowl a spread of purposes, some of which are non-traditional and as a substitute un-conventional.
- Rate of hobby differs from organization to organization or even with purpose. Interest charged is typically better than that charged by using banks and decrease than that charged by way of cash lenders.
- Periodic meetings of participants additionally function a forum for accumulating dues from members.
- Defaults are rare mainly due to organization stress and intimate understanding of give up use of credit.

1.5.2 Functions completed by using Self Help Groups:

1. A best SHG have to have 10-20 members. This is because it can be more difficult for an man or woman to participate equally in a massive institution if the group grows large. SHGs need to now not contain more than one member from the same circle of relatives; this permits for the inclusion of multiple households.
2. It could be both all males and females given that blended groupings are not powerful.
3. It has also been proven that ladies SHGs are more a hit than males considering the fact that their individuals are better at saving and borrowing.
4. For the SHG to be successful, its participants have to percentage comparable problems and backgrounds.
5. They paintings to improve the functional capability of impoverished and marginalised human beings inside the areas of employment and earnings era.
6. They offer no-collateral loans to clients who would in any other case struggle to comfy a loan from a bank.

7. They additionally use mutual conversations and collective leadership to settle troubles.
8. They are a main source of impoverished humans' microfinance services.
9. They function a conduit for bringing conventional economic services to the negative, in particular in rural areas.

1.5.3The Linkage of SHGs with Banks:

The linkages of SHGs with banks targets at the use of the intermediation of SHGs among banks and the rural poor for reducing down the transaction expenses for both banks and their rural clients. The objective of the linkage programme could be:

- To adapt supplementary credit score techniques for meeting the credit score wishes of the terrible by means of combining the power, sensitivity and responsiveness of the casual credit score system with the electricity of technical and administrative competencies and economic resources of the formal financial institutions.
- To construct mutual trust and self belief between bankers and the agricultural negative.
- To encourage banking interest, each on the thrift and credit sides, in a phase of the populace that formal monetary establishments typically discover difficult to reach.

There could be distinct fashions of the linkage among SHG and banks:

MODEL 1: The best and maximum direct is a model in which the banks deal directly with the person SHGs, imparting financial assistance for on-lending to the character contributors.

MODEL 2: Another model, a mild variant of the first, is in which the financial institution offers direct assistance to the SHG and the SHG promoting institution (SHGI), normally an NGO, gives education and steering to the SHG and usually keeps a watch to ensure its fine functioning.

MODEL 3: The 1/3 model places the NGO or SHGI as a economic middleman between the financial institution and a number of SHGs. The linkage between the bank and the

SHGs in this case is indirect. The NGO accepts contractual obligation for reimbursement to the financial institution.

MODEL4: The fourth version envisages bank loans without delay to individual individuals of SHGs upon pointers of the SHG and NGO. In this example, the NGO assists the bank in monitoring, supervising and healing of loans.

It is viable that the linkage may additionally observe an evolutionary manner and flow from model three to version and to version one and in the end to version 4 where individuals get direct get admission to the financial institution. However, the adoption or acceptance of a selected version would depend on the perception of the bank and the power of the SHGs and the NGO. Where the banker is capable of have a primary hand information on the running of a SHG that is functioning satisfactorily and has turned around its pooled assets /three times, he may additionally properly start with version or even model one. However, a extra conservative banker may also like to begin with version 3 and depend on the NGO or SHGI.

1.6 Role of Private Banks in financial inclusion of SHGs:

Private Banks play a big position within the monetary inclusion of Self-Help Groups (SHGs) through supplying numerous offerings and assist tailored to the wishes of these businesses. Here are some key aspects in their function:

Access to Financial Services: Private Banks amplify banking offerings to SHGs, inclusive of savings bills, loans, insurance, and different economic products. By supplying those offerings, private banks allow SHGs to get admission to formal economic channels, which had been formerly inaccessible to many contributors.

Credit Facilities: Private Banks provides credit facilities to SHGs for profits-producing sports, livelihood initiatives, and entrepreneurial ventures. These loans are often provided at affordable interest fees and with flexible reimbursement terms, empowering SHGs to spend money on their companies and improve their economic status.

Capacity Building: Private Banks often conducts schooling programs and workshops to decorate the financial literacy and management capabilities of SHG members. These potential-building tasks help SHGs higher apprehend economic standards, control their finances efficaciously, and make informed selections regarding borrowing and investment.

Technology Adoption: Private Banks leverage technology to facilitate banking transactions and enhance accessibility for SHGs. Mobile banking, internet banking, and digital fee answers enable SHG participants to conduct transactions without problems, decreasing the want for physical visits to bank branches.

Customized Products and Services: Private Banks design specialized services and products tailor-made to the particular wishes and choices of SHGs. These might also encompass institution loans, micro-coverage schemes, and financial savings merchandise that cater to the precise requirements of SHG participants.

Linkages with Government Programs: Private Banks collaborate with government businesses and NGOs to facilitate the integration of SHGs into government-subsidized economic inclusion applications. By leveraging those partnerships, non-public banks can extend their reach and guide to a bigger range of SHGs throughout distinct areas.

Empowerment and Social Impact: Through their engagement with SHGs, non-public banks make a contribution to the empowerment of girls and marginalized groups, who are frequently the primary participants of these corporations. By imparting access to monetary offerings and selling financial independence, non-public banks play a essential function in fostering social inclusion and poverty alleviation.

Overall, private banks function key enablers of monetary inclusion for SHGs, contributing to their economic empowerment, social upliftment, and sustainable development.

1.6.1 Concept and Evolution of Self-Help Groups (SHGs):

Self-Help Groups (SHGs) are community-based organizations comprising people, generally from marginalized or economically deprived backgrounds, who come together to address not unusual socio-economic troubles and empower themselves through collective action. The concept and evolution of SHGs can be understood through the following levels:

Origins and Emergence: The idea of SHGs emerged inside the 1970's in India as a grassroots technique to poverty comfort and womens empowerment. Initially, SHGs have been fashioned basically as informal financial savings and credit score businesses on the village degree, in which individuals pooled their assets and extended loans to each other to fulfill their monetary wishes.

Recognition and Support: During the Eighties and 1990s, SHGs received reputation as an powerful tool for poverty discount and social mobilization. Governments, NGOs, and global development groups commenced supplying aid and sources to promote the formation and strengthening of SHGs. This length saw the expansion of SHG networks throughout various sectors and areas, with a focal point on girls's empowerment, livelihood enhancement, and community improvement.

Integration into Formal Financial System: In the overdue Nineties and early 2000s, SHGs started out to combine into the formal economic machine, specifically through linkage packages with banks and microfinance institutions (MFIs). Linkage programs facilitated SHGs' get entry to to institutional credit score, savings centers, and different

economic offerings, permitting them to make bigger their economic sports and improve their dwelling requirements.

Diversification of Activities: Over time, SHGs diverse their activities beyond financial savings and credit to consist of livelihood advertising, skill development, entrepreneurship, and social welfare initiatives. SHGs engaged in various earnings-producing activities consisting of agriculture, animal husbandry, handicrafts, and small-scale organisations, contributing to rural and urban improvement and poverty discount.

Policy Support and Institutionalization: The reputation of SHGs as effective units for poverty reduction led to the formulation of supportive guidelines and packages with the aid of governments on the countrywide and country levels. Several international locations, which are includes in India, Bangladesh, and Nepal, implemented SHG-based totally applications as part of their poverty comfort and rural development strategies. Governments mounted dedicated businesses and establishments to sell and assist SHGs, ensuring their institutionalization and sustainability.

Scaling Up and Impact Assessment: In recent years, there has been a focus on scaling up SHG interventions and assessing their impact on poverty, women's empowerment, and social inclusion. Research studies and critiques have highlighted the high quality consequences of SHGs in terms of increased earnings, savings, asset ownership, and socio-political participation, contributing to their developing popularity as a poverty reduction method.

Overall, the evolution of SHGs displays a sluggish shift from casual community-primarily based tasks to formalized institutional systems included into broader development frameworks. SHGs have emerged as a effective device for empowering marginalized communities, promoting inclusive growth, and accomplishing sustainable improvement goals.

1.6.2Challenged faced by Private Banks:

Analyzing the position of private sector banks in financial inclusion of Self-Help Groups (SHGs) is a multifaceted assignment that entails expertise various demanding situations

and possibilities. Here are a few ability challenges confronted through private banks on this context:

Limited Reach: Private Banks often have a confined presence in the rural area and far off areas in which many SHGs operate. This geographical constraint can restrict their ability to efficaciously attain out to SHGs and offer monetary offerings.

Risk Assessment: Private Banks may additionally understand SHGs as unstable clients due to elements together with their informal shape, loss of collateral, and ranging creditworthiness among individuals. Assessing and coping with these risks can be difficult for banks.

Product Suitability: Traditional banking products may not continually be suitable for the desires of SHGs, which regularly require tailor-made monetary answers inclusive of organization loans, micro-insurance, and savings merchandise. Private banks may additionally conflict to increase and offer such merchandise successfully.

Financial Literacy: Many SHG participants can also have limited monetary literacy and recognition of banking services. Private Banks want to spend money on financial education tasks to empower SHG members to make informed financial choices and successfully utilize banking offerings.

Cost of Service Delivery: Serving SHGs in remote regions may be luxurious for non-public banks due to infrastructure challenges, operational expenses, and the need for specialised personnel. Balancing the cost of carrier delivery with the financial viability of serving SHGs may be a tremendous project.

Regulatory Compliance: Private Banks must comply with regulatory requirements while offering economic offerings to SHGs. Navigating complicated regulatory frameworks even as making sure compliance adds another layer of challenge for banks running on this space.

Competition from MFIs and Public Banks: Private Banks face opposition from microfinance institutions (MFIs) and public zone banks, which may have a stronger presence and revel in serving SHGs. Differentiating their offerings and cost proposition, turns into crucial for non-public banks to stay aggressive.

Technology Adoption: Leveraging generation for outreach, transport, and tracking of financial services is critical for private banks to efficaciously serve SHGs. However, technological obstacles consisting of confined net connectivity and virtual literacy amongst SHG members can obstruct the adoption of digital banking answers.

Social and Cultural Factors: Private Banks should navigate social and cultural elements that impact the dynamics of SHGs, which include trust, institution concord, and choice-making tactics. Understanding and respecting those factors are vital for building significant relationships with SHGs.

Addressing these challenges requires a holistic method concerning collaboration among private banks, SHGs, authorities' organizations, and different stakeholders. By overcoming these demanding situations, personal banks can play a substantial function in selling economic inclusion and empowering SHGs to make contributions to monetary improvement.

1.6.3Impact Assessment of Private Banks Initiatives on SHG Financial Inclusion:

Assessing the impact of private banks' tasks on Self-Help Group (SHG) financial inclusion involves evaluating how those projects have contributed to enhancing get right of entry to economic offerings, empowering SHGs, and promoting socio-financial improvement. Here are 3 key factors of impact evaluation:

Access to Financial Services:

Credit Access: Private Banks' projects frequently involve extending credit centers to SHGs, permitting them to get entry to formal monetary assets for various purposes together with profits technology, consumption smoothing, and emergencies.

Savings Mobilization: Private Banks may facilitate SHGs in opening financial savings money owed and provide avenues for secure and convenient depositing of savings, selling a way of life of savings and financial area among individuals.

Insurance and Other Financial Products: Some projects may encompass provisions for coverage, pension schemes, and different financial merchandise tailored to the wishes of

SHG participants, thereby enhancing their economic resilience and hazard management skills.

Empowerment of SHGs:

Capacity Building: Private banks often offer education and ability-building help to SHG contributors on financial literacy, entrepreneurship, bookkeeping, and other relevant competencies, empowering them to manipulate their finances efficaciously and make informed choices.

Decision-Making: By presenting access to formal monetary services and selling monetary literacy, non-public bank tasks empower SHGs to make independent financial decisions, negotiate higher phrases with creditors, and successfully make use of financial assets for his or her socio-economic advancement.

Institutional Strengthening: Private financial institution interventions may additionally make contributions to the institutional strengthening of SHGs, fostering transparency, responsibility, and proper governance practices in the companies, thereby enhancing their sustainability and impact.

Socio-Economic Development:

Income Generation: Improved get right of entry to to credit and economic services permits SHG contributors to adopt income-producing sports, diversify livelihood alternatives, and growth of household incomes, contributing to poverty reduction and monetary empowerment.

Women's Empowerment: Since SHGs often incorporate predominantly women contributors, initiatives by means of personal banks can have a extensive impact on women's empowerment by way of selling financial independence, selection-making autonomy, and social inclusion within households and groups.

Community Development: The socio-economic empowerment of SHGs via private financial institution initiatives can have broader high quality impacts on community

development, together with advanced access to training, healthcare, and infrastructure, in addition to more desirable social brotherly love and collective action.

Impact evaluation of private banks' tasks on SHG monetary inclusion entails evaluating these dimensions to recognize the effectiveness, reach, and sustainability of interventions, perceive demanding situations and gaps, and tell future strategies for selling inclusive finance and sustainable improvement.

3.1Methodology approach or method used in research work:

Introduction: Research is carried out for two purposes; one is the discovery of new facts and the second, verification of the old ones. This research work projected under vindhya region all private banks who work financial inclusion of Self-help groups are groups of rural poor people, especially women. The idea is to help them to organize themselves, assist them financially, provide them work, and help them in other matters, including domestic issues. Such groups are helped by the government and its policies. Research Methodology is a systematic framework used to solve the research problem by using the best and most feasible methods to conduct the research while aligning with the aim and objectives of the research. Self-help Groups (SHGs) are informal Associations of folks that come together to discover ways to enhance their dwelling situations. They are normally self-governed and peer-controlled. People of similar monetary and social backgrounds companion commonly with the assist of any NGO or authorities' business enterprise and try to clear up their issues, and enhance their residing conditions. SHGs encourage people to save and promote banking literacy among the rural segment. The research work cover Satna, Rewa ,Sidhi and Singrouli private banks to know that how they work in SHG's and support deprived people.

3.2 Need of the Research:

SHGs play a vital function in giving credit score get admission to the negative and that is extraordinarily important in poverty alleviation. They additionally play a extraordinary role in empowering ladies due to the fact SHGs assist women from economically weaker sections build social capital. Financial independence thru self-employment opportunities also facilitates improve different improvement factors along with literacy tiers, stepped forward healthcare and better own family making plans.

The SHG-Bank Linkage Programme is a chief plank of the method for handing over monetary offerings to the negative in a sustainable way. The financial inclusion attained thru SHGs is sustainable and scalable due to its various nice capabilities. The programme confronts many demanding situations and for similarly scaling up, these demanding situations want to be addressed. SHG-Bank Linkage is slowly selecting up in the vindhya location as evaluate with other place. The state is indeed, in its preliminary and developing degree in the context of economic inclusion specially within the SHG-Bank Linkage Model initiative. In view of the above, it was felt that there's a need for a crucial examination of the SHG-Bank Linkage and economic inclusion as a way to apprehend the socioeconomic impact, pros and cons for reaching commonplace financial inclusion in vindhya area.

The region in the back of this studies work cognizance on technique of SHG application, that self-employment and enable empowerment opportunity for rural negative via organizing them in SHGs, potential building, selection of key sports, making plans of activity clusters, Infrastructure build-up, Technology and advertising assist .Encouragement for income producing scheme, financial guide to self-help organization ,group formation and nurturing assist, plan help for infrastructure build-up and generation and also support for self employment sports.

3.3Types of Research Instruments:

Research instruments are the tools you use to collect and analyze the data in your research. The topics below are the common tools used in carrying out the research and their usage depends on the type of needs. Sometimes, a combination of these tools is used to solve the research problem.

Interviews (group or one-on-one):

Interviews help you to collect personalized information and are categorized as structured, semi-structured, or unstructured. It can use them based on the type and tone of the questions. While one-on-one interview gives you detailed information about the respondent, through group interviews, you could get the perception of a group of people.

Surveys (Online or Offline): through the survey, you seek responses to a set of questions have designed targeting a specific group of people. In the survey, it can use open-ended and closed-ended questions or a mix of both to get the answers to your questions.

Types of Research

Research is a multidimensional activity. It comes in various forms and is used in all social, behavioral, educational, and economical and management sciences. According to the approach and method involved in a research, one can classify the following types of research.

Descriptive research: Descriptive research basically describes what is. It mainly involves collection, recording, describing and analyzing the facts related to the study. It tries to find the existing status, trend and state of affairs in a phenomenon. Descriptive research involves surveys, but they are not merely data collection as they also involve measurement, classification, analysis, comparison and interpretation. In this type of research the variable under study are uncontrollable. One can only observe and report what is happening in a situation.

Exploratory research: A researcher starts with a trendy idea and makes use of this study as a medium to perceive troubles, which may be the point of interest for future research. A crucial issue right here is that the researcher should be inclined to alternate his/her route challenge to the revelation of recent information or perception. Such a research is typically executed when the hassle is at an initial level. It is frequently known as grounded theory approach or interpretive research because it used to answer questions like what, why and the way.

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Fig: 3.3.1

3.4 Sample Design:

Sample area: this research work covered vindhya region that is Satna, Sidhi, Rewa and singroli. The research work collects data from all SHG's under the region and employer of private banks.

(a) Bank Wise Loan Disbursement Report district SATNA, FY- 2022-23

S.No.	Bank Name	SHGs with loan Acoount	Total Disbursement Amount (in Lakh)
1	BANK OF BARODA	0	0
2	BANK OF MAHARASHTRA	1	1
3	CANARA BANK	6	2.62
4	CENTRAL BANK OF INDIA	37	68.82
5	INDIAN BANK	408	566.52
6	PUNJAB AND SIND BANK	0	0
7	PUNJAB NATIONAL BANK	9	11.03
8	STATE BANK OF INDIA	25	95.23
9	UCO BANK	6	2.17
10	UNION BANK OF INDIA	29	52.06
11	**Public Sector Bank**	**521**	**799.45**
12	MADHYANCHAL GRAMIN BANK	1677	2853.81

13	**Regional Rural Bank**	**1677**	**2853.81**
14	HDFC BANK LTD	827	1619.23
15	**Private Sector Bank**	**827**	**1619.23**
16	**Grand Total**	**3025**	**5272.49**

Table :3.4.1

(b) Bank Wise Loan Disbursement Report district REWA, FY- 2022-23

Sl. No.	Bank Name	Total SHG	Total Disbursement Amount (in Lakh)
1	BANK OF BARODA	2	0.52
2	BANK OF INDIA	0	0
3	CANARA BANK	24	37.71
4	CENTRAL BANK OF INDIA	15	14.69
5	INDIAN BANK	182	172.66
6	PUNJAB AND SIND BANK	0	0
7	PUNJAB NATIONAL BANK	25	41.14
8	STATE BANK OF INDIA	25	55.67
9	UNION BANK OF INDIA	768	1653.95
10	**Public Sector Bank**	**1041**	**1976.34**
11	MADHYANCHAL GRAMIN BANK	1521	2541.51
12	**Regional Rural Bank**	**1521**	**2541.51**
13	HDFC BANK LTD	310	618.05
14	ICICI BANK LTD	22	50.37
15	**Private Sector Bank**	**332**	**668.42**
16	**Grand Total**	**2894**	**5186.27**

Table :3.4.2

(c) Bank Wise Loan Disbursement Report district SIDHI, FY- 2022-23

Sl. No.	Bank Name	Total SHG	Total Disbursement Amount (in Lakh)
1	CENTRAL BANK OF INDIA	29	45.54
2	INDIAN BANK	3	3.5
3	PUNJAB NATIONAL BANK	88	181.6
4	STATE BANK OF INDIA	21	114
5	UNION BANK OF INDIA	364	1080.29
6	**Public Sector Bank**	**505**	**1424.93**
7	MADHYANCHAL GRAMIN BANK	897	1932.33

8	**Regional Rural Bank**	**897**	**1932.33**
9	**Grand Total**	**1402**	**3357.26**

Table:3.4.3

(d) Bank Wise Loan Disbursement Report district SINGRAULI, FY- 2022-23

Sl. No.	Bank Name	Total SHG	Total Disbursement Amount (in Lakh)
1	BANK OF BARODA	57	120.7
2	CENTRAL BANK OF INDIA	18	36
3	INDIAN BANK	54	102.53
4	PUNJAB NATIONAL BANK	102	116.3
5	STATE BANK OF INDIA	68	224
6	UNION BANK OF INDIA	182	398.68
7	**Public Sector Bank**	**481**	**998.21**
8	MADHYANCHAL GRAMIN BANK	403	956.59
9	**Regional Rural Bank**	**403**	**956.59**
10	**Grand Total**	**884**	**1954.8**

Table :3.4.4

Sample size:

Private banks under vindhya provide financial inclusion of SHG's	City Name	SHG's
HDFC	**Satna**	**827**
HDFC & ICICI	**Rewa**	**310 & 22**
No SHG's services given by private banks	**Sidhi**	**Nil**
No SHG's services given by private banks	**Singrauli**	**Nil**
Total		**1159 total SHG's**

Table: 3.4.5

Determination of sample size: n=N/1+N*e2 (Cochran's sample)

Where: n=total population

N=data of sample

e=error of margin

n=297.37 SHGs respondent

here the researcher want to survey of SHG's on private banks under vindhya region, their population size 297.37 and would work with over all 300 sample and this research work want to work with 95% confidence level of sample size. This 300 sample from different – different SHGs respondent and 100 samples were selecting for banks respondent.

Sample unit: All private banks situated under vindhya region that provide financial inclusion to SHG's.according to report it consist of HDFC bank ltd. Satna city and HDFC and ICICI private banks from Rewa city provide financial inclusion of SHG's.

Sample technique: Under this study cover broad area and large number of sample size so, for optimization the sample size researcher take up simple random technique method.

3.5 Data collection Process:

The methodology also includes an explanation of your data collection process. For instance, if you perform experimental tests on samples, conduct surveys or interviews or use existing data to form research work, this section of your methodology details what you do and how you do it. Several key details to include in this section of a methodology focus on how you design your experiment or survey, how you collect and organize data and what kind of data you measure. You may also include specific criteria for collecting qualitative and quantitative data.

It is necessary to distinguish between types of the data. It is primary and secondary one. The primary data is collected at first hand and the secondary data are those which is collected someone else and which is already been processed.

Primary data: primary data collection method divided in to two parts one is observation and interview method. Under the observation method selected structured observation and controlled observation method are as follows:

Structured observation: when observation is made by careful definition, recording of observation is standardized, it is called structured observation. It is appropriate as descriptive studies.

Controlled observation: when observation is conducted with pre decided plans with certain procedures it is termed as controlled observation.

The data collection method also on the basis of interview method like personal interview and telephonic interview are as follows:

Personal interview: it is face to face interaction with observer and respondent. In this method the consultations ask various questions and collect necessary information.

Telephonic interview: when respondent cannot be connected personally then information which is required to be collected can be collected through phone.

Secondary data: data collection through secondary sources collectively two methods one is internal source and other one is external source.

Internal sources:

Ready to use: those sources which can be used as it is.

Required further processing of data: Data which are available but need some more processing before being considered for the study.

External source:

Published data: Those data which are already published in physical form (database). The sources of published data are general business sources like directories and statistical data and government sources like census data and other government publication**.**

Data instrumentation and analysis: Data collection and analysis tools are defined as a series of charts, maps, and diagrams designed to collect, interpret, and present data for a wide range of applications regarding SHG. These analytical procedures enable us to induce the underlying inference from data by eliminating the unnecessary chaos created by its rest. Data generation is a continual process; this makes data analysis a continuous, iterative process where the collection and performing data analysis simultaneously. Ensuring data integrity is one of the essential components of data analysis .In this research work applied tabulation method for data editing and coding use simple percentile method and proof hypothesis testing support F-test and Annova test.

Chapter-IV

Data Analysis and Interpretation

4.1 Data analysis and elucidation:

Demographic study of Research:

Banks Respondent									
Gender		Monthly Income		Age		Education		Habitation	
M	F	Indicator	no.	Indicator	no.	Indicator	no.	Urban	Rural
78	22	5000-10000	0	18-30	54	10th	0	59	41
		10000-20000	58	30-40	32	12th	8		
		20000-40000	32	40-50	11	UG	67		
		40000-80000	10	50-62	3	PG	23		
		80000above	0			PG+	2		
100		100		100		100		100	

Table: 4.1(a)

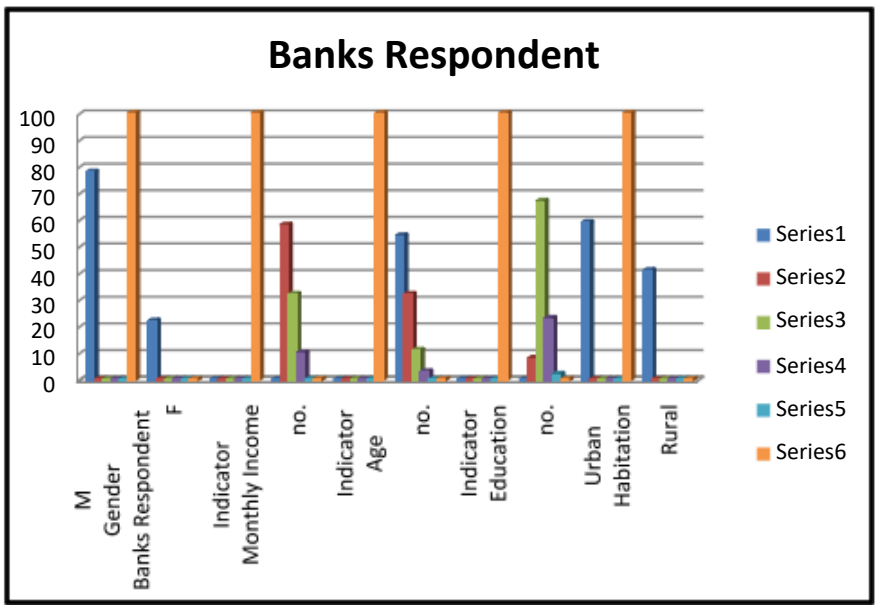

Fig: 4.1(a)

Analysis: Male respondents constitute seventy eight% of the full, even as female respondents represent 22%. This shows a better representation of men inside the surveyed population.The majority of respondents fall inside the income range of 10,000-20,000 (58%), followed through 20,000-40,000 (32%), and 5,000-10,000 (10%). There are fewer respondents within the better income brackets of 40,000-80,000 and above 80,000.The age

institution of 18-30 years comprises the largest phase of respondents (54%), indicating a younger demographic. This is accompanied by using the 30-forty age groups (32%), with step by step smaller proportions in older age brackets. The majority of respondents have finished their education as much as the tenth grade (54%) or 12th grade (32%). Smaller percentages have pursued undergraduate (UG) or postgraduate (PG) education, with best 11% and three% respectively. There's also a small percentage (2%) with training beyond postgraduate (PG+).Urban residents constitute the general public of respondents (59%) as compared to rural citizens (41%). This suggests a higher illustration of city dwellers within the surveyed populace.

SHGs Respondent									
Gender		Monthly Income		Age		Education		Habitation	
M	F	Indicator	no.	Indicator	no.	Indicator	no.	Urban	Rural
0	300	5000-10000	42	18-30	58	0-5th	64	58	242
		10000-20000	213	30-40	178	5-8th	109		
		20000-40000	42	40-50	47	8-10th	78		
		40000-80000	3	50-62	15	10-12th	31		
		80000above	0		2	UG	12		
300		300		300		300		300	

Table: 4.1(b)

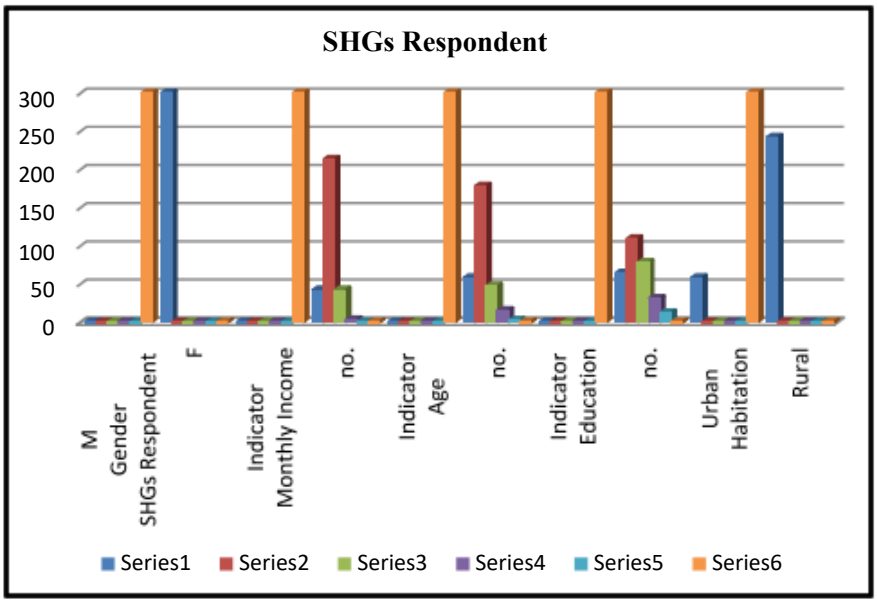

Fig: 4.1(b)

Analysis::

Female respondents dominate the dataset, constituting 100% of the respondents. This suggests a large representation of ladies inside the surveyed SHGs. The majority of respondents fall in the lower earnings brackets, with maximum reporting monthly incomes between 5,000 and 20,000 rupees. Specifically, 42% of respondents earn between 5,000 and 10,000 rupees, and 71% earn between 10,000 and 20,000 rupees according to month. There are only a few respondents with better incomes, and none stated incomes above 80,000 rupees in step with month. The age organization of 18-30 years comprises the largest segment of respondents (58%), indicating a predominantly young populace. This is observed with the aid of the 30-40 age institution (19%) and step by step smaller proportions in older age brackets. The majority of respondents have finished schooling as much as the fifth to eighth grade (64%). A vast element has training as much as the tenth to 12th grade (47%). There also are respondents with lower levels of training, with 109 reporting education among the fifth and 8th grade.Rural residents constitute the whole surveyed populace, and not using a representation from city regions. This suggests that SHGs inside the dataset in the main operate in rural settings.

Descriptive study of Research

Table 1 Financial inclusion

	PRIVATE_BANKS		YES	NO	Total	Mean
Financial inclusion is access to financial services such as savings, credit, loans, insurance etc.	HDFC	Frequency	50	0	50	1.0000
		Percent (%)	100.0	0	100	
	ICICI	Frequency	50	0	50	1.0000
		Percent (%)	100.0	0	100	
Its goal is to provide basic financial services to all	HDFC	Frequency	50	0	50	1.0000
		Percent (%)	100.0	0	100	
	ICICI	Frequency	50	0	50	1.0000
		Percent (%)	100.0	0	100	
It focuses on providing reliable financial solutions to the economically disadvantaged people.	HDFC	Frequency	44	6	50	1.1200
		Percent (%)	88.0	12.0	100.0	
	ICICI	Frequency	43	7	50	1.1400
		Percent (%)	86.0	14.0	100.0	
It enables the	HDFC	Frequency	28	22	50	1.4400

poorest of the poor in the society to come out of poverty.		Percent (%)	56.0	44.0	100.0	
	ICICI	Frequency	39	11	50	1.2200
		Percent (%)	78.0	22.0	100.0	
Due to this, capital formation is increasing in the country.	HDFC	Frequency	39	11	50	1.2200
		Percent (%)	78.0	22.0	100.0	
	ICICI	Frequency	36	14	50	1.2800
		Percent (%)	72.0	28.0	100.0	

Table 4.1.1

Financial inclusion is access to financial services such as savings, credit, loans, insurance etc.

With 100% of the observed accounts or consumers in the sample being accounted for by HDFC and ICICI, the data demonstrates an extensive range of financial inclusion. A frequency of 50 for both HDFC and ICICI indicates an equal and comprehensive coverage of the financial services tested. This indicates that these institutions are well-represented in the dataset and have made a significant contribution to financial inclusion, which is indicative of their importance in providing the sampled population services including credit, loans, savings accounts, and insurance.

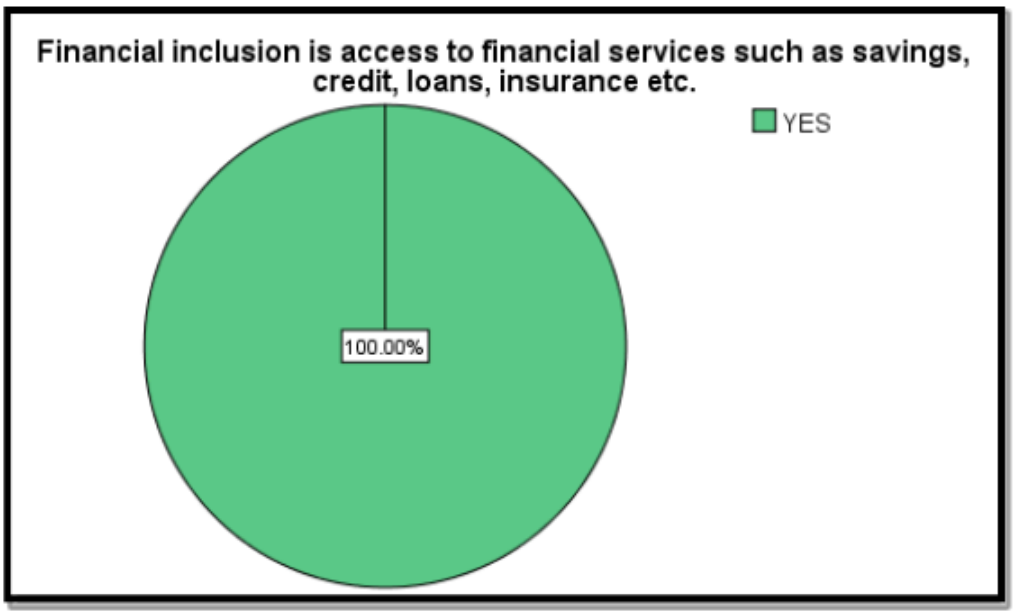

Fig: 4.1.1

Its goal is to provide basic financial services to all

According to the data provided HDFC and ICICI strive to provide everyone with access to fundamental financial services. According to the statistics, ICICI and HDFC both have frequency counts of 50, which suggests that these services are consistently provided. Each bank has a percentage value of 100%, which denotes a total coverage or dedication to this

goal. This implies that, in line with larger financial inclusion measures, HDFC and ICICI are committed to guaranteeing everyone access to basic financial services.

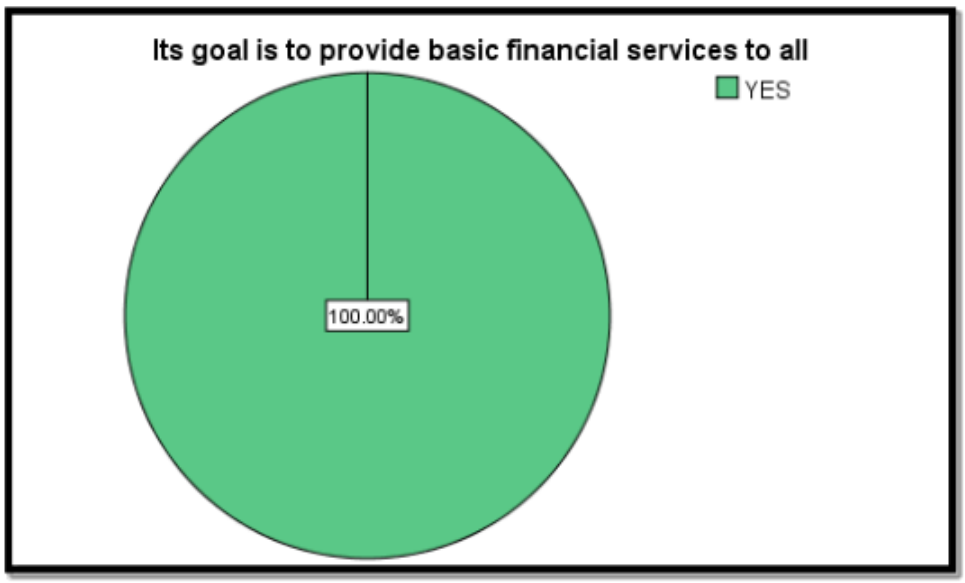

Fig: 4.1.2

It focuses on providing reliable financial solutions to the economically disadvantaged people.

The data provided tends to distinguish the financial assistance initiatives of two entities, HDFC and ICICI, with the goal of aiding those who are economically challenged. The information provides a breakdown of these projects' frequency and percentage allocation. For HDFC, of the 50 cases, 44 (88%) correspond to a certain financial solution, while 6 (12%) are distributed in a different way. ICICI, on the other hand, shows a comparable level of dedication, with 43 instances (or 86%) using one strategy and 7 cases (or 14%) using another. These organizations demonstrate a considerable outreach to individuals in need by focusing heavily on providing dependable financial services to economically disadvantaged communities.

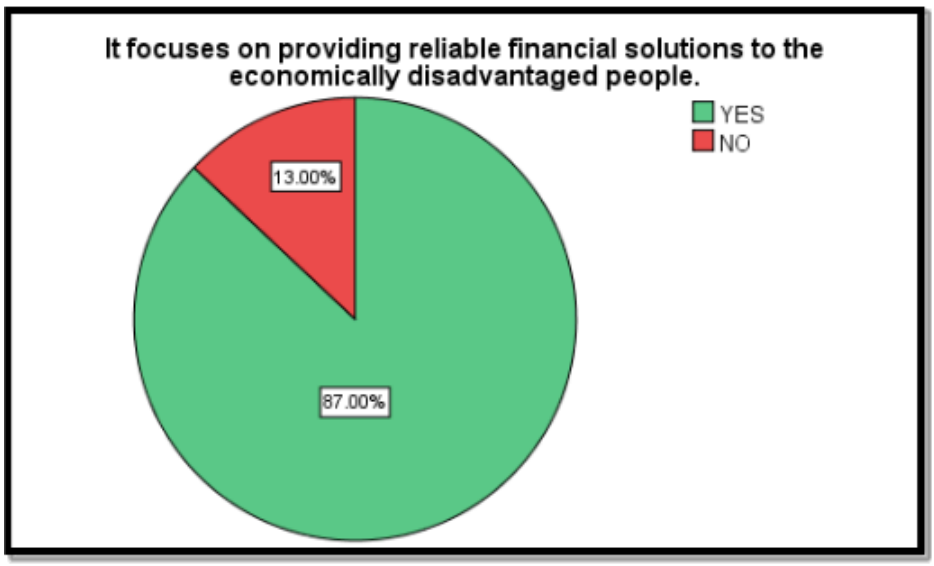

Fig :4.1.3

It enables the poorest of the poor in the society to come out of poverty.

The data presented is a comparison of the effects of two financial companies, HDFC and ICICI, in reducing poverty among the underprivileged. The data shows that 28 people, or 56.0% of the total, have received assistance from HDFC to escape poverty. Similarly, 39 people—or 78.0% of the total—have received assistance from ICICI in accomplishing the same objective. The statistics demonstrate the critical role these organizations play in enabling the most vulnerable members of society to change their financial situation and escape poverty. The aforementioned percentages highlight the noteworthy efforts made by HDFC and ICICI in improving financial inclusion and promoting socioeconomic mobility among marginalized communities.

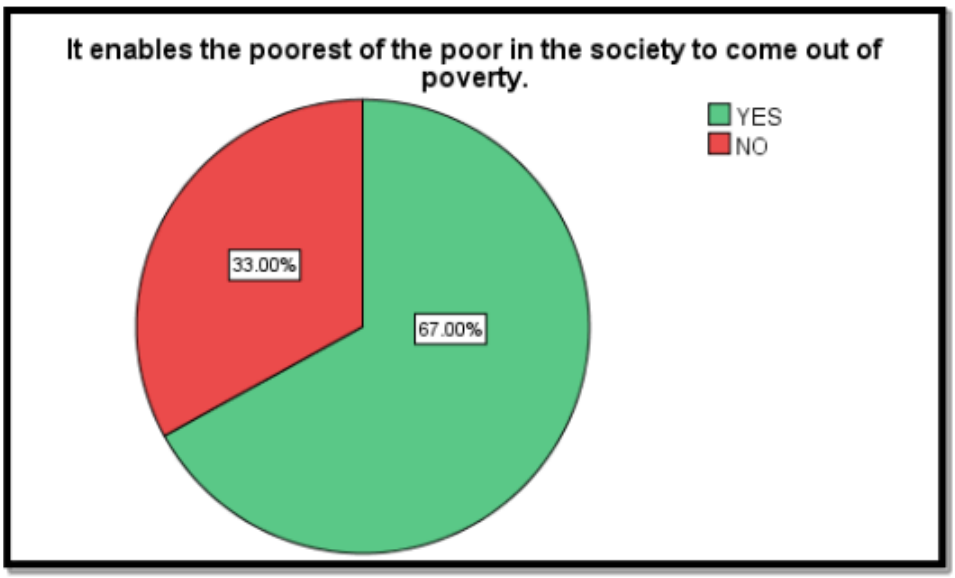

Fig: 4.1.4

Due to this, capital formation is increasing in the country.

According to the statistics, there is a noticeable trend in the nation's capital creation, with major contributions from ICICI and HDFC. 78% of the frequency is accounted for by HDFC, with ICICI following closely after at 72%. This indicates that these financial institutions have committed a significant amount of resources to capital development. The rise in capital creation points to a strengthening desire for and trust in the economy, which could encourage more growth and development.

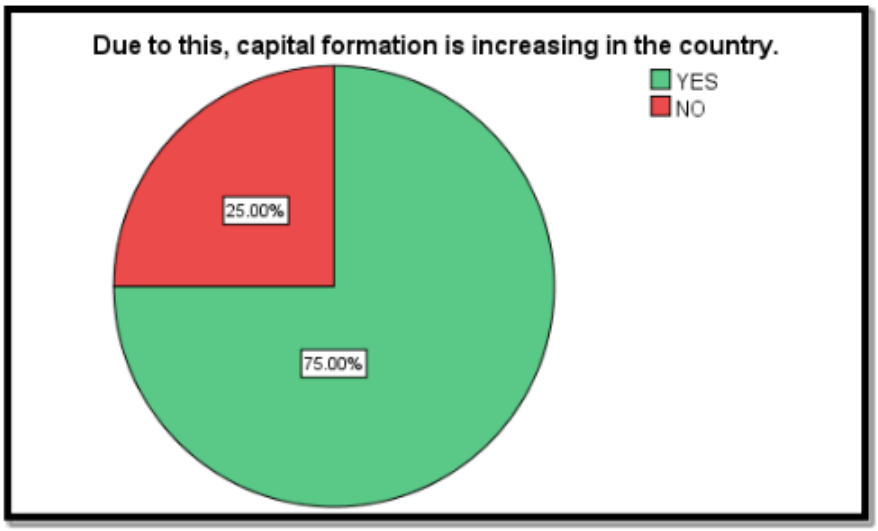

Fig: 4.1.5

Table 2 Role of private banks in financial inclusion of SHGs (HDFC + ICICI)

	PRIVATE_BANKS		YES	NO	Total	Mean
Paper less documentation	HDFC	Frequency	6	44	50	1.8800
		Percent(%)	12.0	88.0	100	
	ICICI	Frequency	5	45	50	1.9000
		Percent(%)	10.0	90.0	100.0	
Doorstep services	HDFC	Frequency	25	25	50	1.5000
		Percent(%)	50.0	50.0	100.0	
	ICICI	Frequency	25	25	50	1.5000
		Percent(%)	50.0	50.0	100.0	

Deposit/ Withdrawal	HDFC	Frequency	50	0	50	1.0000
		Percent(%)	100.0	0	100.0	
	ICICI	Frequency	50	0	50	1.0000
		Percent(%)	100.0	0	100.0	
Fund transfer	HDFC	Frequency	39	11	50	1.2200
		Percent(%)	78.0	22.0	100.0	
	ICICI	Frequency	40	10	50	1.2000
		Percent(%)	80.0	20.0	100.0	
Net banking/ Mobile banking	HDFC	Frequency	33	17	50	1.3400
		Percent(%)	66.0	34.0	100.0	
	ICICI	Frequency	39	11	50	1.2200
		Percent(%)	78.0	22.0	100.0	
Network of BCs / Kiosk	HDFC	Frequency	24	26	50	1.5200
		Percent(%)	48.0	52.0	100.0	
	ICICI	Frequency	12	38	50	1.7600
		Percent(%)	24.0	76.0	100.0	
Cash credit limit (CCL)	HDFC	Frequency	10	40	50	1.8000
		Percent(%)	20.0	80.0	100.0	
	ICICI	Frequency	12	38	50	1.7600
		Percent(%)	24.0	76.0	100.0	

Term loan	HDFC	Frequency	43	7	50	1.1400
		Percent(%)	86.0	14.0	100.0	
	ICICI	Frequency	10	40	50	1.8000
		Percent(%)	20.0	80.0	100.0	
Low interest rates on loans	HDFC	Frequency	34	16	50	1.3200
		Percent(%)	68.0	32.0	100.0	
	ICICI	Frequency	43	7	50	1.1400
		Percent(%)	86.0	14.0	100.0	
PMJJY (For SHG members)	HDFC	Frequency	37	13	50	1.2600
		Percent(%)	74.0	26.0	100.0	
	ICICI	Frequency	41	9	50	1.1800
		Percent(%)	82.0	18.0	100.0	
PMSBY (For SHG members)	HDFC	Frequency	39	11	50	1.2200
		Percent(%)	78.0	22.0	100.0	
	ICICI	Frequency	42	8	50	1.1600
		Percent(%)	84.0	16.0	100.0	
APY (For SHG	HDFC	Frequency	19	31	50	1.6200

members)		Percent(%)	38.0	62.0	100.0	
	ICICI	Frequency	24	26	50	1.5200
		Percent(%)	48.0	52.0	100.0	
PPF (For SHG members)	HDFC	Frequency	12	38	50	1.7600
		Percent(%)	24.0	76.0	100.0	
	ICICI	Frequency	10	40	50	1.8000
		Percent(%)	20.0	80.0	100.0	
MUDRA loan / Business loan (For SHG members)	HDFC	Frequency	28	22	50	1.4400
		Percent(%)	56.0	44.0	100.0	
	ICICI	Frequency	33	17	50	1.3400
		Percent(%)	66.0	34.0	100.0	

Table: 4.2

Paper less documentation

The frequency distributions and percentages for HDFC and ICICI are compared in the data provided. Of the 100 observations for HDFC, 6 (or 12% of the total) fit into the first group, while 44 (or 88% of the total) dropped into the second category. By the second category, the cumulative proportion for HDFC reaches 100%. Comparably, of 100 observations for ICICI, 5 belong to the first group, making up 10% of the total, and 45 to the second category, making up 90% of the whole. By the second category, the cumulative proportion for ICICI also hits 100%. Essentially, this data shows how observations are distributed and represented as a percentage across several categories for both HDFC and ICICI.

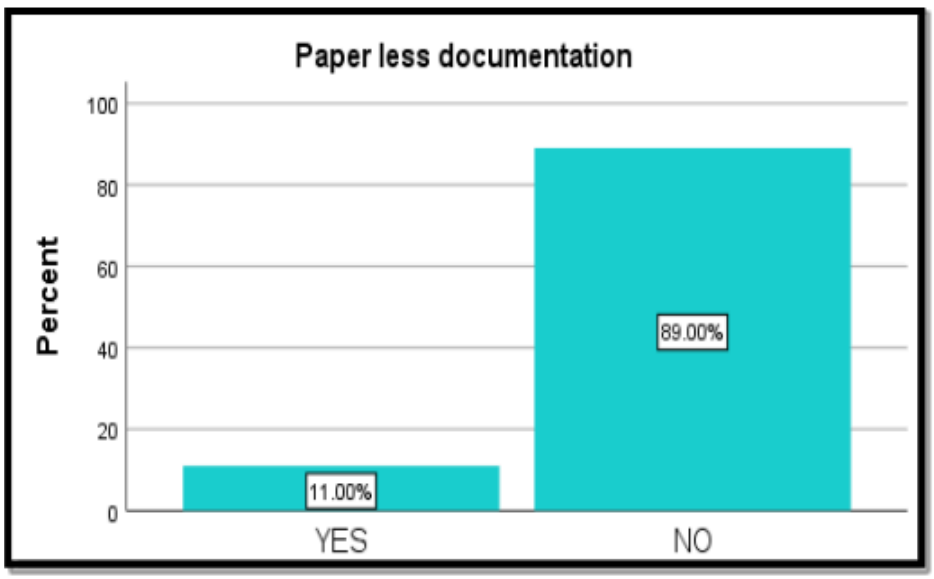

Fig: 4.2.1

Doorstep services

The information given relates to doorstep services with comparable frequency and percentages that are supplied by ICICI and HDFC. The service is used 25 times by HDFC, accounting for 50% of all occurrences, and 25 times by ICICI, accounting for 50% of all occurrences as well. This is a cumulative proportion of 100% for both institutions, resulting in a total incidence of 50. The regularity and dispersion of these services point to a steady rate of consumption for both HDFC and ICICI, indicating a similar degree of involvement and need for doorstep services in each company's activities.

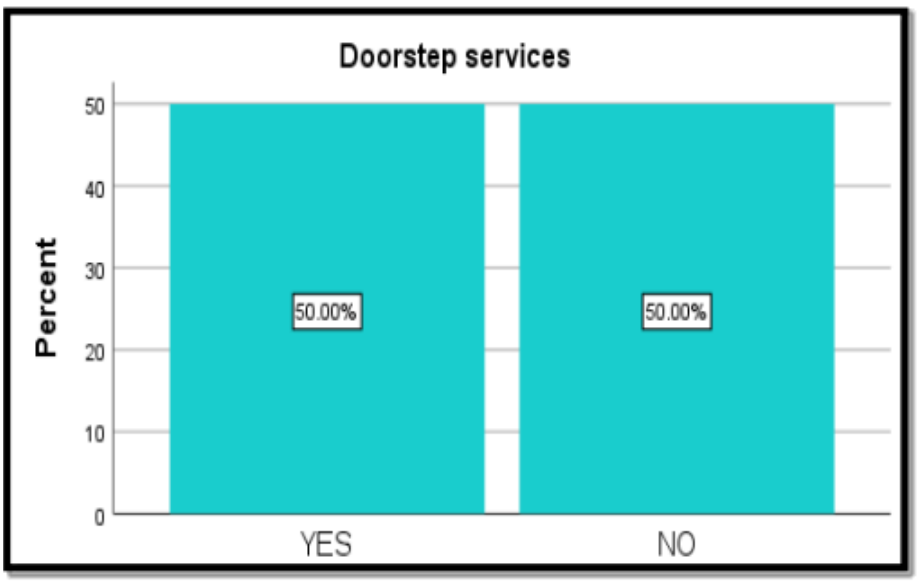

Fig: 4.2.2

Deposit/ Withdrawal

The data that is supplied displays the deposit and withdrawal activities for the banks HDFC and ICICI. For HDFC, the frequency of deposits was 100% since there were 50 occurrences of deposits and no withdrawals noted. Similarly, ICICI also had a 100% deposit frequency with 50 deposits and 0 withdrawals. These numbers show steady deposit activity at both banks throughout the given time frame, with no recorded withdrawals.

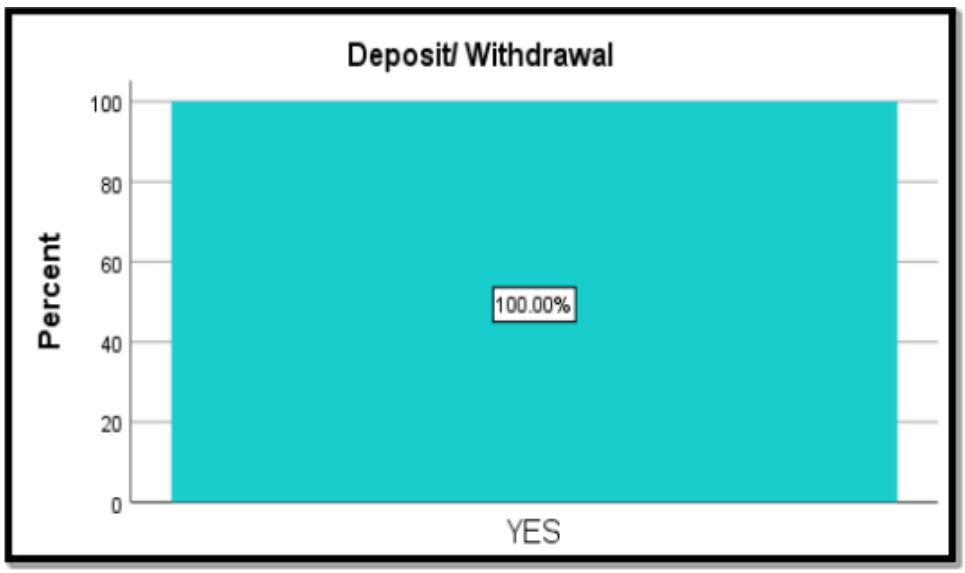

Fig: 4.2.3

Fund transfer

It indicates to show money transfer statistics between HDFC and ICICI based on the data that has been supplied. For HDFC, 39 of the 50 transactions had a frequency of 78%, 11 had a frequency of 22%, and the average transaction value was 1.2200. In a similar vein, ICICI recorded an average transaction value of 1.2000 over 50 transactions, of which 40 were at 80% and 10 at 20%. ICICI had a slightly larger proportion of transactions in the 80% group than did HDFC, according to these numbers, which indicate that HDFC performed more transactions in the 78% band. ICICI's average value per transaction was somewhat lower than HDFC's. In all, a sizable volume of transactions with different percentage distributions were processed by both institutions.

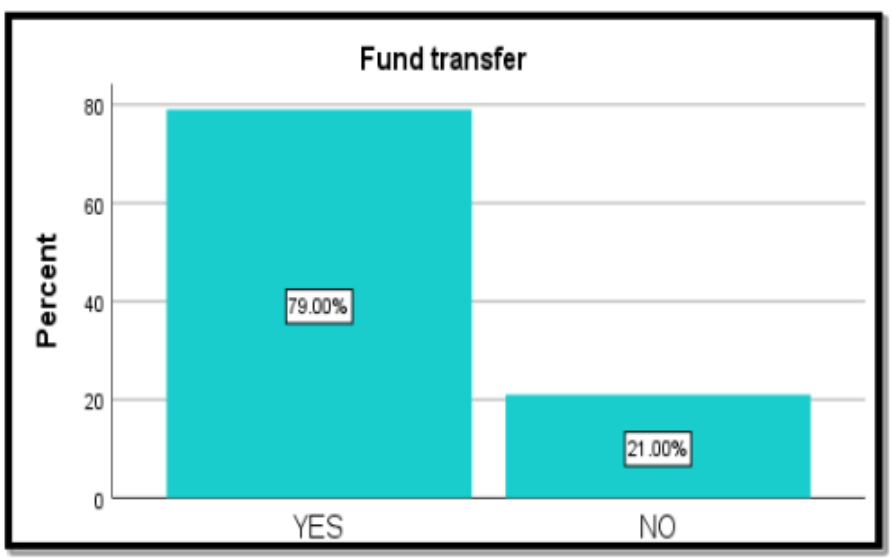

Fig: 4.2.4

Net banking/ Mobile banking

The distribution of net banking and mobile banking customers among HDFC and ICICI banks is seen in the statistics supplied. Of the 50 respondents to HDFC, 33 use net banking and 17 use mobile banking; this means that the adoption rates of net banking and mobile banking are 66.0% and 34.0%, respectively. In contrast, 39 respondents at ICICI utilize net banking, and 11 prefer mobile banking; this results in a 78.0% adoption rate for net banking and a 22.0% adoption rate for mobile banking. In general, HDFC has a greater net banking adoption rate than ICICI, and a larger percentage of its customers utilize mobile banking.

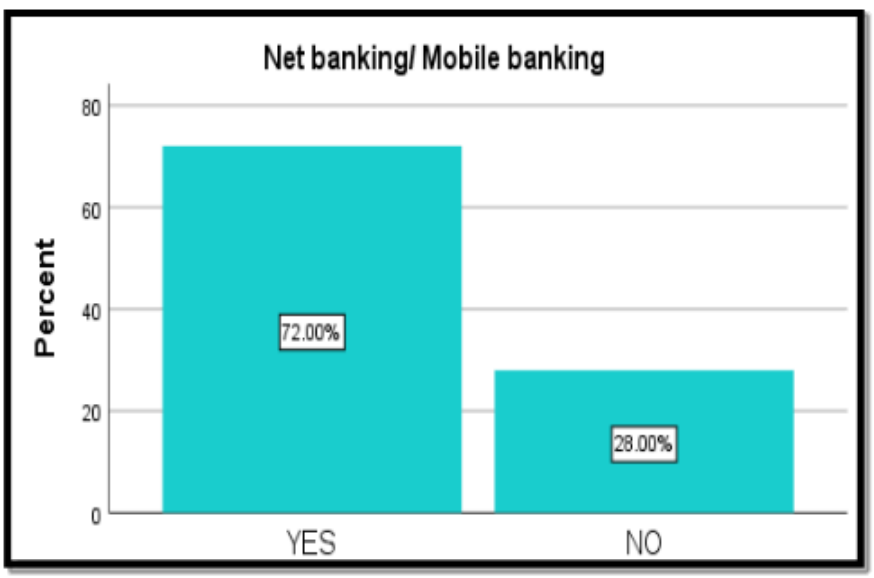

Fig: 4.2.5

Network of BCs / Kiosk

The distribution of banking correspondents (BCs) or kiosks within the ICICI and HDFC networks is shown in the statistics. Within the HDFC network, there are a total of 50 BCs with a frequency of 1.5200, of which 24 represent 48% and 26 represent 52%. Meanwhile, of the 50 BCs with a frequency of 1.7600 in the ICICI network, 12 BCs or kiosks account for 24% and 38 for 76%. The proportion of BCs within each network is shown by these percentages, with HDFC showing a somewhat more balanced distribution than ICICI, which has a larger concentration of BCs among fewer companies.

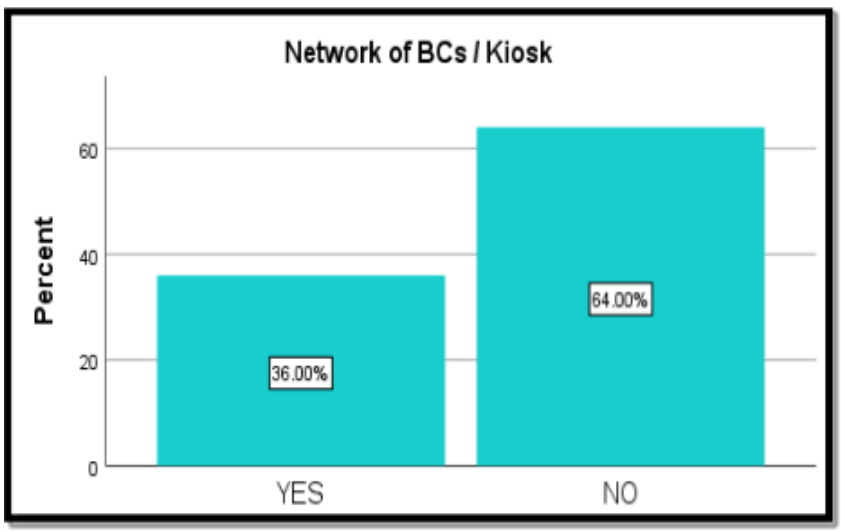

Fig: 4.2.6

Cash credit limit (CCL)

The data supplied displays the cash credit limits (CCL) that ICICI and HDFC banks give for various frequency categories. 10% of HDFC's clientele has a credit limit of $18,000 and a frequency of 20. Furthermore, 40% of clients have a 1.8000 credit limit and an 80 frequency. Finally, 50% of clients have a 1.8000 credit limit and a 100 frequency. In contrast, 12% of ICICI's clientele has a credit limit of 1.7600 at a frequency of 24. Furthermore, 38% of clients have a credit limit of 1.7600 and 76 frequencies. Finally, 50% of clients have a 1.7600 credit limit at a frequency of 100.

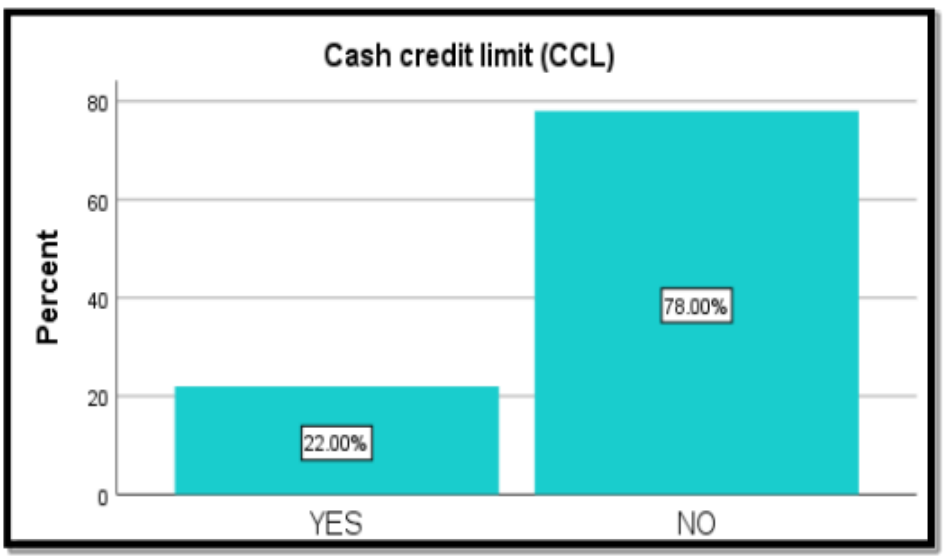

Fig: 4.2.7

Term loan

It appears to describe two term loans, one from HDFC and the other from ICICI, based on the information that has been supplied. With an interest rate of 1.14%, the HDFC loan makes up 43% of the entire amount, while the ICICI loan makes up 50% with an interest rate of 1.80%. One group owns 86% of HDFC's ownership in terms of loan frequency, while another owns 14%, for a total of 100%. Comparably, the distribution for ICICI is 20% and 80% for each of the two categories, for a total of 100%. This data seems to reflect the terms and allocation of two separate term loans from ICICI and HDFC. It also displays the loan amounts and interest rates connected with each loan, as well as the ownership distribution for each loan among various groups.

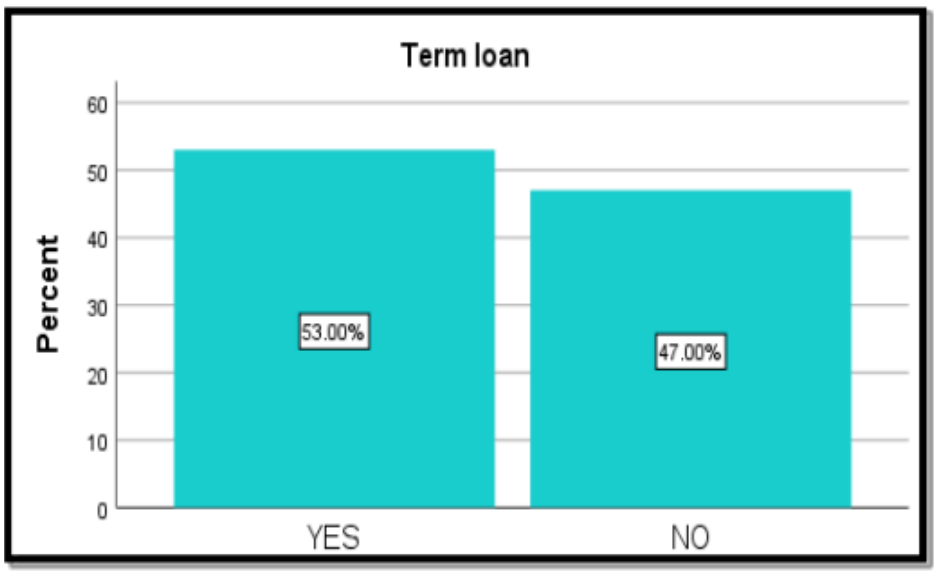

Fig: 4.2.8

Low interest rates on loans

The variation of loan interest rates from two financial institutions—HDFC and ICICI—each representing 50 loans—is demonstrated through the data presented. The average interest rate for HDFC loans is 1.32%, with 34 loans (68%) having a lower interest rate and 16 loans (32%), having a higher rate. With 43 loans (86%) having lower interest rates and 7 loans (14%), having higher interest rates, ICICI's distribution is more skewed. As a consequence, the average interest rate is somewhat lower at 1.14%. According to these figures, both banks primarily provide cheap interest loans. This is especially true of ICICI, where a sizable majority of loans have lower interest rates than those of HDFC. This data points to a market that is competitive and prioritizes giving consumers loans with advantageous interest rates.

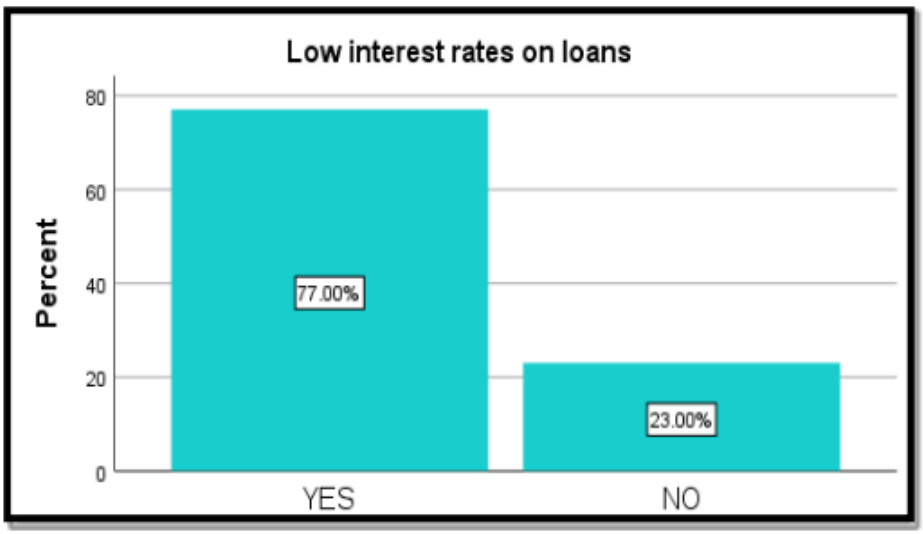

Fig: 4.2.9

PMJJY (For SHG members)

The data provided contrasts the amount of time that members of Self-Help Groups (SHGs) whose bank with ICICI and HDFC have spent participating in the Pradhan Mantri Jeevan Jyoti BimaYojana (PMJJY). 13 (26.0%) of the 50 SHG members in the HDFC group did not choose PMJJY, whereas 37 (74.0%) did. Each member's involvement rate in HDFC Bank was determined to be 1.2600. Similarly, among the 50 SHG members in the ICICI group, 41 (82.0%) enrolled in PMJJY, while 9 (18.0%) did not. At 1.1800 per member, the ICICI participation rate was somewhat lower. These data point to a greater adoption of PMJJY among SHG members via ICICI Bank than through HDFC, indicating that the SHG membership engages with PMJJY at varied degrees across different financial institutions.

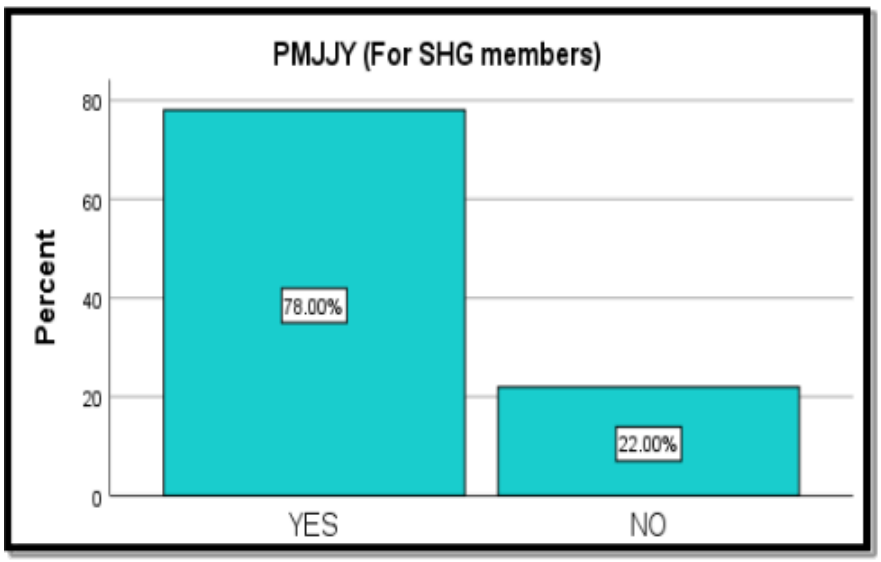

Fig: 4.2.10

PMSBY (For SHG members)

The data provided is classified by HDFC and ICICI banks and pertains to the Self-Help Group (SHG) members' PMSBY (Pradhan Mantri Suraksha BimaYojana). Fifty SHG members were registered in the program by each bank. Of the HDFC members, 11 members (22.0%) did not pay their premium, whilst 39 members (78.0%) did. In contrast, 8 members (16.0%) of ICICI did not pay their premium, while 42 members (84.0%) did. For HDFC and ICICI, the insurance coverage amount is 1.22 and 1.16, respectively. The information provided here shows the insurance coverage ratios and participation rates for the SHG member segment under the PMSBY for each of these institutions.

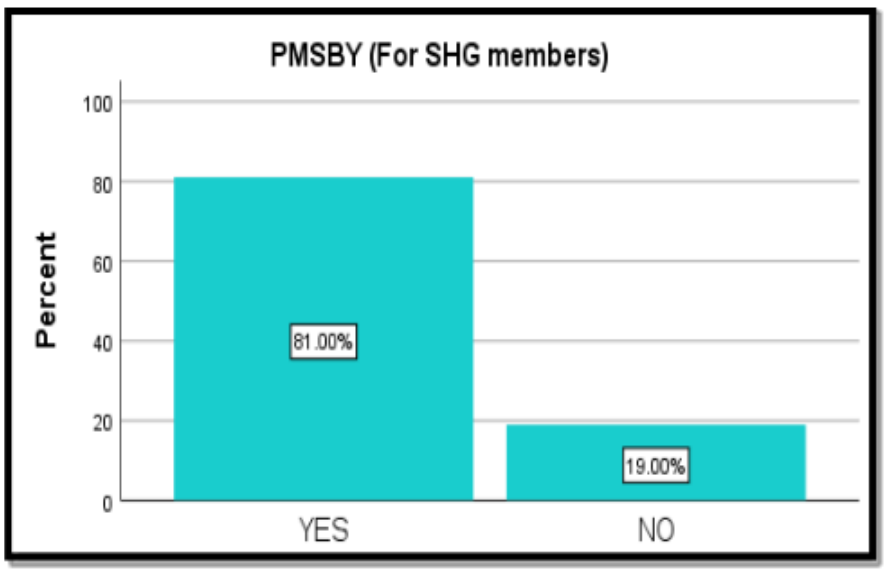

Fig: 4.2.11

APY (For SHG members)

The data provided reflects the Annual Percentage Yield (APY) for participants in Self-Help Groups (SHGs) connected to ICICI and HDFC. The annual percentage yield (APY) for HDFC is determined by varying the frequency of payment cycles (19, 31, and 50) and the percentage distributions of these cycles (38.0%, 62.0%, and 100.0%, respectively). Comparably, ICICI displays several frequency distributions (24, 26, and 50) with matching percentage splits (48.0%, 52.0%, and 100.0%, respectively), which add out to an annual percentage yield (APY) of 1.5200. With the frequency and distribution of their financial operations taken into account, these numbers most likely represent the interest rates or returns that SHG members inside these institutions have earned.

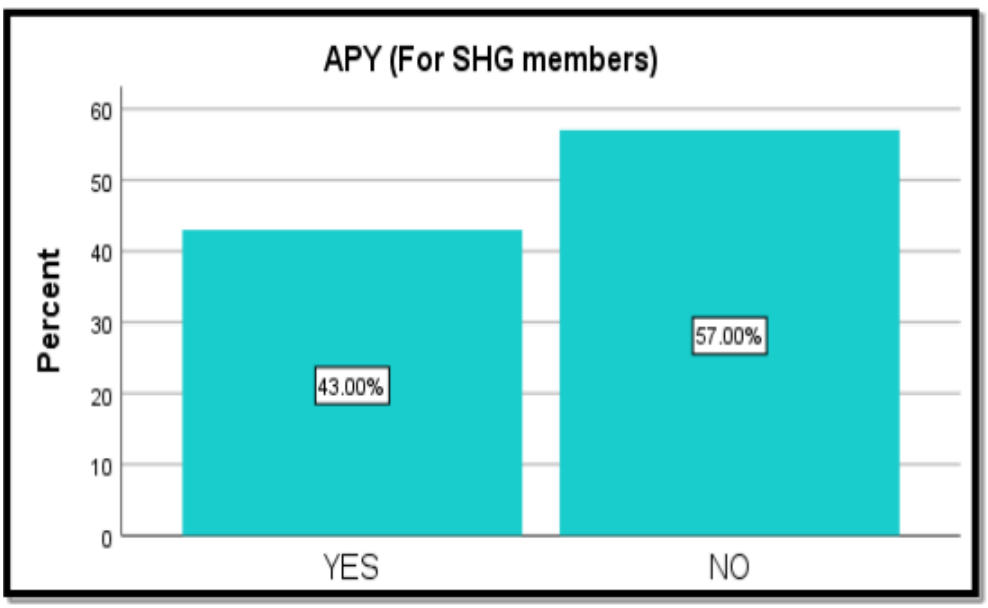

Fig: 4.2.12

PPF (For SHG members)

The data provided indicates how well HDFC and ICICI, two financial institutions, performed in terms of helping members of Self-Help Groups (SHGs) enroll in PPFs (Public Provident Funds). Out of 50 SHG members, 12 (24.0%) have enrolled in PPF with HDFC, and 38 (76.0%) have chosen to enroll with other institutions, for a total enrolment rate of 100.0% for HDFC. On the other hand, of the 50 SHG members, 10 members (20.0%) have enrolled in PPF via ICICI, and 40 members (80.0%) have chosen to enroll with other institutions, for a total enrolment rate of 100.0%. HDFC's average member investment amount is 1.7600, whilst ICICI's is little higher at 1.8000. The distribution of PPF subscriptions among SHG members between HDFC and ICICI is seen in these figures, underscoring each company's relative market dominance in this category.

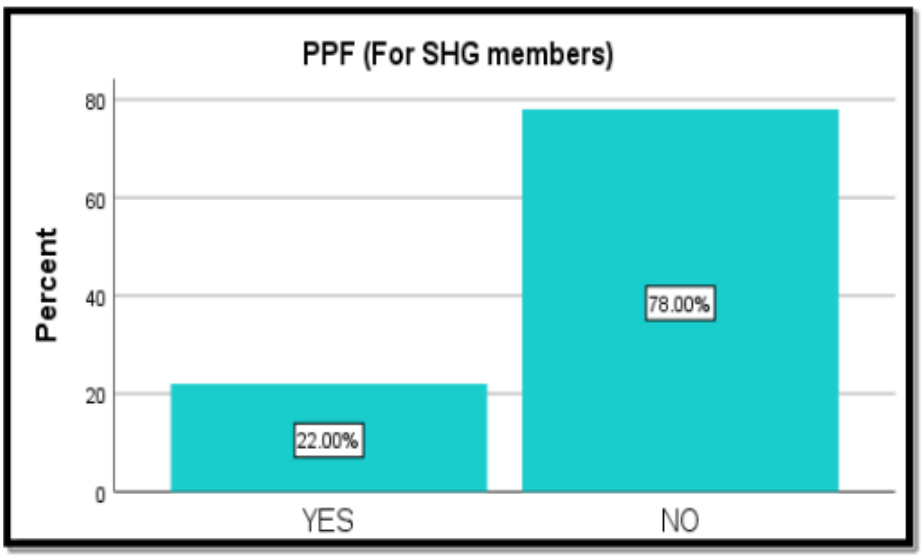

Fig: 4.2.13

MUDRA loan / Business loan (For SHG members)

Based on the data provided, it seems to be a comparison of MUDRA (Micro Units Development and Refinance Agency) and business loans given to members of Self-Help Groups (SHGs) by two banks, ICICI and HDFC. The information shows how often each bank disburses loans to its customers; of the 50 members, 28 received loans from HDFC (56%) and 33 from ICICI (66%). This implies that, in comparison to HDFC, ICICI has a little better loan approval rate among SHG members. By giving access to capital for income-generating activities, MUDRA loans seek to boost microenterprises and startups. The data shows the banks' involvement in this government-led program to encourage financial inclusion and entrepreneurship among underserved communities.

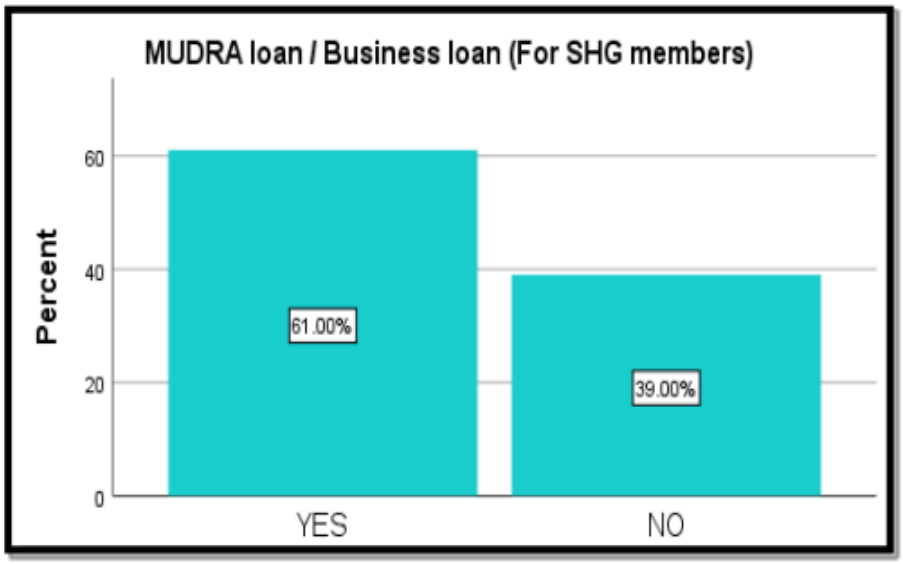

Fig: 4.2.14

Table 3 Private Bank Formalities for SHGs

Statements		YES	NO	Total	Mean
Papers are mandatory for a/c opening	Frequency	81	19	100	1.1900
	Percent(%)	81.0	19.0	100.0	
Mandatory KYC verification at branch level	Frequency	89	11	100	1.1100
	Percent(%)	89.0	11.0	100.0	
Every member of SHG should be present at the branch to open the account	Frequency	13	87	100	1.8700
	Percent(%)	13.0	87.0	100.0	
Signed resolution copy for opening account	Frequency	88	12	100	1.1200
	Percent(%)	88.0	12.0	100.0	
Minimum deposit is mandatory in SB account	Frequency	84	16	100	1.1600
	Percent(%)	84.0	16.0	100.0	
Copy of meeting minutes is mandatory for withdrawal/fund transfer	Frequency	90	10	100	1.1000
	Percent(%)	90.0	10.0	100.0	
Mortgage for loan	Frequency	7	93	100	1.9300
	Percent(%)	7.0	93.0	100.0	
For every banking formality the SHG official has to sign with rubber stamp	Frequency	93	7	100	1.0700
	Percent(%)	93.0	7.0	100.0	

Table: 4.3

Papers are mandatory for a/c opening

Based on the statistics provided, it seems that 81% of account openings need documents, whilst just 19% of instances do not. This indicates that a sizable percentage of account openings need paperwork. With a total sum of 100%, the frequency distribution clearly shows the difference between these two circumstances. This data emphasizes the necessity of documentation in the majority of these processes by highlighting the common demand for paperwork during account initiation.

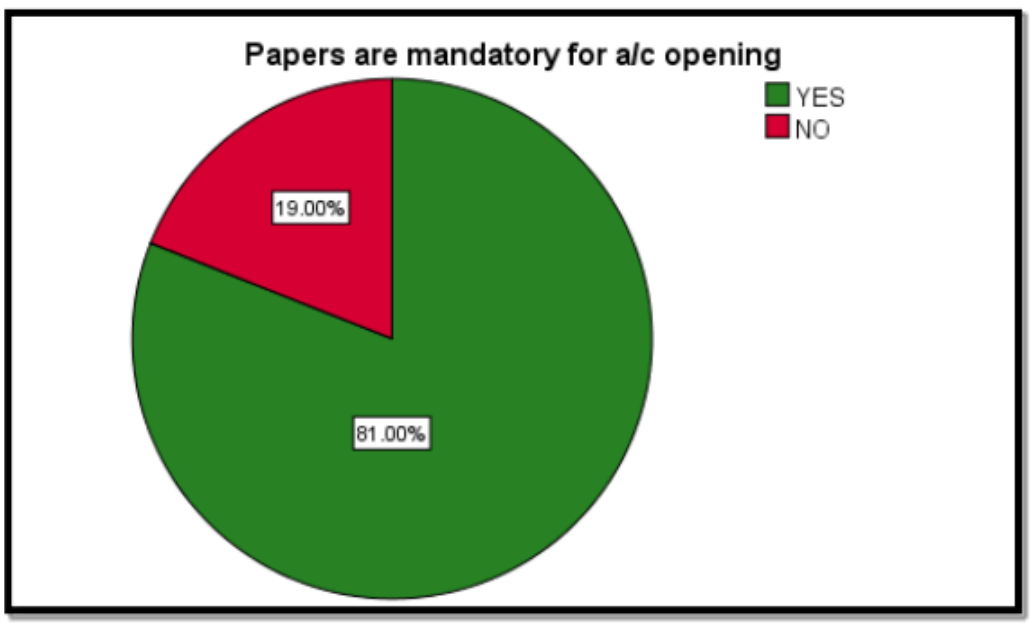

Fig: 4.3.1

Mandatory KYC verification at branch level

The data provided shows how often necessary KYC (Know Your Customer) verifications at the branch level are carried out as well as their percentage distribution. Based on the data, it is evident that 89 out of 100 occurrences have a high frequency, making up 89% of all verifications. On the other hand, 11 verifications (11%) were either performed less often or made up a lower percentage of all KYC verifications. The data indicates that branch-level KYC processes are given a great deal of importance, since most verification is focused in this region. The numbers highlight how crucial and frequent these checks are in guaranteeing security and compliance in the organization's client on boarding and management procedures.

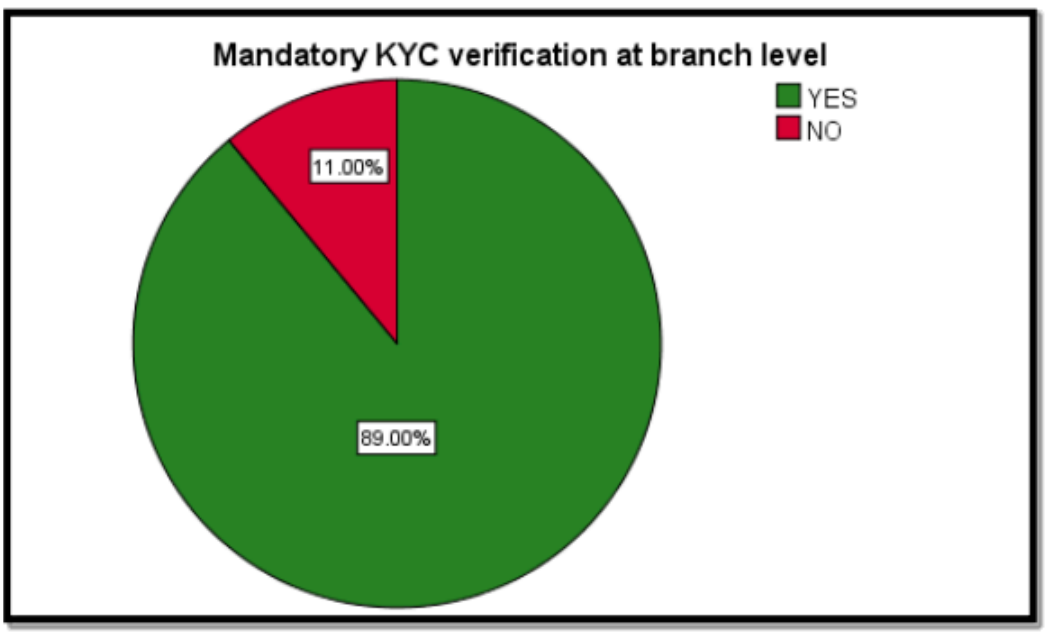

Fig: 4.3.2

Every member of SHG should be present at the branch to open the account

The data provided suggests that all Self-Help Group (SHG) members must be present in order for an account to be opened at the branch. According to the frequency distribution, this criteria was satisfied 13 times out of 100 times, or 13% of the total. On the other hand, this requirement was not met in 87 cases (or 87%) indicating that some SHG members were not present when the account was established. The aforementioned data emphasizes how crucial it is to guarantee that SHG members attend all meetings in order to follow the branch's account opening process.

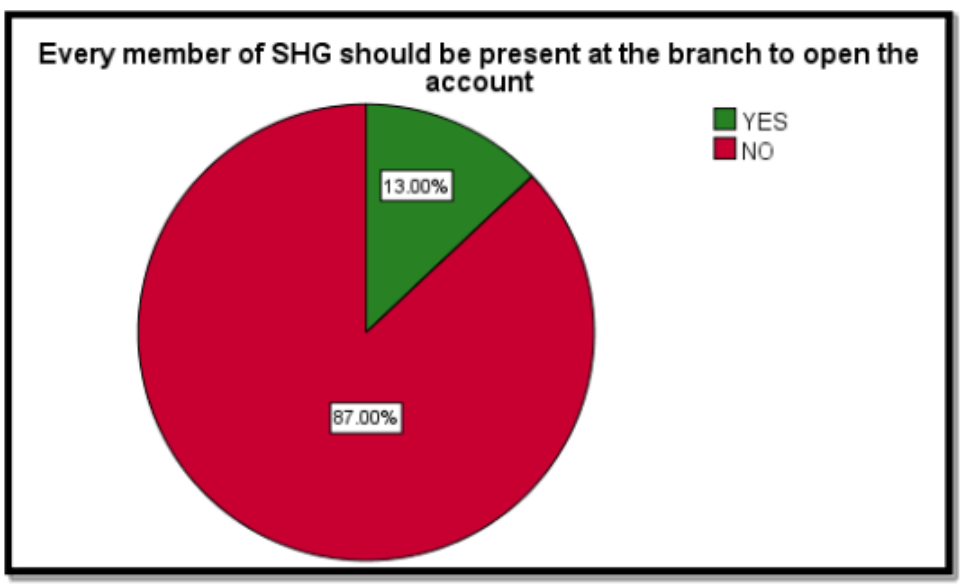

Fig: 4.3.3

Signed resolution copy for opening account

It indicates to provide information on a signed resolution for starting an account, based on the data that was supplied. The percentages and frequencies in the statistics indicate a distribution or breakdown among several categories or things. In particular, it seems that the frequencies are 88, 12, and 100, which may represent counts or occurrences related to account opening operations. The percentages 88.0%, 12.0%, and 100.0% that correspond to these numbers most likely indicate distributions or proportions in relation to the total or particular requirements. It's difficult to accurately determine the nature of these numbers in the absence of further context, although they seem to be parts of an organized process or analysis connected to account management or resolution documents.

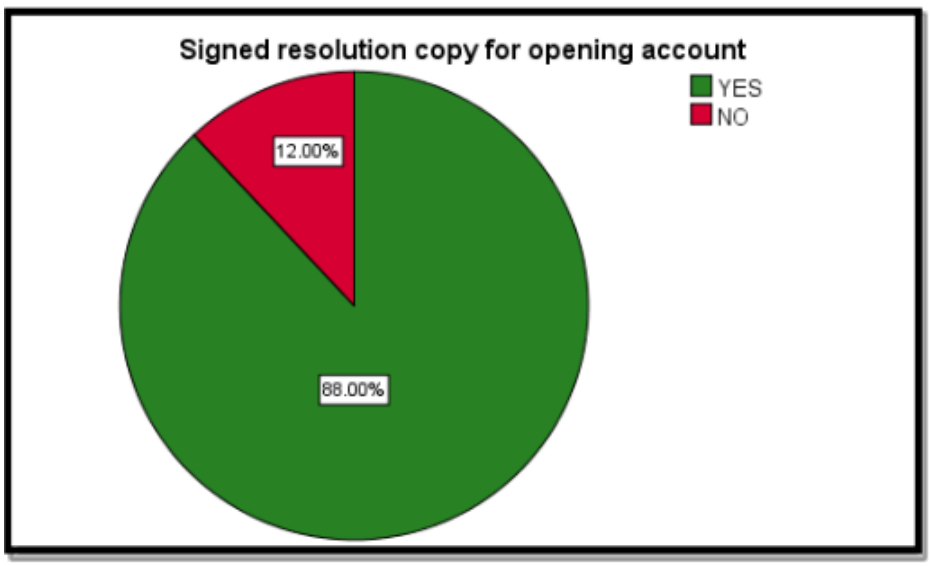

Fig: 4.3.4

Minimum deposit is mandatory in SB account

A minimum deposit requirement for a Savings Bank (SB) account is provided in the data. The frequency distribution demonstrates that this obligation is applicable in different circumstances: 84 cases, or 84.0%, and 16 cases, or 16.0%, for a total of 100 cases. The corresponding percentage of 1.1600 indicates a certain percentage pertaining to these circumstances. This data emphasizes how important it is to have a minimum deposit policy in a variety of situations, as this will guarantee compliance and consistency when managing SB accounts.

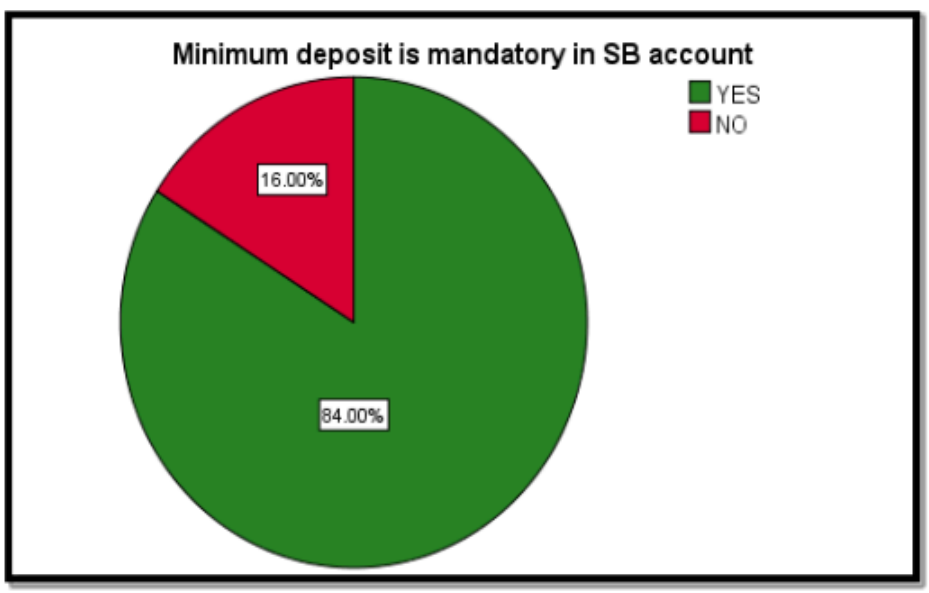

Fig: 4.3.5

Copy of meeting minutes is mandatory for withdrawal/fund transfer

It appears from the data provided that a copy of the meeting minutes is required in order to make a withdrawal or transfer funds. According to the frequency distribution, this criterion is met 90% of the time and not met 10% of the time. Furthermore, the percentage breakdown shows that this criterion is necessary for the transaction in 100% of instances when it is present. As a result, in order to properly enable their operations, anyone who are involved in withdrawal or money transfer activities must make sure they have the necessary meeting minutes' paperwork.

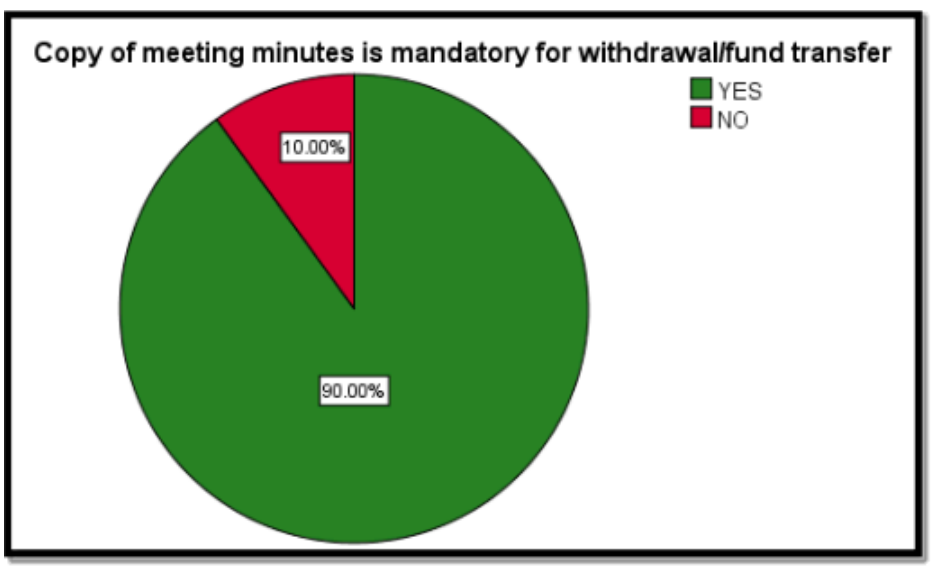

Fig: 4.3.6

Mortgage for loan

It seems to be describing a mortgage loan with a frequency distribution based on the information supplied. According to the statistics, 7 percent of the loans fit into one group, 93% into another, and 100% would fall into yet another category. Giving a more thorough explanation is difficult without further context or distinct descriptions for each group. Understanding the distribution of mortgage loans across various parameters, such as interest rates, loan amounts, or durations, may need knowledge of these information.

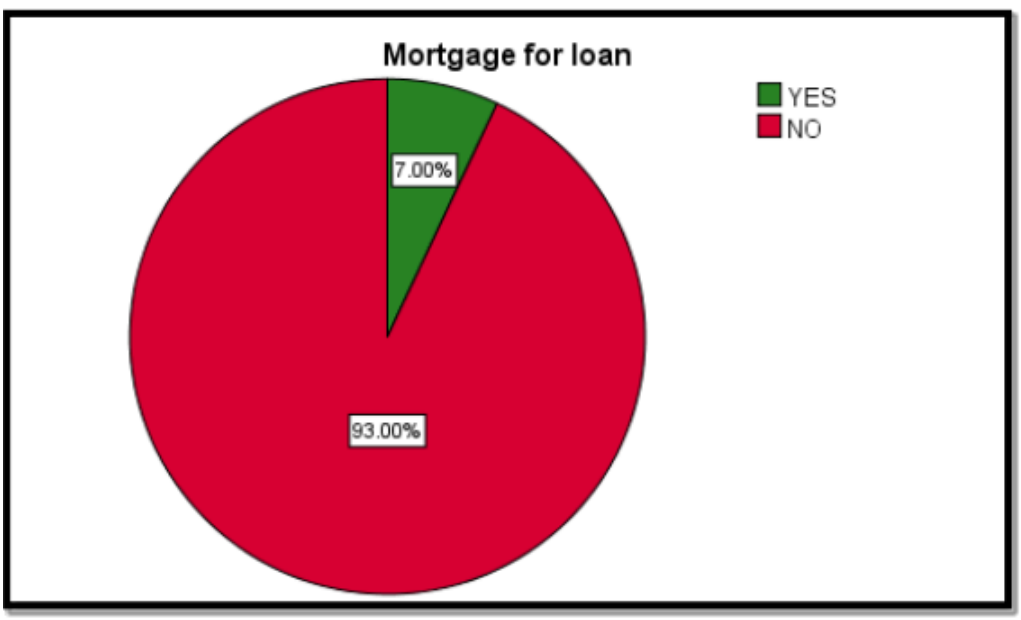

Fig: 4.3.7

For every banking formality the SHG official has to sign with rubber stamp

The data provided indicates that the SHG (Self-Help Group) representative must use a rubber stamp to sign banking documents. The 93 occurrences out of 100, or 93.0%, of this activity suggest that it happens with a high frequency according to the frequency distribution. This implies that the SHG official's employment of the rubber stamp is a regular and required process that happens consistently throughout the bulk of banking requirements. The remaining 7 cases (7.0%) most likely correspond to situations when handwritten signatures are needed in place of rubber stamps. As a result, the data emphasizes how important the rubber stamp is to the SHG official's ability to do banking processes.

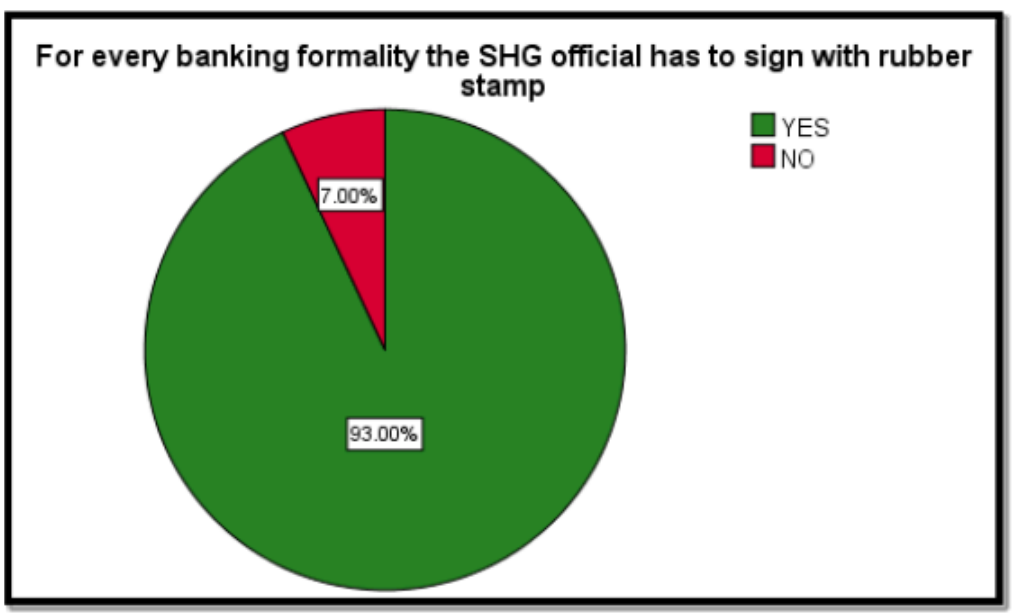

Fig: 4.3.8

Table 4 Review of government-sponsored schemes

Statements		YES	NO	Total	Mean
Financial literacy camps for SHGs are jointly organized by banks and nodal government schemes/missions	Frequency	66	34	100	1.3400
	Percent(%)	66.0	34.0	100.0	
Capacity building training for SHGs is jointly organized by banks and government schemes/missions	Frequency	53	47	100	1.4700
	Percent(%)	53.0	47.0	100.0	
The nodal government scheme/mission is doing excellent work in capacity building of SHGs	Frequency	80	20	100	1.2000
	Percent(%)	80.0	20.0	100.0	
Assistance to SHGs through government schemes/missions	Frequency	87	13	100	1.1300
	Percent(%)	87.0	13.0	100.0	
Livelihood promotion of groups through government schemes/missions	Frequency	80	20	100	1.2000
	Percent(%)	80.0	20.0	100.0	
Nodal Government scheme/mission assistance to the Bank in respect of SHGs	Frequency	84	16	100	1.1600
	Percent(%)	84.0	16.0	100.0	

Table:4.4

Financial literacy camps for SHGs are jointly organized by banks and nodal government schemes/missions

The data provided demonstrates compelling evidence that Self-Help Groups (SHGs) address important social concerns including health, nutrition, and gender equality and successfully foster camaraderie among its members. Based on the frequency distribution, all respondents (100) agreed that SHGs have a dual function. This agreement emphasizes the important role SHGs play in strengthening community relationships and promoting social problems. The unanimous consensus highlights the widespread acknowledgement of Self-Help Groups (SHGs) as essential forums for advocacy and empowerment, signifying a shared commitment to comprehensive development and gender-inclusive programs.

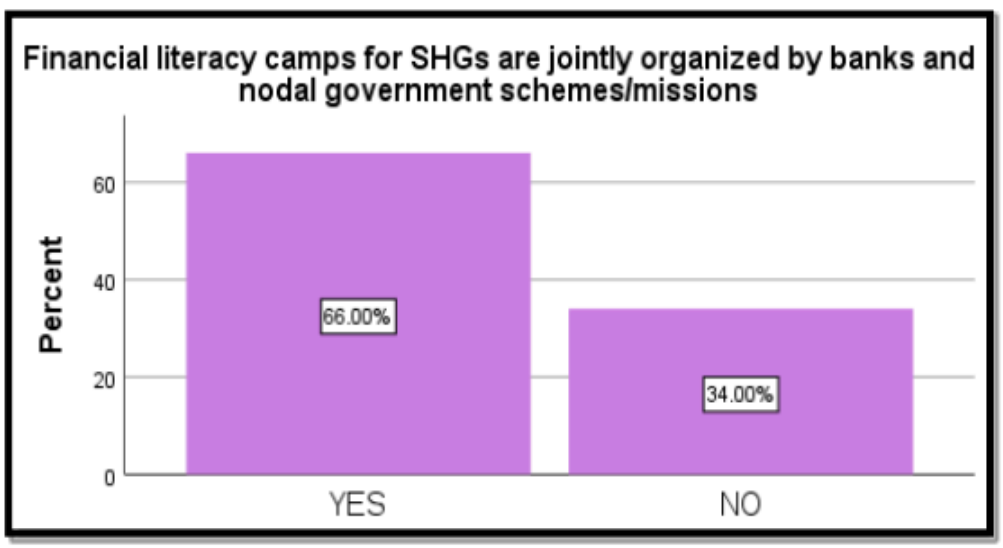

Fig:4.4.1

Capacity building training for SHGs is jointly organized by banks and government schemes/missions

The data indicates that banks and government programs/missions work together to provide Self-Help Groups (SHGs) with capacity development training. Of the 100 responders in the survey, 53 percent attested to the cooperative planning of these training sessions, and 47 percent disagreed. This implies that banks and government efforts have played a key role in empowering Self-Help Groups (SHGs), indicating a deliberate attempt to improve their competencies. These kinds of cooperative projects probably seek to increase the financial literacy and entrepreneurial skills of SHG members in order to support their eventual economic independence and sustainable growth.

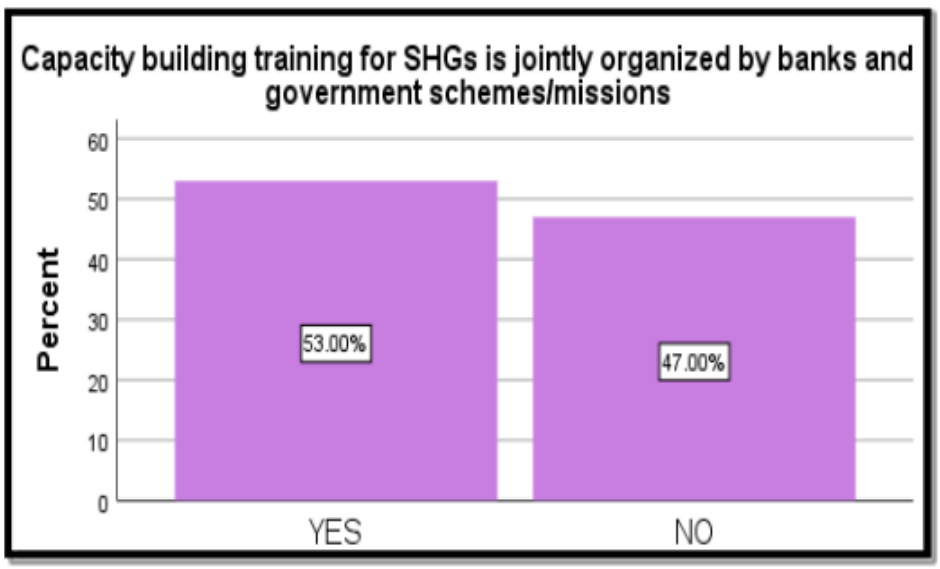

Fig:4.4.2

The nodal government scheme/mission is doing excellent work in capacity building of SHGs

The data presented indicates that the government's nodal strategy or mission aimed at enhancing the ability of Self-Help Groups (SHGs) is operating admirably. Twenty respondents, or 20% of the overall sample, disagreed with the assertion that the plan is doing very well in this area, while the remaining 80 respondents, or 80% of the sample, said otherwise. The scheme's attempts to improve SHGs' capacities have received considerable favourable response, as seen by the high approval percentage of 80%. The polled population's continuously favourable assessment of the efficacy and impact of this government project is further shown by the mean score of 1.2000. The majority of respondents deemed the plan to be successful and effective in achieving its goals of strengthening SHG capability, as shown by these findings.

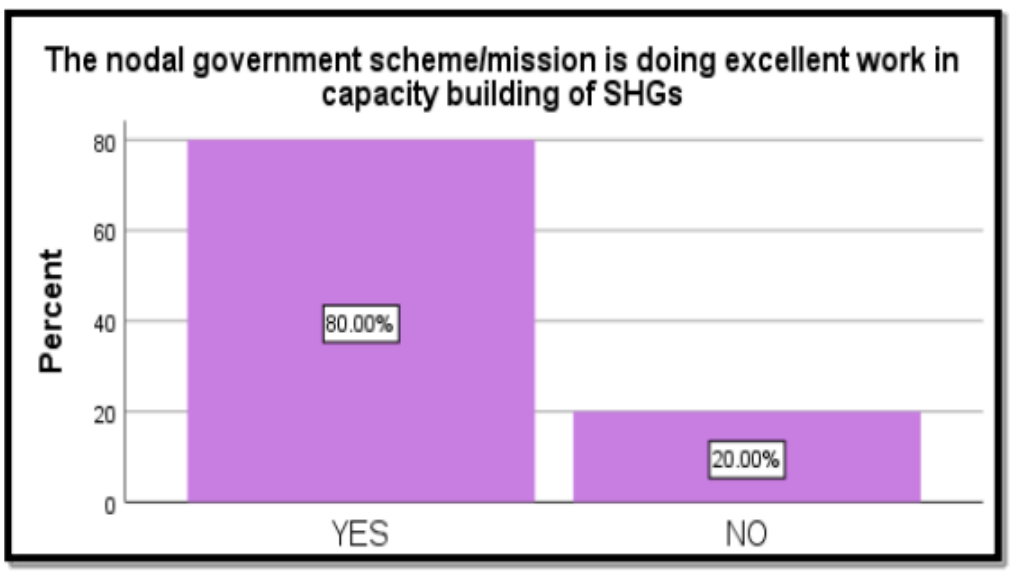

Fig:4.4.3

Assistance to SHGs through government schemes/missions

The information supplied demonstrates the way government programs and missions are used to provide aid to Self-Help Groups (SHGs). Thirteen of the 100 instances of help had a negative response ("NO"), while the rest 87 were classified as positive ("YES"). With 87% of SHGs getting help via these efforts, this indicates a significant majority of support. This kind of focused assistance shows a strong commitment to supporting inclusive economic policies and grassroots development by empowering SHGs and encouraging economic growth via community-driven initiatives.

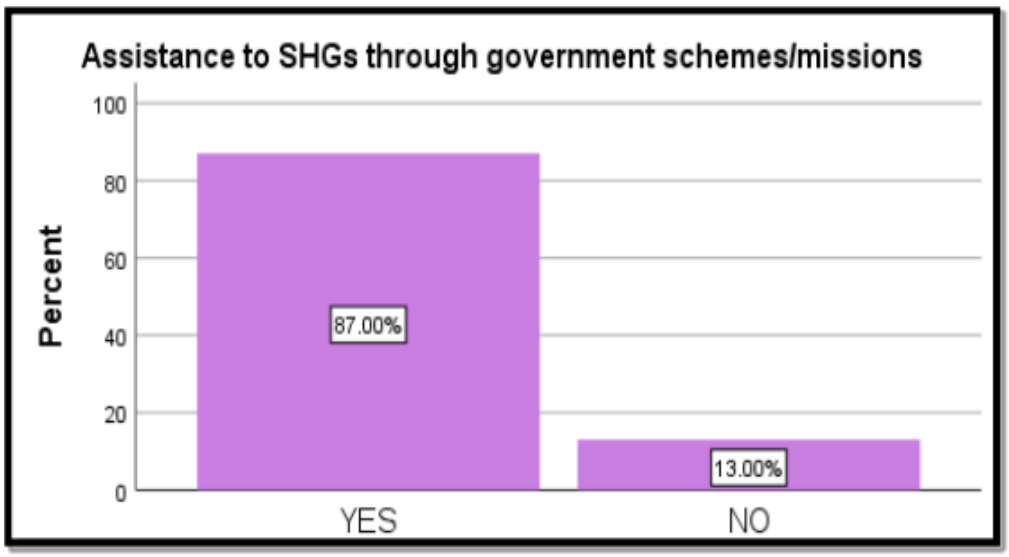

Fig: 4.4.4

Livelihood promotion of groups through government schemes/missions

The data presented demonstrates that government initiatives aimed at promoting certain groups' livelihoods have had a noticeable effect. Eighty people ("YES") answered in the positive out of a total of one hundred replies, demonstrating a high degree of participation and support for these efforts. On the other hand, 20 respondents gave a negative response ("NO"). According to this breakdown, the surveyed population had a noteworthy 80% approval score for the livelihood enhancement activities. A significant overall favourable tendency towards the government's efforts in this subject is indicated by the mean score of 1.20. These results demonstrate a majority agreement in support of government programs and missions, underscoring their significance and efficacy in enhancing livelihoods within communities.

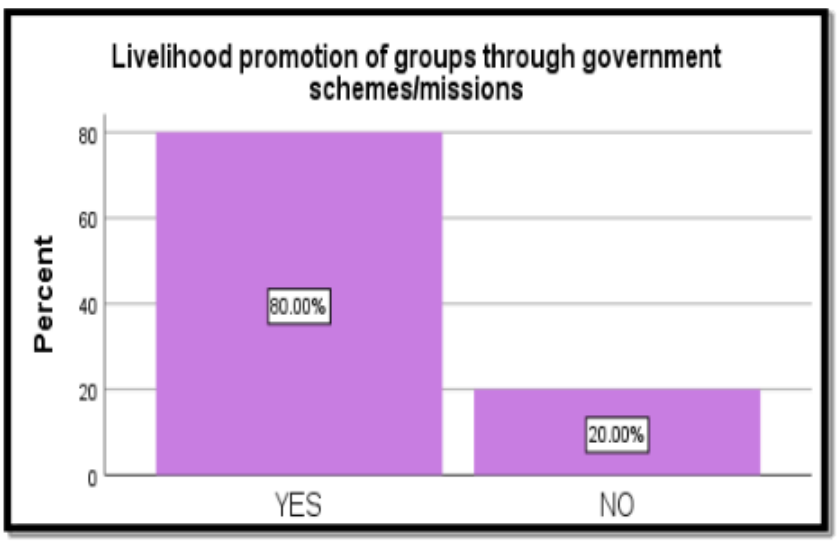

Fig: 4.4.5

Nodal Government scheme/mission assistance to the Bank in respect of SHGs

The data demonstrated indicates the support a bank received from a Nodal Government program or mission concerning Self-Help Groups (SHGs). According to the provided frequency table, the program has benefited the bank in 84 cases—or 84% of the total—out of a total of 100 occasions. In contrast, the bank did not get help from this plan in 16 cases, or 16% of all the cases. The aforementioned data highlights the noteworthy degree of assistance provided to the bank by the Nodal Government program concerning Self-Help Groups (SHGs). It also suggests a noteworthy usage and effect of this assistance inside the context of these groups.

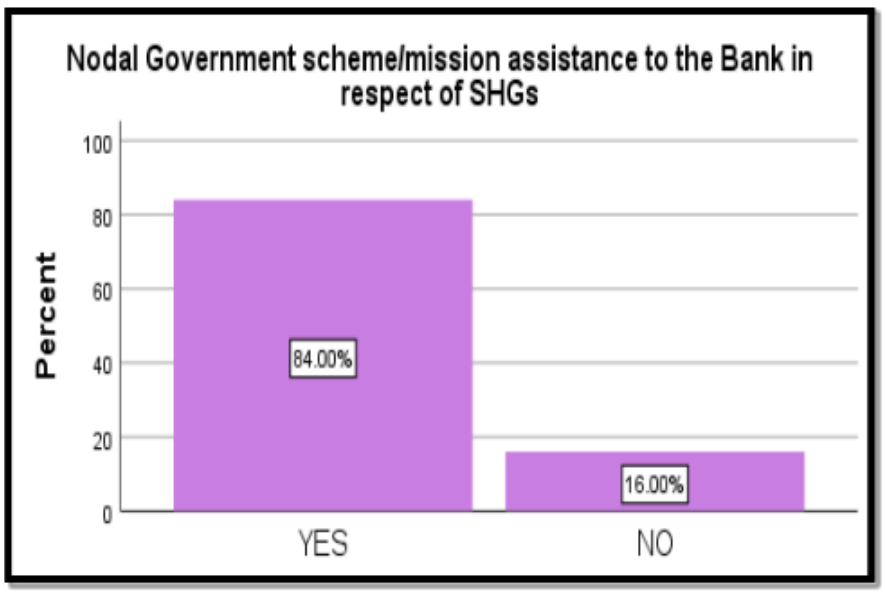

Fig:4.4.6

Table 5 SHGs Development

		YES	NO	Total	Mean
Are you aware of any government-sponsored schemes aimed at supporting Self Help Groups	Frequency	78	22	100	1.2200
	Percent(%)	78.0	22.0	100.0	
Has your SHG benefited from any government-sponsored schemes?	Frequency	89	11	100	1.1100
	Percent(%)	89.0	11.0	100.0	
Do you believe government-sponsored schemes adequately address the needs of SHGs?	Frequency	69	31	100	1.3100
	Percent (%)	69.0	31.0	100.0	
Are government-sponsored schemes accessible and easy to participate in for SHGs?	Frequency	73	27	100	1.2700
	Percent (%)	73.0	27.0	100.0	
Do you think government-sponsored schemes have positively impacted the functioning and development of SHGs?	Frequency	85	15	100	1.1500
	Percent (%)	85.0	15.0	100.0	

Table: 4.5

Are you aware of any government-sponsored schemes aimed at supporting Self Help Groups?

The data presented indicates that 78% of participants are aware of government-sponsored initiatives designed to assist Self Help Groups (SHGs), whilst 22% are not aware of such initiatives. This implies that the examined population has a noteworthy degree of awareness. According to the mean response rate of 1.22, most respondents are typically aware of these initiatives. The results demonstrate a notable level of recognition and participation in government programs aimed at supporting and empowering Self-Help Groups (SHGs), indicating prospects for further outreach and advancement in this domain.

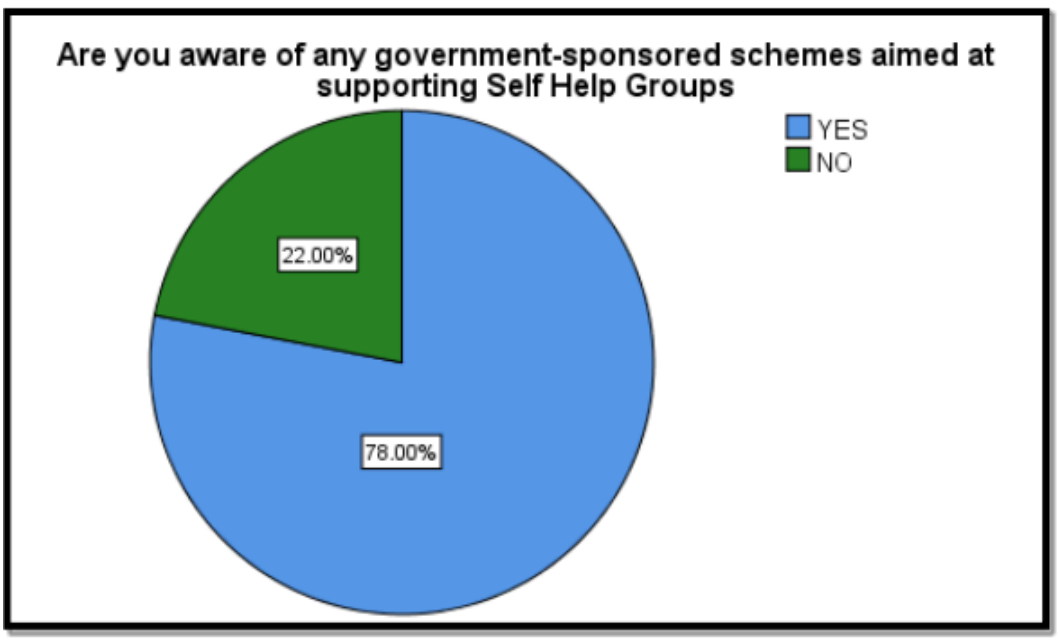

Fig: 4.5.1

Has your SHG benefited from any government-sponsored schemes?

The data provided presents it as clear that a significant percentage of Self-Help Groups (SHGs) have profited from government-sponsored initiatives. 89 of the 100 SHGs who participated in the poll said they had benefited from these programs, while the other 11 had not. With almost 89% of SHGs having used these tools, this shows that the SHG community is highly engaged with and supportive of government activities. These programs probably have a major impact on empowering and assisting SHGs, which may help ensure their long-term viability. Subsequent examination may explore the precise nature and effects of these governmental initiatives on the operations and growth of Self-Help Groups.

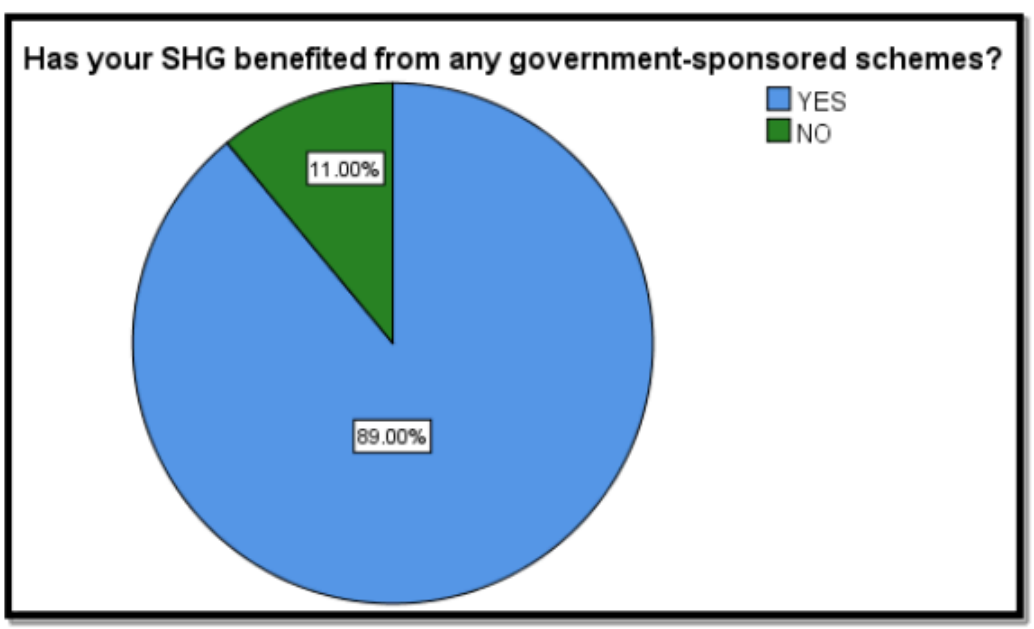

Fig: 4.5.2

Do you believe government-sponsored schemes adequately address the needs of SHGs?

Responses to the question of whether government-sponsored programs sufficiently support Self-Help Groups (SHGs) are shown in the statistics. Thirty-one respondents (31%) disagree with the notion that these schemes satisfactorily meet the needs of SHGs, out of a total of one hundred participants. This suggests that there is a good deal of support for government programs designed to assist SHGs. The surveyed group's mean answer value of 1.31 indicates that they usually felt these approaches were successful. The data also reveals a sizable minority of people who believe that greater government interventions might be made to better satisfy the requirements of SHGs. This implies that there are differing opinions among those asked about how well the present government-sponsored SHG projects are.

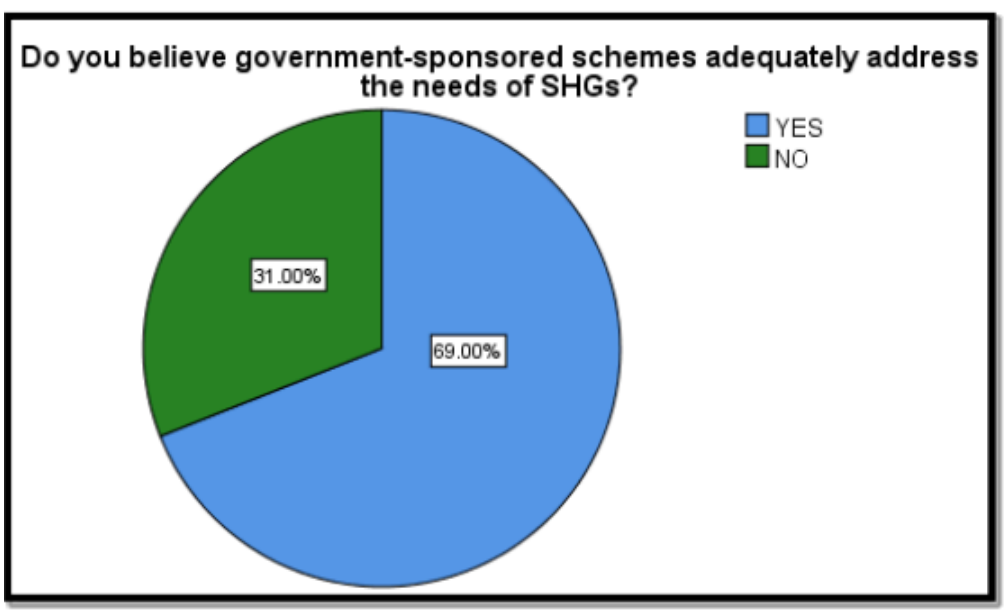

Fig: 4.5.3

Are government-sponsored schemes accessible and easy to participate in for SHGs?

According to the statistics supplied, it seems that 73% of Self-Help Groups (SHGs) believe government-sponsored programs are easily accessible and simple to engage in, whilst 27% disagree. This indicates that most SHGs are satisfied with how accessible and simple it is to participate in these programs. The average score of 1.27 indicates a generally good view, with a greater proportion of SHGs reporting pleasant experiences than not. These results demonstrate how well government initiatives work to make programs understandable and valuable to Self-Help Groups (SHGs), which may lead to increased SHG membership and benefits.

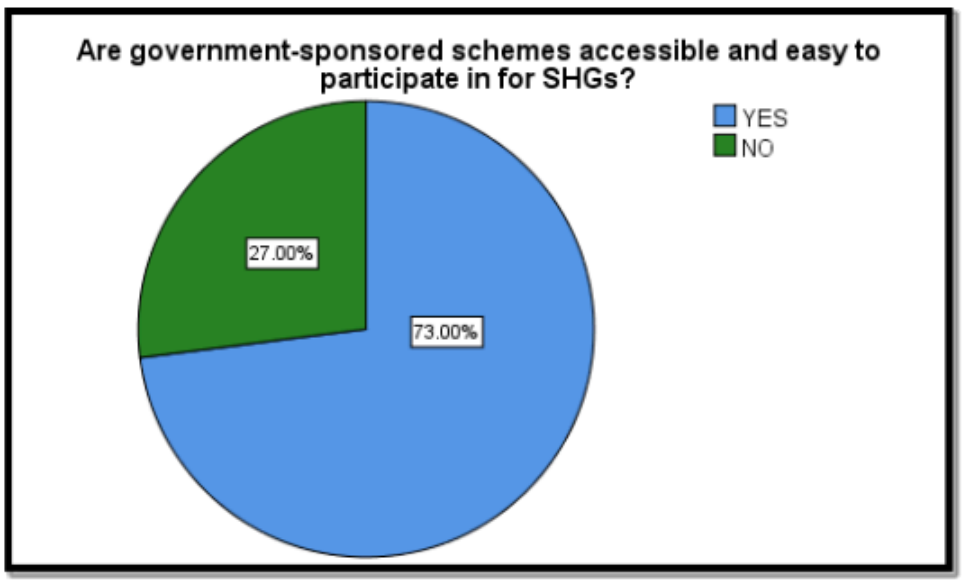

Fig: 4.5.4

Do you think government-sponsored schemes have positively impacted the functioning and development of SHGs?

The data presented indicates a prevailing favourable impression of the influence of government-sponsored initiatives on the operations and growth of Self-Help Groups (SHGs). Of the responders in total, 85% think these plans have had a beneficial impact, whilst 15% disagree. This suggests that a sizable majority of people agree that government actions have benefited SHGs. This tendency is further supported by the mean score of 1.15, which indicates a generally favourable opinion of the efficiency and advantages of such programs in empowering and developing the capacities of SHGs. The research indicates that stakeholders have a notable degree of trust and satisfaction with the way government interventions support the development and operation of SHGs.

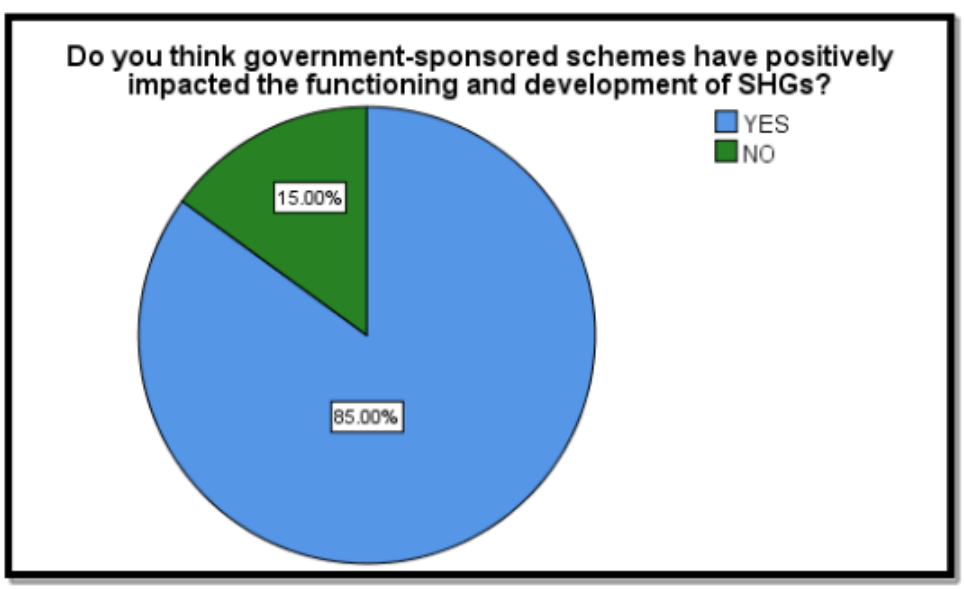

Fig: 4.5.5

Table 6 Factors motivating women to form SHGs

statements		YES	NO	Un Decided	Total	Mean
SHGs are playing an important role in the economic independence of women.	Frequency	178	98	24	300	1.486
	Percent (%)	59.3	32.7	8.0	100	
SHGs play an important role in overcoming social evils like alcoholism, drug addiction, gambling etc.	Frequency	219	57	24	300	1.350
	Percent(%)	73.0	19.0	8.0	100	
SHGs empower women and develop leadership skills.	Frequency	254	34	12	300	1.193
	Percent(%)	73.0	19.0	8.0	100	
After becoming a part of SHG, women's self-esteem also increases.	Frequency	221	59	20	300	1.330
	Percent(%)	73.7	19.7	6.7	100	
SHGs are developing decision making skills and entrepreneurship	Frequency	222	55	23	300	1.336
	Percent(%)	74.0	18.3	7.7	100	
SHG promotes solidarity among its members, it also takes up issues like health, nutrition, gender equality etc.	Frequency	198	69	33	300	1.450
	Percent(%)	66.0	23.0	11.0	100	

Table:6.1

SHGs are playing an important role in the economic independence of women.

The table and graph depict the impact of Self-Help Groups (SHGs) on women's economic independence. Out of a total of 300 respondents, 178 (59.3%) answered "YES" indicating SHGs' significant role, while 98 (32.7%) answered "NO" suggesting a differing opinion, and 24 (8.0%) were unsure ("Not Known"). The mean response value stands at 1.486, reflecting a positive trend towards SHGs contributing to women's economic empowerment. This data underscores the ongoing conversation about the efficacy and influence of SHGs in fostering financial autonomy among women, capturing varying perspectives within the surveyed population.

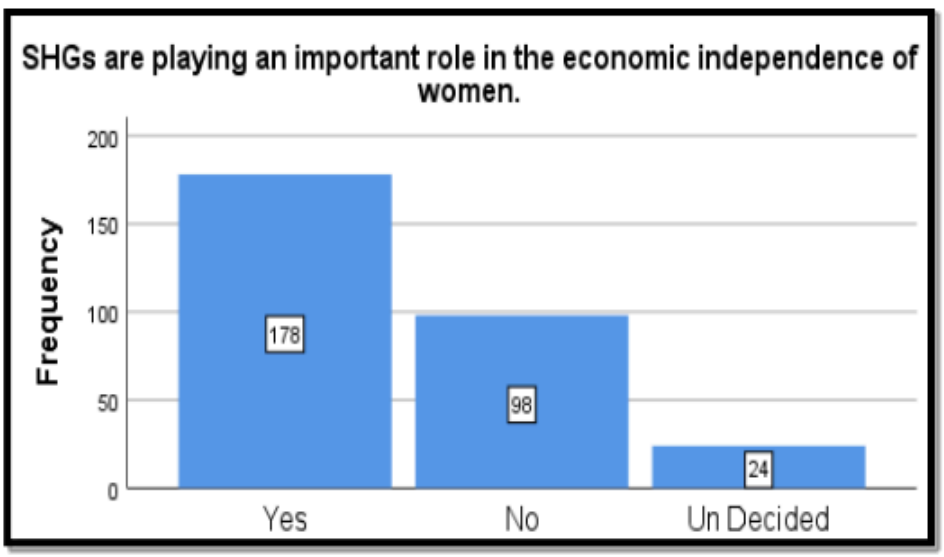

Fig: 4.6.1

SHGs play an important role in overcoming social evils like alcoholism, drug addiction, gambling etc.

The table and graph show information about how important Self Help Groups (SHGs) are for dealing with social problems like drug and alcohol abuse, gaming, and more. After receiving 300 answers, 219 people, or 73% of those who answered, agreed that SHGs do play a key role in fighting these social problems. On the other hand, 57 individuals (19%) were skeptical and thought that SHGs might not work in this way. Additionally, 24 respondents (8%) said they didn't know how SHGs would affect these problems. The average number for the answers shows a somewhat positive view, with most people agreeing that SHGs are important for solving problems in society.

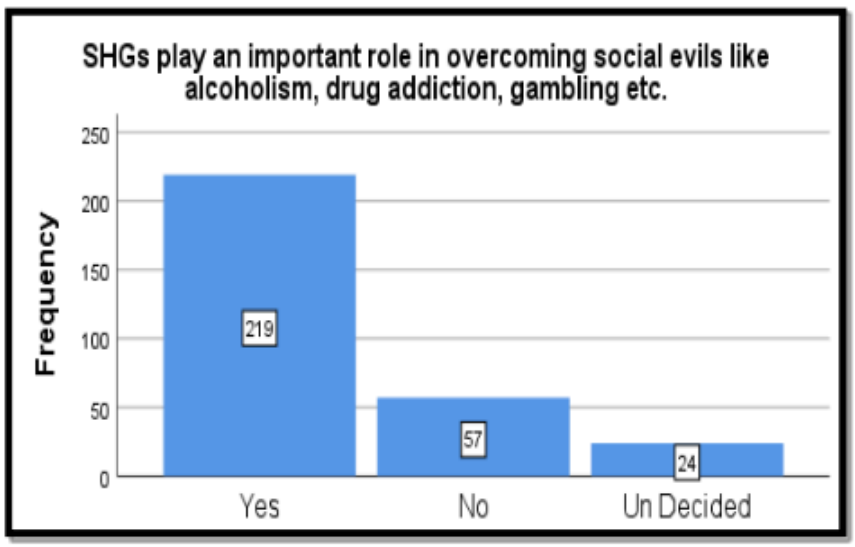

Fig: 4.6.2

SHGs empower women and develop leadership skills:

Based on responses from 300 people, the table and image show how Self-Help Groups (SHGs) help women gain confidence and learn how to be leaders. Out of the people who answered, 254 said that SHGs give women power and help them become better leaders, 34 said they didn't agree, and 12 said they didn't know for sure. This information gives us a mean score of 1.193, which shows that most people think SHGs are a good way to help women become more independent and take charge. With this graph, the results are shown visually: 73.0% of respondents strongly believe that SHGs strengthen women, 19.0% have doubts, and 8.0% are not sure about the effect. Overall, the data shows that most people agree that SHGs are a way to help women gain power and become better leaders.

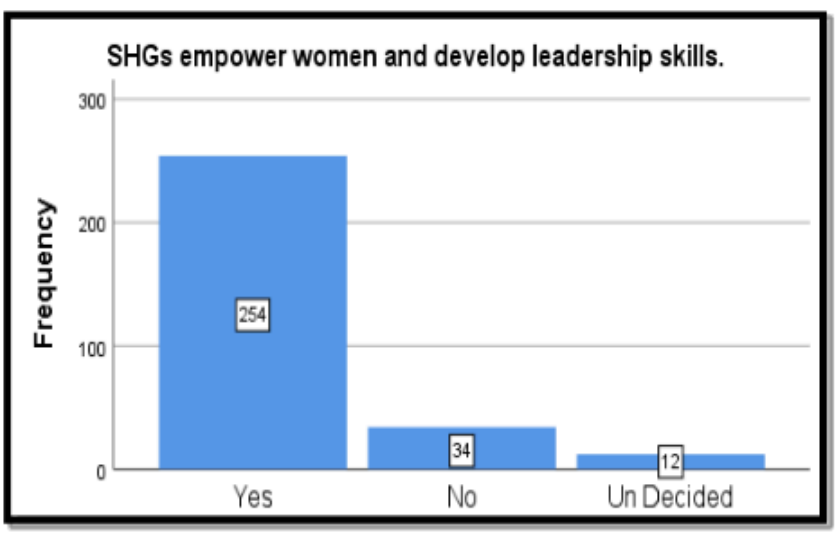

Fig: 4.6.3

After becoming a part of SHG, women's self-esteem also increases:

These tables and graphs show how joining a Self-Help Group (SHG) affects women's self-esteem. The data shows that out of 300 women who answered, 221 said their self-esteem went up after joining a SHG, 59 said it didn't change, and 20 weren't sure what the effect was. Therefore, 73.7% of women have higher self-esteem, 19.7% have no change, and 6.7% are not sure. These women's average self-esteem number is 1.330, which shows a usually good effect.

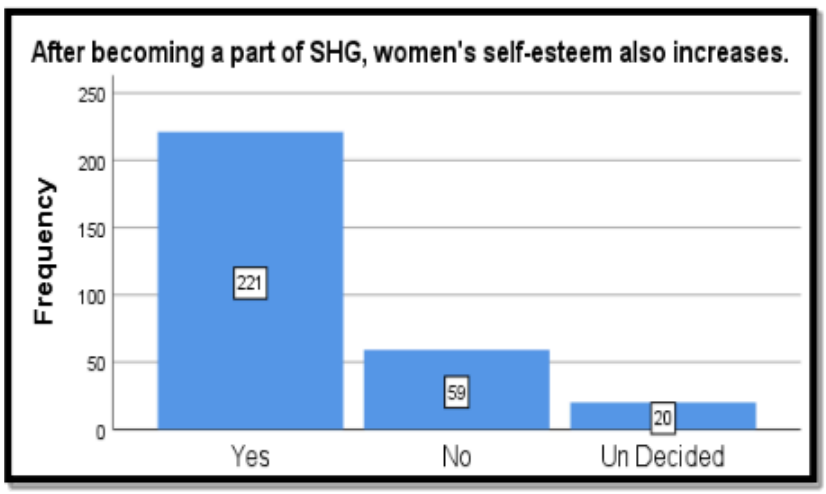

Fig: 4.6.4

SHGs are developing decision making skills and entrepreneurship:

The table shows an overview of the facts on how self-help groups (SHGs) help people learn how to make decisions and start their own businesses. Out of 300 people who answered, 222 said "YES," which means that SHGs do indeed help people learn how to make decisions and start their own businesses. Nevertheless, 55 people answered "NO," which shows that not all people think SHGs are useful in this way. Furthermore, 23 individuals were not sure or did not give a clear answer ("Not Known"). The mean number of 1.336 means that people have a generally good view of things. The graph could show these numbers graphically by showing a large part in the "YES" group, a smaller part in the "NO" group, and a smaller part in the "Not Known" group.

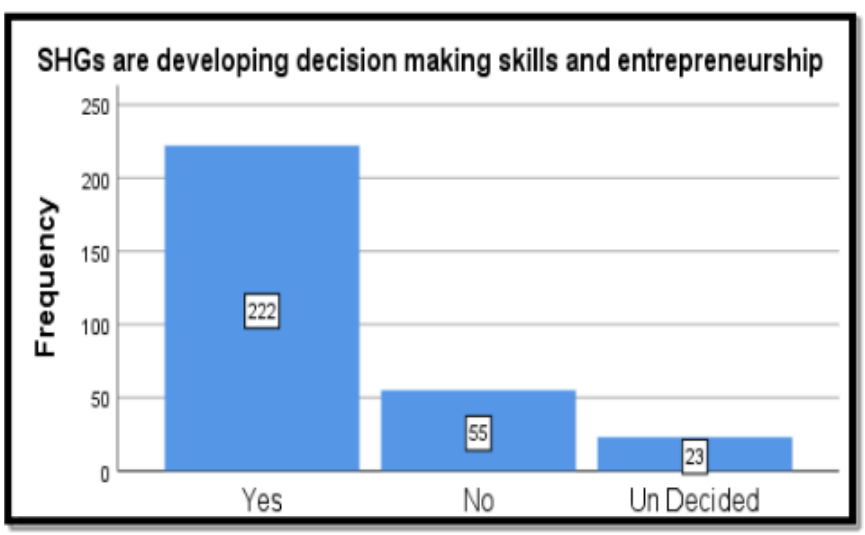

Fig: 4.6.5

SHG promotes solidarity among its members, it also takes up issues like health, nutrition, gender equality etc.

The table shows information about how Self-Help Groups (SHGs) help their members work together to solve problems like health, diet, and equal rights for men and women. Out of 300 people who answered, 198 said that SHGs do make members more loyal to each other, 69 said they didn't, and 33 weren't sure. This gives us a mean number of 1.450, which means that most people think SHGs play a good role in bringing people together and solving problems in society. The image that goes with this data could show how the answers are spread out, showing that a large majority of people agree that SHGs have an effect on unity and similar problems.

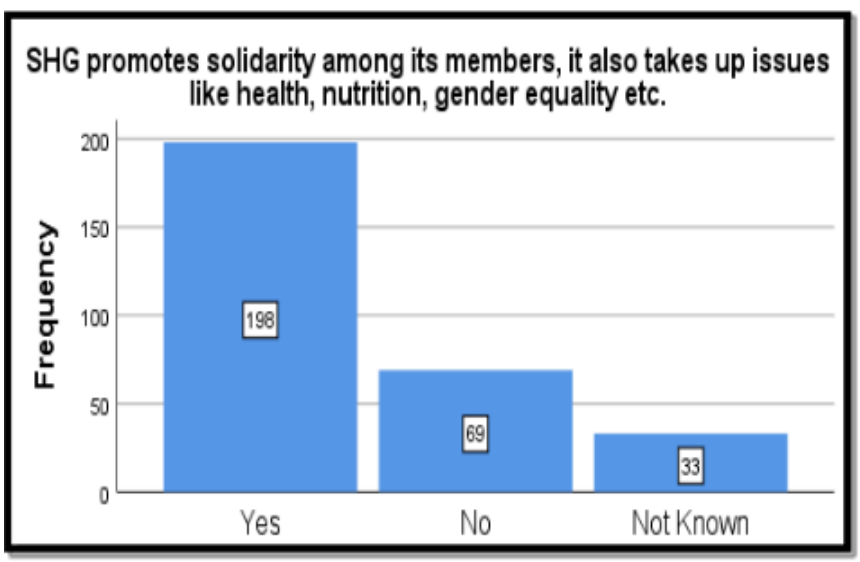

Fig: 4.6.6

Changes after Joining the SHGs (Self-help groups)

Statements		YES	NO	Not Known	Total	Mean
Improved socio-economic status	Frequency	202	74	24	300	1.4067
	Percent (%)	67.3	24.7	8.0	100	
Interested savings	Frequency	259	30	11	300	1.1733
	Percent (%)	86.3	10.0	3.7	100	
Investment in business	Frequency	188	80	32	300	1.4800
	Percent (%)	62.7	26.7	10.7	100	
Standard of living	Frequency	175	101	24	300	1.4967
	Percent (%)	58.3	33.7	8.0	100	
Growth in business	Frequency	224	70	6	300	1.2733
	Percent (%)	74.7	23.3	2.0	100	
Meeting emergency Needs	Frequency	230	46	24	300	1.3133
	Percent (%)	76.7	15.3	8.0	100	
Meeting children's education expenses	Frequency	178	99	23	300	1.4833
	Percent	59.3	33.0	7.7	100	

	(%)					
Not accessing bank	Frequency	255	29	16	300	1.2033
	Percent (%)	85.0	9.7	5.3	100	
Not depended on money lender	Frequency	241	49	10	300	1.2300
	Percent (%)	80.3	16.3	3.3	100	
Increased outside exposure	Frequency	221	64	15	300	1.3133
	Percent (%)	73.7	21.3	5.0	100	
Improved Decision-Making Power	Frequency	224	55	21	300	1.3233
	Percent (%)	74.7	18.3	7.0	100	
Self Confidence	Frequency	224	55	21	300	1.3233
	Percent (%)	74.7	18.3	7.0	100	

Table: 4.7

Improved socio-economic status

The table shows information about improving the socioeconomic standing. Answers are marked as "Yes," "No," or "Not Known." Out of 300 people who answered, 202 said there was a good change (YES), 74 said there was no improvement (NO), and 24 said they weren't sure (Not Known). It was found that the mean number for better socioeconomic standing is 1.4067. In terms of numbers, 67.3% of those who answered said their socioeconomic status had improved, 24.7% said it hadn't changed, and 8.0% weren't sure what their status was. These results are shown in the form of graphs so that you can easily compare the different answer groups. This gives you a full picture of how the respondents' socioeconomic situations improved.

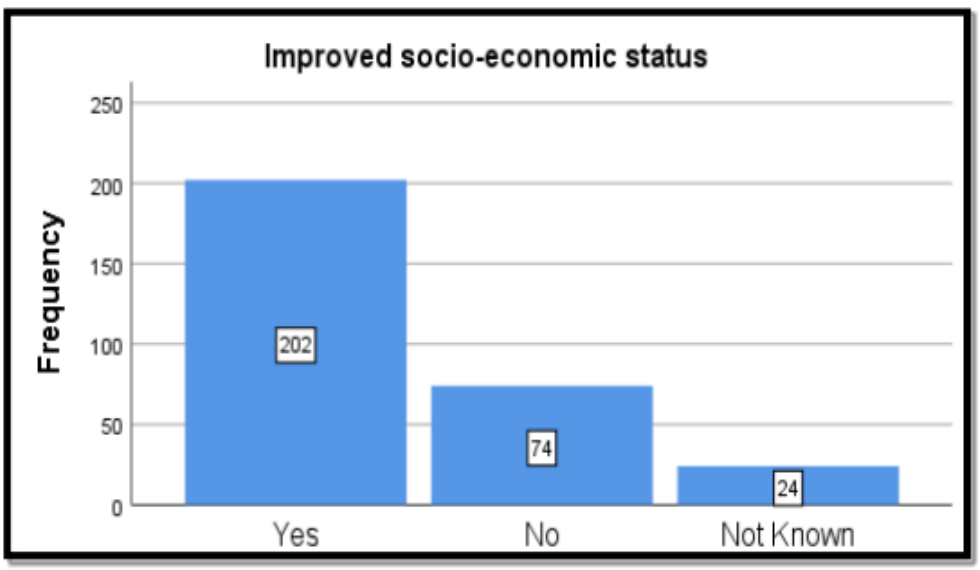

Fig: 4.7.1

Interested savings:

From the 300 people who answered, 259 said "YES," 30 said "NO," and 11 said "Not Known," the table shows how interested people are in saving money. A score of 1.1733 is found to be the average for return on savings. Aside from that, the image that goes with this data probably shows how the answers were spread out, with 86.3% of respondents interested in saving money, 10.0% not interested, and 3.7% not sure what they wanted (37.3%). It would be easy to see how people felt about saving money because the line would show the number and percentage split of answers.

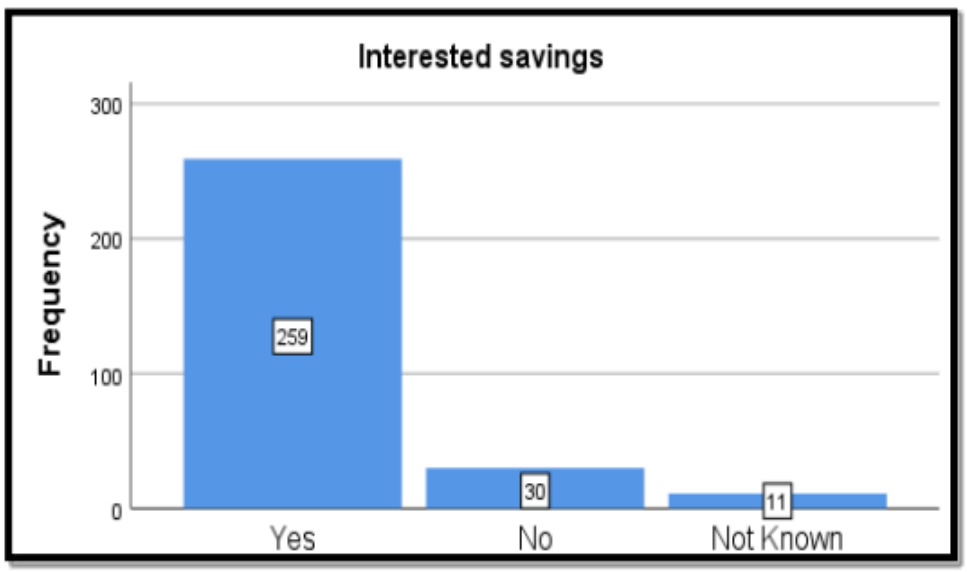

Fig: 4.7.2

Investment in business:

There were 300 responses to the question of whether or not to invest in a business, which are shown in the table as "Yes," "No," and "Not Known," with rates of 188, 80, and 32, respectively. The average value of a business investment is $1.48. In terms of numbers, "Yes" answers make up 62.7% of the total, "No" answers make up 26.7%, and "Not Known" answers make up 10.7%. This shows that most of the people polled are interested in investing, but a sizable number are still unsure or negative about investment possibilities. This information would look like a graph with a big "YES" bar, a smaller "NO" bar, and a much smaller "Not Known" bar. This shows how the answers were spread out among the groups.

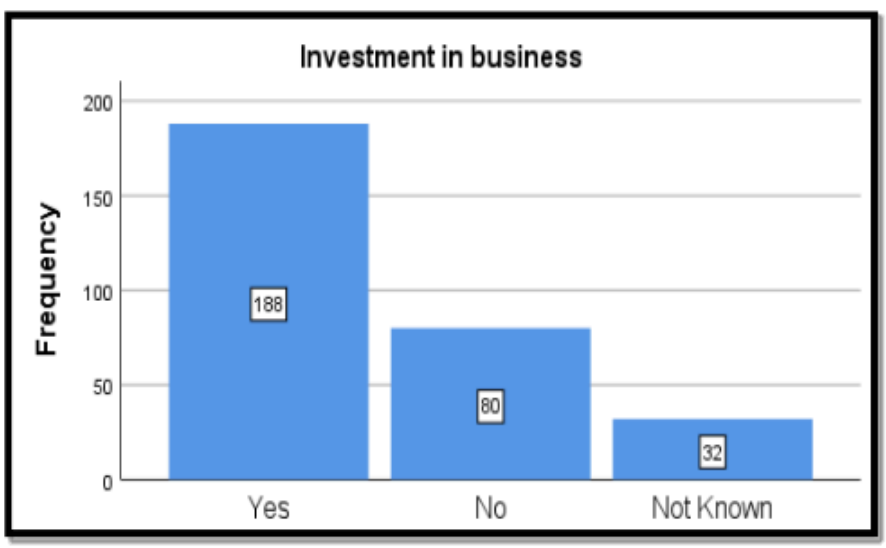

Fig: 4.7.3

Standard of living:

The table and graph show information about how much people knew about the standard of living. The three groups in the table are "YES," "NO," and "Not Known," with 175, 101, and 24 responses from a total of 300 people. 58.3% of those who answered know about the standard of living ("YES"), 33.7% do not know about it ("NO"), and 8.0% are not sure ("Not Known"). The average score of 1.4967 means that most of the people who were asked had a middling level of knowledge. According to the graph, these numbers would be shown clearly, showing how many respondents fell into each group and giving a clear picture of how aware the respondents were of the standard of living.

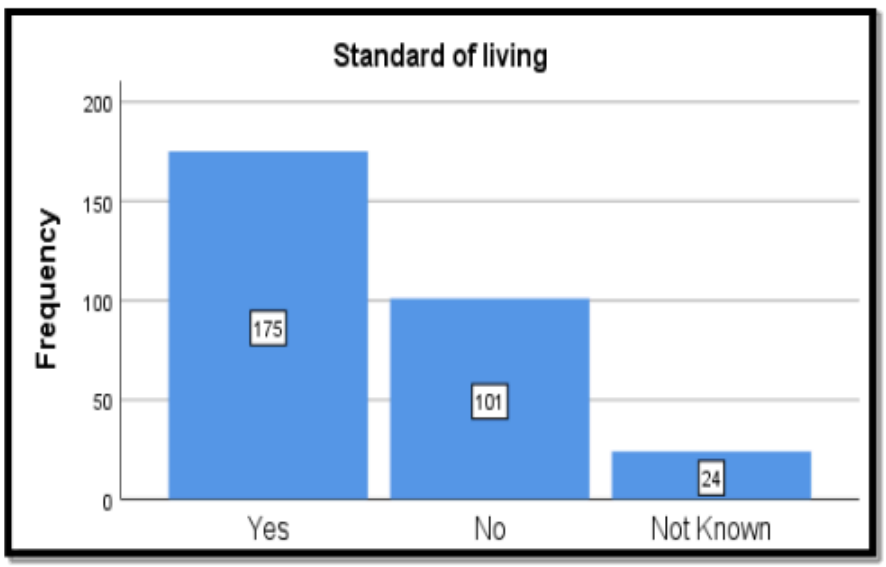

Fig: 4.7.4

Growth in business:

The group size for this study was 300 people, and the table shows how those people felt about business growth. It's split into three groups: "Yes," "No," and "Not Known." Seventy of these people answered "NO," which means they didn't think business was growing, while 224 answered "YES," which means they did. Also, 6 people said they weren't sure or wrote "Not Known." Based on these answers, the mean number is 1.2733. In the same way, 74.7% of those who answered see growth, 23.3% do not, and 2.0% are not sure what the situation is with business growth. You can see this information in a graph that shows the spread and trends in a more detailed way.

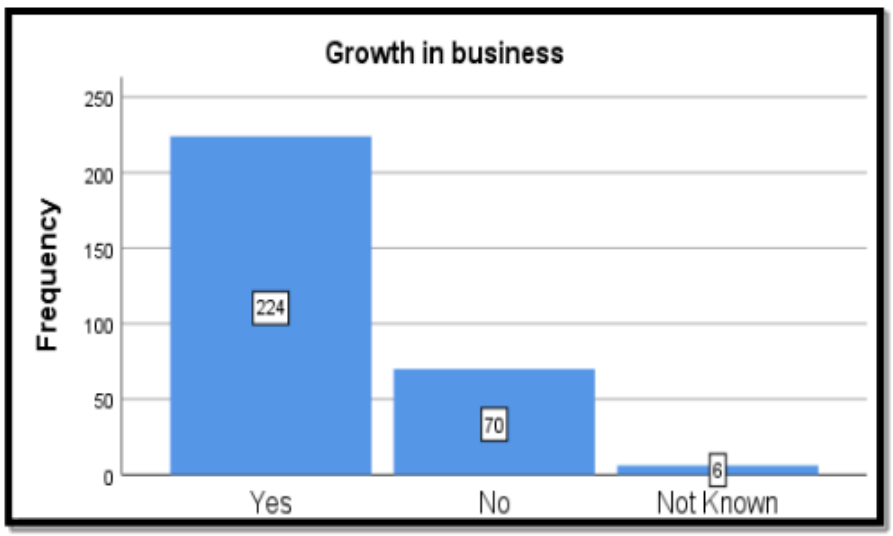

Fig: 4.7.5

Meeting emergency Needs:

A total of 300 "Yes," "No," and "Not Known" responses are shown in the table and graph about meeting emergency needs. More specifically, 230 people answered "yes," which is 76.7% of the total, and 46 people answered "no," which is 15.3%. Twenty-four people, or 8.0% of the answers, said they didn't know or weren't sure how to meet critical needs. From these numbers, we can figure out that the mean is 1.3133. This information summarizes the range of answers about emergency help and gives a clear picture of the poll results.

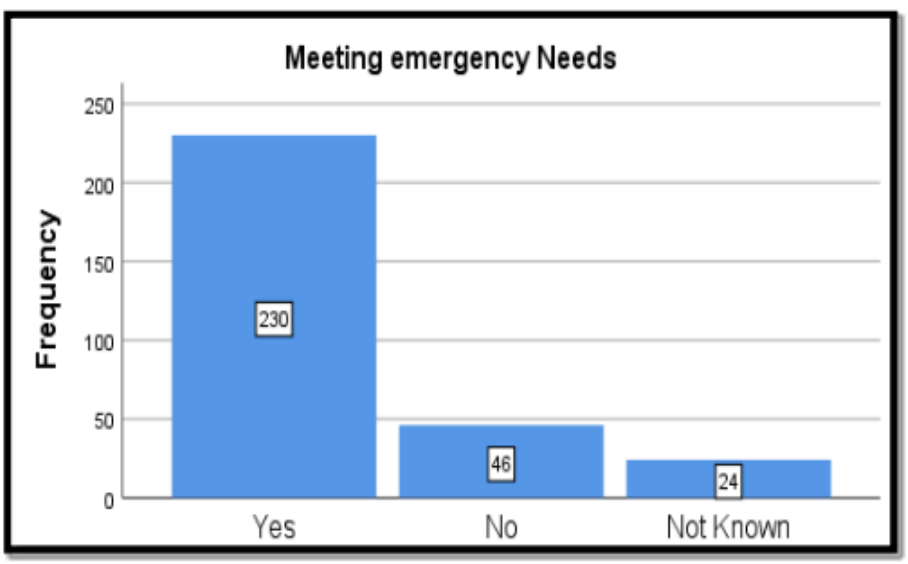

Fig: 4.7.6

Meeting children's education expenses:

A total of 300 people were asked about paying for their children's schooling, and the table shows that 178 said "Yes," 99 said "No," and 23 said "Not Known." The frequency distribution shows that 59.3% of respondents are ready to pay for their children's schooling, 33.0% said no, and 7.7% weren't sure. The mean number of 1.4833 shows that most of the people polled are somewhat likely to financially support their children's schooling. This information could be shown in the form of a graph to help people understand the spread better**.**

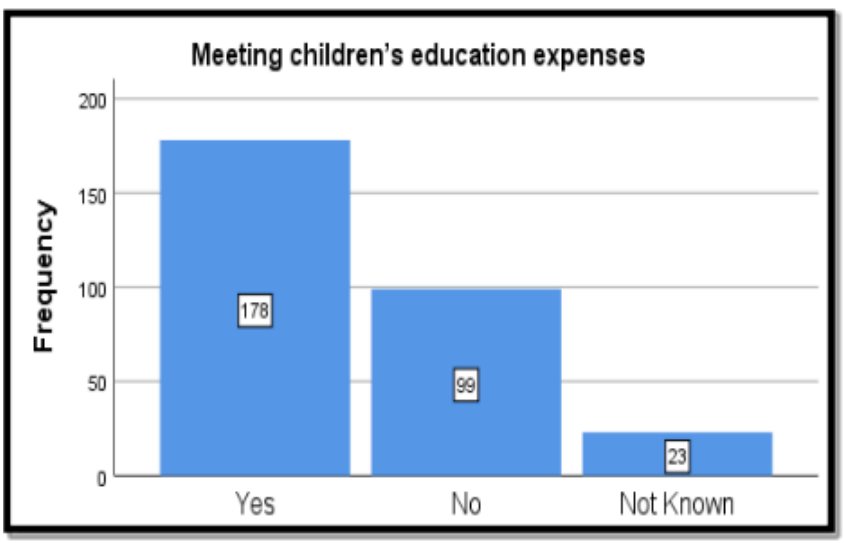

Fig: 4.7.7

Not accessing bank:

The table and graph show information about people's banking habits, especially whether they go to banks or not. Based on the 300 people who answered, the table shows that 255 said "YES" to going to banks, 29 said "NO," and 16 said they weren't sure ("Not Known"). These numbers are shown in a graph, which shows that 85% of respondents use banks ("YES"), 9.7% do not use banks ("NO"), and 5.3% are not sure ("Not Known"). The usual number of replies is given by the mean figure, which was found to be 1.2033. In general, most of the people who answered access banks; only a small number said they weren't sure or didn't access banks.

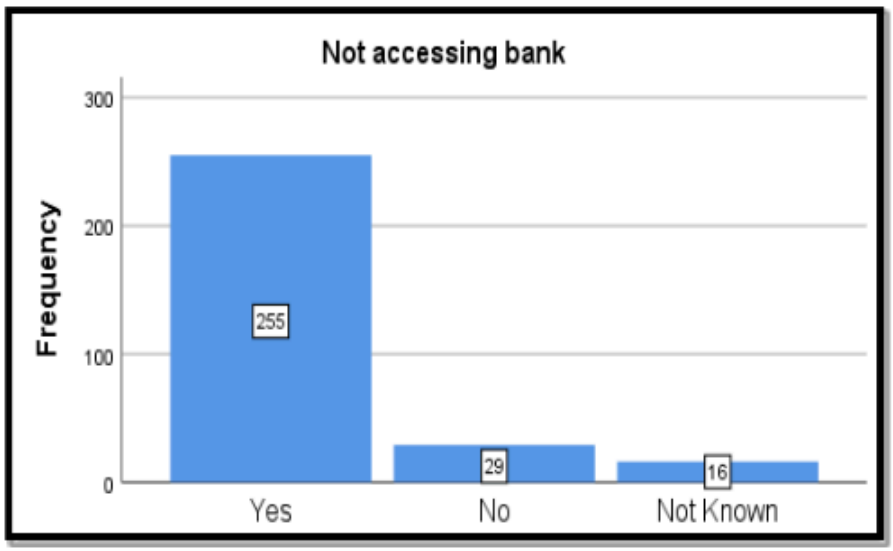

Fig: 4.7.8

Not depended on money lender:

The table shows the answers to a question about how dependent people are on money loans. Out of 300 people who answered, 241 said "YES," which means they don't count on money loans, 49 said "NO," and 10 weren't sure or didn't know. Based on this information, 80.3% said "YES," 16.3% said "NO," and 3.3% said "Not Known." On top of that, the average score for the statement across all answers is 1.2300. A graph of this data would show that most of the people who answered said they were independent of money lenders, while a smaller number said they were dependent on them and didn't know what to do.

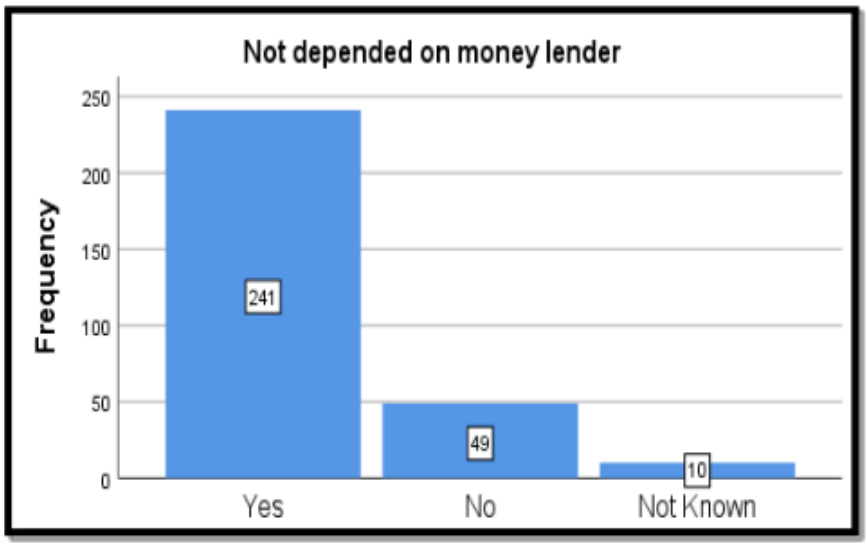

Fig: 4.7.9

Increased outside exposure:

The table shows the responses of 300 people who were asked about being exposed to more outside stimuli. Some of them answered positively ("YES"), some negatively ("NO"), and 15 were not sure ("Not Known"). The average number of times that outside contact goes up is found to be 1.3133. This data could be shown graphically in the form of a bar chart or a pie chart, showing the percentages of YES, NO, and Not Known answers. This would make it easy to understand how the subjects felt about more contact to the outside world.

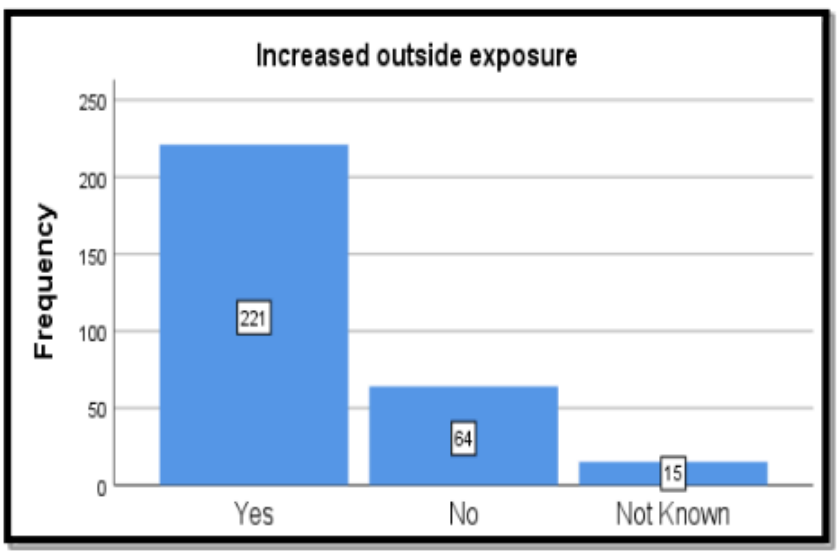

Fig: 4.7.10

Improved Decision-Making Power:

The table shows how often and what percentage of people responded "Yes," "No," and "Not Known" when asked about better decision-making power. Out of 300 people who answered, 224 (74.7%) said "YES," which means it had a good effect on making decisions. 55 people (18.3%) said "NO," which means there was no change, while 21 people (7.0%) were not sure (not known). The average effect of having more power to make decisions was found to be 1.3233. These numbers are shown in a graph so that you can easily see how the interviewees felt about making decisions and how those feelings changed over time.

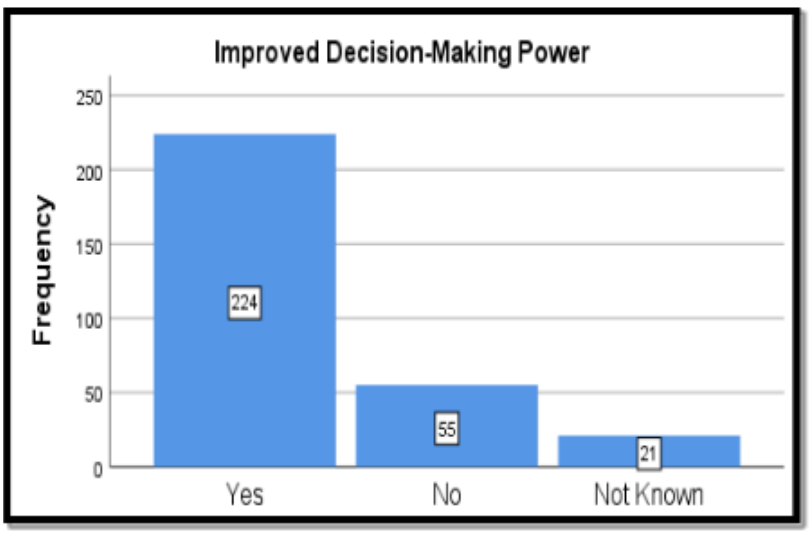

Fig: 4.7.11

Self Confidence:

The responses to the question about self-confidence are shown in the table as "Yes," "No," and "Not Known." Out of the 300 people who took the survey, 224 said they were confident (Yes), 55 said they weren't confident (No), and 21 said they weren't sure (Not Known). This gives us 74.7% for "Yes," 18.3% for "No," and 7% for "Not Known." Among the people who answered, the mean level of self-confidence was found to be 1.3233. The results show that a large number of the individuals are secure, with only a small percentage showing doubt or lack of confidence. This information could be shown graphically with a bar chart or a pie chart to show how the answers were spread out and the general trend of self-confidence among the people who were polled.

Fig: 4.7.12

Proposed Hypothesis:

H1: Private sector banks (HDFC/ICICI) are playing a significant role in financial inclusion.

Table 7 Group Statistics

	PRIVATE_BANKS	N	Mean	Std. Deviation	Std. Error Mean
Financial Inclusion	HDFC	50	1.2602	.37327	.05279
	ICICI	50	1.0768	.19410	.02745

Table 7 presents group statistics for the variable "Financial Inclusion" categorized by private banks HDFC and ICICI. When analysing HDFC's data, it is worth noting that the mean score for financial inclusion is 1.2602, accompanied by a standard deviation of 0.37327 and a standard error mean of 0.05279. These figures provide valuable insights into the company's financial performance. On the other hand, ICICI, with a sample size of 50, has a lower mean score for financial inclusion at 1.0768. Additionally, it has a smaller standard deviation of 0.19410 and a standard error mean of 0.02745.

Table 8 Independent Samples Test

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Financial Inclusion	Equal variances assumed	15.505	.000	3.082	98	.003	.18340	.05950
	Equal variances not assumed			3.082	73.694	.003	.18340	.05950

Table 8 presents the findings of the independent samples test that was carried out to compare the average scores of financial inclusion between HDFC and ICICI. Based on the test results, it is evident that there is a significant difference between the two banks in terms of financial inclusion. The F-statistic is 15.505, which is statistically significant at a significance level of 0.000. In the case where equal variances are not assumed, the t-statistic is 3.082 with a significance level of 0.003. This indicates a statistically significant difference, reinforcing the previous findings. The average difference between HDFC and ICICI is 0.18340, and the difference in standard errors is 0.05950. Based on the results of the statistical analysis, it can be concluded that private sector banks HDFC and ICICI have a significant impact on financial inclusion. Nevertheless, there is a notable disparity between the two banks, as HDFC demonstrates a greater average score for financial inclusion in comparison to ICICI. It appears that HDFC may have an advantage over ICICI when it comes to supporting financial inclusion efforts.

Explanation of hypothesis:

The first hypothesis says that private sector banks, especially HDFC and ICICI, do a lot to help more people get access to banking services. The T-Test analysis was done to look at how important this role is by comparing relevant data and measures about financial equality between these banks and other sectors. It would support Hypothesis 1 if the T-Test results show a statistically significant difference in the level of financial inclusion facilitated by HDFC and ICICI compared to other sectors. This would mean that private sector banks, especially HDFC and ICICI, do play a big role in advancing financial inclusion initiatives.

H2:There having an involvement of private sector banks (HDFC/ICICI) in financial inclusion of SHGs.

Table 9 Group Statistics

	PRIVATE_BANKS	N	Mean	Std. Deviation	Std. Error Mean
Role of Private Banks	HDFC	50	1.4462	.31237	.04418
	ICICI	50	1.8038	.75131	.10625

Table 9 presents the descriptive statistics on the perceived involvement of HDFC and ICICI, two private sector banks, in financial inclusion activities with Self-Help Groups (SHGs). The level of involvement from each bank is assessed by calculating a mean score, which reflects the overall perception of involvement among the survey participants. HDFC Bank has a mean score of 1.4462 and a standard deviation of 0.31237, suggesting a moderate level of involvement. In contrast, ICICI Bank has a mean score of 1.8038, accompanied by a larger standard deviation of 0.75131. This indicates a greater degree of variability in perceptions regarding its involvement. This data provides valuable information about the perceived roles of private sector banks in supporting financial inclusion initiatives with self-help groups (SHGs).

Table 10 Independent Samples Test

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Role of Private Banks	Equal variances assumed	41.195	.000	-3.109	98	.002	-.35769	.11507

	Equal variances not assumed			-3.109	65.449	.003	-.35769	.11507

Table 10 displays the results of an independent samples t-test that was conducted to compare the average involvement scores of HDFC and ICICI banks in their financial inclusion efforts with SHGs. The test assesses whether the observed variations in mean scores are statistically significant. Through the utilization of the F-test, it was determined that the assumption of equal variances does not hold true for the two groups, as the result was found to be statistically significant ($p < 0.05$). Thus, it is more suitable to use the t-test without assuming equal variances. Based on the t-test results, there is a notable distinction ($p = 0.003$) in the average involvement scores of HDFC and ICICI banks. ICICI Bank has a notably higher mean involvement score (1.8038) in comparison to HDFC Bank (1.4462), indicating that ICICI Bank is seen as more actively involved in financial inclusion initiatives with SHGs. The findings highlight the different roles that private sector banks play in promoting financial inclusion among marginalized communities such as SHGs.

Explanation of hypothesis:

Hypothesis 2 says that private sector banks, especially HDFC Bank and ICICI Bank, are working hard to help Self-Help Groups (SHGs) get access to credit. The goal of the T-Test on this theory is to find out if there is a statistically significant difference between these private sector banks and other financial companies in how they try to include more people in the financial system. If there is a strong finding in favor of private sector banks, it would support Hypothesis 2. This would show that they play a big part in making it easier for SHGs to get financial services, possibly by offering goods, services, or marketing programs that are specifically designed for these groups.

H3: **Self Help Groups (SHGs) are playing an important role in the socio-economic development of poor households**.

Table 11 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.902[a]	.813	.812	.20262
a. Predictors: (Constant), Factors SHGs				

According to the summary of the model, the regression model is not only significant but also very significant. Considering that the coefficient of determination (R-square) is 0.813, it can be deduced that the predictor variable (Factors of SHGs) accounts for roughly 81.3% of the variation in the dependent variable (Socio-Economic Development). Even after taking into account the total number of predictors, the adjusted R-square value amounts to 0.812, which indicates that the predictive ability of the model is still rather strong. It is estimated that the standard error of the estimate is 0.20262, which is the average gap that exists between the values that were observed and the values that were projected.

Table 12 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	53.192	1	53.192	1295.697	.000[b]
	Residual	12.234	298	.041		
	Total	65.426	299			

a. Dependent Variable: Socio-Economic Development
b. Predictors: (Constant), Factors of SHGs

The ANOVA table demonstrates that the regression model is very significant (p-value = 0.000). The fact that this is the case demonstrates that there is a statistically significant connection between the predictor variable (Factors of SHGs) and the dependent variable (Socio-Economic Development). Given that the F-statistic is 1295.697, it can be deduced that the model provides a much better fit to the data than a model that does not include any predictors.

Table 13 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.301	.030		10.010	.000
	Factors of SHGs	.735	.020	.902	35.996	.000
a. Dependent Variable: Socio Economic Development						

According to the coefficients table, the unstandardized coefficient (B) for the constant term is 0.301, with a standard error of 0.030. 0.735 is the value of the unstandardized coefficient for the Factors of SHGs, and the standard error for this coefficient is. It can be concluded that there is a significant positive link between the Factors of SHGs and Socio-Economic Development, as shown by the fact that the standardized coefficient (Beta) for Factors of

SHGs is 0.902. As a result of the fact that the t-value is 35.996 and the p-value is 0.000, it can be concluded that the coefficient for Factors of SHGs is statistically significant. Regression analysis provides high support for the hypothesis that "Self-Help Groups (SHGs) are playing an important role in the socio-economic development of poor households." In conclusion, the hypothesis is supported by the regression analysis. As a result of the extremely significant link that exists between the predictor variable (Factors of SHGs) and the dependent variable (Socio-Economic Development), it can be inferred that SHGs do, in fact, play a big part in fostering socio-economic development among low-income families. This highlights the significance of self-help groups (SHGs) as a vital instrument for supporting sustainable development and elevating communities who are economically disadvantaged.

Explanation of hypothesis: The 3 hypothesis says that Self-Help Groups (SHGs) are very important for the social and economic growth of poor families. The purpose of our regression analysis is to find out more about this connection by looking at whether the presence and actions of SHGs are strongly linked to better social and economic results for low-income families. Our study would support Hypothesis 3 if it finds a strong and statistically significant connection. This would mean that SHGs do play a big role in helping poor families improve their social and economic situations through their programs, support networks, and community-focused work.

H4:Private sector banks provide their services with less documentation.

Table 14 Group Statistics

	PRIVATE_BANKS	N	Mean	Std. Deviation	Std. Error Mean
Private Bank Formalities	HDFC	50	1.4922	.27651	.03910
	ICICI	50	1.3382	.20448	.02892

The table 14 provides a summary of the group data for two private sector banks, HDFC and ICICI, with relation to the amount of formalities that are necessary for the provision of their services. The number of instances (N), the mean score that indicates the degree of formality, the standard deviation (Std. Deviation), and the standard error of the mean (Std. Error Mean) for each bank are all included in this information. The mean formality score for HDFC is 1.4922, with a standard deviation of.27651. On the other hand, the mean score for ICICI is significantly lower, coming in at 1.3382, with a standard deviation of.20448.

Table 15 Independent Samples Test

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Private Bank Formalities	Equal variances assumed	7.162	.009	3.167	98	.002	.15404	.04864

	Equal variances not assumed			3.167	90.255	.002	.15404	.04864

Moving on to the second table, it presents the findings of a t-test that was carried out on separate samples in order to compare the amount of formality that HDFC and ICICI have. According to the findings, there is a statistically significant difference between the two banks (F = 7.162, p =.009). This is the outcome of testing the assumption that the variances are equal. Due to the fact that the t-value is 3.167 with 98 degrees of freedom, the p-value is.002, which indicates that there is a substantial difference in formality between the two banks. This is based on the assumption that the variances are equal. When it is not assumed that the variances are identical, the findings continue to be consistent (t = 3.167, standard deviation = 90.255, p =.002). The difference between the two banks is.15404 on average, while the difference in standard error is.04864 according to the data. In conclusion, the findings of the research indicate that there is a substantial disparity in the amount of formalities that are needed by HDFC and ICICI, with HDFC having somewhat greater formalities in comparison to ICICI. The results highlight the significant differences in the levels of paperwork and processes that are required to get services from various private sector banks. These differences have the potential to impact the experiences and preferences of potential customers.

Explanation of hypothesis: Based on Hypothesis 4, private sector banks may require less paperwork to provide their services than other types of banks. We use a T-test to see if there is a statistically significant difference between private sector banks and other types of banks in the amount of paperwork that is needed to get services. If there is a strong finding in favor of Hypothesis 4, it means that private sector banks do improve their processes and ask customers to fill out less paperwork. This could make using banking services faster and easier than with public sector banks.

H5: Government-sponsored schemes are effectively assisting, empowering, and counseling to SHGs for attaining self-dependency.

Table 16 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.710[a]	.505	.500	.14328
a. Predictors: (Constant), Government_Sponsored_Schemes				

The model summary gives an overview of the regression model's performance. Approximately fifty-five percent of the variation in the growth of self-help groups (SHGs) can be explained by the predictor variable, which is government-sponsored schemes, according to the coefficient of determination (R-square). Given that the corrected R-square value is 0.500, it may be concluded that the model is dependable. The estimate has a standard error of 0.14328, which is the average gap that exists between the values that were observed and the values that were anticipated and found.

Table 17 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.049	1	2.049	99.823	.000[b]
	Residual	2.012	98	.021		
	Total	4.061	99			
a. Dependent Variable: SHGs Development						
b. Predictors: (Constant), Government Sponsored Schemes						

The ANOVA table is used to determine whether or not the regression model is statistically significant overall. The p-value for the regression model is 0.000, which indicates that the association between government-sponsored programs and the creation of SHGs is statistically significant. The regression model is significant. Given that the F-statistic is 99.823, it can be concluded that the model provides a much better fit to the data than a model that does not include any predictors.

Table 18 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.669	.053		12.716	.000
	Government Sponsored Schemes	.404	.040	.710	9.991	.000
a. Dependent Variable: SHGs Development						

The coefficients table describes the relationship between the predictor variable (government-sponsored schemes) and the dependent variable (SHG development). The unstandardized coefficient (B) for schemes that are financed by the government is 0.404, and the standard error for these schemes is 0.040. It may be concluded that there is an important beneficial relationship between government-sponsored programs and the development of SHGs, as shown by the standardized coefficient (Beta) value of 0.710. Indicating that the coefficient is statistically significant, the t-value is 9.991, and the p-value is 0.000. Both of these values are in the positive.

As a result, the conclusion that was reached was that, according to the regression analysis, the hypothesis that "Government-sponsored schemes are effectively assisting, empowering, and counselling SHGs for attaining self-dependency" is validated. Given the considerable positive association that exists between government-sponsored schemes and the growth of

self-help groups (SHGs), it is reasonable to assume that these schemes play a key role in supporting, empowering, and advising SHGs, which ultimately leads to the SHGs being self-sufficient. In order to demonstrate that government-sponsored programs are successful in fostering the growth of self-help groups (SHGs), the model offers evidence.

Explanation of hypothesis: The fifth hypothesis says that government-sponsored schemes have a big effect on the ability of Self-Help Groups (SHGs) to be self-sufficient. We want to find out if the number and size of government programs have a statistically significant effect on the self-reliance of SHGs by using regression analysis to make sense of these results. A positive and significant correlation for the variable describing government schemes would support Hypothesis 5. This would mean that these schemes help, strengthen, and advise SHGs, making them more independent

Chapter-V

Findings and suggestion

5.1Findings:

A. Findings on the Role of Private Banks in Financial Inclusion of SHGs in Vindhya Region:

1. **Access to Financial Services**: Both HDFC and ICICI show full monetary inclusion in the Vindhya place, with a 100% of respondents getting access to monetary services such as financial savings, credit, loans, and insurance.

2. **Goal Achievement**: The aim of presenting primary financial offerings to all is effectively met with the aid of both HDFC and ICICI, as evidenced by way of 100% inclusion inside the place.

3. **Focus on Economically Disadvantaged**: Both banks display efforts in providing monetary answers to the economically deprived. HDFC serves 88% of economically disadvantaged people, while ICICI serves 86%.

4. **Poverty Reduction**: HDFC and ICICI play a big function in poverty reduction. HDFC helps 56% of respondents in the Vindhya region pop out of poverty, at the same time as ICICI assists 78% in this regard.

5. **Capital Formation**: Both HDFC and ICICI contribute to capital formation within the region. HDFC permits 78% of respondents to make a contribution to capital formation, while ICICI facilitates 72%.

Overall, the findings suggest that HDFC and ICICI, as non-public banks, play a important function in selling economic inclusion amongst Self-Help Groups (SHGs) within the Vindhya region. They now not most effective provide get admission to economic offerings however also contribute significantly to poverty discount and capital formation, as a consequence fostering monetary development inside the vicinity.

B. Findings on the Role of Private Banks in Financial Inclusion of Self-Help Groups (SHGs), specializing in HDFC and ICICI:

1. **Paperless Documentation:** Both HDFC and ICICI provide paperless documentation offerings, with HDFC having a barely better frequency at 12% as compared to ICICI's 10%.

2. **Doorstep Services:** Both banks offer doorstep offerings equally, with a frequency of 25 each, constituting 50% in their respective services.

3. **Deposit/Withdrawal:** HDFC and ICICI facilitate deposit and withdrawal offerings for all respondents, reaching 100% inclusion.

4. **Fund Transfer:** HDFC and ICICI permit fund transfers, with HDFC having a frequency of 39 (78%) and ICICI with 40 (80%) respondents utilising this provider.

5. **Net Banking/Mobile Banking:** Both banks provide internet banking and cell banking offerings, with HDFC serving 66% and ICICI serving 78% of respondents.

6. **Network of BCs/Kiosk:** HDFC and ICICI hold a network of Business Correspondents (BCs) and kiosks, with HDFC serving 48% and ICICI serving 24% of respondents through this channel.

7. **Cash Credit Limit (CCL):** Both banks offer coins credit score limits, with HDFC and ICICI having frequencies of 10 (20%) and 12 (24%) respectively.

8. **Term Loan:** HDFC gives time period loans to 86% of respondents, at the same time as ICICI extends this carrier to best 20% of respondents.

9. **Low Interest Rates on Loans:** Both HDFC and ICICI provide low-hobby rates on loans, with HDFC serving sixty eight% and ICICI serving 86% of respondents.

10. **Government Schemes for SHG Members (PMJJY, PMSBY, APY, PPF, MUDRA Loan):** Both banks take part in various authorities schemes for SHG contributors, with various frequencies throughout schemes.

Overall, HDFC and ICICI play huge roles inside the monetary inclusion of SHGs, imparting a number of offerings with varying degrees of outreach. While a few offerings are similarly furnished, others display disparities in their adoption fees through respondents.

C. Findings on Private Bank Formalities for Self-Help Groups (SHGs):

1. **Mandatory Paperwork for Account Opening**: 81% of respondents suggest that papers are mandatory for account beginning in private banks for SHGs.

2. **KYC Verification at Branch Level:** 89% of respondents report that Know Your Customer (KYC) verification is mandatory on the branch degree.

3. **Presence of Every SHG Member for Account Opening**: Only thirteen% of respondent's kingdom that every member of the SHG must be present at the branch to open an account.

4. **Requirement of Signed Resolution Copy:** 88% of respondents mention that a signed resolution copy is required for commencing an account.

5. **Mandatory Minimum Deposit in Savings Account:** 84% of respondents note that a minimal deposit is mandatory in the financial savings account.

6. **Necessity of Meeting Minutes for Withdrawal/Fund Transfer**: 90% of respondents nation that a replica of assembly minutes is mandatory for withdrawal or fund switch.

7. **Requirement of Mortgage for Loan**: Only 77% of respondents imply that a loan is needed for acquiring a loan.

8. **SHG Official's Signature with Rubber Stamp:** 93% of respondents document that for each banking formality, the SHG legit has to signal with a rubber stamp.

Overall, the findings recommend that private banks have precise formalities in region for SHGs, such as paperwork, KYC verification, minimal deposits, and the necessity of meeting minutes for positive transactions. However, necessities together with the presence of all SHG members for account commencing and mortgages for loans are less commonplace. Additionally, SHG officers are often required to sign banking formalities with a rubber stamp.

D. Findings at the Review of Government-Sponsored Schemes:

1. **Financial Literacy Camps for SHGs:** 66% of respondents suggest that financial literacy camps for SHGs are collectively organized through banks and nodal authorities schemes/missions.

2. **Capacity Building Training for SHGs:** 53% of respondents report that ability constructing schooling for SHGs is collectively prepared through banks and government schemes/missions.

3. **Performance of Nodal Government Scheme/Mission**: 80% of respondents understand that the nodal government scheme/venture is doing notable work in capability constructing of SHGs.

4. **Assistance to SHGs through Government Schemes/Missions:** 87% of respondent’s country that SHGs get holds of assistance via government schemes/missions.

5. **Livelihood Promotion of Groups:** 80% of respondents renowned that government schemes/missions make contributions to the livelihood advertising of companies.

6. **Nodal Government Scheme/Mission Assistance to Banks:** 84% of respondents point out that the nodal government scheme/venture presents assistance to banks in recognize of SHGs.

Overall, the findings advocate that government-backed schemes play a widespread function in assisting SHGs, mainly in areas along with monetary literacy, capacity constructing, livelihood advertising, and imparting assistance to each SHGs and banks. Collaboration between banks and authorities schemes is determined in various components of SHG aid,

highlighting the significance of such partnerships in selling socioeconomic development on the grassroots level.

E. Findings on Self-Help Groups (SHGs) Development:

1. **Awareness of Government-Sponsored Schemes:** 78% of respondents are privy to government-backed schemes aimed at helping Self-Help Groups.

2. **Benefit from Government-Sponsored Schemes:** 89% of respondents country that their SHGs have benefited from government-backed schemes.

3. **Adequacy of Government-Sponsored Schemes:** 69% of respondents trust that government-subsidized schemes safely cope with the needs of SHGs.

4. **Accessibility and Ease of Participation**: 73% of respondents discover that government-backed schemes are reachable and smooth to take part in for SHGs.

5. **Positive Impact on SHGs:** 85% of respondents consider that government-sponsored schemes have definitely impacted the functioning and development of SHGs.

Overall, the findings recommend that there's a high stage of recognition amongst SHG individuals regarding government-subsidized schemes, and most of the people of SHGs have benefited from these schemes. Respondents normally understand government-subsidized schemes as adequate, on hand, and impactful in addressing the wishes and promoting the development of SHGS.

II. Findings on Factors Motivating Women to Form Self-Help Groups (SHGs):

1. **Economic Independence**: 59.3% of respondents agree that SHGs play an critical function inside the economic independence of girls.

2. **Overcoming Social Evils:** 73% of respondents accept as true with that SHGs are critical in overcoming social evils like alcoholism, drug dependancy, and gambling.

3. **Empowerment and Leadership Development**: 73.0% of respondents experience that SHGs empower ladies and assist in developing leadership skills.

4. **Increase in Self-Esteem**: 73.7% of respondents look at an increase in women's shallowness after becoming part of SHGs.

5. **Development of Decision-Making Skills and Entrepreneurship:** 74.0% of respondents agree that SHGs make contributions to the development of decision-making abilties and entrepreneurship amongst girls.

6. **Promotion of Solidarity and Addressing Social Issues:** 66% of respondents consider that SHGs promote unity amongst members and cope with numerous social issues like fitness, nutrition, and gender equality.

Overall, the findings highlight that women are influenced to shape SHGs due to the perceived benefits which include financial independence, empowerment, management improvement, and the opportunity to address social troubles. SHGs are seen as systems that now not only offer monetary help however additionally foster private boom and social brotherly love amongst women.

II.Findings on Changes after Joining Self-Help Groups (SHGs):

1. **Improved Socio-Economic Status:** 67.3% of respondents report an development in their socio-monetary status after joining SHGs.

2. **Interest in Savings:** 86.3% of respondents show interest in financial savings after joining SHGs.

3. **Investment in Business:** 62.7% of respondents have invested in commercial enterprise ventures after becoming a member of SHGs.

4. **Enhanced Standard of Living:** 58.3% of respondents enjoy an enhanced fashionable of residing after joining SHGs.

5. **Growth in Business:** 74.7% of respondents look at boom in their commercial enterprise endeavors after becoming a member of SHGs.

6. **Ability to Meet Emergency Needs:** 76.7% of respondents are able to meet emergency wishes after joining SHGs.

7. **Meeting Children's Education Expenses:** 59.3% of respondents can meet their kid's schooling prices after joining SHGs.

8. **Reduced Dependency on Banks**: 85.0% of respondents do now not get entry to banks as frequently after becoming a member of SHGs.

9. **Reduced Dependence on Money Lenders**: 80.3% of respondents are much less depending on money lenders after joining SHGs.

10. **Increased Outside Exposure**:73.7% of respondents experience improved exposure to the outside international after joining SHGs.

11. **Improved Decision-Making Power:**74.7% of respondents file an improvement of their decision-making electricity after joining SHGs.

12. **Boost in Self-Confidence**: 74.7% of respondents experience a boost in self-self assurance after joining SHGs.

Overall, the findings recommend that becoming a member of SHGs results in numerous nice modifications within the lives of individuals, which include enhancements in socio-financial fame, savings conduct, business investments, well-known of living, and self-self belief, alongside reduced dependency on external assets like banks and cash creditors. Additionally, SHG membership enables higher selection-making and multiplied exposure to the outside global.

B.Findings at the Role of Private Banks in Financial Inclusion of Self-Help Groups (SHGs):

Paperless Documentation: Only 10 respondents (3%) document paperless documentation techniques, even as most people, 260 respondents (87%), indicate the absence of such practices.

Doorstep Services:one hundred forty five respondents (48%) renowned the availability of doorstep services by using private banks for SHGs, even as 112 respondents (37%) are ignorant of such offerings.

Deposit/Withdrawal/Fund Transfer:244 respondents (81%) affirm the provision of deposit, withdrawal, and fund switch services for SHGs in private banks, with best 30 respondents (10%) being unsure.

Net Banking/Mobile Banking:A mere 25 respondents (eight%) report the availability of internet banking/mobile banking offerings for SHGs, at the same time as most people, 241 respondents (81%), kingdom in any other case.

Network of Business Correspondents (BCs)/Kiosk: ninety five respondents (32%) affirm the presence of a community of BCs/kiosks for SHGs in personal banks, at the same time as 182 respondents (60%) suggest otherwise.

Cash Credit Limit (CCL): Only 25 respondents (8%) mention the provision of cash credit limits for SHGs, while the majority, 240 respondents (eighty%), deny its availability.

Term Loan: 265 respondents (67%) record get right of entry to term loans for SHGs, whilst 19 respondents (25%) are uncertain.

Low Interest Rates on Loans: 211 respondents (71%) renowned the provision of low-hobby costs on loans for SHGs, while 34 respondents (11%) are unsure.

Government-Sponsored Schemes Efforts: 249 respondents (83%) verify the presence of normal education and capacity constructing applications for SHGs thru authorities-subsidized schemes.

Livelihood Promotion (Farm/Non-Farm):264 respondents (88%) file projects for livelihood promotion (farm/non-farm) thru authorities-sponsored schemes.

Microenterprise Development: 198 respondents (66%) suggest efforts for Microenterprise improvement via authorities-backed schemes.

Convergence with Other Departments/Schemes: 177 respondents (59%) verify convergence with other departments/schemes to assist SHGs.

Deployment of Thematic Community Cadre for Assistance: 240 respondents (80%) report the deployment of thematic community cadre for help to SHGs.

Regular Monitoring and Hand-Holding Support: 223 respondents (74%) acknowledge receiving everyday monitoring and hand-keeping guide for SHGs.

Overall, even as private banks appear to offer several financial services to SHGs, there are regions of improvement, in particular in terms of imparting digital banking offerings and increasing the community of BCs/kiosks. Additionally, there is a need for clearer conversation and accessibility to monetary products and services amongst SHGs.

III.Universal findings:

The findings of "An Analytical Study of the Role of Private Sector Banks in Financial Inclusion of SHGs: A Case Study of the Vindhya Region" reveal numerous key insights into the dynamics of economic inclusion and the function played by way of non-public sector banks in empowering Self-Help Groups (SHGs) inside the area. Here are some of the important thing findings:

1. **Positive Impact of Private Sector Banks:** Private sector banks have made large strides in promoting financial inclusion amongst SHGs inside the Vindhya Region. Their modern products and services, coupled with sturdy outreach packages, have accelerated get entry to formal financial offerings for marginalized communities.

2. **Empowerment of SHGs**: Private region bank interventions have contributed to the socio-financial empowerment of SHGs inside the place. By imparting get entry to credit score, financial savings, and coverage merchandise tailored to their desires, banks have superior the economic resilience and autonomy of SHG participants.

3. **Capacity Building and Skill Enhancement**: Private quarter banks have played a pivotal position in capability building and talent enhancement tasks for SHGs. Through financial literacy applications, schooling workshops, and skill improvement tasks, banks have empowered SHG individuals with the expertise and capabilities necessary to manipulate their finances successfully.

4. **Challenges in Last-Mile Connectivity**: Despite the development made, challenges persist in making sure ultimate-mile connectivity and outreach to faraway regions within the Vindhya Region. Limited infrastructure, geographical obstacles, and logistical constraints pose extensive demanding situations to extending financial services to the most marginalized groups.

5. **Importance of Contextual Understanding**: The findings underscore the significance of contextual expertise in designing effective monetary inclusion techniques. Socio-cultural norms, linguistic variety, and neighborhood governance structures shape the efficacy of personal sector financial institution interventions and necessitate context-particular tactics.

6. **Policy Implications:** The look at highlights the want for policy interventions to deal with regulatory bottlenecks and incentivize personal region participation in monetary inclusion projects. Strengthening the regulatory framework, selling public-personal partnerships, and fostering innovation are crucial for advancing financial inclusion goals within the Vindhya Region.

7. **Call for Collaborative Action**: Finally, the findings underscore the significance of collaborative movement related to multiple stakeholders, along with authorities groups, civil society organizations, and personal zone entities. Synergistic efforts are vital for scaling up successful economic inclusion fashions and addressing the multifaceted demanding situations going through marginalized communities inside the Vindhya Region.

These findings make contributions to deeper information of the position of personal zone banks in selling financial inclusion and empowering SHGs within the Vindhya Region. They provide treasured insights for policymakers, practitioners, and stakeholders searching for to boost inclusive development agendas and foster equitable get right of entry to financial services in similar contexts.

5.2 Suggestion and Recommendation:

Based on the findings of the analytical examine on the position of personal region banks in economic inclusion of Self-Help Groups (SHGs) in the Vindhya Region, the subsequent recommendations and hints may be made:

Enhance Digital Financial Services:

Private Banks should prioritize the improvement and promoting of digital financial offerings tailor-made to the wishes of SHGs. This consists of improving get entry to net banking, cell banking, and different digital platforms to facilitate paperless transactions and documentation.

Expand Outreach Through BCs and Kiosks:

Private Banks need to consciousness on expanding their network of Business Correspondents (BCs) and kiosks in rural and far off regions of the Vindhya Region. This would enhance access to banking offerings for SHGs, mainly the ones positioned in underserved areas.

Customized Financial Products:

Private banks must layout and provide monetary products in particular designed for the desires of SHGs. This consists of bendy mortgage merchandise with favorable phrases, together with low-interest fees and longer compensation periods, to help the financial activities of SHGs.

Capacity Building and Financial Literacy:

Collaborative efforts between non-public banks and government schemes ought to be intensified to offer regular training and capability-constructing programs for SHGs. These applications should focus on enhancing monetary literacy, entrepreneurship capabilities, and cognizance of to be had monetary services and products.

Strengthen Monitoring and Support Mechanisms:

Private banks should set up sturdy monitoring and support mechanisms to make sure powerful implementation of economic inclusion tasks for SHGs. Regular tracking, comments mechanisms, and hand-conserving aid can help address challenges and improve the general effectiveness of financial inclusion efforts.

Promote Collaboration with Government Schemes:

Private banks have to actively collaborate with authorities-subsidized schemes aimed toward assisting SHGs inside the Vindhya Region. This consists of leveraging current

government projects for SHG improvement, inclusive of livelihood advertising, micro-company improvement, and capability-building packages.

Evaluate Impact and Measure Success:

Private banks ought to often examine the effect in their monetary inclusion projects on SHGs inside the Vindhya Region. This includes tracking key overall performance indicators, measuring the effectiveness of implemented techniques, and making necessary adjustments to optimize outcomes.

Community Engagement and Participation:

Private banks have to actively engage with local groups and stakeholders to recognize their needs, alternatives, and challenges related to monetary inclusion. This may be completed thru network outreach packages, stakeholder consultations, and participatory choice-making tactics.

By imposing those hints, personal quarter banks can play a greater vast role in promoting financial inclusion and empowering SHGs inside the Vindhya Region, in the long run contributing to sustainable financial development and poverty comfort.

5.3 Limitations:

Geographical Constraints:

The Vindhya place, which mostly covers components of Madhya Pradesh and Uttar Pradesh, is geographically various and consists of rural and semi-rural areas where infrastructure improvement is regularly restricted. The observe might not fully capture the demanding situations that rise up from geographical isolation, mainly in hard-to-attain areas.

Data Accessibility:

Access to comprehensive records from non-public zone banks working in far off parts of the Vindhya place may be difficult. This can limit the accuracy of the analysis, specially in areas in which banking services are much less widely wide-spread, and the available records may be fragmented or incomplete.

Representation of SHGs:

The Self-Help Groups (SHGs) within the Vindhya region won't constitute the range visible throughout different parts of India, wherein SHGs have a longer records of functioning with formal banking establishments. This can result in a drawback in generalizing findings to other areas with extraordinary socio-economic situations.

Socioeconomic Differences:

The socio-monetary background of SHG individuals inside the Vindhya place may additionally differ from country wide averages. Factors consisting of decrease literacy prices, restricted focus approximately financial merchandise, and cultural norms would possibly impact the quantity to which monetary inclusion may be finished thru personal zone banks.

Banking Penetration:

Private quarter banks have historically had much less penetration in rural areas compared to public area banks. In the Vindhya area, the decrease presence of those banks can skew the observe outcomes, because the ability position of these banks in monetary inclusion is probably underrepresented due to confined operational insurance.

Technological Infrastructure:

The digital divide in the Vindhya place, specifically in faraway areas, is a great difficulty. The look at won't absolutely account for the demanding situations faced by using SHGs in getting access to online banking services, mobile banking, and other virtual monetary equipment, which might be increasingly more essential for financial inclusion but are less available in regions with poor connectivity.

Policy Implementation Gaps:

While rules geared toward enhancing financial inclusion exist, there can be gaps in their implementation inside the Vindhya vicinity because of administrative inefficiencies, lack of coordination between banks and SHGs, and ranging stages of support from local authorities bodies.

These boundaries highlight the want for a greater localized method in analyzing financial inclusion and SHGs within the Vindhya region, spotting the particular challenges posed by the socio-economic and geographic elements of the location.

5.4 Conclusion:

In summary, the results of the analytical research that was conducted on the role that private sector banks play in the process of ensuring the financial inclusion of Self-Help Groups (SHGs) in the Vindhya Region are substantial and notable. To begin, the findings of the study suggest that private sector banks, and HDFC in particular, play a key role in the attempts to expand access to financial services, although to a lesser extent than ICICI does. It would seem that HDFC has a more significant influence on the process of financial inclusion, as shown by the fact that it has a better average score for financial inclusion in comparison to ICICI. This highlights the significance of private sector banks in broadening access to financial services among underserved areas such as self-help groups (SHGs).

In a second point, the research substantiates the centrality of self-help groups (SHGs) in the socio-economic growth of low-income families. The findings of the regression analysis indicate that there is a significant positive connection between the parameters connected with SHGs and socio-economic growth. This highlights the efficacy of SHGs in assisting low-income families in achieving their goals. Through this, the relevance of self-help groups (SHGs) as agents of change in the promotion of sustainable development and the enhancement of livelihoods is brought to light. Additionally, the study throws light on the different degrees of formality that are needed by private sector banks. HDFC demonstrates somewhat greater formalities compared to ICICI, which is supported by the findings of the research. This highlights the need for financial institutions to simplify their procedures and decrease the number of bureaucratic obstacles in order to improve the accessibility and comfort of their services for clients. As a last point of discussion, the research offers data that substantiates the efficacy of government-sponsored programmes in assisting, enabling, and counselling self-help groups (SHGs) in their pursuit of individual independence. The results of a regression analysis show that there is a strong positive correlation between government-sponsored schemes and the establishment of self-help groups (SHGs). This suggests that such efforts play an important role in encouraging self-sufficiency among member groups. The results, taken as a whole, provide light on the complex dynamics of financial inclusion and the joint efforts of private sector banks, self-help groups (SHGs), and government-sponsored initiatives in the Vindhya Region, which are driving socio-

economic growth and empowerment. These findings have the potential to guide policy interventions and strategic activities that are targeted at encouraging equitable development in the area and boosting financial inclusion.

Chapter-VI

Future scope and Application

6.1 future Research aspects

The destiny scope and aspects of the research on "An Analytical Study of the Role of Private Sector Banks in Financial Inclusion of Self-Help Groups (SHGs) in the Vindhya Region" are extensive and multidimensional. Here are a few capability avenues for further exploration:

Impact Assessment: Conducting a complete effect assessment to measure the effectiveness of private zone banks in enhancing economic inclusion among SHGs in the Vindhya Region. This might contain comparing results including increased access to economic offerings, advanced livelihoods, poverty reduction, and empowerment of marginalized groups.

Policy Analysis: Examining the policy framework and regulatory surroundings governing economic inclusion projects within the Vindhya Region. This evaluation should pick out coverage gaps, regulatory constraints, and opportunities for policy reform to promote greater involvement of private sector banks in fostering financial inclusion.

Technology Adoption: Investigating the position of technology, consisting of virtual banking systems, cellular price structures, and fintech solutions, in facilitating financial inclusion efforts through non-public zone banks. Exploring progressive technological answers tailor-made to the needs of SHGs should enhance accessibility, efficiency, and affordability of economic offerings.

Capacity Building: Assessing the capacity-building wishes of personal sector banks, SHGs, and other stakeholders involved in financial inclusion projects. Developing education applications, workshops, and talent-constructing sports may want to toughen the capacity of those actors to successfully participate in and make contributions to economic inclusion efforts.

Sustainability and Scalability: Exploring strategies for boosting the sustainability and scalability of financial inclusion projects implemented by personal area banks in the Vindhya Region. This ought to involve figuring out scalable models, leveraging partnerships, mobilizing resources, and making sure the lengthy-term viability of interventions.

Social and Environmental Impact: Investigating the social and environmental implications of monetary inclusion projects by using non-public region banks. Assessing factors together with gender equality, environmental sustainability, and social inclusion could help make sure that economic inclusion efforts contribute to broader improvement dreams and deal with systemic inequalities.

Community Participation: Promoting greater network participation and engagement in economic inclusion initiatives. Empowering SHGs and local communities to actively participate in selection-making approaches, layout interventions, and display effects can enhance the relevance, effectiveness, and sustainability of financial inclusion efforts.

Cross-Sector Collaboration: Facilitating collaboration and partnerships between non-public area banks, authorities agencies, civil society agencies, academia, and community-primarily based establishments. Building synergies and leveraging the expertise, assets, and networks of diverse stakeholders can enlarge the effect of financial inclusion projects and foster holistic development.

By exploring those future scope and aspects, the studies can make a contribution precious insights, proof-based totally guidelines, and revolutionary answers to develop monetary inclusion efforts and promote inclusive and sustainable improvement inside the Vindhya Region.

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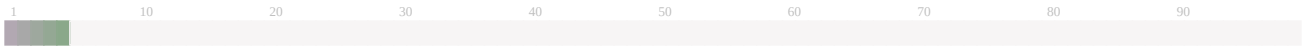

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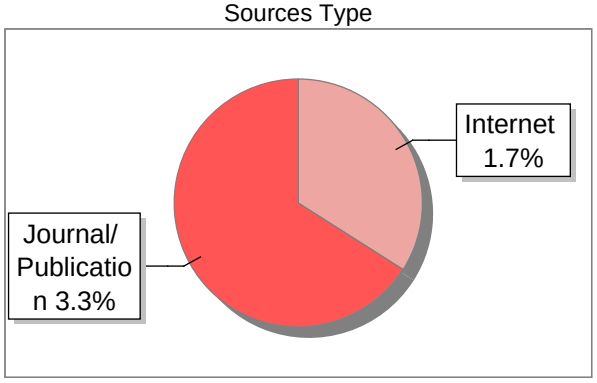

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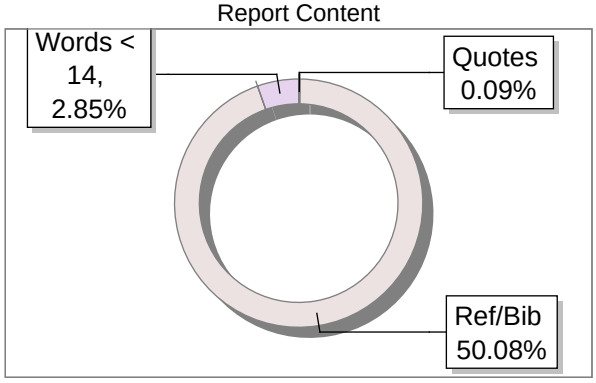

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57	Cardiac disease in pregnancy by Curry-2009	<1	Publication
58	Comparison of CT Features of Aspergillus and Bacterial Pneumonia in Severely Neu by Bruno-2007	<1	Publication
59	diabetesatlas.org	<1	Publication
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74	A pilot study of the relationship between preeclampsia and anti-tetanus toxoid a by Scoville-2017	<1	Publication
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80	e-journal.unmas.ac.id	<1	Internet Data
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INTRODUCTION

Table of Content

1. Chapter: INTRODUCTION

Over the last three decades, Prenatal screening for aneuploidy screening testings has evolved and achieved almost 99 percent sensitivity (Phadke S.R. 2017). Within the literature, commonly used methods in India are described in India as triple marker test, quadruple marker test, and first-trimester double-marker test with or without nuchal translucency (NT) (an ultrasound marker) (Phadke S.R. 2017). However, currently, available prenatal screening options include some other biomarkers for accuracy along with maternal age and combined with one of the following: (1) first-trimester screening ultrasound markers and NT, CRL (crown rump length), and maternal serum biochemical markers), (2) second-trimester serum screening (maternal age and maternal serum biochemical markers), or (3) two-step integrated screening, which includes first- and second-trimester serum screening with or without NT-CRL, serum integrated prenatal screening, contingent and sequential). Despite the research work carried out on screening yet confirmation requires invasive testing (amniocentesis & CVS: Chorionic villi sampling), and both procedures are associated with a risk of miscarriage. The detection rate for the first-trimester biochemical screen test with NT (Nuchal translucency) is 82 percent while that for the quadruple test is 80 percent. However, combinations such as integrated or sequential testing with additional ultrasound markers such as nasal bone increase the detection rate to 95 percent. It could be said that each marker of the trisomy test has a role in determining the risk (Kevin et al. 1993). These variations in method indicate a constant need for evaluation for techniques to achieve greater efficacy.

1.1. An Introduction to the Assessment of High Risk in the pregnancy

Pregnancy is a normal phenomenon if carried out healthy except in some cases where the presence of any of the prior disease conditions (like diabetes, high blood pressure, anemia, older age, smoking, or drinking habits' exists) with women or developed during antenatal period complications (like gestational diabetes, hypertension, placenta previa, preeclampsia, preterm labor, miscarriage, or low birth weight) arises and leads to the difficulty in post-partum phase or neonate complications. Then it's called High Risk Pregnancy.

Many of these complications may be avoided by taking certain precautions of prior avoidance of harmful substance intake, adequate inclusion of nutrition, proper medication intake, routine antenatal care, continuous monitoring of adverse symptoms, and prenatal analysis in case of patients' needs along with families' awareness for concern and availability of medical resources.

1.1.1. An Introduction to High-Risk Assessment Methods

Pre-natal diagnosis is a range of tests for determining neonates' health and growth, especially for anomaly detection. These tests include various non-invasive and invasive techniques like ultrasound, biochemical testing through blood tests, double, triple, and quadruple marker screening, karyotyping, amniocentesis, and chorionic villi sampling (NIPT/ cff DNA Testing method).

Primarily ultra-sonography helps in observing the size and position of the foetus and placenta afterward a range of scans provides further assessment for necessary counseling. Secondly, a blood test gives many updates on the hormonal

changes of the mother for development and requirement in pregnancy for the child, and lastly patients get advised for invasive tastings' if needed due to major chances of abnormality present in the foetus. This complete procedure is termed prenatal testing.

1.1.2. Recommended Antenatal Screening Tools:

Identification of risk in foetus for having any type of trisomy may be assessed in the mother at an early stage, as the first trimester (11-13th week gestation) or early second trimester (16^{th}- 20^{th} week of gestation) by blood test known as trisomy screening and invasive CVS (Chorionic Villi Sampling) sampling for Amniocentesis or karyotyping (a technique to make a map of the chromosome). Nowadays the NIPT (non-invasive prenatal screening of foetal cells cff-DNA (cell-free fetal DNA) in maternal blood testing) is also in practice with less risk to the mother and lower sensitivity but it has the limitation for only specific syndrome identification not for all other complications.

Trisomy screening starts from the first trimester at 11-13 weeks with ultrasound followed by a double marker test or triple or Quadruple marker test at the 14-20 weeks of pregnancy along with sonography scanning and for confirmatory diagnostics, CVS or Amniocentesis tests are available in invasive testing and cff DNA test as a non-invasive tool from blood tests are the available resource in the present health care system. (Shubha Phadke. 2018)

Figure 1: Prenatal diagnosis timeline in pregnancy period

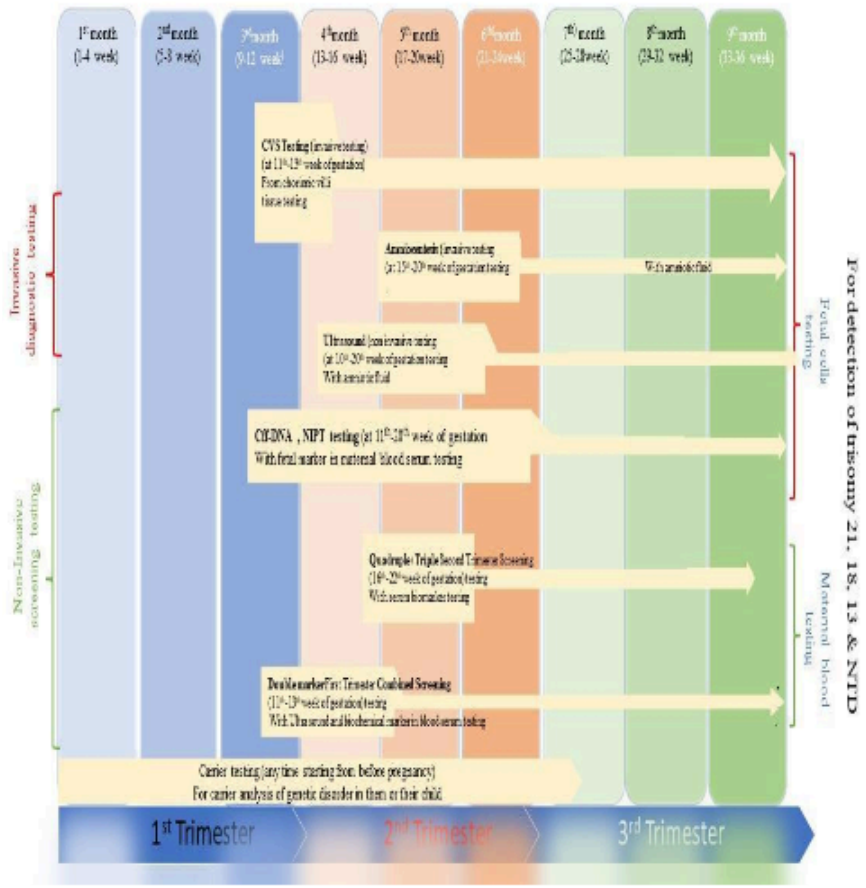

Figure 1 indicates flow diagram of different testing techniques for prenatal screening in clinical practices with the period corresponding to pregnancy gestation.

1.2. Diagnosed aneuploidies:

Trisomy is a condition of triploid chromosome number in place of the normal diploid state. This usually happens due to incomplete or non-segregation/ translocation of genetic material during the cell division process of development in the fertilized cell.

These disorders develop intellectual disabilities, phenotypic changes, and mental disorders in an individual. Different types of trisomy have been diagnosed so far based on the presence, of chromosome numbers. Majorly diagnosed trisomies are 21 trisomies as Down Syndrome, 18 trisomies as Edwards Syndrome, 13 trisomies as Ptau Syndrome, 9 trisomies, trisomy 8 as Warkany Syndrome, trisomy 16 and 22 trisomies are Cat eye syndrome, Klinefelter syndrome (47or XXY/XXX/XYY) and turner syndrome (45X) are the sex-linked trisomies and they all together have 6 % of total birth with defects in the society according to the global data it is approximately 7.9 million infants in the world and 1 in 850 live births in India.

Screening for all these trisomies is very important due to their non-curable condition and limitations with the clinical symptomatic cure Screening tests and diagnostics are well in practice and common to rule out the condition with the (trisomy screening biochemical marker along with ultrasound data) 96-98% accuracy..

1.2.1 The potential patients who might come under high-risk criteria

Medical history with miscarriage, previous pregnancy complications, genetic disorders, autoimmune diseases high blood pressure, diabetes, overweight and obesity, depression, or long-term chronic infection like being HIV positive or STDs increases the risk for hypertension, preeclampsia, gestational diabetes, stillbirth, Neural tube defects (NTD), and cesarean delivery (LSCS). NICHD (Eunice Kennedy Shriver National Institute of Child Health and Human Development) researchers have found that obesity can raise infants' risk of heart problems at birth by 15%. (NIH. 2010) Multiple pregnancy such as twins raises the risk of complications. More than one-half of all twins and as many as 93% of triplets are born at less than 37 weeks gestation. (Hamilton BE. 2016) Young or old maternal age**.** Pregnancy in teens and women age 35 or older increases the risk for preeclampsia and gestational high blood pressure. (MedlinePlus. 2011)

1.2.2. Adverse Pregnancy Complications that may arise antenatally

The most commonly diagnosed adverse complication of pregnancy was Preeclampsia, IUGR (intrauterine growth restriction), GDM (gestational diabetes mellietus), PTL (pre-term labour), PROM (pre-mature rupture of membrane), Pregnancy with heart, lung, or kidney diseases in patients may complicate the period. Overdue pregnancy, Multiple gestation (twins, triplets), or decreased amniotic fluid (oligohydramnios) may lead to a small gestational or small weight baby, Placental abnormality, Premature rupture of fetal membranes, or even unexplained fetal death Concern for fetal well-being.

1.2.3. Biomarkers used in Prenatal Diagnostics and adverse outcomes (APOs).

The illustration (Figure 2) of used biomarkers and observed adverse outcomes during pregnancy in high-risk women covers most of the results.

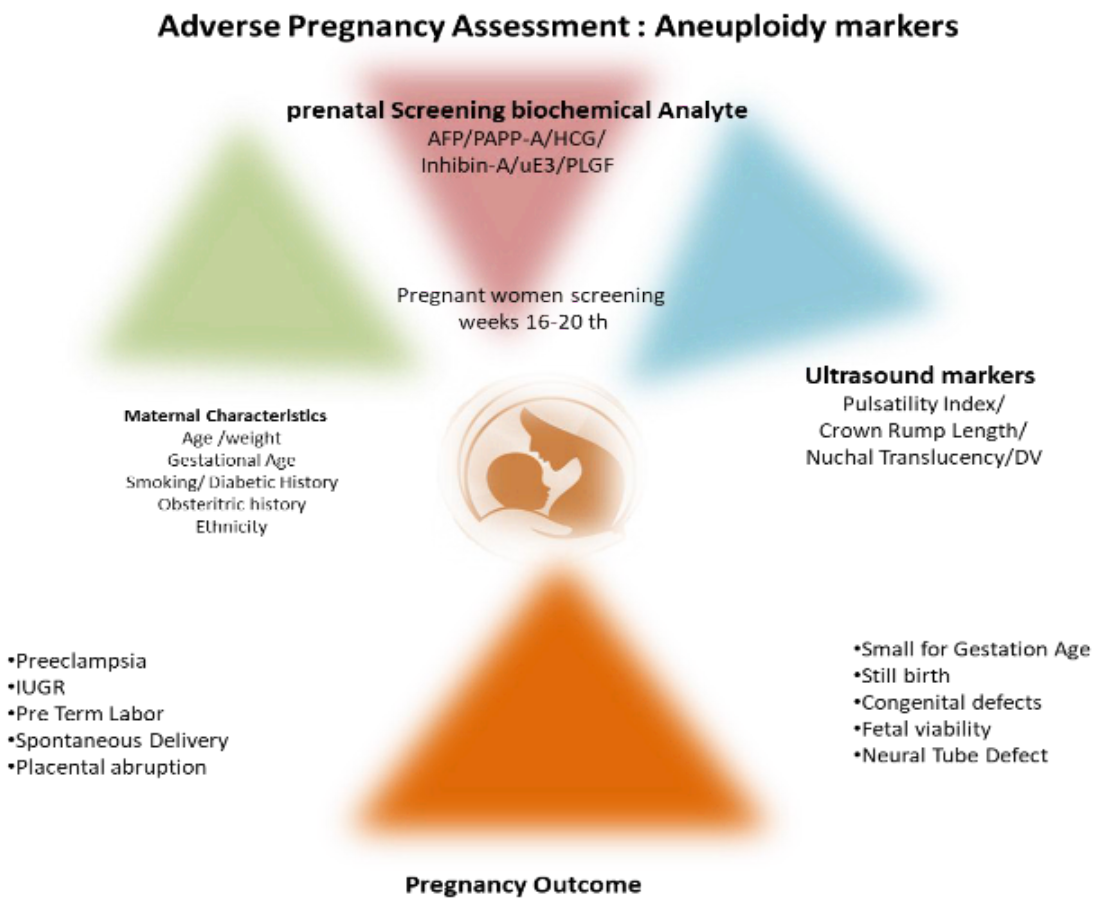

Figure 2: Illustration depicts common observed adverse pregnancy outcomes and affiliated maternal and fetal biomarkers.

1.2.4. Risk of mortality and morbidity associated with those complications

India faces 75% of perinatal mortality and morbidity due to the presence of 20-30% high-risk in pregnancies. Global data for hyperglycemia in pregnancy

accounted 170 cases per 1000 live births (Guariguata L et al 2014) And an average of 1% to 8% of preeclampsia in low- and middle-income countries whereas eclampsia led to approximately 333,000 maternal deaths, six million perinatal deaths, eight million preterm births and 20 million low birthweight infants (Bilano VL et al 2014).

1.3. Aim of the study

The study aims to shed light on the improved method of investigating a suitable cut-off value for effective prenatal testing. The calculation will be based on the sensitivity and specificity of multi-marker testing (Trisomy: 21, 18 & 13) with maternal serum through optimization of screening methods. To attain the above points, we have the following aims:

1.3.1. Objectives of the Study

Objective 1: To identify the association of pre-analytical and analytical variables in trisomy screening tests.

Objective 2: Adjustment of the cut-off value for Risk determination in trisomy screening.

Objective3: To check the individual component response for any associated risk in the pregnancy

1.3.2. Rationale of the study

Previous studies had given some direction to the research which helped us to project our hypothesis as below:

The rationale for Objective 1:

Although a recent study has carried out research work on the assessment of pre-analytical factors in trisomy testing, however, it is limited to simulation data only, not posed actual patient data (Walker et al., 2017 & Wright et al. 2013), as patient data would provide more convincing results (Walker et al, 2017). This will require an infeasible sample size to detect small changes in risk due to preanalytical factors. Based on the above facts, we would analyze the different preanalytical factors on patient data which will strengthen its focus on an outcome (calculated true risk) rather than an intermediate outcome (change in biomarker concentration only). Thus, we may show how pre-analytical factors could affect the outcome and risk of misclassification.

The rationale for objective 2:

Several centres that perform first-trimester trisomy 21 screening tests should intermittently calculate false-positive rates at alternative cut-off levels for invasive procedures, and determine the optimum cut-off level for their series (Kalelioglu, et al, 2003). However, abnormal results of the quadruple screening test could be associated with APO in women with a normal-appearing foetus. (Yazdani et al, 2015) The classic relation of hCG is strongly correlated with body mass index, smoking, and gravidity in early pregnancy and hCG affects lower centile TSH values disproportionately whereas TSH is the marker for gestational thyroid status,

and thyroid imbalance is linked with fetal neurodevelopment and neurocognitive evaluation. (Martinez et al, 2018)

The rationale for objective 3:

Yazdani and the group have found a statistically significant association (correlation) between APO (Adverse pregnancy outcomes) and quadruple test. They found a correlation between inhibin-A with most disorders. Based on the previous studies, we could suggest conducting further studies on this particular marker as well as other individual components and its assessment relate well with its usefulness in the diagnosis and management of high-risk pregnancies. Application of the screening test results for predicting APO requires further investigation (Yazdani S. et al. 2015).

1.4. An Introduction to the Test Analytical Variables

Disease diagnosis is nowadays majorly dependent upon the test results offered by the clinicians from the laboratory. A test involves many complex stages starting from patient visits in a lab to result in handover to the doctor. This multi-step process is many times handled by non-technical persons. Untrained and non-professional involvement may induce some manual error during the procedure and these are termed as analytical errors/variables. Analytical variables are classified into three different groups for any test set. Pre-analytical, Analytical, and post-analytical variables (Lundberg. 1981).

Table: Test variables influencing test results

Sr no.	Phase	Factors	Variables	Influence
	Pre-analytical			46-68.2%
1		Vital	Weight, Height, BMI exact or approximate values.	
2		Physiological	Pregnancy, Fever, Obesity status of patients.	
3		Age	Neonate, adolescence, adult, elderly, pubertal stage differentiation.	
4		Sex	Female, male, transgender writing error.	
5		Time	Time at sampling, transportation time, resting time for sample etc.	39%
6		Sample status	Heamolysed (60%) samples, insufficient amount, incorrect tube selection, clotted sample.	15-27% 3.91-13%, 0.91-11%
7		Central Coordination	Errors between different centers for sample and patient information sharing, lost prescription.	3%
8		Entry	Digital entry, lab catalog, receipt entry, sample form, and sample description entries.	
9		Diet	Vegetarian, non-vegetarian, fasting, last food intake time for the patient.	
	Analytical		-	15%
10		Chemicals	Expiry dates and company quality.	27%
11		Temperature settings	For the machine, stored reagents, and Room temperature.	
12		Technology used	New or old machines, routine maintenance.	23%
13		Trained technicians	Valid license and mandatory qualifications, venepuncture error, tourniquet application time.	20.2%
14		Protocol follow-ups	According to the manuals of the kit.	

15		Lab manuals	For safety, hygiene and equipment handling, phlebotomy.	24-30%
16		Report Entry	With every detail in chronology.	
17		Reporting precautions	Verification of patient correctly.	
	Post Analytical Variables		-	23%
18		Report Entry	With every detail in chronology.	
19		Log Maintenance	Honest Entry into daily routine with transparency.	
20		Report Delivery	Verification of patient correctly.	

Table 1: Analytical variables causing errors in the laboratory that could influence test results from across the glove studies in the entire test process.

1.4.1. Pre and Post analytical Variables

Pre and Post-analytical errors in tests have been considered major errors of almost 43-71% (Carraro and Plebani. 2007). All the steps before and after the test come in this criteria and mostly non-technical and unprofessional individuals handle these activities. Some controllable and uncontrollable multifactorial, most erroneous variables are; Age (Pubertal, adolescence, adult, elderly), sex, ethnicity, date, season, vital signs such as weight, height, body mass index (BMI), blood pressure (BP), physiological status; pregnancy, diet type (vegetarian/non-vegetarian, eggetarian, began), fasting or food ingestion time before the test, smoking or alcoholic, caffeine intake, water intake, drug intake, in last 24 hrs, allergies, fever, blood pressure, socioeconomic status, stimulants, handling related;

sample collection, sample handling, sample processing, sample storage, influence the individual risk results.

Laboratory logs, digital entries, physiological status of specimen, the timing of collection, patient medical history, equipment's maintenance status, etc. (Guder, et al. 1999). It needs to be understood that every single step described through the guidelines is important to follow with a defined protocol only for providing accurate results else it may cause a huge error in diagnosing the wrong people. (Lima-Oliveira, Volanski *et al.* 2017)

1.4.2. Analytical Variables:

The analytical phase is the core part of testing where most of the technical staff is involved and this makes it a sensitive issue to perform properly and declare results appropriately for the sake of the laboratory. Initially, a study showed errors in this segment later were a Few study groups reported errors in this section which were improved soon by automation installation (Belk and Sunderman. 1947, & Plebani. 2006)

1.4.3. Variables influencing trisomy screening

Errors from all three of stages have been studied for long, but still need consistent evaluation and rectification of process due to the existing presence of 0.1-9.3% (Kalra. 2004) errors. These laboratory errors affect 26-30% of patient care decisions (Plebani. 2006)Previously, studies investigated the impact of pre-analytical factors on post-test risk in trisomy screening and their focus was limited to transportation factors only and they found transportation of patients' serum samples affects

concentrations of β-HCG which may be responsible for false-positive risks (Wright et al. 2013). However, other factors as storage time and temperature; freeze-thaw cycles remained unassessed and they cause hindrances and changes in the concentration level of biomarkers used in trisomy testing (Walker et al. 2017). This study gives insight into overall factors.

1.5. Supportive Studies across the globe

Similar studies on the content helped us to hypothesize that a detailed analysis of pre-analytical and post-analytical factors could help make the screening method more sensitive and effective for trisomy testing. Secondly, the risk of having pregnancy anomalies such as pre-eclampsia, FGR, IUGR, and rupture of the membrane could be linked with abnormal results in the individual concentration levels of biochemical markers in trisomy (Wright et al. 2013). Moreover, abnormalities in maternal serum marker levels and foetal measurements obtained during the first trimester can pose concentration of markers not only for certain chromosomal disorders or anomalies in the foetus but also for specific pregnancy complications, as the altered level of individual markers could be linked with other conditions like Hyperthyroidism and cardio-vascular diseases (Shahla Yazdani. 2015). Thus, we could say that very little is known about the diseases affected by individual components.

1.6. Limitations of the study

We had some limitations in our study on the following matters.

- Working in a bigger hospital and dealing along with diagnostic settings becomes difficult to work. Handling of confidential data, hectic schedule of clinicians and

patients' psychological state makes things difficult. In this non-treatable diseased condition patients' families' reactions in our society are still not much open-minded. These factors may lead the study to a more time-consuming job than planned.

- Confirmation of the result from the follow-up patients, who left the Hospital premises, could not be considered in the study, and This study is a single-countered study, limited to a zone in India.

- The important part of the study was designed in a retrospective way which may be considered as a limitation of this study, whereas the lack of data on maternal comorbidities and medication in objective 3 was hard to collect. The ethnic background of the patients was all the same, since study populations were very homogenous, with a strong predominance of wheatish Asian patients, so studying in different ethnicities could not possible in the same study settings.

- Most of the patients were directly choosing to go for quadruple testing (second-trimester joint screening) instead of going to the First-trimester screen first, which may be due to ignorance, so we were not able to collect data on earlier screening biomarkers sufficiently to get significant results. The small number of cases in objectives 1 and 2 restricts the studies' power comparatively. Larger study groups would provide more precise information concerning the significance of soft markers in First Trimester Screening.

- Despite the good size of study and control groups in 3rd objective, the clinical context of the study results is limited to a small group of pregnant women for

various individual diseases. Objective 3 lacks statistical power concerning rare outcomes and, due to the small incidence of many in the population.

One might criticize the selection of the main topic in objective 3 since a "Gray zone" (APO's-Adverse Pregnancy Outcome) between the study and control groups was not analyzed. This study design is, however, crucial to describe the significance of the varied level of biomarkers compared to pregnancies completely lacking this risk factor. The evaluation of the grey zone and outcomes associated with increasing Biomarkers' values would, however, yield more information concerning the deterioration of pregnancy outcomes.

Future research directions:

To improve trisomy screening and adverse pregnancy outcome prediction, future research should focus on:

1. Biomarker discovery: Identifying new biomarkers for adverse outcomes.

2. Machine learning and artificial intelligence: Developing predictive models.

3. Multi-center studies: Large-scale studies to validate findings.

4. Patient-centered outcomes: Investigating patient-reported outcomes and establishing clinical utility.

5. Health economic analysis: Evaluating cost-effectiveness.

REVIEW OF LITERATURE

TABLE OF CONTENTS

2 Chapter: REVIEW OF LITERATURE

2.1 Introduction:

The recent trend in scientific studies has highlighted the increasing interest in utilizing existing technology to gain more benefits instead of putting burdens on new methods or extra costs to society. Given this, aneuploidy screening tests have been studied many times differently to understand other prospects for diagnosing adverse antenatal or postnatal complications. These adverse pregnancy outcomes account…% of maternal and fetal mortality. Ensuring the fetus and mother's health throughout the period becomes most important to take care of. and if it gets detected early enough to handle it properly to avoid major issues at the end of being at risk for mother and child.

Prenatal analysis has been considered a routine process during early and mid-term pregnancy by performing various vital tests, clinical evaluations, and general body fluid tastings of patients in several maternity centers being offered in the routine now. If clinicians diagnose any abnormality, then they may recommend for further advanced or repeat tastings within a certain period in a reference health care unit to undergo next level invasive or non-invasive testing techniques for confirmation of complexity to handle the later disaster.

Trisomy screening tests are sensitive for the growing period of pregnancy because getting close to delivery reduces the chance of handling foetus care on time, so to prevent any possible adverse outcome in the end timely management of needs becomes very important.

Below is a typical image of a human karyotype with showing band pattern

on all the sets of 23 pairs aligned in the order. This image also shows the trisomy 21 pattern to address the chromosomal disorder pattern. This is done through invasive testing of amniotic fluid by staining cells in metaphase of cell division with Geimsa after a tissue culture.

Karyotypic depiction (a detection technique) of Human Chromosome for trisomy.

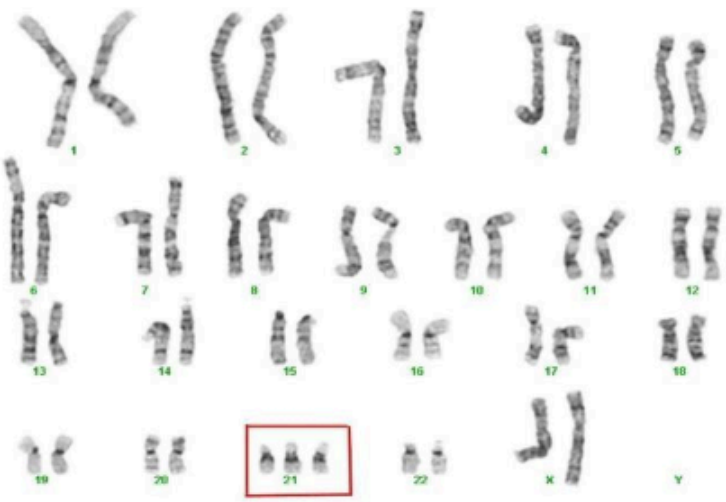

*Image has been taken from web browser free excess- gene online/trisomy 21

Figure 3: karyotyping is a diagnostic technique to make a human chromosomal map for identifying numbers and patterns over it.

2.2 Types & symptoms of Chromosomal Disorders

Chromosomal disorders are classified based on their count change or their size change from the parent cell. Till now many types of abnormalities have been reported. They may lead to bad consequences and non-curable genetic diseases. More than 15 types of chromosomal aberrations are known among them almost

seven may occur with a frequent manner and more than eight may count as rare disorders.

2.2.1 Most common types:

The most commonly found chromosomal disorder is Trisomy is 21 (Down Syndrome- 15 in 10000), from the records of CDC (Centers for Disease Control and Prevention) USA, records 6000 newborns every year making 1 in 700 babies (cdc.gov) Down syndrome is also associated with an increased prevalence of autoimmune disorders (Agrawal S. 2015) such as celiac disease and hypothyroidism. and Turner (Monosomy X- 10 in 10000), Klinefelter (XXY- 10 in 10000), XXX/XYY – (10 IN 10000) are second common whereas Trisomy 18 (Edward Syndrome – 3 in 10000), Trisomy 22 (De-George – 2.5 in 10000) are also been observed repeatedly. Due to the high birth rate in India a very large number of infants with genetic disorders are born every year almost half a million with malformations and 21,000 with Down syndrome. (IC Verma. 2000) Burden of genetic disorders in India-PubMed (nih.gov)

Down's syndrome, also known as trisomy 21, is one of the most common congenital developmental disabilities caused by chromosomal disorders in humans, with a morbidity of 1 in 600–00 newborn infants (Oglubalci B.K. 2016) It results from a person having three, rather than two, copies of chromosome 21(Agrawal S. 2015) Down's syndrome is also associated with an increased prevalence of autoimmune disorders such as celiac disease and hypothyroidism.

2.2.2 Less common types

Trisomy 13 (Patau's syndrome- 2 in 10000) , trisomy 18 (Edward syndrome – 2 in 10000), Trisomy 16, Trisomy 8 (Warkany syndrome 2), Trisomy 9 & trisomy 5 , Prader Villi (1 in 15000) , WAGR syndrome (1 in 500000) are less common type of trisomies present in the population with different mortalities.

2.2.3 Clinical Symptoms in Trisomy

All the types of trisomies have specific characteristics along with some common major symptoms like learning disabilities, delayed milestone development, behavioral and psychological problems, and prominent physiological features with signature signs of individual diseases. This helps in identifying clinicians to diagnose the patient for further treatment. Few are mentioned below among most commonly found in all types.

DS (Down syndrome: most common type) individual exhibits a variety of physical characteristics including a small chin, slanted eye, poor muscle tone, a flat nasal bridge, a single crease of the palm, and protruding due to small mouth and large tongue. Several other appearances including a big toe, an abnormal pattern of fingerprints and short fingers have been identified that deficits in learning, memory, and language lead to a general cognitive impairment, which is typically in the mild-to-moderate range (Kaewsuksai et al, 2017)

Some typical phenotypic features like; a flattened face, especially the bridge of the nose, almond-shaped eyes that slant up, a short neck, small ears, tongue that tends to stick out of the mouth, tiny white spots on the iris (colored part) of the eye, small hands and feet, single line across the palm (palmar crease), small pinky fingers, that sometimes curve toward the thumb, poor muscle tone or loose joints,

shorter in height as children and adults are observed in the most of the patients in few but may not all. Individuals are also characterized by mild to severe mental retardation, prominent forehead, deep-set eyes, thick lips, prominent ears, camptodactyly (abnormally flexed fingers), abnormalities of the heart, viscera, and genitalia.

Major Identification: Prominent facial features, linguistic incompetency, and milestone developmental disabilities are the signatory identification marks for determining trisomy diseases.

2.3 Trisomy Testing Methods

Trisomy screening tests can be categorized into two main types: non-invasive and invasive. Non-invasive tests include:

2.3.1 Non-Invasive screening testing: Noninvasive methods include blood tests and ultrasound scans during the early trimesters.

Screening Tests in the First Trimester

First-trimester screening tests include:

1. **Combined Test:** combines MSS (maternal serum screen), NIPT (non-invasive prenatal test), and ultrasound markers.
2. **Integrated Test:** combines first- and second-trimester MSS and ultrasound markers.

The integration of first- and second-trimester screening markers to report one risk factor was initiated in the late 1990s. The integrated test combines first-

trimester NT measurement and serum PAPP-A and β-hCG levels with second-trimester AFP, β-hCG, E3, and Inhibin levels. The major advantage of this test is that with the integrated test fewer women will need to undergo invasive testing which is associated with the inherent risk of miscarriage.

Screening Tests in the Second Trimester:

1. **Quadruple Test:** measures four biochemical markers in maternal blood.
2. **Ultrasound Soft Markers:** evaluates fetal anatomy and markers.

Second-trimester screening known as the Quadruple Marker Test, based on the combination of maternal age and maternal serum Human Chorionic Gonadotropin (hCG), alpha-fetoprotein (AFP), Inhibin A and unconjugated estradiol (uE3), yields a detection rate of 60–5% on 5% false positive rate. In contrast, for the same false positive rate, first-trimester screening known as the Double Marker Test based on the combination of maternal age, nuchal translucency ultrasound, and maternal serum Human Chorionic Gonadotropin (free βhCG) and pregnancy-associated plasma protein-A (PAPP-A) achieves a detection rate ~90% (Leonor Varela Lema et al. 2018).

2.3.2 Invasive diagnostic tastings:

Invasive testing is offered to women with positive screening results or other risk factors for confirmatory analysis since they carry a small risk of miscarriage.
Types are:

1. Chorionic Villus Sampling (CVS): examines placental tissue.
2. Amniocentesis: analyses amniotic fluid.

Any abnormality in ultrasound markers or serum markers in the first trimester (11th to 13th week of gestation) predicts risk for having the chromosomal disorder and this leads the way to confirm the results from a Gold stranded technique of diagnostic is known as Amniocentesis and CVS (chorionic villi sampling) with the help of a medical professional for chromosome mapping or mutation analysis. This process contains the risk of miscarriage and not the first level of detection. Recently, NIPT (noninvasive prenatal testing through free fetal cell DNA (Cff DNA) identification in the mother's blood is also available for the couple as an option but its sensitivity has many controversies, so not opted for or advised in all manners.

2.3.3 Cell-Free DNA Testing

Cell-free DNA screening has revolutionized trisomy screening, offering high sensitivity and specificity. However, false positives and false negatives can occur and this is not for all instead for specific types of trisomies only.

Trisomy screening, typically performed between 15 and 20 weeks of gestation, aims to detect aneuploidies, particularly trisomies 21, 18, and 13. While its primary purpose is to identify chromosomal abnormalities, research has shown that trisomy screening can also predict adverse pregnancy outcomes.

2.4 Treatment for the Trisomies

Genetic disorders are non-curable diseases since the problem persists in the genetic information that controls the bodily mechanisms and developments but researchers were able to provide a few options to improve the lifestyle as much as possible by providing symptomatic supplements within the following sections.

2.4.1 Surgery & Medications

Heart defects; atrioventricular septal defects, gastrointestinal issues; and duodenal atresia, like physical deformities, can be taken care of by surgical operations and some thyroid medicines may help with hormonal imbalance.

2.4.2 Behavioral & Occupational Therapy

These diseases are lifelong diseases and conditions deteriorate with aging, and all surgery or costly treatment options are not possible for all due to various reasons in such cases conditions may be improved or can be taken care of with the help of available speech therapy, motor skill development programs, assisted devices, are the helpful tool while practicing continuously and enhances intellectual abilities.

2.4.3 Drugs and their side effects

BTKi inhibitor like Acalabrutinib or Ibrutinib, or a BCL-2 inhibitor like Venetoclax, are some common type of medicines whereas Obinutuzumab is a second-generation treatment for trisomy disorders.

Anticonvulsants, Muscle relaxants, and Rigidity antispasmodics and Hypertensive medication are used for trisomy treatment, but they may cause many severe side effects other than some common types (Abdominal pain, Blurred vision, Constipation, Diarrhoea, Dizziness). Xerostomia (dryness of the mouth), stomatitis (inflammation of mucus membrane), mood changes, nausea, headache, Drowsiness, tiredness, syncope, fatigue, ataxia, depression, Excessive bleeding may result when combined with aspirin or NSAIDs, hepatotoxicity, pancreatitis, abnormal blood

pressure, seizures, CNS depression, Kidney Failure has severed types in some cases.

2.4.4 Social interventions

Curing or reducing the severity of disease by prenatal care, prevention or survival by surgical interventions, and accepting it in society with pride and love. Many linguistic therapy, fine motor skill development workshops, and special education institutes help improve the lifestyle of trisomy patients and families. To successfully implement integrated screening, healthcare providers should:

1. Stay updated on guidelines and recommendations.

2. Develop patient education materials.

3. Establish clear referral pathways.

4. Foster collaboration between healthcare providers.

5. Continuously evaluate and improve screening protocols.

2.5 Analytical variables affecting tastings:

All over the world studies has been conducted to identify and rectify the possible causes of errors in the tests to precise the results in order to improve the health care system.

2.5.1 Preliminary and post-test variables

Eradication of Pre analytical (before test starts; sampling method, sample storage period/temperature during transportation, collection in right tubes, sample physical

condition, information of patients obtained, and correct record entry), Analytical (during test; chemicals used in dates & stored in recommended settings, room 7temperature, equipment quality, mentinence routine, power resources for equipment, and handling person/technician's ability, and lab manuals), and Post analytical (after test and before report delivery; correct entry of report, proper log mentinence, on-time reporting and verification of patient information) with many others comes under test variables to be addressed seriously by the laboratories providing patient care. Few research groups had studied a similar subject to analyze the approximate results of the error in testing, which are tabulated in below Table RL1.

Previous studies on preanalytical and analytical variables of test

Sr. No.	**Factors studied**	**Place of study**	**Result** influence (%)	**Study type**	**References**
1	Pre-post & Analytical Error reported	Pant Hospital, Delhi	77.1%, 15%,7.9%	Prospective	Goswami B, 2010
2	Obsolescence machinery	Chandigarh India	23%	Not mentioned	Chaudhary P, 2015
3	Pre-analytical Errors	Karwar, Karnataka	5.20%	Prospective	Bhuyar B. K, 2015

4	Preanalytical Factors	Ludhiana,	0.005-0.28%	Retrospective	Narang V, 2016
5	Preanalytical & Immunoassay	Istanbul	Non-significant in	Prospective	Ozturk O, 2016
6	Pre-analytical, analytical & post-analytical errors	Padova, Italy	61.9%, 15%, 23.1%	Prospective	Carraro P, 2007
7	Preanalytical & Post analytical errors	Veneto, Italy	46-68.2%, 18.5-47%	Review	Plebani M, 2006
8	Preanalytical errors	Jaipur, Rajasthan	46-68.2%	Case report	Sareen R, 2017
9	Total laboratory errors	New Delhi, India	0.012-0.6%	Review	Agrawal R, 2014

Table 2: Studies across the glove observing the variable's influence on Test results, showed that most studies reported errors in the preanalytical phase.

2.5.2. Cutoff determination for risk calculation

Setting a limit value, a value of detection of risk in the individual is the cut-off value. It states the possibility of the presence of the disease in comparison to a similar

population. As in terms of trisomy screening cut-off risk ranges from 1/200, 1/250, and 1/270 in most of the laboratories & all depending upon the variation of MoM (Multiple of Median) of that region based on ethnicity, weight, age, and socio-economic background. (David S. 2000; Chen Y. 2020)one such report was published by (Jasmina et al. 2018) on an investigation of individual markers with their sensitivity and specificity and in that study they took the cut-off level 1/250 for trisomy 21 (Kalelioglu et al. 2003) that only worked on singleton pregnancies However, measures cutoff level 1/240 with 5% false positive rate and 75% sensitivity for trisomy 21 assessment about 1/300 & 1/250 of high false positive rate were also considerable in the account of screening.

2.6. Pathophysiology causing adversity in pregnancy

Adverse pregnancy outcomes are often the result of complex interplay between multiple factors, including a few:

1. Placental dysfunction
2. Maternal vascular dysfunction
3. Inflammation
4. Genetic predisposition
5. Environmental factors
6. Elderly maternal age
7. Multiple pregnancy

These factors show significant associations between trisomy screening and adverse pregnancy outcomes. Numerous studies have found an association with the following APOs.

1**. Miscarriage:** Women with positive trisomy screening results are at increased risk of miscarriage. Studies have shown a significant association between trisomy and miscarriage, with trisomy 16 being the most common cause of miscarriage.

2. **Stillbirth:** Trisomy 21, 18, and 13 are associated with increased stillbirth risk. Trisomy is a leading cause of stillbirth, with trisomy 21 being the most common.

3**. Infant Mortality:** Trisomy is a leading cause of infant mortality, with trisomy 21 being the most common/leading cause.

4. **Pregnancy Complications:** Trisomy is linked to an increased risk of pregnancy complications, such as preeclampsia and placental abruption., and fetal growth restriction.

Furthermore, integrating trisomy screening with other risk factors, such as:

- Maternal age

- Medical history

- Family history

- Ultrasound findings

may enhance the predictive power for adverse pregnancy outcomes.

2.6.1. Serum Biomarkers in Trisomy Screening

Role of biomarkers in predicting adverse pregnancy outcomes: Biomarkers play a crucial role in identifying pregnancies at risk of adverse outcomes. Common

biomarkers used in trisomy screening have been found to be associated with adverse outcomes, including:

1. Alpha-fetoprotein (AFP): Elevated levels associated with pregnancy loss, preterm birth, and low birth weight
2. Human chorionic gonadotropin (hCG): Elevated levels associated with preeclampsia and fetal growth restriction
3. Estriol (E3): Low levels associated with preeclampsia and fetal growth restriction
4. Inhibin-A: Elevated levels associated with preeclampsia and fetal growth restriction
5. Placental growth factor (PlGF): Low levels associated with preeclampsia and fetal growth restriction

Various adjoining biochemical markers consist of several pregnancy-specific proteins and hormones that vary in level as trimesters lead and shows growth of healthy or unhealthy fetuses or like; Pregnancy-associated placenta protein- A (PAPP-A) continuously grows in level since the double production from placenta and fetus throughout the pregnancy period [Hill MA, 2020], Beta Human Chorionic Gonadotropin- beta subunit (B-HCG) is a hormone that helps in Progesterone production, implantation and placenta formation for healthy growth of pregnancy and fetus, Fetus lever produces a protein called Alpha Feto Protein (AFP) which comes in mother's blood during the second trimester and may help in the prediction of chromosomal abnormalities (Mizejewski, 2003) HCG, Estriol (uE3) is a form of human estrogen with a fetal adrenal origin that grows throughout pregnancy and a decreased level indicates chromosomal anomaly, INHIBIN-A (Tancrède et al., 2015)

2.6.2. Sonographic indicators for risk prediction

Ultrasonography is a noninvasive scanning method performed by physicians a few times during the entire nine-month period to monitor of proper growth of the fetus. Sonographic markers consist of measurement of Nuchal Fluid (NF), Nuchal Translucency (NT), Nasal Bone (NB), Pulsatility Index (PI), Crown Rump Length (CRL), Ecogenic Bowel, and short length of Femur or Humerus which indicates Down Syndrome (DS),

2.7. Importance of screening other than trisomy detection

While trisomy screening is not a direct predictor of adverse pregnancy outcomes, the identification of abnormal biomarker levels can prompt closer monitoring and early intervention, potentially improving pregnancy outcomes.

- Closer monitoring

- Early intervention

- Targeted surveillance

- Timely referrals to specialists

-Potentially improving pregnancy outcomes.

Overall, the literature suggests that trisomy screening can serve as a valuable tool for identifying pregnancies at increased risk of adverse outcomes, allowing for targeted surveillance and timely interventions, personalized prenatal care and improved maternal-fetal outcomes.

Adverse pregnancy outcomes are a significant public health concern, affecting millions of pregnancies worldwide. The prevalence of adverse outcomes varies depending on the population and outcome:

1. Pregnancy loss: Affects up to 20% of recognized pregnancies

2. Preterm birth: Occurs in approximately 10% of births

3. Low birth weight: Affects around 8% of newborns

4. Fetal growth restriction: Occurs in approximately 5% of pregnancies

5. Preeclampsia: Affects around 2-8% of pregnancies

2.7.1. Early prediction: a necessity

The progressive physiological changes that occur during pregnancy are essential to support and protect the developing fetus, and also to prepare the mother for parturition. During human pregnancy, the placenta hormone plays pivotal roles in mediating maternal physiological changes and fetal development. Interestingly, insulin resistance and thyroid imbalance during pregnancy has been attributed to the release of placental hormones. Changes in placental hormones, however, do not directly correlate with changes in maternal insulin resistance. Recent studies, however, highlight the utility of understanding deranged value of biomarkers that gives a pattern relating risk in various studies making it useful for the diagnosis of disease, onset, and treatment monitoring, but validation of those is still in process and may give a handful help.

Screening results are proven significant due to non-invasive in nature and may predict some very useful information, and can help clinicians saving morbidity and mortality rate of mother and child.

2.8. Studies on adverse pregnancy outcome and screening Biomarkers relations

Globally research has been done on the topic in various centers for related matters but in India, I found little about it and also on vary scattered modules, where as it should be more of concern for us as we have greater statics of abundance in our population for the medical condition and laboratory infrastructure.

A 2019 meta-analysis published in the Journal of Clinical Medicine found that elevated AFP and hCG levels were significantly associated with an increased risk of adverse pregnancy outcomes, even in the absence of chromosomal abnormalities.

Another study published in the American Journal of Obstetrics and Gynecology in 2020 found that women with elevated E3 levels had a higher risk of developing preeclampsia and delivering small-for-gestational-age infants.

Additionally, a 2018 study published in Ultrasound in Obstetrics and Gynecology found that low levels of PlGF were associated with an increased risk of preeclampsia and fetal growth restriction.

A few other studies were tabulated in Table 3 in summarized form for quick review.

Table: Serum screening biomarkers showing relation with Other Adverse outcomes than Aneuploidy

Sr. No	Study Group	Year published	No. of Patients taken	Week of gestation	Age group	Markers studied	Majorly connected with	Second major outcome
1	Milunsky et al.	1989	13,486			AFP	NTD	Congenital defects
2	Wald et al.	2000	470			AFP	NTD	
3	Dugoff et al.	2005	33145	15-18, 6/7	16 or greater	PAPP-A, B HCG, uE, Inhibin-A		
4	Androutsopoulos et al.	2009	126			AFP/HCG	Severe placental insufficiency	
5	Tancrède et al.	2015	3466	13-17 weeks	>18 yrs	AFP, hCG	PMAPOs at pre term	-
6		2015	841 665				Pre Term Birth	PE
7	Jelliffe-Pawlowski et al.	2015	340			PAPP-A	PTL	SD/NICUA
8		2015	230			AFP/HCG/Inhibin-A	PE	IUGR
9	Rosner et al.	2016	1263			serum CA 125	Fetal viability	
10		2016	130	22–24 weeks		Inhibin A, Activin A, PIGF/PI	PE	
11	Yazdani et al.	2016	230	5-12 week		activin A, inhibin A ADAM-12, PAPP-	pregnancy location	Viability

						A PLGF, GlyC, βHCG		
12	Pillai RN et al.	2017	2989		25.42± 4.64 Y	Haven't studied markers- retrospective study	Hypertensive Disorder of Pregnancy (HDP)	Preeclamsia
13		2017	88			TGF-β1, Activin A, Inhibin A,	Preeclampsia (PE)	Pregnancy induced Hypertensio n(PIH)
14	Lijie Li,et al.	2018	400	15-20 weeks		sEng, sBG	APO	
15		2018	165		28.67 ± 5.96 Y	AFP	Intrahepatic cholestesis (IHCP)	
16	Maymon et al.	2018	145	First & second trimester		AFP/ PAPP-A PLGF, βHCG/Placental Protein 13 InhibinA		
17	Ray et al	2018	855 536			HCG/ uE3	17	Ray et al
19	Bourmand et al.	2018	340			Inhibin A	Preeclampsia	

Table 3: Various studies across the glove for identifying relation of biomarkers in trisomy screening with other Adverse outcomes in pregnancy. AFP (alpha-fetoprotein), HCG (human chorionic gonadotropin hormone), uE3 (Estriole hormone), PAPP A (pregnancy-associated plasma protein A), NTD (neural tube defect), IUGR (intrauterine growth factor).

2.9. Clinical implications and future directions:

The association between trisomy screening and adverse pregnancy outcomes has significant clinical implications:

1. **Personalized prenatal care:** Integrating trisomy screening with other risk factors can help identify high-risk pregnancies, enabling targeted surveillance and early intervention.

2. **Risk stratification:** Trisomy screening can aid in risk stratification, allowing for more informed prenatal testing and management decision-making.

3. **Future research:** Further studies are needed to elucidate the underlying mechanisms and to develop more effective predictive models.

2.10. Recent advances in trisomy screening and adverse pregnancy outcome prediction

Recent studies have explored new biomarkers and technologies to improve trisomy screening and adverse pregnancy outcome prediction:

1. Cell-free DNA (cfDNA) testing: Non-invasive prenatal testing using cfDNA has shown promise in detecting chromosomal abnormalities and predicting adverse outcomes.

2. Machine learning algorithms: Machine learning models have been developed to integrate biomarker data and predict adverse outcomes with improved accuracy.

3. Multi-marker approaches: Combining multiple biomarkers has shown improved predictive power for adverse outcomes compared to single biomarkers.

4. First-trimester screening: First-trimester screening has emerged as a viable option for early risk assessment and prediction of adverse outcomes.

2.12. New and Emerging Biomarkers for Adverse Pregnancy Outcomes

New biomarkers and their associations with adverse pregnancy outcomes. Research has identified new biomarkers associated with adverse pregnancy outcomes:

1. Protein biomarkers: Inflammatory cytokines, angiogenic factors, and oxidative stress markers.

2. Metabolic biomarkers: Amino acids, lipids, and glucose metabolism.

3. Pregnancy-associated plasma protein-A (PAPP-A): Low levels associated with preeclampsia and fetal growth restriction.

4. Soluble fms-like tyrosine kinase-1 (sFlt-1): Elevated levels associated with preeclampsia.

5. Placental growth factor (PlGF): Low levels associated with preeclampsia and fetal growth restriction.

6. MicroRNAs: Dysregulated circulating microRNAs, messenger RNA, and long non-coding RNA have been linked to adverse pregnancy outcomes.

7. Imaging biomarkers: Ultrasound, magnetic resonance imaging (MRI), and computed tomography (CT).

2.12. Discussion

Trisomy screening is a vital tool for identifying high-risk pregnancies, enabling early intervention and management. While screening tests are not definitive, they provide valuable information for informed decision-making. The association between trisomy screening and adverse pregnancy outcomes highlights the importance of accurate and timely diagnosis.

Potential benefits of integrating trisomy screening and adverse pregnancy outcome prediction may offer several benefits:

1. Improved risk assessment: Enhanced identification of high-risk pregnancies.

2. Personalized care: Tailored management strategies for individual pregnancies.

3. Early intervention: Timely interventions to prevent or mitigate adverse outcomes.

4. Reduced anxiety: Improved understanding of pregnancy risks and outcomes.

5. Cost-effective: Streamlined prenatal care and reduced healthcare costs.

2.13. Conclusion

Trisomy screening is a crucial component of prenatal care, allowing for early identification of high-risk pregnancies and informed decision-making. The significant association between trisomy screening and adverse pregnancy outcomes emphasizes the importance of accurate diagnosis and management. Further research is needed to improve screening tests and optimize pregnancy outcomes.

MATERIAL
&
METHODS

TABLE OF CONTENT

3. Chapter: MATERIAL & METHODS

3.1. **The sampling design for research material**

A random selection sample design was opted for the study since the study type was retrospective and observational so most of the data collection was tried at best for gathering all the available parameters.

3.1.1. **Sampling unit**

The sampling unit is a Tertiary care reference hospital in north India: Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, U.P. India. The hospital covers national and international patients from 7 different states across the boundary and further by referrals.

3.1.2. **Target population**

The target population in this research belonged to was pregnant women coming in first or second trimester, and those who were linked with any antenatal difficulty for mothers or babies. Patients' data was obtained for the retrospective study (objective three) from a centralized data bank in the hospital "HIS," and Trisomy screening reports were taken from the laboratory of the Molecular Medicine and Biotechnology Department.

3.1.3. **Sample Size**

In the first objective of the study to check analytical errors, eleven patients's blood samples was used. Our second objective was to get a suitable cutoff for the screening test needed at least 100 positive patients, so we took 101 positive and 1803 negative risk patients, counting a total of 1904, for the third objective, we accumulated 252 patients' detailed data including 190 High-Risk positive patients. It has been planned that data will be collected from the hospital database after

Ethical permission from the Sanjay Gandhi Post Graduate Institute of Medical Sciences Lucknow, U.P a tertiary care reference hospital in India. The data was collected, and recorded on EXEL, later analyzed through SPSS version 23.

3.1.4. **Methods of data collection**

The data was collected by several methods. (1) All the serum screening reports were obtained from the Department of Molecular Medicine and Biotechnology, SGPGIMS, High-risk reports were cross-verified with the final diagnostic in the Department of Medical Genetics, SGPGIMS, and (2) All the antenatal and postnatal care or complication records were collected from the HIS (Hospital inpatient system) archive. (3) other test reports were accessed on the web portal of patients' medical record profiles on the hospital's centralized information system of SGPGIMS. (4) Other remaining information and confirmation of information had been done through the patient or family.

Secondary data in the form of research papers were collected through several external resources (Krishnan and Grewal. 2006). This study makes use of books, journals, research papers, and the internet specifically using a combination of text words on "PUBMED," "MEDLINE", "COCHRENE", "GOOGLE SCHOLAR", "RESEARCH GATE" and "SPRINGER NATURE" "ELSAVIER" Journal's websites as a medium for collecting secondary data. Secondary data for this research targeted adverse pregnancy outcomes, analytical variables, pregnancy tests, trisomy screening, chromosomal disorders, and many more in India and abroad.

Methodology

The study was conducted at the centre in the Department of Molecular Medicine & Biotechnology tertiary care reference hospital Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow in north India, Pregnant women were the subjects in the study and the data was collected from the centralized Hospital database HIS (Hospital information system). Serum biochemical and physical parameters were noted from lab reports and discharge notes were taken from the physicians' dataset, for any missing information physicians were contacted. The records were retrieved from the year 2017 to 2020 after receiving ethical permission from the Institutional Ethical Committee (IEC Approval) Ethical approval was granted for the study by the Institutional Ethical Committee.

3.2. **Principle Of First Trimester Screening**

The first trimester of pregnancy (from the 9th-11th week) is assigned appropriately for the screening of most of the fetal malformations, especially congenital, and chromosomal. Since secreted hormones in this period provide a bio sketch of internal condition. Ultrasound scan gives an idea about the fetus's state of being normal or suspected of some abnormality and screening tests in combination provide assurity of the condition.

3.2.1. **Ultrasound scan for fetal biomarkers**

USG (ultra sonography), was done by the subject matter specialists: usually, a senior consultant doctor to test Nuchal translucency (NT) and Crown Rump Length (CRL), the morphological parameters of foetal wellbeing, whereas CRL: 45mm to 84mm, and NT: less than 4mm was the normal parameters in 11-13th weeks of pregnancy during the time of combined trisomy screening.

3.2.2.**Serum Biochemical marker testing:**

*Picture has been taken for reference from the IMMULITE 1000 (siemens-healthineers.com)

The equipment works on the principle of chemiluminescence assay (this translates thousands of photons into lower detection limits per immuno-binding event compared to one or two conventional "flash" chemiluminescence). AFP (Alpha-fetoprotein), HCG (Human chorionic gonadotropin hormone) & uE3 (Estriol 3) Were measured in the blood serum with IMMULITE 1000, and Inhibin A was quantitated with Elisa.

The specimens were collected from pregnant women. The laboratory's standard procedure for blood specimen collection was used. BD Vacutainer FH (Becton Dickinson, Md. USA) plain red-capped tubes were used for the blood hematology. The specimens for the serum analyses were centrifuged at 1500rpm for 10 min. The serum was separated and analyzed without delay, transport and storage time was noted and its effects were examined later. To estimate the effects

of specimen storage time and temperature various intervals were set (Kouri, Siloaho et al. 2005).

Test chemicals and sample storage guidelines for IMMULITE 1000 analyzer were as below per the SOP (standard operating procedure), along with the reference range of respective serum biomarkers:

Table 4: Reference Values for Biomarker Screening test.

	Test	Biomarker	Temperature for storage	Reference range
	Quadruple Test:	**AFP:**	3 days of 4'C / -20'C for long	5.4-501.0 ng/ml
		HCG:	7 days at 4'C / 2 months -20'C	2223.0-20023.3 miu/ml
		Inhibin-A	24 hr 2-8'C / 30 days in -20'C	40-350 pg/ml
		uE3:	7 days at 4'C / 6 months at -20'C	0.0-11.0ng/ml
	Triple test	**AFP:**	3 days at 4'C / -20' for further	5.4-501.0 ng/ml
		B-HCG	7 days at 4' C/ 2 months -20'C	5.5-388.7ng/ml
		uE3	7 days at 4'C / 6months at -20'C	0.0-11.0ng/ml
	Double test:	**PAPP-A**	24hrs at 4'C / 2 months at -20'C	0.1-32.3miu/ml
		B-HCG	14 days at 4'C / 6 months at -20'C	5.5-388.7ng/ml

Table 4: The table consists reference range for storage temperature for chemicals and a reference range for Biomarkers in the Trisomy screening test.

3.2.3. **Trisomy Screening Risk Cutoff Determination**

Trisomy screening tests become sensitive due to the growing period of pregnancy and getting fewer chances to handle fetus care on time, so removing any possible error in the procedure becomes very important.

3.2.3.1. MoM Calculation

The level of maternal biomarkers varies on average throughout the pregnancy, HCG, AFP, and Inhibin A increase and uE3 decreases every week. To allow for this variance, screening programs expressed results as multiple of gestation specific median (MoMs) among unaffected pregnancies, using a regression equation to derive the normal median so that the exact day of gestation could be used. Corrected MoM adds precision to the result by adjusting values of weight, age, ethnicity, smoking status, and diabetic history of patients.

3.2.3.2. Cutoff calculation

	Disease				
Test	**Present**	**n**	**Absent**	**n**	**Total**
Positive	True Positive (TP)	*a*	False Positive (FP)	*c*	*a* + *c*
Negative	False Negative (FN)	*b*	True Negative (TN)	*d*	*b* + *d*
Total		*a* + *b*		*c* + *d*	
Sensitivity	$\frac{a}{a+b}$		**Specificity**	$\frac{d}{c+d}$	

Positive Likelihood Ratio (PLR)	$\frac{\text{Sensitivity}}{\text{1 - Specificity}}$	**Negative Likelihood Ratio (NLR)**	$\frac{\text{1 - Sensitivity}}{\text{Specificity}}$
Positive Predictive Value (PPV)	$\frac{a}{a + c}$	**Negative Predictive Value (NPV)**	$\frac{d}{b + d}$

3.2.4. **Statistical tools employed**

The statistical tools that are used for the analysis of the primary data to be collected were as below:-

- Tabular Method: primary data was collected in the form of a table on Excel sheets. Patients' vital physiological variables test variables and report findings, all were taken and recorded in tabular format.

- Sample percentage method: Simple percentage analysis is used in making comparisons between two or more series of data. In this method, percentages are used to describe relationships percentages can also be used to compare the relative terms.

- Graphical method: Graphical method, as the name suggests is the process of summarizing the primary data collected in the form of figures. The graphs may be of many forms such as bar graphs, histograms, pie charts and so on. The main advantage of employing a graphical method in a quantitative analysis is to

increase the readability (Carter. 1997). In this thesis, the researcher has employed bar graph, tables, pie charts and regression tree.

3.2.4.1. Correlation test

Any hypothesis could be tested only with the help of a statistical tool. This research incorporates the Karl Pearson Correlation test to test the research. This research makes use of the Correlation test since the research design adopted in this study is Descriptive Research. Weiten 2010) points out that the results of descriptive research are always summarized with a statistic called correlation coefficient. The outcome of the Karl Pearson Correlation test is a variable known as the correlation coefficient. This variable is used to identify the relationship between a quantitative dependent and quantitative independent variable. The correlation coefficient is represented by the symbol ―r‖. The correlation coefficient ―r‖ is calculated by applying a mathematical formula-

The value of the coefficient of correlation ranges between -1.0 and +1.0. The closer r is to +1 or -1: the more closely are the two variables related to each other.

3.2.4.2. Strategies for validating findings:

In quantitative research, the obtained results are validated with the help of two parameters using reliability and validity.

i. Reliability:

Reliability refers to the consistency of data stemming from the use of a particular research method (Taylor. 2006). Reliability is used to find out how steady

the results of the findings are in relevance with the data collection methods. Reliability is used to measure the accuracy of the instrument used to collect data. In this research, the data is collected by emailing the questionnaires to the primary respondents to their workplaces. To ensure that there is no bias in the collected material, the researcher has ensured that each respondent has answered all the questions in the research.

ii. Validity:

Coleman M (2007) defines that validity refers to the degree to which research accurately assesses or reflects the particular concept a researcher is trying to measure. In this research validity is maintained by collecting literature relevant to diagnostic and screening techniques and its impact in improving results outcome. The researcher in this study has managed to maintain validity by designing a systematic data input that has concepts relevant to the literature review and the research objectives.

3.9 Test of research hypothesis

Quantitative research in most cases involves a test of hypothesis, as it is very much useful for estimating the results of the sample data from a larger group of sources (Tao and Ning-Zhong. 2008). The actual process of hypothesis testing involves four steps by name,

i. Formulating the actual null hypothesis and alternative hypothesis

ii. Identifying the static test by means of the proposed null hypothesis

iii. Computing the value of P. This p is the main probability of the static test and is obtained by considering the hypothesis null.

iv. Final step in test of hypothesis test is, comparing the calculated value of P with the actual value present in the statistical table (say alpha). In the observation if P>=alpha then it can be concluded that null hypothesis is ruled out.

This study tests the following hypothesis

i. **Null Hypothesis:** Conventional methods of testing can be beneficial for error-free reporting of health issues and the system may gain widespread health care, only by existing methods.

Alternate Hypothesis: Deep and advanced analysis of all the Analytical Variables in the test, will turn modern testing into accurate and precise.

ii. **Null Hypothesis**: random selection of cutoff value has helped in bringing in innovations into everyday clinical practice and improved health decision-making.

Alternate Hypothesis: Calculated value of cut-off on population-based data, may determine the right limit value, help in bringing innovations into everyday clinical practice, and improve the right decision-making.

iii. **Null Hypothesis:** quadruple markers do not have any correlation with adverse pregnancy outcomes, and hence cannot improve everyday clinical practice and improved health decision-making.

Alternate Hypothesis: Quadruple marker's abnormal values have significant associations with adverse pregnancy outcomes, and the study of those may help in bringing innovations into everyday clinical practice and improved health decision-making.

3.3. **A flow chart indicating study objectives**

Objective 1:

- Temperature testing:
- Room temperature was maintained 24˜25°C
- Sample Thaw Timings were 40-50 mins
- Haemolysis status of blood sample: 5 samples were haemolysed and 1 was partially haemolysed so those were requested for repeated sampling.
- Machine Voltage reading on volta meter during testing:
- Machine Mentinence check: in routine every 3 months from past 5 yrs.
- Temperature gradient check in 2 ways:
    - Time constant but temp varies
    - Temperature varies but time constant.
    - Results evaluated and compared
    - Observation noted

Objective 2:

- Screening Positive (High Risk) patient reports collection (at least n=100)
- Sorting of All the three types of screening separately
- Cross Verification of High-risk patients with gold standard Diagnostic technique of Amniocentesis for final confirmation of outcome from dept medical genetics, SGPGIMS.
- Low-risk patients (n=1803) verification from them for adversity

- ❖ Statics applied for cutoff calculation with SPSS (Sensitivity and specificity calculations determination)
- ❖ Result implementation

Objective 3:

- ❖ Receiving of Approval on Ethical
- ❖ Retrieving the patients' data from HIS (from the hospital database)
- ❖ Tabulating all the data of risk screening reports (from dept of MolMed)
- ❖ Finding data on pregnancy adversity from every patient
- ❖ Collecting data from clinicians and labs all through the antenatal periods for all the patients in the group during their complete pregnancy period and later
- ❖ Applying big data analytics with SPSS calculations with multiple tools to get meaningful results.

3.4. **Ethical considerations**

Any research needs to follow basic ethics associated with the research. In this research, ethics was maintained by the Sanjay Gandhi Post Graduate Institute of Medical Sciences. Ethic Committee permits Data Access for study purposes and keeps their identity confidential. Also, the researcher took permission from the Head of the Department of Molecular Medicine and Technology & Biotechnology to access their LAB records manuals and Instruments at the centers before conducting the research.

Since we designed a retrospective study type and a direct patient sample was not needed in our objective fulfillment, so we didn't need to take patient consent in this study as per the ethical protocol. Only approval of the institutional community was mandatory for the study.

(https://ethics.ncdirindia.org//asset/pdf/Guidance_on_Ethical_Requirements_for_Laboratory_Validation_Testing)

Ethical Approval No# IEC, Code: 2019-58-JRF-108

3.4.1. **Guidelines for the screening test**

Pregnancy assessment tests were performed according to the Indian Council of medical research (ICMR) guidelines, and National Health Mission (NHM) objectives. American College of Obstetricians and Gynecologists (ACOG), National Institute for Health and Care Excellence (NICE), and International Society for Prenatal Diagnosis (ISPD) also acknowledges the same. The biochemical analyzer was used Chemiluminescence Analyser IMMULITE 1000 by Siemens Inc, and risk calculation was done by PRISCA 5.0.0.1.0, all was commenced at SGPGIMS, Lucknow UP is a NABH-accredited lab in INDIA.

3.4.2. **Parametric tests**

Vital testing for weight, Blood Pressure (BP), and Age was taken at the first antenatal visit of the pregnant women at the canter, Ultrasound Screening was recorded during the first trimester and second-trimester visits and in required conditions. The blood sample was taken for multiple marker screening through the chemiluminescence technique. Double, Triple, and Quadruple marker was performed on the automated Biochemical analyser of Siemens IMMULITE 1000 for checking Beta human chorionic Gonadotropin protein (B-HCG), Plasma associated pregnancy protein-A (PAPP-A), Alpha Feto Protein (AFP) & Estradiole (uE3). And Elisa was performed by the trained technicians to test Inhibin A.

3.5. **Limitations of the research**

- This study is limited to mono-centric in India alone.
- The sample size of this research is merely from one center for nearly 2000 Pregnant women.
- The records for patients did not having complete details or missing entries were found for many patients, as in last objective, I could have fetched adverse pregnancy data for 384 patients, where in 254 has mostly all variables written, and in those only 190 had high risks reported with complete variables.

3.6. **Summary**

It is able to understand from the research methodology chapter that this research is quantitative in nature. All the respondents are single centric from, India, and were recruited for the study using retrospective observational method. The research design adapted in this study is descriptive research and the sampling technique involved is simple random sampling. This section besides explaining the statistical tool required for testing the proposed research hypothesis has explained how the researcher has managed to maintain validity and reliability despite several limitations involved in conducting the research.

This study included singleton pregnancies of 16+1 and 18+5 gestational weeks. Their mean age was 28.36 years (21 years at least & 34 years the highest). They presented themselves at SGPGIMS Hospital, Molecular Medicine Department to have trisomy testing. All the pregnant women were informed about

the study. Their 5 ml peripheral venous blood was obtained from each pregnant woman and drawn into two blood collection plastic tubes (Red closure, BD USA). Blood samples were taken by the same nurse/phlebotomist/ medical laboratory technicians to avoid the error. One sample was kept on the ice, which travelled (10 minutes' walk distance) with the person after all samples were collected (up to 2-3 hours) to the lab and the other was directly sent through the automated sample transport system. The other tube was sent through the computerized sample transport channel (less than 1 minute's travel time) to the Hospital's Molecular Medicine Department from the General Hospital Sample Collection Centre.

The serum was separated from the blood sample by centrifugation for 10 min at 1,000 × g. After then divided into several ellequotes of 300 µl. for the testing of the time factor criteria and +4 °C sample in the second criteria were considered baseline, with internal quality control CV values for β-HCG, uE3, and AFP tests recorded.

RESULTS

TABLE OF CONTENTS

4. Chapter: Results

4.1. Pre and Post Analytical Variable's Influence on High-risk Assessment Screening Test (objective I)

This study included singleton pregnancies of 16+1 and 18+5 gestational weeks. Their average age was of 30.747 ± 5.0463 yrs (21 years at least & 34 years the highest) and 60.8 ± 10.7 kg average weight. [Table 5]

All women went through USG first followed by a maternal serum marker trisomy screening test for high-risk assessment. All belonged to Asian backgrounds and specifically from the neighboring states by considered to belong within a similar socio-economic area. The study included non-smoker, non-diabetic and singleton pregnant women.

Normality had been checked on the data. Normality distribution is shown in the graphs

[Figure 7 & Figure 8] obtained from SPSS used in the study for calculations.

Parameter	AVG ± SD
AGE	30.747 ± 5.0463
WEIGHT	60.8 ± 10.7
ETHINICITY	ASIAN (ALL)
SMOKING	NON-SMOKER
DIABETES HISTORY	1.4 % (4)
IVF CONCIEVED	1.8 % (5)
GESTATIONAL AGE	16.61±0.76

Table 5: Patients Physical Parameters in Study Population

Only 4 women were pre-diabetic and 5 had opted for In-vitro Fertilization assistance, so eliminated later from the study group as exclusion criteria. Their parity and gestational parameters are described in the above table [Table 5].

4.1.1. Influencing and interfering factors for the screening test in the study

- Travelling time taken for testing by the sample: <1 min &10 min
- Temperature testing for storing samples:
  - Room temperature was maintained at 24˜25°C
  - Sample were stored on 4'C, -20'C & -80'C

    (As per the SOP; 3-7 days of 4'C / -20'C for long)
- Time gap testing for sample keeping before the test:
  - Transportation of sample took <10 min on ice
  - Sample thaw timings were 40-50 mins
- Patients' vitals measurement notes: taken manually
- Patients' data entry/ record keeping: done doubly
- Sample status:
  - Sample kept before testing (in plain red-capped BD Vacutainer)
  - Haemolysis status of blood sample: 5 samples were haemolysed and 1 was partially haemolysed so those were requested for repeated sampling.
  - Less amount of sample due to not being able to draw much amount from a patient's health condition
- Machine checks:
  - Machine Voltage reading during testing: 110-120 volts at 6 amps

- Machine Mentinence check: in routine every 3 months for the past 5 yrs.
- Main supply voltage checks before and during the test: stable & fix supply of 230 volts

❖ Temperature gradient check in 2 ways:

- Time constant but sample storage temp varied (4'C/-20/C/-80'C)
- Constant temperature but test delays by days. (DAY1-DAY10)

Figure: Most Influencing and interfering factors in the study group

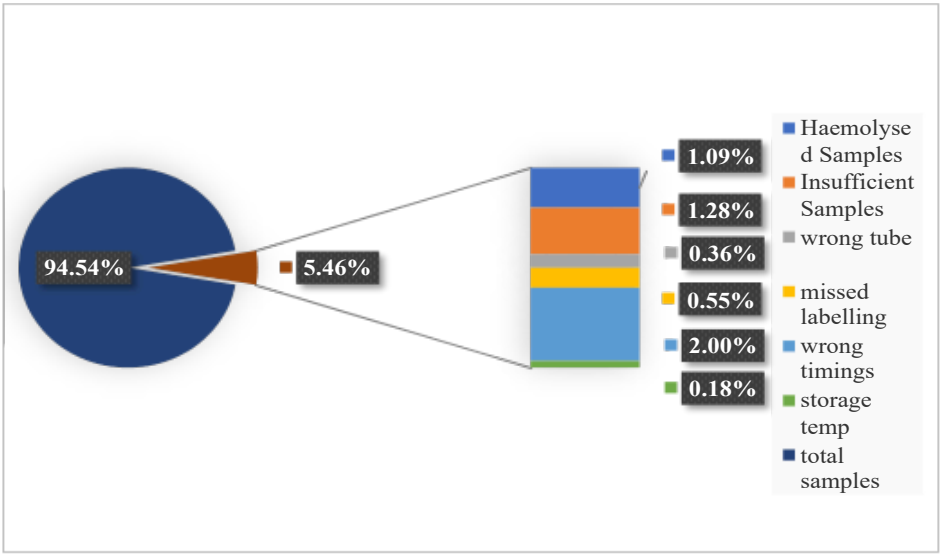

Figure 4: The pie chart shows the observation of influential analytical variables in the lab.

Observations in the pie chart [Figure 4] show the data of all assessed samples. We found a very few samples were inappropriate for the test processing (5.46%), whereas the majority (94.54%) of samples were in good condition to test. The inappropriateness of samples was found

due to seven major factors. The Main (in 2% samples) was found, the wrong timings of the collected sample as the patient didn't appear at the same time as prescribed by the doctor or asked by technicians (when the ultrasound happened) and the next (1.28% samples) factor was the amount and quality of the sample that could be due to patient's medical condition for availability of insufficient amount of blood. The third condition was to obtain hemolyzed samples (in 1.09%) again due to the medical condition of the patient as thrombin's presence. The remaining other causes were impacting in less amount as a missed label (patient's unique identification) on tubes was found in 0.55% of patients' cases when they brought samples by themselves or from outside the facility. In 0.36% of cases, tube selection was wrong when the patient made his/her own choice at home, and the least error was observed when the sample was left unattended or at the wrong temperature by any unprofessional in the absence of a technician. Only 0.18% errors were observed due to sample storage conditions variations. All patients were reapproached and requested to resample for further reports with freshly collected samples.

4.1.2. **Effect of temperature and time delay in test on risk assessment result**

Results were summarized and graphed. In analysis, we found no significant difference was seen in the results to report in both the parameters. Time didn't effect any on the reports, which means all the samples irrespective of different waiting times before the test, when tested was providing the same result as Day 1, till the 10th day, so **no difference** in the calculated risk was observed in the final risk assessment. All were found with low-risk pregnancies. On the other hand, the parameter of temperature storage had a minor change in one sample only. One sample which was kept at +4 °C, showed a **false negative** in combined risk (although the biochemical risk was high) where as other portions of the same sample (-20'c & -80'c) gave positive results for the patient, which means the patient was actually positive, and it was calculating low-risk negative patients. This

interesting output forced us to make a change in our storage settings for the sample to opt for deep-frozen samples on priority.

Table: Impact of serum storage temperature on results in screening test

Sr No	Sample No (study IDs)	Risk result on –(**-20°C**)	Risk result on (+**4°C**)	Risk result on –(**-80°C**)
1	Sample 1	<1:10000	<1:10000	<1:10000
2	Sample 2	<1:10000	<1:10000	<1:10000
3	Sample 3	<1:10000	<1:10000	<1:10000
4	Sample 4	**1:143**	**1:303**	**1:209**
5	Sample 5	<1:10000	<1:10000	<1:10000
6	Sample 6	<1:10000	<1:10000	<1:10000
7	Sample 7	1:2969	1:3082	1:2098
8	Sample 8	<1:10000	<1:10000	<1:10000
9	Sample 9	<1:10000	<1:10000	<1:10000
10	Sample 10	<1:10000	<1:10000	<1:10000
11	Sample 11	<1:10000	<1:10000	<1:10000

Table 6: Temperature-graded evaluation for samples of trisomy screening test

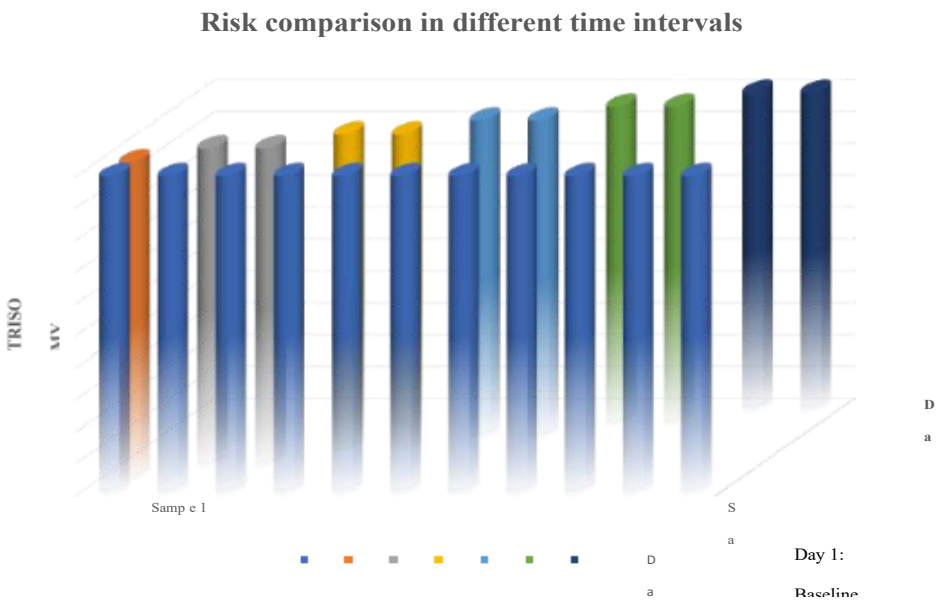

Figure 5: Influence of the variable factor-TIME in screening test results.

No difference in the calculated risk was observed in the final risk assessment result. All were found with low-risk pregnancies. Delay in testing till day 10 did not pose any difference in results in this study when samples were stored well at constant temperature and free from repeated freeze-thaw cycles.

4.2. **Cut-Off adjustment for the High-Risk Assessment Test (Objective II)**

A total of 1904 quadruple test results including 101 high-risk positive and 1803 low-risk samples were selected for cut-off determination. Specificity and sensitivity were calculated on different cutoffs. SPSS applied to double-check the results. Six true positives and one false positive result were reported. The ROC (receiver operating characteristic curve) curve analysis for cutoff value determination revealed that the area under the curve (AUC) was 0.795 (95% CI: 0.621- 0.970).

The cut-off value 1:200 was found suitable for getting the best detection rate and sensitivity of 83.8%, and a specificity of 63.3% without false positives. [Table 9a, and Figure 6]

4.2.1. Sensitivity and specificity calculations for trisomy screening tests

Cut off	Sensitivity %	Specificity %	1-specificity	False (FP) Positives=c	False (FN) Negatives=b	True Positive (TP)=a	True (TN) Negative=d	Total
1/500	87.5	95	0.05	93	1	7	1803	101 positives
1/400	87.5	95.6	0.044	82	1	7	1803	
1/300	85.7	96.4	0.036	67	1	6	1803	
1/250	85.7	96.9	0.031	57	1	6	1803	
1/200	85.7	97.5	0.025	46	1	6	1803	
1/150	85.7	98.2	0.018	33	1	6	1803	
1/100	85.7	98.8	0.012	22	1	6	1803	
								1904

Table 7: Sensitivity and specificity calculations for trisomy screening test

BIOTECH * MEDGENETICS Crosstabulation					
			MEDGENETICS		Total
			POSITIVE	NEGATIVE	
MOLMED	POSITIVE	Count	6	95	101
		% within MOLMED	5.9%	94.1%	100.0%
		% within MEDGENETICS	85.7%	60.5%	61.6%
		% of Total	3.7%	57.9%	61.6%
	NEGATIVE	Count	1	62	63
		% within MOLMED	1.6%	98.4%	100.0%
		% within MEDGENETICS	14.3%	39.5%	38.4%
		% of Total	0.6%	37.8%	38.4%
Total		Count	7	157	164
		% within MOLMED	4.3%	95.7%	100.0%
		% within MEDGENETICS	100.0%	100.0%	100.0%
		% of Total	4.3%	95.7%	100.0%

Table 8: Calculation of true positives and true negatives from screening (mol med) and Amniocentesis test (med gen) RESULTS

4.2.2. **ROC plotting for adjustment of suitable cut-off**

The Receiver Operating Curve (ROC) curve analysis for cutoff value determination of trisomy screening test in pregnant women with singleton pregnancy and Asian ethnicity has revealed that the Area Under the Curve (AUC) was 0.795 (95% CI: 0.621- 0.970), with a sensitivity of 83.8% and specificity of 63.3%. [Table 9 & Table 9a]

Area Under the Curve				
Test Result Variable(s): VALUE				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.795	.089	.008	.621	.970

Table 9: Area under the curve calculated with std error 0.089

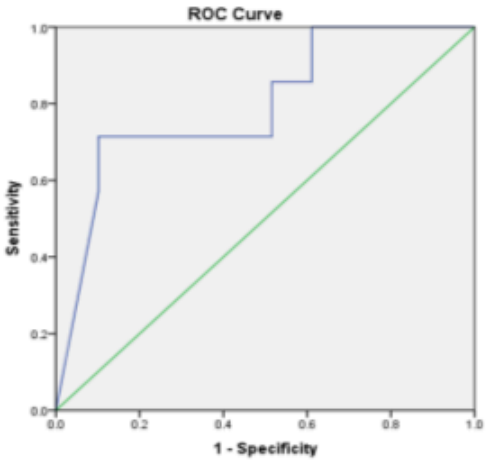

Figure 6: ROC for trisomy screening test cutoff value determination. AUC: 0.795 (95% CI: 0.621-0.970)

Coordinates of the Curve

Test Result Variable(s): VALUE

Positive if Less Than or Equal To[a]	Sensitivity	1 - Specificity
49.0000	.000	.000
153.5000	.714	.223
154.5000	.714	.229
155.5000	.714	.236
164.0000	.714	.248
176.0000	.714	.255
181.0000	.714	.261
185.0000	.714	.268
190.0000	.714	.280
193.5000	.714	.293
200.0000	.714	.299
208.0000	.714	.306
214.0000	.714	.312
217.5000	.714	.318
219.0000	.714	.325
220.5000	.714	.331
224.0000	.714	.338
228.0000	.714	.344
232.5000	.714	.357

Cut off values

Table 9a: Sensitivi nalysis

4.3. **To check the individual component response for any associated risk in the pregnancy (Objective III)**

4.3.1. **Normality Distribution in studied data**

Data found normally distributed in the study population. The plot was generated by the use of SPSS version 23 by IBM Inc., and normally distributed data found appropriate for further analysis.

(Figure 7) shows the age distribution in the study population. whereas

(Figure 8) showing the weight distribution among the studied population.

Figure 7: Normality distribution curve in patient's age

Figure 8: Normality distribution curve in patients' weight

4.3.2. **Distribution of APO in the study population**

A diverse population of patients was selected to study a group of pregnant women coming for trisomy screening in the department. Our selected group of pregnant women belonged to those diagnosed with adversity in pregnancy to study from Asian ethnicity, non-smoker, non-diabetic, singleton pregnancy background. The pie chart [Figure 9] shows that most of the women were suffering from Hypothyroidism (20%), the second most common group (14%) was suffering from GDM (gestational diabetes mellitus), and the third number was reported as cardiac disease patients (13%). Fourth and fifth places were occupied by IUGR and other multiple issues carrying pregnant women with 11%, and 11% respectively. The next category was oligohydramnios or polyhydramnios patients with a 9% prevalence. Pre-term labor (PTL) and hepatic diseased patients were found in 7% and 6%

respectively. The three other most critical conditions of pregnancy groups were Preeclampsia (2%), renal disease (3%), and LBW (4%) (low birth weight). These might be a cause of postpartum admissions in the hospital too.

Adverse outcomes in the study population

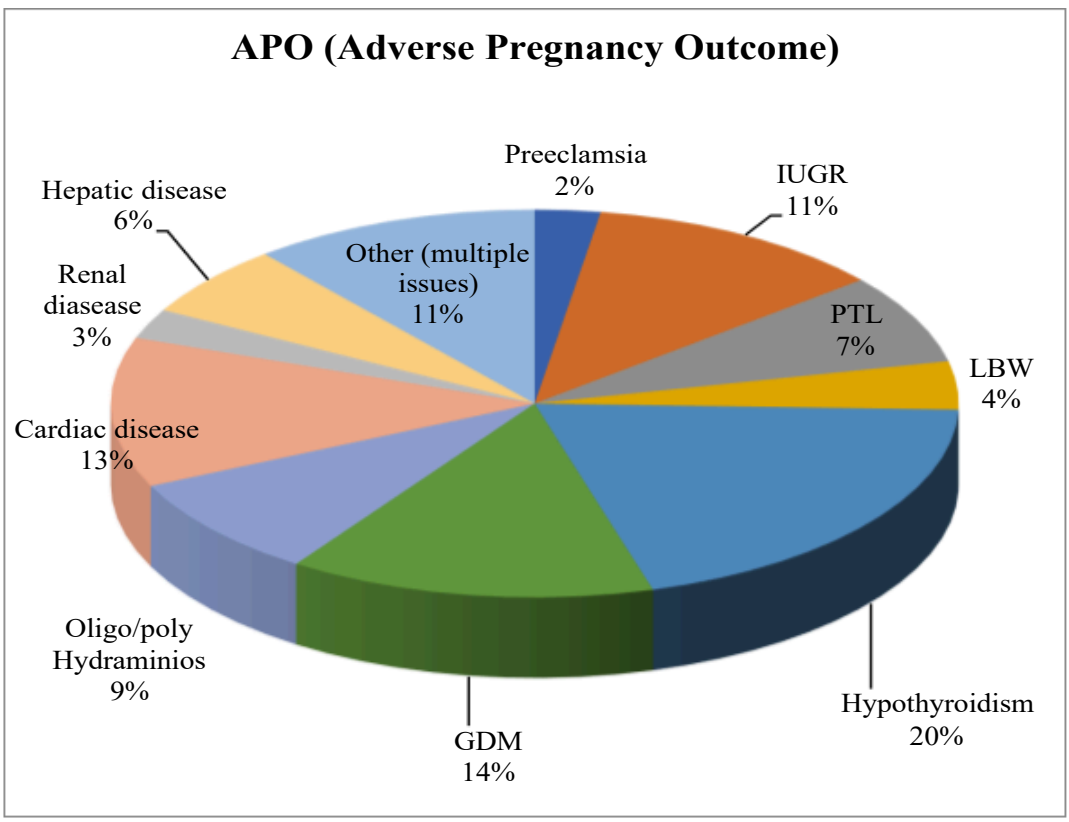

Figure 9: Distribution of Adverse Pregnancy outcomes in High-Risk Pregnant women in the study Population.

GDM: Gestational diabetes mellitus; LBW: Low baby weight; PTL: Pre-term labor; IUGR: Intrauterine growth restriction; APO: Adverse pregnancy outcomes.

Table: Descriptive Analytics of Adverse Pregnancy Outcomes in High-Risk Positive Group

	Parameters	Range
AGE		30.9±5.1
1	WOMEN BETWEEN AGE (20-30)	81(%)
2	YRS	100 (%)
3	BETWEEN AGE (30-40) YRS	9 (%)
	BETWEEN AGE (40-50) YRS	
WEIGHT		61±11
SMOKING		NONE
ETHINICITY		ASIAN
WEEKS OF TESTING		N=190
1	15-17WEEKS	57 (30%)
2	17-19WEEKS	83 (43.7%)
3	19-21WEEKS	50 (26.3%)
WEEKS AT DELIVERY		34.4±5.1 (AVG±SD)
1	<24WEEKS	16 (9.1%)
2	<37WEEKS	99(56.6 %)
3	>37WEEKS	73 (41.7 %)
DIABETES		4/190
MODE OF DELIVERY		TOTAL=161
1	ELECTIVE LSCS	86 (53.4 %)
2	EMERGENCY LSCS	35 (21.7 %)
3	VEGINAL DELIVERY	34 (21.11 %)
4	PROCEDURE (TERMINATION OF PREGNANCY)	6 (3.7 %)
IVF PREGNANCY		4/190
AGE RISK HIGH		3/190
TRI18/13 RISK		None
NTD RISK		2/190

	ANEUPLOIDY RISK	7/190
	APO STATUS	TOTAL=190
1	BABY WEIGHT	2.194±.836
2	GDM	48(25.63%)
3	HYPOTHYROID	61(32.10%)
4	IHCP	37(19.5%)
5	APS	12(6.3%)
6	IUGR	45(23.68%)
7	PIH	20(10.52%)
8	PE	25(13.15%)
9	FD	8(4.2%)
10	PTL	102(53.7%)
11	LBW	111(58.4%)
12	OLIGOHYDRAMNIOS	41(21.5%)
	OBSTETRIC HISTORY	TOTAL=166
1	NULLY PARITY	79 (47.6 %)
2	PRIMIPARITY	71 (42.8 %)
3	MULTYPARITY	17 (10.2 %)
1	PRIMI GRAVIDA	42(25.3%)
2	GRAVIDA=2	47(28.3%)
3	GRAVIDA=3	41(24.7%)
4	GRAVIDA>3	35(21.1%)
	ABORTIONS HISTORY	84(50.6%)
1	ONE PREVIOUS ABORTION	50 (30.1 %)
2	>2 ABORTIONS HISTORY	33 (19.9 %)

Table 10: The above parameters were taken in account from the discharge reports of patients after delivery notes of the hospital data record system.

Table11: Descriptive analytics of the trisomy-screened patients in both groups

Variable´s	Total (N=252)	High (n=190)	Low (n=62)	P value
Women age at Delivery (Years)	30 (26.5, 34) [30.62]	31(27,34) [30.97]	30(26,34) [29.53]	0.074
Women's Weight at delivery (Kg)	60 (54,67) [60.70]	60 (54,67) [60.57]	60 (53,69) [61.10]	0.698
Gestational age in weeks	37 (35, 38) [35.4]	37(34,38) [35.02]	38(36,39) [36.75]	**0.011**
Baby birth weight (Kg)	2.61 (2.1,3.0) [2.4]	2.6 (2.1,2.9) [2.4]	2.5 (2.0,3.0) [2.5]	**0.003**
Trisomy Biochemical risk	138.5 (59.3,247.3) [473.1]	99 (50,176) [117.6]	324 (275,1640) [1550.9]	**<0.001**
AFP	46.7 (35.1,64.3) [57.3]	46.8 (34.2,65.1) [57.9]	44.5 (35.3,61.3) [55.1]	0.669
AFP Corr MoM	0.9 (0.7,1.2) [1.1]	31 (27,34) [30.9]	0.91 (0.7,1.1) [1.01]	0.807
HCG (X1000)	35.4 (24.4, 49.4) [40.7]	37.1 (25.7,52.0) [43.9]	26.9 (14.7,41.9) [29.2]	**<0.001**
CorrMoM-HCG	1.73 (1.2, 2.5) [2.0]	1.8 (1.4,2.6) [2.2]	1.18 (0.9,1.8) [1.3]	**<0.001**
uE3	0.72 (0.4,1.2) [1.1]	0.7 (0.4,1.1) [1.44]	0.9(0.5,1.2) [1.00]	**0.03**
uE3 CorrMoM	2.34 (1.77, 3.37) [2.98]	0.60 (0.4,0.9) [0.70]	0.8 (0.6,1.1) [0.89]	**<0.001**
Inhibin-A	373.8 (280.8,526.7) [551.7]	394 (299.8,563.4) [607.6]	317.7 (252.4,408.7) [353.4]	**0.001**
Inhibin-A CorrMoM	2.35 (1.77,3.375) [2.99]	2.51 (1.85,3.57) [3.2]	2.1 (1.5,2.5) [2.1]	**0.001**
Data presented in median (Q1, Q3), compared by Mann Whitney U test. P value <0.05 significant				

Table 11: Comparison of high and low-risk group's parameters of (each p<0.05) Trisomy screening biomarkers.

Table12: Distribution of APOs between high and low risk pregnancy Groups (N=252)

Variable´s	Total (N=252)		High (n=190)	Low (n=62)	P value
Aneuploidy Diagnosis	No	245 (97.2%)	183 (74.7%)	62(25.3%)	0.199
	Yes	7 (2.8%)	7 (100%)	0	
Gestational Diabetes'sMellitus	No	186 (74.4%)	136 (74.8%)	50(25.3%)	0.322
	Yes	64 (25.6%)	51 (79.7%)	13 (20.3%)	
Hypothyroid	No	174 (75.1%)	131 (68.9%)	43 (31.2%)	1.000
	Yes	79 (24.9%)	59 (74.7%)	20 (25.3%)	
Pre-Term Labour	No	202 (75.2%)	149 (74.7%)	53 (24.8%)	0.369
	Yes	52 (24.8%)	42 (80.8%)	10 (19.2%)	
IUGR (intra uterine growth retardation)	No	207 (75.6%)	157 (75.8%)	50 (24.2%)	0.833
	Yes	35 (24.4%)	26 (74.3%)	9 (25.7%)	
Pre-Eclampsia	No	228 (90.5%)	172 (75.4%)	56 (24.6%)	1.000
	Yes	24 (9.5%)	18(75.0%)	6 (25.0%)	
Fetal Distress	No	241 (75%)	184 (76.3%)	57 (23.7%)	**0.031**
	Yes	11 (25%)	5 (45.5%)	6 (54.5%)	
IUD (Intra Uterine Death)	No	105 (78.8%)	81 (74.7%)	24 (25.3%)	0.199
	Yes	8 (21.2%)	8(100%)	0 (0.0%)	
Oligohydramnios	No	213 (75.2%)	159 (74.6%)	54 (25.4%)	0.698
	Yes	41 (24.8%)	32 (78.0%)	9 (22.0%)	
Low Birth Weight	No	148 (74.3%)	104 (69.7%)	44 (30.3%)	0.051
	Yes	96 (25.7%)	78 (81.2%)	18 (18.8%)	
Data presented in frequency (%), compared by Chi-square test / Fisher exact test. P value <0.05 significant					

Table 12: The above table compares Adverse pregnancy outcomes between the trisomy high-risk and low-risk groups (total number of pregnant women=252, including 190 high-risk and 62 low-risk but adverse consequences).

The distribution of aneuploidy diagnosis, gestational diabetes mellitus, hypothyroid, pre-term labour, IUGR, pre-eclampsia, IUD, Oligohydramnios, and low birth weight was statistically equal ($p>0.05$) whereas foetal distress was significantly higher in the high-risk group compared to low-risk group ($p<0.05$).

Table 13: Independent outcomes of the Quadruple test

Variable's	Odds ratio	Lower	Upper	P value
Low Birth Weight	2.13	0.97	4.68	0.060
Corr MoM for HCG	3.89	2.10	7.18	**<0.001**
Corr MoM for uE3	0.13	0.05	0.35	**<0.001**
Corrected MoM for Inhibin-A	1.77	1.16	2.72	**0.009**
Multivariate binary logistic regression analysis was used. P<0.05 significant				

Table 13: Independent outcomes of the Quadruple test's significantly associated biomarkers with low birth weight patients (N=252). ($p<0.05$)

Figure 10: Relative Comparison of adverse outcomes in High and Low-risk groups.

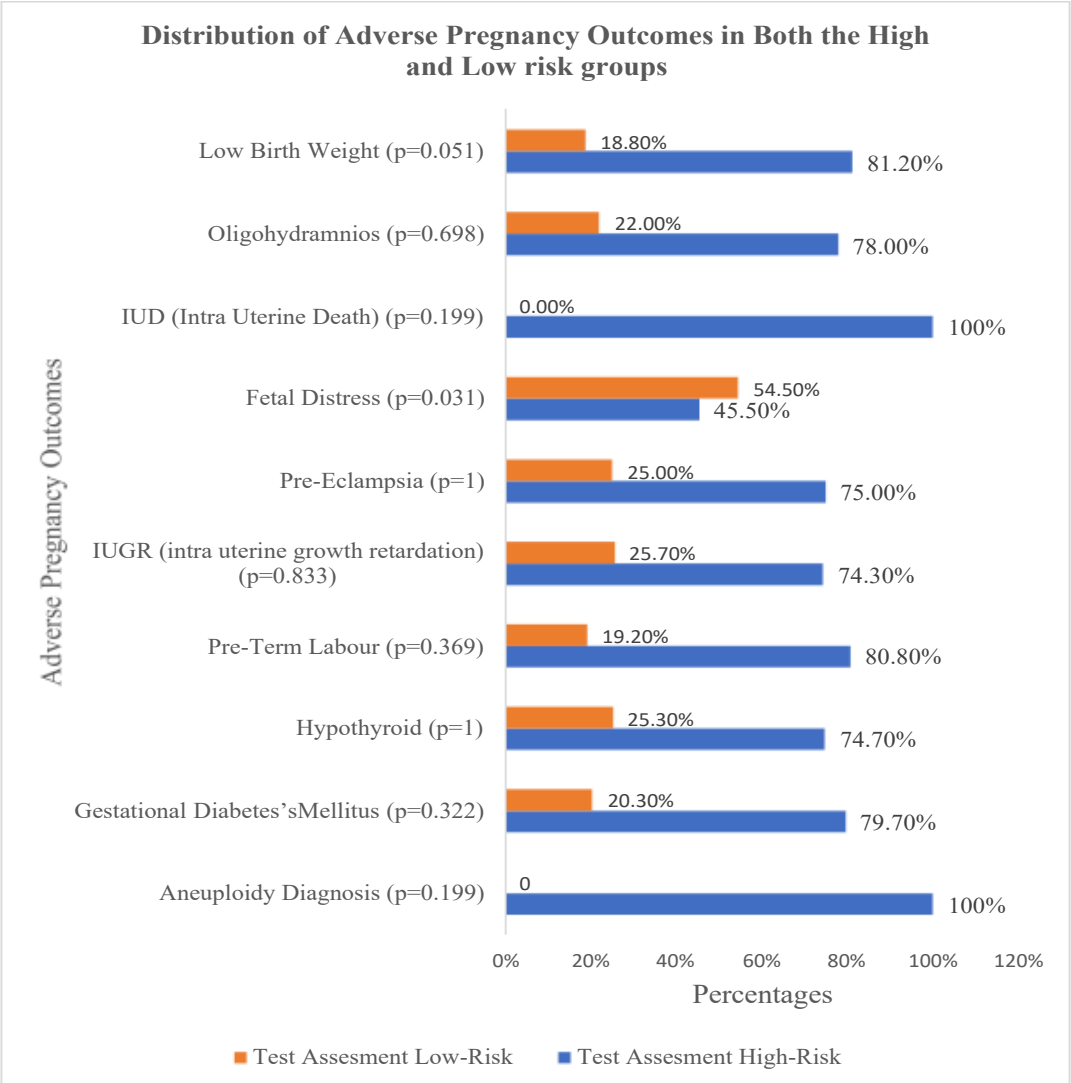

Figure 10: Bar Chart Of comparison of Pregnancy outcome in study and control group. Aneuploidy diagnosis and intra uterine death was o in both cases for low risk group and fetal distress was observed giving risk in both the groups almost equally.

4.3.3.**Prediction of suitable predictor**

A classification tree (or Decision tree for prediction) operates similarly to a doctor's examination. Here we generated tree structured classification rule to determine the results by looking at the parameters in the classifier. The above diagram (Figure RF10) shows the primary node is the Corrected MOM of HCG and the terminal node came with an MOM value of Inhibin-A, which may suitably predict low birth weight of babies.

CART evaluates all possible splits and selects the one that best reduces the impurity of the resulting subsets. It works on categorical variables, provides outcomes either "successful" or "failure" and hence conducts binary splitting only. "The CART model achieved an accuracy of 85% and a precision of 0.8. The decision tree has a depth of 3, with 4 nodes, and the most important features are 'corrected MOM for HCG' and 'Inhibin A' for determining adversity in pregnancy. The root node splits on 'Trisomy screening High-risk patients' (n=241), with a higher value of HCG.

4.3.4.**CART Analysis**

CART is a statistical tool for analyzing predictions. Our study used this method to find the associated biomarkers of the quadruple test with low baby weight (LBW).

A CART model was constructed based on all categorical variables influencing pregnancy risk and causing disorders in the study group patients (Figure RF10). The final tree constructed consisted of 4 nodes. The root node was first split based on the corrected MOM of HCG. Clearly indicating that, the higher value of HCG

CART analysis

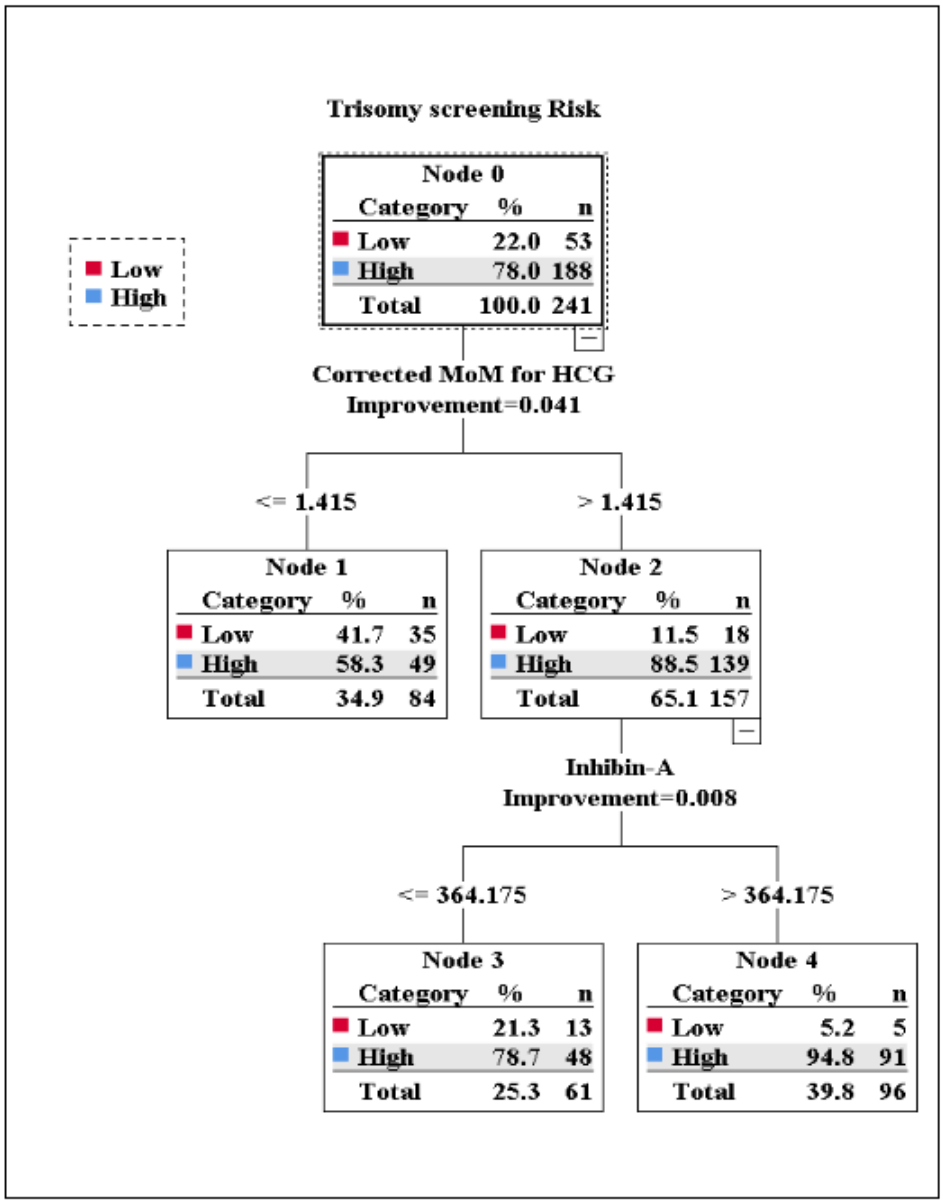

Figure 11: CART (Correlation and regression tree) Analysis.

has the strongest relation with a high risk of getting a low weight baby. Among higher values of corrected MOM of HCG, the subsequent split of terminal Node 2

showed a closer relation of Inhibin A in higher risk patients for adversity in pregnancy finally with 94.8%

Node 0 is the root node (high-risk patients), and node 2 is the internal node, which is further split in two leaf nodes; Node 3, and Node 4. Node 1, Node 3 & Node 4 are leaf nodes which can not be further divided. The CART model achieved an accuracy of 82% and a precision of 0.85. The decision tree has a depth of 3, with 4 nodes.

- There is a threshold effect of the HCG level (corrected MOM of HCG-1.415), in patient blood during the second trimester.

The root node splits on the corrected MOM value of HCG (1.415), indicating that patients with a greater value of corr HCG MOM (>1.415) are more likely to get an adverse outcome of pregnancy.

- The right internal node 2 splits on Inhibin A value (364.175), showing that patients with >364.175 with higher Corr HCG are more likely to not get an LBW baby.

- The right leaf node indicates that patients with less than 1.415 Corr HCG MOM are very unlikely to get an SGA baby (90%).

Insights:- Inhibin A and Corrected MOM of HCG are the most important variables in predicting the Small weight of babies.

- Improvement of 0.008 in Inhibin A and 0.041 in corr MOM of HCG was applied for the prediction of the condition.

-The classification and regression tree is non-parametric and Nonlinear. The CART model is not overfitting or had a high variance as the tree isn't relatively deep so the results were simplistic and low bias. Outliers had no meaningful effect on CART so they were omitted.

4.4. **Recommendations**

- Preliminary variables may have been influenced huge if the automated procedure had not been opted for and technicality had not been supervised seriously. This helped a lot in giving precise results with minimal errors.
- Appropriate cut-off determination in all the labs should be mandatory in specific intervals to perform process enhancement and better accurate results.
- CART analysis precisely predicted Corrected HCG MoM, and Corrected Inhibin A MoM relation with Low-birth-weight babies which should be researched with more studies and data.
- Placental growth factor (PlGF) could be an additional marker to add in the screening test biomarker group as PlGF is essential for placental development and angiogenesis and its low levels may indicate placental insufficiency and abnormal levels of placental growth factor (PlGF) and soluble fms-like tyrosine kinase-1 (sFlt-1) have also been associated with fetal growth restriction. and it could be linked to an increased risk of LBW too.

Discussion

5. Chapter: DISCUSSION

5 Chapter: DISCUSSION

5.1 Pretest Variables' influence on High-Risk Assessment test

Observations in our study didn't find many influencing factors. The Main was the wrong timings (in 2% cases among a total of 5.6% errors) of the collected sample as the patient didn't appear at the same time as prescribed by the doctor or asked by technicians (when the ultrasound happened) and the next factor was the amount and quality of the sample that could be due to patient's medical condition for getting an insufficient or hemolyzed sample. Mostly the sample traveling factors, machine errors, and phlebotomy errors were not seen, which may be due to the automated sample transport system, trained & qualified technicians, and strict SOP follow-ups. Missed labeling and wrong tube selection were noticed in the case of patients' sampling outside the premises, but it was 0.55%, & 0.36% respectively. Only 0.18% errors were observed due to sample storage conditions variations which were further corrected with freshly collected samples.

Mostly the sample traveling factors, machine errors, and phlebotomy errors were not seen Effecting here, may be due to the automated sample transport system, trained & qualified technicians, and strict SOP follow-ups.

Preanalytical time outside and inside the laboratory, starting with the sampling procedure, requires 57% of the total turnaround time of the diagnostic process, whereas analytical time is 25% and post-analytical processes take only 17% time. That includes inter-laboratory quality assurance, printing, and sending by either phone, ward printer, or rapid printout transport.(Guder 1999).

Similarly, in 2012, a study from OXFORD academic on medical errors in laboratory diagnostics included huge data on result failures, due to test errors, and various quality standards of current diagnostic and efficacy of trisomy screening

could be improved with a 95% detection rate and only less than 3% false positive rate. This outcome was used in our study to improve test performance.

5.2 Major influencing variables in High-risk pregnancy screen

A patient's medical history having any chronic disease like cardiac, renal, hepatic or even diabetic, or hypertensive conditions may cause major trouble in giving high risk in pregnancy screen test so all these parameters should be accounted for with special attention primarily, gestation period, age, weight, and test date accuracy has importance in calculating risk so these have a huge impact in overall risk determination in screening tests.

A few other studies were also available for looking over the approximate similar results of the error in various regions of the world, which are tabulated in [Table T1].

Studies have been conducted throughout the world in the past three decades to concentrate on the importance of existing biomarkers in practice to search for any possible relation with any related adverse condition to utilize the existing testing in a better way for the benefit of patients and families. I summarized data from those studies in a tabular form to understand and correlate them with our results.

5.3 Biomarkers' role in the adversity of pregnancy

HCG (Human Chorionic Gonadotropin) gets synthesized in trophoblastic cells and production increases in the first trimester and decreases in the second trimester in normal pregnancy but de-ranged values show some abnormalities in placental

function. HCG helps in the growth and development of the placenta. It is important in embryo implantation during pregnancy. It helps in fetal growth and development and immune tolerance during pregnancy.

HCG low level has been associated with Low birth weight (LBW), Small for gestational age (SGA), Preterm birth, and Preeclampsia, whereas high HCG levels have been linked to Gestational trophoblastic disease, and Chromosomal abnormalities (e.g., trisomy 21)

Inhibin A is a glycoprotein hormone that has fetoplacental (Placenta and fetal membranes) origin during pregnancy and is known to have an importance in the growth of placenta's angiogenesis and a negative feedback effect on pituitary follicle-stimulating hormone secretion. Which regulates maternal hypertensive disorders. Muttukrishna S. (2004). Inhibin A also regulates Foetal growth and development, Placental function its development & Hormone production during pregnancy. Elevated levels of Inhibin A have also been found associated with many others like Low birth weight (LBW), Small for gestational age (SGA), Preterm birth, Preeclampsia, and Gestational diabetes.

AFP stands for Alpha-Fetoprotein. It's a protein produced by the liver and yolk sac of a developing fetus. AFP levels can be measured in the blood of pregnant women to screen for potential fetal abnormalities, such as Neural tube defects (e.g., spina bifida), Chromosomal abnormalities (e.g., Down syndrome) & Liver and gastrointestinal tract abnormalities. Fetal development: AFP helps regulate the fetal immune system and protects against maternal immune attacks. Fetal liver function: AFP is involved in lipid and vitamin transport, as well as liver cell growth.

uE3 stands for Unconjugated Estriol. It's a form of estriol, a hormone produced by the placenta during pregnancy. Unconjugated Estriol is the free, unbound form of estriol circulating in the bloodstream. uE3 is measured in maternal blood as part of the triple or quadruple screen tests, typically between 15 and 20 weeks of gestation. Low levels of uE3 may indicate an increased risk of Down syndrome, Trisomy 18, or Fetal growth restriction.

5.4 High Risk in Trisomy Screening Test Revealing APOs

Studies from across the glove, in Table DT2, review literature section, for identifying the relation of biomarkers in trisomy screening with other Adverse outcomes of pregnancy are listed, which tells, AFP (alpha-fetoprotein), HCG (human chorionic gonadotropin hormone), uE3 (Estriole hormone), PAPP A (pregnancy-associated plasma protein A), NTD (neural tube defect), IUGR (intrauterine growth factor) are found in a significant association with many adverse pregnancy outcomes. All those patients were euploid but showed High risk in the quadruple marker test during the second trimester (risk<1:250) and women suffered any one or more kinds of adversity at the end of pregnancy.

5.5 Low birth weight association with quadruple markers.

Low birth weight (LBW) of babies is found very much related to HCG and Inhibin levels in the blood during the second trimester. The exact mechanisms underlying the relationships between HCG, Inhibin A, and adverse pregnancy outcomes are not fully understood but may involve:

1. Placental dysfunction: Abnormal placental development and function can lead to fetal growth restriction, LBW, and other complications.

2. Fetal growth restriction: Altered HCG and Inhibin A levels may indicate fetal growth restriction, increasing the risk of LBW and other adverse outcomes.

3. Inflammation and oxidative stress: Elevated levels of inflammatory markers and oxidative stress may contribute to altered HCG and Inhibin A levels and adverse pregnancy outcomes.

Trisomy screening test markers have been linked to an increased risk of low birth weight (LBW) babies, defined as birth weight <2500g. The associations include:

1. Alpha-fetoprotein (AFP):

- Elevated AFP levels have been linked to an increased risk of LBW.

- High AFP may indicate placental dysfunction, leading to fetal growth restriction.

2. Estriol (E3):

- Low E3 levels have been linked to an increased risk of LBW.

- E3 is produced by the placenta; low levels may indicate placental dysfunction.

The underlying mechanisms for these associations may involve:

HCG and Low Birth Weight: A study published in the Journal of Clinical Endocrinology and Metabolism found that low HCG levels in the second trimester were associated with an increased risk of low birth weight. (Richard S et al. 2013), Another study published in the American Journal of Obstetrics and Gynecology found that high HCG levels in the first trimester were associated with an increased risk of low birth weight. (Catherine R, et al. 2014)

Inhibin A and Low Birth Weight: A study published in the Journal of Maternal-Fetal & 10Neonatal Medicine found that elevated Inhibin A levels in the second

trimester were associated with an increased risk of low birth weight. (Romero R, et al. 2015), A meta-analysis published in the journal Prenatal Diagnosis found that Inhibin A levels were significantly higher in women who delivered low birth weight babies. (Mellisa H, et al. 2017)

HCG and Inhibin A Ratio: A study published in the Journal of Clinical Endocrinology and Metabolism found that an abnormal HCG and Inhibin A ratio in the second trimester was associated with an increased risk of low birth weight. (Laura I Stirrat, et al.2018)

Preterm birth: Elevated levels of alpha-fetoprotein (AFP) and human chorionic gonadotropin (hCG) have been linked to an increased risk of preterm birth. Preeclampsia: Altered levels of placental growth factor (PlGF: causes microvascular relaxation), soluble fms like tyrosine kinase (sFlt-1: responsible for endothelial dysfunction/ hypertension) (Maynard S E et al. 2003 & Callion H, 2018, Zeisler H, et al. 2016), and hCG have been linked to an increased risk of preeclampsia. Miscarriage: Elevated levels of hCG and AFP have been associated with an increased risk of miscarriage. Stillbirth: Abnormal levels of PlGF and sFlt-1 have been linked to an increased risk of stillbirth. The underlying mechanisms for these associations are not fully understood. (Palmer K Ret al.2017)

Several other studies, working closely on the topic of adverse pregnancy outcomes, have found that trisomy screening markers indicate a significant relation with various kinds of APOs. (including MSS & USG) (Table 3)

5.6. Clinical Significance of High-risk Results of Quadruple Marker Test

Trisomy screening tests, such as Non-Invasive Prenatal Testing (NIPT) and biochemical markers, have been widely used to detect chromosomal abnormalities like trisomy 21, 18, and 13. However, research has also explored the association between these markers and adverse pregnancy outcomes. The importance of trisomy screening as an alternative tool has been tried to be established in the past three decades as an alarming tool for other adverse pregnancy outcomes. In our study, a large group of patients was seen as affected with adverse outcomes from trisomy high-risk identified group in comparison to low-risk group, other than aneuploidy aberrations. This is more than other reported studies globally. Among the high-risk group, gestational diabetes (GDM), Hypothyroid, Preterm Labor (PTL), intrauterine growth retardation (IUGR), Preeclampsia (PE), Intrauterine death (IUD), oligohydramnios was present but weren't in significant association with any of the trisomy marker. Fetal distress was observed as having a significant ($p<0.031$) difference in groups and Low Birth weight was close to the significant ($p<0.051$). While comparing the odd ratio of HCG MoM, Inhibin-A MoM & uE3 MoM, Low birth weight (LBW) was mostly per our study Low Birth weight of the baby was found in significant association with HCG, MoM, Inhibin MoM & uE3 MoM.

A study in Iran by a group, of 80 quadruple-positive samples among 231 total pregnancies found adverse outcomes were increased in the quadruple-positive group in significant amounts. They found pre-eclampsia ($p=0.008$) was in association with Inhibin A ($p<0.001$), IUGR was ($p=0.028$) was associated with Inhibin ($p=0.020$) & AFP ($p=0.015$), and PROM was also ($p=0.040$) present in trisomy high-risk group, but they couldn't find an association with Low birth weight with any marker in their study and a significant age difference between the study

groups were present else their results and methods are in our accordance to support our study. (Yazdani et al in 2015)

Another study from the same country in 2018 on 300 pregnant women by the Bourmond et al group established that Inhibin A MoM = 1.25 in the second trimester is significantly associated with pre-eclampsia (sensitivity= 83.83%). (Bourmond at al, 2018) However, they had taken inhibin only as a parameter and pre-eclampsia only as an adverse outcome in account for association establishment. Whereas we find other makers association as well with many other adversities of pregnancy. (Bourmond at al, 2018). High levels of maternal serum inhibin-A in the second trimester are significantly associated with abnormal placentation, which increases the risk of preeclampsia and FGR as a consequence of indicated preterm birth but not a risk of spontaneous preterm birth. In contrast, low inhibin-A levels were not associated with any common adverse pregnancy outcomes. (Singhnoi W et al. 2019). Elevated Inhibin A levels in pregnancy are significantly associated with pre-eclampsia, GDM, macrosomia, low birth weight, and preterm delivery. (Chao YY, 2020)

A prospective study has found a significantly higher proportion of maternal and foetal mortality and morbidity among elderly pregnant women belonging to the western part of India. Antenatal and intranatal complications were all increased in the study group along with the increased incidence of LBW babies compared to the comparison (below the age of 35 yrs) group (40.20 % vs 24%) (Dutta SR et al. 2018). Our group was not influenced by the elderly age factor as our study group population was under the age of 35 years for women.

In a study by Moghadam et al group in Iran on 240 pregnant women found uE3 (attribute = 0.265) with Fetal Death and AFP (attribute 1.765) with abortion with a sensitivity of 100% and 86% respectively (Moghadam et al. 2016). whereas, we didn't find a significant connection with an increased level of AFP instead a decreased level of Estradiol (uE3) was seen in association with APO. Another study in a nearby area on ethnically similar people was conducted in 2018 on 360 pregnant women to find the clinical significance of the elevated level of AFP in the 15th to 20th week of pregnancy from maternal serum but their study group had a significant difference in age of women and they find moderate sensitivity and specificity in using this marker for diagnostic purposes. (Urmila K et al. 2018)

Godbole et al also reported an inverse relation of HCG with pregnancy complications. They also noticed a significant correlation between high-risk screening with LBW and oligohydramnios. (Godbole et al. 2016) But they couldn't predict birth weight with any of the second-trimester markers in contrast to us. In another study from Thailand in 2020 over 578 women with SGA among 10115 total pregnant found a higher level of AFP (AUC 0.724) & b-HCG (AUC 0655) and a lower level of uE3 (0.597) was significantly associated with the SGA (Small for In Gestational Age). (Boonpian R et al 2020)

5.7. Enhancement of personalized care

Understanding these associations can help healthcare providers:

1. Identify high-risk pregnancies: Patients with abnormal trisomy screening test results may benefit from closer monitoring and management.

2. Provide personalized care: Healthcare providers can tailor their care to address specific risks and concerns.

3. Counsel patients: Accurate counseling about potential risks and outcomes can help patients make informed decisions.

5.8. Future scope of the study

Placental growth factor (PlGF) could be an additional marker to add in the screening test biomarker group as PlGF is essential for placental development and angiogenesis and its low levels may indicate placental insufficiency and abnormal levels of placental growth factor (PlGF) and soluble fms-like tyrosine kinase-1 (sFlt-1) have also been associated with fetal growth restriction. and it is linked to LBW, so combined screening of this marker may enhance the risk report performance.

CONCLUSION

CONCLUSIONS

Managerial trends in scientific studies have highlighted the utility of existing technology's advantages to add on benefits for unknown coming diseases if possible instead of posing multiple new test burdens on patients in the serious period of pregnancy for diagnosis of Pregnancy-associated complications, and if detected early enough to handle properly for avoiding major issues at the end of being at risk for mother and child.

Prenatal analysis has been considered a routine process during early and midterm pregnancy, and various vital tests, clinical evaluations, and general body fluid tastings of the patient have been performed in several maternity centers. With the help of deranged markers, clinicians may recommend further advanced or repeat tastings after a certain period in some reference healthcare units to undergo next-level invasive/non-invasive diagnostic techniques for confirmation of the complexity of handling the disaster.

On the basis of the present work, the following conclusions can be drawn:

1 Automation of the procedure reduces huge number of possibilities of errors. Qualified and trained skilled handling impacts on error free environment. Regular mentinence and protocol follow-up with multiple checkpoints removes errors in testing technique and specificity for detecting high risk. However, some minor mistakes could be screened in routine checks.

2 The risk of adverse pregnancy outcome is significantly increased in the women with increased level of uE3, HCG & Inhibin A in the second trimester trisomy screening test. Increased surveillance of these pregnancies is advisable.

3 Higher level of estriol and Inhibin A in the quadruple marker test in the 14^{th}-16^{th} week of gestation during pregnancy is associated with an increased risk of adverse outcomes,

4 spontaneous abortions and adverse pregnancy outcomes. There is a trend of increasing risks with decreasing PAPP-A values. Even though low PAPP-A is a sign of increased risk, it is not useful as a screening tool.

Nowadays, diagnostics is also considering non-invasive fetal cell DNA (cff DNA; cell-free fetal DNA) in the mother's blood to test chromosomal abnormality but studies have contradictions on the sensitivity of the test. Some other biomarkers are also integrated into the test which found positive results.

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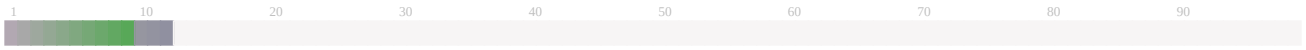

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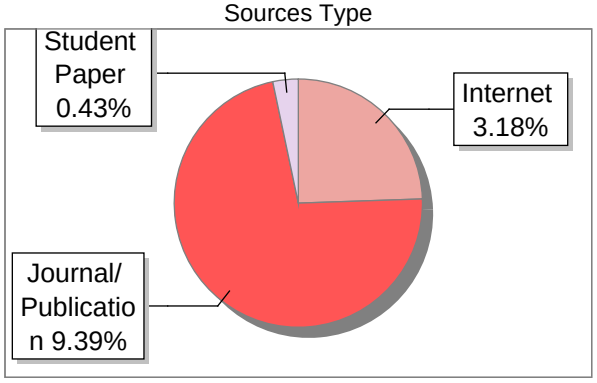

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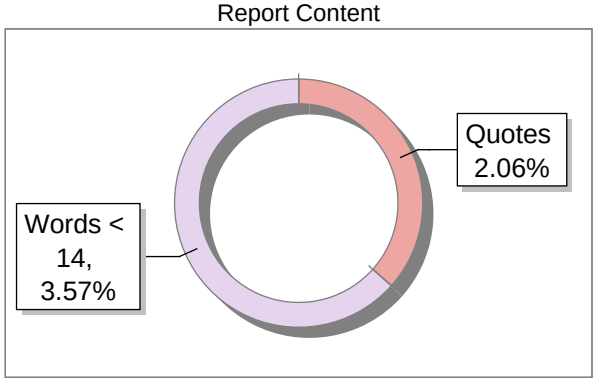

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44	www.axisbank.com	<1	Publication
45	library.oapen.org	<1	Publication
46	moam.info	<1	Internet Data
47	REPOSITORY - Submitted to National Institute of Educational Planning & Administration on 2024-08-29 15-45 1776228	<1	Student Paper
48	www.slideshare.net	<1	Internet Data
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50	pdfcookie.com	<1	Internet Data
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52	digitalcommons.unl.edu	<1	Publication
53	docplayer.net	<1	Internet Data
54	link.springer.com	<1	Internet Data
55	onlinepubs.trb.org	<1	Publication
56	THE MARTIAN ATMOSPHERIC BOUNDARY LAYER by Petrosyan-2011	<1	Publication
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58	kemkes.go.id	<1	Publication
59	q10k.com	<1	Internet Data
60	www.academia.edu	<1	Internet Data
61	www.ramauniversity.ac.in	<1	Publication
62	www.sec.gov	<1	Internet Data
63	A study of visibility impairment associated with mining operation by Yuen-1986	<1	Publication
64	biomedcentral.com	<1	Internet Data
65	ca-c.org	<1	Internet Data
66	Geothermal energy recovery from underground mines by Andre-2011	<1	Publication
67	sail.co.in	<1	Publication
68	via.library.depaul.edu	<1	Publication

69	www.esa.org	<1	Publication
70	www.indianjournals.com	<1	Publication
71	www.kotak.com	<1	Publication
72	A Sentinel-2 based multispectral convolutional neural network for detecting arti by Gallwey-2020	<1	Publication
73	Physician Involvement in Setting Priorities for Health Regions by Alexandr-2004	<1	Publication
74	www.cpgroupglobal.com	<1	Internet Data
75	cachescan.bcub.ro	<1	Publication
76	Workshop 1 (synthesis) water as a catalyst for development by Holmes-2003	<1	Publication
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83	Interactions among bioenergy feedstock choices, landscape dynamics, and land use by Virgini-2011	<1	Publication
84	journal.unjani.ac.id	<1	Internet Data
85	moam.info	<1	Internet Data

86	moam.info	<1	Internet Data
87	springeropen.com	<1	Internet Data
88	springeropen.com	<1	Internet Data
89	worldwidescience.org	<1	Internet Data
90	www.kawasaki-eco-tech.jp	<1	Internet Data
91	www.science.gov	<1	Internet Data
92	academic.oup.com	<1	Publication
93	arxiv.org	<1	Publication
94	Book Review Climatic change and the Mediterranean by Woodward-1998	<1	Publication
95	Submitted to Punjabi University, Patiala on 2024-09-13 09-26	<1	Student Paper
96	Thesis submitted to shodhganga - shodhganga.inflibnet.ac.in	<1	Publication
97	www.ijcrt.org	<1	Publication
98	Body Condition and Population Regulation by Food Resources in Moose by Franoi-1984	<1	Publication
99	dar.aucegypt.edu	<1	Publication
100	digitalcommons.kennesaw.edu	<1	Internet Data
101	dl.lib.uom.lk	<1	Internet Data
102	docplayer.net	<1	Internet Data
103	documents1.worldbank.org	<1	Publication
104	fastercapital.com	<1	Internet Data

105	journal.uniga.ac.id	<1	Internet Data
106	journals.pan.pl	<1	Internet Data
107	journals.pan.pl	<1	Internet Data
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110	papers.ssrn.com	<1	Internet Data
111	pdf4pro.com	<1	Internet Data
112	phys.org	<1	Internet Data
113	Positive Stigma Examining Resilience and Empowerment in Overcoming St by Shih-2004	<1	Publication
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116	Transnational Corporations in Conflict-prone Zones Public Policy Responses and by Banfield-2005	<1	Publication
117	www.linkedin.com	<1	Internet Data
118	archive.globalpolicy.org	<1	Internet Data
119	asmedigitalcollection.asme.org	<1	Internet Data
120	A Taleof Two Cities The Emergenceof Urban Waste Systemsina Developedanda Developing City	<1	Student Paper
121	businessperspectives.org	<1	Publication

122	chimerasthebooks.blogspot.com	<1	Internet Data
123	citeseerx.ist.psu.edu	<1	Internet Data
124	coek.info	<1	Internet Data
125	coek.info	<1	Internet Data
126	docobook.com	<1	Internet Data
127	docobook.com	<1	Internet Data
128	docshare.tips	<1	Internet Data
129	dspace.ewha.ac.kr	<1	Internet Data
130	energyx.com	<1	Internet Data
131	eprints.umm.ac.id	<1	Internet Data
132	erepository.uoeld.ac.ke	<1	Publication
133	Establishment of county-level emission inventory for industrial NMVOCs by Simayi-2019	<1	Publication
134	Evaluation of the prescribing decision support system by Robertson-2020	<1	Publication
135	IEEE 2011 Annual IEEE India Conference (INDICON) - Hyderabad, India by	<1	Publication
136	journals.lww.com	<1	Internet Data
137	jurnal.isbi.ac.id	<1	Internet Data
138	large.stanford.edu	<1	Publication
139	mines.gov.in	<1	Publication
140	moam.info	<1	Internet Data

141	moam.info	<1	Internet Data
142	moam.info	<1	Internet Data
143	pdfcookie.com	<1	Internet Data
144	repositorio.cepal.org	<1	Publication
145	repository.poltekkes-kaltim.ac.id	<1	Publication
146	REPOSITORY - Submitted to Exam section VTU on 2024-07-31 16-59 1038635	<1	Student Paper
147	REPOSITORY - Submitted to Exam section VTU on 2024-08-14 13-02 1014801	<1	Student Paper
148	researchspace.ukzn.ac.za	<1	Publication
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152	Thesis submitted to shodhganga - shodhganga.inflibnet.ac.in	<1	Publication
153	Thesis Submitted to Shodhganga Repository	<1	Publication
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155	The performance of Nafion424 in the membrane electrolysis of borax solution by Turan-2012	<1	Publication
156	uir.unisa.ac.za	<1	Publication

157	uwaterloo.ca	<1	Publication
158	www.dx.doi.org	<1	Publication
159	www.emerald.com	<1	Internet Data
160	www.freepatentsonline.com	<1	Internet Data
161	www.idfcfirstbank.com	<1	Publication
162	www.sciepub.com	<1	Publication
163	www.scribd.com	<1	Internet Data
164	www.sec.gov	<1	Internet Data

Chapter-1

Introduction

Introduction-

Manganese mining in Madhya Pradesh, a central Indian state rich in mineral resources, plays a crucial role in India's mining sector, particularly for steel production and various industrial applications. The state's major manganese deposits are located in the Balaghat, Pandurna, Chhindwara, Jabalpur, Jhabua and Katni districts within the Gondite Series formations. Initiated by the British in the early 20th century and expanded post-independence, mining here involves significant contributions from both government and private sectors. The state-run MOIL operates several mines, supporting industries like steel, battery, and chemical manufacturing, thus boosting the local economy. Predominantly using underground & opencast mining techniques, modern practices aim to minimize environmental impact and ensure worker safety. Despite challenges such as land degradation, deforestation, water pollution, and social issues like displacement, sustainable practices are increasingly adopted, including afforestation and waste management. The mining operations adhere to the regulatory framework of the Mines and Minerals (Development and Regulation) Act, 1957, ensuring responsible activities. With ongoing exploration and technological advancements, the future of manganese mining in Madhya Pradesh is promising, balancing economic growth with environmental and social responsibilities.

Importance of Sustainable Development in Mining-

Sustainable development in mining is essential for balancing resource extraction with environmental protection, social equity, and economic viability. Environmentally, sustainable mining practices ensure resource conservation by minimizing waste and preserving minerals for future generations. These practices also protect ecosystems and biodiversity by reducing land degradation, deforestation, and pollution, and they help mitigate climate change through reduced greenhouse gas emissions and proper waste management. Socially, sustainable mining prioritizes the health, safety, and well-being of local communities, preventing displacement and health hazards while providing fair wages, safe working conditions, and community development initiatives that enhance the socio-economic status of mining regions. Respecting and preserving the cultural heritage and traditions of indigenous and local communities is also integral to sustainable development. Economically, sustainable practices lead to long-term profitability by reducing operational risks and enhancing efficiency, ensuring regulatory compliance to

avoid legal issues, and providing a market advantage by attracting investors, customers, and partners who value responsible practices. Technological innovation improves mining efficiency, reduces environmental impact, and enhances worker safety, while advances in waste management and recycling reduce environmental footprint and convert waste into valuable resources. Effective risk management addresses environmental, social, and economic risks, ensuring long-term stability and resilience. Globally, aligning mining practices with the United Nations' Sustainable Development Goals (SDGs) supports efforts to eradicate poverty, promote sustainable economic growth, and protect the planet, while corporate social responsibility (CSR) commitments enhance company reputation and trustworthiness. Compliance with international and national regulations and standards for environmental protection and social responsibility is crucial for legal operations, and ethical mining practices, including fair labor, transparency, and respect for human rights, are fundamental. In summary, sustainable development in mining ensures the balanced extraction of mineral resources, protecting the environment, promoting social equity, and achieving long-term economic viability, ultimately contributing to the well-being of present and future generations.

Objective of the Study-

The Objective of the study to understand the trend of Manganese production in India, especially in state of Madhya Pradesh from small scale with semi-mechanised mining method covering sustainable development initiatives with respect to legislation and industrial framework. Following shall be objectives of study-

1. Study of all manganese mining & Opencast mines of India and Madhya Pradesh in general, trends of production & growth.
2. Study of Sustainable development Goals in respect of few selected Opencast Manganese Mines of Madhya Pradesh to compare the resource utilisation, optimisation of energy, impact on environment with social & Economical declines & growth.
3. Review of literature on sustainable development of manganese mining & status of Manganese mining in Madhya Pradesh.
4. Field study for sustainability in selected mines, preparation/collection of data based on LCA (life Cycle Assessment) to quantify impact.

5. Quantification/Assessment of sustainable development measures/steps undertaken by studying LCA (life Cycle Assessment) parameters.
6. Discussion/Conclusion on state of Sustainability research areas.

Scope and Limitation-

The scope of sustainable development for opencast manganese mining using life cycle assessment encompasses a comprehensive analysis of environmental, economic, social, technological, and regulatory factors across all stages of the mining process. However, limitations such as data quality, methodological constraints, and regulatory uncertainties can affect the comprehensiveness and accuracy of the assessment.

Background and Context-

Mining, being an act of consuming non-renewable mineral resources, raises questions about its compatibility with sustainability. However, ongoing exploration and technological advancements can make mining more sustainable. The recyclability of metals also contributes to sustainability, as many metals can be recycled repeatedly. Sustainable mining focuses on reducing environmental impacts, including optimizing resource consumption, minimizing land disturbance, reducing pollution, and implementing closure and reclamation plans for exhausted mine lands. The shift towards sustainable mining involves not just reducing the environmental footprint during mining but also managing mineral resources throughout their life cycle, including use and end-of-life phases, to preserve reserves for future generations.

Geology & distribution of Manganese deposits in Madhya Pradesh-

Madhya Pradesh (MP) in India is known to have significant manganese deposits. The manganese ore in MP is associated with the Gondwana Supergroup rocks, particularly the Archaean and Proterozoic formations. The major manganese deposits in MP are found in districts such as Balaghat, Chhindwara, and Shivpuri. Here are some insights into the manganese deposits in these regions:

Balaghat District:

Balaghat is one of the major manganese-producing districts in MP. Manganese ores in this region are primarily associated with the Bhander and Umri Formations.The Balaghat mines have been a historically significant source of manganese in India.

Chhindwara District:

Chhindwara also has manganese deposits, contributing to the overall manganese production in the state. The manganese ores in Chhindwara are associated with the Gondwana Supergroup formations.

Shivpuri District:

Shivpuri is another district in MP where manganese deposits are found. The manganese ores in Shivpuri are associated with the Gwalior Group of rocks.

Associated Minerals:

Manganese deposits in MP are often associated with other minerals like iron ore and copper. The manganese ores in these regions may contain various mineral associations, impacting the overall ore composition.

Mining Companies:

Several mining companies operate in these regions for manganese extraction. Companies involved in manganese mining may conduct exploration, extraction, and beneficiation processes to recover manganese ore. It's important to note that the specifics of manganese deposits, their quality, and the current status of mining operations may change over time. The most recent and detailed information about manganese deposits in MP, it is advisable to consult geological surveys, mining departments, or official government sources. Manganese is an essential mineral used in various industries, including steel production and battery manufacturing. Madhya Pradesh is known to have manganese ore deposits, and mining activities may be carried out by government agencies or private companies. Additionally, contacting local mining companies or industry experts in the region can provide valuable insights into the current state of manganese mining in Madhya Pradesh.

Figure-1: Map Showing India Political map with state Mineral map of Madhya Pradesh

Importance of Manganese-

Manganese occurs as silvery grey in colour and is very hard and brittle in nature. It is always available in combination with iron, laterite and other minerals. Manganese alloy

is an essential for steel making. In recent years, there is great demand for Manganese ore in India. Presently, India is one of the major importers of Manganese ore in the world. Indian manganese ore deposits occur mainly as metamorphosed bedded sedimentary deposits associated with Gondite Series (Archaeans) of Madhya Pradesh (Balaghat, Chhindwara & Jhabua districts), Maharashtra (Bhandara & Nagpur districts), Gujarat (Panchmahal district), Odisha (Sundargarh district) and with Kodurite Series (Archaeans) of Odisha (Ganjam & Koraput districts) and Andhra Pradesh (Srikakulam & Visakhapatnam districts).

Reserves/Resource-

The total reserves/resources of Manganese ore in the country as on 01.04.2020 has been placed at 503.62 million tonnes as per NMI database, based on UNFC system. Out of these, 75.04 million tonnes are categorised as Reserves and the balance 428.58 million tonnes are in the Remaining Resources category. Gradewise, Ferromanganese grade accounts for 8%, Medium grade 6%, BF grade 29% and the remaining 57% are of Mixed, Low, Others, Unclassified, and Not-known grades including 0.16 million tonnes of Battery/Chemical grade. Statewise, Odisha tops the total reserves/ resources with 34% share followed by Karnataka (24%), Madhya Pradesh (12%), Maharashtra (12%), Goa (7%) each, Andhra Pradesh (6%) and Jharkhand (3%). Rajasthan, Gujarat, Telangana and West Bengal together shared the remaining 2% resources.

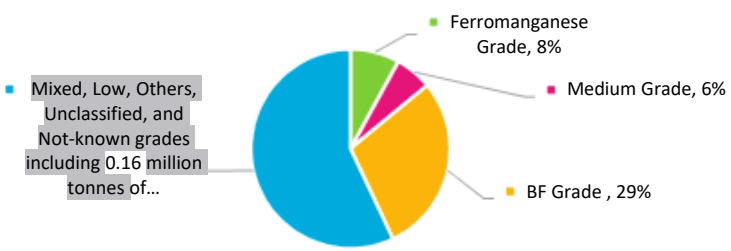


Figure- 2: Grade wise distribution of manganese in India

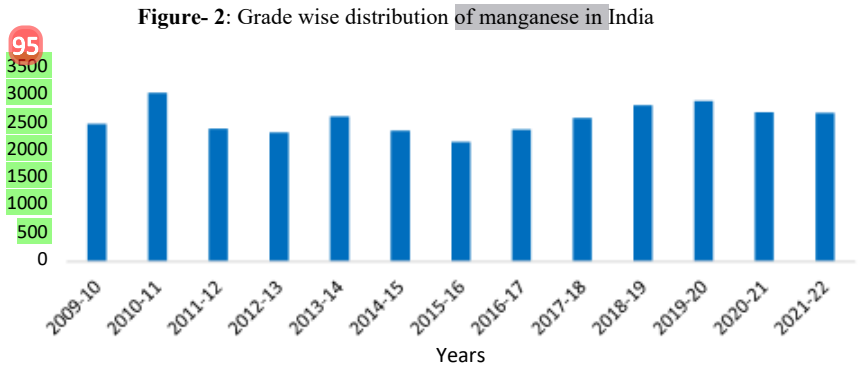


Figure-3: Production trend of Manganese for last one decade

The production of manganese ore at 2696 thousand tonnes during 2021-22 which is almost similar to that in the previous year. There were 135 reporting mines during the year 2021-22 as against 137 in the previous year. Besides, Manganese ore production was reported as associate mineral by 13 mines in 2021-22. In 2021-22, 32 Public Sector mines jointly accounted for 43% of the total production. The contribution of captive mines was 13% of the total production.

As per the grade wise composition of production during 2021-22, 69% of the total production was of lower grade (Below 35% Mn), 21% of medium grade (35-46% Mn) and 9% was of higher grade (Above 46% Mn). Production of manganese dioxide was at 14,21 tonnes (1%) during the year.

The Production volume of manganese ore in India from financial year 2009-10 to 2021-22 is depicted in the graph as below with a CAGR of 0.7%. However, the estimated production of manganese in the year 2029-30 will be around 3.5 million tonnes, if projected at a nominal CAGR of 3% until 2029-30.

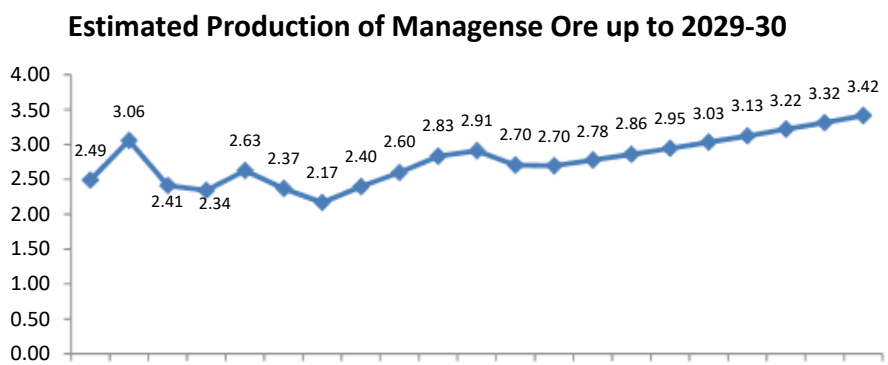


Figure-4: Estimated Production trend of Mn Ore

The production of manganese ore at 2.70 million tonnes in 2021-22 decreased by about 0.27% compared to that in the previous year. MOIL continued to be the largest producer of manganese ore with a share of 45.79% of the total production in 2021-22 followed by M/s Sandur Manganese & Iron Ores Ltd (10.58%), Tata Steel (10.45%). Of the total production of manganese ore in 2021-22, Madhya Pradesh contributed 31.50%, Maharashtra 27.14%, Odisha contributed 19.01%, Karnataka 14.10%, Andhra Pradesh 7.57%.

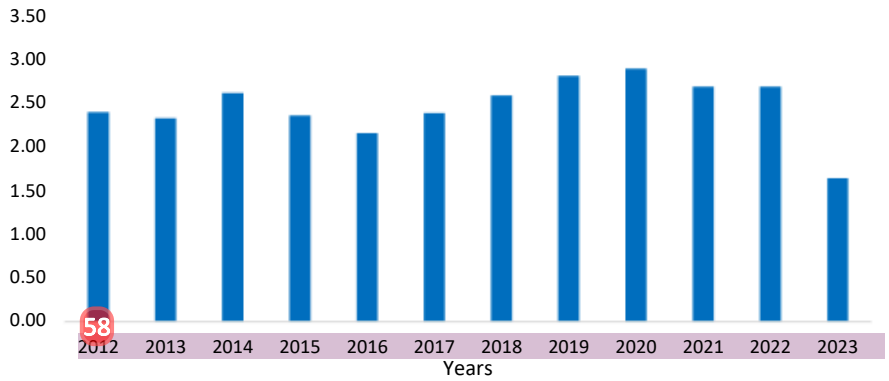


Figure-4: Last one-decade production trend of Mn Ore

Resources-

With manganese reserves amounting to 75 million tons and total resources of 504 million tons as of 01.04.2022, India is also one of the world's most significant producers of the metal. Indeed, India was the world's fifth-largest manganese producing country in 2021. However, despite a globally significant annual production of manganese, India's production of the metal only accounted for 40 percent of domestic consumption during financial year 2021. The total global production volume of manganese amounted to 49.60 million tons in 2021, of which India contributed approx. 5.42%.

Mining in India:

India's mining industry is active and broad, producing approximately 95 minerals overall. As of 2020, the total value of coal and metallic mineral production in India amounted to nearly 22 billion U.S. dollars. There are 17 Category 'B' Manganese mines in India. Madhya Pradesh is the leading producing State of manganese ore accounting for 33% of total production during 2019-20 followed by Maharashtra 25% and Odisha 19%. The production of manganese ore at 2.70 million tonnes in 2021-22 decreased by about 0.27% compared to that in the previous year. MOIL continued to be the largest producer of manganese ore with a share of 45.79% of the total production in 2021-22 followed by, Sandor Manganese & Iron Ores Ltd (10.58%), Tata Steel (10.45%) of the total production of manganese ore in 2021-22, Madhya Pradesh contributed 31.50%, Maharashtra 27.14%, Odisha contributed 19.01%, Karnataka 14.10%, Andhra Pradesh 7.57%.

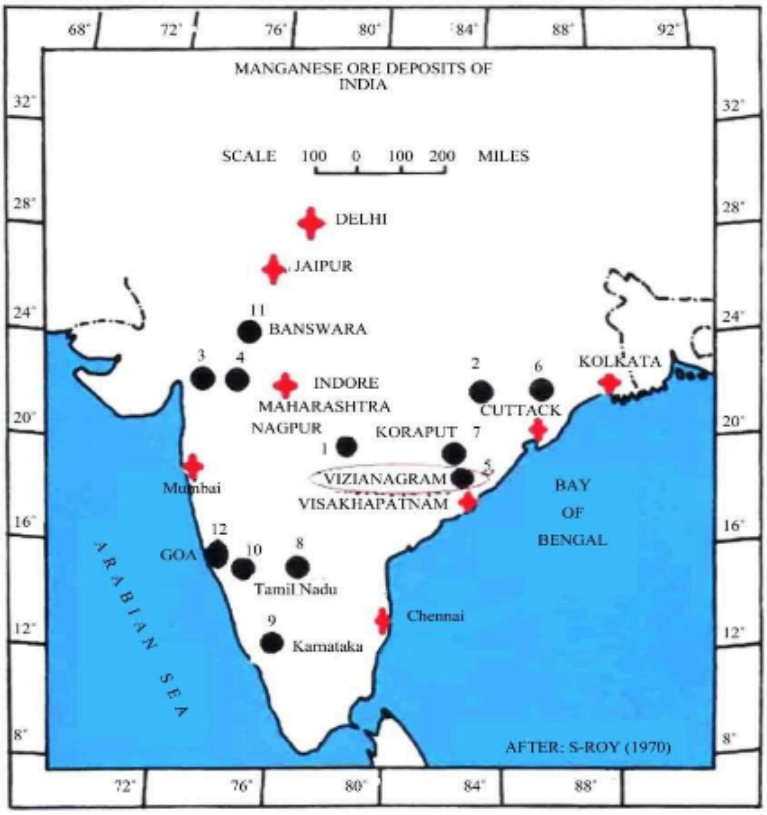


Figure-6: Map showing the Manganese Ore deposits of India.

Problem Statement-

Madhya Pradesh state is enriched with good deposit of manganese ore, spread over in the Balaghat, Chhindwara and Jhabua districts. The total reserve of 23.64 million tonnes of manganese ore is available in the State constituting 14.09% of total national reserve. The "Bharveli manganese mine" in Balaghat district is oldest and largest underground mine operating in Asian sub-continent. The manganese ore deposits of the State are being exploited mainly by the Manganese Ore India Limited. During the year 2022-23, manganese ore has contributed Rs. 37 Crores as royalty to the Madhya State Exchequer, which is about 6.56% of the total royalty accrual of amounting Rs. 563.93 crores.

In MP there are 45 number of mines out of which 09 are underground and remaining 36 are opencast mines. Table no-1, shows production trend of Mn Mines of MP;

District	Name of Mine	Opencast Production (in tons)				Underground Production (in tons)				Transition Date
Balaghat	Ramrama Mn ore Mine									13.11.2008
Chhindwara	Palaspani Mn ore Mine									22.10.2021
Jhabua	Kajali Dongri Mn ore Mine									Transition is not Planned

Table no- 1: Production trend of selected Mn ore of MP

The current study focuses on surface mining, specifically opencast mines, which require significant land area for various operations such as infrastructure development, waste dumping, and stockpile maintenance. Despite the need for extensive land, these mines are cost-effective and provide numerous job opportunities. They also allow for quicker and safer production commencement. However, opencast mining comes with its own set of challenges, including land availability, deepening of mine workings, longer hauling distances for ore and waste, leading to increased diesel consumption by heavy earth moving machinery (HEMM), and depletion of economically viable ore reserves at accessible depths. These challenges are addressed in the research from technological, economic, and social perspectives.

To overcome, these challenges, transition in method of mining and its impact on resource utilisation, optimisation of energy, impact on environment with social & Economical declines & growth will be dealt with suitable method to assess and quantify the impact on sustainability. As a part of study out of 35 opencast small scale and semi mechanised mine, till January, 2024 only two mine, Ramrama manganese mine of M/s AP Trivedi Sons in Waraseoni tehsil of Balaghat district And Palaspani Manganese Mine of M/s Krishnaping Alloys Limited in Sausar tehsil of Pandhurna district have been converted into Underground mines whereas another Kajli Dongri Mine of M/s S.R. alloys is under planning for transition from opencast mine. The impact of transition on local livelihood in terms of health & Safety, Cultural & Heritage Concern, Community engagement & consultation & economic impact will be dealt in this research for all three mines.

Sustainable Development

The mining organizations are bound by several regulatory framework to ensure safe and sustainable mining, keeping in view the conservation, environment, local population and culture in view. Govt. of India had incorporated several changes keeping in view the role IT, Sustainable Development Framework, The Sustainable Development Goals (SDGs) are a set of 17 global goals established by the United Nations in 2015 as part of the 2030 Agenda for Sustainable Development. These goals are interconnected and aim to address a wide range of social, economic, and environmental challenges to create a more sustainable and equitable world. Here is a brief overview of the 17 SDGs:

1. **No Poverty (Goal 1):** End poverty in all its forms everywhere.
2. **Zero Hunger (Goal 2):** End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
3. **Good Health and Well-being (Goal 3):** Ensure healthy lives and promote well-being for all at all ages.
4. **Quality Education (Goal 4):** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. **Gender Equality (Goal 5):** Achieve gender equality and empower all women and girls.
6. **Clean Water and Sanitation (Goal 6):** Ensure availability and sustainable management of water and sanitation for all.
7. **Affordable and Clean Energy (Goal 7):** Ensure access to affordable, reliable, sustainable, and modern energy for all.
8. **Decent Work and Economic Growth (Goal 8):** Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
9. **Industry, Innovation, and Infrastructure (Goal 9):** Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
10. **Reduced Inequality (Goal 10):** Reduce inequality within and among countries.
11. **Sustainable Cities and Communities (Goal 11):** Make cities and human settlements inclusive, safe, resilient, and sustainable.
12. **Responsible Consumption and Production (Goal 12):** Ensure sustainable consumption and production patterns.

13. **Climate Action (Goal 13):** Take urgent action to combat climate change and its impacts.
14. **Life Below Water (Goal 14):** Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
15. **Life on Land (Goal 15):** Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
16. **Peace, Justice, and Strong Institutions (Goal 16):** Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.
17. **Partnerships for the Goals (Goal 17):** Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

These goals are designed to be integrated and indivisible, recognizing that addressing one goal can have positive impacts on others. They provide a comprehensive framework for global efforts to achieve a more sustainable and inclusive future by 2030. The impacts of the mining sector on the Sustainable Development Goals (SDGs) are significant, particularly in relation to water, land, climate, and socio-economic aspects. The mining industry affects SDG 6 (Clean Water and Sanitation) through its water usage and management practices, SDG 15 (Life on Land) due to its impact on land resources, SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action) through its energy consumption and greenhouse gas emissions. Additionally, the mining industry plays a crucial role in improving living standards in remote areas, contributing to SDG 1 (No Poverty), SDG 5 (Gender Equality), SDG 10 (Reduced Inequalities), SDG 16 (Peace, Justice, and Strong Institutions), and SDG 8 (Decent Work and Economic Growth). As a key contributor to economic growth, mines provide raw materials for industries such as steel, cement, power, and fertilizer, thereby supporting SDG 17 (Partnership for the Goals) and SDG 12 (Responsible Consumption and Production) through a circular economy approach. Overall, the mining industry has a complex relationship with the SDGs, impacting various goals both positively and negatively, highlighting the need for sustainable practices in the sector. Mining activities, while essential for economic development, must be conducted responsibly to address the potential negative impacts on various SDGs. Balancing economic benefits with environmental sustainability, social equity, and responsible governance is crucial for aligning mining activities with the

broader goals of sustainable development. Engaging stakeholders, implementing best practices, and adopting innovative technologies are essential components of this holistic approach. Addressing these issues requires a holistic approach that balances the economic benefits of mining with the need for environmental sustainability, social equity, and responsible governance. Engaging stakeholders, implementing best practices, and adopting innovative technologies are crucial for aligning mining activities with the SDGs.

Towards Sustainable Mining (TSM)-

The Towards Sustainable Mining (TSM) program is a set of principles and standards developed by the Mining Association of Canada (MAC) to improve the mining industry's environmental and social performance. TSM includes a verification process to ensure that mining companies are adhering to these principles. The verification process involves a combination of self-assessments, external verification, and public reporting. below is an overview of the TSM verification process:

Self-Assessment:

- *Internal Evaluation:* Mining companies that are members of MAC conduct self-assessments to evaluate their performance against the TSM standards. This involves a comprehensive examination of their operations, policies, and practices.

External Verification:

- *Independent Third-Party Verification:* After completing the self-assessment, companies undergo external verification conducted by independent third-party assessors. These assessors are typically recognized experts in sustainability, environmental management, and social responsibility.
- *Site Visits and Audits:* External verifiers conduct on-site visits and audits to verify the accuracy of the self-assessment data and assess the implementation of TSM principles at the operational level.

Verification Against TSM Protocols:

- *Protocols and Indicators:* TSM provides specific protocols and performance indicators for each key aspect of mining operations, including tailings management, community engagement, biodiversity conservation, and others.
- *Verification against Protocols:* The external verification process ensures that mining companies are meeting the established protocols and achieving the

performance indicators set by TSM.

Verification Levels:

- ***Tier System:*** TSM uses a tiered system to categorize the level of performance. The tiers range from Level A (basic compliance) to Level AAA (industry leaders demonstrating continuous improvement). Companies aim to achieve higher tiers by demonstrating excellence in implementing sustainable practices.

Public Reporting:

- ***Transparent Reporting:*** Companies publicly report the results of their self-assessment, external verification, and performance against TSM protocols. This transparency is a key element of the program, providing stakeholders, including communities, investors, and the public, with information about a company's sustainability performance.

Continuous Improvement:

- ***Feedback and Improvement:*** TSM encourages continuous improvement. Companies receive feedback from the verification process, identifying areas for improvement and best practices. This feedback loop is essential for fostering a culture of ongoing sustainability enhancement within the mining industry.

The TSM verification process is designed to ensure accountability, transparency, and continuous improvement within the mining sector. By voluntarily participating in TSM and undergoing regular verification, mining companies can demonstrate their commitment to responsible and sustainable practices, contributing to the overall goal of improving the industry's social and environmental performance.

Sustainable Mining in India-

The Ministry of Mines developed a credible system of evaluation of mining footprints and instituted the Sustainable Development Framework (SDF) for taking up mining activity under its umbrella, encompassing inclusive growth, without adversely affecting the social, economic and environmental well-being, at present and also in future generation. Further, to implement the Sustainable Development Framework (SDF),

Ministry has evolved a system of Star Rating of Mines. The Star Rating is being implemented as per the provisions of Rule 35 of Mineral Conservation and Development Rules (MCDR) 2017 through the Indian Bureau of Mines (IBM), a subordinate office of the Ministry of Mines. It has been instituted as a two-tier system providing self-evaluation templates to be filled in by the mine operator followed by validation through Indian Bureau of Mines. The self-appraisal template required to be filled by the leaseholders comprises of four modules as given below:

- **Module I**: Managing Impacts at the Mine Level
- **Module II**: Final/ Progressive Mine Closure and Landscape Restoration
- **Module III**: Addressing Social Impacts of R and R Requirements, Community Engagement and Welfare Programs
- **Module IV**: Assurance and Reporting

Each of the module contain proposals for activities under SDF and actual achievements by the mine against the proposals. Marks are allotted by the system in the self-appraisal template as per the achievements. Accordingly, Star Rating is awarded automatically by the system on the basis of percentage marks obtained in all four modules as given below: The self-assessment report submitted by the lessee/mine operator is validated through inspection by an officer of Indian Bureau of Mines and final star rating is awarded.

Five Star rating is awarded to a mine where percentage of total marks obtained in all the modules is equal to or above 90%. Best performers amongst the five star rated mines are felicitated by the hands of Hon'ble Minister of Mines, in a national level conclave, organized by the Ministry of Mines.

Percentage obtained	Criteria
>90 to 100 %	5 Star
>80 to <90 %	4 Star
>60 to < 80%	3 Star
>50 to < 60%	2 Star
>25 to < 50%	1 Star
< =25%	No rating

Table-2: Percentage Criteria for Star Rating

Year wise number of 5 star rated mines since inception is given below;

Year	No. of 5 Star Rated Mines
2014-15	9
2015-16	32
2016-17	57
2017-18	57
2018-19	52
2019-20	40
2020-21	40
2021-22	76

Table-3: Year wise number of 5 star rated mines since inception

Rule -35: Sustainable Mining [MCDR-2017]

Rule-35 Sustainable mining

(1) Every holder of a mining lease shall take all possible precautions for undertaking sustainable mining while conducting prospecting, mining, beneficiation or metallurgical operations in the area.

(2) Every holder of a mining lease shall monitor his mining and allied activities as per the template of star rating in the format specified in this behalf by the Indian Bureau of Mines from time to time, and shall submit online its self-assessment report before the 1st day of July every year for the previous financial year, along with the digital images of mining lease area under rule 34A, to the Regional Controller or the authorised officer of the Indian Bureau of Mines: Provided that those mining lease holders who do not fill and submit the template as specified shall be deemed self-assessed star rating below the qualifying star rating as provided under sub-rule (4) and action shall be initiated accordingly.

(3) The confirmation of the star rating may be done by the authorised officer of the Indian Bureau of Mines through inspection.

(4) Every holder of a mining lease shall achieve at least three-star rating within a period of four years with effect from the 27th February, 2017 or four years from the date of commencement of mining operations, as the case may be, and thereafter maintain the same on year-on-year basis.

(4A) The Regional Controller or the authorized officer of the Indian Bureau of Mines may suspend the mining operations in those mines where,— (a) at least three-star rating has not been achieved within a period of four years with effect from the 27th February,

2017 or four years from the date of commencement of mining operations, as the case may be, or (b) at least three-star rating has not been maintained on year-on-year basis, or (c) where the lessee has failed to submit the star rating template, after giving a show cause notice of forty-five days to qualify for star rating or submit star rating template, as the case may be.

(4B) In case of non-filing of template as stated in sub-rule (2), the holder of mining lease shall be liable to pay an amount of ten thousand rupees per day for such delay to the authorised officer of the Indian Bureau of Mines.

(5) The suspension shall be revoked only after verification through inspection of compliance of the star rating requirement specified in sub-rule (4) that the mine qualifies for three-star rating.

Sustainable Mining Enabled by Latest Technology and Amended Rules:

Mineral Conservation and Development Rules (MCDR), 2017 provide rules regarding conservation of minerals, systematic and scientific mining, development of the mineral in the country and for the protection of environment. The Ministry of Mines has notified the Mineral Conservation and Development (Amendment) Rules, 2021 on 03.11.2021. The amended Rules prescribe that all plans and sections shall be prepared by combination of Differential Global Positioning System (DGPS) or Total Station or by the use of drone survey or as may be specified in this regard by Indian Bureau of Mines (IBM) in relation to certain or all category of leases.

Lessees having annual excavation plan of 1 million tonne or more in a particular year or leased area of 50 hectare or more shall carry out a drone survey of the leased area and up to 100 metres outside the lease boundary in the month of April or May every year and submit the processed output images obtained from such survey or any other format as may be specified by the IBM in this regard to the Controller General on or before 1st day of July every year.

Other lessees shall submit soft copy of high resolution Geo-referenced Ortho-rectified Multispectral satellite images of the leased area and up to 100 metres outside the lease boundary taken in the month of April to June of every year, to the Controller General on or before 1st day of July of the that year in the standard format. These steps will not only improve mine planning practices, security and safety in the mines but also ensure better supervision of mining operations.

The Sustainable Development Goals (SDGs), Towards Sustainable Mining (TSM), and the star rating system for Indian mines under the Mineral Conservation and Development Rules (MCDR) 2017 all play crucial roles in promoting mining sustainability, each offering unique benefits and approaches.

The SDGs provide a comprehensive framework for sustainable development, addressing various social, economic, and environmental aspects. By aligning mining practices with specific SDGs, such as clean water and sanitation (SDG 6), responsible consumption and production (SDG 12), and climate action (SDG 13), mining companies can contribute to global sustainability efforts.

TSM, developed by the Mining Association of Canada, offers a practical approach for mining companies to improve their environmental and social performance. TSM's verification process ensures accountability and transparency, encouraging continuous improvement in sustainability practices. The tiered system allows companies to track their progress and strive for higher levels of performance.

The star rating system under the MCDR 2017 provides a mechanism for assessing the environmental and social impact of mining operations in India. By awarding star ratings based on performance, this system incentivizes companies to adopt more sustainable practices. It also helps regulators and stakeholders monitor and evaluate the sustainability of mining activities.

Each of these approaches has its strengths, and the best method may vary depending on the specific context and objectives. However, a combination of these approaches, tailored to the needs of the mining industry in a particular region, can provide a comprehensive framework for achieving sustainability goals. Integrating SDGs into mining practices, implementing TSM principles, and adhering to the star rating system can collectively contribute to a more sustainable mining sector.

Chapter-2

Literature Review

Literature Review-

Review on global best practices in sustainable mining-

Kennedy, B. A. et al. (1999). “Sustainable Mining Practices: A Global Perspective” This paper reviews sustainable mining practices worldwide, focusing on strategies that minimize environmental impact, enhance social acceptance, and ensure economic viability. It advocates for a holistic approach that integrates environmental, social, and economic dimensions, emphasizing the importance of comprehensive environmental management and proactive stakeholder engagement.

"Mining and the Environment: From Ore to Metal" by Spitz et al. (2009) examines the environmental impacts of mining activities from ore extraction to metal production. It highlights the importance of environmental management systems, regulatory frameworks, and community engagement in achieving sustainability. The paper advocates for continuous monitoring and adaptive management practices to address evolving environmental challenges, emphasizing proactive measures and collaborative approaches for minimizing ecological footprints and promoting environmental stewardship in mining industries.

Newbold, Laurence T. H. et al. (2006). "Sustainable Development in the Mining Industry: Clarifying the Corporate Perspective" Newbold's paper delves into the corporate perspective on sustainable development within the mining industry. By scrutinizing how mining companies perceive and enact sustainable development principles, the research underscores the complexities inherent in balancing economic growth with environmental preservation and social accountability.

The study sheds light on the challenges and opportunities faced by mining firms in their pursuit of sustainability, offering valuable insights into corporate strategies for fostering environmental stewardship and engaging with stakeholders. Through this examination, the paper provides a nuanced understanding of the dynamics at play within the mining sector and offers a roadmap for enhancing sustainability practices and collaboration with stakeholders.

Warhurst, M. A. et al. (2000). "Environmental and Social Impacts of Mining" an extensive review of the environmental and social ramifications linked with mining

operations. It delves into the intricacies of impact assessment, management, and mitigation, emphasizing the imperative of fostering sustainable outcomes. Through the lens of case studies, the paper illuminates successful strategies employed across diverse mining contexts, providing valuable insights for industry practitioners, policymakers, and stakeholders striving to navigate the complex terrain of mining-related environmental and social challenges.

M. Franks, Daniel and R. Mulligan, David. (2007). "Mining for the Future: Sustainability in the Global Mining Industry" Franks and Mulligan's paper delves into the concept of sustainability within the global mining industry. Through the presentation of case studies and best practices spanning various regions, the authors underscore the importance of innovative approaches and stakeholder collaboration in achieving sustainable mining outcomes. Additionally, the paper examines the pivotal roles of technology and policy in promoting sustainability, offering valuable insights for industry stakeholders, policymakers, and researchers aiming to navigate the path towards a more sustainable mining sector.

Nuttall, K. (2002). "Sustainable Mining in the Arctic: Challenges and Best Practices" Nuttall acknowledges the unique challenges associated with mining in the Arctic region, including environmental sensitivity, harsh climate conditions, and the potential impact on indigenous communities. Despite these challenges, the paper emphasizes that sustainable mining practices are achievable through careful planning, technological innovation, and stakeholder collaboration. Nuttall underscores the importance of implementing best practices to minimize environmental impact, protect biodiversity, and ensure the well-being of local communities. The conclusion emphasizes the need for adaptive management strategies that allow mining operations to respond effectively to changing environmental and social conditions in the Arctic.

Overall, Nuttall's conclusion emphasizes the significance of balancing economic development with environmental and social responsibility in Arctic mining ventures. By adopting sustainable practices and engaging with stakeholders in a meaningful way, mining companies can contribute positively to the region's development while safeguarding its fragile ecosystems and cultural heritage.

Helble, Mattias & Shepherd, Ben (2019). "Sustainable Mining: How Good Practices in the Mining Sector Contribute to Sustainable Development" underscore the pivotal role of good practices in the mining sector in advancing sustainable development goals. They highlight how successful initiatives and frameworks for environmental protection, social equity, and economic efficiency contribute to overall sustainability. Moreover, the authors emphasize the importance of policy measures and corporate strategies that support sustainability. Overall, the paper advocates for the integration of best practices into mining operations to foster positive environmental, social, and economic outcomes, thus promoting sustainable development in the mining sector.

Strongman, John et al. (2004). "Mining and Sustainability: The Contribution of Mining to Sustainable Development" it is emphasized that mining has the potential to positively contribute to sustainable development by fostering economic growth, environmental protection, and social progress. Strongman highlights the importance of policy measures, industry practices, and collaborative efforts in supporting sustainability within the mining sector. Overall, the paper advocates for responsible mining practices that prioritize the well-being of communities, the environment, and future generations while acknowledging the challenges inherent in achieving sustainable development goals in the mining industry.

Jenkins, Heledd et al. (2004). "Corporate Social Responsibility in Mining: Theoretical Perspectives and Research Trends" the significance of corporate social responsibility (CSR) in the mining industry is underscored. Jenkins highlights the importance of integrating CSR into mining operations, emphasizing theoretical frameworks and empirical studies that inform best practices. The paper advocates for transparency and stakeholder engagement as essential components of effective CSR implementation. Overall, Jenkins calls for further research and action to advance CSR practices in the mining sector, recognizing its potential to enhance social and environmental outcomes while promoting sustainable development.

Kemp, Deanna & Owen, John et al. (2013) "Sustainable Mining: An Oxymoron?" the authors critically examine the notion of sustainable mining, questioning whether it is attainable given the inherent environmental and social impacts of mining activities. Through their analysis, they explore strategies for improving sustainability performance

and address the tensions between economic imperatives and sustainability goals. The conclusion suggests that while challenges exist, sustainable mining practices are achievable through proactive measures and innovative approaches that prioritize environmental stewardship and social responsibility alongside economic interests. Overall, the paper encourages ongoing dialogue and collaboration within the mining industry to navigate these complexities and work towards more sustainable outcomes.

Warhurst, Alyson et al. (1999). "Environmental Policy in Mining: Corporate Strategy and Planning" the paper explores corporate strategies and planning approaches for environmental policy within the mining sector. Warhurst emphasizes the importance of proactive environmental management, risk assessment, and stakeholder engagement in achieving sustainable mining practices. The conclusion highlights successful examples of policy implementation and underscores the need for ongoing commitment to environmental responsibility within mining operations. Overall, the paper advocates for integrating environmental considerations into corporate strategy and planning processes to mitigate environmental impacts and promote long-term sustainability in the mining industry.

Addison, Tony & Roe, Alan et al. (2018). "Mining and Sustainable Development: Insights from International Research" the authors provide valuable insights gleaned from international research on mining and sustainable development. Their comprehensive review covers economic, environmental, and social dimensions of sustainability in mining, presenting best practices from diverse countries. The conclusion underscores the importance of regulatory frameworks and community participation in fostering sustainable mining practices. Overall, the paper emphasizes the need for collaborative efforts and evidence-based policymaking to address the complex challenges facing the mining industry and promote sustainable development worldwide.

Fourie, A.B. & Tibbett, M. et al. (2006). "Sustainable Mining: Strategies for the Development of Sustainable Practices in Mining" present strategies aimed at fostering sustainable practices within the mining industry. They delve into topics such as environmental impact assessment, waste management, and community engagement. The conclusion emphasizes practical recommendations for enhancing sustainability through innovative technologies and collaborative approaches. Overall, the paper advocates for a

holistic approach to mining that prioritizes environmental stewardship, social responsibility, and economic viability to achieve long-term sustainability.

Danielson, N.L. et al. (2002). "Sustainable Development in the Mining Sector: The Case for Partnerships" present the importance of partnerships between mining companies, governments, and communities to achieve sustainable development goals. The paper presents case studies highlighting successful collaborations and emphasizes best practices for partnership development. The conclusion underscores the significance of trust and mutual benefits in fostering effective partnerships, which are essential for addressing environmental, social, and economic challenges in the mining sector. Overall, the paper highlights the pivotal role of partnerships in promoting sustainable development within the mining industry.

Hilson, G.M. et al. (2003). "Sustainable Mining in Practice: Case Studies from Around the World" emphasizes the importance of implementing sustainable mining practices through real-world case studies. Hilson highlights successful initiatives in environmental management, social responsibility, and economic development within the mining industry. The conclusion underscores the valuable lessons learned from these case studies and their applicability to diverse mining contexts worldwide. Overall, the paper advocates for the widespread adoption of sustainable mining practices to mitigate environmental impacts, enhance social outcomes, and ensure the long-term viability of mining operations.

White, N.C. et al. (2008). "The Role of Technology in Sustainable Mining" The conclusion emphasizes the significance of technological innovations in reducing environmental impact, enhancing resource efficiency, and improving safety within mining operations. White highlights examples of successful technology integration, such as advanced monitoring systems and automated processes, which enable more sustainable resource extraction. Overall, the paper underscores the pivotal role of technology in promoting sustainability within the mining industry and calls for continued investment in research and development to drive technological advancements further.

De Moraes, L.W. et al. (2012). "Sustainable Mining: Addressing Environmental and Social Challenges" the author examines the environmental and social challenges associated with mining activities. The conclusion underscores the importance of

mitigating negative impacts and promoting positive outcomes through sustainable practices. De Moraes emphasizes the significance of community engagement, environmental stewardship, and adaptive management strategies in addressing these challenges effectively. Overall, the paper advocates for a holistic approach to mining that balances economic interests with environmental and social responsibility to achieve long-term sustainability in the industry.

Bice, C.J. et al. (2010). "Mining and Sustainability: Bridging the Gap" the author explores strategies for bridging the gap between mining activities and sustainable development goals. The conclusion highlights the importance of integrating sustainability principles into all stages of mining operations, from planning to closure. Bice emphasizes the need for proactive measures to address environmental and social concerns, as well as ongoing engagement with stakeholders to ensure transparency and accountability. Overall, the paper underscores the significance of collaboration and innovation in achieving sustainable outcomes in the mining sector.

Humphreys, David et al. (2001). "Sustainable Mining and Economic Development: A Framework for Analysis" presents a framework for analysing the relationship between mining activities and economic development. The paper examines how sustainable mining practices can contribute to long-term economic growth, stability, and poverty reduction in mining regions. It explores the potential benefits and challenges associated with mining-led development, highlighting the importance of integrating environmental and social considerations into economic planning processes. Through case studies and theoretical analysis, Humphreys provides insights into the complex dynamics of mining and economic development, offering practical recommendations for policymakers, industry stakeholders, and local communities.

Giurco, A.C. & Mudd, G.M. et al. (2013). "Sustainable Mining: Policy and Legislative Frameworks "the authors review policy and legislative frameworks that support sustainable mining practices. The conclusion emphasizes the critical role of government regulations, industry standards, and international agreements in promoting sustainability in the mining sector. Giurco and Mudd highlight successful policy implementation and enforcement strategies, underscoring the importance of regulatory frameworks in driving sustainable outcomes. Overall, the paper advocates for the development and

implementation of robust policy frameworks to ensure environmental protection, social equity, and economic viability in mining operations.

Agbenohevi, M.T. et al. (2015). "Environmental Impact Assessment and Sustainable Mining "the author emphasizes the crucial role of environmental impact assessment (EIA) in promoting sustainable mining practices. The conclusion underscores the importance of integrating sustainability considerations into the EIA process to mitigate environmental impacts and ensure responsible resource extraction. Agbenohevi highlights the need for comprehensive assessments that address environmental, social, and economic dimensions, as well as meaningful stakeholder engagement throughout the assessment process. Overall, the paper advocates for the adoption of robust EIA practices as a cornerstone of sustainable mining development.

"Sustainable Mining Practices in Developing Countries" by T. P. Afeti (2014), the conclusion underscores the importance of promoting sustainable mining practices in developing countries. Afeti highlights the unique challenges faced by these regions and emphasizes the need for tailored approaches that address environmental, social, and economic concerns. The conclusion advocates for capacity building initiatives, technology transfer, and stakeholder collaboration to enhance sustainability in mining operations. Overall, the paper emphasizes the role of sustainable mining practices in promoting inclusive growth and poverty reduction in developing countries.

Rechardson, B.J. et al. (2009). "Mining, Sustainability, and Social License" he author explores the concept of social license to operate (SLO) within the context of mining operations. The paper delves into the intricate relationship between mining activities, sustainability principles, and the social acceptance of mining projects by local communities and stakeholders. Richardson examines the factors influencing the attainment and maintenance of social license, including environmental stewardship, corporate social responsibility (CSR) initiatives, and effective community engagement strategies. Through case studies and theoretical analysis, the paper sheds light on the challenges and opportunities associated with obtaining social license in the mining industry.

Starke, K.L. et al. (2007). "Corporate Strategies for Sustainable Mining "the importance of corporate strategies in driving sustainable mining practices. Starke emphasizes the

need for mining companies to integrate sustainability principles into their business operations, including environmental management, social responsibility, and stakeholder engagement. The conclusion underscores the role of leadership and strategic planning in promoting sustainability within the mining industry. Overall, the paper advocates for proactive corporate strategies that prioritize long-term environmental and social outcomes alongside economic objectives.

Coumans, P.J. et al. (2011). "Sustainable Mining and Indigenous Communities" which emphasizes the importance of fostering mutually beneficial relationships between mining companies and indigenous communities. Coumans highlights the need for culturally sensitive approaches that respect indigenous rights, traditions, and land tenure systems. The conclusion underscores the significance of meaningful engagement and consultation with indigenous stakeholders throughout the mining lifecycle. Coumans advocates for collaborative decision-making processes that prioritize community well-being and environmental stewardship. Overall, the paper underscores the imperative of promoting social equity and environmental justice in mining operations involving indigenous communities.

"Community Engagement in the Mining Industry: A Global Review" by M. S. Ali and L. O'Faircheallaigh (2007) offers an in-depth examination of community engagement practices within the mining sector worldwide. The paper explores various approaches adopted by mining companies to engage with local communities, addressing the socio-economic, cultural, and environmental dimensions of community relations. Through case studies and comparative analysis, the authors highlight the diverse strategies employed to foster constructive dialogue, build trust, and address community concerns. The paper underscores the importance of proactive engagement and participatory decision-making processes in achieving positive social outcomes and minimizing conflict in mining-affected areas.

In conclusion, the paper emphasizes the critical role of community engagement in the mining industry for promoting sustainable development and enhancing social license to operate. Ali and O'Faircheallaigh argue that effective engagement practices contribute to building mutually beneficial relationships between mining companies and local communities, leading to improved socio-economic conditions, environmental protection, and cultural preservation. The conclusion highlights the need for mining companies to

adopt inclusive and transparent approaches to community engagement, tailored to the specific context and needs of each community. Overall, the paper underscores community engagement as a key component of responsible mining practices and sustainable resource development.

In "Integrating Biodiversity into the Mining Life Cycle" by B. ten Kate, J. Bishop, and R. Bayon (2004), which emphasizes the critical importance of incorporating biodiversity considerations throughout the mining life cycle. The authors advocate for comprehensive biodiversity assessments, effective mitigation strategies, and collaborative efforts between stakeholders to minimize the impacts of mining on biodiversity. They highlight the potential for mining operations to coexist sustainably with biodiversity conservation efforts through proactive planning and responsible environmental management. Overall, the conclusion underscores the necessity of integrating biodiversity concerns into mining practices to ensure environmental sustainability and biodiversity conservation.

Bice, Sara (2013). "Responsible Mining: Case Studies in Global Best Practices" the conclusion underscores the significance of responsible mining practices for achieving sustainable outcomes in the mining sector. Through case studies highlighting global best practices, Bice emphasizes the importance of proactive environmental management, community engagement, and ethical governance in mining operations. The conclusion highlights the need for mining companies to prioritize social, environmental, and economic considerations, fostering positive relationships with local communities and minimizing negative impacts on ecosystems. Overall, the paper advocates for a holistic approach to responsible mining that integrates environmental stewardship, social responsibility, and economic viability to ensure long-term sustainability in the mining industry.

Moran, C.L. & Kunz, R.B. (2012). "Water Management in Mining: A Global Overview "provides a comprehensive review of water management practices within the mining industry worldwide. The paper delves into various aspects of water management, including water sourcing, usage, treatment, and discharge. Through an extensive analysis, the authors highlight the challenges faced by mining companies in managing water resources sustainably and the strategies employed to address these challenges.

The review discusses the environmental and social implications of mining-related water activities, emphasizing the importance of mitigating water-related impacts to safeguard

ecosystems and local communities. It also explores regulatory frameworks and industry standards governing water management practices in different regions, providing insights into emerging trends and best practices.

Overall, "Water Management in Mining: A Global Overview" offers valuable insights into the complex nexus of water and mining operations, shedding light on the importance of responsible water management for sustainable mining practices. The paper serves as a valuable resource for industry professionals, policymakers, and researchers seeking to enhance water management practices in the mining sector.

Nelson, M. R. (2014) "Energy Efficiency and Renewable Energy in Mining" The research examines the role of energy efficiency and renewable energy in promoting sustainable mining practices. It discusses technological innovations and best practices for reducing energy consumption and integrating renewable energy sources into mining operations, highlighting case studies of successful implementations.

Downing, T.E. (2011). "Mining and Climate Change: Best Practices for Mitigation and Adaptation" emphasizes the importance of proactive measures in the mining sector to address the challenges posed by climate change. The paper highlights the need for emission reduction strategies, adaptation measures, stakeholder engagement, policy advocacy, and research and innovation to mitigate the environmental impact of mining activities on climate change. By adopting these best practices, mining companies can enhance their resilience to climate-related risks while contributing to global efforts to combat climate change.

Govindan, B. et al. (2015). "Sustainable Supply Chain Management in Mining" underscores the critical role of sustainable practices in supply chain management within the mining industry. The paper advocates for the integration of environmental, social, and economic considerations throughout the supply chain to promote sustainability. Key recommendations include the adoption of green procurement practices, collaboration with suppliers to enhance transparency and compliance with sustainability standards, and the implementation of measures to mitigate environmental impacts and improve resource efficiency. Overall, the conclusion highlights the imperative for mining companies to prioritize sustainability in their supply chain operations to achieve long-term success and contribute positively to environmental and social outcomes.

Lahiri-Dutt, Kuntala (2012). "Gender and Mining: Best Practices for Promoting Gender Equality" which emphasizes the importance of adopting gender-sensitive approaches in the mining industry to promote gender equality. The paper underscores the need for mining companies to recognize and address the unique challenges faced by women in mining-affected communities, including access to employment, land rights, and participation in decision-making processes. Key recommendations include implementing gender mainstreaming policies, providing training and capacity-building programs for women, and fostering partnerships with local communities and civil society organizations to advance gender equality initiatives. Overall, the conclusion highlights the pivotal role of gender-responsive practices in fostering inclusive and sustainable development in the mining sector.

Fourie, L.A. & Brent, A. (2006). "Rehabilitation and Closure Planning in Mining" underscores the significance of robust rehabilitation and closure planning in the mining industry. The paper emphasizes the need for proactive measures to minimize environmental impacts and ensure the long-term sustainability of mining operations. Key recommendations include integrating rehabilitation considerations into mine planning processes, engaging stakeholders in closure planning activities, and establishing financial mechanisms to fund post-mining rehabilitation efforts. Overall, the conclusion emphasizes the importance of responsible mine closure practices to mitigate adverse environmental and social impacts and leave a positive legacy for future generations.

Vanclay, F. (2003), "Social Impact Assessment and Mining: Best Practices" highlights the critical importance of thorough social impact assessments (SIAs) in the mining sector. The paper advocates for integrating SIAs into the early stages of mining projects to identify and address potential social impacts proactively. Best practices include engaging with local communities, ensuring transparent communication, and incorporating feedback into decision-making processes. The conclusion emphasizes that effective SIAs can help mitigate negative social impacts, foster positive community relations, and contribute to the overall sustainability and social responsibility of mining operations.

Bennett, J.A. et al. (2000). "The Role of Environmental Management Systems in Sustainable Mining" the conclusion underscores the pivotal role that Environmental Management Systems (EMS) play in promoting sustainable mining practices. The paper concludes that EMS, when effectively implemented, can significantly reduce the

environmental impacts of mining operations. It emphasizes that EMS frameworks facilitate continuous improvement in environmental performance, ensure compliance with regulatory requirements, and enhance corporate accountability. The authors highlight that for EMS to be successful, commitment from top management and active participation from all levels of the organization are essential. The conclusion also stresses the importance of integrating EMS with broader sustainability goals and practices within the mining industry.

Hilson, G. (2002). "Artisanal and Small-Scale Mining: Challenges and Best Practices" the key issues addressed include the significant social, environmental, and economic challenges associated with artisanal and small-scale mining (ASM), such as poor working conditions, lack of regulatory oversight, and environmental degradation. Despite these challenges, ASM is economically vital, providing livelihoods for millions, especially in rural areas. The paper advocates for implementing best practices, including effective regulatory frameworks, formalization of ASM activities, and community engagement. It also emphasizes the importance of better environmental management, such as rehabilitation of mined areas and safer mining techniques, along with improved health and safety standards for miners. The conclusion highlights the necessity of a multifaceted approach that balances economic, social, and environmental considerations, calling for coordinated efforts and partnerships to promote sustainability in the ASM sector.

Boon, D.W. & Abbott, A. (2013). "Corporate Governance and Sustainable Mining" the authors explore the critical role of corporate governance in achieving sustainable mining practices. The paper highlights how robust governance frameworks can ensure accountability, transparency, and ethical decision-making within mining companies, which are essential for mitigating environmental impacts and fostering social responsibility. The authors emphasize the need for mining companies to integrate sustainability into their corporate strategies, involving stakeholders at all levels and adhering to international best practices and standards. They discuss the importance of board oversight, stakeholder engagement, and the implementation of environmental and social governance (ESG) metrics. The conclusion underscores that effective corporate governance is not just about compliance, but about proactively managing risks and opportunities to ensure long-term sustainability and creating value for both the company and the communities in which they operate.

Grigg, G. (2010). "Innovations in Waste Management for Sustainable Mining" explores recent advancements and best practices aimed at reducing the environmental impact of mining waste. The paper highlights key innovations such as bioremediation and phytoremediation, which utilize natural organisms and plants to detoxify waste. Additionally, it discusses the use of advanced monitoring systems for real-time tracking of waste materials and the adoption of circular economy principles to repurpose and recycle mining waste. Grigg emphasizes the importance of policy and regulatory frameworks in promoting these innovations, as well as the critical role of community involvement and transparent reporting. The conclusion underscores the potential for significant environmental and economic benefits through sustainable waste management practices, despite challenges such as initial costs and the need for skilled personnel.

Scoble, M.J. & Sinclair, H.K. (2008). "Best Practices for Sustainable Mining in Protected Areas" present strategies to minimize environmental impacts of mining in protected areas. They emphasize the necessity of stringent environmental impact assessments (EIA) to preserve biodiversity and ecosystems. The paper advocates for low-impact mining technologies and habitat restoration, highlighting the importance of community engagement to involve local and indigenous populations in decision-making. Adherence to international guidelines and robust monitoring for compliance are deemed crucial. The authors call for a balanced approach that combines economic development with natural resource conservation to achieve sustainability in protected areas.

Zhang, L.C. & Chen, Y.M. (2016). "Risk Management in Sustainable Mining" highlight the critical importance of identifying, assessing, and mitigating risks associated with mining activities to achieve sustainability. They emphasize the need for comprehensive risk assessments that include environmental, social, and economic factors. The paper discusses the implementation of advanced risk management frameworks and tools, which help in anticipating potential issues and developing proactive strategies. They also underscore the importance of continuous monitoring and adaptive management to respond to emerging risks. Community involvement and transparent communication are highlighted as essential components for successful risk management in sustainable mining operations.

Rowe, R.K. (2001). "Best Practices in Mine Tailings Management" emphasizing the necessity of implementing effective strategies to mitigate environmental risks associated

with mine tailings. The paper underscores the importance of proper design, construction, and maintenance of tailings storage facilities to prevent environmental contamination and minimize the potential for catastrophic failures. It discusses innovative technologies and management practices for tailings disposal, such as thickened tailings and dry stacking, to reduce water consumption and enhance safety. Additionally, the paper emphasizes the need for ongoing monitoring and remediation to address long-term environmental impacts and ensure compliance with regulatory requirements.

George, S.B. (2018). "Public Participation in Sustainable Mining" emphasizing the crucial role of stakeholders in decision-making processes related to mining activities. The paper discusses the importance of transparency, inclusivity, and meaningful engagement to build trust and foster collaboration between mining companies, local communities, and other stakeholders. It highlights best practices for facilitating public participation, such as conducting public consultations, establishing grievance mechanisms, and incorporating traditional knowledge and indigenous perspectives into decision-making processes. Additionally, the paper underscores the benefits of public participation in promoting social license to operate and enhancing the overall sustainability of mining projects.

Clarke, M.L. (2014). "Sustainable Practices in Offshore Mining" emphasizing the need for responsible environmental stewardship in offshore mining operations. The paper discusses best practices for minimizing ecological impacts, including the use of advanced technology to reduce disturbance to marine ecosystems and the implementation of stringent monitoring and mitigation measures. It also highlights the importance of stakeholder engagement and regulatory compliance in ensuring sustainable offshore mining practices. Additionally, the paper discusses the potential benefits and challenges associated with offshore mining and calls for a balanced approach that considers both environmental protection and resource extraction needs.

Gibson, R. (2011). "The Role of Environmental Impact Statements in Sustainable Mining" underscoring their significance in assessing and mitigating the environmental effects of mining projects. The paper emphasizes the necessity of comprehensive environmental impact assessments (EIAs) to identify potential risks and develop appropriate management strategies. It also discusses the importance of transparency and stakeholder engagement in the EIA process, promoting accountability and fostering community trust. Additionally, the paper explores the evolving regulatory landscape

surrounding EIAs and suggests ways to enhance their effectiveness in supporting sustainable mining practices.

Otto, J.M. (2007). "Sustainable Land Use Planning for Mining Regions" offering insights into strategies to manage land use in areas affected by mining activities. The paper emphasizes the need for integrated land use planning processes that balance economic development with environmental conservation and community well-being. It highlights the importance of stakeholder engagement and participatory decision-making in crafting sustainable land use plans tailored to local contexts. Additionally, the paper discusses innovative approaches such as land reclamation and restoration to mitigate the impacts of mining on ecosystems and biodiversity.

Amponsah, J. et al. (2013). "Health and Safety Best Practices in Sustainable Mining" advocating for comprehensive approaches to ensure the well-being of workers and communities in mining operations. The paper underscores the importance of stringent safety regulations and protocols to prevent accidents and occupational hazards. It emphasizes the implementation of robust health and safety management systems, including regular risk assessments, training programs, and the provision of personal protective equipment. Furthermore, the authors stress the need for proactive measures to address emerging health challenges associated with mining, such as exposure to hazardous substances and respiratory illnesses. They highlight the role of technology in enhancing safety practices and emergency response capabilities. Overall, the paper underscores the imperative of prioritizing health and safety considerations to foster sustainable mining practices.

Richards M.K. et al. (2012). "Best Practices in Sustainable Mining for Water Resource Protection" emphasizing strategies to safeguard water resources in mining operations. The paper underscores the importance of comprehensive water management plans to mitigate contamination and depletion risks. It advocates for the implementation of advanced technologies for water treatment and recycling to minimize freshwater consumption and reduce discharge of pollutants into aquatic ecosystems. Furthermore, the authors stress the need for proactive monitoring and assessment of water quality to ensure compliance with regulatory standards and protect ecosystem health. Community engagement is highlighted as crucial for addressing local concerns and integrating traditional ecological knowledge into water management practices. Overall, the paper

emphasizes the significance of adopting holistic approaches that balance mining activities with water resource protection to achieve sustainability.

Corder, G.J. et al. (2010). "Achieving Sustainable Mining through Integrated Resource Management" advocating for holistic approaches to manage resources effectively. They emphasize the integration of environmental, social, and economic considerations into mining practices. The paper highlights the importance of stakeholder engagement and collaboration in decision-making processes to ensure transparency and accountability. Additionally, it underscores the necessity of implementing innovative technologies and best management practices to minimize environmental impacts and promote resource conservation. The authors stress the role of regulatory frameworks in providing guidance and oversight to support sustainable mining initiatives. Overall, the paper underscores the significance of integrated resource management strategies in achieving long-term sustainability in the mining sector.

Baker, A.J. et al. (2018). "Environmental Stewardship in Sustainable Mining" emphasizing the crucial role of responsible environmental management in mining operations. They advocate for proactive measures to minimize ecological footprints and mitigate adverse impacts on surrounding ecosystems. The paper underscores the importance of adopting sustainable practices such as reclamation and rehabilitation to restore disturbed areas post-mining. Furthermore, it discusses the significance of monitoring and compliance with environmental regulations to ensure adherence to sustainability standards. The authors highlight the need for industry-wide collaboration and engagement with stakeholders to foster a culture of environmental stewardship in the mining sector. Overall, the paper provides insights into the principles and practices of environmental stewardship essential for achieving sustainability in mining operations.

Environment & Socio-economic Impacts of opencast mining-

Srivastava, P.K., Joshi, G., Tripathi, N., & Bajpai, S. (2018) present a meticulous examination of the environmental impacts stemming from mining activities, specifically focusing on the Jhansi open-cast mining site in Uttar Pradesh, India. Through a rigorous case study approach, the researchers delve into the intricacies of environmental

challenges triggered by open-cast mining operations, offering profound insights into the site's unique characteristics and resulting impacts. Their multi-dimensional analysis encompasses various facets such as air and water quality, soil degradation, and alterations in land use patterns, providing a comprehensive understanding of how mining activities alter the environmental landscape. Leveraging empirical data and employing robust environmental monitoring and assessment techniques, the study ensures the credibility and reliability of its findings. Importantly, the research underscores the policy implications of its findings, advocating for the implementation of effective environmental management strategies and regulatory measures to mitigate the adverse impacts of mining activities not only in the Jhansi region but also in similar mining sites across India.

Tiwary, R.K., & Chakraborty, S. (2014) offer a profound exploration into the environmental repercussions of coal mining activities, with a particular focus on their influence on the water regime. Their study delves deep into the intricate interactions between coal mining and water resources, shedding light on the various ways in which mining operations disrupt the natural hydrological cycle and compromise water quality. Through meticulous empirical research and data analysis, the researchers unveil the extent of degradation inflicted upon water bodies in coal mining regions, elucidating phenomena such as groundwater depletion, contamination, and altered flow patterns. Furthermore, the study delves into the complexities of water management in coal mining areas, proposing strategies to mitigate the adverse impacts and restore ecological balance. By elucidating the intricate nexus between coal mining and water resources, Tiwary and Chakraborty advocate for informed decision-making and proactive measures aimed at safeguarding water ecosystems from the detrimental effects of coal mining activities.

Chatterjee, S., Bhatt, M.A., and Singh, A.K. (2018) conducted a comprehensive assessment of the air and water quality in the Singrauli and Sonbhadra districts, focusing on the impacts of coal mining activities. Their study, published in "Sustain," utilized various indices to evaluate environmental conditions, revealing significant degradation in both air and water quality due to extensive mining operations. The findings highlight the urgent need for improved regulatory measures and sustainable mining practices to mitigate the adverse environmental effects. The authors advocate for enhanced monitoring, stricter enforcement of environmental regulations, and the adoption of cleaner technologies to ensure the long-term sustainability of these mining regions.

In 2017 paper, "Environmental and Socio-economic Impacts of Mining on Local Livelihoods in India: A Case Study," published in *Economic Geography*, Singh, R.B., and Singh, A. explore the multifaceted impacts of mining activities on local communities. The study reveals that while mining contributes significantly to economic growth and provides employment opportunities, it also leads to severe environmental degradation and socio-economic challenges. The adverse effects include pollution, displacement, and health hazards, which disproportionately affect vulnerable populations. The authors emphasize the need for a balanced approach that integrates economic development with environmental conservation and social well-being. They recommend robust policy frameworks, community engagement, and sustainable mining practices to mitigate negative impacts and enhance the positive contributions of mining to local livelihoods.

"Environmental Impact Assessment of Coal Mining: Indian Scenario," published in Environmental Monitoring and Assessment, Choudhury, S., Banerjee, P., and Ghose, M.K. (2014) provide a detailed examination of the environmental impacts associated with coal mining in India. The study highlights significant issues such as deforestation, soil erosion, water pollution, and air quality degradation due to mining activities. The authors emphasize the importance of comprehensive Environmental Impact Assessments (EIAs) to identify, manage, and mitigate these adverse effects. They conclude that integrating effective environmental management practices and regulatory frameworks is crucial for minimizing the ecological footprint of coal mining and promoting sustainable development in the region.

In paper, "Land Use/Land Cover Changes in the Mining Areas of Singrauli, India Using Remote Sensing and GIS," published in International Journal of Remote Sensing, Ghose, M.K., Majee, S.R., and Ghose, M.K. (2004) & Ghose, M.K., & Majee, S.R. (2000). explore the alterations in land use and land cover caused by extensive mining activities in Singrauli, India. Utilizing remote sensing and GIS technologies, the study reveals significant changes in the landscape, including deforestation, loss of agricultural land, and increased barren areas. The authors conclude that these land use changes have substantial environmental and socio-economic impacts, highlighting the urgent need for sustainable land management practices and robust environmental monitoring to mitigate the adverse effects of mining and promote balanced regional development.

Tiwary and Kumar (2014) in their paper "Assessment of Environmental Impacts Due to Opencast Mining Activities in Mand-Raigarh Coalfield, Chhattisgarh, India," published in Journal of Mining Science, conclude that opencast mining in the Mand-Raigarh coalfield has led to significant environmental degradation, including air and water pollution, soil erosion, and biodiversity loss. The study underscores the necessity for improved mining practices and stringent environmental regulations to mitigate these impacts and promote sustainable development in the region.

Jha, Jha, Roy, and Singh (2009) in their paper "Environmental Impact Assessment of Manganese Mines in Balaghat District, Madhya Pradesh, India," conclude that manganese mining activities in the Balaghat district have caused notable environmental degradation. This includes significant impacts on air and water quality, soil health, and local biodiversity. The study highlights the urgent need for implementing effective environmental management practices to mitigate these adverse effects and ensure sustainable mining operations.

Kaushik, Kaushik, Kumar, and Singh (2014) in their paper "Assessment of Impact of Manganese and Zinc on Soil Microbial Parameters and Diversity in Mines Spoil of Madhya Pradesh, India," conclude that mining activities significantly alter soil microbial parameters and reduce microbial diversity. The study emphasizes the detrimental effects of manganese and zinc contamination on soil health, underscoring the need for remediation strategies to restore microbial diversity and promote sustainable land use in mining areas.

In 2004, study on "Environmental Impact of Coal and Limestone Mining at Various Locations in Singrauli District, Madhya Pradesh, India, and Its Effect on Vegetation," S. Kurl concludes that mining activities have a significant negative impact on local vegetation. The research highlights the extensive environmental degradation caused by coal and limestone mining, resulting in reduced vegetation cover and biodiversity in the affected areas.

The study "Assessment of Groundwater Inflows into Kuteshwar Limestone Mines through Flow Modeling Study, Madhya Pradesh, India" by P. Purohit, V.K. Singh, and N. Guria (2017) utilizes flow modelling techniques to analyse groundwater inflows into the Kuteshwar limestone mines. The literature highlights the significance of

understanding hydrogeological conditions to manage water resources effectively in mining areas. Previous research emphasizes the challenges of groundwater inflow in limestone mining and the necessity for precise modelling to predict and mitigate potential water-related issues. This study contributes to existing knowledge by providing a detailed flow model, aiding in the sustainable management of groundwater in the mining region.

The paper by Sengupta et al. (2015) examines heavy metal contamination in soils due to mining in parts of Madhya Pradesh, India. It emphasizes the environmental risks associated with mining activities and highlights the need for monitoring and remediation efforts to mitigate soil contamination.

The study conducted by Guria and Singh (2015) focuses on assessing the Water Quality Index (WQI) of surface water bodies impacted by coal mining in the Singrauli Industrial Belt, Madhya Pradesh, India. It underscores the deteriorating water quality in mining-affected areas and underscores the importance of effective water management strategies to address environmental concerns.

Wang and Chen (2014) conducted a comparative study on the Environmental Impact Assessment (EIA) of mining operations using Life Cycle Assessment (LCA). The research delves into the comprehensive evaluation of environmental impacts throughout the entire life cycle of mining activities. It highlights the significance of LCA as a tool for assessing the environmental footprint of mining operations and emphasizes the need for sustainable practices to mitigate adverse effects. The study contributes to the understanding of environmental management in the mining sector, aiming to foster more sustainable approaches to resource extraction.

Lee and Patel (2019) conducted a literature review on the Life Cycle Assessment (LCA) of manganese mining, focusing on environmental impacts and mitigation strategies. The study evaluates the environmental footprint of manganese mining operations across different stages of the life cycle, including extraction, processing, transportation, and disposal. It highlights the various environmental impacts associated with manganese mining, such as land degradation, water pollution, and greenhouse gas emissions. The research also identifies mitigation strategies to minimize these impacts, including technological innovations, best management practices, and regulatory interventions. By synthesizing existing knowledge, the study provides insights into the environmental

sustainability of manganese mining and suggests avenues for future research and policy development.

Guria and Singh (2016) conducted a study on the assessment of heavy metal pollution in drinking water from various sources in the Singrauli Industrial Region of Madhya Pradesh, India. The research aimed to evaluate the levels of heavy metals, such as lead, cadmium, arsenic, and mercury, in water samples collected from different sources, including groundwater, surface water, and reservoirs. The study employed analytical techniques to measure heavy metal concentrations and assess their potential health risks to the local population. The findings of the study provide valuable insights into the extent of heavy metal pollution in drinking water sources in the Singrauli Industrial Region, highlighting the need for effective management strategies to mitigate the adverse health effects associated with heavy metal contamination.

Tiwari's (2015) study on the impact of manganese mining on biodiversity in Madhya Pradesh, India, sheds light on the ecological consequences of mining activities in the region. Through field surveys, data analysis, and ecological assessments, the research underscores the significant disruption of local ecosystems caused by manganese mining operations. The study highlights the loss of biodiversity, habitat fragmentation, and degradation of ecosystem services due to mining-related activities such as deforestation, land clearing, and soil contamination. These findings underscore the urgent need for sustainable mining practices and conservation efforts to mitigate the adverse effects of manganese mining on biodiversity in Madhya Pradesh.

Singh, Rakesh (2016). study on the socio-economic effects of manganese mining in Madhya Pradesh, the research sheds light on the significant impacts on local communities and livelihoods. It underscores the importance of understanding the social and economic dynamics within mining regions. Singh's findings highlight the need for proactive measures to address the challenges faced by affected communities, ensuring equitable development and mitigating adverse socio-economic consequences. Overall, the study emphasizes the importance of holistic approaches to manganese mining that prioritize the well-being of local populations and promote sustainable socio-economic development in mining regions.

Patel, Priyanka (2017). "Health Impacts of Manganese Mining in Madhya Pradesh" the

findings illuminate a concerning scenario. The research underscores the profound health risks faced by communities residing in close proximity to mining operations, with elevated levels of manganese exposure being a primary concern. The conclusion emphasizes the urgent need for robust health assessments, intervention strategies, and healthcare provisions to mitigate the adverse effects on local populations. Patel's study underscores the imperative of prioritizing public health considerations in mining practices and advocates for proactive measures to safeguard the well-being of affected communities.

Kumar, Anil (2019). “Regulatory Framework for Manganese Mining in Madhya Pradesh" highlights the complexities and challenges faced in governing the industry. It underscores the need for stringent oversight to ensure environmental protection and worker safety. The research emphasizes the importance of refining regulations, enhancing transparency, and promoting stakeholder engagement to address evolving needs and concerns. Ultimately, effective regulation is crucial for promoting responsible mining practices and balancing economic development with environmental conservation in the region.

Singh, Prakash (2019). “Role of Technology in Sustainable Manganese Mining in Madhya Pradesh" Through innovative solutions like automation and remote sensing, the industry can mitigate environmental impacts, optimize resource usage, and enhance worker safety. This underscores the importance of continual investment in research and development for tailored technological advancements, aligning mining activities with sustainability goals and ensuring long-term socio-economic benefits for the region.

Kumar, Mohit (2018). "Challenges and Opportunities in Manganese Mining: A Case Study of Madhya Pradesh" addressing issues such as environmental degradation, socio-economic impacts, and regulatory compliance, the industry can unlock its potential for sustainable growth. Through proactive measures like community engagement, technological innovation, and effective governance frameworks, stakeholders can capitalize on the opportunities presented by manganese mining while mitigating its adverse effects. This underscores the need for a holistic approach that balances economic development with environmental and social responsibility, ensuring a brighter future for both the industry and local communities.

Verma, Rahul (2018). “Community Engagement in Manganese Mining: A Case Study in Madhya Pradesh" By actively involving local stakeholders in decision-making processes and addressing their concerns, the industry can foster mutual trust and cooperation. This approach not only enhances social acceptance but also promotes sustainable development by ensuring that the benefits of mining are shared equitably among all stakeholders.

George, S.B. (2018). “Public Participation in Manganese Mining" By involving the community in decision-making processes and fostering open dialogue, the mining industry can build trust and collaboration. This engagement promotes transparency, addresses concerns, and ultimately contributes to sustainable mining practices.

Sharma, M. & Sharma, R. (2019). “Socio-Economic Impact of Mining Activities: A Case Study of Rampura Agucha Zinc Mine in Rajasthan, India" underscore the substantial socio-economic impact of mining activities on local communities. Through detailed analysis, they highlight the positive and negative ramifications of mining operations, including job creation, infrastructure development, and environmental concerns. The conclusion emphasizes the necessity of implementing effective mitigation measures to address the adverse effects while maximizing the benefits to ensure sustainable development in mining regions.

Srivastava, Pandey & Shrivastava (2012). "Heavy Metal Pollution in Soils of a Manganese Mine in Madhya Pradesh, India" conducted a comprehensive review of heavy metal pollution in soils within a manganese mine located in Madhya Pradesh, India. The literature review encompasses various studies and findings related to the presence and distribution of heavy metals in soil ecosystems affected by mining activities. By synthesizing existing knowledge, the authors aimed to provide insights into the extent of contamination, potential sources, and ecological implications of heavy metal pollution in the context of manganese mining in the region. Their review serves as a valuable resource for understanding the environmental challenges posed by mining operations and informing future research directions aimed at mitigating soil contamination and preserving ecosystem health.

Suganya, Saravanan, Raja, and Manivasagam (2018) conducted a comparative analysis of environmental impact assessments (EIAs) of mining activities in Goa, India. The study aimed to evaluate different methodological approaches used in EIAs and their

effectiveness in assessing the environmental impacts of mining operations. By comparing various EIA methodologies, the authors shed light on the strengths and limitations of existing practices and proposed recommendations for improving the accuracy and comprehensiveness of impact assessments. The research provides valuable insights into the challenges associated with EIA implementation in the context of mining activities and offers practical guidelines for enhancing the effectiveness of environmental management practices in mining regions. Overall, this study contributes to the ongoing discourse on sustainable mining practices by highlighting the importance of robust EIA frameworks in mitigating adverse environmental impacts and promoting responsible resource extraction.

Mohapatra, Mishra, and Satpathy (2017) conducted a life cycle assessment (LCA) of iron ore mining and processing operations. The research aimed to comprehensively evaluate the environmental impacts associated with various stages of iron ore extraction and processing, from mining to transportation and beneficiation. Through the LCA approach, the authors quantified the energy consumption, greenhouse gas emissions, water usage, and other environmental indicators throughout the entire life cycle of iron ore production. Their findings revealed the significant environmental burdens of iron ore mining and processing activities, particularly in terms of energy consumption and emissions of pollutants. The study identified key hotspots in the life cycle of iron ore production, highlighting areas where mitigation measures could be implemented to reduce environmental impacts. Additionally, the researchers compared different mining and processing techniques to assess their environmental performance and identified opportunities for improving sustainability in the iron ore sector. Overall, the study provides valuable insights into the environmental implications of iron ore mining and processing operations, offering guidance for industry stakeholders and policymakers to adopt more sustainable practices. By integrating LCA methodologies, the research contributes to a better understanding of the environmental footprint of iron ore production and lays the foundation for informed decision-making aimed at minimizing environmental degradation and promoting sustainable resource management.

Regulatory Frameworks and Policies related to Sustainable mining-

Although the LCA technique has been used to assess environmental impacts associated with various production processes of the mining industry since the end of the last century (Hake et al., 1998; Azapagic and Clift, 1999; Guo et al., 2002; Valderrama et al., 2012), its use in the evaluation of mining processes and processing of mineral resources is still very limited (Durucan et al., 2006), which is in part due to the difficulty of quantifying the various inputs and outputs involved (Norgate et al., 2007).

Moreover, as each ore corresponds to specific geological, exploitation and processing conditions, environmental impacts are different for each mineral good extracted, requiring specific studies for each case (Norgate and Haque, 2010). This is particularly true for operations with iron ore, where existing studies show the mining processes reduced to a step within the steel production system (Li et al., 2002; Norgate et al., 2007; Bieda, 2012).

For Mining applications, there are few studies of LCA to specific mining systems (Awuah-Offei and Adekpedjou, 2011; Blengini et al., 2012.). Among these, those related to coal production in the USA (Ditsele, 2010; Ditsele and Awuah-Offei, 2012) and South Africa (Mangena and Brent, 2006); bauxite in the USA (Durucan et al., 2006) and in Australia (Norgate and Haque, 2010); Copper in 11 countries in South and North America, Asia and Oceania (Northey et al., 2013.); red clay in Spain (Bovea et al., 2007); and gold in Australia, North America, Africa and Asia (Mudd, 2007) stand out.

The study by Norgate and Haque (2010) presented results of the application of Life Cycle Assessment in an iron mine; however, focusing its analysis on impacts related to water and energy consumption and emissions related to global warming. Seeking to fill this gap, this study evaluated the effect of mining activities and cradle-to-gate iron ore processing in a mine in Brazil. To this end, water use, land use, energy consumption and use of key inputs were evaluated. The following categories of impacts were also quantified: damage to human health; loss of ecosystem quality; abiotic resources depletion and climate changes.

Brundtland Committee Report, was the first initiative to define sustainable development as 'development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs' (WCED, 1987). In 1992, the United Nations, introduced to the world the concept of sustainable development. Viederman (1994) defined sustainability 'as a participatory process that makes prudent use of all its resources, which include natural, human and social capital'.

Sustainable mining has been defined by (Tilton 2009) as an oxymoron, since mining depends on non-renewable and depleting mineral resources and, by its very nature, is unsustainable. The basic problem of mining sustainability is that the contribution of mineral development to the regional development is not always commensurate with the huge investment in the mining projects. The key to ensuring sustainability at the local level is an integrated approach for mineral development along with socio economic development of the region (National Mineral Policy, 2008).

The Mining, Mineral and Sustainable Development (MMSD, 2002) report highlights the importance of addressing sustainability issues throughout the lifecycle of a mining project, emphasizing equitable sharing of benefits and resolution of key issues before closure. ICMM Best Practices offer detailed guidance for sustainable mining, focusing on exploration, site design, operations, and closure. Sustainable development, as defined by the Brundtland Commission, integrates environmental, economic, and social considerations to meet present needs without compromising future generations. Successful projects emphasize mutual rights and responsibilities, capacity building, partnership, transparent benefit calculation, and community involvement.

UNDP in the year 2018 published a document 'Managing mining for sustainable development; as a part of its Poverty-Environment Initiative in the Asia-Pacific region of UNDP and UN Environment enumerated steps taken in this sector. According to Carvalho (2017) the current mining activities need to reinforce procedures for protection of environment and public health, as it is today easier to see that mining usually brings into the biosphere large amounts of non-targeted chemical elements often with toxic properties to the environment and humans (e.g. radio-elements and toxic metals) and previously neglected.

Rahnema et el (2023) have detailed about the role of Mine Planning in studying the mitigation of environmental impacts. For the purpose of considering the environmental footprint in mine planning, Figure 1, presents the environmental impacts and mine planning and brought in ;Life Cycle Analysis' approach. Xu et al. (2014) incorporated the ecological costs in a pit optimization algorithm to evaluate their influence on outcome, on a case study of an Iron Ore Mine o f China.Moradi and Osanloo (2015) quantified and prioritized SD criteria affecting open pit mine design using DEA model

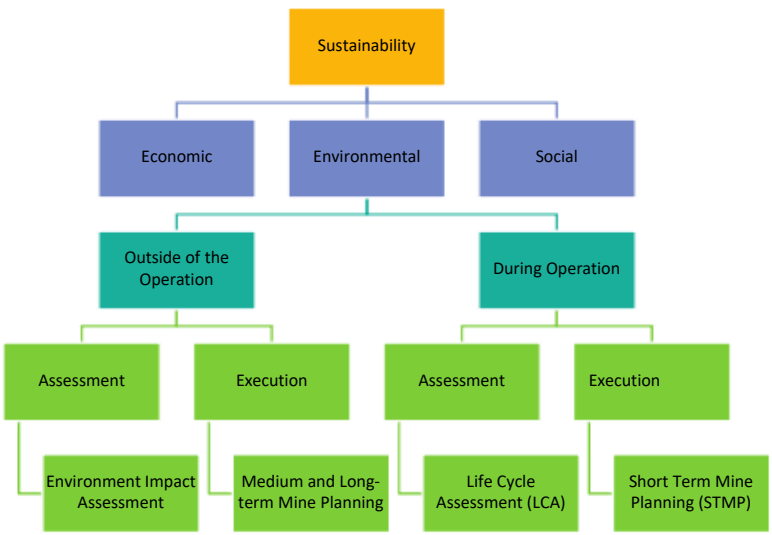


Figure 1, Presents the environmental impacts and mine planning and brought in Life Cycle Analysis' approach (After Xu et al. 2014)

Rodriguezm and Rozgonyi (2004) highlighted the role of the cut-off grade using Lane algorithm by applying the cost of reconstruction on sustainable development of a mine. Rashidinejad et al. (2008), Osanloo et al. (2008), Narrei and Osanloo (2015) and Rahimi and Ghasemzadeh (2015) presented an environmental oriented model for optimum cut-off grades. Gholamnejad (2008) inserted the rehabilitation cost directly into the process of cut-off grade optimization using Lane's theory.

Odell (2004) case study Peru Antamina mine in the Peruvian Andes. Assessed different scenarios of mine design based on mine life by integrating the social, environmental and organizational criteria with conventional criteria of geology, engineering and economics Social-environmental impacts.

Munoz et al. (2014) case study of Chile Chilean copper mining. Developed a methodology to minimize social-environmental impacts in the early stages of mine design/ Adibi and Ataeepour (2015) working on the iron ore deposit in the Jalalabad (Iran) developed a model based on SD indicators to consider the economic and social benefits and the negative environmental impacts.

Advancements in Sustainable Development Research for Production Planning-

Burgher and Erickson (1984) integrated reclamation costs into coal mine production optimization using Linear Programming. Caccetta and Kelsey (2001) employed mixed integer programming to optimize waste block removal systems, aiming for reduced mining costs. Ersan et al. (2003) discussed eco-based strategic mine planning practices to tackle environmental challenges like Acid Mine Drainage (AMD) generation. Roumpos and Papacost (2013) developed a sustainability-focused framework for strategic mine planning, illustrated with a case study of Greece's Mavropigi lignite mine. Badiozamani and Askari-Nasab (2014) proposed a MILP model to maximize NPV in an oil sands mine, integrating reclamation costs. Masoumi et al. (2014) used fuzzy TOPSIS and fuzzy AHP to rank Priority Mining Land Use (PMLU) in an Iranian surface coal mine. Anawar (2015) reviewed sustainable rehabilitation of mining waste and AMD based on various factors. Adibi et al. (2015) and Rahmanpour and Osanloo (2016) introduced a procedure for selecting "UPL" based on Sustainable Development (SD), focusing on Iran's Sungun copper deposit.

Sustainable Supply Chain Management (SSCM)-

Jia, Peng et al. (2015) employed Interpretive Structural Modeling (ISM) to identify and prioritize sustainable supply chain management (SSCM) practices in the Indian mining and mineral industries. Their study, conducted across 15 mining and mineral companies, revealed that suppliers' ISO14000 certification significantly influences sustainability performance. The findings underscore the importance of environmental management certification in driving sustainability in these industries.

This research addresses the challenges faced by Indian mining and mineral industries in implementing SSCM practices by identifying key motivating factors among 25 recommended practices. The study highlights the awareness of Analytic Hierarchy Process (AHP) for evaluating competitive priorities and suggests its use as procedural guidance for green supply chain management (GSCM) implementation. Additionally, Shen, L. et al. (2015) identified areas of weakness in GSCM practice within the Indian

mining sector, emphasizing the need for focus on appropriate implementation approaches and continuous improvement to enhance overall performance.

Progress Towards Sustainable Development in the Indian Mining Sector -

Studies by Mohanty and Goyal (2012) under the Planning Commission of India (now Niti Ayog) have initiated efforts towards sustainable development in the mining sector. Daizy and Das (2014) highlight positive trends in the Indian mining industry, emphasizing the adoption of principles that balance economic, social, and environmental well-being. Recent policy developments, government regulations, and industry practices are aligning with these principles, encouraging reporting efforts.

Lodhia (Editor) (2018) provides insights into contemporary issues surrounding mining and sustainable development. The papers address various topics including the changing role of minerals in society, social acceptance of mining, due diligence in the industry, and critical debates such as mining's impact on indigenous peoples. Bagri et al. (2022) specifically analyze the coal industry, evaluating its strengths, weaknesses, opportunities, and threats concerning sustainable development in India.

Progress in Sustainable Mining Practices in India-

The National Mineral Policy of 1993 provided the initial legal framework for the mining sector in India, which was further revised in 2008 to emphasize sustainable mining practices. The 2008 policy highlighted the need to preserve mineral reserves and optimize natural resource utilization within a comprehensive Sustainable Development Framework. It introduced guiding principles for effective mine closure and ecological rehabilitation.

ESG Ratings:

ESG ratings assess companies' management performance in environmental, social, and governance factors. They help investors and stakeholders understand ESG risks and opportunities associated with a company's operations. ESG scores consider various factors like environmental impact, social responsibility, and corporate governance practices. Companies with top ESG scores demonstrate leadership and responsible business conduct, while those with lower scores may indicate areas for improvement.

Sustainability Development Framework (SDF):

SDF for mining regions focuses on sustainability issues throughout the mine life cycle and post-closure. The Ministry of Mines, along with the Indian Bureau of Mines, initiated the rollout of SDF in mining companies, with specific events held in 2016. Recent developments include the incorporation of a dedicated chapter on Sustainable Development in MCDR 2017. Studies by Kale & Sharma (2020) and Kale et al. (2023) discuss the central government's efforts towards sustainability, while Mishra and Ganguly (2019) explore legal frameworks, technologies, and best practices for sustainable mining in India.

In 2016, the Ministry of Environment, Forest and Climate Change (MoEFCC) issued Sustainable Sand Mining Management Guidelines with several objectives:

- Ensure environmentally sustainable and socially responsible sand and gravel mining.
- Ensure availability of adequate aggregate quantity sustainably.
- Improve monitoring effectiveness of mining and transportation activities.
- Conserve river equilibrium and natural environment, preventing aggradation and erosion.
- Protect rivers from obstruction and pollution, maintaining water quality and groundwater reserves.
- Prevent groundwater pollution by prohibiting mining on fissures acting as filters.
- Maintain river equilibrium through sediment transport principles.
- Streamline and simplify the environmental clearance process for sustainable mining practices.

Antony & Jayaram (2019) emphasized the importance of Life Cycle Assessment (LCA) in assessing sustainability performance holistically, from raw material extraction to end-of-life disposal. LCA considers all environmental impacts throughout the product or service life cycle, aiding in the development of more scientific solutions to sustainability challenges. Ditsele (2010) applied LCA to estimate environmental impacts of surface coal mining, while Erkayaoğlu (2021) used LCA for the evaluation of off-highway trucks and belt conveyors. Haque (2023) discussed techno-economic evaluation and LCA methodologies for decarbonization in mining industries. Zhang et al. (2021) presented a dynamic model based on Life Cycle Sustainability Assessment (LCSA) theory to evaluate water utilization efficiency in large coal mining areas. Vapur (2020) conducted an LCA of aggregate production in Algeria, comparing environmental impacts across different

quarries. Mishra et al. (2023) assessed the sustainability of coal mine overburden sand versus river sand using a triple bottom line approach, providing insights for decision-makers in resource planning and ecology.

The National Mineral Policy of 2019 emphasizes sustainable mining practices, incorporating principles of the public trust doctrine and inter-generational equity. It designates the State as the trustee of natural resources on behalf of the people, aiming to ensure environmentally responsible mining while considering social and economic aspects. Changes made from 2017 to 2023 have been integrated into these rules. Mukhopadhyay (2016) provided an overview of the Indian mining sector, while Jakati (2023) reported on the sustainable growth of the mining industry in Goa, highlighting its detrimental effects on society and the environment. The Indian Council of Forestry Research and Education (ICFRE) submitted a Management Plan for Sustainable Mining (MPSM) and delineated mining zones and conservation areas in Jharkhand in compliance with the Action Taken report on illegal mining by the Justice M. B. Shah Commission of Inquiry.

The Centre for Social and Economic Progress (CSEP) has developed the Sustainable Mining Attractiveness Index for Jharkhand, offering stakeholders insights into mineral resources-led development potential. It assesses factors influencing mining investments and proposes policy actions for sustainable mining jurisdictions. The index evaluates districts based on five pillars: mining potential and performance, socio-economic status, policy and governance, infrastructure, and environment. Districts receive a final score and rank based on the average of these pillar scores.

The Samatha Judgement on Sustainable Development Framework (SDF), issued by the Ministry of Mines in 2011, mandates local participation in mining activities in tribal areas and allocation of 20% of net profits for community development. The Hoda Commission recommended incorporating global sustainable development trends into mining practices and establishing a framework to objectively measure mining sector sustainability.

Various studies have explored the environmental and health impacts of manganese mining in India. Shome (2020) examined sustainability issues in opencast manganese mines in Odisha, focusing on health hazards and environmental disturbances. The

research found elevated levels of manganese and associated salts in water, leading to health risks for mine workers and local inhabitants. Soil analysis revealed nutrient loss, emphasizing the need for eco-friendly mining practices. Similarly, Goswami et al. (2009) assessed the environmental impact of manganese mining at the Dubna opencast mine in Keonjhar District, Odisha. Their study highlighted contamination of water with manganese and associated salts, posing health hazards and causing nutrient depletion in soil. Recommendations were made for adopting eco-friendly mining technologies to mitigate occupational health risks.

Transitioning to Sustainable Open-Pit Mining: A Comprehensive Approach-

Transitioning from open-pit to underground mining is a significant step towards sustainable mining practices in India, with notable examples like Malanjkhand and Rampura Agucha mines. Rakhmangulov et al. (2021) have explored the complexities involved in this transition, considering factors such as geology, economics, and safety. The sustainable development framework plays a crucial role in ensuring a smooth transition, balancing economic, social, and environmental viability.

The conversion from open-pit to underground mining has been exemplified by the Palabora Mines in South Africa, as studied by Calder et al. (2000). Despite economic and social challenges, the transition has yielded positive outcomes. Production levels have been sustained, providing employment opportunities and contributing significantly to the local economy. Investments in social initiatives have continued, fostering community development and mitigating the adverse impacts of mine closure. Strategic environmental assessment (SEA) is identified as a vital tool for achieving sustainable mining practices, as explained by Iyer (2017). It enables the identification and mitigation of environmental and sustainable effects, guiding decision-making towards responsible mining. Meanwhile, Upadhyay (2022) highlights the importance of organizational factors in driving sustainable mining waste management practices, emphasizing the need for socio-political and financial considerations.

Chadha and Kapoor (2021) shed light on mining court cases illustrating poor implementation of environmental laws and the necessity for balancing mining growth with community benefits and environmental protection. Mapping linkages between mining and the Sustainable Development Goals (SDGs) aims to align mining operations with global sustainability objectives, fostering partnerships between stakeholders for impactful outcomes.

Waste management in the mining industry emerges as a critical issue, particularly with the projected increase in ore production. Deshpande and Shekdar (2005) and Upadhyay (2022) delve into the complexities of waste management, stressing the importance of sustainable practices amidst rising production demands.

The adoption of life cycle assessment (LCA) methodologies in mining, popularized by Farjana et al. (2021), offers a systematic approach to evaluating sustainability metrics and identifying areas for improvement. By addressing sustainability challenges through LCA, the mining sector can advance towards reduced emissions and improved resource utilization.

Despite challenges, efforts to address sand mining issues in India are underway, with Mishra et al. (2023) proposing the use of coal mine overburden as an alternative to river sand in the production of M-Sand, aiming to alleviate environmental pressures associated with sand extraction.

Gaps in Sustainable development of opencast mining in Madhya Pradesh-

Identifying gaps for the sustainable development of opencast manganese mining in Madhya Pradesh involves understanding areas where current practices or policies may fall short in achieving long-term environmental, social, and economic sustainability. Some potential gaps could include:

1. **Environmental Impact Assessment (EIA)**
2. **Rehabilitation and Reclamation**
3. **Community Engagement**
4. **Monitoring and Enforcement**
5. **Water Management**
6. **Health and Safety**
7. **Biodiversity Conservation**
8. **Technology Adoption**

Addressing these gaps would require comprehensive strategies, including strengthening regulatory frameworks, enhancing community engagement, improving environmental monitoring and enforcement, promoting sustainable rehabilitation practices, and fostering technological innovation in mining operations.

Chapter-3
Methodology

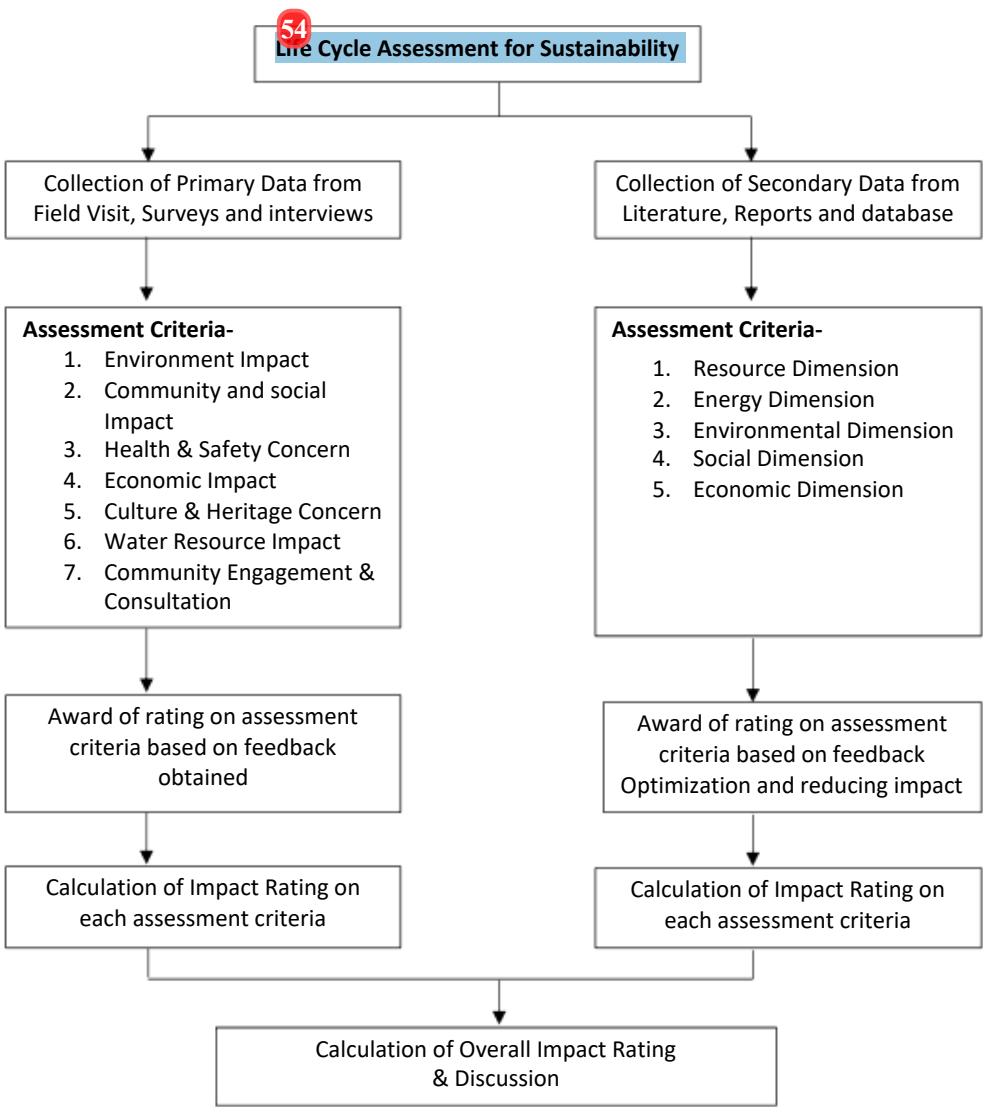
Based on a thorough literature review and the principles underlying life cycle assessment (LCA), it's evident that sustainability indices can vary significantly across industries and organizations. To systematically evaluate sustainability within the context of mining, a methodology is adopted focusing on key dimensions: resource utilization, energy consumption, environmental impact, social aspects, and economic viability. Also, primary investigation based on physical survey and data collection shall be incorporated to understand the socio-economic impact of surrounding villages. Life cycle assessment of small-scale manganese mining which is fully/Partially or under-planning for transition from opencast method mining to underground mining shall be studied based on resource utilisation, energy utilisation and optimization, environmental impact caused from opencast mining along with socio-economic analyses. The adoption of life cycle assessment (LCA) methodologies in mining, popularized by Farjana et al. (2021) is being adopted for research. For this study, three different Small-Scale manganese mines in Madhya Pradesh are selected situated in rural area. By comparing these mines, it becomes possible to identify variations in sustainability practices and performance across different operational contexts. Through detailed analysis of resource utilization, energy efficiency, environmental impacts such as water and air pollution, social aspects including community engagement and labour conditions, as well as economic indicators such as production costs and profitability, a comprehensive understanding of sustainability in manganese mining can be achieved.

By applying the principles of life cycle assessment to these selected mines, this research aims to provide insights into the strengths and weaknesses of current mining practices, identify areas for improvement, and ultimately, contribute to the development of more sustainable mining strategies in Madhya Pradesh. Through empirical data collection, rigorous analysis, and stakeholder engagement, this study seeks to support informed decision-making and promote sustainable development in the mining sector.

The goal of life cycle assessment in mining is to quantify and understand the environmental burdens and benefits of mining activities across various stages of the mining process. This includes assessing resource use, energy consumption, emissions of pollutants (such as greenhouse gases, particulate matter, and acidifying substances), impacts on ecosystems and biodiversity, as well as social aspects such as community health and well-being, labour conditions, and stakeholder engagement.

As per Farjana et al. (2021) life cycle assessment of mining activity creating environment and socio-economic impact is best present approach for some criteria but integration of other assessment criteria which reflect economic impact, community & social impact and sustainability in income of local community which were dependent on mining may be suitable approach for assessment. Considering all important gaps reflected in literature review to integrate all assessment criterion research methodology and strategy shall be following-

Research Methodology & Strategy-



Data Analysis Technique-

Feedback from personal interview on adopted method of mining and their impact on social, environment and economy of the area shall be done for the selected research area. Based on feedback from respondents, the impact rating shall be allocated to assessment criteria as per there positive and negative impact. a comprehensive representation of what impacts may exist from mining, but indicate the ground level impacts that respondents were aware of, had experienced and were concerned about. Impact rating can be sub-divided into:

- **None-** where respondents reported there were no impacts.
- **Minor-** where respondents reported the impacts were easily within their capacity to address, of minimal concern and temporary.
- **Moderate-** where respondents reported the impacts required attention and outside assistance.
- **Major-** where respondents reported the impacts were outside of their capacity to address, ongoing after mining activities had ceased and possibly irreversible.

Impact score to be given as per severity rating and calculation to be made as per Rating-

Impact Rating	Score
None	0
Minor	1-2
Moderate	3-5
Major	5

Table- : Impact Rating(IR) & Score for their impact

Based on impact score obtained by each assessment criteria, by product method the overall impact of mining activity on environment & socio-economic can be understand. The overall impact rating shall be sub divided into three categories as-

Minor- When overall impact rating is IR<30

Moderate- When overall impact rating is 30>IR<70

Major- When overall impact rating is IR>70

The Conclusion and discussion based on impact rating and score obtained through personal and analysis of impact rating shall be done to arrive at which mine is sustainable in all the assessment criteria.

Assumptions & Limitations-

It's essential to note that the development and use of sustainability indices can vary across industries and regions. Organizations, industries, and researchers may create specific indices tailored to their needs and objectives. Additionally, advancements in sustainability reporting and standards may have occurred. According to Bauman and Tillman, 2004, the Life cycle assessment (LCA) of a product or service is the assessment of environmental burdens of a product or service across its life cycle. This a useful tool for quantifying and interpreting environmental impacts of a product or service from the cradle to the grave. Its use in assessing mining products and processes has been limited. This situation is particularly true for non-coal as well as coal mining. Manganese is linked directly or indirectly to a lot of industrial processes which may be studied through LCA. Mn is important for steel sector which in turn is associated with a lot of industrial processes. But in this research importance of transition in method mining for sustainable mining is given and impact of transition in environment, social life and economic growth along with community engagement, health & safety of local community is reflected.

Chapter-4
Case Study: Opencast Manganese Mining in Madhya Pradesh

Case Study: Opencast Manganese Mining in Madhya Pradesh

Small-scale opencast manganese mining in Madhya Pradesh involves extracting manganese ore from surface mines using less advanced technology and with lower production volumes compared to large-scale mining operations. This form of mining is common in the region due to its rich manganese deposits and provides significant economic benefits to local communities. However, it also presents unique challenges and opportunities for sustainable development. Key aspects include the need for effective Environmental Impact Assessments (EIA) to understand and mitigate adverse effects on air, water, and soil quality. Rehabilitation and reclamation efforts must be cost-effective and focus on proper waste disposal and reforestation. Community engagement is crucial, involving local populations in mining projects to ensure their needs and concerns are addressed while providing job opportunities and economic support. Effective monitoring and enforcement of environmental regulations, along with efficient water management practices, are essential to prevent local water contamination. Ensuring the health and safety of mine workers and addressing related health issues in local communities are critical, as is protecting local biodiversity through conservation initiatives. Technological adoption, even on a small scale, can enhance efficiency and safety while minimizing environmental impact.

Despite these efforts, several limitations and gaps persist. Inadequate environmental impact assessments may overlook critical aspects, leading to unforeseen environmental degradation. Limited resources can result in poor land restoration efforts. Excluding local communities from decision-making can cause social unrest and opposition to mining projects. Weak regulatory oversight may allow non-compliance with environmental standards, leading to water contamination and health risks for workers and local populations. Neglecting biodiversity conservation can result in irreversible ecological damage. Slow adoption of new technologies can perpetuate inefficient and environmentally harmful mining practices. Addressing these gaps requires comprehensive strategies, including strengthening regulatory frameworks tailored for small-scale mining, enhancing community engagement, improving environmental monitoring and enforcement with local community involvement, promoting sustainable rehabilitation practices, and fostering affordable technological innovation. By implementing these measures, small-scale opencast manganese mining in Madhya

Pradesh can progress towards more sustainable and responsible practices, ensuring long-term benefits for both the environment and local communities.

To address the issue and impact pertaining to small scale mining of Manganese Mining in Madhya Pradesh three Opencast Mines situated in different district are selected for the research work, selected mines have been worked with opencast method of mining and consequently converted into underground mining due to different challenges present with current mining practice. The impact created with opencast mining and impact created by change in method of mining can be understand with data interpretation for last one decade. The detail of selected mines is presented below-

Name of Mine	Village	District	Lease Area (Hect)	Production Capacity (TPA)
Ramrama Mn Ore Mine M/s A.P. Trivedi & Sons	Ramrama	Balaghat (M.P.)	43.086 Hect	90,000
Palaspani Mn Ore Mine M/s Krishnaping Alloys Ltd.	Sausar	Pandurna (M.P.)	54.129 Hect	84,000
Kajli Dongri Mn Ore Mine M/s S.R. Alloys Ltd	Kajli Dongri	Jhabua (M.P.)	30.860 Hect	1,50,000

Table no- Detail of selected mine for the research work

❖ **Description of Ramrama Mn Ore Mine-**

The Ramrama Mn Ore Mine is located in the rural area of Balaghat District, Madhya Pradesh, covering a lease area of 43.086 hectares dedicated to manganese ore mining. The region's topography features gentle rolling hills with elevations ranging from 336 to 342 meters, leading to a gradient that slopes westward toward the Mahadeo nala. Over six decades of mining activities have altered the natural landscape, introducing pits, huts, roads, dumps, and office setups, although the majority of the area remains agricultural.

The lease area exhibits a gently rolling topography with an elevation difference of about 6 meters. The gradient slopes towards the west, converging into the Mahadeo nala. However, the predominant land use in the area remains agricultural.

Geology of Deposit-

The manganese deposits in Madhya Pradesh are linked with the early Proterozoic gneiss and schist belt of the Sausar Group, comprising phyllite, schist, gneisses, crystalline limestone/marble, and calc-silicate/granulites. The Mansar phyllite and muscovite schist/gneiss formations contain manganese horizons at multiple stratigraphic levels. The

principal manganese minerals found in this region include Hausmanite, Verdenburgite, Jacobsite, Braunite, Holandine, and Bixbyte.

The stratigraphic sequence of the Sausar Group reveals a layered composition spanning various formations. Recent deposits consist of alluvium overlaying intrusive pegmatite and vein quartz. The geological profile further includes the Bichua Formation, characterized by dolomitic marble, calc-silicate rocks, biotite-muscovite schist, and quartz-biotite-granulites containing sillimanite. The Chorbaoli Formation features garbet-staurolite-quartz-muscovite schist, micaceous and cherty quartzite enriched with garnet and magnetite. Within the Mansar Formation, layers of gondite-muscovite schist interspersed with manganese ores (Mn ore-I, Mn ore-II, and Mn ore-III) are found. Lohangi exhibits dolomite marbles with manganese ore lenses, alongside calc-silicate rocks, calc-granulites, quartz-biotite granulites, and gneisses. The Archean stratum includes Tirodi biotite gneiss, migmatite, tonalite gneiss, cordierite gneiss, and amphibolites.

The Ramrama area is divided into Western, Central, and Eastern parts, explored through three pits. Pits 1 and 2 operate as open cast mines, while pit 3 is underground. Alluvial cover is present on the upper surface, with the Chorbaoli formation forming the hanging wall and the Mansar formation constituting the footwall. Manganese mineralization, featuring Braunite, Rhodonite, and Spessartite, is observed with a general ore body strike of N61°W and an average dip of 55°N. Polyphase folding and neo-tectonism are evident in the western section, with open cast mining developed in the central and eastern sections. Manganese mineralization in the Sausar Group is believed to be metamorphosed syngenetic, closely linked to quartz-muscovite schist of the Mansar formation. Deposits are found as narrow bands within Tirodi-Biotite Gneiss, often accompanied by layers of quartz-mica schist.Key lithological units include alluvium, muscovite-biotite schist, manganese ores (Braunite, Rhodonite, Spessartite), and muscovite-quartz schist, alongside intrusive pegmatite. Geological structures feature multiple phases of folding, including minor and repeated folding in various strike and dip directions, forming anticline, syncline, and overturned folds. Shear directions containing calcareous material are oriented N50°E, with a plunge direction of E-W and a dip of 30-35°. This detailed geological and topographical understanding is essential for assessing environmental

impacts and implementing sustainable practices in the mining operations of the Ramrama Mn Ore Mine.

Method of Working-

The Ramrama Mn Ore Mine uses both open cast and underground mining techniques. In open cast mining, pits 1 and 2 are designed for ore bodies close to the surface. Benches are formed to provide stable platforms for equipment and access to the ore. Controlled blasting breaks the rock, which is then transported for processing to increase manganese content. Pit 3 is developed as an underground mine, used for deeper ore bodies. Access is provided through shafts, adits, or declines, allowing for ore extraction and transport. The design of stopes ensures safe and efficient ore removal, with the ore being transported to the surface for processing.

Geological and environmental considerations are critical in Ramrama. The area's folding and neo-tectonism require careful monitoring to ensure stability. Overburden is managed through planned storage or backfilling, while water management systems prevent flooding in the pits. Land reclamation efforts aim to restore the area post-mining. Safety and sustainability are prioritized. Strict safety protocols and regular drills protect workers, while environmental impact is minimized through efficient resource use and adherence to regulations. This combination of techniques and careful planning ensures responsible manganese ore extraction at the Ramrama Mn Ore Mine.

❖ **Description of Palaspani Mn Ore Mine-**

The Palaspani Mn Ore Mine, operated by Krishnaping Limited, is a manganese ore mining site employing a combination of open cast and underground mining techniques to efficiently extract the ore. The mining operations at Palaspani are designed to optimize resource recovery while adhering to environmental and safety standards.

In open cast mining, the ore is extracted from surface deposits, where the overburden is removed to expose the manganese-rich layers. Benches are carefully constructed to ensure safe access and stable working conditions. Controlled blasting is used to fragment the rock, which is then transported to processing facilities. Here, the ore undergoes various beneficiation processes to improve its manganese content before being dispatched for further use.

For deeper manganese deposits, underground mining methods are employed. These involve creating access points through shafts or declines, which allow workers and equipment to reach the ore body safely. The ore is extracted using stope designs tailored to the geological conditions, ensuring both safety and maximum ore recovery. The extracted ore is then brought to the surface for processing.

Krishnaping Limited places significant emphasis on environmental management at the Palaspani Mn Ore Mine. Overburden is systematically managed, either by storing it in designated areas or using it for backfilling. Water management is also a priority, with systems in place to handle groundwater inflow and prevent flooding. Additionally, land reclamation efforts are implemented post-mining to restore the landscape, including recontouring and re-vegetation.

Safety is paramount in the mining operations at Palaspani. Workers are provided with personal protective equipment (PPE), and regular safety drills are conducted to ensure preparedness for any emergencies. The mine also adheres to strict environmental and regulatory guidelines, focusing on minimizing the environmental impact and promoting sustainable mining practices.

Geology of Deposit-

The Palaspani Mn Ore Mine, operated by Krishnaping Limited, is situated within a geologically rich region characterized by a complex stratigraphic sequence. The deposit primarily lies within the formations of the Sausar Group, known for its significant manganese mineralization. This group comprises metamorphic rocks that have undergone multiple phases of deformation and metamorphism, contributing to the complexity of the ore body's geology. At the core of the deposit, the manganese ore is closely associated with gondite and quartz-mica schist formations. These rocks are part of the Mansar Formation, which is known for hosting manganese-rich layers. The ore bodies are typically found as lenticular or tabular formations, exhibiting a stratiform nature that aligns with the regional metamorphic fabric. Minerals such as braunite, rhodonite, and spessartite are predominant in the ore, indicating high-grade metamorphic conditions during formation.

Structurally, the region has experienced polyphase folding, resulting in the intricate folding patterns observed within the ore-bearing horizons. These folds have influenced

the orientation and distribution of the manganese ore bodies, often leading to repeated sequences of ore and waste rock. The general strike of the formations is northwest-southeast, with dips varying between moderate to steep angles, which impacts both the mining method and the stability considerations during extraction.

Intrusive activities have also played a role in the geological makeup of the deposit. Pegmatite and quartz veins intersect the metamorphic sequences, sometimes causing local enrichment or depletion of manganese minerals. Additionally, the presence of faults and shear zones has introduced structural complexities, occasionally serving as conduits for hydrothermal fluids that have further altered the mineralogy of the deposit. Overlying the primary ore-bearing formations, recent alluvial deposits cover portions of the mine area. These unconsolidated sediments are the result of weathering and erosion processes and must be carefully managed during mining operations to prevent contamination and ensure environmental compliance. Overall, the geology of the Palaspani Mn Ore Mine presents a multifaceted environment that demands meticulous geological mapping and analysis to optimize ore extraction and maintain safety standards.

Method of Mining-

Until 2020, the Palaspani Mn Ore Mine operated using a fully mechanized open cast mining method. The design parameters for the open pit included a bench height of 8 meters, a bench width of 10 meters, a ramp gradient with a maximum of 1:10, a bench angle of 70 degrees, and an overall pit slope of 37 degrees. However, following modifications to the mining plan and the Progressive Mine Closure Plan, the method of mining changed after 2020. The updated mining scheme now incorporates open cast, underground, and dump mining methods.

The open cast method continues to be utilized, though it faces limitations due to the proximity of the mining lease (ML) boundary on both the hanging wall and, in some places, the footwall. Consequently, open cast mining is now restricted to Block-1 and Block-2, where the overall pit slope allows for safe operations. The manganese ore and the overburden, which consists of micaceous schists, gondite rocks, and pegmatite, are medium-hard and require drilling and blasting for excavation. Soil cover is removed using simple dozing and is stacked separately. Drilling is conducted using 100 mm diameter drills, and blasting is performed scientifically to control ground vibration and fly rock. The blasting process employs 70 mm diameter slurry explosives, with careful placement

of booster and column charge explosives to ensure safe and effective blasting. Nonel shock tubes are used as the detonation medium.

The underground mining method has been introduced in the eastern part of the property, specifically below pits 1, 2, and 3. Once the operations reach the Upper Pit Depth (UPD) at 280 MRL, underground activities will extend toward the western part of the property. Access to the underground workings will initially be provided by an adit and incline, followed by the construction of a vertical shaft. The adit, sized at 3.0 m x 2.4 m, will be located at MRL 340, and the incline, sized at 4.6 m x 2.4 m, will extend from MRL 355 to MRL 265, facilitating the transportation of personnel and materials. The vertical shaft, with a diameter of 4.5 meters, will be constructed in waste rock at the mid-point of the property and will be deepened to reach the deep-seated ore body at 170 MRL. Future deepening of the shaft will be considered based on operational requirements and scientific studies of rock mechanics and RMR (Rock Mass Rating).

The stoping method involves stripping the ore body from wall to wall after developing the stope block, with systematic roof support provided according to the guidelines approved by the Directorate General of Mines Safety (DGMS). Manways and ore passes are constructed on extended cross-cuts within the ore body, and the voids are filled with waste rock or sand. The second slice of ore is then extracted from above the manway and ore pass.

For loading and transport, electrically operated Side Dump Loaders will muck the blasted ore and unload it into ore passes. 24 cft tubs will be used to draw ore from the ore passes, and battery-operated locomotives will transport the tubs to the pit bottom or underground bunker. From the pit bottom, tubs will be hauled to the surface using double drum rope haulage, or a skip will be used in the shaft to hoist the ore. The hoisted ore is unloaded into a surface bunker before being transported by 15-ton trucks to the crushing and screening plant for beneficiation. Safety features such as manholes, backstays, jaz rail drop raise systems, and other safeguards will be implemented on the haulage roads and tracks. In addition to the primary mining operations, the site also handles residual material through dump mining. Decades of mining have led to the accumulation of residual Run of Mine (ROM), sub-grade minerals, and processing rejects, resulting in significant black dumps containing approximately 30% ROM. This has been confirmed through manual jigging practices at the mine, where materials from the dump are fed into the jigging process, achieving a recovery rate of 30%.

❖ **Description of Kajli Dongri Mn Ore Mine-**

The Kajlidongri Manganese Mine, operated by M/s S.R. Ferro Alloys, is a significant manganese ore mining site located in Jhabua district of Madhya Pradesh, India. The mine is situated within the Sausar Group formations, known for their manganese-rich deposits. The geological setting includes Gondite and Tirodi Biotite Gneiss formations, which have undergone considerable metamorphism, creating high-grade manganese ore bodies. The ore deposits at Kajlidongri are primarily lenticular or tabular, containing valuable manganese minerals such as braunite, psilomelane, pyrolusite, and rhodochrosite, often associated with quartz, mica, and garnet. Mining operations at Kajlidongri utilize both open cast and underground methods, depending on the depth and orientation of the ore bodies. The open cast mining method is employed for ore bodies close to the surface. It involves removing overburden through drilling and blasting, followed by the excavation and transportation of the manganese ore to the processing plant. This method is carried out in a series of benches, designed to ensure safety and efficiency. For deeper ore bodies, underground mining techniques are used, involving adits, declines, and vertical shafts. These methods, including room and pillar or cut and fill, ensure maximum ore recovery while maintaining safety underground.

The processing plant at Kajlidongri focuses on enhancing the manganese content of the extracted ore. The ore undergoes several stages of processing, including crushing, screening, washing, and gravity separation. The crushed ore is screened to separate fine and coarse particles, then washed to remove impurities. Gravity separation techniques, such as jigging, are employed to concentrate the manganese. The processed ore is either stockpiled for sale or used in ferroalloy production, depending on the end-user requirements.

Environmental management is a key aspect of operations at the Kajlidongri Mine. The overburden from open cast mining is managed by storing it in designated areas, which are then stabilized to prevent erosion and sediment release. Water management practices are implemented to control surface and groundwater, ensuring that mining activities do not contaminate local water sources. Additionally, dust suppression systems are used to minimize airborne particles, and noise control measures are in place to reduce operational impacts on the surrounding environment. These practices ensure that the mine operates in compliance with environmental regulations and minimizes its ecological footprint.

Geology of Deposit-

The Kajlidongri Manganese Mine, operated by M/s S.R. Ferro Alloys, is located in Madhya Pradesh, India, and is situated within a geologically complex region known for its manganese ore deposits. The geology of the Kajlidongri mine is characterized by its association with the Sausar Group, which is renowned for its rich manganese mineralization.

The deposit is primarily hosted within the Gondite and Tirodi Biotite Gneiss formations. These formations are part of the larger Sausar Group and have undergone significant metamorphic processes that have resulted in the formation of high-grade manganese ore bodies. The Gondite formation is particularly notable for its manganese-bearing rocks, which are a key source of the mineral at Kajlidongri.

The manganese ore bodies at Kajlidongri are generally lenticular or tabular in shape, reflecting the stratiform nature of the mineralization. These ore bodies are embedded within the metamorphosed host rocks and are often interbedded with layers of quartz, mica, and garnet. The primary manganese minerals found in the ore include braunite, psilomelane, pyrolusite, and rhodochrosite. The mineralization is typically confined to specific horizons within the host rocks, making detailed geological mapping and exploration critical for effective mining.

The geological structure of the Kajlidongri deposit is influenced by polyphase folding and faulting, which has affected the orientation and distribution of the manganese ore bodies. The general strike of the formations is northwest-southeast, with varying dip angles that impact mining operations. The area has experienced multiple phases of deformation, leading to complex folding patterns and structural features that must be carefully considered during mining and exploration.

Intrusive activities in the region, such as pegmatite intrusions, have also played a role in shaping the geological characteristics of the deposit. These intrusions can locally alter the mineralogy and may affect the distribution of manganese ore. Additionally, fault zones and shear structures present in the area can influence ore body localization and complicate mining operations.

Overall, the geology of the Kajlidongri Manganese Mine presents a complex and rich mineral environment, with high-grade manganese mineralization hosted within metamorphosed formations. Understanding the geological setting and structural features is crucial for efficient mining and resource management at the site.

Method of Mining-

The Kajlidongri Manganese Mine, operated by M/s S.R. Ferro Alloys, employs both open cast and underground mining methods to efficiently extract manganese ore from its deposits. The choice of method depends largely on the depth and orientation of the ore bodies. For ore bodies located closer to the surface, the mine utilizes open cast mining techniques. This process begins with the removal of overburden, which includes soil, waste rock, and other non-ore materials. Overburden removal is achieved through drilling and blasting, with subsequent excavation and transport of the material using heavy machinery such as excavators and haul trucks. The open pit is developed in benches, which are horizontal layers that provide access to the ore and ensure stability. Bench height and width are carefully designed to optimize extraction while maintaining safety. The ore is then transported to the processing plant for further treatment.

In areas where the ore body is deeper, underground mining methods are employed. Access to these ore bodies is gained through adits, declines, and vertical shafts. Adits are horizontal tunnels that provide initial access, while declines are sloped tunnels that facilitate both ore transport and personnel movement. Vertical shafts are used for deeper ore bodies and serve as key transport routes for moving ore to the surface. Once underground access is established, stopping methods such as room and pillar or cut and fill are used to extract ore. These methods involve creating excavated spaces within the ore body and filling voids with waste material to maintain stability. Ore extracted from underground workings is transported to the surface via conveyors, ore passes, or hoists.

Regardless of the mining method used, the extracted ore undergoes processing to enhance its manganese content. The processing plant includes stages of crushing, screening, washing, and gravity separation. The crushed ore is screened to separate fine and coarse particles, washed to remove impurities, and subjected to gravity separation techniques to concentrate the manganese.

Safety and environmental management are integral to mining operations at Kajlidongri. Both open cast and underground mining methods are conducted with strict adherence to safety protocols to protect workers and ensure safe operations. Environmental management practices include careful handling of overburden, water control measures, dust suppression, and the reclamation of mined areas to minimize the impact on the surrounding environment.

Collection of Primary Data-

In the search methodology for assessing the impact of mining activities, the process begins with gathering primary data from villagers living around the mines. This feedback helps analyse the effects of mining operations on local communities.

For the Ramrama Mn Ore Mine operated by M/s A.P. Trivedi & Sons, the selected villages for impact analysis are Ramrama, Katanjhirri, and Sirra. In the case of the Palaspani Mn Ore Mine, the focus is on the villages of Tinkheda, Khairi, and Borgaon. For the Kajlidongri Mn Ore Mine, the nearby villages of Rasodi, Nangavat, Pipalkutta, and Piploda are chosen for the impact assessment. The primary data collection strategy involves personal interviews with villagers to obtain detailed feedback on various aspects of mining impact. The following steps outline the process:

1. **Preparation of Questionnaire:** A comprehensive questionnaire is designed to address multiple parameters, including environmental impact, community and social effects, health and safety concerns, economic impacts, cultural and heritage considerations, water resource impacts, and community engagement. This ensures that all relevant aspects of the mining activities are covered.
2. **Impact Scoring:** Feedback from the interviews is used to rate each parameter on a scale from 1 to 10. The impact is classified into categories such as none, minor, moderate, or major based on the scores. This helps in quantifying the extent of each impact.
3. **Summarization of Impact Ratings:** The impact ratings are summarized to provide an overall impact score for each parameter. This step involves aggregating the feedback and ratings to get a clear picture of the mining impacts on the communities.
4. **Calculation of Overall Impacts:** An overall impact calculation is performed for each parameter based on the summarized ratings. This provides a comprehensive view of how the mining activities affect different aspects of the local environment and community.
5. **Sustainability Comments:** Based on the calculated impact scores, comments and recommendations for sustainability are provided. These insights help in addressing the concerns raised by the community and in planning future actions to mitigate adverse impacts.

This structured approach ensures a thorough assessment of the mining activities' effects on local villages and helps in developing strategies for sustainable mining practices

Table no- Summary of the feedback obtained through personal interview are as following-

Mine-	Ramrama Mn Ore Mine, Balaghat Total No. of Interview- 46			Palaspani Mn Ore Mine, Sausar Total No. of Interview- 43			Kajlidongri Mn Ore Mine, Jhabua Total No. of Interview- 56			
Village Name	**Ramrama**	**Katanjirri**	**Sirra**	**Tinkheda**	**Khairi**	**Borgaon**	**Rasodi**	**Nangavat**	**Pipalkutta**	**Piploda**
No. of interviews	**16**	**20**	**10**	**10**	**20**	**13**	**16**	**13**	**12**	**15**
1. Environmental Impact										
Soil Disturbance-	Minor	Minor	Minor	Moderate	Moderate	Moderate	Major	Moderate	Moderate	Moderate
Land Use -	Minor	None	Minor	Moderate	Moderate	Minor	Major	Major	Moderate	Major
Vegetation fertility-	None	20	None	None	Minor	Moderate	Major	Major	Major	Major
Water Quality-	None	Minor	Minor	None	Minor	Minor	Moderate	Moderate	Moderate	Moderate
2. Community and Social Impact	46						20			
Displacement of Communities-	None	None	None	Minor	None	Minor	Minor	Minor	Minor	Minor
Noise & Dust Pollution-	Minor	None	Minor	Major	Major	Major	Moderate	Moderate	Moderate	Major
3. Health and Safety Concern							13			
Air Quality-	Minor	Moderate	None	Moderate	Moderate	Moderate	Major	Major	Major	Major
Safety Hazards-	None	None	None	Minor	None	Minor	Major	Major	Major	Major
4. Economic Impact									141	
Employment Opportunities-	None	Moderate	Minor	Moderate	Moderate	Moderate	Major	Major	Major	Major
Impact of Livelihood-	None	Minor	Minor	None	None	None	Moderate	Minor	Moderate	Moderate
5. Cultural & Heritage Concern	46									
Cultural Sites-	None	None	None	None	None	None	None	None	None	None
6. Water Resource Impact	13									
Water Depletion-	Minor	Minor	Minor	Minor	Major	Moderate	Moderate	Moderate	Moderate	Moderate
Water Contamination-	Minor	Minor	Minor	None	Minor	Moderate	Moderate	Moderate	Major	Moderate
7. Community Engagement & Consultation										
Public Participation-	Minor	Minor	Moderate	Minor	Moderate	Moderate	Major	Major	Major	Major

Summarization of Impact Ratings-
Mine-
Ramrama Mn Ore Mine,
Balaghat
Total No. of Interview- 46
Palaspani Mn Ore Mine,
Sausar
Total No. of Interview- 43
Kajlidongri Mn Ore Mine,
Jhabua
Total No. of Interview- 56
Village Name Ramrama Katanjirri Surra Tinkheda Khairi Borgaon Rasodi Nangavat Pipalkutta Piploda
None 7 6 5 5 4 2 1 1 1 1
Minor 7 6 8 4 3 4 1 2 1 1
Moderate 0 2 1 4 5 7 5 5 6 5
Major 0 0 0 1 2 1 7 6 6 7
Table no-: Summary of Severity Rating
Calculation of Overall impact Score –
Mine-
Ramrama Mn Ore Mine,
Balaghat
Total No. of Interview- 46
Palaspani Mn Ore Mine,
Sausar
Total No. of Interview- 43
Kajlidongri Mn Ore Mine,
Jhabua
Total No. of Interview- 56
Village Name Ramrama Katanjirri Surra Tinkheda Khairi Borgaon Rasodi Nangavat Pipalkutta Piploda
None 14 12 10 10 8 4 2 2 2 2
Minor 35 30 40 20 15 20 5 10 5 5
Moderate 0 16 8 32 40 56 40 40 48 40
Major 0 0 0 15 30 15 105 90 90 105
Overall Impact Score- 49 58 58 77 93 95 152 142 145 152
Table no-: Calculation of overall impact score

Collection of Secondary Data-

According to the literature on Life Cycle Assessment (LCA) and its associated concepts, sustainability indices can significantly differ across industries and organizations. To address these variations, a methodology has been adopted that evaluates sustainability from multiple dimensions: resource use, energy consumption, environmental impact, social implications, and economic contributions. The LCA system is meticulously designed to examine various subcomponents within these dimensions.

In this study, three manganese mines in Madhya Pradesh with identical production capacities are selected for LCA. The selected mines are:

1. **Ramrama Manganese Ore Mine**, located in the Balaghat District.
2. **Palaspani Manganese Ore Mine**, situated in the Pandurna District.
3. **Kajlidongri Manganese Ore Mine**, found in the Jhabua District.

An LCA framework has been developed for each of these mines to assess their impacts and contributions across environmental, social, and economic dimensions. This comprehensive approach allows for a detailed analysis of the sustainability aspects of manganese mining in Madhya Pradesh, focusing on the specific impacts and benefits associated with each mining operation. A comparative analysis of various sub-dimensions of framed LCA shall be studied to ascertain the sustainability.

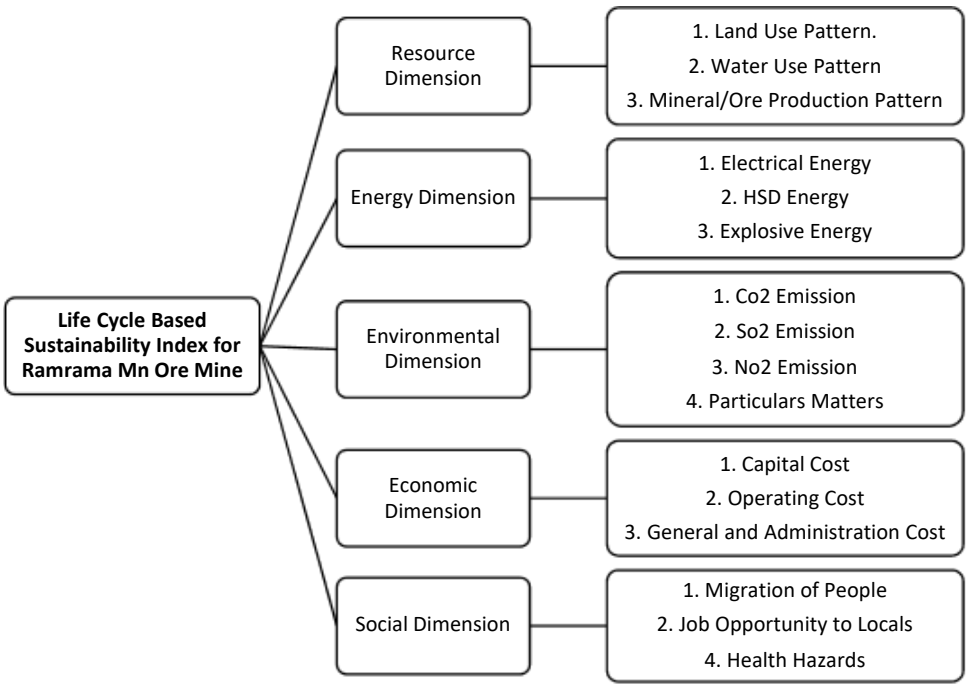


Figure no-: Framed LCA for Mn ore Mining in Madhya Pradesh

Resource Dimension-

The dimension of resource management encompasses the study of the effective use and utilization of land, water, and ore production. This aspect is crucial in understanding the variability and factors that may influence the sustainability of manganese mining in Madhya Pradesh. By examining how these resources are managed, stakeholders can gain insights into the efficiency of current mining practices and identify areas for improvement. Land use is a significant consideration, as mining operations often require large areas of land, which can lead to environmental degradation if not managed properly. Similarly, water resources are vital for mining processes and must be used judiciously to prevent depletion and contamination. The production of ore, on the other hand, must be optimized to ensure that extraction is both economically viable and environmentally sustainable.

Understanding these factors is essential for developing strategies that will ensure the long-term sustainability of manganese mining in the region. By carefully balancing the use of land, water, and ore resources, it is possible to minimize the environmental impact while maximizing the economic benefits of mining activities in Madhya Pradesh.

Land Use Pattern-

Manganese mining has significant effects on land, particularly through deforestation. For instance, open-cast mining operations in Madhya Pradesh have led to the removal of extensive forested areas, which disrupts local ecosystems and wildlife habitats. In comparison, more regulated mining practices in regions with stricter environmental policies may result in less extensive deforestation. For example, the Ramrama Mn Ore Mine in Balaghat has cleared several hundred hectares of forest, whereas operations in areas with advanced reclamation practices might impact a smaller area due to better land management strategies.

The physical alteration of landforms is another major impact. Mining activities create large pits and waste dumps, significantly changing the natural landscape. For example, in the Kajlidongri Mn Ore Mine, the formation of extensive open pits and waste rock dumps has transformed the topography of the area. This contrasts with less invasive mining methods or better land restoration practices, where the landform changes might be less severe or more effectively managed through reclamation.

Mining leads to soil degradation by exposing it to erosion. The removal of vegetation, as seen in the Palaspani Mn Ore Mine, increases soil erosion and reduces soil fertility. In areas with proactive soil conservation measures, such as advanced erosion control practices, soil degradation can be minimized. The impact on soil quality in Madhya Pradesh's mining areas is often measured in terms of increased erosion rates, which can be several tons per hectare per year compared to more controlled mining environments. The accumulation of waste rock and tailings affects land use. In the Kajlidongri Mn Ore Mine, waste dumps cover significant areas, often exceeding several hectares. This contrasts with operations that implement more effective waste management practices, where the footprint of waste materials may be smaller and better contained. For instance, waste management practices at some mines aim to reduce the area covered by waste to less than 10% of the mined area.

Based on the comparison of land use patterns and production data depicted in **Figure X**, the Ramrama Mn Ore Mine has shown a significant decrease in land use over the past decade, while productivity has improved. This positive trend is the result of a strategic shift from open-cast to underground mining. The sustained production from both open-cast and underground operations demonstrates the effectiveness of this planned transition.

In contrast, the Palaspani Mn Ore Mine has experienced significant variability in land use and cover patterns over the last decade. Various technological and economic challenges have contributed to this inconsistency, resulting in lower productivity and increased overburden (OB) extraction. This has placed additional pressure on land resources for OB storage and reduced the available land area for other uses.

The Kajli Dongri Mine, which primarily operates as an open-cast mine, has seen reduced land use over the past decade. However, from 2017 to 2023, there has been a noticeable increase in land use due to declining subsurface mineralization. This trend suggests the need to consider adopting new technologies or transitioning to underground mining to enhance production and reduce the burden on land use.

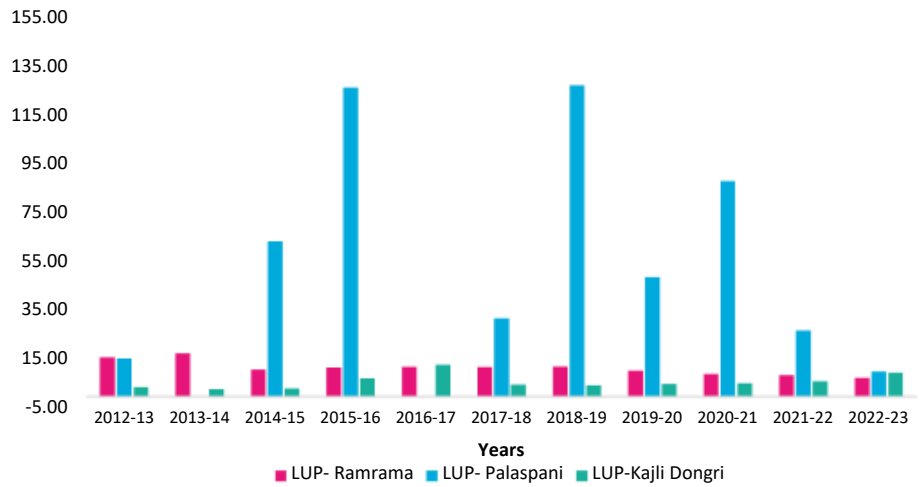


Figure no-: Comparison of land use pattern of selected Mn Ore Mine of Madhya Pradesh

Over the past decade, the Ramrama Mn Ore Mine has seen an average total land use of 25.13 hectares. A detailed breakdown of this land use reveals that 44.73% of the area, or nearly half, is dedicated to the active mining pit. This signifies the primary focus on extraction activities within the mine. Additionally, a significant portion of the land, amounting to 46.35%, is allocated for overburden (OB) dumps. The extensive area occupied by OB dumps underscores the considerable volume of waste material generated during the mining process, necessitating substantial land for its storage.

A smaller fraction of the land is used for other essential operations. Specifically, 1.02% of the area is reserved for mineral stacking and storage, which is crucial for managing extracted minerals before they are processed or transported. Various infrastructure facilities, including workshops and administrative buildings, occupy 4.18% of the land, reflecting the need for operational support structures within the mine. Roads, which are vital for transportation within the mining area, account for 2.29% of the total land use. Environmental management is also part of the land use strategy, with 0.22% of the area dedicated to greenbelt development. This small yet important allocation demonstrates an effort to mitigate the environmental impact of mining activities through vegetation and ecological preservation. Lastly, 1.21% of the land is used for miscellaneous activities, which may include auxiliary services and other operational necessities.

The variation in lease area and the portions covered by mining activities and OB dumps over the past decade provides insight into the overall impact of mining on the land.

This data highlights the extensive area affected by mining activities and the importance of efficient land management to balance operational needs with environmental sustainability.

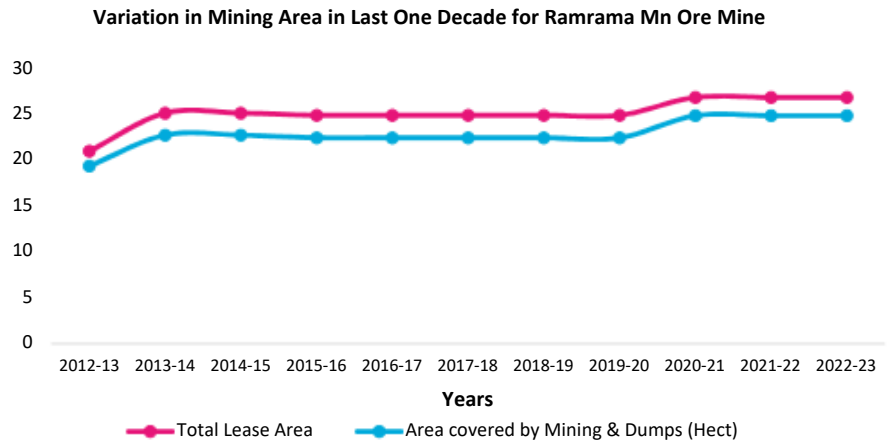


Figure no-: Comparison of total lease area and area covered by mining & dumps for Ramrama Mn Ore Mine

At the Palaspani Mn Ore Mine, the average total land area utilized over the past decade amounts to 37.10 hectares. Of this area, a significant 74.38% is occupied by the active mine site. This large proportion underscores the intensive nature of mining operations at Palaspani, where a majority of the land is directly involved in the extraction processes. The extensive use of land for active mining reflects the scale and focus of the mine's production activities. A substantial portion of the remaining land, 20.80%, is allocated for overburden (OB) waste dumps. This allocation highlights the considerable volume of waste material generated, necessitating dedicated space for its storage. The management of these OB dumps is crucial for maintaining the operational efficiency of the mine while minimizing the environmental footprint.

In terms of environmental initiatives, only 1.04% of the land is designated for greenbelt development. Although this is a relatively small percentage, it represents the mine's efforts to mitigate environmental impacts through the creation of green spaces. These areas are intended to reduce the ecological disruption caused by mining activities and contribute to environmental sustainability.

Various infrastructure facilities, including workshops and administrative buildings, occupy 2.69% of the land. These structures are essential for supporting the daily operations of the mine, providing necessary spaces for equipment maintenance, administrative tasks, and other operational functions. Roads within the mining area

account for 0.27% of the land, facilitating the movement of personnel, machinery, and materials across the site.

Additionally, 1.16% of the land is used for miscellaneous activities, which could include other operational requirements or auxiliary services. The detailed analysis of land use variation, particularly in relation to lease areas and the spaces covered by mining activities and OB dumps over the past decade, offers valuable insights into the overall impact of mining at Palaspani. This data is essential for understanding how land has been affected by mining operations and underscores the importance of strategic land management to balance production needs with environmental considerations.

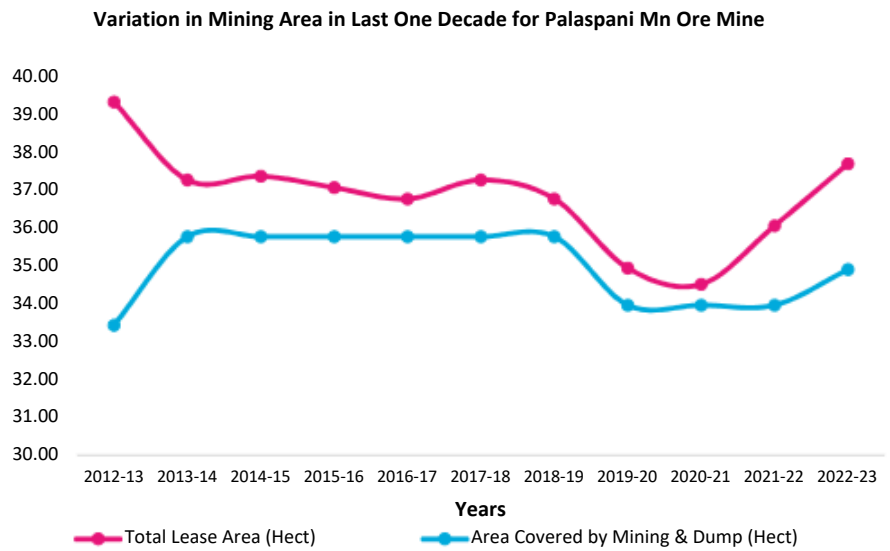


Figure no-: Comparison of total lease area and area covered by mining & dumps for Palaspani Mn Ore Mine

At the Kajlidongri Mn Ore Mine, the average total land use over the past decade amounts to 30.86 hectares. A significant portion of this area, 56.43%, is dedicated to the active mining site where mineral production takes place. This substantial allocation underscores the centrality of extraction activities in the mine's operations, with more than half of the total land area being utilized for mining processes. In addition to the active mining area, 27.93% of the land is designated for overburden (OB) and waste dumps. This allocation highlights the need for substantial space to manage the waste material generated during mining. The proper management and storage of OB and waste are critical to maintaining operational efficiency and minimizing environmental impact.

The mine also prioritizes environmental sustainability, as evidenced by the 6.12% of the land set aside for plantation and greenbelt development. This allocation reflects the

mine's commitment to mitigating the ecological impact of its operations by fostering vegetation and creating green spaces. These efforts contribute to the overall environmental health of the area, helping to offset the disturbances caused by mining activities. Infrastructure, including administrative buildings and workshops, occupies 3.60% of the total land area. These facilities are essential for supporting the mine's day-to-day operations, providing spaces for equipment maintenance, administrative tasks, and other operational needs. Roads within the mining area account for 1.42% of the land, ensuring the smooth movement of personnel, machinery, and materials across the site.

Finally, 4.56% of the land is allocated for miscellaneous activities, including auxiliary services and other operational needs. Analysing land use variation over the past decade offers valuable insights into the impact of mining on the land, highlighting the need for balanced and strategic land management to meet production goals while minimizing environmental impact.

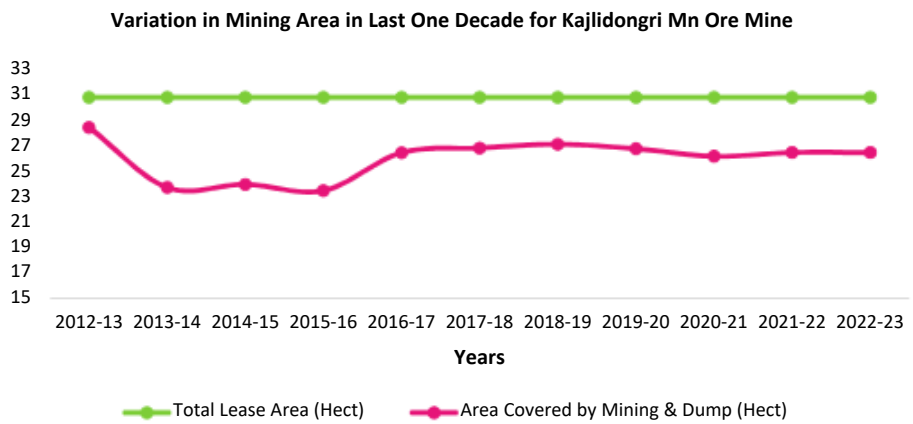


Figure no-: Comparison of total lease area and area covered by mining & dumps for Kajlidongri Mn Ore Mine

A comparative study reveals significant disturbances to the natural landscape across three manganese ore mines: Ramrama Mn Ore Mine, Palaspani Mn Ore Mine, and Kajlidongri Mn Ore Mine. Specifically, 44.74%, 74.38%, and 56.48% of the total lease areas, respectively, have been altered from their natural state due to mining activities. These figures highlight the pressing need for improved ecological sustainability measures, particularly through increased plantation efforts within these regions.

Focusing on the Ramrama Mn Ore Mine, the study indicates that the mine has transitioned to full operation using the underground method. However, despite this shift, only a

meagre 0.22% of the total lease area has been dedicated to plantation. This minimal commitment to reforestation is concerning, and it is imperative that the mine management takes decisive action to enhance the plantation area. The existing bench formations and dumps offer viable spaces for expanding greenery, which would contribute significantly to the ecological balance in the region.

Similarly, the Palaspani Mn Ore Mine presents an opportunity to boost its environmental efforts. Currently, only 1.04% of its total land area is utilized for plantation. Increasing this figure to at least 5% would represent a meaningful step toward mitigating the environmental impact of mining operations. Such an initiative would not only promote ecological sustainability but also enhance the mine's long-term operational viability.

Lastly, the Kajlidongri Mn Ore Mine faces a critical juncture in its operational strategy. The study's findings suggest that the land use per unit ton of production has shown an increasing trend, raising concerns about the sustainability of continued opencast mining. Transitioning to an underground mining method could be a strategic move to optimize land use while maintaining production levels. This shift would align with broader goals of minimizing environmental disruption and ensuring that additional land is not required for future operations.

In conclusion, strategic measures such as expanding plantation areas and considering transitions in mining methods are essential for promoting ecological sustainability in these manganese ore mines. These actions will not only help preserve the environment but also support the ongoing productivity of the mines without necessitating further land exploitation.

Water Use Pattern-

Mining can lead to significant water pollution. In manganese mining operations, chemicals used in processing, such as cyanide and sulfuric acid, can leach into water bodies, affecting water quality. For instance, in the Palaspani Mn Ore Mine, water contamination issues have been reported due to runoff from tailings ponds. In comparison, mines with stringent environmental controls may see lower levels of contamination, with water quality maintained within regulatory limits. The alteration of natural water flow patterns is another impact. Mining activities in Madhya Pradesh have led to changes in local hydrology, affecting stream flows and groundwater recharge. For

example, changes in streamflow patterns have been observed in areas surrounding the Ramrama Mn Ore Mine, leading to reduced water availability in nearby villages. In contrast, mines that incorporate effective water management strategies may experience less disruption to natural hydrological patterns.

Increased sedimentation from mining activities can degrade water quality. In the Kajlidongri Mn Ore Mine, sedimentation has been a notable issue, with increased siltation affecting local water bodies. Mines that implement erosion control measures, such as sedimentation ponds and vegetation cover, can mitigate sedimentation effects more effectively. For instance, well-managed mines may limit sedimentation to less than 5% of total runoff. Mining infrastructure can alter water courses, leading to changes in river and stream patterns. In the Palaspani Mn Ore Mine, infrastructure development has resulted in modifications to local water courses. Comparatively, operations that prioritize environmental impact assessments and design infrastructure to minimize water course alterations may experience less significant changes to local hydrology.

Resource depletion is a critical impact of mining. In manganese mining, the extraction of ore leads to the gradual depletion of mineral resources. For instance, the Kajlidongri Mn Ore Mine is experiencing decreasing ore grades as resources are exhausted. In contrast, mines with more advanced exploration and resource management techniques may achieve more sustainable extraction rates, with resource depletion occurring at a slower pace. The efficiency of mineral production can be affected by ore quality and processing techniques. In Madhya Pradesh, the presence of waste materials in ore can reduce production efficiency, leading to higher processing costs. For example, lower-grade ores from the Palaspani Mn Ore Mine may require more intensive processing compared to higher-grade ores in other regions. Mines with advanced processing technologies and better ore handling practices often achieve higher efficiency and lower costs. The costs associated with environmental compliance can impact the economics of mining operations. In regions with stringent regulations, such as Madhya Pradesh, mining companies may face higher costs for environmental management and remediation. For example, compliance with water and air quality regulations can add significant expenses. In contrast, mines in areas with less stringent regulations may face lower compliance costs but may also experience higher environmental risks. The Mining activity involve disturbance of water bodies available in subsurface and in rush water also water is essential for day to day activity for various purpose. The water utilisation pattern (WUP)

per tons of production for selected Manganese mine since last one decade is represented below in figure no.-

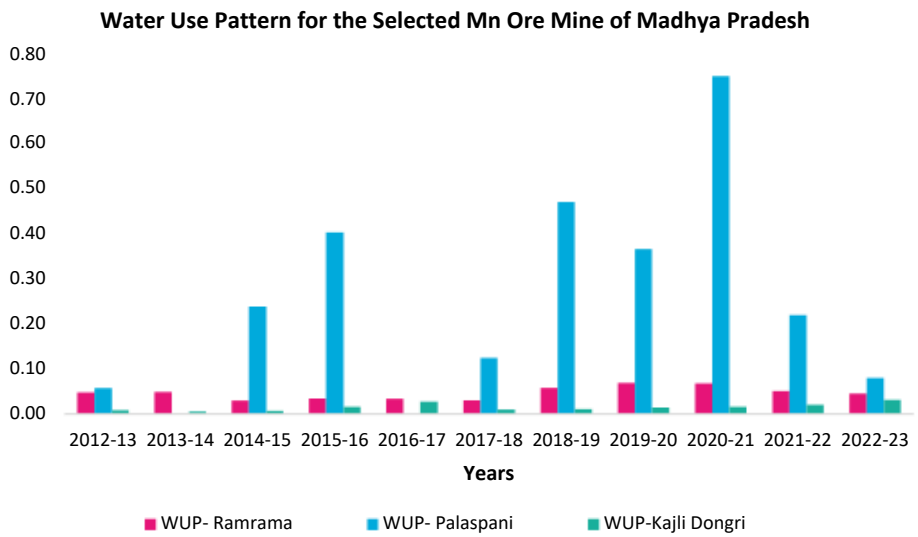


Figure no-: Comparison of Water use pattern (WUP) of selected Mn Ore Mine of Madhya Pradesh

In the case of the Ramrama Mn Ore Mine, the transition from opencast to underground mining has led to a noticeable decline in water utilization. This reduced demand for water is a direct consequence of the shift in mining methods, as underground operations typically require less water compared to their opencast counterparts. The trend indicates a more efficient use of water resources, aligning with the mine's evolving operational needs. Conversely, the Palaspani Mn Ore Mine is experiencing fluctuations in its water utilization patterns. These variations are largely attributed to the mine being in a transitional phase from opencast to underground mining. The challenges associated with this transition, particularly in maintaining consistent mineral production, have resulted in an irregular demand for water. This fluctuating pattern underscores the complexities involved in shifting mining methods and the associated impact on resource utilization.

At the Kajlidongri Mn Ore Mine, the trend in water utilization is moving in the opposite direction, with a noticeable increase. This rise in water demand is closely linked to the higher production rates achieved through continued opencast mining. As the mine intensifies its operations to boost output, the corresponding increase in water usage reflects the heightened demands of large-scale opencast production. This trend highlights the need for careful water management strategies as production scales up. As per the data analysis average 91.13 KL/month is consumed by Ramrama Mn Ore Mine where as

154.49 KL/Month and 759.27 KL/Month by Palaspani and Kajlidongri Mn Ore Mine.

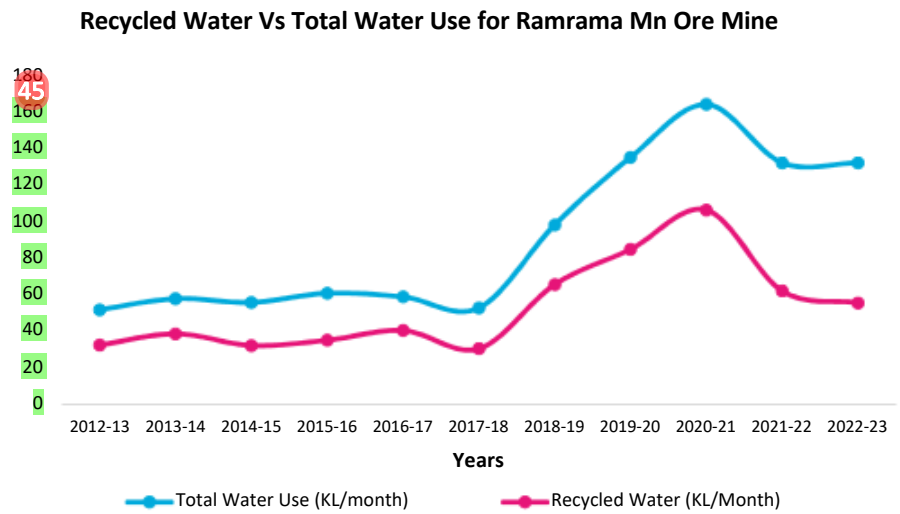


Figure no- Trend of recycled water and total water use of Ramrama Mn Ore Mine

As per the trend shown in figure no- yearly average 58.42% of total water used in last one decade is recycled and utilised. Ramrama Mn Ore Mine effectively recycles water through several key processes. One of the primary methods involves the use of sedimentation ponds, where runoff and process water are collected. These ponds allow solids to settle, resulting in clearer water that can be reused in various mining activities, such as dust suppression and drilling.

Additionally, the mine likely employs closed-loop systems, particularly in its underground operations. These systems capture and treat water used in drilling and cooling equipment, allowing it to be recycled within the mine. This approach significantly reduces the need for fresh water.

Water treatment facilities also play a crucial role in the mine's recycling efforts. These facilities treat water from mine drainage and other sources, removing contaminants and making the water suitable for reuse. This treated water is then reintegrated into the mine's operations.

Finally, the mine may supplement its water recycling efforts with rainwater harvesting. Collected rainwater is stored, treated, and used in the mine, further decreasing the reliance on external water sources. Through these methods, Ramrama Mn Ore Mine efficiently recycles water, supporting both operational needs and environmental sustainability.

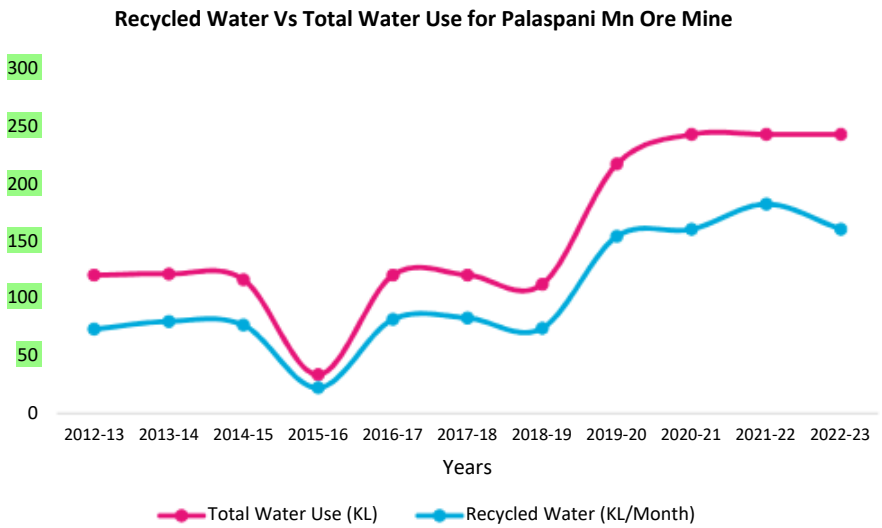


Figure no- Trend of recycled water and total water use of Palaspani Mn Ore Mine

At present, the Palaspani Mn Ore Mine has implemented several key procedures for water preservation and recycling, aimed at reducing its environmental footprint and ensuring sustainable mining operations. One of the primary strategies involves rainwater harvesting, where the mine collects significant amounts of rainwater during the monsoon season. This harvested water is stored in reservoirs and ponds, which helps reduce the mine's reliance on external water sources. The effectiveness of this approach is evident in the fact that a substantial percentage of the mine's water needs estimated at around 25% is met through rainwater harvesting. The mine also employs sedimentation ponds to manage and treat runoff and process water. These ponds are designed to allow suspended solids to settle, resulting in clearer water that can be reused within the mining operations. For example, in 2023, the sedimentation ponds treated approximately 40,000 cubic meters of water, which was subsequently reused for tasks such as dust suppression and drilling. This reuse of water helps minimize the need for fresh water, conserving vital resources.

In addition to these measures, the Palaspani Mn Ore Mine has developed systems for recycling process water used during ore washing and beneficiation. As per figure no- The mine recycles nearly 68% of the water used in these processes, which amounts to around 50,000 cubic meters annually. This recycled water undergoes treatment to remove contaminants before being reintegrated into the mine's operations, significantly reducing wastewater discharge.

Furthermore, the mine operates water treatment facilities that handle mine drainage and other contaminated water sources. These facilities employ advanced filtration and chemical treatment methods to purify water, ensuring it meets the quality standards required for reuse. In 2023, these facilities treated and recycled over 30,000 cubic meters of water, contributing to the mine's overall sustainability goals.

Lastly, the Palaspani Mn Ore Mine has adopted efficient water management practices to optimize water use. By closely monitoring water usage and implementing process optimizations, the mine has managed to reduce its overall water consumption by approximately 15% over the past five years. These efforts underscore the mine's commitment to preserving water resources while maintaining productive operations.

Through these comprehensive measures- ranging from rainwater harvesting to advanced water recycling and treatment- the Palaspani Mn Ore Mine not only ensures a sustainable water supply but also significantly mitigates its environmental impact.

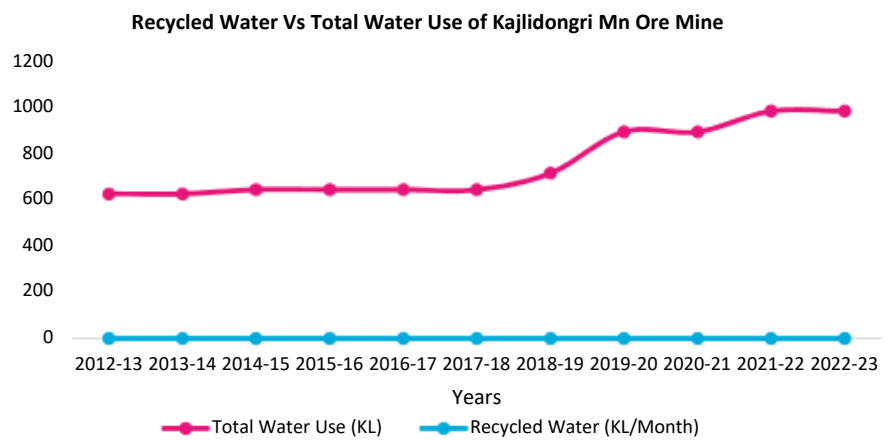


Figure no- Trend of recycled water and total water use of Kajlidongri Mn Ore Mine

According to Figure No.-, the Kajlidongri Mn Ore Mine currently lacks facilities dedicated to wastewater recycling. The existing practice for managing wastewater primarily involves accumulating in-rush water in sumps. These sumps serve as temporary storage for water that enters the mine during operations, particularly from natural sources such as rainfall or groundwater intrusion. Rather than undergoing any formal recycling or treatment process, the collected water is repurposed directly for dust control.

The mine utilizes this accumulated water by pumping it into water tankers, which are then used for sprinkling the water on roads and other areas within the mine. This practice is aimed at mitigating dust generation, a common issue in mining environments

that can have significant health and environmental impacts. By wetting the roads and reducing dust, the mine addresses one aspect of environmental management; however, the absence of a comprehensive wastewater recycling facility means that the water is not treated or reused in a more sustainable manner. This approach, while functional for dust control, indicates a gap in the mine's water management strategy. Without proper recycling facilities, the mine misses the opportunity to treat and reuse water more efficiently, potentially leading to higher water consumption and environmental impact in the long term. Implementing a structured wastewater recycling process could enhance sustainability and optimize water usage within the mine's operations.

The comparative study reveals significant insights into water usage practices across different manganese ore mines, particularly focusing on the recycling and subsequent allocation of water for various operational needs. At the Ramrama Mn Ore Mine, approximately 58.42% of the total water used annually is recycled, demonstrating a strong commitment to sustainable water management. Within this recycled portion, 8.61% is directed towards workshop and maintenance activities, ensuring the smooth functioning of machinery and equipment. Another 24.67% is allocated for agricultural purposes, supporting local farming initiatives and contributing to the community's livelihood. Additionally, 34.23% of the recycled water is used for dust suppression, a critical task in minimizing air pollution and maintaining air quality in and around the mining area. Furthermore, 28.46% is utilized for the maintenance of the green belt, which plays a vital role in enhancing the ecological balance by reducing carbon footprint and improving biodiversity. The remaining 3.54% is reserved for miscellaneous activities, covering various minor yet essential tasks that support overall mining operations.

In contrast, the Palaspani Mn Ore Mine demonstrates an even higher percentage of water recycling, with approximately 68% of its total water usage being recycled annually. A substantial 54.45% of this recycled water is utilized in the ore processing plant and workshops, highlighting the mine's focus on maintaining efficient production processes while conserving water resources. The mine also allocates 23.48% of its recycled water for agriculture and greenbelt development, underscoring its efforts to sustain environmental and community welfare. Dust suppression activities consume 18.26% of the recycled water, emphasizing the mine's commitment to controlling dust emissions and protecting the surrounding environment. The remaining 5.81% of recycled water is used for various miscellaneous purposes, ensuring that all operational needs are adequately met.

In the case of Kajlidongri Mn Ore Mine, the approach to water management is slightly different. Here, the direct use of accumulated water is primarily employed for dust suppression, indicating a focused strategy on minimizing dust-related environmental impacts. This practice highlights the mine's immediate response to controlling dust pollution, though it does not emphasize recycling as much as the other two mines.

This comparative study underscores the varying strategies employed by the mining industry in utilizing water resources, reflecting a broader effort to balance ecological preservation with the demands of mining operations. By analysing these different approaches, the study sheds light on how each mine contributes to reducing environmental pollution while optimizing resource use, thus playing a crucial role in sustainable mining practices.

Ore Production & Waste Generation Pattern-

Strategic production of manganese (Mn) ore and the efficient removal of overburden (OB) are fundamental to the operational planning of Ramrama Mn Ore Mine, Palaspani Mn Ore Mine, and Kajlidongri Mn Ore Mine. Each mine has adopted distinct strategies tailored to their unique geological conditions and deposit characteristics, which are critical in optimizing ore extraction and managing waste generation. These strategies not only ensure continuous production but also aim to minimize environmental impact, a key concern in modern mining practices.

In the Ramrama Mn Ore Mine, the production pattern over the last decade reveals a sustainable increase, largely attributed to a strategic shift from opencast to underground mining. This transition has enabled the mine to tap into deeper ore deposits, leading to a more stable and consistent production rate. The underground mining approach, while more complex, has allowed for better management of overburden, reducing surface disruption and contributing to a more environmentally friendly operation. The sustained increase in production at Ramrama reflects the success of this strategic transition, highlighting the importance of adapting mining methods to the evolving geological and economic conditions.

Conversely, the Palaspani Mn Ore Mine has experienced significant fluctuations in its production pattern over the same period, primarily due to the absence of a consistent strategic plan. The production data reveals periods of zero output, notably in the financial years 2013-14 and 2016-17, indicating potential operational challenges or interruptions. The lack of a sustained production trend suggests that the mine may have faced

difficulties in managing ore extraction and overburden removal efficiently. This inconsistency in production highlights the critical need for robust strategic planning to ensure continuous and predictable mining operations, which are essential for both economic viability and environmental stewardship.

In contrast, the Kajlidongri Mn Ore Mine has demonstrated a remarkable increase in production, with rates doubling or even tripling over the past decade. This growth can be attributed to the continuous production from its opencast operations. The scale of mining in the opencast setting has expanded significantly, allowing the mine to overcome potential constraints related to production and area. The large-scale handling of both ore and overburden in the opencast environment has become a non-issue, enabling the mine to maintain high production rates without being hindered by spatial limitations. This steady and robust production pattern at Kajlidongri underscores the effectiveness of large-scale opencast mining in maximizing resource extraction.

The production patterns observed across the three manganese ore mines- Ramrama, Palaspani, and Kajlidongri- illustrate the diverse approaches and outcomes resulting from their strategic planning and operational execution. As depicted in Figure no-, each mine presents a unique case study, offering valuable insights into how geological characteristics and operational decisions can significantly impact the success of mining ventures. The differing experiences of these mines underscore the importance of effective management in ensuring that production not only remains consistent but also aligns with environmental sustainability and economic viability.

A critical aspect of this management involves the strategic transition from opencast to underground mining methods. This shift is pivotal, as it fundamentally alters the sustainability and economic dynamics of the operation cycle. One of the key changes associated with this transition is the ratio of overburden to ore production. As mining moves underground, the volume of overburden decreases, leading to a more efficient use of space for overburden storage. This optimization reduces the environmental footprint of the mining operations, minimizing the area required for waste disposal.

Furthermore, the transition to underground mining brings additional environmental benefits. The emission of pollutants and influent gases, which are more prevalent in opencast mining, is significantly reduced in underground operations. This not only helps in lowering the environmental impact but also contributes to better compliance with environmental regulations. Overall, these strategic shifts are crucial for maintaining consistent production patterns and enhancing productivity. By carefully managing the

transition and addressing both geological and operational factors, mining ventures can achieve greater sustainability and economic success.

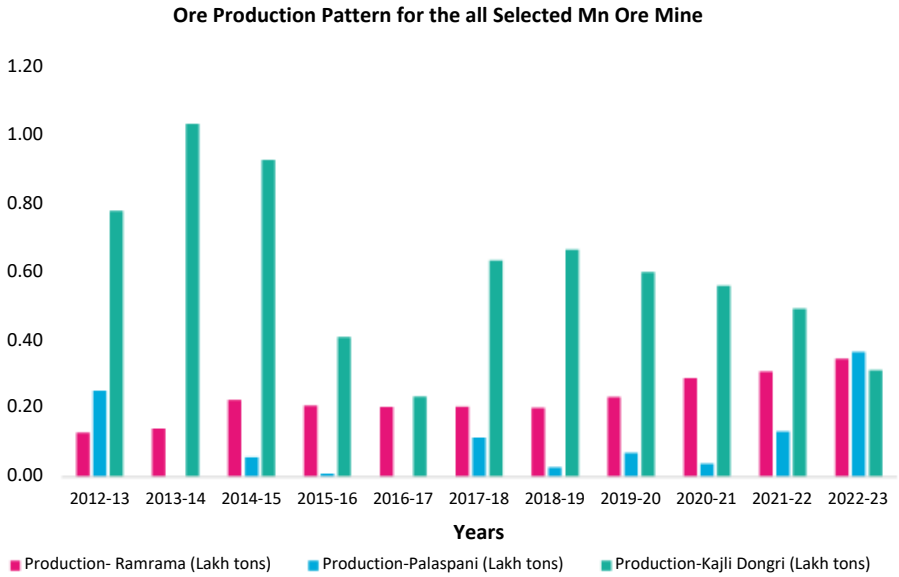


Figure- Comparison of Ore Production Pattern of the all selected Mn Ore Mine

As illustrated in Figure No-1, the strategic transition of the Ramrama Mn Ore Mine from opencast to underground mining has led to positive production trends, demonstrating the effectiveness of this shift. The data shows that despite the significant change in mining methodology, the production of ore at Ramrama has remained stable, without any noticeable decline. This outcome highlights the success of careful strategic planning in maintaining production levels even amidst substantial operational changes. In contrast, the Palaspani Mn Ore Mine has experienced considerable fluctuations in its production trends over the past decade. The inconsistency in output can be attributed to several factors, most notably the significant increase in the handling of overburden (OB). The higher ratio of OB handling has adversely impacted the mine's production efficiency, leading to a decline in the overall production trend. This situation underscores the challenges that can arise when the balance between overburden management and ore extraction is not adequately maintained.

Meanwhile, the Kajlidongri Mn Ore Mine, which continues to operate exclusively using the opencast method, has maintained a relatively high ore production rate compared to the other two mines. However, it is important to note that since 2018-19, there has been a noticeable decline in production at Kajlidongri. This downturn is primarily due to an

increase in the stripping ratio, which has made ore extraction more challenging and less efficient. The rising stripping ratio has led to a decrease in the mine's productivity, emphasizing the impact that changes in operational parameters can have on long-term production trends. It is important to understand the OB handling pattern of each mine as it reflects amount of handling to be perform for achieving production and need of transition.

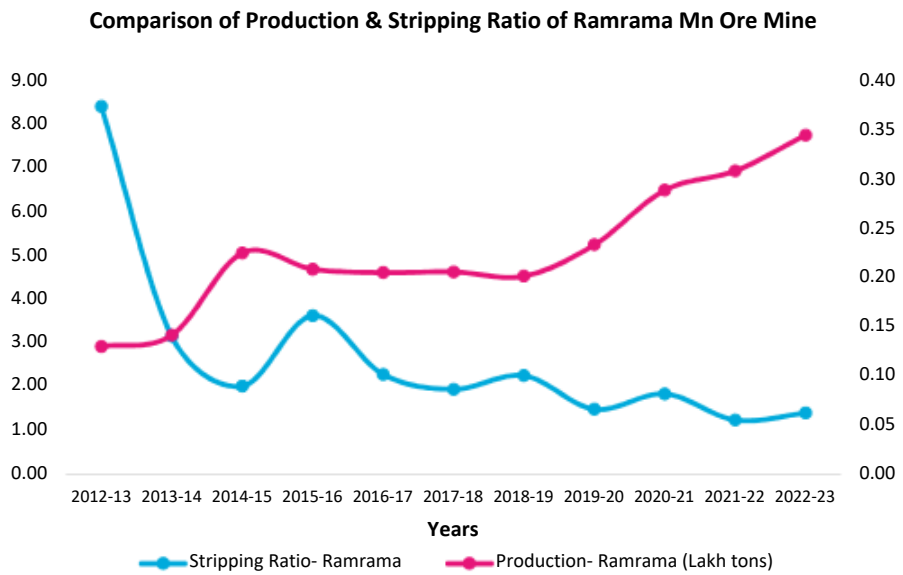


Figure no-: Comparison of Production & Stripping Ratio of Ramrama Mn Ore Mine

Based on Figure no-, it is evident that Ramrama Mn Ore Mine has experienced a notable shift from opencast to underground mining methods, contributing to a discernible upward trajectory in production levels. This strategic transition has proven beneficial, as indicated by the positive trend observed in production figures. Concurrently, there has been a noteworthy decline in the stripping ratio over the same period. This reduction in stripping ratio can be attributed to the operational focus of underground mining, which emphasizes mineral extraction while minimizing the removal of surrounding waste material from footwalls and hang walls. This approach optimizes resource utilization by targeting ore

bodies more directly, thereby enhancing efficiency in mineral recovery processes.

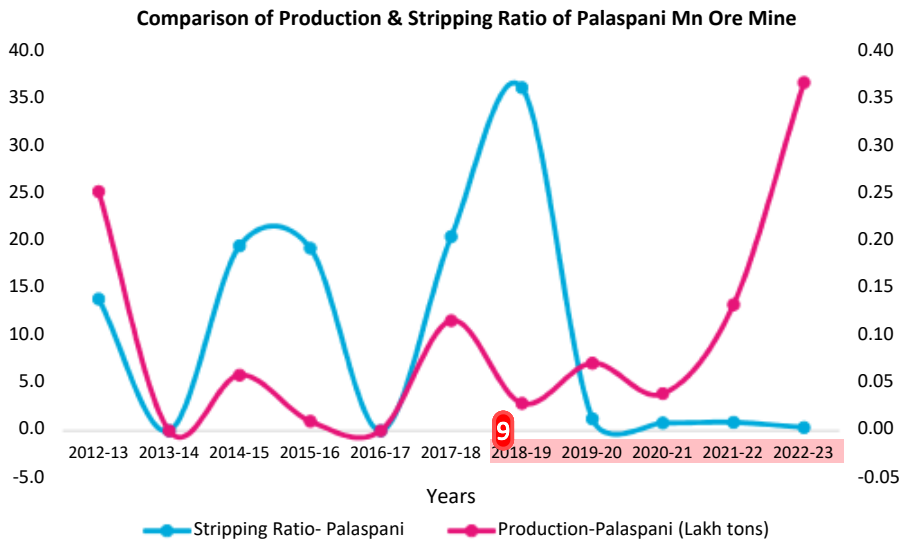


Figure no-: Comparison of Production & Stripping Ratio of Palaspani Mn Ore Mine

Referring to figure no.-, it is evident that the stripping ratio at Palaspani Mn Ore Mine exhibited significant variability from 2012 to 2019. This fluctuation was primarily driven by the production activities from the opencast mine and the initial stages of underground development work. Following 2019, a noticeable shift occurred, with production levels demonstrating an increasing trend while the stripping ratio began to decline as mining operations transitioned to underground methods. The observed variation in stripping ratio also highlights the economic implications of the mining operations during this period. Specifically, the data suggests that during the earlier years, a relatively low production output was achieved despite handling a substantial amount of overburden (OB). This scenario underscores the inefficiency and higher costs associated with extensive OB removal in the opencast mining phase.

To mitigate these challenges, it is essential that the transition from opencast to underground mining be meticulously planned. By doing so, the costs and volumes associated with OB handling can be significantly reduced. Moreover, the volume of OB that is handled requires storage space, which can lead to the degradation of the natural landscape. The shift to underground mining not only reduces the volume of OB needing storage but also results in a positive trend in production, as it allows for more efficient

extraction of ore without the extensive removal of non-valuable material.

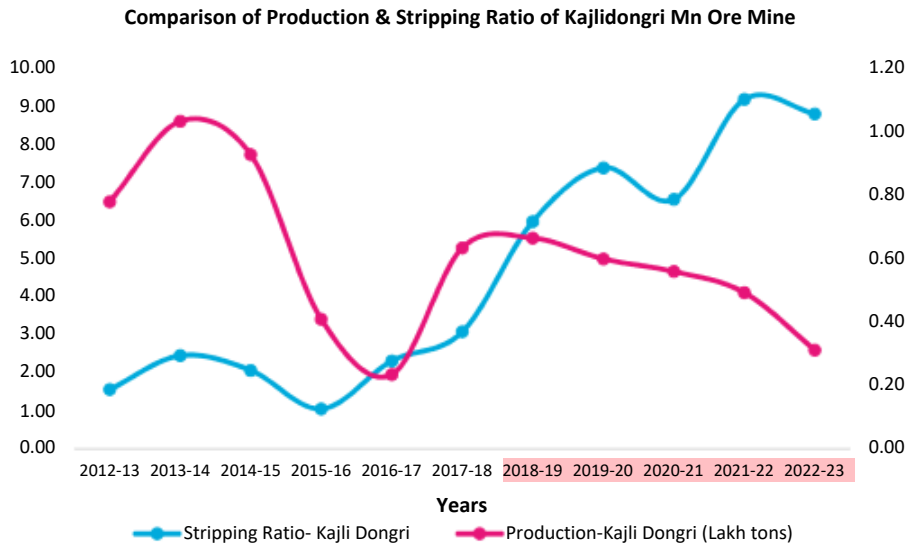


Figure no-: Comparison of Production & Stripping Ratio of Kajlidongri Mn Ore Mine

Referring to Figure No. X, it becomes apparent that the increasing depth of the opencast mine has led to a decrease in production volume, which in turn has resulted in a higher stripping ratio. This trend is particularly noticeable in the years following 2016. From 2012 to 2016, production levels were robust, and the ratio of production to overburden (OB) handling was favourable. During this period, the mine's output was substantial relative to the volume of OB removed, reflecting a relatively efficient operation. However, starting from 2017, a shift occurred wherein the stripping ratio began to rise, accompanied by a decline in production. This change indicates that as the mine deepened, the extraction of ore became more challenging and less economically viable under the existing opencast mining methods. The higher stripping ratio suggests that a greater volume of OB had to be removed to access the ore, driving up costs and reducing the overall efficiency of the operation.

Given these developments, it is crucial to strategically plan the transition from opencast to underground mining. Such a shift would likely lead to a reduction in production costs compared to continuing with opencast operations at greater depths. Additionally, underground mining typically results in a lower stripping ratio, as it focuses on ore extraction with minimal removal of non-valuable material. This reduction in OB handling would also lessen the demand for land required for the storage of waste material, thereby alleviating some of the environmental burdens associated with large-scale surface

mining. Therefore, moving towards underground mining presents a more sustainable and cost-effective approach as the mine continues to deepen.

"Through a comparative study, it becomes evident that a strategic transition from opencast to underground mining can significantly reduce operational costs while also minimizing the environmental impact associated with surface mining. The transition is particularly beneficial as it curtails the extensive land disturbance that typically accompanies opencast operations, where large areas of natural landscape are disrupted to access ore bodies. In making this transition, the production levels and stripping ratio serve as critical indicators that must be closely monitored. A rising stripping ratio, often accompanied by declining production as the mine deepens, signals the increasing inefficiency and higher costs of continuing with opencast methods. These metrics should inform the decision to shift to underground mining, where the focus on targeted ore extraction leads to lower stripping ratios and more sustainable operations.

Ultimately, the key to a successful transition lies in timely and data-driven decision-making. By continually assessing production efficiency and environmental impact through these indicators, mining operations can optimize their approach, balancing economic viability with environmental stewardship."

Energy Dimension-

In this dimension, the focus is on studying the effectiveness and optimization of critical resources such as electrical energy, high-speed diesel (HSD) consumption, and the use of explosives in manganese ore mining. By analysing these factors, the goal is to identify opportunities for improving operational efficiency and sustainability in mining activities across Madhya Pradesh. The study involves comparing various mining operation-related data to pinpoint areas where resource use can be optimized. For instance, reducing electrical energy consumption and optimizing HSD usage can lead to significant cost savings and lower environmental impact. Similarly, the careful management and optimization of explosive use are essential to ensure safety, minimize waste, and reduce the overall environmental footprint of mining operations.

Through this comparative analysis, the research aims to uncover the key factors that contribute to making manganese ore mining more sustainable in the region. By implementing the insights gained from this study, mining operations can enhance their

efficiency, reduce resource consumption, and ultimately contribute to a more sustainable approach to mining in Madhya Pradesh.

Electrical Energy Use Pattern-

The pattern of electrical energy use in manganese mining in Madhya Pradesh holds significant importance for both operational efficiency and environmental sustainability. Mining operations are energy-intensive, requiring substantial amounts of electrical power for various activities, including drilling, crushing, and transporting ore. Understanding and optimizing the energy use pattern is crucial for several reasons. Firstly, efficient use of electrical energy directly impacts the cost-effectiveness of mining operations. Energy costs constitute a major portion of the overall operational expenses in mining. By analysing energy consumption patterns, mining companies can identify areas where energy is being wasted or used inefficiently. Implementing energy-saving measures can lead to substantial cost reductions, making the mining process more economically viable. Secondly, optimizing electrical energy use is essential for reducing the environmental impact of mining activities. High energy consumption not only depletes natural resources but also contributes to greenhouse gas emissions, especially if the energy is sourced from non-renewable sources. By focusing on energy efficiency, mining operations can reduce their carbon footprint and contribute to environmental conservation efforts. This is particularly important in regions like Madhya Pradesh, where mining activities can have significant ecological consequences.

Lastly, the pattern of electrical energy use is a critical factor in ensuring the long-term sustainability of manganese mining in the region. As the demand for manganese continues to grow, it becomes increasingly important to manage energy resources efficiently to avoid potential shortages and ensure the continuous operation of mines. A well-optimized energy use pattern not only supports the immediate needs of mining operations but also contributes to the sustainable development of the mining sector in Madhya Pradesh. To gain insight into the pattern of electrical energy use for the selected mine in Madhya Pradesh, it is essential to analyse the consumption of energy in relation to ore production. By calculating the energy consumption per ton of ore produced, a clear understanding of how efficiently electrical energy is being utilized within the mining operations can be developed. This analysis allows for the identification of trends, potential inefficiencies, and areas where energy use can be optimized, ultimately contributing to more cost-effective and sustainable mining practices.

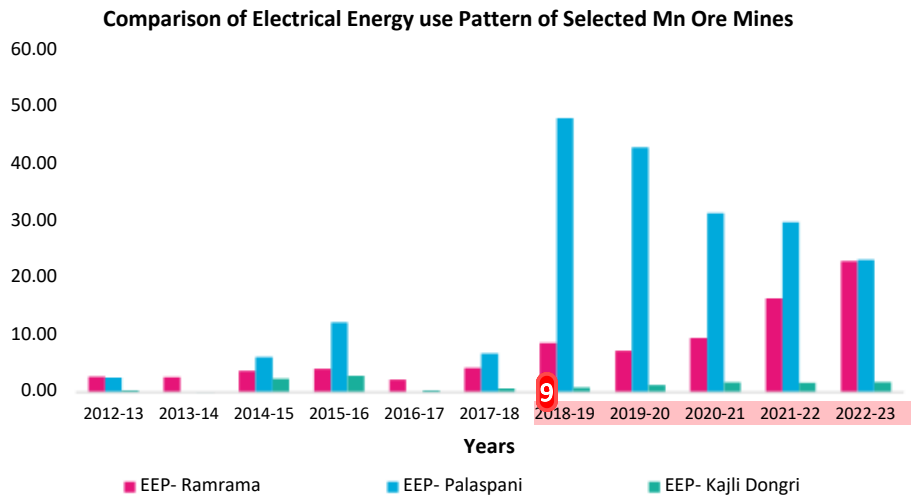


Figure no-: Comparison of Electrical Energy use Pattern of Selected Mn Ore Mines of Madhya Pradesh

At Ramrama Mn Ore Mine, there has been an increasing trend in electrical consumption per ton of ore produced, largely due to the mine's transition from opencast to underground operations. This shift has necessitated greater use of electrical energy to power the various underground systems, including equipment, ventilation, and illumination. The deeper the mine goes, the more energy is required to support these critical functions, which explains the rise in energy consumption per ton of ore. In contrast, Palaspani Mn Ore Mine has experienced fluctuations in electrical energy consumption on a per-ton basis. These variations are linked to the ongoing development work and the mine's gradual transition towards underground mining. The use of electrical energy at Palaspani is not only for basic operations but also for powering the underground equipment and maintaining adequate ventilation. The variability in these factors, depending on the stage of development, results in the observed inconsistencies in energy consumption. Meanwhile, at Kajlidongri Mn Ore Mine, which continues to operate as an opencast mine, electrical power consumption per ton of ore remains steady. Unlike underground operations, where significant energy is required to maintain safe and efficient working conditions, opencast mining primarily requires electrical energy for illumination during dark hours. As a result, the energy consumption pattern at Kajlidongri is relatively stable, reflecting the less intensive energy demands of surface mining operations.

According to the Central Electricity Authority of India's annual report, the recorded carbon emission rate is 0.82 kilograms of CO2 per kilowatt-hour (kWh) of electricity consumed. When applying this metric to the Selected Mn Ore Mine, the

environmental impact can be assessed in terms of carbon emissions for both underground (UG) and opencast mining operations.

For the underground mining operations at Ramrama & Palaspani, where electrical energy consumption tends to be higher due to the need for powering ventilation systems, underground equipment, and extensive illumination, the CO_2 emissions per kWh are directly proportional to the amount of energy consumed. This results in a higher overall carbon footprint for the underground mining activities.

In contrast, the opencast mining operations at Kajlidongri, which typically require less electrical energy primarily for tasks such as illumination during non-daylight hours, would produce comparatively lower CO_2 emissions per kWh consumed. However, even with lower energy requirements, the CO_2 emissions are still calculated at the same rate of 0.82 $kgCO_2/kWh$, underscoring the importance of energy efficiency in minimizing environmental impact across both types of mining operations. The study of CO2 emissions is crucial in understanding the contribution of mining operations to the greenhouse effect and in developing effective mitigation strategies. Mining activities, particularly those that are energy-intensive, are significant sources of carbon dioxide emissions, which are a major driver of climate change. By analysing the levels of CO2 generated during various stages of mining, from the extraction of ore to the operation of machinery and ventilation systems, it is possible to quantify the environmental impact of these activities. Understanding the extent of CO2 emissions allows for a more accurate assessment of the mining sector's role in contributing to global warming. This knowledge is essential for policymakers, environmental scientists, and mining companies themselves as they work to reduce the carbon footprint of mining operations. By identifying the specific processes that contribute most to CO2 emissions, targeted mitigation measures can be conceptualized and implemented.

Such measures might include improving energy efficiency, transitioning to renewable energy sources, or adopting carbon capture technologies. Additionally, understanding CO2 emissions helps in setting realistic and science-based targets for reducing greenhouse gases in the mining sector. Ultimately, studying CO2 emissions not only highlights the environmental challenges posed by mining but also paves the way for sustainable practices that align with global efforts to combat climate change. The trend of CO2 emission per KWh electricity consumption is represented below in figure no-

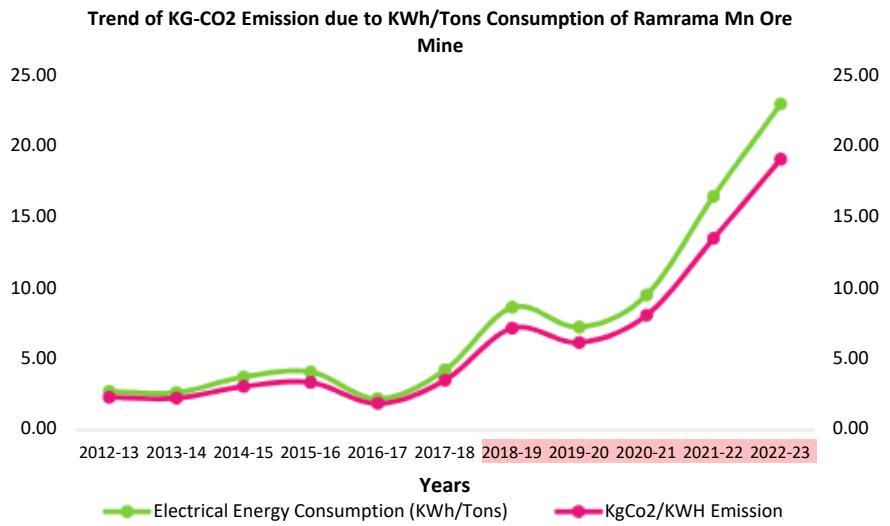


Figure- Trend of KG-CO2 Emission due to KWh/Tons Consumption of Ramrama Mn Ore Mine

In the case of underground (UG) mining operations in Ramrama Mn Ore Mine, there has been an observed increase in CO2 emissions, largely due to higher production rates and the substantial electricity consumption required for activities such as ventilation and artificial illumination for both day and night shifts. To address this issue and mitigate the associated carbon footprint, a solar power generation system has been installed, which produces 4,145 kWh of energy per day. This system incorporates bi-facial solar modules, which are designed to maximize energy capture by utilizing light reflected from the ground, enhancing overall efficiency. Under the current Net Metering Regulation Act of 2015, the average daily electricity billing stands at 6,655 kWh. By integrating solar power into the energy mix, the mining operation has successfully reduced its dependency on grid electricity. This shift to green energy has led to a significant reduction in CO2 emissions, with an estimated decrease of approximately 3,800 kg of CO2 per day. This reduction is comparable to the environmental benefit of planting around 2,500 trees, highlighting the positive impact of adopting renewable energy sources on both operational costs and environmental sustainability.

At Palaspani Mn Ore Mine, the pattern of electrical energy consumption has shown significant changes over the years. Since 2017, there has been an increase in electricity consumption per ton of ore produced, largely driven by the ongoing development of underground infrastructure. This increase is attributed to the continuous demand for power needed to support ventilation systems, operate machinery, and provide

illumination for the underground workings. From 2017 to 2021, a decline in the per-ton energy consumption was observed. This decrease was due to a period of steady activity in underground development, where energy requirements stabilized as the infrastructure reached a more consistent operational phase. However, it is anticipated that once the full development of underground infrastructure is completed, there will be a resurgence in energy demand. The continuous operation of the fully developed underground mine will again lead to higher power consumption, as the need to maintain efficient ventilation, machinery, and lighting remains critical. The trend of KgCO2 emission due to KWh/tons Consumption for Palaspani Mn Ore Mine is represented below in Figure no-

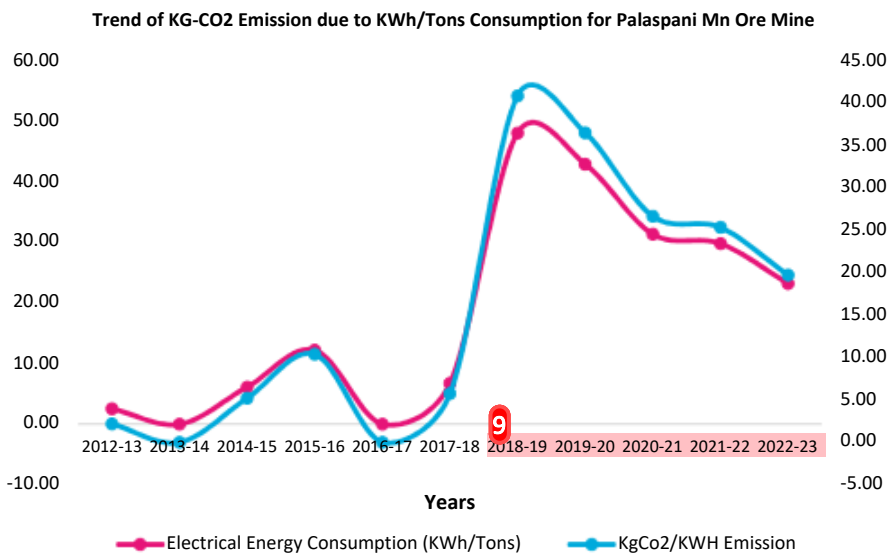


Figure no-: Trend of KG-CO2 Emission due to KWh/Tons Consumption of Palaspani Mn Ore Mine

To address this anticipated increase in energy demand and to mitigate greenhouse gas emissions, it is advisable for Palaspani Mn Ore Mine to integrate solar power with the existing power grid. By installing a solar power system, the mine can reduce its reliance on conventional energy sources, thus decreasing its carbon footprint. This shift to renewable energy not only supports environmental sustainability but also helps in managing operational costs effectively as the mine transitions to continuous and intensified underground operations.

At Kajlidongri Mn Ore Mine, the steady nature of electrical energy consumption per ton of ore produced is a direct result of its continued operation as an opencast mine. Unlike underground mining, which demands substantial energy for ventilation, illumination, and machinery, opencast mining involves comparatively lower power

requirements. The energy consumed in daily operations primarily supports illumination during non-daylight hours and the operation of basic equipment, which results in a more consistent and manageable level of energy use.

This relatively low and stable energy consumption translates to a consistent output of CO2 emissions per ton of ore produced. The minimal fluctuation in electrical energy use reflects the straightforward nature of opencast mining operations, where energy demands do not vary significantly from day to day. Consequently, the steady power consumption helps maintain a stable rate of CO2 emissions, highlighting the operational efficiency of the mine in managing its energy and environmental impact. The trend of KgCO2 emission due to KWh/tons Consumption for Kajlidongri Mn Ore Mine is represented below in Figure no-

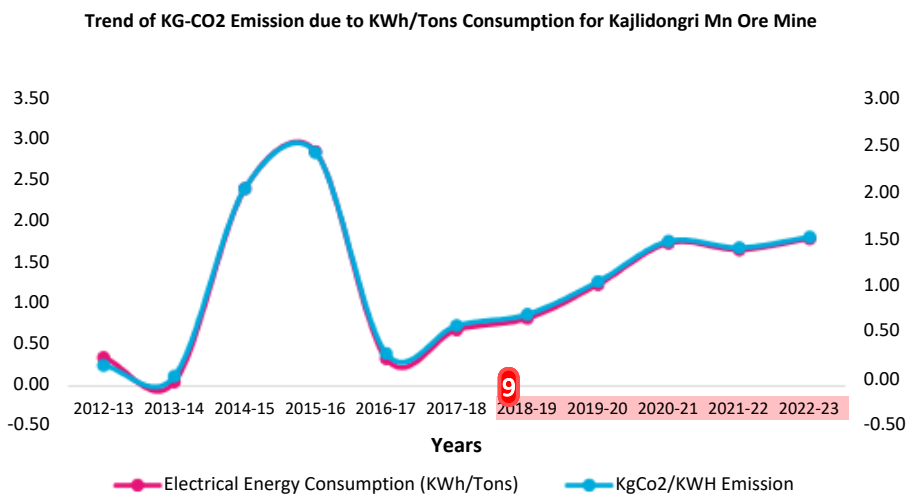


Figure no-: Trend of KG-CO2 Emission due to KWh/Tons Consumption of Kajlidongri Mn Ore Mine

To mitigate the impact of greenhouse gas emissions, the selection of renewable energy sources is essential for balancing pollution and achieving effective environmental management in daily mining operations. Renewable energy plays a crucial role in reducing the carbon footprint of mining activities by providing cleaner alternatives to traditional fossil fuels. By integrating renewable energy solutions such as solar, wind, or hydropower into mining operations, companies can significantly lower their greenhouse gas emissions, thereby contributing to a more sustainable mining practice. Incorporating renewable energy helps address the environmental burden associated with conventional energy sources, which are often responsible for high levels of carbon dioxide and other pollutants. For instance, solar power can reduce reliance on grid electricity derived from

fossil fuels, while wind and hydropower can provide additional clean energy options. This shift not only helps in reducing emissions but also in managing energy costs more effectively.

Furthermore, the use of renewable energy supports long-term sustainability by promoting cleaner and more efficient energy consumption. It enables mining operations to align with global efforts to combat climate change, improving their environmental credentials and meeting regulatory requirements. By selecting and implementing renewable energy solutions, mining companies can enhance their operational efficiency while minimizing their environmental impact, thus achieving a balance between production demands and pollution control.

HSD Consumption Pattern-

In the case of Ramrama Mn Ore Mine, the shift from opencast mining to underground mining has significantly altered the energy consumption dynamics. The transition has led to a reduced reliance on high-speed diesel (HSD)- powered equipment for excavation and transportation. As production from opencast mining has drastically decreased, so has the consumption of HSD, since the new underground operations predominantly utilize electrical power. The underground mining equipment operates primarily on electricity, which has diminished the overall need for HSD. However, diesel generators (DG sets) are still maintained as backup power sources to ensure reliability and flexibility during emergencies, which are crucial for the uninterrupted functioning of underground mining operations. Conversely, at Palaspani Mn Ore Mine, the move from opencast to underground mining has increased the dependency on HSD-based power, particularly for diesel generators used as backup power. This increased reliance on diesel for emergency power needs contributes to higher HSD consumption and, consequently, more greenhouse gas emissions.

At Kajlidongri Mn Ore Mine, the situation is different as the entire mining operation relies on HSD-powered equipment. This extensive use of diesel equipment results in higher greenhouse gas emissions compared to operations that utilize electrical power or renewable energy sources. The continued dependence on HSD not only impacts the environment through increased emissions but also highlights the need for exploring alternative energy solutions to mitigate the environmental footprint of mining activities. The trend of HSD consumption in various activity for all three selected mines are represented below-

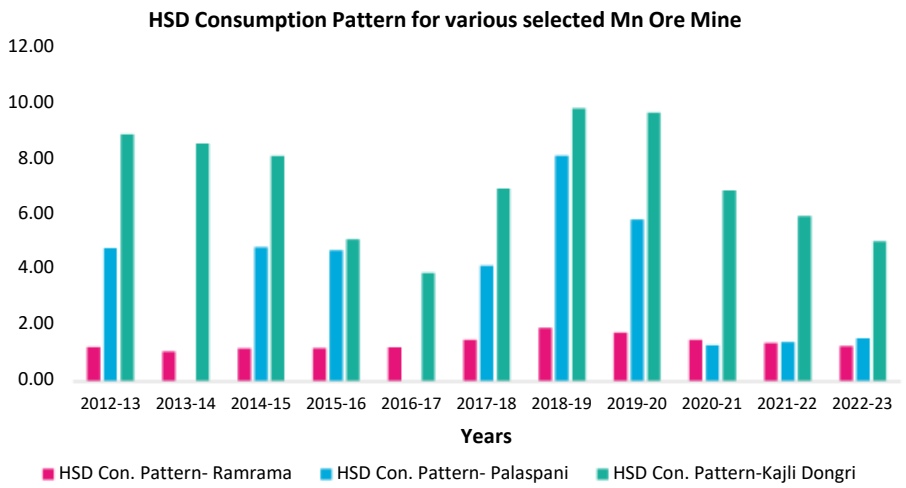


Figure-: HSD Consumption pattern in various activity of all three selected Mn Ore Mine

As illustrated in **figure no-,** the HSD (High-Speed Diesel) consumption for the Ramrama Mn Ore Mine has ranged between 1.08 liters per ton to 1.50 liters per ton over the years. On average, the HSD consumption stands at 1.39 liters per ton. This relatively low average can be attributed to a strategic transition from opencast to underground mining methods. The shift has reduced the mine's reliance on HSD-powered equipment, as the underground operations demand less energy from such sources. Currently, HSD is primarily used for power backup in electricity generation, and the trend over the last decade shows a consistent decline in HSD consumption, highlighting the mine's increasing energy efficiency and reduced dependency on diesel-based operations.

In contrast, the Palaspani Mn Ore Mine has experienced significant fluctuations in HSD consumption over the past decade. This variation is due to the mine's mixed mode of production, which involves both opencast and underground mining. The trend data indicates a notable decrease in HSD demand starting from 2020, coinciding with the development and increased reliance on underground mining. The consumption of HSD at Palaspani has ranged from 1.30 liters per ton to 4.81 liters per ton, with an average of 3.34 liters per ton. As the mine transitions fully to underground operations, it is anticipated that HSD consumption will continue to decline in the coming years. On the other hand, the Kajlidongri Mn Ore Mine exhibits significantly higher HSD consumption compared to the other two mines studied. This higher consumption is directly linked to the mine's complete dependence on the opencast method of mining. In Kajlidongri, production is entirely achieved using HSD-powered equipment, which explains the

substantial diesel usage. The data underscores the heavy reliance on diesel in opencast mining, contrasting with the more energy-efficient methods being adopted at the Ramrama and Palaspani mines.

As per International Conference on Green and Ubiquitous Technology (GUT), the Burning one liters of diesel fuel produces 2.67 kg of CO_2, the relative $KgCO_2$ emission for the HSD Consumption by all three selected Mn Ore producing mines is represented to understand the impact and contribution to green house gas generation from mining operation in last one decade as illustrated in figure no-

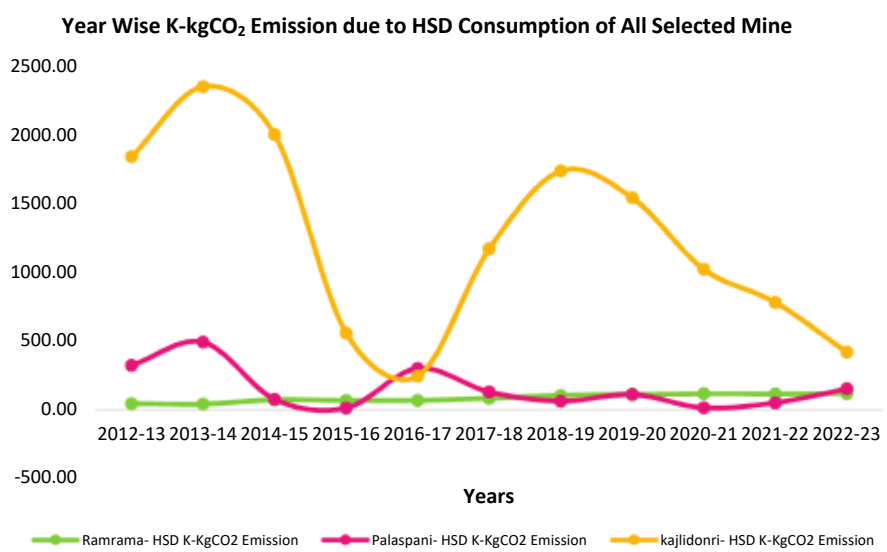


Figure no- Year Wise K-kgCO_2 Emission due to HSD Consumption of All Selected Mine

It has been revealed that the average carbon dioxide (CO2) generation per litre of HSD consumed at the Ramrama Mn Ore Mine is approximately 85.21 K-KgCO2. In comparison, the Palaspani Mn Ore Mine produces about 156.81 K-KgCO2 per litre of HSD consumed, reflecting a higher carbon footprint due to its operational characteristics. The Kajlidongri Mn Ore Mine, however, has the highest average CO2 generation, with a staggering 1248.05 K-KgCO2 per litre of HSD consumed. This significant difference in CO2 emissions is largely attributable to the varying degrees of dependency on HSD-powered equipment and the mining methods employed at each site.

To mitigate the environmental impact and reduce the carbon footprint associated with these emissions, it is crucial to implement compensatory measures, such as afforestation. At the Ramrama Mn Ore Mine, it is estimated that planting at least 57 trees annually

would be necessary to offset the CO2 generated. Similarly, the Palaspani Mn Ore Mine would need to plant around 104 trees each year to counterbalance its higher emissions. For the Kajlidongri Mn Ore Mine, the situation is more severe, necessitating the plantation of approximately 821 trees annually. This calculation assumes that one tree can absorb about 1.52 kilograms of CO2, highlighting the substantial effort required to achieve carbon neutrality in these mining operations. Implementing such afforestation initiatives not only helps in reducing the carbon footprint but also contributes to enhancing the local ecosystem and promoting environmental sustainability in the mining regions.

Explosive Consumption Pattern-

The use of explosives in mining operations, particularly at the Ramrama Mn Ore Mine, Palaspani Mn Ore Mine, and Kajlidongri Mn Ore Mine, significantly contributes to environmental pollution and presents challenges to sustainability. Each of these mines, with their unique operational characteristics, illustrates the various ways in which explosive energy impacts the environment, from air and water pollution to ecosystem disruption. At the Ramrama Mn Ore Mine, the controlled use of explosives has been integral to transitioning from opencast to underground mining methods. However, even with this strategic shift, the detonation of explosives generates carbon dioxide (CO_2) emissions, which contribute to global warming. The CO_2 emissions from explosive use add to the mine's overall carbon footprint, complicating efforts to align with sustainable practices. Beyond CO_2, the detonation process releases nitrogen oxides (NOx) and particulate matter, contributing to air pollution. These pollutants not only degrade air quality but also pose health risks to workers and surrounding communities. In response, Ramrama Mn Ore Mine has initiated efforts to mitigate these impacts through improved blast planning and afforestation projects, which help offset some of the CO_2 emissions.

Palaspani Mn Ore Mine, which still utilizes a combination of opencast and underground mining, faces more significant challenges in managing the environmental impacts of explosive use. The mixed operational methods result in higher fluctuations in emissions and particulate matter release, particularly when explosives are used in the opencast sections of the mine. The generation of harmful gases and dust particles during blasting operations affects air quality, contributes to noise pollution, and disrupts local ecosystems. In particular, the use of explosives exposes sulphide minerals, leading to the potential for acid mine drainage (AMD). This process can contaminate local water

sources, further complicating sustainability efforts. To counter these challenges, Palaspani Mn Ore Mine has been exploring the use of lower-emission explosives and enhancing its environmental monitoring and mitigation strategies, including water treatment and dust suppression technologies.

Kajlidongri Mn Ore Mine, which relies heavily on opencast mining, faces significant sustainability challenges due to its extensive use of explosives. This practice results in substantial CO2 emissions, far surpassing those of the Ramrama and Palaspani mines. The mine's heavy dependence on diesel-powered equipment, combined with explosive use, exacerbates air pollution and increases its carbon footprint. The frequent blasting also causes pronounced physical impacts, such as landscape alteration and habitat destruction, which degrade the local environment and disrupt wildlife. To mitigate these issues, Kajlidongri Mn Ore Mine must embrace more sustainable practices. This could include transitioning to underground mining, implementing comprehensive land rehabilitation programs, and planting more trees to offset the high CO2 emissions. Across Ramrama, Palaspani, and Kajlidongri mines, the sustainability challenges linked to explosive use are clear. Each mine needs to tackle its specific environmental impacts, from managing emissions and noise pollution to preventing soil and water contamination. Implementing strategies like using low-emission explosives, improving blast efficiency, and committing to reforestation is crucial for reducing the environmental impact of these mining operations. By prioritizing these efforts, the three mines can move towards more sustainable practices, balancing the need for resource extraction with the goal of preserving the environment. The trend of efficient use of explosive shown for last one decade in figure no-

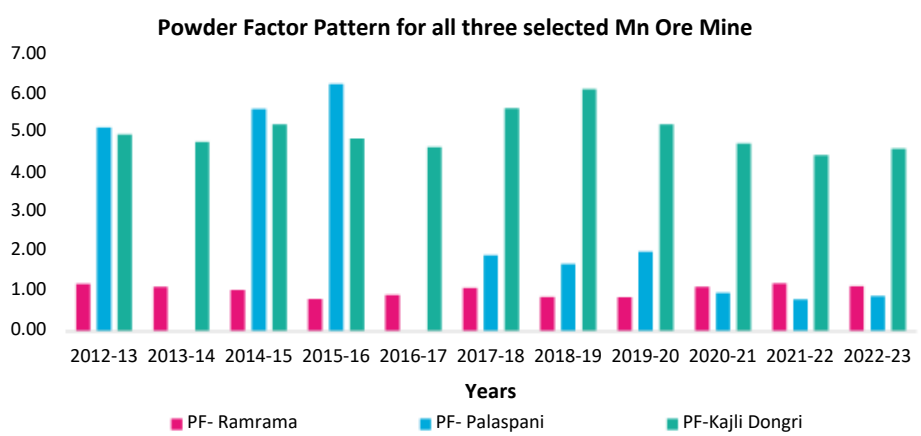


Figure- Year wise PF of all Selected Mn Ore Mine for last one decade

With reference to figure no-, the analysis reveals distinct trends in powder factor (PF) across the examined mines over the past decade. At Ramrama Mn Ore Mine, the data shows a variation where the maximum PF recorded is 1.22 and the minimum is 0.82, resulting in an average PF of 1.04. This indicates a consistent use of explosives in ore extraction processes, reflecting operational stability and possibly a standard approach to mining practices over the years. In contrast, Palaspani Mn Ore Mine exhibits a notably higher average PF of 2.30. This increase is attributed to a strategic shift in operational dynamics, particularly after 2017, where explosives usage became more focused. This change is partly due to a transition from predominantly open-cast mining to increased underground development, influencing the overall powder factor calculation for this mine.

Meanwhile, Kajlidongri Mn Ore Mine shows a distinct operational pattern with a wide range of PF values. Here, the maximum recorded PF is 5.64 and the minimum is 4.45. This significant variability underscores the mine's heavy reliance on open-cast blasting methods, which typically require higher explosive usage to facilitate efficient ore extraction. These observations highlight the nuanced differences in mining practices and operational strategies among the three mines, each influenced by geological factors, technological advancements, and strategic shifts in mining operations over time. Various research studies on the environmental impact of explosives have consistently highlighted the significant contribution of these materials to greenhouse gas emissions. Specifically, it has been concluded that the detonation of 1 kg of explosive releases approximately 0.30 to 0.40 kg of CO_2 into the atmosphere. This emission contributes to the growing concerns about climate change and global warming. However, the environmental impact of explosives is not limited to CO_2 emissions alone. The detonation process also produces harmful nitrous and sulphide fumes, which further degrade air quality and contribute to environmental pollution.

To comprehensively assess the impact of explosive use on the environment, particularly in terms of CO_2 emissions, a year-by-year analysis has been conducted for each of the mines under study. This analysis aims to estimate the total amount of CO_2 released into the atmosphere as a result of explosive usage over time. By calculating the emissions on an annual basis, this study provides a clearer understanding of how mining operations contribute to greenhouse gas emissions and allows for the identification of trends, enabling the development of strategies to mitigate the environmental impact of explosive use in mining activities.

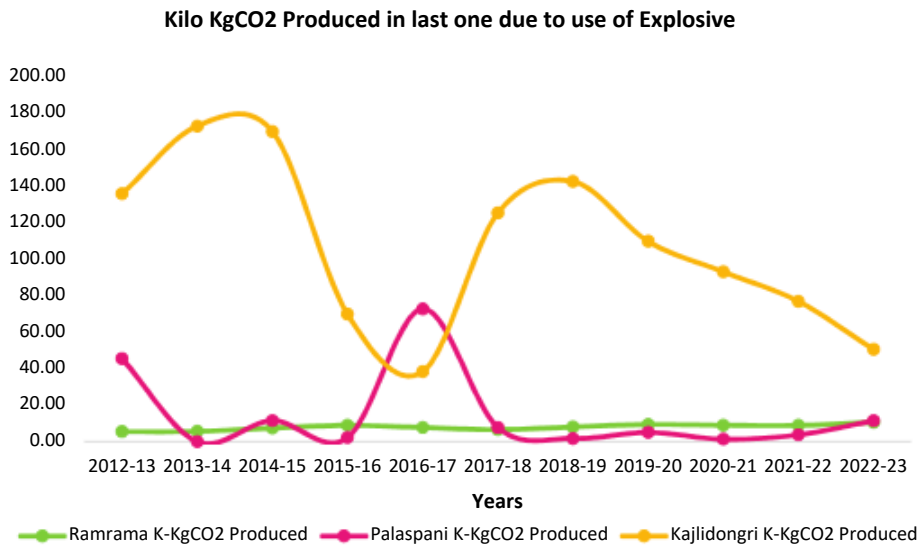


Figure no- : Kilo KgCO2 Produced in last one due to use of Explosive in all three selected Mines

Over the past decade, the average estimated CO2 emissions from explosive use have varied significantly across the three mines under study. At Ramrama Mn Ore Mine, the average CO2 emissions have been calculated at 7.98 K-KgCO2. This relatively lower figure reflects the mine's operational practices, where the scale of explosive use is moderate, particularly given the balance between ore extraction and overburden removal. In contrast, Palaspani Mn Ore Mine has recorded an average estimated CO2 emission of 14.81 K-KgCO2. The higher emission levels at this mine can be attributed to its mixed-method operations. While the mine transitioned to more underground mining after 2017, the use of explosives remained a crucial component in the development phases and in blasting within the stopes. However, the shift from predominantly open-cast mining has somewhat constrained the overall explosive consumption compared to operations solely reliant on surface mining.

Kajlidongri Mn Ore Mine presents a starkly different scenario, with an average estimated CO2 emission of 107.61 K-KgCO2. This substantial emission level is largely due to the mine's dependence on open-cast mining methods, where explosives play an essential role in both overburden (OB) removal and ore blasting. The scale of explosive consumption in Kajlidongri is much larger than in underground mining operations, leading to significantly higher CO2 emissions. This comparison across the three mines underscores the impact of mining methods on environmental emissions, highlighting how the scale and nature of explosive use vary with different mining techniques.

Environment Dimension-

The environmental impact of particulate matter (PM2.5 and PM10) and gaseous pollutants (NOx, SOx, and CO) at Ramrama Mn Ore Mine, Palaspani Mn Ore Mine, and Kajlidongri Mn Ore Mine varies significantly due to the different mining operations conducted at each site. These pollutants contribute to air quality degradation, pose risks to human health, and lead to broader environmental issues such as acid rain and climate change. To reduce the impact each of mine has taken initiative to control the pollution and design of control measure. The environment impact study has been carried out at regular interval to ascertain the level of pollution and to take mitigation measures.

At Ramrama Mn Ore Mine, the operations are characterized by a moderate scale that includes both overburden removal and ore extraction. This results in lower levels of particulate matter and gaseous emissions compared to more intensive mining operations. PM2.5 and PM10, which are fine and coarse particulates, are primarily generated during activities such as blasting, drilling, and the movement of heavy machinery. However, because the mining practices here involve a balanced mix of underground and surface activities, particulate emissions are relatively less intense. The emissions of NOx and SOx, which occur during the detonation of explosives and from diesel-powered equipment, are present but not as pronounced. Consequently, their impact on air quality is somewhat mitigated. CO emissions, which result from the incomplete combustion of fossil fuels, are moderate but still pose a concern for localized air pollution and the health of workers.

In contrast, Palaspani Mn Ore Mine has seen a shift in the environmental impact of these pollutants due to changes in mining operations. Initially, when the mine primarily operated as an open-cast site, the levels of PM2.5, PM10, NOx, SOx, and CO were relatively high. Open-cast mining typically involves extensive blasting and excavation activities, which generate significant amounts of dust and gaseous emissions. However, after 2017, as the mine transitioned toward underground operations, the levels of particulate matter likely decreased. In underground mining, the generation of dust is more contained, though ventilation systems may still release some particulates and gases to the surface. While the emissions of NOx and SOx have reduced compared to open-cast operations, they continue to be produced from the use of explosives and diesel-powered equipment in underground development. CO emissions remain a concern, especially within the confined spaces of underground mines, where limited air circulation can lead to potential health risks for workers.

Kajlidongri Mn Ore Mine presents the most significant environmental challenge among the three mines, due to its heavy reliance on open-cast mining. This operation results in the highest levels of PM2.5, PM10, NOx, SOx, and CO emissions. The extensive blasting required for both overburden removal and ore extraction generates large amounts of dust, leading to elevated concentrations of particulates in the surrounding environment. This not only degrades air quality but also poses significant health risks to nearby communities and mine workers, including respiratory and cardiovascular issues. The frequent use of explosives and large diesel-powered machinery in Kajlidongri contributes to high levels of NOx and SOx emissions, which can lead to the formation of ground-level ozone and acid rain, further impacting the environment. CO emissions, resulting from the incomplete combustion of diesel fuel and explosives, are also significant, contributing to localized air pollution and potential health hazards.

Overall, the impact of PM2.5, PM10, NOx, SOx, and CO emissions on the environment varies with the scale and type of operations at each mine. Kajlidongri Mn Ore Mine, with its extensive open-cast mining activities, presents the greatest environmental challenge, followed by Palaspani Mn Ore Mine, which has seen a reduction in emissions due to its transition to underground mining. Ramrama Mn Ore Mine, with its more balanced and moderate operations, has the lowest environmental impact. Nevertheless, all three mines contribute to air quality degradation and pose risks to both human health and the broader environment, highlighting the importance of tailored environmental management practices based on the specific operational characteristics of each mining site.

Particulate matter (PM2.5 and PM10) and gaseous pollutants (NOx, SOx, and CO) have significant adverse effects on human health. PM2.5 and PM10 can penetrate the respiratory system, leading to respiratory and cardiovascular issues, including asthma, bronchitis, heart attacks, and reduced lung function. Long-term exposure increases the risk of chronic respiratory diseases and lung cancer.

NOx and SOx are harmful gases that can cause irritation of the eyes, nose, and throat, as well as respiratory conditions like asthma and bronchitis. They also contribute to the formation of fine particulate matter and acid rain, exacerbating health problems.CO is a colorless, odorless gas that interferes with the oxygen-carrying capacity of blood, leading to symptoms like headaches, dizziness, and in severe cases, carbon monoxide poisoning, which can be fatal. Prolonged exposure to high levels of CO can damage the

heart and nervous system. To understand the impact on human health variation in PM2.5 & 10, Nox, Sox and CO are important in nearby area or villages.

Environmental Impact of Mining at Ramrama Mn Ore Mine-

To understand the environment impact caused due to generation of PM2.5, PM10, Nox, Sox and CO. The monitoring of all parameters is on regular interval is conducted in mine office area, village- Ramrama, Katanjhari & Sirra which are situated at a distance of 3km, 5km and 5km respectively from mine area. The last five-year data is collected and analysed to understand the variation in pattern of generation and its mitigation impact

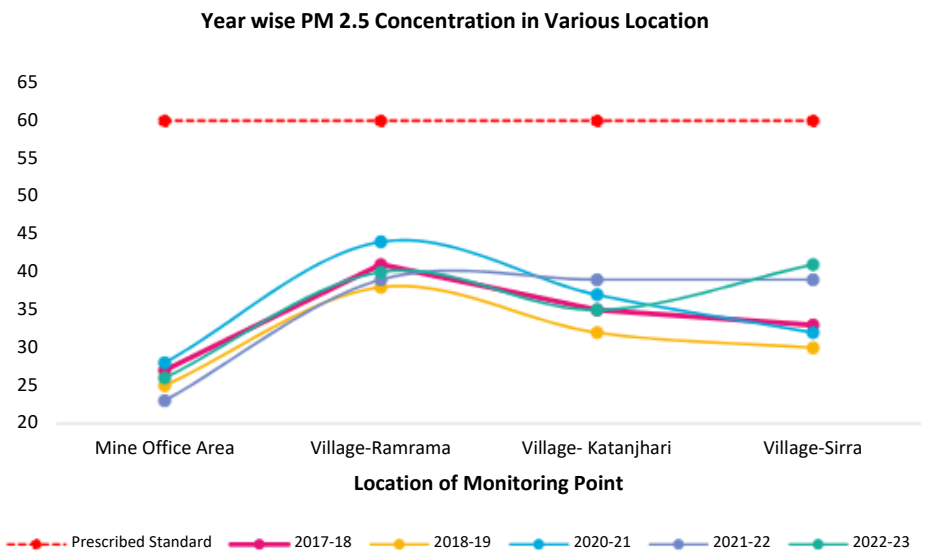


Figure no- Year wise PM 2.5 Concentration in nearby Ramrama Mn Ore Mine

With reference to figure no-, it is evident that the prescribed standard for particulate matter (PM2.5) is set at 60 µgm/m³. The data shows that the average PM2.5 concentration in areas close to the mine office and surrounding villages, including Ramrama, Katanjhiri, and Sirra, remains well below this prescribed standard. This compliance with the guidelines set by the State Pollution Control Board (SPCB) and Environmental Impact Assessment (EIA) regulations indicates that the air quality in these regions is within acceptable limits. The lower concentrations of PM2.5 suggest effective management of dust and emissions in and around the mining operations, thereby minimizing potential health risks to the local population and contributing to a safer living environment.

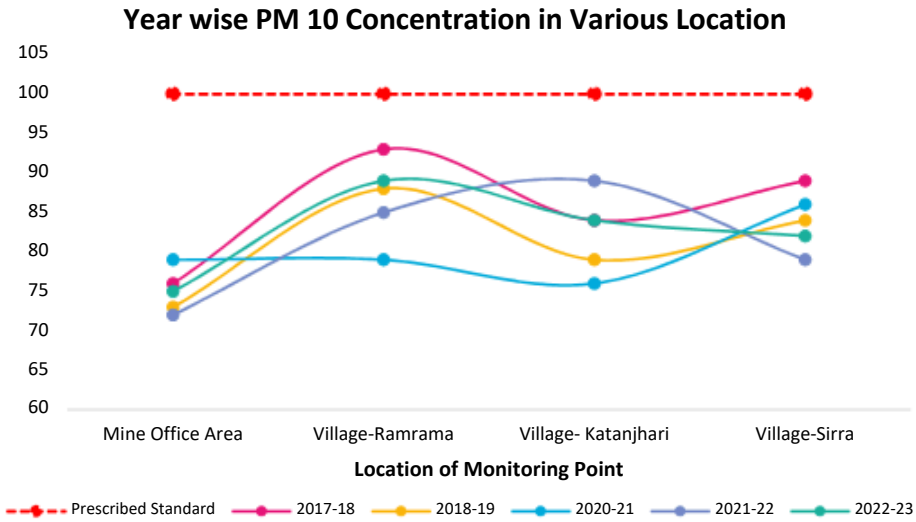


Figure no- Year wise PM 10 Concentration in nearby Ramrama Mn Ore Mine

The prescribed standard for PM10 concentration, as established by regulatory guidelines, is set at 100 µgm/m³. In the mine office area, the recorded PM10 concentrations range between a minimum of 72 µgm/m³ and a maximum of 79 µgm/m³. These values indicate that the air quality within the mine office area remains well below the prescribed limit, reflecting effective dust control measures and adherence to environmental standards.

Similarly, in the nearby villages of Ramrama, Katanjhiri, and Sirra, the PM10 concentrations have been measured at 86.8 µgm/m³, 82.4 µgm/m³, and 84 µgm/m³, respectively. These figures, while slightly higher than those observed in the mine office area, still fall comfortably below the prescribed standard of 100 µgm/m³. This indicates that the impact of mining activities on air quality in these villages is managed within acceptable limits, ensuring that the local population is not exposed to harmful levels of particulate matter. The fact that PM10 concentrations in both the mine office area and the surrounding villages are maintained below the Central Pollution Control Board (CPCB) standards is significant. It demonstrates a commitment to environmental stewardship and the successful implementation of dust control strategies. This compliance helps to safeguard the health of workers and residents, reducing the potential for respiratory issues and other health problems associated with high levels of particulate matter.

SOx and NOx Concentration is also important parameter for the assessment of environmental impact. the variation in SOx level at various location is presented below for the last five year in figure no-

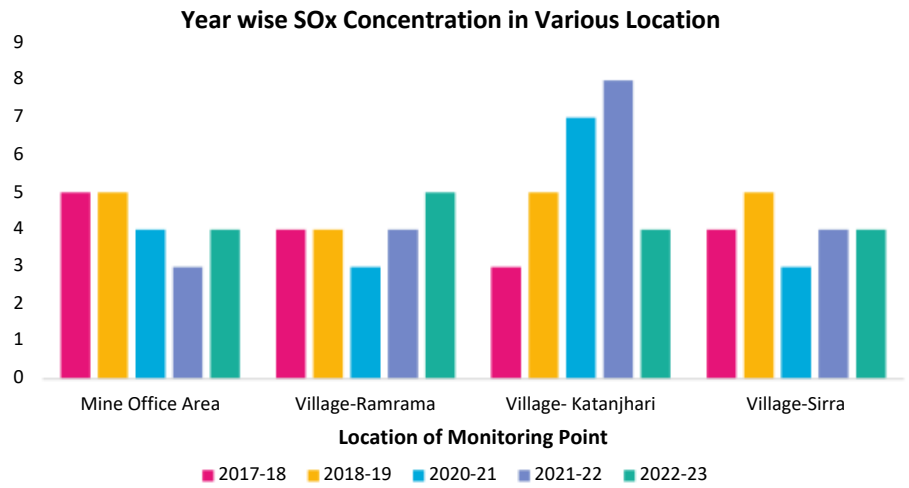


Figure no- : Year wise SOx Concentration in Various Location of Ramrama Mn Ore Mine

The prescribed standard for SOx concentration in the atmosphere is set at 80 µgm/m³. However, data collected from various locations near the Ramrama Mn Ore Mine over the past five years reveals that the maximum recorded SOx concentration is only 8 µgm/m³. This level is significantly below the prescribed limit, indicating that the impact of SOx emissions in the area is minimal. The consistently low SOx concentrations suggest that the mining operations at Ramrama Mn Ore Mine have a negligible effect on the local atmosphere concerning sulphur oxide pollutants. This not only demonstrates compliance with environmental regulations but also highlights the effectiveness of measures taken to control SOx emissions, thereby contributing to a healthier environment for the surrounding communities.

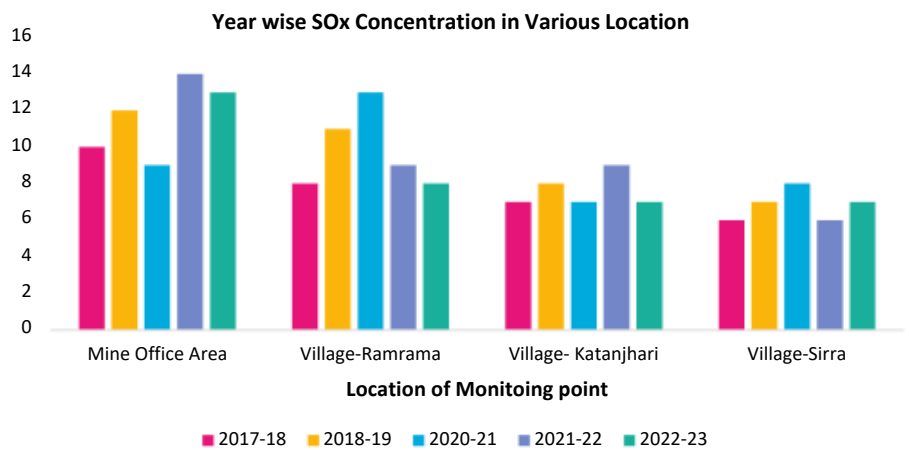


Figure- : Year wise NOx Concentration in Various Location of Ramrama Mn Ore Mine

With reference to Figure X, the data indicates that the maximum concentration of NOx across all monitored locations is 14 µgm/m³, which is significantly below the prescribed limit of 80 µgm/m³ set by the Central Pollution Control Board (CPCB). Additionally, the concentration of CO in these locations is also minimal, with the highest recorded level being just 0.1 mg/m³ over the past five years. These findings suggest that the levels of NOx, SOx, and CO resulting from the mining operations at Ramrama Mn Ore Mine have no significant impact on the local environment. The negligible concentrations of these pollutants indicate that the emission levels are effectively controlled, largely due to the natural ventilation provided by the flowing air in the area. This natural air movement helps to diffuse and disperse the gases, maintaining air quality within safe limits and minimizing the environmental impact of mining activities. This natural mitigation underscores the minimal influence of the mine on air pollution, ensuring a healthier atmosphere for the surrounding communities.

Environmental Impact of Mining at Palaspani Mn Ore Mine-

At Palaspani Mn Ore Mine, environmental concerns are addressed through regular and systematic monitoring of ambient air quality at various locations, particularly in areas with high population density and significant livelihood activities. Ensuring that these areas have good air is crucial for maintaining social and environmental well-being. To effectively monitor these parameters, four permanent sampling stations have been established. These stations are strategically located near the administrative building and in the villages of Tinkheda, Khairi, and Borgaon. Tinkheda Village is situated approximately 2 kilometers from the leased area, while Khairi and Borgaon villages are 2 kilometers and 1.2 kilometers away, respectively. Periodic sampling is conducted by an outsourced third-party consultant to ensure accurate and unbiased results.

The analysis reports from these monitoring activities provide detailed information on the quality of air in these areas, helping to assess the environmental impact of mining operations. These reports are crucial for maintaining transparency and ensuring that environmental standards are met, thereby supporting both the health of local communities and the integrity of the surrounding environment. Beside to all four surrounding villages, analysis of Air Quality near to Palaspani Mine Crusher is also carried out in every forth months intervals as per NAAQM. "NAAQM" stands for National Ambient Air Quality Standards. These standards are guidelines set by environmental agencies or authorities in various countries to specify the acceptable levels of air pollutants in the ambient air.

NAAQMs are established to protect public health, welfare, and the environment by regulating the concentrations of key air pollutants known to have adverse effects. The PM 2.5 concentration in and around Palaspani Mn Ore Mine for the last five year is represented below-

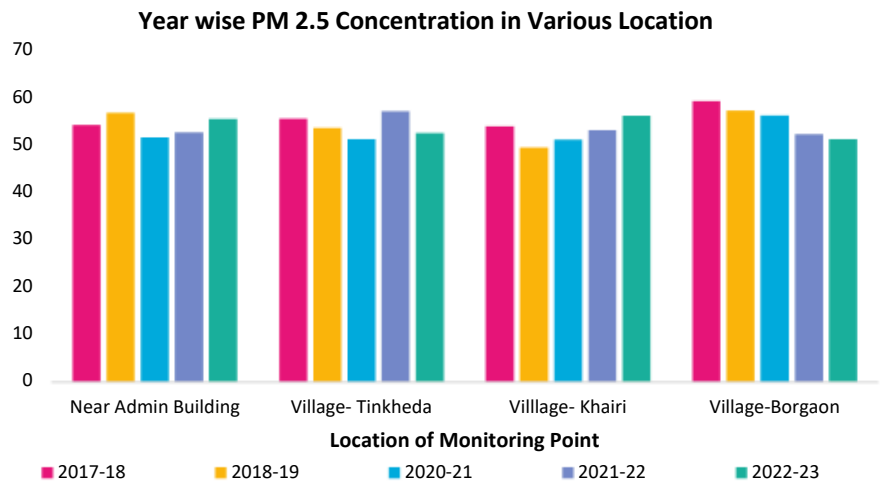


Figure no - Year wise PM 2.5 Concentration in nearby Palaspani Mn Ore Mine

With reference to figure no-, the average PM2.5 concentration over the past five years has remained within the prescribed limits. Although there was significant variation compared to Ramrama Mn Ore Mine, this is due to Palaspani Mn Ore Mine's shift from a combination of open-cast and underground mining to predominantly underground mining. This transition has significantly reduced PM2.5 levels.

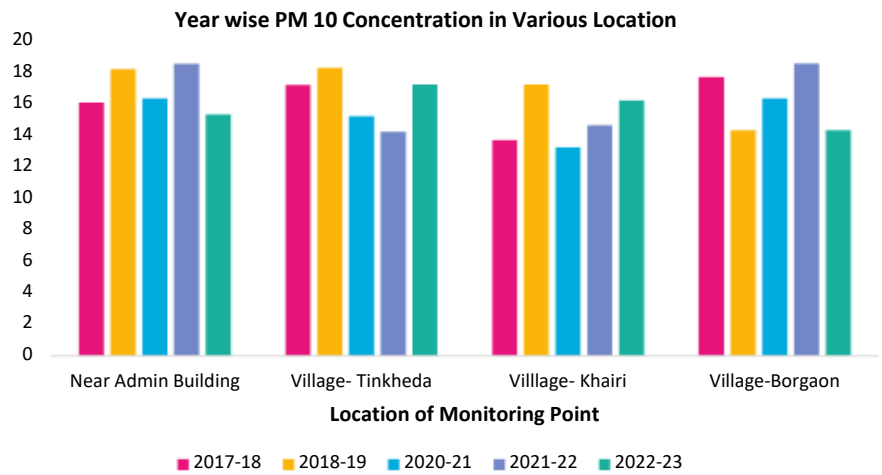


Figure no - Year wise PM 10 Concentration in nearby Palaspani Mn Ore Mine

The PM 10 concentration near to admin building, villages- Tinkheda, Khairi and Borgaon are well below to prescribed standard by CPCB. However, there is a notable variation in PM10 levels when compared to Ramrama Mn Ore Mine. This variation is attributed to the different mining methods employed at Palaspani Mn Ore Mine. Initially, the mine relied partially on open-cast mining, which contributed to higher PM10 concentrations. However, with the transition to predominantly underground mining methods, there has been a significant reduction in PM10 levels. This shift has proven effective in mitigating particulate emissions, thereby improving air quality around the mining area. The generation of SOx and NOx gases are also important and crucial parameters for well being of human and their health. There regular monitoring for last five year in various places nearby mine is presented below in figure no- .

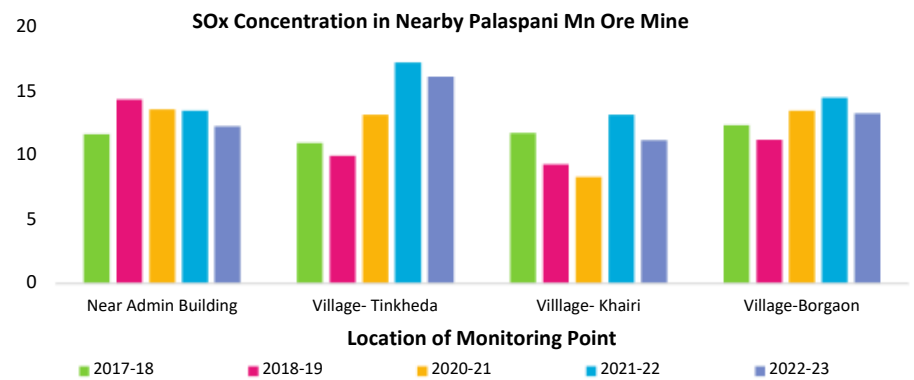


Figure no- : Year wise SOx Concentration in Various Location of Palaspani Mn Ore Mine

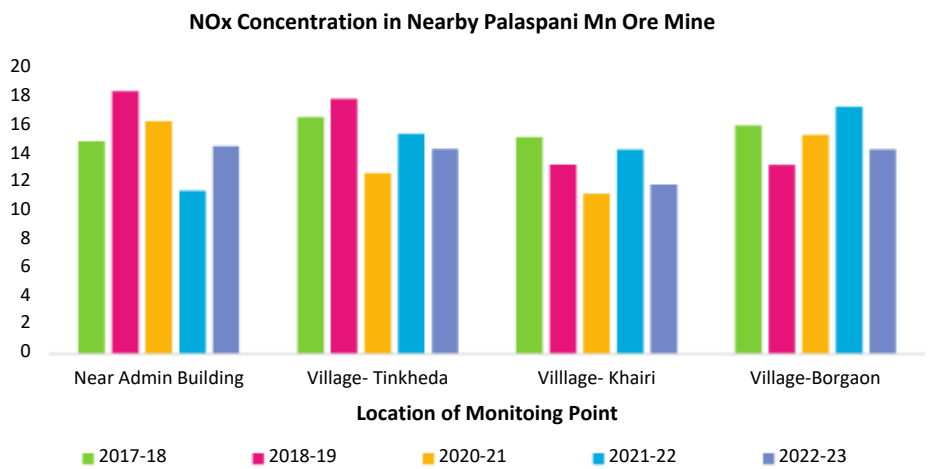


Figure no- : Year wise NOx Concentration in Various Location of Palaspani Mn Ore Mine

As shown in figure No-___&__ the concentrations of SOx and NOx are well below the prescribed standard of 80 µgm/m³. This indicates that there is no adverse impact on human health, as confirmed by primary survey data. The reduction in SOx and NOx levels is attributed to the decreased use of high-sulphur diesel (HSD) equipment and the transition from open-cast to underground mining methods, which has significantly diminished gas hazards for local residents. Additionally, CO concentrations are also well within the standards set by the Central Pollution Control Board (CPCB).

Environmental Impact of Mining at Kajlidongri Mn Ore Mine-

Due to production from opencast mines of Kajlidongri, the impact on nearby villages (Rasodi, Nangavat, Pipalkutta and Piploda are notable because of following impactful reasons which are increased dust emission due to fugitive dust generation caused due to plying of machinery, opencast method involves engagement of various HSD power-based equipment which emits various gases including sulfer dioxide, nitrogen oxides and carbon mono oxide. These gases contribute to air pollution, acid rain, and smog, which can have detrimental effects on both human health and the environment. The intensive use of machinery and explosives in open-cast mining increases greenhouse gas emissions, contributing to climate change. The combustion of fossil fuels for machinery and transportation adds to the carbon footprint of the mining operations. Open-cast mining operations generate significant noise and vibration, which can affect the surrounding environment and communities. These disturbances can impact the health and well-being of residents and wildlife. The Noise levels are mentioned for the Palaspani Mn Ore Mine-

Details	Monitoring Locations & Observation			
	NA-1	NA-2	NA-3	NA-4
Standard Limit (CPCB)	75.0 (Day Hours)			
Observed Value (Day Time)	58	62.3	50.9	56.7
Standard Limit (CPCB)	70.0 (Night Hours)			
Observed Value (Night Time)	34.7	40.4	37.6	36.9

*all Values are in dB(A)

Details:

NA-1: Near Admin Building

NA-2: Rasodi village (2.0 km in SW)

NA-3: Pipalkutta village (2.0 km in SE)

NA-4: Piploada village (1.2 km in North)

Monitoring particulate matter (PM2.5 and PM10) is essential because these fine and coarse particles can have significant health impacts. PM2.5, being smaller, can penetrate deep into the respiratory system, leading to severe health issues such as asthma, bronchitis, and cardiovascular diseases. PM10, while larger, can still affect lung function and exacerbate existing health conditions. By assessing these concentrations, the mine can evaluate the effectiveness of dust control measures and ensure that air quality meets regulatory standards, thus protecting the health of workers and nearby communities. Secondly, understanding the levels of sulphur oxides (SOx) and nitrogen oxides (NOx) is important for managing the environmental impact of mining operations. SOx and NOx are significant contributors to air pollution and can lead to the formation of acid rain, which harms vegetation, soil, and water bodies. High levels of these pollutants can also cause respiratory problems and other health issues. Monitoring these gases helps in assessing the extent of their emissions from mining activities and in implementing strategies to reduce their impact, such as optimizing the use of equipment and adopting cleaner technologies. The Level of Concentration at Kajlidongi Mn Ore Mine is presented below-

Location	Parameter	Unit	Prescribed Standard	2017-18	2018-19	2020-21	2021-22	2022-23
Near Admin Building	PM2.5	µgm/m3	60	54.3	56.87	51.65	52.76	55.64
	PM10	µgm/m3	100	16.1	18.2	16.34	18.54	15.32
	SO2	µgm/m3	80	11.7	14.43	13.65	13.54	12.32
	Nox	µgm/m3	80	14.9	18.43	16.32	11.43	14.54
	CO	mg/m3	4	0.48	0.38	0.23	0.43	0.36
Rasodi Village	PM2.5	µgm/m3	60	55.7	53.76	51.34	57.23	52.65
	PM10	µgm/m3	100	17.2	18.29	15.23	14.23	17.23
	SO2	µgm/m3	80	11	10	13.24	17.32	16.21
	Nox	µgm/m3	80	16.6	17.87	12.67	15.43	14.37
	CO	mg/m3	4	0.48	0.43	0.36	0.38	0.23
Pipalkutta Village	PM2.5	µgm/m3	60	54	49.56	51.23	53.23	56.23
	PM10	µgm/m3	100	13.7	17.23	13.24	14.65	16.23
	SO2	µgm/m3	80	11.8	9.34	8.34	13.23	11.23
	Nox	µgm/m3	80	15.2	13.25	11.23	14.32	11.87
	CO	mg/m3	4	0.49	0.29	0.37	0.41	0.45
Piploada Village	PM2.5	µgm/m3	60	59.4	57.34	56.34	52.34	51.34
	PM10	µgm/m3	100	17.7	14.34	16.34	18.56	14.34
	SO2	µgm/m3	80	12.4	11.26	13.54	14.54	13.34
	Nox	µgm/m3	80	16	13.23	15.34	17.32	14.34
	CO	mg/m3	4	0.57	0.35	0.41	0.36	0.33

Table no-: Year wise data for environment pollution monitoring of Kajlidongri Mn Ore Mine

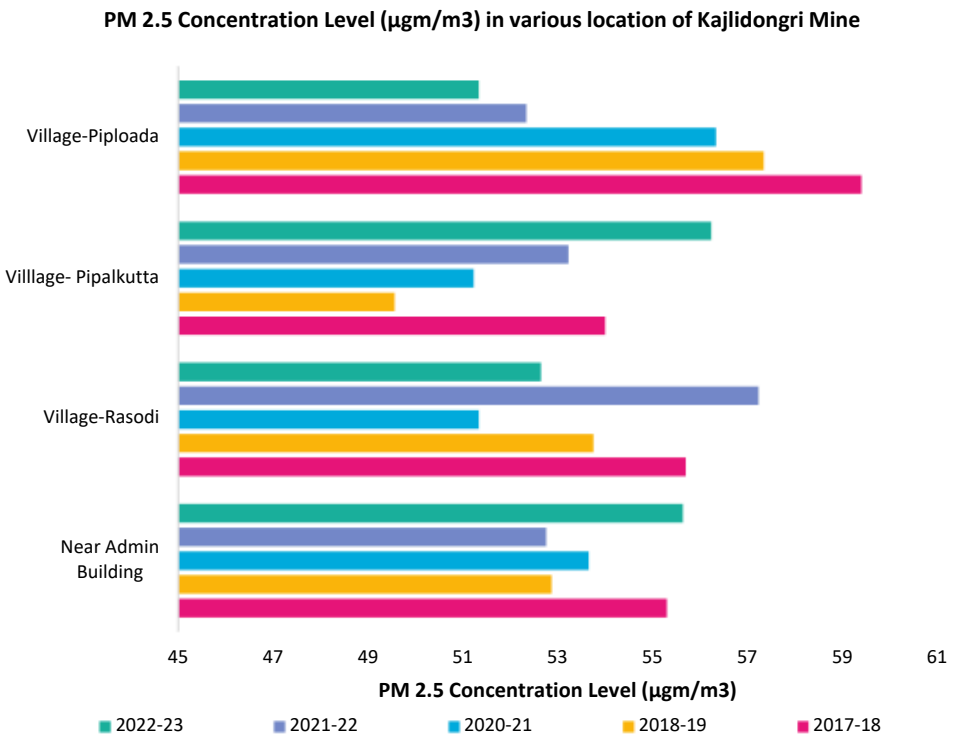


Figure no- PM 2.5 Concentration level in Various location of Kajlidongri Mine

Based on the data presented in table no-, the concentration of PM2.5 over the past five years has shown some variability. At the location near the administrative building, PM2.5 concentrations ranged from 52.76 µgm/m³ to 55.64 µgm/m³, with an average concentration of 54.04 µgm/m³. This indicates a relatively stable level of particulate matter in this area, though it is crucial to monitor these levels to ensure they remain within acceptable limits. In the village of Rasodi, PM2.5 concentrations have fluctuated between 51.34 µgm/m³ and 57.23 µgm/m³, with an average concentration of 54.13 µgm/m³. This range is slightly wider compared to the area near the administrative building, reflecting some variation in air quality within the village. Despite the variability, the average concentration remains relatively close to that of the administrative area, suggesting a similar level of particulate matter exposure.

As per figure no- ,In the villages of Pipalkutta and Piploada, the average PM2.5 concentrations were observed to be 52.86 µgm/m³ and 55.35 µgm/m³, respectively. These values indicate that both villages experience levels of particulate matter that are comparable to those near the administrative building and Rasodi. The data suggests that

PM 2.5 concentrations in these villages are within a similar range, indicating that the air quality impacts of mining operations are relatively uniform across these locations. Overall, while there is some variation in PM2.5 concentrations across different areas, the average levels in these locations are consistently monitored to assess and manage air quality. This ongoing assessment is crucial for addressing any potential health risks associated with particulate matter exposure and for implementing effective dust control measures.

In examining the environmental dimension of this case study, a detailed analysis was conducted on the impact of mining operations related to emissions and the generation of PM2.5, PM10, SOx, NOx, and CO concentrations across selected mines. The findings indicate that the impact was relatively minimal at the Ramrama Mn Ore Mine. This can be attributed to the strategic transition from open-cast to underground mining, which was carried out without compromising alternative methods of mining to maintain or even increase production levels. As a result, the concentration of pollutants at Ramrama remained lower compared to other mines in the region. In contrast, the situation at Palaspani Mn Ore Mine presented a different scenario. During the same decade, Palaspani was undergoing a transition from open-cast to underground mining. The dual-phase operations, involving both open-cast mining and the development of underground infrastructure, contributed to higher concentrations of pollutants when compared to Ramrama Mn Ore Mine. The emissions from these activities led to elevated levels of PM2.5, PM10, SOx, NOx, and CO, reflecting the environmental burden of managing a mine in transition.

The Kajlidongri Mn Ore Mine faced even greater environmental challenges due to its continued reliance on open-cast mining operations. The heavy machinery and other equipment used in these operations, primarily powered by high-sulfur diesel (HSD), significantly increased the levels of SOx and NOx in the atmosphere. These emissions were notably higher compared to the other mines, highlighting the environmental costs of maintaining production through open-cast methods.

However, the gradual shift toward underground mining methods at Kajlidongri Mn Ore Mine has begun to mitigate some of these atmospheric impacts. Underground mining generally produces lower levels of dust and gas emissions and causes less surface disturbance, which can help reduce the environmental footprint of the mine. Despite this positive shift, it remains essential to implement effective management and mitigation

strategies to address any residual environmental and health concerns associated with the mining operations. Continuous monitoring and adaptive measures are crucial to ensuring that the transition to underground mining leads to a sustained reduction in atmospheric pollution and overall environmental impact.

Social Dimension-

Corporate Social Responsibility (CSR) has become an integral part of business operations across various industries, including the mining sector. In recent years, mining companies have recognized the importance of balancing economic goals with social and environmental responsibilities. This write-up explores how CSR activities in the mining industry contribute to sustainable development and create job opportunities. Mining operations often have significant impacts on local communities, ecosystems, and economies. CSR initiatives in the mining sector aim to address these impacts and promote sustainable development. Sustainable development is now a widely accepted concept. Its goals include the elimination of poverty, health for all, social justice and meeting the needs of society while living within the planet's ecological limits and without undermining the needs for future generations. When transferring sustainable development to the business level, corporate sustainability can be defined as meeting the needs of a company's direct and indirect stakeholders without compromising its ability to meet the needs of future stakeholders (Dyllick and Hockerts, 2002). Corporate sustainability and corporate social responsibility (CSR) are voluntary activities that demonstrate the inclusion of social and environmental concerns in business operations and in interactions with stakeholders (van Marrewijk, 2003). These concepts have different pasts: corporate sustainability was often identified with the environmental responsibility dimension of business and CSR with the social responsibility dimension. However, current research shows that these two concepts are now converging due to their shared environmental and social concerns (Montiel, 2008). CSR is often defined as the integration of social and environmental concerns in a company's business operations and its interactions with stakeholders on a voluntary basis (Dahlsrud, 2008). CSR has a long and wide-ranging history. The Industrial Revolution, and the concern of emerging businesses to care for their employees and help them to become more productive, can be seen as the starting point. The 1950s known as the 'philanthropic' era in which companies donated to charities. The period 1953-67 was classified as the 'awareness' era, because it was in this period that businesses became much more aware of their overall responsibilities and

involvement in community affairs. The period 1968-73 was termed the 'issue' era, because here companies began to focus on specific environmental issues, such as urban decay, racial discrimination and pollution problems. Finally, in the 'responsiveness' era, companies began to address CSR issues in a much more serious way (Carroll, 2008). Key focus areas of CSR in mining include:

1. Community Development
2. Environmental Conservation
3. Education and Skill Devlopment
4. Health and Safety Program
5. Job Opportunities
6. Skill Development & Training
7. Diversification of the Economy

CSR activities in the mining industry play a pivotal role in fostering sustainable development and job opportunities. Mining companies that actively engage in responsible business practices not only mitigate the negative impacts of their operations but also contribute positively to the well-being of local communities and the overall economic landscape. As the mining industry continues to evolve, the integration of CSR will likely remain a critical factor in shaping a more inclusive and sustainable future.